Market Reaction to Announcements to Invest in ERP Systems

Daniel C. Benco
Southeastern Oklahoma State University

Larry Prather
Southeastern Oklahoma State University

We examine the reaction of 111 firms that announce investments in ERP systems. To ensure that the results are robust, we use equally weighted and value weighted indices, estimate event study betas with OLS and Scholes-Williams techniques, and use GARCH and EGARCH methods to examine how differences in assumptions concerning event period return variance affect the results. Further examination controls for firm size, industry, and health. Finally, matched-pair analysis examines whether ERP announcements by a firm affect non-announcing firms. Results reveal that only healthy firms that announce ERP investments experience statistically significant event period returns. Moreover, those results are robust.

Introduction

Information technology (IT) investment has expanded significantly during the past few decades; investment in information processing equipment and software grew at a compounded annual growth rate of about 25 percent between 1980 and 1999 (BEA 2002), becoming the largest category of capital investment in the US during the past decade (Ranganathan and Brown, 2006). A sizable component of that growth is enterprise resource planning (ERP) systems that promise to integrate seamlessly all information flowing through the company including manufacturing, engineering, marketing, and finance through one enterprise database (Davenport, 1998; McAlary, 1999). Each module is business-process specific, interacts with a single company-wide database, and represents a single application from user and systems perspectives (Poston and Grabski, 2001).

ERP systems are the most ambitious use of IT by businesses and incorporate best business practices into one integrated software application package that can affect every function within a business. By constructing one firm-wide database with which all applications interact, ERP systems reduce data redundancy and data errors and, as a result, significantly enhance data integrity and reliability and provide cur-

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rent, accurate information to all decision makers (Latamore, 2000). Moreover, ERP systems can provide high levels of process integration across interdependent organizational units (Park and Kusiak, 2005), increase throughput and delivery speed by reducing order cycle time and customer response time (Cotteleer and Bendoly, 2006; McAfee, 2002), and reduce cash-to-cash cycle times and the time needed to reconcile financial data, thereby reducing the amount of operating capital (Mabert, Soni, and Venkataramanan, 2000 and 2003). Finally, ERP investments provide growth options and can enhance a firm's agility and innovativeness (Fichman, 2004; Sambamurthy, Bharadwaj, and Grover, 2003).

ERP system implementation has not proven to be universally successful. There are many reports of failed projects (Barker and Frolick, 2003; Davenport, 1998; Gargeya and Bradley, 2005). Recent research has attempted to address the alignment of ERP systems to strategies by using an analytic network process model built on a strategic alignment model to reduce failure (Presley, 2006) that may increase the success rate of ERP implementation.

ERP systems are not only ambitious, but they also require a significant capital investment and require substantial time to implement. For example, Umble and Umble (2002) report that survey results from 63 companies indicate that the average implementation cost was $11 million and took 23 months to complete. META Group (2003) reports that the average cost of an ERP system was $17.5 million and required 20 months to implement. Thus, ERP systems should be subject to review in the capital budgeting process.

Despite numerous studies on the announcement effect of IT investments in general, few studies examine the announcement effect of ERP system implementations.[1] Results of IT announcements in general present mixed findings on the announcement effect for all announcing firms and subgroups based on firm size and industry. Examination of the announcement effects for ERP announcements is limited. Hayes, Hunton, and Reck (2001) use conventional event study methodology to examine abnormal returns around ERP investment announcements. They report that the market reacts positively to ERP announcements, that the effect is largest for small/healthy firms, and that only large ERP vendors produce significant market reaction. Ranganathan and Brown (2006) also study ERP announcements but focus on differences in the announcement effect due to project-specific variables such as functional scope, physical scope, and vendor status.

Our focus is to extend the research of Hayes, et al. (2001) in several ways. This is important because, despite the project-specific factors, an investment should not be undertaken that does not add value to the firm. Thus, we want to examine more closely these firm-specific factors. We first use multiple event study models, indexes, and test statistics to examine the robustness of results. These additional tests

[1]See Ranganathan and Brown (2006) for an excellent review of IT and ERP announcement studies.

are vitally important because empirical results hinge critically upon the assumptions used by the model and test statistic. The goal is to ensure that previous findings are not an anomaly of a specific model, beta estimation method, or assumption about the behavior of returns variances. In short, we want to ensure that results are robust. Second, we include matched sample testing to strengthen the analyses. Elayan, Pukthuanthong, and Roll (2005) use a matched sample event study analysis to ascertain whether an announcement to take action by a firm has adverse effects on a matched sample firm that chose not to take action. While we do not expect any reaction to non-announcing firms, we pursue similar testing to ascertain whether an ERP announcement adversely affects non-announcing firms. Gaver and Gaver (1993) also argue that using matched samples may mitigate industry and macroeconomic forces. The matched sample (control group) is selected by finding observations in the same population from which the sample of interest (treatment group) is drawn such that these observations are as similar as the sample firms as practicable.

Results reveal that only healthy firms that announce ERP investments experience statistically significant event period returns. Moreover, those results are robust to the use of index, model, or statistical test.

