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Do Enterprise Systems Enable Supply Chain Integration?

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Abstract — **Features of ERP systems such as standardized business processes, data integrity, real-time availability, visibility and processing capability of information are expected to create an excellent backdrop for embarking on integration with external partners in the supply chain. This paper reports on the enabling role of ERP systems in achieving supply chain integration from an interpretive case study analysis. Study observed that the organization is slow in embarking on changes to the inter-enterprise processes and not taking full advantage of the high potential. Reasons noted for constraining role of ERP systems in achieving an effective supply chain integration are changes in power and organizational structures, inadequate integration of internal processes, limited flexibility of processes, lack of decision support capability of the ERP system, and general inertia for further changes consequent to ERP implementation. In addition other factors such as supply chain partners inability to take a holistic view, complexity of developing technology interfaces, industry characteristics, and lack of information technology sophistication of the smaller partners are also limiting the potential.**

Keywords — **Enterprise Systems, Supply Chains, Integration**

I. INTRODUCTION

Enterprise Resource Planning (ERP) systems, comprehensive transaction management systems are now in most of the organizations today and has become a defacto standard. Having achieved some level of integration within enterprise by implementing Enterprise Resource Planning (ERP) systems at great cost and efforts, many large organizations have moved on to address the supply chain. In order to leverage all this integrated information into a real competitive advantage and achieve returns on investment in ERP systems, organizations are extending beyond their enterprise. Organizations have realized that it is not possible to achieve successful e-business and supply chain integration without a sound, robust and well integrated back-end enterprise wide information system. After consolidating the gains of internal standardization of processes and integration, organizations are now investigating how they can help them move beyond the enterprise and achieve supply chain efficiencies.

Recognizing the need for further research in this area, this study investigates the role of ERP systems in enabling the supply chain integration using an interpretive case study approach. It will first present a review of the literature on ERP systems and analyze its strengths and weaknesses in the context of supply chain management. It then briefly explains the research framework and methodology and discusses findings.

II. LITERATURE REVIEW

A. ERP systems and Supply Chains

Integrating information across the enterprise and across the supply chains has long been considered an important strategy to achieve substantial cost efficiencies. Though enterprise resource planning (ERP) systems were considered costly and risky in the 1990s, its benefits are well recognized in the literature. Some of the benefits ERP systems could bring include operational efficiency and reduced costs, enforcing a discipline of best practice processes and consistency [1], [2], [3], [4].

After successfully achieving the benefits of information and process integration across the enterprise globally and improving internal processes, organizations are now examining how these ERP systems can help improve processes across the supply chain. Typical features of enterprise systems such as data integrity, real-time availability, visibility and processing capability of information and standardized business processes are expected to create an excellent backdrop for embarking on integration with external partners in the supply chain [5]. Even though the primary focus of ERP systems was to execute and integrate internally oriented applications such as finance, accounting, manufacturing, order processing and human resources, today, they are considered a critical prerequisite for supply chain integration and e-commerce [6].

In this environment, organizations moving in the direction of supply chain integration have several options. These include, implementation of ERP (Enterprise resource planning) system and SCM (Supply chain management) systems, implementing a full ERP system that has all the capability, to custom-built application integration, or to implement some supply chain management software. Implementing both ERP and SCM systems is the most popular option. After the implementation of enterprise systems, several companies are now concentrating on adding SCM systems. ERP systems are viewed as a precursor to SCM effort and complementary in nature. While the ERP systems aim to integrate and optimize internal business processes within the organizations, the

SCM systems take a broader approach and facilitate integration of processes across the enterprise. The focus of ERP system is on transactions, while the SCM offers intelligent decision support. ERP systems store data about all events in the sourcing, production and delivery cycle, and act as integrators of SCM systems. Together, they can position the organization for effective management of the supply chain.

SCM software solutions such as i2, Manugistics etc. can increase the speed and accuracy in planning and scheduling by concurrently managing the constraints across the supply chain [7]. Drawing its resources and transactional data from enterprise systems, these SCM systems can dynamically take into consideration the constraints imposed by customers, markets and suppliers and can support the decision processes in supply chain with their modeling and analytical capability.

