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THE IMPACT OF ENTERPRISE RESOURCE PLANNING SYSTEMS ON FIRM PERFORMANCE

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Abstract

Debate exists regarding the contribution of information technology to firm performance. Prior research has examined technology and firm performance in the aggregate. This study, however, focuses on a specific technology—enterprise resource planning (ERP)—and its impact on firm performance. Economic and industrial organization theories are used to predict how ERP technology should affect firm coordination and transaction costs. ERP is expected to (1) reduce costs by improving efficiencies through computerization and (2) enhance decision making by providing accurate and timely enterprise-wide information. These effects should be associated with improved firm performance. This issue is examined empirically using archival financial data of COMPUSTAT firms that have implemented ERP systems compared to control firm counterparts. Results indicate a significant increase in costs as a percentage of revenue but a decrease in the number of employees as a percentage of revenue the year after ERP implementation. However, control firms experience a greater reduction in employees. Results indicate a paradox where firms having fewer employees supporting more revenue simultaneously experience higher cost to revenue ratios after their ERP implementation.

Keywords: ERP, economic impact, coordination costs

1. INTRODUCTION

Fully 70% of *Fortune* 1,000 firms have or are in the process of installing enterprise resource planning (ERP) systems (Hoffman 1998). Anecdotal evidence suggests firms expect ERP to deliver improved performance. Specifically, firms expect ERP to provide (Brown 1997; Davenport 2000; Gilbert 2000; Glover et al. 1999; Knorr 1999; Rizzi and Zamboni 1999; Wah 2000):

- Reduced asset bases and costs, enhanced decision support, more accurate and timely information, reduced financial cycles, and increased procurement leverage;
- Increased customer satisfaction through integration and consistency;
- Conversion to Year 2000 compliant software;
- Response to pressure from trading partners who have already converted their systems;
- Globally integrated information access across the enterprise and supply chain;
- Enabling e-business; or
- Flexibility to change quickly and configure the business in response to a changing marketplace while making tacit process knowledge explicit.

Table 1. 1998 Survey Results of Returns to ERP

Panel A: Hard Returns – tangible benefits from ERP implementation		Panel B: Intangible Returns – intangible benefits from ERP implementation	
Return	% of Survey Respondents*	Return	% of Survey Respondents*
Inventory reduction	32	Information/visibility	55
Personnel reduction	27	New/ improved processes	24
Productivity improvement	26	Customer responsiveness	22
Order mgmt. improvement	20	Cost reduction	14
Financial close cycle reduction	19	Integration	13
Technology cost reduction	14	Standardization	12
Procurement cost reduction	12	Flexibility	9
Cash mgmt. improvement	11	Globalization	9
Revenue/profit increases	11	Year 2000	8
Transportation/logistics cost reduction	9	Business performance	7
Maintenance reduction	7	Supply/ demand chain	5
On-time delivery improvement	6		

*1998 survey of 62 *Fortune* 500 companies by Benchmarking Partners Inc. for Deloitte Consulting LLC. Percentage of survey respondents reported. Based on multiple answers per respondent (Fryer 1999).

Survey results of *Fortune* 500 companies suggest perceived tangible and intangible benefits from ERP of cost reductions and revenue improvements (Table 1). Finally, many firms announce performance improvements attributed to their ERP system (Appendix A, Panel A).

While some firms announce improvements from ERP adoption, others can experience negative financial effects because:

- Implementation process can be burdensome in time and money, requiring substantial software, hardware, implementation, and training costs (Davenport 2000; Wortmann 1998);
- ERP vendor best practice models within a given industry (Schrageheim 2000) may introduce rigidity causing delays and failures (Knorr 1999; Williamson 1997; Wortmann 1998);
- Best practices do not anticipate the needs of evolving organizations and may stifle creativity and innovation (Arnold et al. 2000);
- ERP imposes a hierarchical command and control perspective, which may be inappropriate (Davenport 2000).

Many firms have announced negative results attributed to their ERP implementation (Appendix A, Panel B). Given this equivocal evidence, the objective of this research is to investigate whether ERP implementations are associated with improved financial performance. Since ERP implementations are often performed with business process reengineering (Davenport 2000; Grabski et al. 2000; Wortmann 1998), the separate effect cannot be disentangled.

