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Enterprise resource planning systems and its implications for operations function

Mahesh Gupta[a,*], Amarpreet Kohli[b]

[a]Department of Management, College of Business and Public Administration, University of Louisville, Louisville, KY, 40292, USA
[b]Speed Scientific School, University of Louisville, Louisville, KY 40292, USA

Abstract

Over the last decade, our world has changed dramatically due to the growing phenomenon of globalization and revolution in information technology. There is tremendous demand on companies to lower costs, enlarge product assortment, improve product quality, and provide reliable delivery dates through effective and efficient coordination of production and distribution activities. To achieve these conflicting goals, companies must constantly re-engineer or change their business practices and employ information systems.

In 1990s, Enterprise Resource Planning (ERP) systems have emerged as an enabling technology, which integrates various functional (operations, marketing, finance) information systems into a seamless suite of business applications across the company and thereby, allowed for streamlined processing of business data and cross-functional integration. Thus, ERP systems provide an enticing solution to managers who have struggles with incompatible information systems and inconsistent operations policies. However, successful implementation of ERP systems requires active participation from senior-level managers from various functional areas so as to delineate its impact on the business level as well as functional level strategies.

In this paper, we have endeavored to provide operations managers a brief overview of ERP systems and highlight its implications for operations function. Specifically, the objective of this paper is to give a broad based overview of enterprise resource planning systems. Using SAP R/3 as an example system, we discuss how an ERP system can assist in enhancing strengthening business strategy and making consistent operations decisions: process design, production planning and scheduling, inventory management, quality management, human resource management.

Keywords: Enterprise resource planning; Business strategy; Operations management

"Elizabeth Benson, purchasing manager for Tristen, Inc., hung up the phone and turned quickly to her desktop computer. She had just received word of a fire in a manufacturing plant belonging to a key vendor… Both Benson and the vendor knew that if the situation were not dealt with quickly both Tristen and its auto manufacturing customer's assembly lines would soon shut down for lack of parts…

Benson's first move was to generate an on-line report of resin inventory across all warehouses. This allowed her assess where shortages were most likely to occur. Next she assessed the manufacturing forecast for the next several days to analyze where product would be needed and when. Using this information Benson generated materials movement requests to reallocate the resin across the organization. She also transmitted purchase order revisions to the vendor in order to reroute incoming resin shipments to appropriate locations.

No matter how good a job Tristen did in reallocating its own inventory, the battle would still be lost if the company's other vendors ran out and were unable to supply Tristen with needed sub-components. By running a 'where-used' report across the Bills-of-materials for all the sub-components in the item database, Benson was able to generate a list of vendors that needed notification of the impending shortage. Checking again with the production plan Benson forecast each affected vendor's resin needs so that appropriate supplies could be sent.

Still facing a shortage, Benson's final step was to search the item database for alternative materials that could be

* Corresponding author. Tel.: +1 502 852 4783; fax: +1 502 852 4875.
E-mail address: mahesh.gupta@louisville.edu (M. Gupta).

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used. Checking these alternatives against a list of approved vendors yielded several supply combinations. A quick cost rollup calculations allowed for vendor selection and the generation of purchase orders for immediate Electronic Data Interchange (EDI) transmission to the new sources. Three hours after she had begun Benson rested. In that short time she had managed to avert a disastrous plant shutdown, both for Tristen and its customers. Savings potentially ran into the millions of dollars…"

Escalle and Cotteleer (1999)

1. Introduction

Due to dynamism in the current borderless world market, companies are confronting new markets as well as new competition. Decision-making processes are requiring different time horizons and geographical dispersions. Consequently, decisions require quick changes regarding product developments, material flows, production planning, and scheduling. It is necessary for companies to evolve ways to keep operational efficiency at its peak, i.e. in terms of high levels of flexibility, dependability and quality. Consequently, matrix or decentralized organizational structure that crosses functional areas and encompasses a multitude of business processes is being adopted by many organizations. Compared to function-oriented hierarchical organizations where information transfer is inflexible and slow-a decentralized process oriented structure is where information flow is highly flexible, fast and disjointed (Keller, 1999).

Historically, companies had maintained different information systems for different business functions such as accounting, production, marketing, purchasing, etc. These legacy systems had their own methods and systems of collecting and storing information based upon their needs. Although these systems enabled managers to improve decision making within a specific functional area, these systems lacked functional integration and made communication and cooperation among business functions exceedingly difficult. Consequently, a company as a whole is loosing its competitive edges because it is not able to realize its full potential.