Literature Review

Davenport (2000) asserts that advances in information technology and the plethora of mergers and acquisitions in the 1980s and 1990s created a global economy in which many of the larger players are conglomerates with too many non-integrated information systems and too many different ways of doing the same thing. Moreover, these companies' systems cannot communicate effectively with each other, their databases are many and redundant, and their need for specialized labor or software to convert data from one legacy system to another is expensive. Because ERP systems promise seamless integration of information, companies increasingly have invested in ERP systems.

Several studies discuss ERP implementation effects on firms and report mixed results. Minahan (1998) suggests that ERP systems can leverage information to make better decisions. Palaniswamy and Frank (2000) suggest that ERP systems can reduce the number of systems greatly (resulting in significant cost savings) and can improve the performance of the manufacturing function significantly. A firm may not see the kind of savings it is looking for, however, if it does not make changes in the way it conducts business to take advantage of the new ERP system.

Brynjolfsson and Hitt (1996) examine the productivity paradox, which was the observation in the early 1990s that IT spending did not contribute to profitability. They report that investments in IT make a statistically significant contribution to firm output. Poston and Grabski (2001) analyze accounting and non-accounting performance measures and report a decrease in the cost of goods sold as a percentage of sales in the third year.

Dos Santos, Peffers, and Mauer (1993) examine abnormal returns around announcements of IT investments for 97 firms and find no abnormal returns for either their full sample or any of the industry subsamples. Im, Dow, and Grover (2001) analyze 238 IT investment announcements, representing the 97 firms (1981–1988) studied by Dos Santos et al. (1993) and 141 from 1989–1996. They test for a size effect and an industry effect and report no abnormal returns to IT investment announcements in general. They find that when small firms are analyzed separately, however, that (1) announcements result in a positive price reaction, (2) both price and volume reactions increase over time, and (3) industry and size effects increase over time.

Hayes et al. (2001) examine market reaction to a firm's announcement to implement an ERP system. They report an overall positive reaction to initial ERP announcements, which is most positive for small/healthy firms and more positive for larger ERP vendors than for smaller ERP vendors.

Hunton, McEwen, and Wier (2002) examine changes in financial analysts' earnings predictions after they receive an announcement that a firm planned to implement an ERP system. They report that the overall reaction to the announcement is positive, with mean post-announcement earnings forecasts significantly exceeding mean pre-announcement earnings forecasts.

One deficiency the above studies have in common is that the studies do not examine the robustness of their results using multiple indexes, beta estimation techniques, models, and test statistics. Because event study results hinge critically on these issues, it will be helpful to examine how changes in these factors affect results.

Another deficiency of prior studies is that they focus only on firms that announce an ERP investment. Testing of matched pairs permits us to control for confounding macroeconomic or industry influences. For example, Larcker (1983) uses a matched-pair design to control for macroeconomic or industry influences. O'Connor (1994) uses matched pairs to examine differences in marketing strategies and operational tactics to determine how surviving and failing firms differ. Loughran and Ritter (1997) compare the operating performance of firms conducting seasoned equity offerings with non-issuing firms with the same growth rate. Kathuria, Porth, and Joshi (1999) test for agreement of manufacturing strategies between general managers and manufacturing managers, and Kearns and Lederer (2000) obtain paired responses from the IS executive and another senior executive within the same organization to reduce common source variance associated with sampling. Finally, Elayan, et al. (2005) use a matched sample event study analysis to ascertain whether an announcement to take action by a firm has adverse effects on a matched sample firm that chose not to take action. Thus, we include matched pair tests to strengthen results.

Table 1—Sample Distribution

Panel A: Announcement Year

	1992	1993	1994	1995	1996	1997	1998	1999	Total
Total Announcements	33	19	36	114	297	734	2,286	3,811	7,330
Less:									
Non-ERP	16	15	22	44	47	84	186	499	913
Vendor/Product Only	13	4	10	54	176	443	1,637	2,680	5,017
Duplicates	3	0	0	2	32	68	177	340	622
No CUSIP Number	1	0	2	2	30	99	199	197	530
Confounding Events	0	0	1	5	10	17	40	59	132
Subtotals	0	0	1	7	2	23	47	36	116
Insufficient CRSP Data	0	0	1	0	0	1	1	2	5
Announcing Sample	0	0	0	7	2	22	46	34	111
Matched Pair Sample	0	0	0	7	2	22	46	34	111

Panel B: SIC Classification of ERP Sample Firms

2-Digit SIC Code	20	22	23	25	26	27	28	29	32	33	34	35	36	37	38
Announcing Sample	7	3	1	2	3	3	12	1	1	6	3	11	11	15	6
Matched Pair Sample	7	3	1	2	3	3	12	1	1	6	3	11	11	15	6

2-Digit SIC Code	42	45	48	49	50	51	56	58	59	67	73	78	79	99	Tot
Announcing Sample	1	2	1	1	3	1	2	1	2	1	8	1	1	1	111
Matched Pair Sample	1	2	1	1	3	1	2	1	2	1	8	1	1	1	111

Data and Methodology

We examine the impact of ERP investment announcements on the stock price of announcing firms and on a matched sample of non-announcing firms to test whether any significant impact on firm value occurs. If ERP investment announcements possess significant information content, then an association between these announcements and abnormal security returns should exist. The reaction may be positive if the ERP investment announcement suggests positive risk-adjusted net cash flows or negative if the announcement represents a commitment of resources that may not result in positive risk-adjusted net cash flows.