2. HYPOTHESES DEVELOPMENT

The literature is ambiguous regarding the impact of information systems on firm performance (see Brynjolfsson and Yang 1996). However, the technology coordination cost literature suggests that information systems are expected to contribute by

- (1) increasing scale efficiencies of firm operations (Harris and Katz 1991; Mitra and Chaya 1996);
- (2) processing business transactions effectively (Malone et al. 1987; Johnson and Lawrence 1988);
- (3) collecting and disseminating timely information for decision making (Simon 1955);

- (4) monitoring and recording employee performance effectively (Zmud and Apple 1992); and
- (5) maintaining records of business functions within the organization or maintaining communication channels with lower cost (Cash and Konsynski 1985).

We next examine how ERP should affect internal firm operations. Internal operations are categorized as production and coordination costs (Malone et al. 1987). The organization cost categories defined by Gurbaxani and Whang (1991) are utilized (Table 2). ERP systems are not production automation tools and are not expected to impact production costs.

Internal coordination costs involve both agency costs (Jensen and Meckling 1973) and decision information costs (Jensen and Meckling 1992). External coordination costs involve costs based on microeconomic production theory, economies of scale (Samuelson 1976), and contractual costs (Coase 1937; Williamson 1981).

Table 2. Information System Affects on Economic Performance of the Firm

Cost Categories (Gurbaxani and Whang 1991)	ERP Effects on Firm Costs	Related Cost Category Found in COMPUSTAT Database
INTERNAL COORDINATION COSTS		
Agency Costs		
• Monitoring Costs	Decreases Administrative Monitoring Costs Decreases Cost of Defects and Errors in Product and Information	Decrease in SG&A Decrease in COGS
• Bonding Costs	Decreases Administrative Reporting Costs	Decrease in SG&A Decrease in COGS
• Residual Loss	No effect	—
Decision Information Costs		
• Information processing costs	Enhances Decision-making Increasing Revenues and/or Decreasing Costs	Decrease in SG&A Decrease in COGS Increase in Revenue
○ Communication	Enhances Decision-making Increasing Revenues and/or Decreasing Costs	Decrease in SG&A Decrease in COGS Increase in Revenue
○ Documentation	Enhances Decision-making Increasing Revenues and/or Decreasing Costs	Decrease in SG&A Decrease in COGS Increase in Revenue
• Opportunity costs due to poor information	Enhances Decision-making Increasing Revenues and/or Decreasing Costs	Decrease in SG&A Decrease in COGS Increase in Revenue
EXTERNAL COORDINATION COSTS/MARKET TRANSACTION COSTS		
Operational		
• Search Costs	Decreases Administrative Costs	Decreases SG&A
• Transportation Costs	Decreases Administrative Costs	Decreases SG&A
• Inventory Holding Costs	Decreases Inventory Costs	Decreases SG&A
Communications Costs	Decreases Administrative Costs	Decreases SG&A
• Contractual		
• Costs of Writing Contracts	No effect	—
• Costs of Enforcing Contracts	No effect	—

NOTE: SG&A = Selling, General and Administrative Costs
COGS = Cost of Goods Sold

2.1 Agency Costs

ERP systems should reduce *monitoring costs* by automating process steps and by providing an electronic trail of employee responsibility (Gurbaxani and Whang 1991). Since ERP systems should reduce monitoring costs, selling, general, and administrative (SG&A) expenses—expenses that result from the general administration of company operations and that are not directly related to the acquisition or production of goods (Kieso and Weygandt 1989)—should be reduced. Cost of goods sold (COGS) reflects the direct costs and overhead (including power, light, supervisory labor, depreciation of plant assets, and supplies) associated with the physical production of products for sale (Kieso and Weygandt 1989). ERP should decrease the costs of monitoring production employees reducing COGS.

Bonding costs involve the employee reporting their actions to their employer, which is time consuming and effort intensive (Gurbaxani and Whang 1991). ERP should automate the process and provide easier access to reporting for employees in sales and back office operations, reducing SG&A costs, and for production labor and factory supervisory employees, reducing COGS. *Residual loss* is associated with principal specific welfare losses from dealing with agents (Gurbaxani and Whang 1991), thus these costs are not expected to be influenced directly by an ERP system.

Few empirical studies have examined technology's effect on agency costs, although some studies address internal coordination costs in general. Research has found technology investments associated with a decrease in total costs (Alpar and Kim 1990), and internal coordination costs (Shin 1999). Other research found higher technology investment associated with lower production costs and total costs, but higher overhead costs (Mitra and Chaya 1996).

2.2 Decision Information

Decision rights should be located where the combined decision information and agency costs (called internal coordination costs by Gurbaxani and Whang) are minimized (Jensen and Meckling 1992). Since ERP is expected to provide more timely and accurate enterprise-wide information for decision-making, *information processing costs* (communication and documentation) and *opportunity costs due to poor information* should be reduced. Reductions should be evident in SG&A costs and in COGS overhead.