In 1990s, companies implemented variants of ERP systems with a central/common database and standardized software to replace stand-alone legacy systems and to create necessary interface among functional areas. Conceptually speaking, ERP systems enable all functional areas 'talk' directly to each other and the data availability to all in real-time to prevent non-optimal decision making (Jacobs and Whybark, 2000). An important characteristic of ERP systems is the ability to implement it in modules. A company does not have to perform a full-scale implementation rather selective modules (where a module usually represents a functional area of an organization) can be implemented based on the needs of a particular company (Gupta, 2000). Some of the most important reasons companies implementing ERP systems cite are to improve the level of systems integration, and to standardize as well as improve processes.

The belief that ERP implementation leads inevitably and automatically to improved operations has become something of a universal paradigm in the corporate world. With the projected growth of the ERP market at 66.7 billion dollars by 2003 from 16.7 billion dollars in 1998, most Fortune 500 companies have already adopted ERP systems and many midsize companies are planning ERP implementations. Clearly, ERP systems have significant implications for all functional areas of a company. From an operations manager's perspective, if implemented successfully and fully comprehended by managers, such systems can go a long way to help operations managers in decision-making process. As seen in the Intoduction, Escalle and Cotteleer (1999) provided a hypothetical but excellent example of the capabilities of a successfully implemented ERP system to demonstrate its usefulness to operations managers.

The purpose of this paper is to demonstrate how ERP systems can be used as an enabling technology or tool to improve operations performance, i.e. to enable operations managers in their decision making process. More specifically, this paper provides an overview of enterprise resource planning systems, i.e. what it is and what its strategic relevance is, and demonstrates how it assists operations manager in developing consistent business/operations strategies and in making consistent set of decisions, such as product/process design, quality management and control, production planning and scheduling, and inventory management.

The rest of the paper is organized as follows. In the rest of this section, we discuss the evolution of ERP systems to show that operations planning and inventory management were at the root of its inception and briefly discuss main characteristics of various commercially available ERP systems. In Section 2, we suggest that ERP system as an enabling information technology should support company's business strategy and thereby, strategies of the functional areas in a consistent manner. In this section, we use a specific ERP system, i.e. SAP/R3 as an example to highlight how various modules can enhance operations decision-making process. In the third section, we discuss an example of how ERP system modules can be implemented to make operations decisions in an integrated manner and provide some insights on the selection of a specific ERP system. Finally, we conclude our paper with some discussion on the future of ERP systems by citing its role in integrating companies across the supply chain.

1.1. ERP Evolution

The foundation for ERP started with the concept of inventory control in the 1960s. Based on traditional

inventory control concepts such as reorder point system, customized software packages were designed to suit the requirements of manufacturing companies. In the 1970s the focus shifted to the famous material requirement planning (MRP) systems to plan and control manufacturing. These systems played an important role in translating the master production schedule built for the end items into time phased net requirements for the sub-assemblies, components, raw materials planning, and procurement. The system launches orders to control work-in-processes and raw material inventories through proper timing of order placement (Schoreder, 2003; Shankarnarayanan et al., 2000). Next, closed loop MRP system evolved by combining the output of MRP and routing information to determine the capacity required. This served as control loop to make sure that the MRP plans generated are realistic/valid by the capacity available. In the 1980s MRP systems further evolved into manufacturing resource planning (MRP-II) systems which began with aggregate planning and demand management, and ends with a comprehensive schedule which includes components to be manufactured in-house as well as those to be procured from outside. Thus, MRP-II essentially was an extension of MRP to the shop floor and distribution management.

Similarly, information systems were being developed and implemented in other functional areas, each with its own database and data architecture to enable managers to focus on its role and to improve decision making within a specific functional area-marketing, finance, and human resource. Although such functional information systems matured in terms of functionalities over the years of testing, modification, and maintenance, these systems had also caused problems such as data redundancy, information inconsistency and/or inaccuracy, and high system maintenance costs. In late 70s and early 80s, the need for enterprise wide integrated systems intensified as global competition became inevitable, product innovation became important factors to retain customer, and quicker production/distribution became norms (Kalakota and Robinson, 2000). The introduction of systems thinking based management philosophies such as total quality management and just-in-time systems necessitated the management of relationships among functional areas and cross organizational processes.

Consequently, from a business enterprise perspective other functional areas were added and attempts to integrate all departments and functions across a company were made to transform MRP II system into a single computer system. In mid-1990s, the Gartner Group coined the term ‘enterprise resource planning (ERP)’ to refer to the next generation systems which differ from the earlier ones in the areas of relational database management, graphical user interface, fourth generation languages, client-server architecture and open system capabilities (Dahlen and Elfsson, 1999; Keller, 1999; Koch et al., 1999). ERP systems played central role in enabling organizations to reorient their departmental functions into enterprise business processes (customer management, supplier management, product management, etc.).

