Journal of International Information Management

Volume 11 | Issue 2 Article 6

2002

# Implementing Enterprise Resource Planning Systems: A Study of Benefits and Concerns

Y Helio Yang
*San Diego State University*

Nikhil Varaiya
*San Diego State University*

Sherry A. Irwin
*San Diego State University*

# Implementing Enterprise Resource Planning Systems: A Study of Benefits and Concerns

**Y Helio Yang**
**Nikhil Varaiya**
**Sherry A. Irwin**
**San Diego State University**

## ABSTRACT

*In the 1990's information technology and business process re-engineering have combined to provide organizations a competitive advantage. Enterprise Resource Planning (ERP) systems were particularly considered examples representing such development. This paper reports the results of a survey on ERP implementation to explore its benefits and concerns. Our results show companies can expect more intrafirm benefits, such as reduced inventory, improved quality, and shortened cycle time, than interfirm benefits from current ERP technology. Existing ERP technology is not yet capable of handling the complexity of the whole supply chain. More supplier relationship management functionalities need to be integrated. Our results also suggest that so-called "best practices" of current ERP technology fit financial processes better than manufacturing and operational processes in today's business environment. Hence business process reengineering efforts are necessary but not sufficient to the success of an ERP system implementation.*

## INTRODUCTION

In today's competitive environment, organizations increasingly have to confront new markets, new competition and increasing customer expectations. In turn, this has created tremendous pressures on manufacturers to: (1) lower total costs throughout the supply chain, (2) shorten throughput times, (3) reduce inventory to a minimum, (4) enlarge product assortment, (5) improve product quality, (6) provide more reliable delivery dates and higher service to the customer, and (7) efficiently coordinate global demand, supply, and production. In addition, relentless competition means that organizations have to constantly re-engineer their business practices and procedures to be more and more responsive to market conditions. In the 1990's information technology and business process reengineering (BPR) have combined to help organizations attain a competitive advantage. Enterprise Resource Planning (ERP) systems were

particularly considered examples representing such development. According to AMR Research (1999), the ERP market is projected to grow to $66.6 billion in 2003 from $16.7 billion in 1998. Although there are discussions on pros and cons of ERP implementation at the firm level, little research provides overall assessments of its benefits and impacts. This paper conducted a survey to study ERP implementation and to investigate its contributions and concerns to an organization.

The paper is structured as follows. The next section provides the background on the evolution of ERP systems, followed by the research questions addressed in this paper. Then the research method and data analysis are discussed, followed by both general findings and specific results on the research questions, and further discussion of the implications of this study. The final section provides concluding remarks.

## ERP EVOLUTION

In the 1970's the focus of manufacturing systems was on Material Requirements Planning (MRP) systems, which translated the master schedule, built for the end items into time-phased requirements for the sub-assemblies, components and raw materials. Then the concept of Manufacturing Resource Planning (MRP II) evolved and extended to include purchasing, detailed shop floor control, distribution, and other resources of a manufacturing system. In the mid 1990's MRP II was further extended to cover areas like engineering, finance, and human resources. It ultimately covered the complete scope of activities within any business enterprise, not just in the manufacturing sector. Hence the term Enterprise Resource Planning (ERP) was coined. In addition to system requirements, ERP addresses technology aspects like client/server distributed architecture, relational database management systems, object oriented programming, graphical user interface, etc.

The root of ERP systems lies in their modules. Modules are the separate blocks designed to control specific business functions within the organization. Although ERP offerings range from custom and industry specific to mass off-shelf systems, most offer the following modules: Finance, Manufacturing, Customer Service, Logistics, and Human Resources.

Additional modules exist including Project Management, Product Data Management, Marketing and even custom modules for specific industries such as apparel and retail. In most ERP systems, not all the modules need to be implemented. In fact, many firms will opt to start with a few of the critical modules and then phase in the other modules. For example, most companies with more than $1 billion in revenue invested in financial applications in 1996 and 1997, and in 1998 they concentrated on automating distribution, engineering, manufacturing and divisional plants (AMR Research, 1999).