Assuming rational decision making, better information should lead to cost minimizing/revenue maximizing actions reflected in reduced SG&A and COGS, and increased revenues. Technology spending is associated with improved intermediate decision variables (Barua et al. 1995), the complexity and uncertainty regarding specific activities (Ragowsky et al. 1996), and increases in revenue generation (Venkatraman and Zaheer 1990).

2.3 Transaction Cost

Transaction cost economics posits that firms economize on transaction costs. External sourcing of inputs may entail costs in obtaining market information, communicating with vendors, transporting goods, and holding inventories (Gurbaxani and Whang 1991). An ERP system is expected to provide an accessible and accurate database of information that reduces administrative *search, transportation, inventory holding, and communications* costs. Because of the difficulties involved in allocating these costs, they are reflected as SG&A costs (Kieso and Weygandt 1989). Empirical research has supported technology spending and operational improvements, such as lower growth in operating expenses (Harris and Katz 1991), improved cost efficiency (Bender 1986), and higher return on assets, sales growth, and non-production labor productivity (Weill 1992).

2.4 Hypotheses

This study examines the changes in firm performance from one year before to one, two, and three years after ERP implementation. While a longer time horizon after implementation analysis is preferred (Knorr 1999; Wah 2000), no four or five year post-implementation financial data is publicly available for a meaningful portion of the sample. To control for macro-economic effects, a control sample is constructed. This allows us to test whether ERP adoption by treatment (TRMT) firms results in improved financial performance, ex post, either on an inter-temporal basis or relative to that reported by their control (CTRL) firm counterparts.

Based on the previous discussion and summarized in Table 2:

$$H1: SG\&A/Revenues_{POST,TRMT} < SG\&A/Revenues_{PRE,TRMT}$$

$$H2: SG\&A/Revenues_{POST,TRMT} - SG\&A/Revenues_{PRE,TRMT} < SG\&A/Revenues_{POST,CTRL} - SG\&A/Revenues_{PRE,CTRL}$$

$$H3: \text{COGS/Revenues}_{POST,TRMT} < \text{COGS/Revenues}_{PRE,TRMT}$$

$$H4: \text{COGS/Revenues}_{POST,TRMT} - \text{COGS/Revenues}_{PRE,TRMT} < \text{COGS/Revenues}_{POST,CTRL} - \text{COGS/Revenues}_{PRE,CTRL}$$

Measuring return in relation to investment provides another test of profitability. This can be done using residual income (RI), defined as net operating income less “imputed” interest (Horngren et al. 1999). RI is based on each firm’s imputed interest, its cost of capital. These values are generally unavailable. A 12% cost of capital is assumed for each firm. ERP adoption is expected to result in improved firm performance:

$$H5: \text{RI}_{POST,TRMT} > \text{RI}_{PRE,TRMT}$$

$$H6: \text{RI}_{POST,TRMT} - \text{RI}_{PRE,TRMT} > \text{RI}_{POST,CTRL} - \text{RI}_{PRE,CTRL}$$

ERP is predicted to automate clerical tasks resulting in a reduction in employees. While the 1990s were associated with a general downsizing of firms, the hypothesis reflecting treatment firms relative to control firms should indicate whether ERP enables maintaining or increasing revenues while reducing the number of employees (EMP):

$$H7: \text{EMP/Revenues}_{POST,TRMT} < \text{EMP/Revenues}_{PRE,TRMT}$$

$$H8: \text{EMP/Revenues}_{POST,TRMT} - \text{EMP/Revenues}_{PRE,TRMT} < \text{EMP/Revenues}_{POST,CTRL} - \text{EMP/Revenues}_{PRE,CTRL}$$

PRE and POST refer to costs before and after ERP implementation, respectively. POST represents separate analysis of one, two, and three years after the ERP implementation.

3. SAMPLE SELECTION AND VALIDATION

3.1 Treatment Firms

The sample was selected by identifying firms that publicly disclosed ERP adoption from 1980 to 1997 in PR Newswire press releases (see Appendix B). The sample was limited to firms that implemented SAP, PeopleSoft, Oracle, BAAN, or J. D. Edwards. An initial sample was identified through key word searches and was reduced to the final treatment group of 54 firms using the following:

1. The specific year the ERP implementation started or ended was identified;
2. Cost and revenue information was available through the COMPUSTAT database; and
3. ERP implementation must have been completed before December 1997.

