

Exploring the rationales for ERP and SCM integration

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Abstract

Enterprise resource planning (ERP) and supply-chain management (SCM) have been growing in popularity across various industries. New initiatives in resources planning, electronic commerce and extended supply chain drive the trend among corporations towards integrating strategic business applications. ERP systems assist enterprises in automating and integrating corporate cross-functions such as inventory control, procurement, distribution, finance and project management. Through information sharing, SCM enables supply-chain partners to work in close coordination to facilitate supplier-customer interactions and minimize transaction cost. This research examines these two important concepts in terms of their evolution, functions and current development and further explores the rationales for their integration by analyzing the problems of ERP and presenting the solutions of SCM. This study is concluded with the imminent development of SCM and ERP systems and the industrial trend toward their integration.

Introduction

Enterprise resources planning (ERP) systems assist enterprises in automating and integrating corporate cross-functions such as inventory control, procurement, distribution, finance, and project management. In recent years as many companies began to search for ways to replace their existing applications running on mainframes that no longer meet the growing corporate needs, ERP systems have become fixtures to provide a basis for business process management integration across business functions (Mabert *et al.*, 2000)

Supply-chain management (SCM) enables supply-chain partners to work in close coordination through information sharing to facilitate supplier-customer interactions and minimize transaction cost (Lawrence, 1999; Premkumar, 2000; Lee and Whang, 2000). This is how demand for improved supply-chain efficiencies will increase as business enterprises adopt SCM applications. As the global commercial market involves greater complexity into the management of both internal and external corporate supply chains, the market competition and the benefits from the advance in technology will increasingly encourage the use of SCM system applications.

In the past few years, companies have integrated strategic applications at an unprecedented rate. New initiatives in resources planning, electronic commerce and extended supply chain push the trend among corporations towards integrating strategic business applications. ERP and SCM have been growing in popularity across various segments of the electronic industry, particularly the manufacturing and distribution sectors. This research examines these two important concepts in business

applications in terms of their evolution, function and current development. The authors further explore the rationales for their integration by probing the problems that ERP systems have encountered in recent years and the solutions of how SCM systems can alleviate some of these problems and how SCM systems can complement ERP systems and allow for smoother operations. This study is concluded with the imminent development of SCM and ERP systems and the industrial trend toward their integration.

Enterprise resources planning

Concept and evolution of ERP

Kumar and Van Hillegersberg (2000) define ERP systems as configurable information systems packages that integrate information and information-based processes within and across functional areas in an organization. In this sense, ERP systems are designed to integrate business functions and allow data to be shared across many boundaries and divisions within the company. For example, a customer service department of a company would have access to information being used by its finance and accounting divisions. This ability to share information gives businesses increased flexibility and allows them to operate more efficiently than before.

ERP systems consist of series of integrated modules from accounting, distribution, marketing and sales, manufacturing, to human resources. Instead of concentrating on specific functional areas, these modules focus on business processes. Typically, ERP systems include a single repository of data, and all business processes occur seamlessly within a single information system.

Today's ERP systems are an outgrowth of materials requirement planning (MRP) systems. MRP systems were developed largely for manufacturing concerns and were initially designed for inventory controls from 1970s to 1980s. The inventory levels could be reduced by an integrated control of supply



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and demand, measured against on-hand inventory and replenishment lead times. As these systems evolved (e.g. MRPII in the early 1990s), they began to incorporate financial control and measure, master production scheduling and capacity planning. ERP has extended the reach of the planning system to include the entire enterprise, from marketing to product development, and to achieve total organizational excellence through integration (Mabert *et al.*, 2000).

Functions of ERP

The major goal of ERP is to unite the various departments across an enterprise through one system application package. The information managed by an ERP system can be utilized in many different ways. For example, executives and employees in production, customer service, accounting and finance are able to rely on the information within the system to make more effective decisions. This system with its ability to share information in today's business world becomes an invaluable tool, which provides various departments with the capacity to work in concert and communicate across a common interface.

From another aspect, ERP enables the integrated flow of information to be the core system that provides the data needed for all corporate components. In this way, how to take advantage of that information for the use of gaining competitive edge is the key to success. Since the above mentioned concept is clear but not yet perfect, the core system requires all components working together to attain excellent performance. In their case studies on the mainstream ERP systems, Palaniswamy and Frank (2000) also recognize that better cross-functional integration is a critical success factor.