At least 500 software vendors worldwide provide enterprise resource planning packages. The top five vendors, SAP, Oracle, PeopleSoft, J.D. Edwards, and Baan accounted for 61% of the overall ERP sales in 1998. These vendors usually serve Fortune 500 companies and midsize companies with $250 million or more in annual sales. ERP vendors serving smaller size compa-

nies include QAD, Symix, Lawson, IFAS, Intentia, JBA, Glovia, Lilly, Made2Manage, and others.

Opinions about ERP implementation and perceived benefits vary substantially. According to a 1999 Cambridge Information Network study, 22% of CIOs do not expect to ever recoup their ERP cost, while 15% think that doing so will take more than 4 years. Major ERP vendors like Baan, PeopleSoft, and 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). Stein (1999) notes that many companies still are not sure whether they are getting a positive return on their ERP investment. Sweat (1999) notes that almost every Information Technology department has a story about enterprise projects spinning out of control, growing in scale, and consuming more cash, time and human capital than anyone had anticipated. In part, such results are due to ERP software developers using so-called "best practices in industry" to define business processes in building their software packages. Hence ERP implementation typically requires process reengineering at the same time. However, for some organizations, processes are a company's competitive advantage and reworking those practices to match software could significantly threaten business performance. For example, Dell chose to abandon its ERP implementation half way through for this reason (Bingi, et al., 1999).

On the other hand, Fichman and Moses (1999) reviewed the results of ERP implementation with a large office supply manufacturer and found improvements in almost every key operational metric. Aldred (1998) reported increased sales and capacity utilization in a tool manufacturer. CaseBook Water & Power Technologies, a $30 million manufacturer of water purification systems has seen improvements in materials management, project management, and employee productivity due to its ERP system (Wash, 2000). Connolly (1999) reported benefits from 23 companies that had implemented ERP. In addition to cost savings, and increased sales, order fulfillment, quality, companies were able to standardize business processes, build clean databases, and avoid costly Y2K updates. Some companies reported that ERP software gave them new capabilities to make real-time business decisions.

## RESEARCH QUESTIONS

Given the mixed results, but potentially high returns from ERP, it is important to objectively evaluate ERP implementations. Unfortunately consistent guidelines and measurements to determine ERP adoption and return on investment in an ERP system do not exist. Motwani, et al. (2002) conducted a case study of successful and unsuccessful ERP projects. However their constructs focused more on cultural factors and are limited to the two firms studied. Hence we conducted a survey to study the benefits resulted from these software installations and process changes, and the concerns during implementation. Furthermore we explore the following three research questions:

Based on an extensive review of extant writings on ERP, we identified 18 claimed ben-

efits to measure ERP implementation. These benefits can be classified into three categories: intrafirm, interfirm, and overall benefits. We examine and analyze the following question:

Is there a significant difference between intrafirm benefits and interfirm benefits from ERP implementation?

As noted earlier, ERP vendors can be segmented into large vs. small size segments. Since the coverage, complexity and functionality vary among these vendors, we examine and analyze the following question:

Is there a significant difference between different sized ERP software vendors in terms of benefits, concerns, composition of the team, number of modules implemented, and BPR levels?

ERP implementation typically requires reengineering to refit business processes into the best practices within an industry, as determined by the ERP vendors. For example, Baan's approach is to conduct a BPR concurrent with an ERP implementation and aim to shorten the total implementation time frame using its comprehensive scenario and compact scenario. The level of the reengineering effort varies among processes. Hence we examine and analyze the following question:

For various business processes, is there a significant difference among BPR levels in term of ERP benefits?

## RESEARCH METHOD

### *Survey Instrument*

To gain access to the experience of a broad set of companies, a survey was selected as the data collection method. Questions include type of ERP software and modules implemented, factors in selecting software vendors, budget and schedule of implementation, composition of implementation team, extent of eight business processes reengineered, benefits on eighteen measurements, and concerns during implementation. Since ERP implementation is likely to be a corporate decision, the unit of analysis is at the corporate level. To verify content validity, an ERP project manager at a local manufacturing firm provided feedback on the survey structure and general composition. This firm had just finished the first phase of an ERP implementation at the time the survey was designed.