The annual reports for the year before, during, and the three years after implementation were reviewed for each company to validate announcement information sources. No conflicting information was found. Four firms had undergone exceptional changes during the time period of this study and were removed.

3.2 Control Sample

Using COMPUSTAT, control firm counterparts were selected by matching four-digit SIC codes and similar revenues for treatment firms. The control firms were contacted¹ to inquire whether the firm had adopted ERP and the implementation dates. The firm remained in the control firm sample as long as it had not implemented ERP or adoption dates were after three years after their treatment firm counterpart’s dates of ERP adoption. The data for each control firm was gathered from COMPUSTAT for the identical years of its treatment firm’s dates.

3.3 Descriptive Statistics

The majority of firms implemented ERP between 1995 and 1997 (Panel A of Table 3). The average implementation length was 1.46 years. The distribution of firms implementing the various ERP packages is consistent with reports on ERP vendor market

¹Firms have been contacted and all responding firms were consistent with the researchers’ classifications; the researchers continue to follow up on outstanding control firm confirmation data.

share for 1996.² The main industries represented by sample firms are motor vehicles and accessories (SIC = 37), electronics (SIC = 36), and chemical and allied products (SIC = 28) (Panel B of Table 3).

Table 4 presents the mean (median) revenues and costs for treatment firms. The distribution of cost as a percentage of sales is listed in Panel B of Table 4. Similar data are reported for the control firms in Panels A and B of Table 5.

Table 3. Statistics of Sample Firms

Panel A: Distribution of 50 sample firms by implementation date:		
Year(19)	Number of Implementations	
Implementation duration less than or equal to 1 year:		
89	0	
90	0	
91	0	
92	0	
93	1	
94	3	
95	3	
96	10	
97	10	
1 Year Total	27	54%
Implementation duration equal to 2 years:		
93 & 94	2	
94 & 95	3	
95 & 96	9	
96 & 97	9	
2 Year Total	23	46%
Total of All Implementations	50	100%
Panel B: Distribution of 50 sample firms by SIC code:		
SIC	Number of Sample Companies	
10	1	
15	1	
20	1	
21	1	
23	1	
25	1	
28	6	
29	2	
30	1	
33	1	
34	1	
36	7	
37	10	
38	3	
39	1	
48	3	
49	3	
51	1	
60	2	
68	1	
74	2	
Total Sample Companies	50	

²For 1999, ERP market share breakdown: SAP at 51%, Oracle at 24%, PeopleSoft at 12%, J. D. Edwards at 8%, and BAAN at 5% (Gilbert 2000).

Table 4. Descriptive Statistics of Firm Treatment Sample

Panel A: Distribution of sample data — reported values			
Item	Mean	Median	Std. Dev.
	(\$000)	(\$000)	(\$000)
Net Sales	11,980.26	2,674.70	26,116.38
Total Assets	14,507.71	3,605.21	33,823.12
COSTS			
<i>4-Year Average Before Implementation (N=50)</i>			
Cost of Goods Sold	8,041.15	1,561.64	20,227.66
Selling, General, and Admin.	2,073.50	474.70	4,352.16
Employees	63.39	16.30	125.11
<i>1-Year Before Implementation</i>			
Cost of Goods Sold	8,283.18	1,652.10	21,204.48
Selling, General, and Admin.	2,313.77	517.50	4,640.50
Revenues	8,447.71	1,677.71	20,700.01
Employees	62.11	17.06	119.30
<i>1-Year After Implementation (N=50)</i>			
Cost of Goods Sold	8,447.71	1,677.71	20,700.01
Selling, General, and Admin.	2,489.58	649.98	4,495.61
Revenues	8,989.01	1,883.00	22,131.89
Employees	58.71	18.38	107.87
<i>2-Year After Implementation (N=48)</i>			
Cost of Goods Sold	8,989.01	1,883.00	22,131.89
Selling, General, and Admin.	2,599.55	678.45	4,393.50
Revenues	13,528.97	3,074.81	27,797.67
Employees	55.53	20.40	88.66
<i>3-Year After Implementation (N=26)</i>			
Cost of Goods Sold	7,894.53	3,278.00	11,268.66
Selling, General, and Admin.	2,485.72	830.90	4,420.67
Revenues	12,195.82	4,665.52	18,099.37
Employees	56.89	23.00	87.45
Panel B: Distribution of sample data — % of sales			
Item	Mean	Median	Std. Dev.
COST AS A PERCENTAGE OF SALES			
<i>1-Year Before Implementation (N=50)</i>			
Cost of Goods Sold	59.0%	61.4%	18.0%
Selling, General, and Admin.	24.8%	24.3%	12.8%
Employees	0.556%	0.553%	0.233%
<i>1-Year After Implementation (N=50)</i>			
Cost of Goods Sold	60.6%	63.6%	19.2%
Selling, General, and Admin.	26.1%	26.5%	12.5%
Employees	0.540%	0.566%	0.215%
<i>2-Year After Implementation (n=48)</i>			
Cost of Goods Sold	59.7%	61.0%	18.0%
Selling, General, and Admin.	26.0%	24.4%	12.3%
Employees	0.529%	0.493%	0.260%
<i>3-Year After Implementation (n=26)</i>			
Cost of Goods Sold	62.0%	63.1%	14.2%
Selling, General, and Admin.	23.1%	21.9%	11.8%
Employees	0.480%	0.464%	0.184%