Information managed by ERP systems can be used in business in many ways. Take a simple ERP function as an example. After a salesperson enters an order from the customer on a computer, the transaction data go through the entire company. The system then updates the inventory of parts and supplies automatically and worldwide if needed. Production schedules and balance sheets change as well. Most efficient of all, the employees of different departments have the information needed just in time to complete their jobs. The feedback would be fast. As for the salesperson, he or she then can inform the delivery dates, and the managers can receive the effects of financial, inventory, or SCM decisions immediately.

Current development of ERP

The ERP system providers include some major vendors such as SAP, JD Edward, Baan, Oracle and PeopleSoft. They provide a set of standardized business processes for enterprise management, and promote their packaged ERP applications to improve business performance (Mabert *et al.*, 2000). However, the ERP industry has not been performing as it originally expected. According to an ERP survey, when quantifiable cost savings and revenue gains were balanced against the amount shelled out for software, hardware, consulting help and ongoing support, there is an average negative value of 1.5 million (Stedman, 1999).

On the other hand, in order to compete with the fast growing SCM application providers, major ERP vendors are attempting to extend beyond the core functionality of their ERP products to include the SCM capabilities. Evidence of this change can be seen in the numerous acquisitions and strategic alliances formed recently. Baan, for example, acquired supply-chain application vendor Berclain, adding some internally developed supply-chain capabilities to its ERP applications (*Electronic Buyers News*, 1997). However, as the range of ERP implementation becomes broader, adopting an ERP system is much more costly than before. This problem has seriously limited the market potential of ERP systems. To solve the dilemma, top ERP vendors are developing packaged products rather than full ERP implementation to meet the needs of organizations with different sizes. This is another major change in current ERP market. These packaged products essentially are component-based solutions and thus do not have the breadth of full ERP implementations. These packaged systems normally have a modular approach, which allows quick and customized delivery and installation at lower cost platform. As a result, even medium- and small-sized companies are able to benefit from the advantages of ERP systems, which were limited to large companies in the past.

SCM

Concept and evolution of SCM

SCM is a concept that has gained considerable support as managers have increasingly recognized the importance of logistics as the last cost-cutting frontier. SCM systems have developed in recent years to offer more cost-effective solutions for logistics within companies and the chain itself. The supply chain represents the whole

production process of any goods, starting from supplier processes, raw materials, manufacturing process to post production and product distribution.

According to Ferguson (2000), the concept of SCM incorporates two important ideas:

- 1 SCM is a collaborative effort that combines many parties or processes in the product cycle; and
- 2 it shows that SCM can cover the entire product cycle, from the introduction of raw materials to the point at which the consumer purchases the product.

SCM can form a loop that begins with the customer and ends with the customer (Yang and Papazoglou, 2000). The concept depicts the supply chain as a network, which clearly explains the relationship among all the components along the supply chain. While autonomous or semi-autonomous business entities are responsible for the activities along the chain, the supply chain is therefore a set of facilities and distribution options that perform the supply activities. Accordingly, a streamlined SCM is the network of facilities and distribution options to support an association of vendors, suppliers, manufacturers, distributors, retailers, and other trading partners (Kwan, 1999). Software developers have wisely recognized the potential for making the supply chain more efficient through automation.

Interest in SCM has steadily increased since the 1980s when firms saw the benefits of collaborative relationships within and beyond their own organization (c.f. Yang and Papazoglou, 2000; Ayers, 2000). Firms find that they can no longer compete effectively in isolation of their suppliers or other entities in the supply chain (Sandeep, 1998). The term does not replace supplier partnerships, nor is it a description of the logistics function. Linking a firm's supply-chain strategy to its overall business strategy and some practical guidelines are offered for successful SCM.