### *Sample*

Surveys were mailed to 251 potential respondents in June 1999. The mailing list was compiled from: (a) many ERP vendors' client lists on their web site, (b) attendant lists from an ERP executive conference, (c) articles citing companies implementing ERP from sources such as Datamation, AMR Research, Information Weekly and CIO. A reminder letter was sent one month after the first mailing. In addition to the printed version, the survey was also posted on a web site at the same time. The survey web site was publicized at SAP and Oracle user groups, various bulletin boards, GeoCities, Planet IT, as well as at a major information technology convention.

Fifteen of the mailed surveys were returned as undeliverable. Out of the remaining 236

mailed surveys, 42 surveys were returned for a response rate of 18% for the mailed survey. An additional twenty-nine responses were received from the web site. Sixteen of the returned survey responses were discarded because their companies did not complete an ERP implementation. This resulted in a usable sample of sixty-three observations. Two-tailed t-tests are conducted on benefits, concerns, and software size and show no significant differences between respondents by mail and respondents by Internet at .10 level. A majority of the respondents were information system managers or ERP project managers and some are managers in finance or engineering departments. One third of the respondents are from the service sector including apparel, consulting, software, and restaurant industries. Two thirds of the respondents are from the manufacturing sector including electronics, automotive, furniture, and aerospace industries. However, two-tailed t-tests show no significant difference (p=.10) between manufacturing and service sectors in terms of concerns, benefits, software size, number of BPR processes and number of modules implemented.

## *Data Analysis*

The respondents were asked to rate the improvement and benefit level for eighteen measurements using a five-point Likert scale. These measurements are from three categories: intrafirm, interfirm, and overall. Intrafirm benefits denote the benefits achieved through coordinating and integrating business processes and information within the enterprise. There were nine measurements in this category. Interfirm benefits denote the benefits achieved through coordination and integration beyond the enterprise boundary to connect with external customers and suppliers. There were six measurements in this category. Overall benefits assess the impacts on competitive advantages. There were three measurements under this category.

Inspection of the correlation matrix for the nine intrafirm benefit measurements reveals that 34 of the 36 correlations (94%) are significant with 28 being significant at the .01 level and 6 at the .05 level. Inspection of the correlation matrix for the six interfirm benefit measurements reveals that 11 out of the 15 correlations (73.3%) are significant, with 8 being significant at the .01 level and 2 at the .05 level. Inspection of the correlation matrix for the three overall benefit measurements reveals that all three correlations (100%) are significant at the .01 level. Bartlett's test of the overall significance of the intrafirm, interfirm, and overall benefits correlation matrices were all significant at the .001 level. These correlation analyses provide an adequate basis for an empirical examination of R-type factor analysis for construct validity (Hair, et al., 1998). By grouping the measurements, we will be able to see a comprehensive picture in terms of understanding the contributions of ERP implementation.

Principal components analysis was used to explore the underlying structure of the questionnaire items for each benefit category. Table I shows the results of varimax rotated factor loadings of two-factor solutions for intrafirm and interfirm benefits and the one-factor solution for overall benefits. Factors were extracted with eigenvalues greater than 1.0. The factor loadings either exceeded or are close to the .6 level. Inter-item correlations were also used to check the scales for internal consistency. Cronbach's reliability coefficient alpha is calculated for each scale, as recommended by many researchers (Flynn, et at., 1990, Malhotra and Grove,

1998). Cronbach's alpha values for each scale ranged from .7691 to .8902. These values well exceed the .5 to .6 criterion generally considered adequate for exploratory work (Nunnally, 1978).

Analysis on the principal components identified two factors. Five items loaded significantly on the first factor. Three of the items dealt with the improvement of finished goods inventory, work-in-process inventory, and raw materials/components inventory. Two of the items dealt with quality improvement in defect rate and customer return rate. Hence the factor is labeled "quality&inventory". Four items loaded significantly on the second factor. The items include product design time, delivery time to the customers, response time to customer requests, and the development of a knowledge base to share information. Hence the factor is labeled "time".