Table 5. Descriptive Statistics of Firm Control Sample

Panel A: Distribution of sample data — reported values			
Item	Mean	Median	Std. Dev.
	(\$000)	(\$000)	(\$000)
COSTS			
<i>1-Year Before Implementation</i>			
<i>(N=42)</i>			
Cost of Goods Sold	7,808.60	1,082.45	20,587.27
Selling, General, and Admin.	1,595.05	208.69	4,287.44
Revenues	11,127.32	1,783.61	27,356.87
Employees	38.50	9.26	79.50
<i>1-Year After Implementation (N=42)</i>			
Cost of Goods Sold	7,176.01	1,121.54	19,553.52
Selling, General, and Admin.	1,376.76	284.40	3,484.26
Revenues	10,223.05	1,647.65	25,973.10
Employees	38.50	9.26	79.50
<i>2-Year After Implementation (N=41)</i>			
Cost of Goods Sold	6,672.74	1,261.22	20,364.89
Selling, General, and Admin.	1,524.03	289.75	3,513.60
Revenues	9,604.09	1,757.31	26,411.55
Employees	40.68	9.66	81.35
<i>3-Year After Implementation (N=21)</i>			
Cost of Goods Sold	2,561.64	1,357.65	5,578.61
Selling, General, and Admin.	658.12	344.75	901.25
Revenues	3,873.97	1,975.53	6,691.27
Employees	33.43	10.43	65.93
Panel B: Distribution of sample data — % of sales			
Item	Mean	Median	Std. Dev.
COST AS A PERCENTAGE OF SALES			
<i>1-Year Before Implementation</i>			
<i>(N=42)</i>			
Cost of Goods Sold	60.7%	65.4%	22.0%
Selling, General, and Admin.	25.4%	21.5%	23.6%
Employees	0.827%	0.729%	0.638%
<i>1-Year After Implementation (N=42)</i>			
Cost of Goods Sold	57.6%	62.6%	20.5%
Selling, General, and Admin.	25.9%	23.3%	16.4%
Employees	0.543%	0.473%	0.346%
<i>2-Year After Implementation (N=41)</i>			
Cost of Goods Sold	58.7%	64.7%	21.7%
Selling, General, and Admin.	24.5%	21.8%	13.6%
Employees	0.507%	0.499%	0.335%
<i>3-Year After Implementation (N=21)</i>			
Cost of Goods Sold	57.7%	62.7%	19.0%
Selling, General, and Admin.	24.6%	21.6%	18.4%
Employees	0.508%	0.554%	0.228%

Table 6. Pairwise Sample T-Test Results for Difference in Ratio After Versus Year Before Adoption for ERP Adopting (Treatment) Firms
t-statistic (p-value)

	Comparison of ratio after versus before ERP implementation:			
	SG&A/ Revenues	COGS/ Revenues	Number Employees/ Revenues	Residual Income at 12%
1 year after vs. year before	1.470 (.07)* N=45	1.312 (.10)* N=49	-2.024 (.02)** N=46	0.147 (.44) N=51
2 years after vs. year before	1.195 (.12) N=44	0.696 (.25) N=48	-3.018 (.00)** N=45	0.113 (.46) N=50
3 years after vs. year before	0.059 (.48) N=23	-1.702 (.05)** N=26	-3.372 (.00)** N=42	0.535 (30) N=27

* T-value significant at .10 level, 1-tail.

**T-value significant at .05 level, 1-tail.

NOTE: Sample size varies due to the non-availability of post-implementation data for all sample firms.