Moreover, SCM is a business philosophy that has evolved out of the field of logistics. During the 1960s, the emphasis was on physical distribution and little focus was placed on business-to-business (B2B) relationship (i.e. supplier-customer relationship). In the 1980s, the shift was towards total quality management (TQM), which focused on ways to make the product better. Again little emphasis was on the importance of B2B relationships. During the late 1980s and early 1990s, process reengineering became the trend. American enterprises began to learn Japanese business practices that incorporated supplier relationships. *Keiretsu*, a supplier

partnership involving partial ownership of the suppliers themselves, was observed to be an effective method of improving quality and reducing cost. Chrysler as a typical example saw the importance of partnering with suppliers and offering them incentives to work together on development and cost cutting procedures (Dyer, 1996).

The evolution of SCM has gradually formulated B2B relationship in recent years. The enterprise system solution providers quickly recognize the potential of SCM and continue developing systems that could allow better B2B relationships and improve production and forecasting simultaneously.

Functions of SCM

SCM systems support demand and manufacturing planning and B2B communication. Companies must recognize the importance of planning as a function in the supply chain because randomness and uncertainty ultimately can create chaos on a company's distribution network. SCM systems offer the flexibility and speed necessary against demand uncertainty. In addition, a SCM system is capable of coordinating the supply chain to ensure the effective implementation of just-in-time (JIT) practices. B2B communication is a critical function in the practice of SCM.

SCM systems have two important system functions, maintaining timely information sharing across the overall supply chain and facilitating the synchronization of the entire supply chain. The philosophy of SCM is that a firm has the right product in the right place, at the right price, at the right time, and in the right condition. Under this assumption, an enterprise requires not only the free flow of information within its organizational boundary, but also the timely sharing of the right information with the right business partners. The reason is that the success of a firm's SCM would depend upon the accuracy and velocity of the information which every business partner provides (Zheng *et al.*, 2000).

SCM systems can facilitate the synchronization of the entire supply chain because they can assist a firm in integrating internal business processes within the corporate boundary so that all internal functional areas can operate in synchronization. Further, SCM systems allow an individual organization to integrate its business processes with those of its business partners. In other words, when an organization becomes a node of a supply chain, its business success relies on not only the internal efficiency and productivity of the firm, but also that of its business partners.

Current development of SCM

While the ERP software market has entered a mature stage, the SCM application market is in its fast growing phase, showing a very strong and robust growth in recent years. A recent survey of SCM practices also indicates that approximately 80 per cent of manufacturers in the USA have launched major supply-chain initiatives as of 1999 (c.f. *Logistics Management & Distribution Report*, 1999a; 1999b). While the annual sales of ERP software and service were estimated to exceed \$84 billion by 2002 (Kirkpatrick, 1998), the SCM market is expected to be nearly doubled from 1998 to 2003. I2 Technologies, Manugistics and ILOG, for example, are the three popular SCM system providers in this market. The current development of these system providers focuses on either integrating SCM software packages with existing ERP packages or partnering with ERP vendors to provide a common solution.

Major problems associated with ERP solutions

Problems with implementation

The time and cost associated with ERP implementations can be enormous (c.f. Davenport, 1998b; Reda, 1998; Jacob, 1999; Bingsi *et al.*, 1999; Mabert *et al.*, 2000). As observed by Soh *et al.* (2000), ERP implementation is more complex due to cross-module integration, data standardization, adoption of the underlying business model, compressed implementation schedule, and the involvement of a large number of stakeholders. The ERP industry as discussed earlier has not been performing as originally expected. The average ERP implementation takes 23 months (Wheatley, 2000). For example, the implementation of the R/3 system on average takes about one year to one and a half years. Some have even exceeded three years. During this long implementation period, software and user specification change and the technicians who are implementing the package must constantly adapt and make adjustments in order to accommodate these changes (c.f. Davenport, 1998a; Mendel, 1999).

Another problem associated with implementation is the speed the systems themselves operate at. ERP systems run on cycle updates, rather than on real time processing. Accurate analysis necessary for quick decision-making is lost in these cyclical updates. Therefore, the system may become reactive instead of proactive. To be successful enterprises require being proactive and responding to change quickly and effectively with the right information to guide them. A

reactive system is more likely to pose a serious threat to a major corporation (Allen, 1998).