Two factors are identified for the interfirm benefits. Three items loaded significantly on the first factor: the quality level of suppliers, delivery time from suppliers, and real time integration with suppliers' information systems. This factor is labeled "supplier". Three items that loaded on the second factor are real time integration with customers' information systems, management of global market, and e-commerce development. This factor is labeled "customer". The e-commerce definition at the time of the survey was mainly on business to customer (B2C) transactions over the Internet. The three items loaded on the factor labeled "overall" benefit include competitive advantage, market share, and the potential of new business development.

## RESULTS

Table II shows a detailed breakdown of software packages. For the choice of software, the majority of respondents use either Baan or SAP systems, with the two systems accounting for 51.7% of respondents (26.7% Baan and 25% SAP). The next two highest percentages were 10% for Oracle and 7.5% for both JD Edwards and Lawson Systems. Clearly, SAP and Baan have a dominant position within the respondent groups. Table III provides a breakdown of modules implemented by respondents. The most widely implemented module among respondents was the finance module (92.6% of respondents), followed closely by the manufacturing module (88.1%). This supports findings in the existing literature. A KPMG study on major motor carriers and third–party logistics providers also found that most of their respondents use primarily the accounting and general ledger functions of ERP software (Bradley and Thomas, 1999).

In selecting a software package, the important factors among respondents in rank order were flexibility, availability of support resources, availability of implementation resources, industry specialization, and cost. Nearly 70% of the respondents considered flexibility very important or most important while only 28% of them considered cost very important.

## Table 1. Factor Analysis Results

| Intrafirm | | | Interfirm | | |
|---|---|---|---|---|---|
| Items | Factor 1 Quality&Inv. | Factor 2 Time | Items | Factor 1 Supplier | Factor 2 Customer |
| Finished goods inventory | **.909** | .170 | Supplier defects | **.934** | .149 |
| Defect rates | **.820** | .255 | Integration with supplier | **.899** | .228 |
| WIP inventory | **.781** | .413 | Delivery time from suppliers | **.664** | .511 |
| Customer return | **.736** | .412 | e-commerce development | .035 | **.950** |
| Material inventory | **.589** | .553 | Integration with customer | .436 | **.772** |
| Design cycle time | .164 | **.872** | Management of global market | .460 | **.619** |
| Delivery time | .329 | **.868** | | 2.524 | 2.218 |
| Knowledge base | .310 | **.723** | | 42.07% | 79.04% |
| Response time | .373 | **.721** | | | |
| Eigenvalue | 3.367 | 3.298 | | .8320 | .7691 |
| Cumulative % of variance | 37.41% | 74.05% | | | |
| Cronbacch's alpha | .8751 | .8604 | | | |

## Table 2. ERP Software Packages Implmented

| ERP Software | Percent |
|---|---|
| Baan | 25.4 |
| SAP | 23.8 |
| ORACLE | 9.5 |
| JD Edwards | 6.3 |
| Lawson | 6.3 |
| QAD | 4.8 |
| PeopleSoft | 4.8 |
| Fourth Shift | 3.2 |
| Other | 16.0 |

## Table 3. Percentages of ERP Modules Implemented

| Module | Percent Implemented |
|---|---|
| Finance | 93% |
| Manufacturing | 88% |
| Product Data Management/Documentation Control | 84% |
| Transportation | 83% |
| Project Management | 67% |
| Customer Service | 65% |
| Human Resources | 56% |

Figure 1 shows the distribution of the total number of modules implemented. Since the presumed goal of ERP is to integrate enterprise-wide systems, companies can be expected to implement more than one module. On average respondents had implemented 3.97 modules, with 36.5% of them implementing 5 modules and 19% implementing 4 modules. Only 13% of the respondents had implemented 3 modules or less.