While transaction centric ERP systems provide some tools that can support supply chain integration, some of their features could also obstruct integration with business partners [8]. Internal process integration and real-time information visibility and tracking are the most important tools a transaction-centric ERP systems offer to support supply chain integration with business partners [8]. The unwillingness of business partners to share information, however, may actually obstruct the integration even though ERP system offers opportunities for sharing of information about demand, products and production.

B. Information Overload

Large volumes of transaction based planning and operational data generated and stored by ERP system could be useful for planning and demand management. ERP systems, while providing good transactional engine for operational control, tend to increase the volume of information available to managers [9]. Thus, too much information in overwhelming detail, may contribute to information overload. This information, however, is about the internal processes and internal supply chain. Information sharing and transfer from the other partners, external supply chain information and the product demand and planning information may actually may further intensify the information overload.

C. Data Reliability and Controls

Right operational data to move onto the next level of collaborative planning in supply chain is critical. If the system cannot find basic control and operational data to feed into planning model, the intra-enterprise planning becomes irrelevant. The multi-enterprise collaborative planning is almost impossible in such a situation where even basic operational data is not available. Despite the latest systems, absence of control data and reliability of the data are considered main barriers for an effective supply chain [10]. In this context, ERP system provides operational data that is consistent, accurate and real-time.

Enterprise systems generally have the ability to streamline the entire financial and operational reporting process, without any need for traditional batch controls and audit trails. In a supply chain context where information is shared and transferred among the partners, data integrity is critical. The risk for data accuracy and integrity in an ERP enabled environment may still exist because of the close interfaces with other business partners.

Unless there are special data cleansing programs incorporated in the ERP systems, it is not possible to guarantee accuracy and currency of the operational data. Even though ERP software vendors incorporated software features that will ensure data entry accuracy and cross-checking of the validity of data, and specified user views of data, the risk may still exist.

Reliability of data is the key to the effective and successful collaboration between supply chain partners. Reliability of data, on the customer side, involves attributes such as deliverability, quality, service, and agility. On the supplier side, reliability means reliable forecast and sharing data with vendors. Because of their real-time orientation, enterprise systems are more dependent upon programmed controls than on human intervention to validate important transactions. This risk is further exacerbated by the elimination of several supervisory roles and control roles as a result of implementing enterprise systems. In many instances, the organizations are dependent on one or two individuals for their critical data.

The issue becomes critical in a supply chain context since this information is the basis on which partners in the supply chain make decisions and carry out collaborative planning. Importantly, in an environment where ‘trust’ is critical in initial stages, lack of reliability of the operational data that is routinely shared by the partners may endanger the potential collaborations and the eventual supply chain integration.

D. Internal Integration

Since most of the claimed benefits of ERP systems over legacy systems and best-of-breed systems arise from the integration of information across functional areas, the ability to extract benefits will be reduced if only a limited set of ERP modules are implemented. Evidence from the field suggests that the so-called integration is not full and complete even in organizations where full implementation has reportedly taken place [11].

In certain organizations where only two or three modules are implemented for whatever reasons, the level of integration, and therefore the extent of the visibility and accessibility of the information across the organization, is limited. If information integration is not achieved because of limited implementation, then all potential benefits of ERP systems should not be expected, including that of improved managerial decision-making. If internal integration itself is not completely achieved, the potential to extend that integration of information and processes across the enterprise is also low.

E. Decision Support Capability

ERP systems, because of their transaction-centric nature, have traditionally inadequate or limited capability to support decision-making in organizations. Even though

increased transaction processing efficiencies, higher quality information and greater accessibility of information, and greater support for ad hoc reporting were identified as some of the benefits of implementing ERP, very little impact on the business analysis and decision support areas was noticed in the past research [12]. Recognizing and acknowledging this weakness, several major ERP software vendors have started offering extension products such as Advanced Planning and Scheduling (APS), Supply Chain Management (SCM), Customer Relationship Management (CRM), Product Life cycle Management (PLM), Business intelligence Warehousing (BW) etc that offer decision support capability.