Problems with hidden cost

Cost is a critical part of an ERP implementation for both large and small businesses alike. While the range of ERP implementation becomes broader with the introduction of fast upgrading software applications, enterprises adopting ERP systems are more costly than before. Companies that install ERP systems may underestimate cost that is hidden. In addition to a long implementation time as pointed out previously, an ERP system has an average total cost of ownership of \$15 million but rewards the business with an average negative net present value of \$1.5 million (Wheatley, 2000). While most experts agree that ERP failures are not systemic, the following five types of common hidden cost may increase implementation cost dramatically (Slater, 1998; Soh *et al.*, 2000):

- 1 Training is the most underrated hidden cost. The cost to train an entire staff on a new system and process is enormous. This cost often gets taken for granted.
- 2 Integration and implementation are often overlooked. Many consultants recommend multiple dry runs with real orders. Too often add-on modules such as taxes and bar coding are not factored into the test runs.
- 3 The cost for data conversion is hidden. Companies often do not recognize the cost associated with transferring data from the old system to the new package. Included in this cost is the need to modify the data to fit into the new system. The need to hire professionals can send this type of cost higher.
- 4 High consulting cost becomes inevitable. Though this cost is not entirely hidden, many companies do not budget consulting fees properly. Experts recommend contracts be set up prior to implementation, which outline goals to be met by target dates. In addition to the significant knowledge disparity among implementation personnel and the insufficient understanding of the functionality of ERP systems and the implications of adoption among users, high cost is invited as critical areas of mismatches could not be successfully identified by the consultants who lack understanding their customers' business processes.
- 5 A cost often overlooked is the notion that the project will end on a certain date. Management must recognize that these projects require unique budgets.

Problems with process automation and system complexity

An imperative hidden cost often incurred by businesses implementing ERP is the loss of efficient process due to an inability to automate their business processes.

Frequently, ERP vendors offer their system packages as a solution to making the company more efficient without first looking at the corporate business processes *per se*. Automating an inefficient process would only generate more problems and unnecessary spending. Moreover, removing efficient processes rather than integrating them highlights the problem of inflexibility that can arise with an ERP implementation (Mendel, 1999).

As for the complexity of system process, it does not just involve purchasing a software package but rather an extensive and complex business process. In some cases, organizations must change how they do business in order to benefit from a migration to enterprise solutions. Because the systems are complex, organizations typically do not have the required expertise in-house to implement the systems and implementation can take a long time to complete (c.f. Davenport, 1998a; Mendel, 1999). As discussed earlier, they instead must rely on consultants or employees of the software vendor, and such experts' help would be very expensive.

ERP and SCM integration

The rationales

Based on the previous examination, Table I summarizes the objectives, focuses, goals and functions of ERP and SCM systems. The summary also supports further exploration in the rationales for ERP and SCM integration.

In a global business perspective, companies are actively expanding outside of their original area to seek new opportunities over the world. While the dynamic and fast changing external environment has put great

pressures on companies' operations and decisions, how to react quickly to external changes and how to compete effectively in the global environment become a crucial issue. Inside a dispersed company, it requires building integrated information systems, which allow data transmission across the border of a geographic area to another. Furthermore, the enterprise demands more effective communication between head office and local units. Even within an area, companies want to build corporate applications through which different departments can cooperate more efficiently with each other. In one word, they need to establish a streamline business process, which can significantly enhance the communication and cooperation among functional departments. To achieve this goal, functional integration is required, which is the process of integrating all business functions to work together, e.g. a firm's logistics or distribution functions must integrate with supply-management, manufacturing, and information technology before the functional integration can be extended to other companies in the supply chain (Ferguson, 2000).

From the standpoint of technology, information system architecture has been moving from a two-tier to a three-tier client server. Old legacy systems need to be converted to new, more powerful and flexible systems, and old data need to be migrated into new forms. Faced with all these needs, companies are seeking integrated business and technology solutions. The settlement would fall into ERP and SCM, which in essence combines business processes with state-of-the-art technology to provide solutions for the whole enterprise.

