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Enterprise resource planning
An integrative review

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Abstract *Enterprise resource planning (ERP) system solutions are currently in high demand by both manufacturing and service organisations because they provide a tightly integrated solution to an organisation's information system needs. During the last decade, ERP systems have received a significant amount of attention from researchers and practitioners from a variety of functional disciplines. In this paper, a comprehensive review of the research literature (1990-2003) concerning ERP systems is presented. The literature is further classified and the major outcomes of each study are addressed and analysed. Following a comprehensive review of the literature, proposals for future research are formulated to identify topics where fruitful opportunities exist.*

1. Introduction

Enterprise resource planning (ERP) system is a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organisation. These sets usually include a set of mature business applications and tools for financial and cost accounting, sales and distribution, materials management, human resource, production planning and computer integrated manufacturing, supply chain, and customer information (Boykin, 2001; Chen, 2001; Yen *et al.*, 2002). These packages have the ability to facilitate the flow of information between all supply chain processes (internal and external) in an organisation (Al-Mashari and Zairi, 2000a). Furthermore, an ERP system can be used as a tool to help improve the performance level of a supply chain network by helping to reduce cycle times (Gardiner *et al.*, 2002). However, it has traditionally been applied in capital-intensive industries such as manufacturing, construction, aerospace and defence. Recently, ERP systems have been expanded beyond manufacturing and introduced to the finance, health care, hotel chains, education, insurance, retail and telecommunications sectors.

ERP is now considered to be the price of entry for running a business, and at least at present, for being connected to other enterprises in a network economy to create "business to business" electronic commerce (Boykin, 2001). Furthermore, many multinationals restrict their business to only those companies that operate the same ERP software as the multinational firm. It is a fact that ERP is for big firms and smaller firms have to adjust their business model and approach according to the practices and software adopted by the big firms. With the opening up of the economy, small to medium sized enterprises (SMEs) have found the going very difficult. Since they do not have the robustness associated with large companies, SMEs have to tap the power of IT and an integrated information system to stay competitive and customer oriented. ERP is often considered the answer for their survival (Rao, 2000). Therefore, the ERP software market has become one of today's largest IT investments worldwide. A recent survey predicts that the spending on ERP will reach $66 billion in 2003[1] (Themistocleous *et al.*, 2001). It continues to be one of the largest, fastest-growing and

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most influential players in the application software industry in the next decade (Adam and O'doherty, 2000; Yen *et al.*, 2002). There are several reasons why a continued growth of ERP projects is to be expected (Stensrud, 2001):

- The ERP vendors are continuously expanding the capabilities of their packages by adding functionality for new business functions such as sales force automation, supply-chain, order management, data warehousing, maintenance-repair-and-overhaul, etc.
- The ERP vendors are transitioning to Web-based applications. This may lead to faster flow of information in the logistics chain, and therefore, many ERP customers will require these Web-based ERP systems.
- The emergence of e-commerce will also increase the demand for Web-based ERP systems.
- The share of ERP systems in certain geographical markets such as the former Eastern Bloc, Asia and South America is not widespread.

ERP packages touch many aspects of a company's internal and external operations. Consequently, successful deployment and use of ERP systems are critical to organizational performance and survival (Markus *et al.*, 2000b). Potential benefits include drastic declines in inventory, breakthrough reductions in working capital, abundant information about customer wants and needs, along with the ability to view and manage the extended enterprise of suppliers, alliances and customers as an integrated whole (Chen, 2001). In the manufacturing sector, ERP implementation has reduced inventories anywhere from 15 to 35 per cent (Gupta, 2000). Among the most important attributes of ERP (Nah *et al.*, 2001; Soh *et al.*, 2000) are its abilities to:

- automate and integrate business processes across organizational functions and locations;
- enable implementation of all variations of best business practices with a view towards enhancing productivity;
- share common data and practices across the entire enterprise in order to reduce errors; and
- produce and access information in a real-time environment to facilitate rapid and better decisions and cost reductions.

ERP packages are attracting increasing attention from both academic and industrial communities. No comprehensive review has been carried out on the development and implementation of ERP. A review of the recent development of ERP is needed to make decisions concerning ERP selection and implementation and to aid in guiding more research. The objective of this paper is to present an integrative review of ERP systems and to identify areas where further research is needed. A total of 76 citations on ERP systems were reviewed. Table I provides the sources. The majority of the citations were found in journals (72 per cent), while proceedings, conferences and others contributed to the remainder (28 per cent). Three journals, *Business Process Management Journal*, *Journal of Information Technology* and *Communications of the ACM*, accounted for 48 per cent of the citations.

The remainder of the paper is organised as follows. In Section 2, an overview of ERP systems is presented. The ERP evolution is outlined in Section 3. Section 4 considers

Source	No. of citations
Books on ERP systems	5
Conference papers	
Information Systems (International Conference): Proceedings 20th	1
Information Systems (International Conference): Proceedings 21st	1
Information Systems (Americas Conference): Proceedings 5th	1
IEEE (Management Innovation and Technology: International Conference): Proceedings 2000	1
Management of Data (International Conference): Proceedings of the ACM	1
Systems Thinking in Management (International Conference)	1
Software Reusability (5th Symposium): Proceedings	1
Manufacturing Research (National Conference): Proceedings 16th	1
Journal papers	
Automation in Construction	1
Business Horizons	1
Business Process Management Journal	10
Communications of the ACM	8
Computer Standards and Interfaces	1
Computers in Industry	1
Data & Knowledge Engineering	1
Datamation	1
European Journal of Information Systems	1
European Journal of Operational Research	1
Expert Systems with Applications	1
Harvard Business Review	1
IEEE Software	1
Industrial Management & Data Systems	4
Industrial Marketing Management	1
Information and Management	1
Information and Software Technology	1
Information Systems Management	2
International Journal of Agile Management Systems	1
International Journal of Physical Distribution & Logistics Management	1
International Journal of Production Economics	2
International Journal of Production Research	1
ISA Transactions	1
Journal of Information Technology	8
Journal of Information Technology: Cases and Applications	1
Logistics Information Management	1
Management Decision	1
Web sources	8
Total	76

Table I.
Summary of journals reviewed on ERP systems

the major vendors of ERP systems and the main drawbacks of these systems. The criteria for selecting an ERP system are addressed in Section 5. Implementation of an ERP system is an extensive, lengthy and costly process, typically measured in millions of dollars. The investment is in both software itself and in related services such as consulting, training and system integration. Therefore, the various implementation approaches and the factors influencing the implementation process are presented in

Section 6. Finally, conclusions and the implication for future research are explored in Section 7.

2. ERP: an overview

ERP allows companies to integrate various departmental information. It has evolved from a human resource management application to a tool that spans IT management. For many users, an ERP is a "do it all" system that performs everything from entry of sales orders to customer service. It attempts to integrate the suppliers and customers with the manufacturing environment of the organisation. For example, a purchase entered in the order module passes the order to a manufacturing application, which in turn sends a materials request to the supply-chain module, which gets the necessary parts from suppliers and uses a logistics module to get them to the factory. At the same time the purchase transaction shows in general – a ledger module as revenue. The traditional application systems, which organisations generally employ, treat each transaction separately. They are built around the strong boundaries of specific functions that a specific application is meant to cater for. ERP stops treating these transactions separately as stand alone activities and considers them to be a part of interlinked processes that make up the business (Gupta, 2000).

An overview of ERP systems including some of the most popular functions within each module is shown in Figure 1. However, the names and numbers of modules in an ERP system provided by various software vendors may differ. A typical system integrates all these functions by allowing its modules to share and transfer information by freely centralising information in a single database accessible by all modules (Chen, 2001).