In the 2000s ERP systems are evolving into Extended ERP systems to exploit technological advances in the areas of Internet and electronic commerce, and thereby requiring companies to consider changing their business processes yet again. This time the focus is on making an organization’s extended networks of suppliers and distributors more effective by improving the quality of communication and interaction between enterprises.

Thus, Enterprise Resource Planning system is a new breed of Information Technology (IT) solutions that promise to effectively integrate islands of information and structure systems to reflect best practices ensuring total transparency and real-time information sharing across the intra-organizational processes (e.g. major functional areas) as well as inter-organizational processes (e.g. suppliers and customers).

1.2. ERP vendors/choices

Fortune Magazine (1998) states that the ERP software, a $10 billion market, is ‘the best stuff that Bill Gates doesn’t own.’ In 1996, SAP earned revenues of $2.4 billion, Oracle earned $1.2 billion, PeopleSoft’s revenues were $450 million and Baan earned $416 million. The top four ERP products have a 60–70% feature overlap, which makes it difficult to accurately differentiate between the systems.

SAP dominates the ERP software market. SAP R/3 has a function set and data dictionary that is approximately five times larger than Baan IV, which is the number four player in the market. SAP sales are more than its three closest competitors combined. SAP spent more on R&D in 1996 as a percentage of sales than any of its competitors. The amount spent was $382 million, which is three times more development dollars spent than its nearest competitor and is almost equal to Baan’s total sales.

Oracle is the number one manufacturer of database software. They are the number two software manufacturer in the world behind Microsoft. Oracle focuses on areas other than the ERP market. Their ERP product earns less than one-quarter of the company’s total revenue. For SAP, PeopleSoft, and Baan, Oracle is a competitor and a partner. They can provide an organization with the sole source for the database and applications layers of their IT infrastructure. Oracle applications are a broad and complete product (Stein, 1998; Cusack, 1997).

PeopleSoft is the number three vendor in the ERP market. They differentiate themselves by facilitating an incremental approach to technology acquisition and deployment for their customers. A middle market solution offered by PeopleSoft through direct sales channels has been a huge hit with their customers. SAP and Oracle, on the other hand, rely on reseller channels and consulting partners.

Baan is best known in the aerospace, automotive, defense, and electronics industries for their ERP software.

Baan competes with larger ERP vendors by focusing on customizability. Baan provides a tool called Orgware that uses customized business processes to automatically configure its enterprise software to a customer's unique way of doing business. It is predicted by analysts that Orgware could cut implementation times by up to 50%. The success of Orgware is due to Baan separating business processes from the software product. SAP and other vendors are working on extracting business processes from their software to make the systems more flexible.

From a company's perspective, several choices are available when choosing the best system. For example, it can decide (i) to have one vendor for all ERP modules, (ii) to combine existing legacy programs and new ERP modules, or (iii) to create a system based on the vendors' specialized strengths. For instance, PeopleSoft is known for its human resource applications and SAP for its manufacturing applications.

2. ERP systems and a company's business strategy

The strategic impact of ERP systems varies among industries, companies and, over time, within an individual company. Throughout the ERP system selection and implementation process, a strategic business perspective emphasizing cooperative and cross-functional approach should be clearly communicated across functional areas by the top management of the company (Laughlin, 1999).

ERP systems or certain modules of such systems may be more significant to some business units and/or some functional areas within a business unit than others. The importance of IT in an individual company can be considered by looking at two aspects (O'Leary, 2000), the dependence and the degree of dependence on the existing system, and the strategic importance of the IT development initiatives for the company. Thus, companies can be divided into four categories according to whether the strategic impact of these two aspects is high or low. The company's core competencies direct the decision to make/own versus buying an information technology solution pertaining to a functional area or the whole enterprise. In house development of ERP solutions may be ideal from the point of best fit, but it has to be kept in mind that individual companies may not be able to develop them quickly. Companies where IT is in the support role should consider customizable predefined solutions rather than make/own philosophy.

ERP system needs to have the flexibility to provide Information Technology (IT) solutions irrespective of the line of business and the strategy the organization uses to compete in the market. Further more, ERP system needs to support the strategy of each of the functional areas based on the business strategy and it needs to be sensitive to both external (customers, competition) and internal (management, workforce) environments. For example, ERP System offered by SAP uses the latest advances in information technology and provides a solution to meet the unique needs of each industry. The system is designed to fit any industry and has predefined solutions that are based on the best industry practices (the customers also have the option to customize the solution to their requirements). Managers can use SAP solution maps and the business framework to develop and customize their own individual solution maps, which can be used as a plan to integrate best of breed industry solutions into their existing IT environment. Further, SAP provides flexible interfaces to interact with other vendor software and also provide regular updates to the software based on best industry practices (SAP, 1998).