Organizations are increasingly 'bolting-on' such extensions on top of existing ERP system and deriving the powerful decision support capability [13]. For example, SAP, even in their recent 'mySAP ERP' all-in-one solution, has incorporated new reporting functionality in the form of 'Business Analytics' to their new customers in the mid-market. These developments explicitly signal that ERP systems by themselves have limited capacities to meet such needs, and software vendors are offering additional tools and solutions to support decision-making capability. As noted by Holsapple & Sena, the increase in such third party offerings and extensions to ERP systems by the major software vendors reflects the weakness of ERP systems in delivering unstructured decision support benefits [14].

F. Lack of Open Technologies and Architecture

ERP systems were originally intended to replace a multitude of legacy systems. Even though the later versions are now 'web-enabled,' the emphasis is still on the integrated architecture. This lack of open component based ERP system architecture in a dynamic supply chain management context may become its weakness [15].

With concerted move by almost all the major software vendors towards open integration technologies, acceptance of XML standards for document exchange and conversion, steady move towards web services standards and service-oriented architecture for technology, process and information integration, it is now feasible to extend the capability of enterprise systems to deal with external partners and achieve supply chain efficiencies. Technologies such as Web services would allow applications interactions across organizational boundaries economically and incrementally. With Service Oriented Architecture (SOA) as its underlying philosophy, Web services are expected to transform the inter-organizational business transactions in future [16]. These Web services, designed to support application-to-application interaction without human assistance, can be accessed by disparate devices from handheld devices to large servers. In supply chain management context, flexibility in business processes is critical. Web services that will allow loose coupling of business processes, allow the organization to mix and match their offerings without making large investments in change management [16].

G. Process Standards and Open Technologies

The moves by various industry groups and organizations towards development and acceptance of process management standards for different industries are expected to make process and information integration between partners in supply chain easier [17].

Some of the process activity standards popular in the industry are 'SCOR' (Supply Chain Operations Reference Model by Supply Chain Council) for manufacturing supply chains, DCOR/VCOR (Design Chain Operations Reference model for design and Value Chain Operations Reference model for value chains), eTOM in telecom industry, ITIL (Information Technology Infrastructure Library) for information technology industry, SEI (Software Engineering Implementation) capability maturity model for software industry etc. are expected to make process and information integration between the enterprises easier [17].

Recent developments of modern business process modeling and management tools such as PetriNets, eBRL, and several workflow modeling tools and languages are also expected to contribute to the full exploitation of the ERP systems' potential that is so far untapped.

H. Other Challenges

In spite of such exciting developments in technologies, standards and tools, several barriers are still apparent. For example correct implementation of ERP system is considered important pre-requisite for integrating supply chain. Without a properly functioning ERP system, supply chain integration may create more upstream and downstream problems at Internet speed [18].The dynamic changing nature of supply chain, extent of change required in organisational culture, trust and understanding between partners, lack of standardized approaches to sharing information and knowledge, differences in technology investments between partners, implementation of SCORE and/or other modeling methodologies or lack of it, availability of relatively less expensive 'bolt-ons', the extent of internal integration of processes and data, problems with the continuous usage of legacy systems and other managerial factors pose new challenges and raises new questions.

III. RESEARCH FRAMEWORK AND METHODOLOGY

A. Research Framework and Significance

Academic and industry literature reported significant benefits of implementing ERP systems that include process improvements, standardized processes, information and data discipline [19]. However, research on how firms are extending and exploiting the capabilities of their enterprise systems beyond their enterprise is inadequate [20], [6].

Based on a comprehensive review of the research on ERP systems, Cumbie and others, identified the paucity of studies in supply chain context [21]. Burgess and Houghton on a study of the effectiveness of ERP systems in generating innovations in supply chain management pointed out the overwhelmingly positivist research that

generally ignored the social component, which is important in supply chain management context [22]. Research in supply chain management, by its nature is multidisciplinary and the research in the past generally lacked pluralist perspectives [22].

While some past studies have investigated the benefits and potential impact of ES on various organizational dimensions, processes and supply chains using quantitative methods, interpretive case studies that investigated the role of ERP systems in enabling supply chain integration are limited. Based on a Delphi study conducted on the future impact of ERP systems on Supply Chain Management (SCM), Akkermans and others have predicted a modest role for ERP systems. They have cautioned that "one should not expect too much from ERP for SCM in extended enterprises" and suggested further academic research on the business impact of ERP systems [23].