Financial values were not adjusted for inflation as the inflation rate for the study period experienced modest to low inflation rates (www.globalfindata.com 2000). Financial information of each firm during the year(s) of implementation is disregarded. According to accounting standards, preliminary project and immediate post-implementation costs of getting the ERP implementation up and running are expensed as incurred.³ The year before ERP implementation is used to capture stable costs before implementation (results are not significantly different when a four year pre-implementation average is used).

4. RESULTS

Paired samples t-tests were performed (Table 6) using pooled data across vendors, comparing performance ratios after versus before ERP implementation. Firm performance is defined as the ratio of cost to revenues in order to capture both the cost reduction and revenue enhancing effects of ERP systems on the firm. This approach also controls for firm size.

Results indicate that ERP implementation is associated with a significant *increase* ($t = 1.470$, $p = 0.07$) in SG&A/revenues one year after implementation over the year prior to implementation. However, ERP implementation has *no* significant association with SG&A/revenues two or three years after implementation. H1 is not supported.

ERP implementations are found to be associated with a significant *increase* ($t = 1.312$, $p = 0.10$) in COGS/Revenues one year after implementation over the year prior to implementation. However, ERP implementation has *no* significant association with COGS/revenues two years after implementation. As predicted, ERP implementation is found to be associated with a significant *decrease* ($t = -1.702$, $p = 0.05$) in COGS/revenues for three years after implementation. H3 is partially supported.

ERP implementation is *not* found to be association with changes in RI one, two, or three years after ERP implementation. H5 is not supported. However, ERP implementations are associated with a *decrease* in EMP/revenues for one ($t = -2.024$, $p = 0.02$), two ($t = -3.018$, $p = 0.00$) and three ($t = -3.372$, $p = 0.00$) years after implementation. H7 is supported.

To examine whether these results are due to macroeconomic events or whether they can be attributed to the ERP system implementation, the control firms' performance relative to the ERP adopters over the corresponding time period was examined. Control firms were tested for significant changes in their before versus after treatment counterpart ERP adoption period (Table 7). Table 8 provides tests of differences between the treatment and control sample. Firms implementing ERP experienced *no* statistical difference from non-adopters in changes in SG&A/Revenues one, two, and three years after ERP adoption. H2 is not supported.

³Under AICPA Statement of Position 98-1, which clarifies FAS 86, an ERP implementation project covers three phases: (1) preliminary project stage, where costs are expensed as incurred, (2) application development stage, which includes software design, interfaces, coding, new hardware and software installation and testing of the system and costs should be capitalized, and (3) post-implementation/operation stage, which including user training where costs are expensed as incurred.

Table 7. Pairwise Sample T-Test Results for Difference in Ratio After Versus Year Before Adoption For Non-ERP Adopting (Control) Firms
t-statistic (p-value)

	Comparison of ratio after versus before ERP implementation:			
	SG&A/ Revenues	COGS/ Revenues	Number Employees/ Revenues	Residual Income at 12%
1 year after vs. year before	-0.736 (.23)* N=37	-2.077 (.02)** N=42	-3.784 (.00)** N=39	1.884 (.03)** N=37
2 years after vs. year before	-0.872 (.19) N=36	-1.271 (.11) N=41	-4.023 (.00)** N=36	1.560 (.06)* N=37
3 years after vs. year before	0.991 (.17) N=22	-1.549 (.07)* N=24	-3.029 (.00)** N=21	1.571 (.07)* N=22

* T-value significant at .10 level, 1-tail.

**T-value significant at .05 level, 1-tail.

NOTE: Sample size varies due to the non-availability of post-implementation data for all sample firms.

Table 8. Independent Sample T-Test Results for Difference between ERP Adopters Versus Non-Adopters
t-statistic (p-value)

Panel A: t-test results	Difference between groups based on change in ratio after minus before treatment group adoption period:			
	Change in SG&A/ Revenues	Change in COGS/ Revenues	Change in Number Employees/ Revenues	Change in Residual Income at 12%
1 year after less year before	-0.976 (.33) N=46, 37	2.327 (.02)** N=51, 42	-0.653 (.52) N=47, 39	-0.837 (.41) N=51, 37
2 years after less year before	1.076 (.29) N=25, 36	1.874 (.07)* N=30, 41	3.445 (.00)** N=27, 36	-0.502 (.62) N=50, 37
3 years after less year before	-0.148 (.86) N=8, 22	1.210 (.25) N=10, 24	1.971 (.06)* N=9, 21	0.274 (.79) N=27, 22
Panel B: ERP Adopters Means	Mean change in ratio after minus before ERP implementation:			
	Change in SG&A/ Revenues	Change in COGS/ Revenues	Change in Number Employees/ Revenues	Change in Residual Income at 12%
1 year after less year before	-1.126	0.0324	-0.00910	16.982
2 years after less year before	0.0115	0.0169	-0.00039	14.615
3 years after less year before	0.0156	0.0179	-0.00131	134.376
Panel C: Non-Adopters Means	Mean change in ratio after minus before ERP implementation period of treatment group:			
	Change in SG&A/ Revenues	Change in COGS/ Revenues	Change in Number Employees/ Revenues	Change in Residual Income at 12%
1 year after less year before	-0.0168	-0.0203	-0.00328	129.233
2 years after less year before	-0.0279	-0.0194	-0.00349	171.868
3 years after less year before	0.0219	-0.0210	-0.00409	66.100