The various modules of ERP include engineering data control (bill of materials, process plan and work centre data); sales, purchase and inventory (sales and distribution, inventory and purchase); material requirement planning (MRP); resource flow management (production scheduling, finance and human resources management); works documentation (work order, shop order release, material issue release and route cards for parts and assemblies); shopfloor control and management and others like costing, maintenance management, logistics management and MIS. Also, the model of ERP includes areas such as finance (financial accounting, treasury management, enterprise control and asset management), logistics (production planning, materials management, plant maintenance, quality management, project systems, sales and distribution), human resources (personnel management, training and development and skills inventory) and workflow (integrates the entire enterprise with flexible assignment of tasks and responsibilities to locations, positions, jobs, groups or individuals) (Siriginidi, 2000).

Although an ERP system is a pure software package, it embodies established ways of doing business. Studies have illustrated that an ERP system is not just a pure software package to be tailored to an organisation but an organizational infrastructure that affects how people work and that it "imposes its own logic on a company's strategy, organisation, and culture" (Davenport, 1998; Lee and Lee, 2000). For example, SAP R/3, as one of the major ERP vendors, currently stores over 1,000 predefined processes that represent financial, logistics and human resources best practices in a repository called "business engineer" (SAP Web site, 2002; Scott and Kaindl, 2000). The

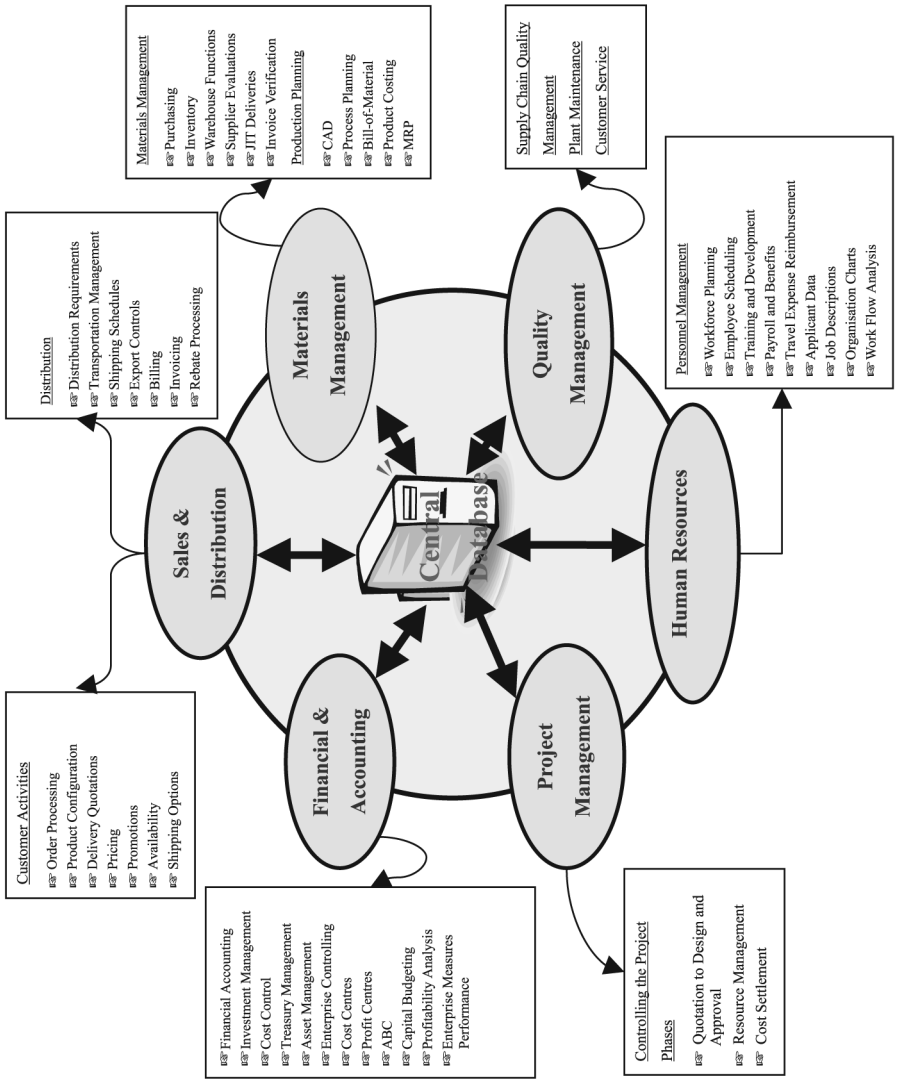


Figure 1.
ERP system modules

evolution of ERP is described in the next section in order to better comprehend the ERP planning and implementation issues.

3. Evolution of ERP

Manufacturing enterprises involved in manufacturing, sales and distribution activities have been using computers for 30 years to improve productivity, profitability and information flow across the enterprise. ERP system traces its roots commencing from standard inventory control packages to material requirements planning (MRP), and

manufacturing resource planning (MRP II). An inventory control system was the software designed to handle traditional inventory processes. It was one of the early business applications, which did not belong to the finance and accounting area.

In the 1970s, the production-oriented information systems were known by the name MRP. MRP at its core is a time phased order release system that schedules and releases manufacturing work orders and purchase orders, so that sub-assemblies and components arrive at the assembly station just as they are required. Some of the benefits of MRP are reduction of inventories, improved customer service, enhanced efficiency and effectiveness (Siriginidi, 2000).

As competitive pressures increased and users became more sophisticated, MRP evolved and expanded to include more business functions such as product costing and marketing. In the early 1980s, MRP expanded from a material planning and control system to a company-wide system capable of planning virtually all the firm's resources. This expanded approach was MRPII. A major purpose of MRPII is to integrate primary functions (i.e. production, marketing and finance) and other functions such as personnel, engineering and purchasing into the planning process to improve the efficiency of the manufacturing enterprise (Chen, 2001; Chung and Snyder, 2000; Mabert *et al.*, 2001). MRPII has certain extensions like rough cut capacity planning and capacity requirements planning for production scheduling on the shop floor as well as feedback from manufacturing shops on the progress of fabrication. Since the 1980s, the number of MRPII installations has continued to increase, as MRPII applications became available on mini and micro computers (Siriginidi, 2000).

Like MRP, MRPII focused on the manufacturing process. The next stage of MRPII evolution was just-in-time (JIT) methodology that combined with the plummeting price of computing to create the islands of automation in late 1980s.

The Gartner Group of Stamford, CT, USA, coined the term ERP in the early 1970s to describe the business software system that is the latest enhancement of an MRPII system (encompasses all MRPII modules). A key difference between MRPII and ERP is that while MRPII has traditionally focused on the planning and scheduling of internal resources, ERP strives to plan and schedule supplier resources as well, based on the dynamic customer demands and schedules (Chen, 2001).

The maturity stage of ERP occurred in the mid-1990s. The scope offered by ERP expanded to include other "back-office" functions such as order management, financial management, warehousing, distribution production, quality control, asset management and human resources management. The evolution of extended-ERP systems has further expanded in recent years to include more "front-office" functions, such as sales force and marketing automation, electronic commerce and supply chain management systems. The scope of ERP implementation encompasses what is often referred to as the entire value chain of the enterprise, from prospect and customer management through order fulfilment and delivery. An enterprise, to stay competitive, has to not only identify information needs but also ensure that the information infrastructure provides the right support to serve the enterprise, its customers and suppliers. If it does not do so, then it runs the risk of being disconnected and excluded from future opportunities (Siriginidi, 2000).