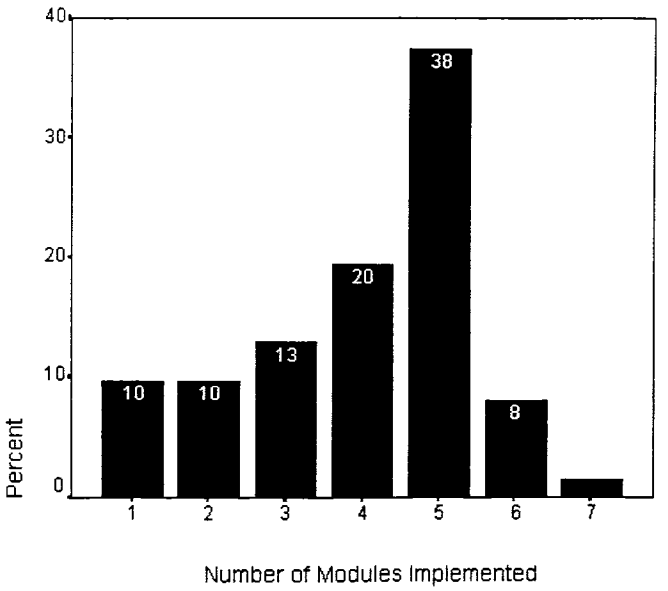


**Figure 1. Percentage of Modules Implemented**

In terms of composition of the ERP implementation team, an average team included 15% software vendor's employees, 30% consultants, and 55% company's own employees. Relating to payback, fifty-five percent of the respondents expected to get payback in less than 2 years. However, an important point to note is that the factors in the payback calculation are not all financial. They could come from operational efficiencies and effectiveness or informational data availability and quality. Despite horror stories in the literature of implementations running over schedule, 54.8% of respondents reported finishing their implementation on schedule. However attaining a scheduled implementation may be costly, as 61.5% of the implementations were over budget.

As for the concerns generally occurring during ERP implementation, the top three are: not enough user training, weak internal processes, and not enough qualified consultants. Ninety-four percent of the respondents had concerns on user training. This result was not surprising since only 27% of respondents included user training throughout the whole ERP implementation process and 58% trained users occasionally. Eighty-seven percent of them considered weak internal processes as the major concern. This reflects the need of conducting BPR at the time of implementing ERP. In addition, seventy-eight percent of them had concerns on finding qualified consultants.

For the ERP implementations that had run over schedule (n=28) or over budget (n=24), Table IV shows their Spearman's correlations (and one-tailed *p*-values) with various concerns, number of BPR processes, and ERP software size. Over-scheduled ERP projects are significantly and positively correlated with the number of reengineered business processes (p=.013), not enough budgets (p=.054), and not enough qualified consultants (p=.096). Limited software

technology is the only concern that significantly and positively correlated with over-budget ERP projects (p=.000).

**Table 4. Correlations of Over-Schedule or Over-Budget Implementations with Concerns Significant Correlations (alpha <10; one-tailed test) are in Bold**

| | Over-Schedule | Over-Budget |
|---|---|---|
| Large or small software | -.140 (p=.238) | -.036 (p=437) |
| Number of EPR processes | **.423 (p=.013)** | .135 (p=.265) |
| Limited software technology | .114 (p=.290) | **.728 (p=.000)** |
| Weak internal processes | .021 (p=.460) | -.058 (p=.406) |
| Poor project management | .251 (p=.108) | .257 (p=.144) |
| No schedule incentives | -.239 (p=.130 | .251 (p=.157) |
| Not enough budget | **.329 (p=.054)** | .265 (p=.144) |
| Weak executive support | .083 (p=.341) | .122 (p=.309) |
| Not enough user training | -.170 (p=.203 | -.032 (p=.446) |
| Not enouth qualified consultants | **.259 (p=.096)** | .229 (p=.159) |

***Comparisons On Intrafirm And Interfirm Benefits***

Table V shows paired t-test results comparing intrafirm and interfirm benefits. On average, the intrafirm "Time" benefit and "Quality&Inventory" benefit are higher than the interfirm "Supplier" benefit at a moderate statistical significance level of .10. Statistically there is no significant difference between the two intrafirm benefits and the interfirm "customer" benefits.