Thus, SAP addresses specific strategic needs through the process of design/classifications based on customer order, i.e. make-to-order production and repetitive manufacturing (Keller, 1999). One or more of these process flow strategies can be associated with an organization based on its business strategy. SAP's emphasis on the process oriented structure requires a company to define the operation function as to how things are done, what should be done, who should do something and what information is needed for doing it. Defining and modeling every small part of the business helps SAP dissolve any discontinuities in the business process chains. SAP uses the event controlled process chain modeling to describe the business process flows, when and where information needs to be read and which functional area is responsible for performing a specific task/process and how this is going to be achieved (Keller, 1999).

Following Porter's framework, there are two types of business strategy—Imitation and Innovation. Under the first strategy, the low cost producer type companies usually enter a mature market, with a standardized product/service and exit late and under the second strategy, the innovator type companies produce a multitude of products and compete based on distinctive, highly customized or quality products. In the current market, there is a sharp focus on the customer that has intensified competition and forced many companies to be differentiators rather than imitators to retain the market edge. This means that operations planning and control must be extremely flexible and ready to deliver a quality product. Irrespective of the business strategy an organization may adopt ERP system to integrate all the business processes to help increase productivity (Anonymous, 1998; Martin, 1998).

2.1. ERP system and product innovators/differentiators

Companies using a make-to-order process design strategy are product innovators or differentiators; they require a high degree of flexibility in their operations. The production environment is usually a job shop, and operations needs to be highly responsive to changing requirements and short production runs. Companies with this strategy produce specialized products with a wide array of product variants. Based on customer demand

and forecasts prior to production. Production in this environment is based on work orders (Schroeder, 2003).

SAP's solution for a product differentiation strategy begins with sales and operations planning. Wholesale orders, customer orders and long term forecasts, determined by demand management tasks are combined into a master schedule. The master schedule is used along with MRP to produce a set of planned orders for procurement and production. Job shops are set up to produce the specific orders that are grouped by the master schedule for a specific period of time. Grouping similar orders reduces setup time and helps operations maintain flexibility to produce different orders (Curran et al., 1998).

In general, top management can customize and modify ERP implementation to incorporate non-standard and company specific processes where the derived competitive advantage and differentiation aspects are clearly demonstrated. This implementation strategy may or may not be cost effective and may pose additional challenges, e.g. maintaining adequate skills and documentation and/or encouraging ERP vendors to incorporate modifications in the future upgrades.

2.2. ERP systems for repetitive manufacturing

Repetitive manufacturing refers to the manufacturing of standardized products. Companies using a repetitive manufacturing process design strategy are usually high volume producers that emphasize low cost through superior process design. This process design is similar to the make-to-stock process design strategy. Organizations, that primarily produce standardized products, have very little or no input/influence on product selection. Factors that influence new product selection are still based on market potential, economic feasibility and operations compatibility, but are primarily driven by technological feasibility. Product development, prototype construction, testing and final product design is driven by the organization decision. In other words, the customer is unaware of the products or product variants being produced (Schroeder, 2003).

ERP solutions for companies with a mass production strategy should support the operations mission (*low cost production*), distinctive competence (*superior process design*), objectives (*efficiency, deliverability, quality, and flexibility*) and policies (*how operational objectives will be achieved*). The SAP's solution for this breed of companies starts with sales and operations planning. Long-term sales forecast is critical for a mass production strategy. SAP achieves this by the demand management process where wholesale orders, retail orders, and customer orders are combined into a master schedule. The costing for the products is based on manufacturing costs plus the cost based on the bill of material and routings. To achieve a high level of efficiency—costing, quotations, inquiry, availability check, and delivery date determination needs to be complete before the order processing is completed (Keller, 1999). The SAP's solution is to fix as many numbers of variables that go into a mass product manufacturing. Master schedule is used as input for procurement of materials and workforce management for the period of production. The process flow sequences and the time duration of production for each step in operations is predetermined and the operations personnel need to be able to understand the requirements and adhere to it. The predetermined process sequence and time duration specified to complete a job, forces superior process design and effective personnel management. Further, SAP makes sure that material is available at the production lines at each of the resources at the right time (Jacobs and Whybark, 2000; Keller, 1999).

