# IMPLEMENTING ERP IN MANUFACTURING

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**The authors interviewed IT and other personnel at 30 manufacturing firms of various sizes to discover the major issues concerning the implementation of enterprise resource planning (ERP). Among the conclusions reached, the authors were surprised to learn that smaller organizations implementing ERP with a "big-bang" approach proved more successful than larger firms using a gradual rollout.**

TO COMPETE EFFECTIVELY IN TODAY'S global business environments, firms must use information technology to support the continuous improvement of business processes. Enterprise resource planning (ERP) is the latest in an evolutionary series of computer tools developed for managing information and organizations. ERP systems are simply integrated information systems. They integrate processes, information, and people across functions, plants, companies, and geographic locations. This permits companywide or enterprisewide communication and coordination, using a common database available in real-time. The potential benefits of using an ERP system include quicker information response time, improved on-time delivery, lower inventory levels, better resource management, and improved interaction with customers and suppliers.[1,2]

Although many organizations have already installed packaged ERP systems, other companies are still considering the adoption of ERP as the backbone of their information systems. For example, in a recent survey study, Mabert et al.[2] reported that close to 44 percent of the firms that responded had installed an ERP system and close to 30 percent of respondents were currently installing or planning to install an ERP system. Another study indicated that 53 percent of large firms and only 9 percent of small/medium firms had installed a packaged ERP system.[3] In addition, the study reported that of those firms planning to make a significant investment in ERP within the next two years, 30 percent of the large firms and 87 percent of the small/medium firms currently do not have an ERP system.

Although investments in ERP systems and spending for information technology (IT) in general have slowed recently as a result of the depressed economy, some analysts are predicting a recovery in IT budgets in 2003.[4-6] According to a recent survey by AMR Research (Boston), ERP will remain the largest component of companies' applications budget through 2004.[6] Also, the greatest growth in core ERP adoption is projected for the midrange and small organization marketplace.[7-9]

Empirical research addressing ERP implementation issues is rather limited. Most of the research is in the form of personal experiences or case studies.[10-14] While case studies are useful in providing detailed descriptions of how and why individual companies have implemented ERP, a broader perspective is also desirable for understanding general trends and issues. Researchers in Europe[9] and the United States[2] have conducted broader investigations using mail survey methodologies. Mabert et al.[2] conducted a survey of U.S. manufacturing firms concerning their experiences with the implementation of packaged ERP systems. The survey included questions about preimplementation issues, implementation experience, ERP system configuration, benefits, and future directions. Van Everdingen et al.[9] surveyed midsize companies in Europe and explored issues

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**EXHIBIT 1** ERP Implementation Stage

| Stage | Small/Medium (Percent) | Large (Percent) | All Firms (Percent) |
|---|---|---|---|
| Early to mid-implementation | 0.0 | 37.5 | 20.0 |
| Late implementation (near completion) | 7.2 | 18.8 | 13.3 |
| Implementation completed within past year | 7.2 | 6.2 | 6.7 |
| Implementation completed over one year ago | 85.6 | 37.5 | 60.0 |
| **Total** | **100.0** | **100.0** | **100.0** |

related to criteria for selecting an information system and for choosing an ERP supplier.

This article contributes to the understanding of ERP implementation issues by reporting the results of in-depth interviews conducted at several organizations. Because the liter ature indicates that many firms have experienced difficulty in implementing ERP and the final results have been uncertain,[15-21] particular attention was paid in this study to identifying the major problems encountered during implementation. Other areas addressed included the reasons why ERP was adopted, the implementation strategy followed, the success achieved, and user satisfaction with the system. Because smaller firms may have different needs and may face different problems,[3,22,23] the responses were analyzed and compared relative to company size.

## RESEARCH METHODOLOGY

This study was based on face-to-face interviews at 30 manufacturing firms in the Upper Midwest of the United States. Companies were randomly contacted to identify organizations that had implemented or were in the process of implementing an ERP system and were willing to participate in the study. Because of time and resource constraints, the firms were constrained to the Upper Midwest. In each participating organization, the person interviewed was directly responsible for overseeing the ERP implementation project. The majority of the individuals interviewed were from the information systems area (77 percent), while accounting, human resources, and operations were also represented. Each interviewee was asked to respond to the same set of questions, which included both open and closed forms.

To determine whether company size had any impact on the ERP issues investigated in this study, firms were categorized based on the number of employees. Companies with 1000 or more employees were classified as "large," and the balance of the companies were classified as "small/medium." This classification scheme is equivalent to the approach used by Treleven et al.[3] and Van Everdingen et al.[9] The participating companies ranged in size from 50 employees to 45,000 employees. Sixteen of the firms were categorized as "large," having average annual sales of $2.5 billion, while the remaining fourteen firms had less than 1000 employees and averaged $98.5 million in sales.