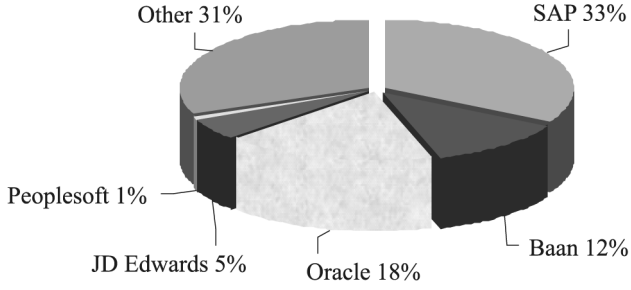
The technological evolution of ERP from MRP has been presented in detail by Chen (2001) and Chung and Snyder (2000).

Information system technology evolved from mainframe-based computing through the client/server era to the Internet era. Earlier the ERP systems were developed only to work with huge mainframe computers. Most of the current ERP systems are based on the client/server solution model (Rao, 2000; Siriginidi, 2000). In a client/server environment, the server stores the data, maintaining their integrity and consistency and processes the requests of the user from the client desktops. The load of data processing and application logic is divided between the server and the client (Gupta, 2000). Now, ERP vendors are – as many other software vendors – forced to move from a traditional client/server to a browser/Web server architecture in order to deliver e-business capabilities (Scheer and Habermann, 2000; Yen *et al.*, 2002). These systems are built with a clear separation of functional components. The user interface implemented using graphical user interface (GUI) techniques is deployed on client machines. Powerful server machines host the databases and business logic written as server procedures. The databases are built using relational database technology. Relational database systems have enabled the vendors to put in the necessary flexibility in terms of business logic and data structures to support parallel business practice implementations. These technologies in general have allowed the users to architect the system in such a way that installation, customisation and extensions are possible in shorter timeframes (Rao, 2000).

4. Main vendors of ERP systems

Business information systems can be either designed as custom applications or purchased as off-the-shelf standard solutions. The development of custom applications is generally expensive and is often plagued by uncertainties, such as the selection of appropriate development tools, the duration of the development cycle, or the difficulties involved in assessing costs. Therefore, companies are radically changing their information technology strategies by purchasing off-the-shelf software packages instead of developing IT systems in-house (Holland and Light, 1999).

Out of more than 100 ERP providers worldwide, SAP-AG, Oracle, JD Edwards, PeopleSoft and Baan – collectively called the "Big Five" of ERP software vendors – control approximately 70 per cent of the ERP market share (Mabert *et al.*, 2001) (Figure 2). The middle end products include SSA, BPCS, Inertia Movers, etc., that offer good functionality and could be implemented faster. The low-end products like QAD, MFG, PRD, etc., could be implemented very fast, but offer limited functionality



Source: Mabert *et al*. (2000); Coffey *et al*. (2000); Everdingen *et al*. (2000)

Figure 2.
Market shares of ERP system vendors

(Rao, 2000). The key features of some of the popular ERP packages including MFO/PRO from Qad, IFS/AVALON, SAP, JD Edwards, BAAN IV, Marshal(R) and PeopleSoft, have been provided in Siriginidi (2000).

The top five ERP vendors have seen a growth rate of 61 per cent over the past year. Although there are some differences in the marketing strategies and products of these five ERP vendors, they have similar offerings and shortcomings. Most ERP vendors still use the same basic model as MRP II for the manufacturing planning portion of their systems (Chung and Snyder, 2000). ERP has packaged processes best business practices in the form of a business blueprint. This blueprint could guide firms from the beginning phase of product engineering, including evaluation and analysis, to the final stages of product implementation. Many ERP systems also come with industry-specific solutions, or templates, that enhance the standard system by addressing key issues or business processes within an industry group (Mabert *et al.*, 2001).

Established in Germany in 1972, SAP AG, with 33 per cent market share, is the major ERP package vendor for the *Fortune* 500 companies. With more than 20,000 employees and an estimated revenue of $3.1 billion in 1997, up 30 per cent from 1996 (Scott and Kaindl, 2000), SAP has become one of the largest software companies in the world. To stay ahead of the competition, SAP spends 20-30 per cent of its annual revenues on R&D (Scott and Kaindl, 2000). SAP's first two products operated on mainframe hardware; R/1 was batch-oriented, but in 1981 was replaced by R/2, an online system. In 1992, SAP introduced R/3, a powerful client/server architecture product, which quickly gained dominant market share. SAP R/3 is an integrated suite of financial, manufacturing, distribution, logistics, quality control and human resources application systems and can address or facilitate changes in the business processes (Al-Mashari and Zairi, 2000b; Bancroft *et al.*, 1998; Mandal and Gunasekaran, 2002). Its architecture consists of three main layers of software (Al-Mashari and Zairi, 2000b):

(1) SAP GUI, representing the presentation layer.

(2) SAP application layer.

(3) SAP database layer (Bancroft *et al.*, 1998).

Applications of the SAP R/3 system are coded in the programming language ABAP/4 (Advanced Business Application Programming Language). ABAP/4 is an interpreted language, which makes it very easy to integrate new ABAP/4 application programs into the system (Doppelhammer *et al.*, 1997). SAP offers modules for logistics and human resources and also expands its product line to supply chain management, sale force automation and data warehousing (Yen *et al.*, 2002).

PeopleSoft was founded in 1987 and went public in 1992 (O'Leary, 2000). PeopleSoft can be scaled to accommodate from ten to 500 users. PeopleSoft dedicates its products (PeopleSoft™) to human resource and client/server technology. In many cases, firms have chosen some other ERP (e.g. SAP) for all other modules and PeopleSoft for human resources. They continue to prove its value in enterprise-wide applications and financial and supply chain applications. Currently, it targets the service sector with products designed to help companies handle their intangible costs (Yen *et al.*, 2002).

Baan was founded in The Netherlands in 1978. Bann has approximately 3,000 clients in 5,000 sites worldwide (O'Leary, 2000). It sells manufacturing software to

companies that are wary of SAP product. It stocks up on small software suppliers, which results in a wider variety of product offerings. They continue to develop enterprise applications in areas that SAP and Oracle are less competitive (Yen *et al.*, 2002).

Oracle is the second-largest supplier of software in the world. Oracle was founded in 1977 in the USA (O'Leary, 2000). It offers ERP applications designated to work with its database software. Oracle is a leading database software provider that sells most of its applications to manufacturers and consumer goods companies. Oracle intends to dominate its database software by levering over the ERP market (Yen *et al.*, 2002). Oracle's reputation in ERP systems is for developing a product that can be interfaced with other products in order to construct a "best of breed" (BoB) system (O'Leary, 2000).

JD Edwards provides ERP applications (OneWorld™) for managing the enterprise and supply chain. Their integrated applications give customers control over their front office, manufacturing, logistics and distribution, human resources and finance processes. JD Edwards continues to allow its ERP solutions to operate in the computing environment and also to be XML enabled (Yen *et al.*, 2002). OneWorld is designed for between five and 500 users (O'Leary, 2000).

To summarise, such systems have a few common properties: they are based on a central, relational database, they are built on a client/server architecture, and they consist of various functional modules. In addition to a base module, there are modules for general accounting, budgeting, fixed assets, sales order management, procurement, inventory management, customer service management, etc. ERP systems may support most functional units and processes of a company – if its structure and working procedures are not too far from the mainstream (Kueng *et al.*, 2000).