* T-value significant at .10 level.

** T-value significant at .05 level.

NOTE: Sample size varies due to the non-availability of post-implementation data for all sample firms. N = number of ERP adopting firms, number of Non-adopting firms.

Control firms significantly *outperformed* ERP adopters in changes in COGS/Revenues one ($t = 2.327$, $p = 0.02$) and two ($t = 1.874$, $p = 0.07$) years after the treatment firms adopted their ERP package, but there is *no* significant difference in the third year after implementation. H4 is not supported.

Firms implementing ERP experienced *no* statistical difference from non-adopters in changes in RI one, two, and three years after the treatment firms adopted ERP. H6 is not supported. With respect to EMP/revenues, *no* significant difference between groups is found for one year after the treatment firms adopt ERP ($t = -0.653$, $p = 0.52$), control firms experience significantly greater *decreases* in EMP/Revenues two and three years after treatment firms adopt ERP ($t = 3.445$, $p = 0.00$; $t = 1.971$, $p = 0.06$). H8 is not support.

5. CONCLUSION AND LIMITATIONS

Based on the sample of 50 companies implementing ERP packages from 1993 to 1997, results indicate a significant *increase* in costs as a percentage of revenue but a *decrease* in the number of employees as a percentage of revenue the year after ERP implementation. However, matching control firms experience a greater reduction in employees. In addition, these firms had significant increases in residual income. Results indicate a paradox where firms having fewer employees supporting more revenue simultaneously experience higher cost to revenue ratios after their ERP implementation. Because of the expense of ERP and implementation difficulties, firms could be reducing costs by streamlining processing and eliminating automated clerical duties, but increasing costs from hiring expensive ERP computer engineers. Another reason that costs as a percentage of revenue increase after implementing an ERP system, is that on-going fixes and fine-tuning of installations may continue past the officially stated implementation ending date.

The limitations to this study include:

- Industry experts predict a four to five year return for ERP implementations (Knorr 1999; Wah 2000; Wortmann 1998), hence the three year longitudinal window may be insufficient to capture the effects of ERP on firm performance.
- This study was not able to control for implementation and organizational characteristics .
- The sample only included firms that voluntarily disclosed the announcements. As a result, the sample may be biased.

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⁴This paper and the following reference list contain URLs for World Wide Web pages. These links existed as of the date of submission but are not guaranteed to be working thereafter. The contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced. The author(s) of the Web pages, not ICIS, is (are) responsible for the accuracy of their content. The author(s) of this article, not ICIS, is (are) responsible for the accuracy of the URL and version information.

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Appendix A. Examples of Company Performance and ERP

Panel A: Stories by Firms Implementing ERP—Positive Impacts

- Arizona Electric Power Corporation implemented J.D. Edwards ERP software and reduced month-end closings from 38 to 9 days, decreased invoice processing from 30 to 2.5 days, and reduced annual material and supply costs by \$350,000 (www.jdedwards.com 2000).
- Hoechst Marion Roussel implemented SAP and found greater flexibility and accelerated decision-making at all levels of the firm (www.sap-ag.de 1997).
- Westcoast Energy Inc. found after implementing SAP, its average materials procurement went from 23 to 12 days and financial month-end closing went from 12 to 6.5 days. Westcoast has projected its SAP implementation has saved \$2.5 million per year in bottom-line cost savings from the elimination of non-value-added steps in their business processes (www.sap-ag.de 1997).
- Purina Mills Inc. stated that its ERP led to system consolidation of many business processes at their headquarters. As such, they reduced headcount by eliminating redundant staff in branch offices and in the accounting function, leading to a 43% reduction in headcount costs (Wah 2000).
- Peak USA Energy Services says ERP has led to additional revenues and costs savings of about \$900,000 annually (Wah 2000).