## RESULTS

### ERP Implementation Background

Exhibit 1 summarizes the progress that the organizations have made toward implementing an ERP system. Sixty-seven percent of the firms have completed the implementation of their ERP system, with the majority having completed the implementation over one year ago. Interestingly, the small and medium companies were further along in the ERP adoption process than the large companies. One of the possible explanations for this result is the implementation strategy selected by the organizations.

As indicated in Exhibit 2, the large companies tended to use a phased implementation strategy, phasing b y module or site or both. On the other hand, the most common implementation strategy followed by the small and medium companies was the big-bang approach, bringing all modules online for the entire company in one shot. Mabert et al.[2] concluded that firms able to use the big-bang approach experienced the shortest implementation time.

Exhibit 3 presents a summary of the responses related to the importance of various reasons for investing in an ERP system. The motivations for ERP investment were measured on a five-point Likert scale, with 1 representing "not important" and 5 representing "very important." The summary lists the mean, median, and mode responses. Firms of all sizes rated *improve control of information resources* (highest rating for small/medium firms; mean = 4.36), *overcome inefficiencies of legacy systems*, *integrate functional areas' information systems* (highest rating for large firms; mean =

**EXHIBIT 2** Implementation Strategy

| Strategy | Small/Medium (Percent) | Large (Percent) | All Firms (Percent) |
|---|---|---|---|
| Big-bang approach | 57.1 | 25.0 | 40.0 |
| Gradual phase-in by module | 35.7 | 37.5 | 36.7 |
| Gradual phase-in by site | 7.2 | 12.5 | 10.0 |
| Gradual phase-in by module + site | 0.0 | 25.0 | 13.3 |
| **Total** | **100.0** | **100.0** | **100.0** |

**EXHIBIT 3** Reasons for ERP Implementation

| Reasons | Small/Medium | | | Large | | |
|---|---|---|---|---|---|---|
| | Mean[a] | Median | Mode | Mean[a] | Median | Mode |
| Improve control of information resources | 4.36 | 4.0 | 4 | 3.69 | 4.0 | 5 |
| Overcome inefficiencies of legacy systems | 3.86 | 5.0 | 5 | 3.94 | 4.0 | 5 |
| Integrate functional areas' information systems | 3.79 | 4.0 | 4 | 4.25 | 5.0 | 5 |
| Respond to Y2K problem | 3.50 | 4.5 | 5 | 2.25 | 1.0 | 1 |
| Support advanced planning and scheduling system | 3.43 | 4.0 | 4 | 3.25 | 4.0 | 4 |
| Business intelligence potential | 3.36 | 3.0 | 5 | 2.56 | 3.0 | 2 |
| Pursuit of business process reengineering | 2.71 | 3.0 | 3 | 2.69 | 2.5 | 1 |
| Development of data warehouse | 2.57 | 2.5 | 1 | 2.31 | 2.0 | 2 |
| E-commerce/E-business potential | 2.50 | 2.0 | 2 | 2.81 | 3.0 | 2 |
| Support supply-chain management | 2.50 | 2.0 | 2 | 3.81 | 4.0 | 5 |
| Link with customers through ERP system | 2.14 | 1.5 | 1 | 3.06 | 3.0 | 2 |
| Link with suppliers through ERP system | 1.86 | 1.0 | 1 | 3.06 | 3.0 | 2 |

[a] Scale 1 to 5, "not important" to "very important."

4.25), and *support advanced planning and scheduling system* among the top five reasons for implementing ERP. Each of the above reasons received a mean rating greater than 3.25. Large companies also included *support supply-chain management* (mean = 3.81) among the top five reasons. In addition, small and medium companies considered *respond to Y2K problem* (mean = 3.50) as an important motivation; however, this reason received the lowest rating for large organizations (mean = 2.25). The reasons rated the lowest in importance for small and medium firms were *link with customers through ERP system* (mean = 2.14) and *link with suppliers through ERP system* (mean = 1.86).

Additional comments or elaborations provided by the respondents were consistent with the Likert-scale results. Across all organizations, the following ideas were frequently expressed as the basis for the ERP investment decision: upgrade/update information system, acquire integrated system, and adopt consistent system across facilities and locations. In response to an open-ended question about other major reasons for investing in ERP, only one additional reason was identified (mentioned by 10 percent of the companies): to support business growth and corresponding information growth requirements.