4.1 Drawbacks of the ERP systems

Although ERP systems have certain advantages such as low operating cost and improving customer service, they have some disadvantages due to the tight integration of application modules and data. Huge storage needs, networking requirements and training overheads are frequently mentioned ERP problems. However, the scale of business process re-engineering (BPR) and customisation tasks involved in the software implementation process are the major reasons for ERP dissatisfaction. Baan, PeopleSoft, as well as SAP calculate that customers spend between three and seven times more money on ERP implementation and associated services compared to the purchase of the software license (Scheer and Habermann, 2000). This means that ERP projects are large, costly and difficult and that they require large investment in capital and staff and management time (Adam and O'doherty, 2000). Yen *et al.* (2002) identified the following disadvantages of ERP: its high cost prevents small businesses from setting up an ERP system, the privacy concern within an ERP system and lack of trained people may affect ERP's efficiency. Implementation of an ERP project is painful, and customisation is costly and time-consuming. The various shortcomings of the ERP systems such as functionality and technicality are shown in Figure 3. Some of these shortcomings have been discussed by O'Connor and Dodd (2000).

The different types of ERP system misfits (the gaps between the functionality offered by the package and that required by the adopting organisation), based on Asian organisations, have been presented by Soh *et al.* (2000). The observed misfits

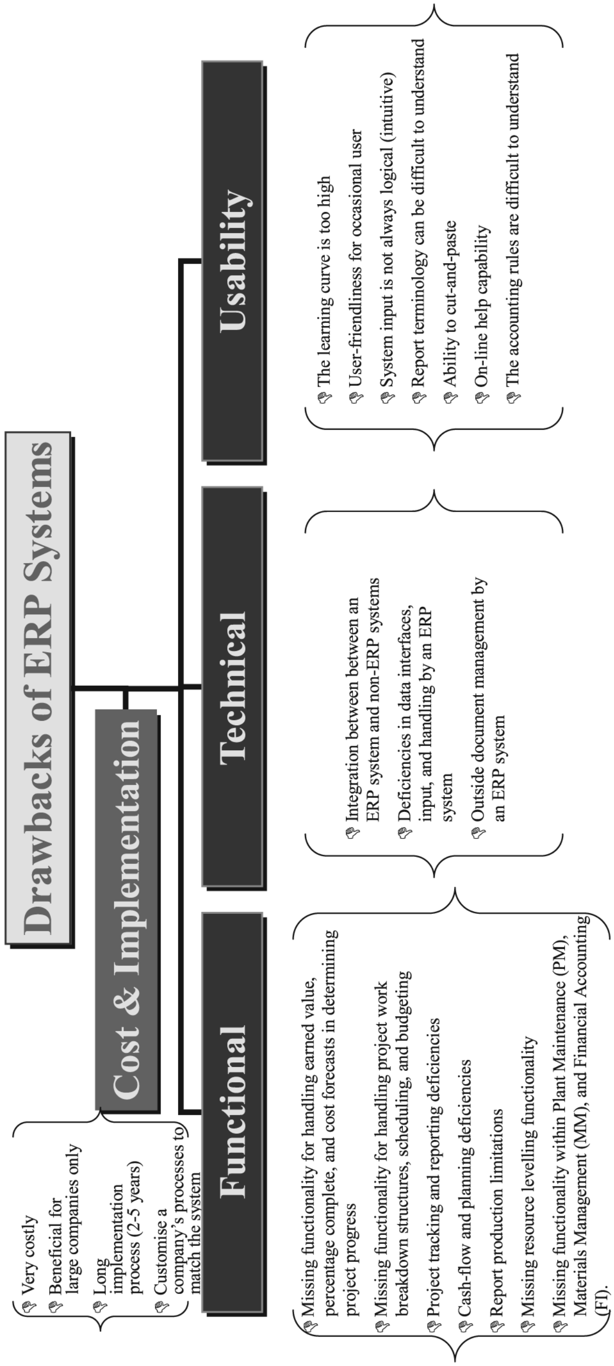


Figure 3.
Drawbacks of ERP systems

were clustered into three broad categories: data, process and output, in line with a traditional software application perspective. Data misfits arise from incompatibilities between organizational requirements and the ERP package in terms of data format, or the relationships among entities as represented in the underlying data model. Functional misfits arise from incompatibilities between organizational requirements and ERP packages in terms of the processing procedures required. Output misfits arise from incompatibilities between organizational requirements and the ERP package in terms of the presentation format and the information content of the output. Their findings suggest that the "misfit" issue may be worse in Asia because the business models underlying most ERP packages reflect European or US industry practices.

ERP systems are complex, and implementing one can be a difficult, time-consuming and expensive project for a company. For instance, the ERP adoption time, typically, takes from a few months for firms accepting all default settings, to years for firms needing to make major modifications. It costs tens of millions of dollars for a medium sized company and $300-500 million for large international corporations (Mabert *et al.*, 2001). Along with obvious costs of an ERP implementation, there are also some possible hidden costs that may include losing some very intelligent employees after the initial implementation is done, continual implementation and training, waiting for return on investment (ROI) and post-ERP depression (Coffey *et al.*, 2000). Moreover, even with significant investments in time and money, there is no guarantee of the outcome (Mabert *et al.*, 2001). Although most ERP systems have business practice processes in their repository, not all of them are necessarily best in class applications for a specific firm. The firm still needs to select those applications available from software vendors for its specific requirements, and integrate both applications and ERP system into the firm's IT backbone. Because ERP has made it easy to integrate other competing best in class applications, most firms either face the high cost of modifying the ERP modules to meet their requirements or simply do not install the applications. Indicative of the problems, some retailers were reported to face difficulties, when they implement ERP applications that were developed with manufacturers in mind (Chung and Snyder, 2000). One of the aims of implementing ERP systems is to uphold the highest quality standards of the business process. However, when the business condition has been changed, the system may not guarantee that the process embedded in ERP is still best. Hence, for example, a multi-agent system for adaptive inventory control in an ERP system maintenance has been proposed by Kwon and Lee (2001).

Themistocleous *et al.* (2001) proposed a model to identify, analyse and present the problems of ERP systems, as well as to examine new approaches to application integration (AI). They claimed that ERP systems amplified the need for integration, as existing systems have to be incorporated with ERP applications. AI securely incorporates functionality from disparate applications and leads to the development of new strategic business solutions for enterprises. The results of the research confirm AI as a new means of system integration that adds value by placing business logic in the applications network, thus creating a more dynamic information system infrastructure. Additionally, organisations face many problems when customising ERP packages. Thus, customisation problems did not allow companies to make serious changes on the ERP package.

IT and business managers also argue that ERP suites tend only to have one best in class application. For instance, PeopleSoft is linked with a good human resources module and Oracle with financials. Furthermore, organisations may be left waiting for the next upgrade from their ERP software vendor when they require further functionality.

5. Selection criteria of an ERP system

The normal symptoms that would suggest the need for ERP would be high levels of inventory, mismatched stock, lack of coordinated activity, excessive need for reconciliation, flouting of controls, poor customer response levels and operations falling short of industry benchmarks in terms of cost controls and general efficiency. The tangible benefits due to ERP adoption include: reduction of lead time by 60 per cent, 99 per cent on-time shipments, increased business, increase of inventory turn over by 30 per cent, reduction in cycle time by 80 per cent and work in progress reduced to 70 per cent. The intangible benefits include: better customer satisfaction, improved vendor performance, increased flexibility, reduced quality costs, improved resource utility, improved information accuracy and improved decision-making capability (Siriginidi, 2000).