Data

We use the Lexis-Nexis database to identify firms that announce an ERP investment. To be included in our sample the firm must: (1) announce an ERP investment between January 1, 1982 and December 31, 1999, (2) be listed on the NYSE, AMEX, or Nasdaq, and (3) have a sufficient time series of return data in the CRSP database. To prevent bias in our results, the firm must not have had any other major firm-specific announcements (e.g., mergers, joint ventures, takeovers, lawsuits, earnings, dividends, capital expenditures, or patents) during the announcement period. Descriptive statistics for our final sample of 111 announcing firms appear in Table 1.

To select the matched non-announcing firms we match the SIC codes of non-announcing firms to the SIC codes of announcing firms. If one or more four-digit matches are found, the total assets at t–1 for the non-announcing firm are compared to the total assets at t–1 for the announcing firm. The matched firm whose total assets are closest in reported value to the corresponding announcing firm's total assets is selected for inclusion in the matched pair sample. If no four-digit matches are found, then matches on the first three digits of the SIC code or the first two digits of the SIC code are used, respectively. To be selected as a non-announcing matching firm, (1) the firm's fiscal year-end must match that of the announcing firm, (2) the two-digit SIC code is the same as the announcing firm, (3) total assets must be similar to the announcing firm, and (4) the non-announcing firm does not make an ERP investment announcement during the relevant four-year window. This screening resulted in a sample of 111 non-announcing firms matching firms.

Table 2—Descriptive Statistics for the Matched Non-announcing Firms

	Number of Firms	Percentage of Firms
Panel A: Distribution of Matches on SIC Code Criterion		
4-Digit	16	14.4
3-Digit	20	18.0
2-Digit	75	67.6
	111	100
Panel B: Distribution of Differences in Reported Total Assets		
Difference		
<10%	96	86.5
<20%	9	8.1
<30%	5	4.5
≥ 30%	1	0.9
	111	100

Table 2 presents descriptive statistics of the matched firms. All 111 matched firms match on at least the first two digits of the SIC code and 96 of the 111 matched firms report total assets within 10 percent of the announcing firm's reported total assets. Only one matching firm's total assets differ from its corresponding announcing firm's total assets by more than 30 percent.

Methodology

We employ event study methodology to measure the announcement effect on a firm's stock. Estimates use a 155 day event window from -200 through -45.[2] To ensure that the results are robust, we utilize OLS and Scholes and Williams (1977)

[2]As a robustness test, we also use a +45 through +200 event window because Berk, Green, and Naik (1999) suggest that risk may decline after real options are exercised.

beta estimates. Scholes and Williams (1977) and Dimson (1979) argue that nonsynchronous trading causes OLS estimators of market model parameters to be biased and inconsistent. Cowan (1992) compares the results of using both the Scholes and Williams and OLS beta estimates, however, and concludes that neither is uniformly superior.

Because the homoskedasticity assumption of the traditional market-model approach may be violated, we also utilize generalized autoregressive conditional heteroskedasticity (GARCH) and exponential generalized autoregressive conditional heteroskedasticity (EGARCH) models to ensure robustness. The GARCH model, proposed by Bollerslev (1986), allows the conditional variance to change as a function of past-realized residuals and past variances. The EGARCH model, proposed by Nelson (1990), does not impose non-negativity constraints on the coefficient estimators of the market model parameters and allows past residuals of different signs to have a differential impact on future volatility compared to the standard GARCH model. Akgiray (1989) reports that the variance of daily stock returns exhibits strong autoregressive conditional heteroskedasticity properties, and Boehmer et al. (1991) provide evidence that event study regression models that account for time-varying conditional variance properties and stochastic parameters generate more efficient estimators than the traditional event study methodology.

We use both the CRSP equally weighted (EW) index and the CRSP value-weighted (VW) index as market proxies to mitigate benchmark bias. These robustness tests are particularly vital in light of the findings of Lehmann and Modest (1987), who furnish empirical evidence that the selection of the market proxy affects risk-adjusted performance. The choice of the CRSP value-weighted index is important theoretically because it is closer in spirit to the essence of CAPM, whereas our motive for using the CRSP equally weighted index is that Kothari and Warner (2001) find that it mitigates some size-related bias and produces the least model misspecification.

Our tests of statistical significance utilize the parametric standardized cross-sectional t-test and non-parametric tests, including the generalized sign Z-test and rank Z-test. Our rationale for using a multiplicity of tests is that no single test appears to dominate the others in terms of power and Type I and Type II errors (e.g., Cowan, 1992). Appendix A provides details on the event study methodology and test statistics that we employ.