Especially in case of medium-sized enterprises or subsidiaries of large companies that are typically found in Australian context, the problems and challenges confronted by them in implementing IT-enabled innovations could be different. While the Internet has facilitated a shift towards dynamic communication with supply chain partners, the complexity of integrating the supply chains poses an enormous challenge to organizations in general, and medium sized enterprises in particular.

Studies on other IT-enabled innovations such as e-Commerce adoption and other information systems adoption, have consistently pointed out at the unique challenges faced by SMEs [24]. After improving internal processes through ERP, organizations are now examining how ERP systems and Internet can help them improve processes across the supply chain.

To take advantage of the supply chain management systems and thereby manage technology and processes well, organizations must ensure that their own ERP systems are correctly implemented. In an environment where the ERP system is not well implemented with full integration of internal processes and information, embarking on supply chain integration may actually create upstream and downstream problems at Internet speed [18]. It is not clear whether the enterprise systems are contributing to the process improvements at the supply chain level and its performance. While generic observations are made in terms of the potential benefits of such attempts, no evidence is available yet that explains how these systems are facilitating or hindering supply chain integration. This paper reports the work-in-progress research that investigates the role of enterprise systems in supply chain integration, with particular focus on medium sized enterprises. Thus the underlying research questions are:

1. How do enterprise resource planning systems facilitate improvement in supply chain management and integration in medium-sized enterprises?

2. What are the limitations of ERP systems in achieving such improvements in supply chain management and integration?

B. Research Methodology

In view of the exploratory nature of the work, a case study method that involves an interpretive approach is adopted to capture the corresponding contextual richness and complexity [25]. When the research involves 'what' and 'how' type of questions investigating the real life phenomenon where the boundaries between the context and phenomenon are not clearly understood, exploratory case study method is considered appropriate [25]. Using a case study approach, this research aims to explain the enabling and/or disabling role of enterprise systems in organisational attempts to achieve improvement in their supply chain management and integration.

Given the nature of questions, in-depth interviews based on the perceptions, views and experiences of the key individuals in the organization are considered more insightful. The theoretical propositions to be developed in this study based on case study analysis will be later validated using a larger questionnaire survey and further case studies. Findings of this exploratory study will lead to several theoretical propositions/hypotheses and identification of various variables contributing and/or hindering supply chain integration.

This study offers rich insights into the effects and influence of enterprise systems and the factors influencing the preparedness of organizations that are embarking on supply chain integration. Though anecdotal, the outcomes of this study will help managers in maximizing the benefits of enterprise systems and in achieving measurable supply chain performance improvements. The knowledge thus gained would assist the organizations in deriving better return on significant investments already made on enterprise systems and extended enterprise systems/supply chain management systems.

In accordance with the recommended qualitative research practice [26], data analysis was conducted in parallel with data collection, allowing each process to inform the other. The objective of initial analysis was to understand the participants' perception of the issues.

Using semi-structured in-depth interviews with key respondents, primary data is collected in this study. The participants included managers who were responsible for implementation of the enterprise system and supply chain management initiative and functional experts/operations managers who were responsible for managing the processes.

A total of five managers were interviewed in this study. Interviews were approximately 90 minutes each. Permission to conduct the study was negotiated with the senior management who authorized interviews to begin. The interviews were recorded using the tape recorder with prior permission from the respondents. Detailed manuscripts of the interviews are being transcribed from the tapes and saved for further analysis.

A list of topics drawn from the literature briefly discussed earlier was used as an interview guide that collects information on the role played by the ERP systems in enabling or limiting the supply chain management and

integration.

In this context, respondents were asked to explain the impact of each of the main features of their ERP systems on their objective of achieving supply chain integration and improving supply chain efficiencies. Some of the issues considered for data collection include the role of best practice business processes embedded in ERP systems, software and process fit achieved by their company, real-time visibility of information, ability of ERP systems to adopt to changing supply chain needs, adequacy of ERP functionality for decision support and standardization of processes and information.