The deployment of ERP has two issues, viz., selection and implementation. The system selection process is deceptively difficult. While most ERP packages have similarities, they also have fundamental design differences. The selection involves listening to the views of various people whose involvement would be essential and the criteria to go beyond technical issues such as proven experience of the supplier in the desired industry, along with support infrastructure. Selecting a system that is simple offers smart tools for system administration, a consistent interface and supports graphical and character interfaces that could reduce the implementation time.

The various selection criteria of ERP systems are well documented (Bernroider and Koch, 2001; Chen, 2001; Everdingen *et al.*, 2000; Rao, 2000; Siriginidi, 2000; Sprott, 2000; Verville and Halingten, 2002). From the clients' view point, the selection factors to be considered, as addressed by Siriginidi (2000), include the stability and history of the ERP supplier, last 12-month track record of ERP sales, implementation support from suppliers and improvement in ERP packages.

In another study, Bernroider and Koch (2001) discussed the results from an empirical study of Austrian companies concerning differences in the characteristics of the ERP system selection process between small or medium and large sized organisations. In particular, they addressed the fields of software packages considered and chosen, the weights assigned to different selection criteria, the size and structure of the team responsible for the decision, the methods employed and the effort expended. The analysis conducted showed that there is a significant influence of organizational size on the software package selected. SAP R/3 systems are selected more often by large organisations, while small or medium sized companies often choose software supplied by Baan. A total of 29 different ERP selection criteria have been identified; the adaptability and flexibility of the software is more highly valued by smaller organisations, as these advantages may be unique business processes that need to be preserved. A short implementation time and therefore, lower costs are also given more importance, as resources are a bigger issue. The high importance attributed to fit with current business procedures, flexibility, costs, user-friendliness of the system and short

implementation has also been found in another empirical study of European midsize companies conducted by Everdingen *et al.* (2000). With regard to evaluating ERP suppliers, they also reported that all the European mid-markets tend to focus on product characteristics such as the functionality and quality of the products and services, rather than on characteristics of the ERP supplier of the product. At the same time, the speed of implementation, the possibilities of the product for interfacing with other applications and the price of products and services are also important supplier selection criteria. Sprott (2000) identified four incremental selection criteria that organisations should use to choose the supplier of an enterprise applications. These are applicability, integration, adaptability and upgradability.

In his paper, Chen (2001) analysed several critical planning issues prior to the ERP adoption decision, including needs assessment and choosing a right ERP system, matching business process with ERP system, understanding the organizational requirements, and economic and strategic justification. He reported that competitive strategy, targeted market segments, customer requirements, manufacturing environment, characteristics of the manufacturing process, supply chain strategy and available resources all enter into the decision of ERP adoption.

Verville and Halingten (2002) investigated the decision process for selecting an ERP system through a case study. They reported that the three distinct types of an ERP system evaluation were vendor, functional and technical. Criteria such as vendor reputation, financial stability, long term viability and the vendor's vision/corporate direction were factors that were considered during the vendor evaluation.

In recent years, most ERP system suppliers have increased their focus on small or medium sized organisations, especially as the total European midsize market for IT products and services surpasses US $50 billion per year (Everdingen *et al.*, 2000). There are some reasons for this trend, including a saturation of the market, as most large organisations have already implemented an ERP solution, increasing possibilities and need for the integration of systems between organisations and the availability of relatively inexpensive hardware (Gable and Stewart, 1999). Rao (2000) identified the criteria for the selection of an ERP system for SMEs. These criteria are affordability, domain knowledge of suppliers, local support, technical upgradability and incorporation of latest technologies.

Frequently, references are made to factors proposed (Gable and Stewart, 1999) within a framework that identifies four main dimensions of the specificity of small to medium sized organisations: organizational, decisional, psychosociological and information systems.

In their study of ERP migrations, Kremers and van Dissel (2000) suggested that migrations have a bad reputation with the users of ERP systems. They consider such projects as time-consuming and expensive. As a result, many organisations do not migrate the moment a new version becomes available. In addition, migrations are usually motivated by technical reasons rather than by business opportunities. These findings suggest that many organisations may have problems leveraging their (often large) investments in ERP systems. In addition, new improved versions of ERP systems regularly become available at the same time for all users. Therefore, at best, organisations may try to compete on the basis of the capability to migrate to a new version quickly.

The literature review on this research topic shows that most of the studies have focused on the US and European business (Table II). Further research is required to

Author(s)	Type and field of study	Size of organisations	Selection factors considered
Siriginidi (2000)	Theoretical	Large size	Stability and history of the ERP supplier Last 12-month track record of ERP sales Implementation support from suppliers Improvement in ERP packages including stability of the product and functionality
Bernroide and Koch (2001)	Empirical Austrian	Mid and large size	Implementation time Adaptability and flexibility of software Costs Vendor support Team size and structure Market position of vendor Customer and supplier needs
Everdingen *et al.* (2000)	Empirical European	Midsize	Fit with business process Flexibility User-friendliness Costs Scalability Supplier support and training Product functionality and quality Implementation speed Interface with other systems Price Market leadership Corporate image and international orientation
Sprott (2000)	Theoretical	Large size	Applicability Integration Adaptability Upgradability
Chen (2001)	Theoretical	Large size	Competitive strategy Targeted market segments Customer requirements Manufacturing environment Characteristics of the manufacturing process Supply chain strategy and available resources
Rao, 2000	Theoretical	SMEs	Affordability Domain knowledge of suppliers Local support Technical upgradable Incorporation of latest technologies
Verville and Halingten (2002)	Empirical USA	Large size	Vendor evaluation Functional and technical aspects of the software

Table II.
ERP selection criteria (comparison of papers)

identify the various selection criteria of ERP systems for Far East, Gulf and Middle East organisations. The homogeneity of the business market among different countries should be addressed.

5.1 ERP or best of breed

An ERP "solution" can be put together in a number of ways. At one end, an organisation can install a single vendor package. At the other end, it can integrate different modules from different vendors and/or custom software for a BoB solution. Both approaches are undoubtedly complex due to their scale, scope and BPR requirements. The trade-offs of these two approaches are fairly simple. A multi-vendor solution can provide the best functionality for each module, but implementing it becomes more complex because of the interfaces that need to be established. A single vendor solution may not have all the functionality required, but it will be easier to implement (Mabert *et al.*, 2001).

Until recently, most vendors (SAP, PeopleSoft, Oracle, etc.) have promoted a "one size fits all" solution built on "industry best practices". This approach forced organisations to either conform to the "best practices" and configurations suggested by vendors and implementation consultants or embark on extremely costly reconfiguration of their ERP package (Clemmons and Simon, 2001).

Light *et al.* (2001) highlight BoB as an alternative approach to enterprise IT infrastructure development. In their paper, the differences between BoB and single vendor ERP approaches are discussed and the issues organisations need to consider when deciding on a strategy are shown to centre on the complexity of implementation, required levels of business process alignment and associated maintenance. ERP requires a clean slate approach, whereas BoB offers the chance for organisations to recognise the existing ways of work and make trade-offs with stakeholders. This is an important distinction, as the BPR associated with BoB can facilitate implementation and the management of complexity. Another important difference is that ERP systems do not offer the same levels of flexibility, and potentially, the responsiveness associated with BoB. However, the trade-off is likely to be concerned with the future maintenance requirements. BoB approaches have the potential to require higher degrees of maintenance due to the complex connections made between different components, whereas maintenance of components and connections between components, of single vendor ERP systems is largely outsourced to the vendor. However, the paper presented a comparative analysis between ERP and BoB approaches, particularly with respect to the impact on business process and BPR implementation. Other issues such as technology and cost require more research effort.