The development of ERP software has been based upon a traditional functional view of organizations. Consequently, ERP systems are usually considered to support more on intrafirm

processes than interfirm processes. However, this result shows that companies had achieved benefits to communicate with their external customers, but supplier relationship is a weaker interfirm area in ERP implementation at the time of our survey.

**Table 5. Comparison between Intrafirm Benefits and Interfirm Benefits Pairs with Siginficant Difference (alpha<10;two-tailed test) are in Bold**

| Benefits Pair | First benefit mean (standard deviation) | Second benefit mean (standard deviation) | Difference in paired means | Sig.. (2-tailed) |
|---|---|---|---|---|
| Time --Quality & Inventory | 2.92 (.95) | 2.72 (.98) | .20 | .307 |
| **Time -- Supplier** | 3.00 (.93) | 2.64 (.73) | .36 | **.057** |
| Time -- Customer | 2.91 (1.02) | 2.77 (.97) | .14 | .525 |
| **Quality & Inventory-Supplier** | 2.93 (.84) | 2.62 (.78) | .31 | **.071** |
| Quality & Inventory -- Customers | 2.80 (.87) | 2.80 (1.08) | .00 | 1.00 |
| Supplier -- Customer | 2.61 (.79) | 2.79 (.99) | -.18 | .259 |

***Comparisons On ERP Software Package Sizes***

As noted earlier, the top five ERP software packages are classified as "large" size and the remaining software packages are classified as "small" size. Two-tailed t-tests show no significant statistical differences (at p=.10) between the large and small sized ERP software on all benefits, all business process reengineering levels, and the total number of modules implemented. ERP projects using large software vendors tend to hire more consultants in the implementation team (p=0.64), but have less concerns on the limitation of the software technology (p=.059).

***Comparison On BPR Levels And ERP Benefits***

On average, the purchasing process had the highest reengineering level, followed by manufacturing process, financial reporting process, customer service process, transportation/logistics process, accounts payable/receivable processes, quality assurance process, and human resource process. Table VI shows Spearman's correlations between all benefits and the reengineering

levels of all eight business processes. The reengineering effort at accounts payable/receivable processes is positively and statistically significantly correlated with all intrafirm and interfirm benefits (p values from .001 to .050). Reengineering of customer service process is positively and significantly correlated with the "Overall" benefit (p=.024). Reengineering of financial reporting process is positively and significantly correlated with the intrafirm "Time" and "Quality&Inventory" benefits and interfirm "Customer" benefit (p values from .056 to .076). The most reengineered processes such as purchasing and manufacturing show no significant correlations with benefits from ERP implementations.

**Table 6. Correlations of BPR Levels with ERP Benefits**
**Significant Correlations (alpha <10; one-tailed test) are in Bold**

| | Intrafirm "Time" Benefit | Intrafirm "Quality & Inventory" Benefit | Interfirm "Supplier" benefit | Interfirm "Customer" benefit | "Overall" benefit |
|---|---|---|---|---|---|
| Accounts payable/receivable BPR level | **.523** p=.003 n=26 | **.254** p=.046 n=45 | **.526** p=.001 n=32 | **.266** p=.050 n=39 | .098 p=.274 n=40 |
| Customer service BPR level | .121 p=.283 n=25 | .121 p=.241 n=36 | -.007 p=.487 n=26 | -.009 p=.480 n=32 | **.347** p=.024 n=33 |
| Financial reporting BPR level | **.290** p=.076 n=26 | **.243** p=.056 n=44 | .227 p=.114 n=30 | **.255** p=.064 n=37 | .050 p=.384 n=38 |
| Human resources BPR level | -.095 p=.379 n=13 | -.265 p=.144 n=18 | .047 p=.437 n=14 | .255 p=.162 n=17 | -.276 p=.134 n=18 |
| Manufacturing BPR level | .010 p=.481 n=23 | -.072 p=.327 n=41 | .074 p=.363 n=25 | -.169 p=.174 n=33 | .133 p=.230 n=33 |
| Purchasing BPR level | .153 p=.233 n=25 | .082 p=.299 n=42 | .162 p=.192 n=31 | .055 p=.371 n=38 | -.093 p=.287 n=39 |
| Quality BPR level | .083 p=.368 n=19 | .204 p=.132 n=32 | .275 p=.113 n=21 | .233 p=.437 n=25 | -.064 p=.373 n=28 |
| Transportation/ logistics BPR level | .017 p=.473 n=19 | -.033 p=.426 n=34 | -.100 p=.329 n=22 | .057 p=.382 n=30 | -.126 p=.245 n=32 |