As is typical in any case study research, this study had limitations, including lack of generalizability and subjective bias [25], [26]. The findings of this study were specific to the situation observed and provide anecdotal evidence. Although the organization was accessible for research, the extent of cooperation from different respondents in the organization was not uniform, and the respondents may have either overrated or underrated the impact of ERP systems [27]. Even though this company had had an ERP system in place for more than two years at the time of the study, it was possible that the potential impact of these systems on supply chain integration and management are predicted by the managers based on their perception and planning, and could become apparent only after a relatively long period of time [27], [28]. Further, the limitations of studying a complex decision-making phenomenon influenced by the emotions, imagination and memories of decision-makers, the difficulty in isolating decision processes, and the difficulty in pinning down decision choices in time or in place, render it a complex subject for empirical research [27], [26].

The limitations discussed above could thus have influenced the process as well as the outcomes of this study. However, these limitations are unlikely to have affected the validity and reliability of the outcomes significantly because the objective of the study was not to generalize, but to provide anecdotal evidence.

C. Case Study Organization Background

A business unit of a large manufacturing organization was selected for this study. This unit employs about 160 staff. It is a part of a large manufacturing group that has several plants, distribution centers and other facilities throughout Australia and Asia-pacific region and employs about 2000 employees overall. The company manufactures several products required for the construction & mining industry and has several trading enterprises and product divisions. It has both large businesses, small & medium sized enterprises (SMEs) and small individual contractors as its suppliers. In 2001-2002, SAP R/3 was implemented in this unit. Later on Supply Chain Management application software was also installed in 2003.

When the field study was conducted in 2004/2005, this unit already had some experience of working with the ERP system and its supply chain management extension. The objective for implementing the ERP then was to streamline and standardize their internal processes and information management practices and facilitate better control and management. The supply chain management initiative was primarily implemented in order to improve their demand management and supply efficiencies. This organization was selected because of the access given to the researcher, its implementation of several modules, and therefore it's potentially rich organizational context to study the role of enterprise systems in enabling supply chain integration.

IV. ANALYSIS AND FINDINGS

Although largely anecdotal, interpretative in nature and limited to one case study organization, the findings in this study, because of their rich contextual nature, provide some insights into the opportunities, implications and limitations of ERP implementation in achieving supply integration. The study findings, some of them expected, confirm some of the past research findings and contribute to the knowledge in a modest way. A brief discussion of the key findings is presented below.

A. Standardization of Processes.

Study observed that the implementation of enterprise systems and the resultant standardization of business processes and information across the organization generally prepared the organizations better for supply chain integration. The case study organization appears to have taken a pragmatic approach with regard to the return on investment in ERP and SCM systems and believed that the real benefits will flow through in time. Even though there are some initial benefits such as process standardization, data consistency, and information visibility across the enterprise, there are no discernable benefits on the enterprise bottom line such as profitability and no visible direct cause and effect relationships between ERP implementation and profitability.

ERP system through its embedded best practice processes enforces internal processes. In time, with most of the business organizations having an ERP system in place, ERP system is expected to facilitate harmonized processes across the supply chain and access to consistent high quality single source of data.

B. Lack of Flexibility

An information system must be able to change dynamically in line with the changing customer needs in terms of product variety, volumes and demand. Management is aware of the limitations an ERP best practice business processes bring in. After investing significant amount of time and effort for implementing the new processes embedded in ERP software solutions and training the employees for managing and executing the processes, the management is reluctant to even consider changing the processes to meet the supply chain management needs. Supply chain integration is generally facilitated by enabling technologies as well as by the redesigning of inter-enterprise processes. By locking in the business processes with the implementation of ERP systems, the management consciously agreed to compromise the potential

improvements in the supply chain efficiencies by redesigning some of the inter-enterprise processes.

C. Change Management Implications

Managers believed that achieving internal process integration by implementing ERP systems gave them and the organization an important change management experience. However, it also appears to have resulted in some consequent inertia to embark on any further changes in the supply chain processes. The changes to the power and organizational structures consequent to the ERP implementation have made some managerial roles more powerful than others, and they are effecting these further changes to processes. In general, organization appears to be very slow and careful in embarking on the changes to the inter-enterprise processes after an ERP implementation.