6. Implementation of an ERP system

A tremendous effort has been made in discussing the implementations of ERP systems. Al-Mashari and Zairi (2000a) proposed an integrative framework for SAP R/3 implementation. Their framework was based on the premise that effective deployment of SAP R/3 is greatly determined by the extent to which certain key elements such as the business case, implementation strategy, change management and BPR, are comprehensively considered and fully integrated. A more detailed case study focused on SAP R/3 implementation is available from Sieber *et al.* (2000).

The successful implementation of an ERP system increases competitiveness by increasing quality, reducing redundancy, speeding up processes, reducing lead times and inventory levels and increasing customer satisfaction (Coffey *et al.*, 2000; Gupta, 2000). It has become increasingly clear that implementing an ERP system requires extensive efforts to transform the organisation's processes. ERP systems are

supposedly based on best practice generic business processes. Therefore, when purchasing an off-the-shelf ERP system, organisations obtain these practices and subsequently are pushed into the direction of implementing them (Kremers and van Dissel, 2000).

According to a recent study, more than 70 per cent of *Fortune* 1000 companies have either begun the implementation of an ERP system or plan to do so in the next few years (Coffey *et al.*, 2000). Another positive aspect is that smaller firms that are very dependent on large companies, are going to be forced into ERP packages to stay compliant with larger organisations' ERP systems.

Enterprise preparedness for embarking an ERP system has been discussed by Siriginidi (2000). For instance, infrastructure resource planning, education about ERP, human resource planning, top management's commitment, training facilities and commitment to release the right people are among the factors that should be considered before implementing an ERP package. Chen (2001) claimed that economic and strategic justifications for an ERP project prior to installation are very necessary, not only because of the enormous investments and risks involved; the justification process helps to identify all the potential benefits that can be accrued with ERP implementation, which later become yardsticks for performance evaluation. Reductionism and complex thinking in the realm of ERP implementations have been discussed by Wood and Caldas (2001).

Failures of ERP system implementation projects have been known to lead to organizational bankruptcy (Davenport, 1998; Markus *et al.*, 2000b). A methodological framework for dealing with the complex problem of evaluating ERP projects has been proposed by Teltumbde (2000). A study of problems and outcomes in ERP projects has been conducted by Markus *et al.* (2000b). Two basic research questions were addressed. First, how successful are companies at different points in time in their ERP experiences, and how are different measures of success related? Second, what problems do ERP adopters encounter as they implement and deploy ERP, and how are these problems related to outcomes? Markus *et al.* (2000b) developed a four-phase model of ERP implementation: chartering, project, shake-down and onwards and upwards. The findings showed that the success of ERP systems depend on when it is measured and that success at one point of time may only be loosely related to success at another point of time. Companies experience problems at all phases of the ERP system life cycle and many of the problems experienced in later phases originated earlier, but remained unnoticed or uncorrected. These findings suggest that researchers and companies will do well to adopt broad definitions and multiple measures of success and pay particular attention to the early identification and correction of problems.

However, current ERP research has focused on the ERP implementation stage, post-implementation and other organizational issues, the issue of acquisition process for ERP software is, for the most part, being ignored. Further research work in this area should be aimed to detail the difference in the ERP implementation between SMEs and large organisations. Most ERP systems contain best practice models. Current studies have not focused on the knowledge transfer practices involved in an ERP implementation including the various types of knowledge transferred and factors affecting this transfer.

There are different approaches to ERP strategy, ranging from skeleton implementations to full functionality. There are also important differences in how

organisations manage the gap between their legacy systems and the ERP business processes. It appears easier to mould the organisation to the ERP software rather than vice versa. In the following section, various implementation techniques will be presented.

6.1 Implementation approaches

ERP systems are now the most common IT strategy for all organisations. From a management perspective, the nature of the ERP implementation problem includes strategic, organisation and technical dimensions. Therefore, ERP implementation involves a mix of business process change (BPC) and software configuration to align the software with the business processes (Holland and Light, 1999).

There are two different strategic approaches to ERP software implementation. In the first approach, an organisation has to re-engineer the business process to accommodate the functionality of the ERP system, which means deep changes in long-established ways of doing business and a shake up of important peoples' roles and responsibilities. This technique will take advantage of future ERP releases, benefit from the improved processes, and avoid costly irreparable errors. The other approach is customisation of the software to fit the existing process, which will slow down the project, introduce dangerous bugs into the system and make upgrading the software to the ERP vendor's next release excruciatingly difficult, because the customisations will need to be torn apart and rewritten to fit with the new version (Koch *et al.*, 1999). However, the former approach has proven to be more logical and effective; historically, ERP implementations have had to deal with the critical issue of changing the business process or modifying the software (Boykin, 2001; Clemmons and Simon, 2001). Since each alternative has drawbacks, the solution can be a compromise between complete process redesign and massive software modification. However, many companies tend to take the advice of their ERP software vendor and focus more on process changes.

The current generation of ERP systems also provides reference models or process templates that embody the current best business practices (Kumar and Hillegersberg, 2000). When improving business processes, reference models can be included. Reference models provided by ERP software vendors or consultant companies benefit the customer by utilising business process knowledge and best practices, providing the opportunity to compare business software solutions or pinpointing positive or negative implementation issues (Scheer and Habermann, 2000).

An ERP implementation often entails transferring the business knowledge incorporated in the basic architecture of the software package into the adopting organisation. In their paper, Lee and Lee (2000) proposed a new approach to analysing ERP implementations from a knowledge transfer perspective. First, the types of knowledge transferred during an ERP implementation and the factors affecting this transfer were identified. Then they investigated how conflicts between the business knowledge transferred from the ERP package and the existing organizational knowledge are resolved. Their results indicated that the business processes which are incorporated in an ERP package are transferred into an organisation along with the business rules inherent in the processes due to process automation, the limited flexibility of such packages and the cross-functional nature of an ERP package. The results also suggested that an organisation's adaptive capability concerning the role and responsibility redistribution, the development of new types of required knowledge

and the introduction of a different knowledge structure influences an organisation's ability to internalise these standardised processes into business routines that provide a competitive advantage.

ERP projects are complex and require reliance on many different types of expertise often sourced outside the organisation. Consultants often advise managers to undertake some degree of re-engineering of key processes before acquiring ERP systems (Bancroft *et al.*, 1998); this adds to the complexity and political character of the projects (Adam and O'doherty, 2000). These difficulties have led some researchers to take a negative view on ERP systems. Wood and Caldas (2000) characterised the goals of ERP systems and questioned whether the current interest in ERP in the business community is justified more by political reasons than by sound managerial reasoning. Indeed, these authors found low levels of satisfaction in their survey of firms having implemented ERP systems with 45 per cent of firms perceiving no improvements whatever from implementation and 43 per cent claiming that no cycle reduction had been obtained.

ERP implementation should involve the analysis of current business processes and the chance of re-engineering, rather than designing an application system that makes only the best of bad processes. Therefore, ERP implementation and BPR activities should be closely connected. In principle, it would be always better to carry out BPR in advance of ERP. Pragmatically, it may not be easy to do so because BPR is effort intensive and costs money and time. Also, carrying out BPR in advance of ERP implies that the enterprises need to put resources into two successive projects. In addition, it would be worth implementing the ERP package in its vanilla form. ERP packages offer many best business practices that might be worth including as a part of BPR (Gulla and Brasethvik, 2002). After the ERP implementation, one could get into continuous process re-engineering. Several enterprises may have different primary objectives in implementing ERP. They would probably fall in one of the following: standardisation of objectives, BPR, elimination of organizational and technical bottlenecks, improvement in quality of information, replacement of out-of-date procedures and systems, integration of business processes, reduction in stand alone systems and interfaces, and covering areas previously neglected. The objectives and the corresponding expectations should be clearly documented (Siriginidi, 2000).