## DISCUSSION

It is interesting to see that quality and inventory loaded as one single construct in assessing ERP benefits. The deployment of total quality management and just-in-time production in the last two decades has certainly integrated these two operational priorities. Companies realize that quality improvement can help reduce inventory, and lowered inventory further helps them discover hidden quality problems. The two loaded factors in interfirm benefits reflect two important components: supplier relationship management and customer relationship management. Companies need to communicate and coordinate information and activities with upstream suppliers and downstream customers. As might be expected, in general ERP achieved more benefits on intrafirm processes than interfirm process. However ERP systems also prove to be beneficial to customer relationship management including the development of business-to-customer e-commerce. Currently many ERP vendors are even more vigorously developing or buying capability in technology-assisted selling, marketing automation, field service, and call center management.

Our study shows that the weaker area of typical ERP systems is in supplier relationship management. Supply chain systems need to deal with much higher complexity of information integration from many disparate systems spanning multiple organizations. Typical supply chain management software such as i2, Manugistics, and SC21 use outside-in interfirm integration verses ERP vendors' inside-out intrafirm integration. As we move closer to a network economy, these two initiatives will need to converge (Kumar and Hillegersberg, 2000). In fact, many major ERP vendors are aggressively developing or buying supply chain planning and supply chain execution functionalities to support supply chain management. ERP vendors also use portal strategies like MySAP.com and PeopleSoft Business Network (PSBN) for user self-service and internal and external content delivery (Girard, 1999). Scheer and Habermann (2000) argued that while companies are on their way to new business dimensions, implemented ERP systems couldn't remain inside organizational boundaries. With today's e-commerce expanded from business-to-customer to business-to-business commerce, adding applications for electronic procurement, hub-based trading communities, storefronts, and real-time trading communities offer ERP vendors a great opportunity to grow.

Although ERP packages vary greatly in scope and costs, statistical analyses fail to support significant differences in benefit levels and BPR levels. This result suggests that decision makers better choose software packages based on their needs than brands. To avoid running ERP implementations over schedule, companies need to be particularly careful about extent of their business process reengineering. Companies also need to be aware that limited ERP software technology is the dominating factor that causes implementations to run over budgets.

ERP system implementations usually require concurrent reengineering on business processes. Analyses on the relationship between BPR levels and ERP benefits show that only reengineering of the financial processes, including accounts payable and receivable and financial reporting, generates higher ERP benefits. Surprisingly the most reengineered processes such as purchasing and manufacturing show no significant correlations with any intrafirm and interfirm benefits. Recall that the financial and manufacturing modules are the two most widely imple-

mented modules; these results may suggest that so-called "best practices" of current ERP technology fit financial processes better than manufacturing and operational processes. Indeed manufacturing and operational processes are more complex and difficult to standardize. For example, ERP systems typically and often incorrectly assume infinite capacity and fixed lead times in developing production plans. Additional advanced production system (APS) features need to be incorporated with ERP systems to provide more realistic and sophisticated production plans. Hence business process reengineering efforts are necessary but not sufficient to the success of an ERP system implementation.