Empirical Results

Panel A of Table 3 presents results of tests of the announcement effect of ERP investment announcements for the full sample of 111 announcing firms using EGARCH methodology and the CRSP value-weighted index. The AARs are slightly positive on event days -1, 0, and +1; however, the standardized cross sectional t-test suggests that only the event day -1 AARs are statistically different from zero at the

Table 3—All Firms

The upper section of Panels A and B, columns one and two, present the event day and average abnormal return (AAR). Column three presents the percentage of firms with positive average abnormal returns. Columns four through six present the absolute test statistics for the two-tailed tests of the hypothesis that the abnormal return is zero. The lower section of Panels A and B, columns one through three, present the event period, mean cumulative abnormal return, and median cumulative abnormal return. Column four presents the percentage of positive cumulative average abnormal returns. Columns five through seven present the absolute test statistics for the two-tailed tests of the hypothesis that the cumulative average abnormal return is zero. Tests for both panels include the standardized cross-sectional t-test, generalized sign Z-test, and rank Z-test

Panel A: Announcing

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	0.56%	48.6	1.660*	0.181	0.610
0	0.05%	43.1	0.139	-0.970	-0.120
+1	0.17%	45.0	0.513	-0.586	-0.670

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	0.78%	-0.15%	46.7	1.335	-0.203	-0.100

Panel B: Non-announcing

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	-0.25%	52.2	-0.601	0.900	-0.350
0	0.52%	55.0	1.259	1.208	0.810
+1	-0.32%	47.7	-0.783	-0.240	-0.470

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	-0.15%	-0.17%	49.5	-0.072	0.330	-0.005

*, **, *** Denotes significance at the 10 percent, 5 percent and 1 percent level, respectively

10 percent level. Moreover, the -1 through +1 event period CAARs are small and positive but not statistically different from zero.

Table 3 also presents results of examining the impact of ERP investment announcements on matched pairs of 111 non-announcing firms to determine if non-announcing firms are affected by the announcement of announcing firms. This analysis is important because industry-wide events or phenomena may occur that have a similar impact on other firms in an industry regardless of whether those firms announce ERP investments. Thus, this testing mitigates confounding macroeconomic or industry influences and allows us to focus on differences for the event of interest (Larcker, 1983).

Panel B of Table 3 shows that non-announcing firms did not react significantly to ERP announcements by announcing firms when an EGARCH model with CRSP value-weighted index is used. To ascertain whether differential reaction was exhibited between the announcing and non-announcing samples, the Kolmogorov-Smirnov test was used to test each sample for normality. Because the Kolmogorov-

Smirnov test rejected the hypothesis of normality for each of the samples ($p < 0.01$ for each sample), the Mann-Whitney U test was used to examine the difference in the sample medians. Results suggest that there is no difference between the CAARs of the announcing and non-announcing firms ($p = 0.877$).

Table 4 summarizes robustness tests for all announcing and all non-announcing samples. The table layout provides columns for the major types of method (OLS, Scholes-Williams, GARCH, and EGARCH) with each column divided into two sub-columns for the index used. The rows represent event days -1, 0, +1 and event period -1 through +1. Cells have entries if some test statistic detects statistical significance for that combination of method and index. The entry in the cell will have a plus or minus sign to show the direction of the abnormal return, a number (1, 5, or 10) indicating the level of statistical significance, and an abbreviation of the test statistic. Abbreviations for the test statistics are std = standardized cross-sectional test, gs = generalized sign test, and rz = rank z test.

Table 4—All Firm Robustness

Columns one through nine list the event day and event-study method and index combinations. The rows represent event-days -1, 0, +1 and event-period -1 through +1. Cells have entries if one of our test statistics detects statistical significance for that combination of method and index for that event-day. The entry in the cell will have a plus or minus sign to show the direction of the AAR, a number (1, 5, or 10) indicating the level of statistical significance, and an abbreviation for the test statistic (std = standardized cross-sectional test, gs = generalized sign test, and rz = rank z test)

Event	OLS		SW		GARCH		EGARCH	
Day	EW	VW	EW	VW	EW	VW	EW	VW
All Announcing (N=111)								
-1			+ 10 std	+ 10 std				+ 10 std
0								
+1								
-1,+1	+ 10 gs	+ 10 gs						
All Non-announcing (N=111)								
-1								
0				+ 10 gs				
+1								
-1,+1								

Contrary to Hayes et al. (2001), the results for all 111 announcing firms (upper panel) reveal that there is little evidence of reaction. No combination of index, method, or test statistic ever produces a result that is significant at the 5 percent significance level (or better). Moreover, statistical significance at the 10 percent level tends to be random rather than robust with respect to index, method, or test statistic. The lower panel reveals that the results for the 111 non-announcing firms are similar. Given the weak and sporadic evidence, it is difficult to support a general market reaction for all announcing or non-announcing firms.

The Firm Size Hypothesis

Although prior studies consider the impact of firm size and industry on the reaction to IT investment announcements, little research specifically examines the impact of firm size and industry on ERP investments. Yet firm size and industry may be important. For instance, Joaquin and Khanna (2001) demonstrate that a firm with smaller assets in place has an advantage with respect to new investment projects because exit costs are lower. Thus, firm size may play a role in investment decisions and smaller firms may be more likely to benefit from investments in new technologies than larger firms. This would also be consistent with the findings of Im et al. (2001) for IT investments.