According to Table I, ERP aims to improve internal efficiency by integrating different parts in the organization, while SCM focuses on external relationships with trading partners in the supply chain. Indeed, the proliferation of ERP systems forces companies to provide communication and

Table I

Comparison of SCM and ERP systems

	SCM systems	ERP systems
Objective	Integrating and optimizing internal business processes of a single organization as well as the interaction of the organization with its business partners across the entire supply chain	Integrating and optimizing internal business processes within the boundary of a single organization
Focus	Optimizing information flow, physical distribution flow, and cash flow over the entire supply chain	Optimizing information flow and physical distribution flow within a single organization
Goal	Constraint-based tool providing reasonable and feasible business plans based on the availability of the required key resources	Non-constraint-based tools providing business plans without the consideration of the availability of key resources
Function	Manufacturing management, inventory management, logistics management, and supply-chain planning	Manufacturing management, financial management, and human resource management

information flow between supply-chain agents, overcoming natural boundaries. Therefore, integration of ERP and SCM is a natural and necessary process in strategic and managerial consideration. Technologically, ERP is said to be the backbone of SCM. Because they both rely on very similar framework, such as intranet, extranet and electronic data interchange, it is very possible and feasible for their integration. Most ERP system providers have been enhancing their products to include sales-force automation, data warehousing, document management, and after-sales service and support. And the most important trend today is the integration with SCM.

The future of ERP is to improve the supply chain and foster greater collaborating across multiple enterprises. The core of ERP, an integrated set of applications that link together such back-office operations as manufacturing, financials and distribution, will become a subclass of a much bigger and broader enterprise business system. ERP will extend into transportation, warehousing, sales-force automation, and even beyond that into engineering with computer-aided design and product data management systems (McGee, 1998). Consequently, it is feasible and possible for the integration of these two technologies.

In this sense, ERP system applications originally linking back-office applications into a single system would extend beyond their core functionality to include not only sales-force automation, data warehousing, document management, and after-sales service but also SCM to increase efficiency and productivity for the key customers (Stein, 1998a).

Methods of integration

Many ERP providers have quickly recognized the integration of ERP and SCM system applications as a necessity to remain competitive and maintain sales. The SCM system applications soon were added to existing ERP solutions to act as modular enhancements. Three methods of integrating SCM software with ERP packages have been recognized. First is the notion of conformity. It requires all of the members of the supply chain to embrace the same system. In a large supply chain this form of integration should be viewed as impractical. Issues of trust and security further complicate any chance of success with this method. The second integration method is middleware. This method, though very practical, is very expensive. Programmers are required to establish links between various systems. The benefits are strong, but the cost must be

weighed. The third method, and the latest, is to use specialized integration technologies or software (SIS) to extend ERP functionality. The mapping of different packages is already done in these technologies. The software is preprogrammed to integrate SCM software with ERP system packages. By doing this, the ERP system will become a business-services framework, a central information repository, and a data-distribution facility (Radding, 1999).

In other words, this integration solution depends upon how data are kept consistent between ERP and SCM systems. I2 uses SAP's application link enabler to exchange data between R/3 and Rhythm (I2's SCM product suite). Oracle and the other ERP vendors also have APIs with which I2 and other vendors can use common denominator middleware to interface. However, this means that system providers have to change their middleware interface software quite often, which is often a trial and error process and does not usually perform well (Allen, 1998). SIS is designed specifically to allow ERP and other systems to share processes and data. It removes the chore of developing an interface to every other vendor's software. For example, a major company in this area is CrossWorlds Software. This software, which runs on Windows NT, claims to work by simply pointing and clicking on a sending application (such as SAP) and a receiving application (such as Manugistics) and then selecting the processes to link together. Table II summarizes the integration methods.

SCM solutions

Providing proactive solutions

Perhaps the principal problem ERP system solutions face is their inability to process data real time (Kochan, 2000). The packages are often overburdened with information and are forced to process information in cycles, rather than in real time. This forces ERP systems to be reactive instead of proactive. It is this reactive processing that makes it difficult for demand and factory planning. These functions rely heavily on the constant evaluation of information regarding processing, materials, and constraints within the process. Without real-time processing, the data for these functions become obsolete and relatively useless for planning.

SCM offers a more proactive solution to the ERP system (c.f. Allen, 1998). These software packages do not conduct nearly the number of transactions at one time as ERP systems do, thus giving them the ability to process in real time. SCM systems can consider all

Table II
System integration methods

Method	Solution
Conformity	Requiring all of the members of the supply chain to embrace the same system
Middleware	Establishing links between various systems via programming
Special integration software	Extending ERP functionality and allowing ERP and other systems to share processes and data

relevant constraints in the process simultaneously and order the necessary raw materials at the same time. This is an essential function for the supply chain of any large corporation.