SAP begins with the identification of a customer objective or targeted goal for an implementation. The implementation may be the result of a new technology choice, reengineering the business, organizational restructuring, improving operations, or vertical integration. Definition of the objective allows SAP to identify the relevant process areas in which the business wants to gain greater value. SAP offers the following business process areas under which customer requirements can be related—enterprise planning, product development and marketing, asset management, organization and personnel, procurement logistics, production logistics, revenue and cost controlling, and external accounting (Curran et al., 1998; Keller, 1999).

Compaq Computers has a make-to-order process design strategy. The company needs superior process design that is tightly coupled with sales and procurement. In Compaq's case the objective of an SAP implementation would be to increase the total net value added chain (Porter) by tightly integrating and improving sales and distribution, and procurement and production logistics. SAP uses the event-controlled process chains (process flow method) for linking and establishing relationships between the identified process (functional) areas. Using a process flow method helps quantify and analyze the micro-level process design decisions that affect decisions in other parts of operations, including scheduling decisions, inventory levels, job descriptions, and quality control methodologies. Initially, all of SAP's predefined process elements of the identified areas are included in the solution. As the customer requirements are understood by individual area specialists, a process analysis is performed and unnecessary elements are eliminated. In addition, interfaces to other systems are defined at this point.

3. ERP systems for operations decision making

Operations management (OM) is concerned with decision making for the operations function. Over the past couple of decades, manufacturing operations have become complex, automated, and geographically dispersed. The decision-making process involves different time horizons,

and different geographical dispersions require quick changes regarding materials flow, logistics, and production schedules (Palaniswamy and Frank, 2000). Schroeder (2003) describes a framework that categorizes and defines major OM decision areas: process, capacity, inventory, quality, and work force management. In SAP, these operational decisions fall into the following areas—enterprise planning, product development and marketing, production logistics, and procurement logistics, quality systems and human resource management (Curran, 1998; Keller, 1999; Jacobs and Whybark, 2000; Ptak and Schragenheim, 2000).

SAP's answer to operations management lies in the production logistics suite that is based on the industry standard MRPII (manufacturing requirements planning). SAP, with its predefined solutions, is able to provide quick deliverability by shortening planning cycles, providing up-to-date information, and increasing productivity of work processes. All processes/services can be geared to specific requirements, taking into account different production methods from make-to-order to mass production. Each suite of the application is geared to improve the value chain areas of the organization, thereby ensuring coordinated interaction between business processes across functional boundaries. SAP is able to create a master schedule due to its integration of sales forecasts, customer orders (sales and distribution), production using MRP, and procurement using materials management module. Further, Total Quality Management (TQM) is promoted using the quality management module.

3.1. Enterprise planning

Enterprise Planning is divided into two areas, *strategic* enterprise planning and *operational* enterprise planning. Operational enterprise planning is synonymous with the term aggregate planning that is used frequently in production/operations management. Operational planning is carried out annually and is concerned with matching supply and demand. The starting point for the operations manager is usually the sales forecast that determines which product has to be produced in the planning time frame. The planned sales quantities are passed on to the production-planning department in production logistics. However, the decisions made in production planning are dependent on financial planning and human resource management.

3.2. Product development and customer relationship management

Product development consists of the planning of a new product based on market pull, technology push or inter-functional development (Schroeder, 2003). SAP's solution for new product design incorporates all phases of new product design from specification of market or consumer requirements, product development phase, and release/transfer to production. SAP's integration of the functional areas forces production processes to be in synch with the new product development. This prevents the manufacture of a product that is unfeasible or prohibitively expensive to produce and fail to reach the final product stage.

In today's highly competitive markets, products come and products go very fast. A company's most important real asset is a loyal customer base. Truly speaking, it is the only asset that appreciates over time while a typical asset (e.g. building a plant) starts depreciating the day it starts operating. To retain customers, the companies must have a strong focus on measuring and managing its relationships with individual customers. ERP systems can play an important role in creating and maintaining a customer-focused culture by empowering employees to manage successful interactions with the customers by providing accurate information on a timely basis.

3.3. Production logistics

Production logistics involve planning, execution and performance control of the work orders. Production planning starts with type, quantity and deadlines of the products to be produced and determined. SAP allows all processes to be geared to specific requirements taking into account both make-to-order and make-to-stock process strategies.