Panel B: Stories by Firms Implementing ERP—Negative Impacts

- Hershey Foods' \$112 million ERP software from SAP fouled up the company's candy shipments for Halloween in October 1999. Hershey announced a 19% drop in third-quarter profits because of order-processing problems, which will likely result in lost market share (Boudette 1999; Stedman 1999).
- Whirlpool said problems with a new SAP system and a high volume of orders combined to delay shipments of appliances to many distributors and retailers (Boudette 1999).
- Medline is suing Andersen Consulting in connection with Andersen's ERP implementation. Medline charged that Andersen failed to configure the ERP systems appropriately (Stein 1997).
- Hydro Agri's fertilizer stores experienced an increase from 20 to 90 seconds in order processing time after implementing SAP's ERP package (Stedman 1998).
- A-dec Inc. found calls to their help desk increased 64% after implementing BAAN's financial and manufacturing modules (Stedman 1998).

Appendix B. Examples of Press Release of ERP Adoption

1. News Release/Announcement:

HEADLINE: Plaut Consulting Leads Accelerated SAP R/3 Implementation at Cabletron Systems

DATE: July 21, 1997

Networking leader is one of the first in U.S. to support 1,100 users utilizing Windows NT applications servers and an Oracle database. Multisite, enterprisewide R/3 implementation is on time and within budget.

Plaut Consulting Inc. announced today that its management consultants led a successful 12-month implementation of SAP's R/3 integrated business application solution for Cabletron Systems, a leading manufacturer of computer networking systems and services. Cabletron completed its first quarter-end close on the new system in June.

According to Klaus Schottenhamel, President of Plaut Consulting, "This fast and effective R/3 implementation illustrates not only that Plaut can manage projects of this size and scope within budget and on time, but it also showcases our ability to successfully partner with multiple parties to get the job done."

Data Gathered:

- Client: Cabletron Systems
- Implementation window: 12 months ended July 1997
- Years of Implementation: Calendar year 1996 and 1997
- ERP Vendor: SAP
- Consultant: Plaut Consulting

2. News Release/Announcement:

HEADLINE: Daw Technologies Selects Oracle Over Its Competitors for Financial and Manufacturing Applications; Oracle's FastForward(SM) Approach Enables Rapid Implementation; Month-End Close Cut from Two Weeks to Two Days

DATELINE: SALT LAKE CITY, July 7, 1997, Monday

Oracle Corp. (Nasdaq: ORCL) today announced that Daw Technologies (Nasdaq: DAWK), a global provider of ultraclean environments that specializes in the design, manufacture and installation of cleanrooms to the semiconductor industry, expects to complete its six-month Enterprise Resource Planning (ERP) implementation of Oracle Applications(TM) in July. The rapid implementation has been made possible by Oracle Consulting Services'(SM) new FastForward(SM) approach, an offering designed to deliver fast time-to-benefit for mid-sized companies implementing Oracle Applications. The Oracle package, including Oracle Financials(R), Oracle(R) Manufacturing and Oracle(R) Projects application suites as well as Designer/2000(TM), Developer/2000(TM) and Discoverer(TM) tools, is expected to help Daw Technologies manage its rapid growth through improved data access, consistent data integrity, and more cost-effective systems for managing projects.

Data Gathered:

- Client: Daw Technologies
- Implementation window: 6 months ended July 1997
- Years of Implementation: Calendar year 1997
- ERP Vendor: Oracle
- Consultant: Oracle Consulting Services

3. News Release/Announcement:

HEADLINE: Nabi Goes Live with HP Rapid/3 Implementation OF R/3

DATELINE: ORLANDO, Florida, August 25, 1997

Hewlett-Packard Company today announced that Nabi, a leading biopharmaceutical company, has gone live with an HP Rapid/3 implementation of SAP's R/3. The fixed-price project, managed by HP's Professional Services Organization, was completed in only seven months.

The company urgently needed to integrate its business functions and replace existing systems as a result of its rapid growth. Nabi, one of the world's largest independent providers of human plasma products, required a new system that could deliver timely, accurate data and that could interface with its plasma-donor management system. In 1996, Nabi selected R/3 to meet its current and future needs and chose HP's Rapid/3 accelerated-implementation approach, which incorporates SAP's AcceleratedSAP methodology to deliver benefits to the organization quickly. According to Nabi, the project would not have been as successful without HP's participation.

Data Gathered:

- Client: Nabi
- Implementation window: 7 months ended August 1997
- Years of Implementation: Calendar year 1997
- ERP Vendor: SAP
- Consultant: Hewlett-Packard's Professional Services Organization