Extending B2B relationship

Today's business environment is changing rapidly in terms of business relationships that are forming. Companies must have the ability to establish strong partnerships and clear communication to form an effective supply chain. ERP systems in the past were unable to provide successful links with companies outside of the company operating on that system. The system applications were often set up with the purpose of improving transaction processing within the company and not outside of it. The shift toward B2B e-commerce puts an emphasis on accessing data that reside in the systems of suppliers, customers, and channel partners (Fulcher, 2000). SCM systems are more geared for the B2B relationship because these systems provide the means for closer relations with companies outside of the company. This is a critical advantage for companies as they move into new methods of doing business that require effective methods of sharing information.

Reviving ERP market

ERP market growth has been reduced considerably, with analysts estimating annual rates of 15 per cent to 17 per cent (Sherman, 2000). Initially the drop was attributed to the Y2K issue, but by now the vendors has recognized that the drop may be related to lack of confidence in the systems (c.f. Wah, 2000). Although ERP packages strive to integrate all the major processes of a firm, customers have discovered the lack of some essential functionality in ERP (Scott and Kaindl, 2000). By examining the problem from two perspectives, the product development and marketing challenge for the vendor and the implementation and integration problem for the consumer, Sprott (2000) reports that the ERP system providers face a more complex problem than organizations managing in-house developed applications.

By integrating SCM modules into existing ERP systems, a new market is emergent. The benefits of SCM software systems would be added to the value of the existing packages and could help boost many ERP vendors' sales. With new business practices such as JIT and SCM taking shape, it becomes even easier for vendors to show customers potential uses of the new packaged systems.

The major ERP providers such as SAP and PeopleSoft have put their large stakes in the SCM software industry. SAP as an example has the unique philosophy of allowing its customers to have considerable control over what functions their ERP systems perform. The SCM system solutions at SAP are no different. Initially, SAP attempted to partner with I2 on designing and integrating a software package into existing SAP systems. However, SAP instead has designed a system of their own that is more efficient and less expensive than those of the major SCM providers such as I2 or Manugistics.

A benefit is that by linking supply-chain applications with other business systems, users can trim down cycle times, reduce inventory, and better connect with suppliers, distributors, and end customers (Stein, 1998b). As for cross-enterprise application integration, companies are able to link their ERP systems directly to the disparate applications of their suppliers and customers.

Conclusions

The movement towards B2B e-commerce and SCM have ultimately forced ERP system providers to reevaluate their models. ERP vendors would have to shift toward more flexible systems to compensate for the need to adapt to changing business cultures. The notion of "plug and play" modules to perform specialized tasks is a very realistic alternative in the near future, as customers increasingly demand more specialized tasks from ERP vendors. Point and click systems are also a near-term direction to support more user-friendly operation and thus reduce training cost. Perhaps ERP vendors' strongest assets are the large customer bases they possess. In the 1980s TQM was the business fad, then came business process

reengineering in 1990s, now companies are looking at EPR and SCM as the solution. The trend indicates that ERP will adapt through the incorporation of modular upgrades to current systems and the exploitation of the small- to medium-sized markets.

Accordingly, the industrial trend between ERP and SCM is that the integration of supply-chain capabilities with ERP systems will continue to be enhanced in the near future. One of the main reasons is that cross-enterprise integration will continue to be one of the major organizational goals, especially for those whose business success is directly dependent upon the success of their supply chain. Driven by the market forces such as shifting channel power and demand for fast cycle-time-to-market, SCM has created a critical and influential business success. Consequently, organizations begin to rely on SCM systems as a new source of competitive advantage.

In conclusion, the core of ERP, an integrated set of applications that link together back-office operations, will become a subclass of a much larger and broader enterprise business system. The integration of ERP and SCM will create a new spectrum in the information industry, i.e. the integration of all core business processes through one comprehensive information system and the cooperation among multiple parties and trading partners in the value chain to create a collaborative business and operational environment.

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