In an exploratory survey, Wood and Caldas (2001) found that most of the companies in the survey (71 per cent) admitted that implementation followed re-engineering or was conducted simultaneously with re-engineering. However, 24 per cent of the firms affirmed that the implementation process was focused on its human side and its transformational dimension, while 36 per cent of companies confirmed that the implantation process was more heavily focused on IT.

An empirical investigation of the reality of ERP system implementations in Irish organisations has been carried out by Adam and O'doherty (2000). They focused specifically on the profiles and sizes of the organisations implementing ERP and on the key parameters in their relationship with their suppliers of ERP software. They found that the ERP implementations in Irish organisations are different to the projects that have been reported elsewhere in two key respects. First, the organisations interested in ERP software were, on average, far smaller than the case studies reported in the literature and the majority of the cases they reviewed were SMEs. Second, the duration

of implementation was far shorter than that reported elsewhere. These results are not surprising if one considers the smaller average size of Irish organisations, but they indicated that the ERP movement is truly ready for an extension towards the SME market. They also indicated that the duration of the implementation of ERP software may be related to the size and complexity of the client organisation and that SMEs can expect to have better time implementing ERPs that the current literature suggests. They also found that software implementers play a key role, not only in technical terms but also in managerial and political terms, because they can help their clients in correcting their expectations and perceptions of ERP systems and implementations. Chan (2001) identified the essential knowledge required for ERP software implementation in SMEs. Furthermore, he proposed a framework for interrelating the various areas of knowledge. The framework comprises three dimensions: the project management, the issues and the technical knowledge dimensions.

6.2 Factors affecting the implementation process

The difficulties of ERP implementations have been widely cited in the literature (Appleton, 1997; Davenport, 1998). Although companies spend millions on ERP packages and the implementation process, there is extensive evidence that they experience considerable problems, particularly during the actual implementation project. In response to these problems, there has been a developing body of academic literature (Bancroft *et al.*, 1998; Holland and Light, 1999; Markus *et al.*, 2000b; Motwani *et al.*, 2002; Nah *et al.*, 2001; Parr and Shanks, 2000) which addresses the difficulties of ERP implementation by proposing critical success factors (CSFs) and process models of the implementation. Both are aimed at better planning and hence, more successful ERP implementation.

Bancroft *et al.* (1998) provided CSFs for ERP implementation, including top management support, the presence of a champion, good communication with stakeholders and effective project management. The factors specific to ERP implementation include re-engineering business processes, understanding corporate cultural change and using business analysts on the project team. In another study, Holland and Light (1999) developed a CSFs framework to help managers successfully plan and implement an ERP project. Their CSFs model includes strategic factors, such as the overall implementation strategy, and tactical factors such as technical software configuration and project management variables. The approach has been illustrated by two case studies. The case analysis highlighted the critical impact of legacy systems upon the implementation process and the importance of selecting an appropriate ERP strategy.

Research on the critical factors for initial and ongoing ERP implementation success has been discussed by Nah *et al.* (2001). In their paper, 11 factors were identified to be critical to ERP implementation success: ERP teamwork and composition; change management program and culture; top management support; business plan and vision; BPR with minimum customisation; project management; monitoring and evaluation of performance; effective communication; software development, testing and troubleshooting; project champion; appropriate business and IT legacy systems. In their study of the complexity of multi site ERP implementation, Markus *et al.* (2000a) claimed that implementing ERP systems can be quite straightforward when organisations are simply structured and operate in one or a few locations. But when

organisations are structurally complex and geographically dispersed, implementing ERP systems involves difficult, possibly unique, technical and managerial choices and challenges.

In her study to describe and identify the risk factors associated with enterprise-wide/ERP projects, Sumner (2000) concluded that some of the unique challenges in managing enterprise-wide projects included the challenge of re-engineering business processes to "fit" the process which the ERP software supports, investment in recruiting and reskilling technology professionals, the challenge of using external consultants and integrating their application-specific knowledge and technical expertise with the existing teams, the risk of technological bottlenecks through client/server implementation and the challenge of recruiting and retaining business analysts who combine technology and business skills.

In a study aimed at determining the factors for success or failure in the implementation of ERP systems in SMEs, Marsh (2000) suggested that key success factors include cross-functional team approaches, organizational experience of similar scale IT or organizational change projects, and deep understanding of the key issues relating to ERP implementations. Marsh (2000) identified the failure factors including top-down or consultant-driven implementations, IT department-driven implementations, or implementations where the ERP is seen as a quick technological fix to problems within the operation of the firm, rather than as a strategic investment.

Typically, ERP initiatives in organisations are motivated by senior executives other than the chief information systems officer (CIO). Willcocks and Sykes (2000) tackle the issue of ERP implementation from the perspective of the IT managers of a company. They observed that most CIOs and their IS/IT departments seem to have been "asleep at the wheel" in understanding and dealing with the ERP phenomenon. They suggest how the CIO and the IS department can transform themselves in dealing with the challenges of adopting, implementing, and if necessary, adapting enterprise-wide systems to the specific needs of their organisation.

The technical and organizational complexities of projects represent conceptually general rivers of implementation effort. Francalanci (2001) investigated the impact of the technical size and organizational complexity of SAP R/3 projects on implementation effort. Specifically, project size was measured in terms of the number of SAP modules and sub-modules that were implemented, while complexity is defined as the organizational scope of the project in terms of users involved and the overall company size. His findings suggested that both technical size and organizational complexity of projects are relevant drivers of implementation effort. The results indicated that implementation effort not only grows with the number of modules and sub-modules that were selected for implementation, but that SAP was found to require increasing resources to be implemented in larger companies and for a higher number of users, thus indicating that, while there was a technical component of effort that was independent of the organizational breadth of the project, each user added an organizational component of costs.

Sarker and Lee (2000) examined through a case study the role of three key social enablers, strong and committed leadership, open and honest communication, and a balanced and empowered implementation team, that are necessary conditions/precursors for successful ERP implementation. They claimed that, while

all three enablers may contribute to ERP implementation success, only strong and committed leadership can be empirically established as a necessary condition.

In summary, one of the most widely-cited variables critical to the successful implementation of a large customised system, as shown in Table III, is top management support. Given the cross-functional nature and large budget of a typical ERP implementation, the extent of top management support appears to be an important characteristic. Two types of top management support roles have been associated with systems implementation projects: the project *sponsor* and the project *champion* roles. The project sponsor is responsible for budgetary support and ensuring that key business representatives play a role on the project team. The project champion may or may not be a formal member of the project team, but can play a key role in change management efforts. In some organisations, the sponsor also serves as the business champion for the project; in other situations, a champion emerges from among the key business leaders (Brown and Vessey, 1999).

6.2.1 Implementation models. Aderet (2002), Al-Mudimigh *et al.* (2001), Bancroft *et al.* (1998), Markus *et al.* (2000b) and Parr and Shanks (2000) have all proposed models of ERP implementation in order to gain a deeper understanding of the process and hence, provide guidelines for successful implementation. Bancroft *et al.* (1998) presented a view of the implementation process which was derived from discussions with 20 practitioners and from studies of three multinational corporation implementation projects. The Bancroft model has five phases: focus, as is, to be, construction and testing and actual implementation. The focus phase is essentially a planning phase in which the key activities are the set-up of the steering committee, selection and structuring of the project team, development of the project's guiding principles and creation of a project plan. The as is phase involves analysis of current business processes, installation of the ERP, mapping of the business processes on to the ERP functions and training of the project team. The to be phase entails high-level design and then detailed design subject to user acceptance followed by interactive prototyping accompanied by constant communication with users. The key activities of the construction and testing phase are the development of a comprehensive configuration, the population of the test instance with real data, building and testing interfaces, writing and testing reports and finally, system and user testing. Finally, the actual implementation phase covers building networks, installing desktops and managing user training and support. In summary, the model of implementation extends from the beginning (focus) of the project proper to the cut-over of the live system.