Another motivation for examining firm size is the work of Banz (1981) and Reinganum (1981) who report return differences in firms grouped by size that are not explained by the capital asset pricing model. Moreover, Moeller et al. (2004) find size-related CAAR differences for acquiring firms. There may be two related issues here. First, there may be differences in the relative size of investment compared to value of the firm. Second, incentives of managers in small firms may be better aligned with the goals of shareholders. Numerous explanations for the firm size anomaly in stock returns have been proposed, such as information asymmetry, analyst coverage, transaction costs, and trading activity. Despite attempts to solve the size effect puzzle, however, it remains an anomaly in the literature. If information asymmetry causes the size effect, we would expect that because the media follows large firms more closely, investors would be more confident about larger firms. The result would be that large firms should react less to ERP announcements because investors feel well informed about firm prospects. Smaller firms would possess more information asymmetry because investors would feel less confident that they understand firm prospects; therefore, they would react more to ERP announcements. This explanation is consistent with Hong et al. (2000), who report that information concerning small-capitalization firms diffuses more slowly, and also with Merton (1987) and Grossman and Miller (1988), who state that arbitrage may be less effective for small-capitalization stocks. It is also consistent with the findings of Im et al. (2001).

Despite the reason for the size effect, Dimson and Marsh (1986) suggest that size should be considered in event studies. To examine the firm size hypothesis, we divide the sample into three groups and assign the 40 firms with the highest (lowest) total assets to the large (small) sub sample.

As shown in Panel A of Table 5, none of the event day -1, 0, or +1 AARs for the 40 large firms are significantly different from zero when EGARCH methodology is used with the CRSP value-weighted index. Additionally, the event period (-1 to +1) CAARs are not statistically different from zero.

Panel B of Table 5 presents the results for the 40 small firms using EGARCH methodology and the CRSP value-weighted index. Results reveal that small firms do not react significantly to ERP announcements. To ascertain whether differential

Table 5—Announcing Firm Size

The upper section of Panels A and B, columns one and two, present the event day and average abnormal return (AAR). Column three presents the percentage of firms with positive average abnormal returns. Columns four through six present the absolute test statistics for the two-tailed tests of the hypothesis that the abnormal return is zero. The lower section of Panels A and B, columns one through three, present the event period, mean cumulative abnormal return, and median cumulative abnormal return. Column four presents the percentage of positive cumulative average abnormal returns. Columns five through seven present the absolute test statistics for the two-tailed tests of the hypothesis that the cumulative average abnormal return is zero. Tests for both panels include the standardized cross-sectional t-test, generalized sign Z-test, and rank Z-test

Panel A: Large

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	0.18%	45.0	0.528	-0.348	0.150
0	-0.17%	42.5	-0.499	-0.664	-0.590
+1	-0.24%	40.0	-0.690	-0.981	-1.130

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	-0.23%	-0.61%	40.0	-0.381	-0.981	-0.907

Panel B: Small

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	1.26%	50.0	1.629	0.249	0.310
0	-0.58%	42.1	-0.748	-0.725	-0.590
+1	-0.02%	44.7	-0.027	-0.400	-0.140

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	0.66%	-0.08%	47.4	0.493	-0.076	-0.243

*, **, *** Denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

reaction was exhibited between the large firm and small firm samples, the Kolmogorov-Smirnov test was used to test each sample for normality. Because the Kolmogorov-Smirnov test rejected the hypothesis of normality for the small firm sample ($p < 0.01$ for each sample), the Mann-Whitney U test was used to examine the difference in the sample medians. Results suggest that there is no difference between the CAARs of the large firms and small firms ($p = 0.905$).

We now examine the effects of robustness tests for the large and small announcing and non-announcing samples. The sample size for each of these four groups is 40 firms. For large firms, no method, index, or test statistic is able to reject the null hypothesis of no reaction for both the announcing and non-announcing firm samples. The same is true of small announcing firms. Thus, our results differ from those of Im et al. (2001) for small firms. Small non-announcing firms stand in stark contrast to the other small firm samples. The event day 0 AARs are positive and statistically significant for small non-announcing firms with every combination of method and index, except the EGARCH method with the CRSP equally weighted index. Moreover, this result is robust with respect to the test statistic. The only difference between the combinations of methods, indexes, and test statistics is the level of significance. Thus, there is strong evidence that small non-announcing firms react positively to the announcement that small competitor firms will invest in an ERP system. This result is both unexpected and unexplained. Perhaps this suggests disbelief that the firms will be able to seamlessly transition to the new systems, thereby creating a competitive advantage for the non-announcing firms. The event period -1 through +1 CAARs are small and not statistically different from zero. Thus, the economic effect over the event period is not statistically different from zero.

The large announcing and non-announcing samples and small announcing and non-announcing samples were tested for normality so that an appropriate test of the equality of CAARs for the announcing and non-announcing firms could be conducted. Results reveal that the hypothesis of equal CAARs could not be rejected for large announcing and non-announcing firms ($p = 0.914$) or small announcing and non-announcing firms ($p = 0.699$).

The Firm Industry Hypothesis

Industry may be important as well. Porter and Millar (1985) conclude that the processes of banks are more information-intensive than the processes of manufacturing firms and, as a result, service firms may perform differently than manufacturing firms. Dos Santos et al. (1993) confirm an industry effect for IT investment announcements (manufacturing versus banking). The *ex ante* expectation is that service firms are more information intensive and will experience larger market reactions to ERP investment announcements than non-service firms.