## CONCLUSION AND FUTURE RESEARCH

The implementation of an ERP system is extremely costly to an organization. Not only is time and money swallowed up during implementation, but invaluable human assets as well. Decision makers must ensure that forethought and analyses take place beforehand. This study uses a survey instrument to analyze the benefits and concerns of ERP implementation. Our results show companies can expect more intrafirm benefits, such as reduced inventory, improved quality, and shortened cycle time, from current ERP technology. ERP technology is not yet capable to handle the complexity of the whole supply chain. More supplier relationship management features need to be integrated. Our results also show that the BPR effort in financial processes concurrent with the ERP implementation achieves more benefits. This may suggest that the so-called "best practices" defined in current ERP technology fit well in financial functions of today's business. However the non-financial processes may be more complex than the current "best practices" defined.

The paper provides a first step to evaluate tangible and intangible effects achieved through comprehensive information technology and system implementations such as ERP systems. The limited sample size in this study prohibited us from employing causal models to examine interrelationships among variables. Furthermore, ERP technology and systems are continuously evolving. Future research should consider the dynamics of new business models, advanced communication technology, and enhanced information systems. It would also be interesting to investigate the relationship between the intrafirm and interfirm benefits generated from ERP implementation and the cultural factors of a firm.

## REFERENCES

AMR Research, 1999, Enterprise Resource Planning Software Report: 1998-2003, Boston, AMR Research Inc.

Aldred, Katherine, 1998, "Scheduling Software Helps Tool Manufacturer Nail Down Processes," Industrial Engineering Solutions, 30 (6), 52-54.

Bingi, Prasad, Sharma, Maneesh K. and Godla, Jayanth K., 1999, "Critical Issues Affecting an ERP Implementation," Information Systems Management, 16 (5), 7-25.

Bradley, Peter and Thomas, Jim, 1999, " Carriers and 3PL's Embrace ERP Software," Logistics Management and Distribution Report, 38 (4), pp. 20-25.

Computerworld, 1998, Special Report: Enterprise Resource Planning, URL: http://www.computerworld.com/home/features.nsf/all/980914erpindex.

Connolly, J., 1999, "ERP: Corporate Cleanup," Computerworld, March 1.

Fichman, Robert G. and Moses, Scott A., 1999, "An Incremental Process for Software Implementation," Sloan Management Review, 40 (2), pp. 39-53.

Flynn, B., S. Sakakibara, R. Schroeder, K. Bates, E. Flynn, 1990, "Empirical Research Methods in Operations Management," Journal of Operations Management, 9 (2), 25-284.

Girard, Greg, 1999, "Maximum Supply Chain Performance Takes an Application Architecture," AMR Research. Retrieved June 6, 1999 from the web site: http://www.amrresearch.com/preview/9906scsexec.asp

Hair, J., R. Anderson, R. Tatham, and W. Black, 1998, Multivariate Data Analysis, Prentice Hall, Upper Saddle River.

Kumar. K. and J. Hillegerberg, 2000, "ERP Experiences and Evolution," Communications of ACM, 43 (4), pp. 23-26.

Malhotra, M. and V. Grover, 1998, "An Assessment of Survey Research in POM: from Constructs to Theory," Journal of Operations Management, 16 (4), pp. 407-425.

Motwani, J., D. Mirchandani, M. Madan, and A. Gunasekaran, 2002, "Successful Implementation of ERP Projects: Evidence from Two Case Studies," International Journal of Production Economics, 75 (1-2), pp. 83-96.

Nunnally, J., 1978, Psychometric Methods, New York, McGraw-Hill.

Scheer, A. and F. Habermann, 2000, "Making ERP A Success: Using Business Process Models to Achieve Positive Results," Communication of the ACM, 43 (4), pp. 57-61.

Stein, Tom, 1999,"Making ERP Add Up," InformationWeek, 735, pp. 59-62.

Sweat, Jeff, 1999. "Savvy Companies Apply the Painful Lessons Learned from Implementing Enterprise Resource Planning Software to Next-Generation Applications," InformationWeek, 746, pp. 44-49.

Wash, L., 2000, "Give ERP a Chance," Management Review, 39 (3), pp. 20-24.