Parr and Shanks (2000) presented a project phase model (PPM) of ERP implementation project that is a synthesis of the existing ERP implementation process model and focuses on the implementation project. Two case studies of ERP implementation within the same organisation, one unsuccessful and later a successful one, were reported and analysed in order to determine which CSFs are necessary within each phase of the PPM. The PPM has three major phases: planning, project and enhancement. In addition, because the focus of the model was on the implementation project itself, the project phase was divided into five sub-phases: set-up, re-engineering, design, configuration and testing and installation. Parr and Shanks claimed that the PPM, together with associated CSFs, provides guidance for practitioners when planning ERP implementation projects and also provides researchers with a foundation for further empirical research.

Author(s)	Validation	Critical factors of ERP implementation
Bancroft *et al.* (1998)	Yes. Three multinational companies	Top management support Presence of a champion Good communication with stakeholders Effective project management
Holland and Light (1999)	Yes. Two case studies	Strategic factors, such as the overall implementation strategy Tactical factors such as technical software configuration Project management variables Critical impact of legacy systems upon the implementation process Importance of selecting an appropriate ERP strategy
Nah *et al.* (2001)	No	ERP teamwork and composition Change management program and culture Top management support Business plan and vision BPR with minimum customisation; project management Monitoring and evaluation of performance Effective communication Software development, testing and troubleshooting Project champion Appropriate business and IT legacy systems
Markus *et al.* (2000a)	No	Simple structure of organisations Operate in one or a few locations
Marsh (2000)	Yes. Nine case studies	Success factors include: Cross-functional team approaches Organizational experience of similar scale IT or organizational change projects Deep understanding of the key issues relating to ERP implementations Failure factors including: Top-down or consultant driven implementations IT department driven implementations Implementations where the ERP is seen as a quick technological fix to problems within the operation of the firm, rather than as a strategic investment
Francalanci (2001)	No	Technical size and organizational complexity
Sarker and Lee (2000)	Yes. One case study	Strong and committed leadership Open and honest communication Balanced and empowered implementation team
Umble *et al.* (2003)	Yes. One case study	Clear understanding of strategic goals Commitment by top management Excellent project management A great implementation team Data accuracy Extensive education and training Focused performance measures

Table III.
Critical factors of ERP implementation (comparison of papers)

An integrative framework for ERP implementation has been proposed by Al-Mudimigh *et al.* (2001). The framework was based on an extensive review of the factors and the essential elements that contribute to success in the context of ERP implementation. Although ERP packages provide generic off-the-shelf business and software solutions for customers, there is growing evidence that failure to adapt ERP packages that are implemented in companies with different corporate and national cultures, to fit these cultures, leads to projects that are expensive and overdue. Krumbholz *et al.* (2000) presented a research which synthesises social science theories of culture, in order to be able to model and predict the impact of culture on ERP package implementation. In their paper, they described a knowledge meta-schema for modelling the surface and deeper manifestations of culture and predictions of ERP implementation problems based on national culture differences. The results provided evidence for an association between corporate culture and ERP implementation problems, but no direct evidence for an association between national culture and implementation problems. Furthermore, the results demonstrated that these diverse implementation problems can be caused by a mismatch between a small set of core values which are indicative of a customer's corporate culture. Huang and Palvia (2001) proposed a framework for examining ERP implementation in selected advanced and developing countries. Their research showed that ERP technology faces additional challenges in developing countries related to economic, cultural and basic infrastructure issues. No validation of the proposed framework was presented. Also, additional research work is required to investigate the relationships between the various components of their framework.

Daily operations, planning and decision-making functions in organisations are increasingly dependent on transaction data. Vosburg and Kumar (2001) discussed issues related to the origin of dirty data, associated problems and costs of using dirty data in an organisation, the process of dealing with dirty data then migrating to a new system (ERP) and the benefits of an ERP in managing dirty data. They explored these issues using the experiences of a company, which implemented an ERP system in their organisation. The guidelines for companies planning to implement ERP solutions to overcome dirty data problems has been presented in Vosburg and Kumar's paper. Stijn and Wensley (2001) discussed the issues relating to the representation of process knowledge during the implementation and in-use phase of ERP systems. They suggested that ERP may, very well, embed some of the process knowledge that is resident in organisations.

7. Conclusion and implications for future research

ERP systems are sets of integrated applications that can provide a total solution to an organisation's information system needs by addressing a large proportion of business functions including financial, accounting, human resources, supply chain and customer information. They support a process-oriented view of the business as well as business processes standardised across the enterprise. Recently, these packages are implemented on client/server architectures that are more flexible and scalable than mainframe systems. Many papers have been written on this topic. In this paper, a comprehensive review of the recent research work in ERP systems has been presented. In addition, it has been observed that from the year 2000 till date an increasing number of papers about ERP packages has been published. The *Business Process Management*

Journal, *Journal of Information Technology* and the *Communications of the ACM* were the journals where majority of the papers on this subject were published.

Most ERP systems still lack the more advanced product costing techniques, such as activity-based costing (ABC), life-cycle costing and target costing. Also, they lack the capabilities of the advanced techniques for dealing with uncertainties such as fuzzy logic. Furthermore, state-of-the-art techniques such as neural networks and genetic algorithm should also implement in the existing ERP systems. Further research effort is required to incorporate these new techniques in ERP systems.

In most countries, SMEs are the backbone of the economy. While in the past many SMEs were acting on local markets, today Web-based technologies and community networks are changing the basis of competition. More and more SMEs are now exposed to the forces of global competition. From this point of view, it is crucial that SMEs continuously improve their competitiveness to assert themselves in the market. Therefore, SMEs are moving towards ERP packages. Although in recent years most ERP system suppliers have increased their focus on SMEs, current ERP systems are still expensive. As the financial resources of SMEs are clearly limited, they cannot afford them. There is a need to provide micro ERPs, i.e. near ERP capabilities built into a product and sold at an affordable price, including implementation. Research effort is required to provide an ERP system that has the flexible assurance capabilities to evolve with the dynamic changes of a company.

Currently, there are two approaches for the implementation of ERP systems namely moulding the business process to match the ERP software or vice versa. Each technique has drawbacks as discussed in Section 6.1. Further research is necessary to develop a new technique for adopting the ERP system to overcome the shortcomings of the current approaches. The new implementation model should take the SMEs into consideration.

Future trends in ERP, including developments such as Web-based procurement applications and outsourcing of ERP applications, have been suggested by Al-Mashari (2003) and Gupta (2000).

ERP software still requires many resources and efforts to integrate all of the major business functions in the initiating firm. Some of the topics will be on the impact of ERP on organizational alignment, organizational learning, infrastructure, mass customisation, competitive advantage and organizational structure. A customer relation management (CRM) module should be included in the ERP packages.

Since most ERP vendors are moving towards Internet Web-based applications to fulfil the e-commerce era, the development of security issues needs to be addressed.

We hope that this paper reinforces the ongoing research, provides a broad view of the current status in ERP systems research, and offers potential directions for the development of the ERP systems.

Note

1. AMR Research, available at: www.amr.com

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