The major reasons for investing in ERP systems identified in this study are fairly consistent with the findings of prior research. In the Mabert et al. study,[2] the top two motivations to implement ERP were to replace legacy systems and to simplify and standardize systems. These two reasons were ranked highly by firms of all sizes in this study. However, the third highest motivation reported by Mabert et al.[2] was to improve interactions with suppliers and customers. As previously reported for this research, this reason was rated the lowest in importance by small and medium firms and had a moderate average rating of 3.06 for the large companies.

## Implementation Problems

To investigate the problems that organizations encountered during ERP implementation, respondents were asked to rate the extent to which several issues caused problems in implementing ERP in their organizations. The potential problems were measured on a five-point

**EXHIBIT 4** ERP Implementation Problems

| Problems | Small/Medium | | | Large | | |
|---|---|---|---|---|---|---|
| | Mean[a] | Median | Mode | Mean[a] | Median | Mode |
| Lack of ERP training and education for affected employees | 3.43 | 3.5 | 4 | 3.07 | 3.0 | 4 |
| Lack of in-house expertise in ERP | 2.71 | 3.0 | 3 | 3.00 | 3.0 | 3 |
| Lack of clear goals for ERP effort | 2.71 | 2.5 | 2 | 1.93 | 2.0 | 1 |
| Lack of companywide support and involvement | 2.64 | 2.5 | 2 | 2.75 | 3.0 | 3 |
| Lack of data accuracy | 2.57 | 2.0 | 2 | 2.73 | 2.0 | 2 |
| Lack of top management commitment and support | 2.36 | 2.0 | 1 | 2.50 | 2.0 | 1 |
| Lack of communication to users | 2.29 | 2.0 | 2 | 2.27 | 2.0 | 2 |
| Lack of project management strategy to manage process | 2.29 | 2.0 | 2 | 2.00 | 2.0 | 2 |
| Lack of software vendor support | 2.14 | 1.5 | 1 | 2.07 | 2.0 | 1 |
| Unsuitability of hardware and/or software | 2.00 | 1.5 | 1 | 1.93 | 2.0 | 2 |
| Attempting the implementation without any outside help | 2.00 | 1.0 | 1 | 1.75 | 1.0 | 1 |
| Abdicating implementation responsibility to consultants | 1.92 | 1.0 | 1 | 1.86 | 1.5 | 1 |
| Lack of formal implementation plan | 1.86 | 1.0 | 1 | 2.00 | 2.0 | 2 |

[a] Scale 1 to 5, "not at all" to "great extent."

Likert scale ranging from not at all (1) to a *great extent* (5). As shown in Exhibit 4, the number-one problem for organizations of all sizes was *lack of ERP training and education*. Small and medium firms gave a mean rating of 3.43 for this issue, while large firms rated it at 3.07 on average. For both groups of organizations, the mode response (highest frequency of occurrence) was 4.

Firms of all sizes also agreed on the second highest rated problem: *lack of in-house expertise in ERP* (small/medium = 2.71, large = 3.00). *Lack of data accuracy* and *lack of companywide support and involvement* were included in the top five problems for both small/medium organizations and large organizations. Both of these issues received a mean rating greater than 2.50. Small and medium companies also considered *lack of clear goals for ERP effort* (mean = 2.71) among the top five problems. In addition, large companies considered *lack of top management commitment and support* as a moderately important problem (mean = 2.50) although the mode response was 1. For all organizations, all other potential problems received average ratings below 2.50, with the most frequent Likert-scale response (i.e., mode) being 1 or 2. Thus, those issues appear to be fairly minor causes of implementation problems for the studied firms. In response to an open-ended question about other major implementation problems, one additional problem was identified: 30 percent of the respondents felt that resistance to change was a major problem in their implementation effort.

Lack of training and lack of in-house expertise in ERP were supported as top implementation problems by the responses to a follow-up, open-ended question. When asked how the ERP implementation process would be different if they had it to do over again, more and better training and education in ERP and more help from consultants and outside experts were the two most common responses. However, several respondents were quick to add that organizations had to be careful about developing too much dependence on consultants or being influenced or led too much by them. Thus, the use of consultants and the extent of their assistance are issues that must be carefully managed.

## Implementation Results

Despite the problems that the surveyed organizations experienced during implementation of their ERP systems, the majority of the firms rated the implementation process as a successful effort. Respondents were first asked how their organizations defined a successful ERP system implementation. The open-ended question focused on the successful completion of the implementation project as opposed to the resultant benefits or results derived from installing and using an ERP system. Common themes were identified in the definitions of a successful ERP implementation, and the results are summarized in Exhibit 5.