Panel A of Table 6 presents the results for 21 announcing firms in the service industry using EGARCH methodology with the CRSP value-weighted index. While AARs on all three event days are greater than 1 percent, none of the AARs are statistically different from zero. The cumulative effect is that the event period (-1, +1) CAARs are greater than 4.3 percent and are statistically different from zero at the 1 percent level. These results are consistent with those of Porter and Millar (1985) and Dos Santos et al. (1993).

Panel B of Table 6 presents analysis for the 90 announcing non-service firms. Similar to the results for service firms, the AARs of non-service firms are not statistically different from zero. In addition, their magnitude is smaller which results in a much smaller event period CAAR that is not statistically different from zero. Thus, the market appears to view the announcements of ERP investments by service firms more favorably than those of non-service firms. The mean cumulative effect during the event period is greater than 4 percent. To ascertain whether differential reaction was exhibited between the service and non-service firm samples, the Kolmogorov-Smirnov test was used to test each sample for normality. Because the Kolmogorov-Smirnov test rejected the hypothesis of normality for the service firm sample (p <

Table 6—Announcing Firm Industry

The upper section of Panels A and B, columns one and two, present the event day and average abnormal return (AAR). Column three presents the percentage of firms with positive average abnormal returns. Columns four through six present the absolute test statistics for the two-tailed tests of the hypothesis that the abnormal return is zero. The lower section of Panels A and B, columns one through three, present the event period, mean cumulative abnormal return, and median cumulative abnormal return. Column four presents the percentage of positive cumulative average abnormal returns. Columns five through seven present the absolute test statistics for the two-tailed tests of the hypothesis that the cumulative average abnormal return is zero. Tests for both panels include the standardized cross-sectional t-test, generalized sign Z-test, and rank Z-test

Panel A: Service

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	1.46%	57.9	1.533	0.805	0.300
0	1.44%	47.4	1.508	-0.113	0.290
+1	1.48%	42.1	1.551	-0.572	0.190

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	4.38%	1.30%	57.9	2.651***	0.805	0.458

Panel B: Non-service

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	0.37%	46.7	1.044	0.171	0.530
0	-0.25%	42.2	-0.698	-1.015	-0.270
+1	-0.10%	45.5	-0.291	-0.382	-0.810

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	0.02%	-0.33%	44.4	0.032	-0.593	-0.317

*, **, *** Denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

0.01 for each sample), the Mann-Whitney U test was used to examine the difference in the sample medians. Results suggest that there is no difference between the CAARs of the firms in the service sector and firms in the non-service sector (p = 0.288).

We now examine robustness tests for the combinations of industry and announcing status. Results for the 90 non-service firms show no evidence of a reaction for either the announcing or the non-announcing firms. Moreover, the evidence of a reaction for the 21 announcing service firms is weak (10 percent level) and mixed.

The strongest reaction comes from the 21 service non-announcing firms. The event day 0 AARs are positive and statistically significant at the 10 percent level (or greater) for all combinations of method and index. Moreover, the results are not confined to a single test statistic. These results are robust; however, we cannot explain these unexpected results. Despite the strong announcement day reaction, the event period CAARs are not statistically different from zero with any method, index, or test statistic.

The service announcing and non-announcing samples and non-service announcing and non-announcing samples were tested for normality so that an appropriate test of the equality of CAARs for the announcing and non-announcing firms could be conducted. Results reveal that the hypothesis of equal CAARs could not be rejected for service announcing and non-announcing firms ($p = 0.648$) or non-service announcing and non-announcing firms ($p = 0.957$).

The Firm Health Hypothesis

Hunton et al. (2002) examine the impact of the interaction of firm size and health on ERP announcement effects and find that earnings forecast revisions in the small/healthy and large/unhealthy firms were greater than the forecast revisions of small/unhealthy firms. Moreover, Hayes et al. (2001) show that the market reacts favorably to small/healthy firms and large/unhealthy firms.

Altman (1983) applies multiple discriminant analysis to a sample of firms to develop a discriminant function to assess financial health, and his Z-score enjoys widespread use as a predictor of impending bankruptcy. We use the following version of Altman's function:

$$Z = 1.2\,(WC/TA) + 1.4\,(RE/TA) + 3.3\,(EBIT/TA) + 0.6\,(BVE/TD) + (Sales/TA) \quad (1)$$

where:

WC = Working capital;
TA = Total assets;
RE = Retained earnings;
EBIT = Earnings before interest and taxes;
BE = Book value of equity; and
TD = Total debt.

We compute Altman's Z-score at the end of the year before the announcement year. We then divide the firms into two groups, healthy (Z-score ≥ 2.99) and unhealthy (Z-score < 2.99).

Panel A of Table 7 presents results for healthy firms using EGARCH methodology with the CRSP value-weighted index. All three event day AARs (-1 through +1) are positive and the event day -1 AARs are significantly different from zero at the 1 percent level using the standardized cross-sectional test. The event period CAARs are also statistically positive using EGARCH methodology with the standardized cross-sectional test. These results are consistent with Hayes et al. (2001) and Hunton et al. (2002).