In general, ERP systems allow data to be shared and processed interchangeably, increasing their usefulness in 'what if' simulation and production planning. ERP systems allow the feasible production plans to be made and thereby, minimize use of too much unexpected overtime, etc. Adjustments to production schedules are relatively easy to make. ERP systems' planning and control functions allow operations managers to implement a combination of systems due to inter-mingle the best practices of these operating systems. For example, a company might standard ERP modules to make decisions in other non-operating functional divisions, Just-in-time (JIT) system to minimize inventories both within the company and with its supply chain members, and Theory of Constraints (TOC) for managing bottlenecks and producing optimal schedules.

3.4. Procurement logistics

Procurement logistics also known as materials management in R/3 terminology allows for flow of material through effectively through different departments and procurement of raw material and components from the suppliers. This process area of SAP R/3 has a wide range of integrated functions that help optimize material flow through functional areas as inventory management, purchasing, and warehouse operations.

In general terms, the key question is 'how are ERP systems employed to effectively manage inventory?'

Basically, the companies must make two basic inventory management decisions: first is *how to track the inventory* (i.e. to have information on how much is on hand, where it is located, how much will be used and by when), and second is *how much and when to order* (i.e. which of the conventional inventory control models, e.g. economic order quantity, economic run size, quantity discount models or their variations will be implemented by ERP system). It is important to realize that an ERP system is a technology and not a model in itself. It is not there to take over management decision but to inform and complement the management's decisions on inventory management. Thus, what it does is to enable operations managers to adopt more effectively the inventory models best suited for their business environment. The ERP system can be set up to align itself to the current or chosen inventory management model (Gunasekaran, 2002).

The procurement function starts once a requisition is received. The purchasing manager is to source out the most suitable supplier, negotiate with the suppliers, purchase the raw material and do all the administrative paper work. Generally, the requisition comes with a label 'at once' and leaves no time to do value analysis, negotiations, working with engineering on standardization, working with vendors on annual contract, etc. Thus, it is very challenging, if not impossible, to manually perform this function effectively. ERP systems provide the ability to generate automatic purchase order (PO) by allowing the purchasing manager ability to (a) enter a valid quote from a vendor to the purchasing database, (b) identify the vendor as the preferred vendor on the part master record, and (c) set the automatic purchase order code on the part master record to yes. When the purchasing manager approves a requisition, ERP system can automatically create a PO for the preferred vendor, price the PO by matching the order quantity discounts on the vendor quote, and/or specify purchasing defaults, e.g. shipping instructions, payment terms, etc. Additionally, ERP systems can eliminate the clerical costs associated with mailing PO by electronically transmitting PO in standard electronic Data Interchange (EDI) format and thereby, can result in fast and accurate order process.

3.5. Quality management

Quality management is performed using an enterprise wide quality system in SAP R/3. Although ERP systems are not a substitute for a quality management system, it does have a number of features than can help companies solve their quality problems by assessing quality of purchased parts, routing receipts of raw materials for inspection, tracing the origin and use of defective material, material shortage and invalid production schedules. The costs of poor quality show up in rework, scrap, inspection costs, warranty costs, and more importantly unsatisfied/lost customer orders.

For example, ERP systems can provide an inspection code to allow quality control engineers to indicate whether a part, on its arrival, requires incoming inspection or not. The systems can also specify the test types to be performed and test equipment to be used. More over, the information is maintained on-line and regularly updated. The ERP system uses data collected over a period of time to calculate vendor quality performance ratings and to see if there are any trends. Ideally, the incoming inspection should ensure good quality of parts and raw materials. In reality, the problems are detected during the production process or the final inspection. ERP systems are quite capable of providing an incoming inspection audit trail and thereby, answer a myriad of questions, e.g. were the parts inspected? "Who inspected them using which test equipment?" "What were the results?" Thus, the corrective actions can be taken to purge the bad raw material and recall defective products that might have been shipped to customers.

3.6. Organization and human resource management

Also known as personnel management, it allows for long-term management of personnel, payroll, training and career development. Integration of this process area with production planning and financial accounting allows effective resource management in an enterprise. SAP R/3 system allows the company to define its organizational structure, which can then be used as a basis for planning, personnel costs and management. The ability to integrate archived data into other areas-such as benefits administration, financial and cost accounting allows for better planning and management across functional areas. Workforce management in SAP R/3 begins with creation of a job description that defines the scope of responsibility. Job definition allows the workforce to have the authority consistent with the responsibility assigned to them. SAP R/3 deals well with scenarios like creation/alteration of a company's organization structure or a new job/position. The former event is handled by creation of a new job description and the latter is handled by review of current employees to fill the open job/position. Once a job/position is filled the corresponding payroll information is entered that immediately affects the personnel costing. Personnel management continues with training and overhead management. These business scenarios allow a company to provide training based on the current and future requirements of the company.