As shown, the responses differed based on company size. The large firms defined success in terms of completing the project on time and within budget (43.8 percent), without disruptions to normal business (37.5 percent) and

**EXHIBIT 5** Definitions of ERP Implementation Success

| Themes | Small/Medium (Percent) | Large (Percent) |
|---|---|---|
| Short implementation duration | 28.6 | 0.0 |
| On-time and within budget | 21.4 | 43.8 |
| Maintain data integrity | 21.4 | 0.0 |
| System works | 21.4 | 6.3 |
| Without disruptions to normal business | 7.1 | 37.5 |
| User acceptance | 7.1 | 37.5 |
| Other[a] | 28.6 | 25.0 |
| **Total[b]** | **135.6** | **150.1** |

[a] All other themes; each mentioned by only one respondent in total.
[b] Total greater than 100 percent because of multiple responses.

**EXHIBIT 6** End-User Satisfaction

| Satisfaction Level | Small/Medium (Percent) | Large (Percent) |
|---|---|---|
| Extremely satisfied | 7.1 | 6.2 |
| Very satisfied | 28.6 | 25.0 |
| Satisfied | 42.9 | 43.8 |
| Somewhat satisfied | 21.4 | 18.8 |
| Not satisfied | 0.0 | 6.2 |

with user acceptance of the implemented system (37.5 percent). In contrast, the theme mentioned most frequently by small and medium firms was related to achieving a short duration of implementation (28.6 percent). For the companies that defined success in this manner, they typically considered an ERP implementation completed in less than one year as a success. Other common themes mentioned by small/medium companies included completing the project on time and within budget (21.4 percent), while maintaining data integrity (21.4 percent) and with the ERP system actually working (21.4 percent).

Next, the respondents were asked to rate the success of their organizations' ERP system implementation. For those firms that were still involved in the implementation project, they were asked to estimate the eventual outcome based on their organizations' current progress. Success was measured on a five-point Likert scale ranging from *not at all successful* (1) to *very successful* (5). The most frequent rating for small and medium companies was 4, with an average rating of 3.85. Large companies had an average rating of 4.13, with the most frequent response being 5. Across all companies, only 23 percent rated their implementation success as 3 or below. Clearly, the majority of the firms, regardless of size, considered their ERP implementation project a success. This result is consistent with the high level of ERP system success reported by Mabert et al.[24]

Finally, the respondents described end-user satisfaction with the ERP system by responding to a five-point rating scale ranging from *not satisfied* to *extremely satisfied*. Exhibit 6 summarizes the results. The responses were very similar for large companies and small/medium companies. In both cases, at least 75 percent of the respondents rated end-user satisfaction as *satisfied, very satisfied*, or *extremely satisfied*.

## ERP Extensions

As the implementation of an ERP system is viewed by many organizations as the beginning of the development of an overall information technology infrastructure, the final area investigated in this study concerns the extensions to ERP systems implemented and planned by the surveyed organizations. As shown in Exhibit 7, the large organizations have been more active in investing in extensions to their ERP systems. For example, the results indicate that 50 percent or more of the large firms have or are implementing an advanced planning and scheduling system (62.5 percent), a data warehouse system (56.3 percent), and a supply-chain manage-

**EXHIBIT 7** Extensions to ERP System

| ERP Extension | Implemented/ Implementing | Planned for Future | Considering | No Plans |
|---|---|---|---|---|
| **SMALL/MEDIUM (PERCENT)** | | | | |
| Advanced planning/scheduling system | 50.0[a] | 21.4 | 14.3 | 14.3 |
| Data warehouse | 42.9 | 21.4 | 14.3 | 21.4 |
| E-business/E-commerce enabled | 35.7 | 42.9 | 14.3 | 7.1 |
| Linking customers to ERP system | 28.6 | 7.1 | 35.7 | 28.6 |
| Business intelligence capabilities | 28.6 | 14.3 | 28.6 | 28.6 |
| Supply-chain management system | 14.3 | 28.6 | 35.7 | 21.4 |
| Linking suppliers to ERP system | 7.1 | 14.3 | 42.9 | 35.7 |
| **LARGE (PERCENT)** | | | | |
| Advanced planning/scheduling system | 62.5[a] | 12.5 | 6.3 | 18.8 |
| Data warehouse | 56.3 | 31.2 | 12.5 | 0.0 |
| Supply-chain management system | 50.0 | 25.0 | 18.8 | 6.3 |
| E-business/E-commerce enabled | 43.8 | 43.8 | 12.5 | 0.0 |
| Linking customers to ERP system | 31.2 | 31.2 | 12.5 | 25.0 |
| Linking suppliers to ERP system | 31.2 | 50.0 | 12.5 | 6.3 |
| Business intelligence capabilities | 18.8 | 56.3 | 12.5 | 12.5 |

[a] Totals may not add to 100 percent because of rounding.

ment system (50 percent). Other ERP enhancements include E-business or E-commerce enabled, business intelligence capabilities, linking customers to ERP system and linking suppliers to ERP system. For each of these extensions, more than 60 percent of the large firms have implemented, are implementing, or have plans to implement the extension in the future.