Panel B of Table 7 repeats the analysis of Panel A for unhealthy firms. There is little statistical evidence of any reaction for unhealthy firms. To ascertain whether differential reaction was exhibited between the healthy firm and unhealthy firm samples, the Kolmogorov-Smirnov test was used to test each sample for normality. Because the Kolmogorov-Smirnov test rejects the hypothesis of normality for both

Table 7—Announcing Firm Health

The upper section of Panels A and B, columns one and two, present the event day and average abnormal return (AAR). Column three presents the percentage of firms with positive average abnormal returns. Columns four through six present the absolute test statistics for the two-tailed tests of the hypothesis that the abnormal return is zero. The lower section of Panels A and B, columns one through three, present the event period, mean cumulative abnormal return, and median cumulative abnormal return. Column four presents the percentage of positive cumulative average abnormal returns. Columns five through seven present the absolute test statistics for the two-tailed tests of the hypothesis that the cumulative average abnormal return is zero. Tests for both panels include the standardized cross-sectional t-test, generalized sign Z-test, and rank Z-test

Panel A: Healthy

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	0.98%	50.7	2.758***	0.428	0.710
0	0.20%	49.3	0.552	0.194	0.230
+1	0.55%	49.3	1.530	0.194	0.440

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	1.73%	0.52%	52.1	2.795***	0.663	0.797

Panel B: Unhealthy

Event Day	AAR Percent	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1	-0.30%	44.4	-0.487	0.295	0.090
0	-0.26%	30.6	-0.419	-1.965**	-0.540
+1	-0.58%	36.1	-0.948	-1.297	-1.810*

Event Period	Mean CAAR	Median CAAR	Percent Positive	Standardized Cross-sectional t	Generalized Sign Z	Rank Z
-1, +1	-1.14%	-1.30%	36.1	-1.070	-1.297	-1.306

*, **, *** Denotes significance at the 10 percent, 5 percent and 1 percent level, respectively

samples ($p < 0.01$ for each sample), the Mann-Whitney U test was used to examine the difference in the sample medians. Results suggest that there is a statistically significant difference between the CAARs of the healthy firms and unhealthy firms ($p = 0.029$).

Robustness tests reveal that event day -1 AARs for the 74 healthy announcing firms are statistically positive at the 5 percent level using GARCH methodology with either the CRSP equally weighted or value-weighted index or using EGARCH methodology with the CRSP equally weighted index. Using the Scholes-Williams technique with either index or EGARCH methodology with the CRSP equally weighted index produces statistically significant event day -1 AARs at the 10 percent level. Thus, this finding is robust. The event period CAARs are also statistically positive using EGARCH methodology with the standardized cross-sectional test, and this result is robust with respect to method, index, and metric. The standardized cross-sectional test rejects the hypothesis of no reaction for every combination of

Table 8—Firm Health Robustness

Columns one through nine list the event day and event-study method and index combinations. The rows represent event-days -1, 0, +1 and event-period -1 through +1. Cells have entries if one of our test statistics detects statistical significance for that combination of method and index for that event-day. The entry in the cell will have a plus or minus sign to show the direction of the AAR, a number (1, 5, or 10) indicating the level of statistical significance, and an abbreviation for the test statistic (std = standardized cross-sectional test, gs = generalized sign test, and rz = rank z test)

Event	OLS		SW		GARCH		EGARCH	
Day	EW	VW	EW	VW	EW	VW	EW	VW
-1			+10 std	+10 std	+5 std	+5 std	+5 std	+1 std
0								
+1					+10 std		+10 std	
-1,+1	+10 std, 1 gs		+10 std, 5 gs	+10 std	+1 std, gs	+5 std	+1 std, 5 gs	+1 std
Unhealthy Announcing (N=37)								
-1								
0		-10 gs						-5 gs
+1	-5 rz	-10 rz	-10 rz	-5 rz	-10 rz	-10 rz	-10 rz	-10 rz
-1,+1								
Healthy Non-announcing (N=74)								
-1							+5 std	
0		+10 gs		+5 gs		+5 gs		+10 gs
+1							+10 std	
-1,+1							+1 std, 5 gs	
Unhealthy Non-announcing (N=37)								
-1								
0								
+1							-10 rz	
-1,+1								

method and index at the 10 percent level (or better) except for OLS with the CRSP value-weighted index.

Robustness tests for the 37 unhealthy announcing firms reveal that event day +1 produces consistently negative AARs despite the method or index. While robust in terms of index and method, the results are weak and only statistically significant with the rank Z test.

Non-announcing firm robustness tests reveal that the 37 unhealthy firms have little reaction, with only the EGARCH method with the CRSP equally weighted index detecting significance at the 10 percent level. Non-announcing healthy firms, however, experience reaction on event day -1, +1 and event period (-1, +1) with the EGARCH model and the CRSP equally weighted index. Those results are not robust, however, as they disappear with all other combinations of models and indexes.