4. ERP—example implementation and guidelines

Top management of the company must ask questions whether the system's technical imperatives coincide or conflict with the company's business imperatives, and what is the impact of ERP implementation on company's business strategy and functional strategies (Davenport, 1998; Laughlin, 1999). The operating assumptions of

the ERP system being implemented should be support the company's operating policies.

For example, SAP R/3 provides operations with a consistent decision making ability that supports the chosen business strategy. To better understand the integration and decision making process in SAP, let us consider implementing SAP for a company with make-to-order process strategy or the differentiation product strategy. In real life, DELL, a computer manufacturer, and Hillerich and Bradsby, a specialized baseball bat manufacturer, fit this profile.

4.1. Example of an implementation

SAP uses the sales and distribution module to provide and predict long-term sales forecasts. SAP recognizes different types of customer orders and uses sales information for long-term forecasting and marketing. Sales logistics modules are integrated with production logistics modules via the demand management functions, which determine quantities and dates for finished products and important assemblies. This integration allows production planning to be streamlined with customer demand. Production personnel can immediately see the requirements and plan production processes accordingly. Customer orders and long term production plans (aggregate planning) are used to perform resource requirements planning to check if needed resources are available and if production is feasible. Long-term production plans are translated into a master production schedule (MPS) based on demand management. Capacity checking and leveling occurs throughout all stages of planning (Keller, 1999).

Irrespective of the type of aggregate planning strategy (chase, level or a combination), rough-cut capacity is balanced against the master production schedule. The master production schedule is used for developing a detailed material requirement plan, which is compliant with the industry standard and internationally recognized planning concept MRPII. Capacity requirements planning concepts are incorporated to perform scheduling and dispatching individual orders and shop floor control reporting.

Materials requirement planning is expressed as a set of planned orders for purchased material, material transferred from another plant and manufactured items. Materials required for manufacturing are obtained by passing the requirements to procurement and stock transfer processes. Integration of production logistics and procurement logistics ensures availability of required material on the production floor at the right time. Procurement processes translate the input from MRP into requisitions and requisitions are further managed by supply management or electronic data interface (EDI) with the suppliers. SAP recognizes that high quality products and services are no longer differentiators but givens, because most businesses now design their operations and processes to ensure high quality. Prior to ERP systems, many companies enforced quality by adding specific quality constraints to traditional production logistics (Anonymous, 1998).

In SAP, as soon as the product flows out of production it is recorded as 'goods receipt'. SAP associates this good receipt transaction into an enterprise wide quality system. Each product output can be associated with predefined quality criteria that includes information about type of quality sampling (acceptance or process control), control limits, sequence of operations, measurements that need to be taken and recorded, and what criteria should be used to accept or reject material. SAP uses this information to create a QM order, which is used to control the inspection process and record results. This process takes periodic samples, and as long as the sample measurements fall with in the control limits, production is continued. When the sample falls outside the predefined quality criteria the process issues notifications and generates follow-up activities. If the product needs to be rejected the cost associated with this production is recorded in the QM order and serves as an input to costing process (Keller, 1999). SAP, by enabling an enterprise wide quality system, helps setup an environment that continuously improves a stable process. Further, the quality criteria can be re-evaluated and adjusted to get the desired quality as needed.

When production or maintenance requests an item from the inventory, the system processes the order automatically, and updates the inventory records. The SAP R/3 system monitors the inventory and compares it with the demand. The system automatically orders items from vendors, and puts them in inventory. This is a good example of how the system makes decisions, which used to be made by employers. SAP R/3 is designed so that all materials—standard stock, consignment stock, and consumable material—can be managed consistently (Jacobs and Whybark, 2000). By managing the consignment stock it becomes easier for the company to put the inventory decisions on the vendor (Hoffman, 1997). The vendor owns the consignment stock until it is used or sold by the company. This kind of vendor/customer transaction is becoming very common in the grocery industry. In this case the vendors are responsible for their shelf space and the amount of inventory they decide to keep.

Workforce Management is usually a key factor in successfully managing the operations function. Effective management of workforce determines the quality, flexibility, delivery and cost of operations. Today's challenge for most companies is recruiting employees and managing their organizational growth over time. SAP R/3 allows the company to define its organizational structure, a system that can then be used as a basis for planning, personnel costs and management.