The top three ERP extensions that the small and medium organizations have or are implementing are an advanced planning and scheduling system (50 percent), a data warehouse system (42.9 percent), and E-business or E-commerce enabled (35.7 percent). The advanced planning and scheduling system and the data warehouse system were the two most common ERP enhancements for firms of all sizes. In contrast to the high level of interest in ERP extensions by large firms, more than 50 percent of the small/medium firms are just considering (i.e., no current plans) or have no plans to implement each of the following enhancements: supply-chain management, business intelligence capabilities, and linking customers or suppliers to ERP system. In response to an open-ended question about other ERP extensions, no other application received significant support from either group of firms.

Concerning the extensions to ERP systems, the results of this study are supportive of prior research. Mabert et al.[2] reported the top four ERP extensions as data warehouse, E-business or E-commerce enabled, supply-chain system, and advanced planning and scheduling system. Combining the responses for firms of all sizes, the same four ERP enhancements topped the list in this study. The results of this study and the Mabert et al.[2] study also support the recent attention that supply-chain management and advanced planning and scheduling extensions to ERP systems have been receiving in the literature.

## CONCLUSION

The experiences of companies that have implemented or are implementing an ERP system can serve as valuable lessons to those companies that are considering the adoption of packaged ERP systems or that have recently begun the implementation process. The purpose of this study was to conduct a systematic survey on the ERP implementation experiences of a number of manufacturing firms to identify general trends related to several ERP implementation issues. Particular attention was paid to identifying the major problems encountered during implementation so that companies currently implementing ERP, or thinking about adopting ERP, are sensitive to these potential obstacles. In addition, because smaller firms may face different problems and have different implementation experiences than larger firms, the data collected in this study was analyzed and compared relative to company size. This study produced a number of important results for businesses to consider.

First, large companies tend to use a phased implementation strategy for their ERP systems,

***Small and medium firms typically place importance on achieving a quick ERP implementation.***

phasing by module or site or both. In contrast, the most common strategy followed by smaller companies is the big-bang approach, bringing all modules online for the entire company in one shot. Previously reported ERP implementation cases indicate that the big-bang approach is a risky venture for large organizations.[27] The high frequency of the big-bang approach for smaller companies is supported by the importance that small and medium firms typically place on achieving a quick ERP implementation as reported in this study. Van Everdingen et al.[9] also found that midsized companies considered short implementation times as an important selection criteria for a new system.

Second, smaller firms tend to experience the same ERP implementation problems as larger firms. The number-one problem for organizations of all sizes was lack of ERP training and education, followed by lack of in-house expertise in ERP. Lack of training and education has been identified in the literature as an important problem for organizations to address.[21,28] Lack of data accuracy and lack of companywide support and involvement were also included in the list of the most common problems experienced by both small/medium organizations and large organizations. Thus, company size does not appear to have a major impact on the ERP implementation problems most frequently encountered by organizations. As such, smaller firms can learn from the implementation experiences of their larger counterparts.

Third, although smaller firms tend to define the successful completion of the implementation project different than larger firms, the majority of the companies surveyed in this study rated the implementation process as a success. In addition, firms of all sizes reported a high level of user satisfaction with the ERP system.

Finally, larger firms tend to be more active in investing in extensions to their ERP systems. Although the percentages of companies that have implemented or are implementing the various ERP enhancements differ between larger and smaller companies, firms of all sizes appear to be the most interested in the following enhancements: advanced planning and scheduling system, data warehouse, and E-business or E-commerce enabled. While the large firms also appear to be highly interested in supply-chain management extensions, there is very little interest in this ERP enhancement by the small/medium firms.

The obvious limitation to this study is the small sample size, which was confined to the Upper Midwest. However, the sample included firms of varying sizes from a variety of manufacturing industries. There seems to be little reason to assume that the experiences related to this sample are unique to the specific group of organizations participating in this study. In fact, where appropriate, the results of this study were generally consistent with the findings of the prior research on ERP implementation. Thus, the experiences of the studied organizations should add to the overall understanding of ERP implementation issues, providing managers with useful information for making related decisions. ▲

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