D. Powerful Partners

Powerful partner in their supply chain appear to be playing a significant role in determining the supply chain integration and management decisions. In some cases, where the major customers are powerful players in the industry, their decision as to the extent and nature of information and process integration is a powerful factor influencing the medium-sized enterprise. This case study organization is skeptical about going ahead on their own in selecting and implementing the technologies, inter-enterprise processes and standards and in investing time and money while their major customer and/or supplier may steer them in a different direction.

E. Lack of Decision Support Capability

ERP system improved operational decision making within the case study organization. Centralization of information, and increase in visibility and accessibility of information across the organization, facilitated by the ERP system have contributed to improvements in operational decision-making. In particular, it resulted in improved degree of control, standardization and managerial monitoring of the operational performance and resulted in improvements in organizational performance. Most of these decisions, however, are still very much on the internal supply chains. For example, the 'Available To Promise (ATP)' check in a web-enabled ERP environment can be performed in real-time and the customer inquiry can be answered about the availability of the product. ERP system, however, does not have capability to analyze the profitability of that order instantaneously before the sales person answers customer inquiry. Thus, the ERP system, in its present state, does not offer any additional decision support capability in managing the supply chain and/or in improving the supply chain efficiencies.

F. Technology

Despite the evident advantages and advances in technology, integrating the supply chain is still considered a complex task by the case study organization. The sheer complexity of developing interfaces with external partners, general reluctance of their supply chain partners to invest in money and time, and the trust related issues have all been cited as reasons for not achieving sufficient progress. The extended ERP systems in terms of Supply Chain Management (SCM) systems software solutions, advocated by the ERP vendor, may appear to be offering the additional functionality.

The management, however, believes that such extended functionality may again be constrained because of the additional investments in information technology required to create and manage interfaces with partner systems from time to time. The adoption of SCOR (Supply Chain Operations Reference) model, a process reference model developed by the Supply Chain Council (SCC) for manufacturing industry, appears to be at least helping this organization in developing a consistent process descriptions and structure independent of software platforms along with the frameworks for their relationships, metrics, and management practices. Though the impact and influence of such initiative is still not known and uncertain, the case study organization is hopeful of achieving higher level of integration with their major business partners in future.

G. Insufficient Integration

Insufficient integration of internal processes even after implementing ERP system is one of the major problem hindering the supply chain process improvements and integration. Selective and limited implementation of application modules and limited access to the managerial and operating staff because of cost implications are reportedly contributing to lack of full integration among internal business processes.

Integration and standardization of internal processes and information enabled by implementing ERP systems have certainly created uniform information flows, process structures and data models in this case study organization and therefore may help the company achieve dynamic supply chain configuration and integration easier in future.

V. CONCLUSIONS

Though ERP systems and other information and communication technology infrastructure have facilitated transparency and transfer of information across the supply chain, supply chain collaboration and integration is complex and challenging. Creating effective partnerships between several businesses is a complex thing and requires holistic and systemic view of the supply chain by all the partners. ERP systems were not designed just to support supply chain management and integration across multiple enterprises.

Lack of advanced decision support capabilities, lack of process flexibility in adapting to changing supply chain configurations and needs, inadequacy of technology interfaces to extend the ERP systems, and other change management implications, typical in an ERP-enabled environment, appear to be limiting the enabling role they can potentially play in achieving supply chain integration. In a way, ERP system may thus become a strategic disadvantage in network based economy dominated by the

supply chains rather than individual enterprises.

Integration of processes across the supply chain is just not connecting a series of internal processes across partner organizations. It is necessary to take a holistic view spanning the enterprises across and design these inter-enterprise processes rather than simply connecting them from one enterprise to another. ERP systems thus in its current state appears to have a modest role to play in achieving supply chain integration. The open, modular, component based ERP systems with service oriented architecture and web services standards, expected to come in future, may facilitate better interfacing of disparate ERP systems and IT infrastructure components and help achieving easier integration of supply chain partners.

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