4.2. Guidelines for implementation

Most Fortune 500 companies have already adopted ERP systems and many midsize companies (less than 1000 employees) are planning ERP implementations. Many organizations have successfully adopted ERP systems, yet many more organizations spent fortunes only to find that business performance has not improved to the satisfactory levels within the expected time frame (Robinson and Wilson, 2001; Slater, 1998a,b). In general, ERP system offers the potential of big benefits. It is the quality of the systems that makes benefits possible. In many cases, ERP will enable a company to operate more efficiently than it did before, but in other cases, the system's assumptions will run counter to the company's best interest. Each company that is considering ERP must question whether the system's technical imperatives coincide or conflict with the company's business imperatives.

Although various commercial ERP systems (discussed in Section 5) are available, a company should select a system by carefully weighing various factors, e.g. support, functionality, user interface, flexibility, reliability, and integration. The ERP system usually contains many modular applications, e.g. sales and distribution, financial investments, production planning, material management, human resource management. Depending upon organizational size (e.g. small to large firms), structure (e.g. centralized to decentralized), and complexity (e.g. low to high variety of products), the company should decide whether to implement these modular applications as an entire suite of applications or in a phased manner (O'Leary, 2000).

Davenport (1998) shed light on the issue of ERP implementation issues and its effect on company strategy. He gave an example of an industrial product manufacturer that had built its strategy around its ability to provide extraordinary customer service in filling orders for spare parts. Because it is able to deliver parts to customers 25% faster than its competitors-often by circumventing formal processes and systems, it has gained a large and loyal clientele, who are happy to pay a premium price for its products. If, after implementation of the ERP, the company has to change to a less flexible process for order filling, its core source of advantage may be at risk. The company may integrate its data and improve its processes only to lose its competitive edge and its customers. On the contrary, Compaq Computers is an excellent example company that carefully thought out its plan to implement an ERP system to support its business strategy. Compaq decided to shift from a build-to-stock to a build-to-order business strategy. Consequently, the management realized that a crucial advantage to gain would be the superior capabilities for forecasting and order management processes. The company decided to develop proprietary application modules in computer language used by the ERP vendor to be sure that they are included in ERP system. It cost considerable more money but it was justified as a strategic necessity.

5. Conclusions

In today's knowledge economy, information technology is a driving force in organizational change. ERP systems along with other technological advances such as E-commerce are playing a major role in assisting a company's strategic plan. The global competition, along with shorter product lifecycles, ever-increasing market niches, and the pressure to react quickly to the changing external business environment has forced companies to make decisions in an integrated manner.

One of the greatest benefits of ERP system such as SAP R/3 is the integration of processes, data and organizational elements, i.e. it unites all of a company's major business processes (from order processing to product distribution) within a single family of software modules. This tight integration makes simultaneously satisfying operational, financial, and managerial principles possible. ERP systems have potential to make a company stronger and successful but it also has the potentials to kill a company. Thus, in order to obtain benefits and avoid serious difficulties, companies need to solve the ERP implementation problems. In this paper, we have provided a broad overview of ERP system and then, focused primarily on its implications for operations function. However, this work should be extended to delineate its implications for other *internal supply chain members* (i.e. functional areas) as well as external supply chain members (Tam et al., 2002).

As shown in the paper, ERP systems have been used to improve internal operations and efficiencies. Today's dynamic business environment requires companies to internally monitor and make decisions in response to changes in the marketplace. To effectively compete in the international business world, companies must position themselves to quickly access both internal and external market information and make prudent business decisions. For example, Coca-Cola has extended its ERP system to its bottlers and has further plans to extend its system not only backward to suppliers but forward to major customers such as McDonalds and Wal-Mart. With this forward extension, Coca-Cola and its partners will be able to gather data from its customers on various trends in the industry, e.g. changes in tastes and preferences, sales data for improved forecasting and inventory management and to better serve their customers (Oliver, 1999).

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Mahesh Gupta is a professor in the Department of Management, University of Louisville. He obtained his MCom from the University of Jammu, India, MSc from the University of Manitoba, Canada, and PhD from the University of Louisville, USA. Dr Gupta has published in numerous journals including International Journal of Operations and Production Management, International Journal of Production Research, European Journal of Operational Research, and Production and Inventory Management Journal. Dr Gupta is a member of DSI and POMS.

Amarpreet Singh Kohli is currently pursuing a PhD in the Department of Industrial Engineering at University of Louisville. His PhD thesis focuses on collaborative planning forecasting and replenishment (CPFR) using system dynamics approach. His research interests are in the areas of Enterprise Resource Planning and Supply Chain Management systems. Presently, he is involved in a practicum training project with a supply chain consultancy firm that is applying Lean principles across various industries. He has also worked as a Graduate research Assistant at Logistics and Distribution Institute (LODI) and School of Business at the University of Louisville.