The healthy announcing and non-announcing samples and unhealthy announcing and non-announcing samples were tested for normality so that an appropriate test of the equality of CAARs for the announcing and non-announcing firms could be conducted. Results reveal that the hypothesis of equal CAARs could not be rejected for healthy announcing and non-announcing firms (p = 0.343) or unhealthy announcing and non-announcing firms (p = 0.247).[3]

Because Berk, Green, and Naik (1999) suggest that risk may decline after real options are exercised, as a final test of robustness we also use a +45 through +200 event window with the EGARCH model to ascertain whether potentially changing betas alter previous conclusions. These results do not alter our previous conclusions.

Conclusion

ERP systems are espoused to incorporate best business practices into one integrated software application package that can affect every function within a business. It is often thought that rapid growth has caused firms to have too many non-integrated information systems and that these firms' systems cannot communicate effectively with each other. Therefore, converting data from one system to another can be an expensive proposition. It is believed, however, that ERP systems can reduce data redundancy and data errors, enhance data integrity and reliability and provide current and accurate information to decision makers. Because ERP systems promise seamless integration of information, there is reason to believe that ERP systems may provide cost savings and may create a competitive advantage.

As with other capital investments, if ERP systems can create a cost savings or competitive advantage, the net result may be an increase in firms' future free cash flows and stock price. Research in this area leaves room for further analysis. Because of the limitations of previous research in this area, we examine the market reaction of 111 firms that announce that they will invest in ERP systems. Additionally, to understand how various firm-specific factors affect market reaction, we control for firm size, industry, and health. Finally, we use matched-pair analysis to control for externalities.

To increase the robustness of our findings, we use OLS and Scholes-Williams beta estimation methods and both GARCH and EGARCH models. In addition, we use both the CRSP equally weighted and value-weighted indexes to mitigate benchmark bias. Finally, we use both parametric and non-parametric test statistics to examine the sensitivity of the results to the selected test statistic.

Results reveal that only healthy firms that announce ERP investments experience statistically significant event period returns. Moreover, those results are robust.

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[3]As a further test of robustness, we ran the following instrumental variable regression model:

$$CAAR = \alpha + \beta 1(Size) + \beta 2\ (Service) + \beta 3\ (Health)$$

where the instrumental variables (size, service, and health) took the value of 1 for large, service, or healthy firms, respectively. Otherwise, the instrumental variables were assigned a value of zero. Results for the announcing firms reveal that the R^2 is 0.11 and the F-statistic's p-value is 0.007. CAARs for healthy firms were statistically different from zero (p = 0.003), but no other variables were statistically different from zero. Results for the non-announcing firms produce an R^2 of 0.011, the F-statistic's p-value is 0.756, and results reveal that no variable was statistically different from zero.

The results for the full sample and other subsamples, however, do not reveal a statistically significant reaction.

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Appendix A

We use event study methodology to determine announcement effects. If security returns follow a single-factor market model, returns can be expressed as

$$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt}, \tag{A.1}$$

where:

R_{jt} = Realized return of stock j on day t;
R_{mt} = Market return on day t;
ε_{jt} = Random variable that is homoskedastic, uncorrelated with R_{jt} and R_{mt}, and has an expected value of zero;
β_j = A measure of the sensitivity of R_{jt} to the market for stock j.

The estimated coefficients are used to compute abnormal daily returns for the announcement period where event day +t (-t) represents the t^{th} trading day after (before) the announcement date (t = 0). AR_{jt} is the abnormal return of stock j on day t and measures the difference between the observed and expected daily returns. Formally, abnormal returns of stock j on day t are

$$A_{jt} = R_{jt} - (\hat{\alpha}_j + \hat{\beta}_j R_{mt}) \tag{A.2}$$

where:

R_{jt} = Realized return of stock j on day t;
R_{mt} = Market return on day t; and
$\hat{\alpha}_j$ and $\hat{\beta}_j$ = Market model parameter estimates for stock j.

The average abnormal return (AAR_t) across announcing firms on day t is

$$AAR_t = \frac{\sum_{j=1}^{N} A_{jt}}{N} \tag{A.3}$$

where:

N = The number of firms (j) making announcements.

The cumulative average abnormal return (CAAR) between event day T_1 and day T_2 is

$$CAAR_{T_1,T_2} = \frac{1}{N} \sum_{j=1}^{N} \sum_{t=T_1}^{T_2} A_{jt} \tag{A.4}$$

where:

T_1 and T_2 = The beginning and ending days of the event period, respectively.

Because abnormal returns are linearly related to beta, we use two methods of estimating betas. First, we utilize OLS regression to estimate coefficients and the estimate of the beta for security j is

$$\beta_j = \frac{Cov_{j,m}}{\sigma_m^2} \tag{A.5}$$

where:

$Cov_{j,m}$ = The covariance of the returns between security j and the market m.

Scholes and Williams (1977) show that errors in variables problems can occur with high-frequency (daily) data when OLS is used to estimate coefficients. Consistent estimators, however, can be computed as

$$\hat{\alpha}_j = \frac{1}{T-2}\sum_{t-2}^{T-1} R_{jt} - \hat{\beta}_j \frac{1}{T-2}\sum_{t-2}^{T-1} R_{mt} \tag{A.6}$$

and

$$\hat{\beta}_j^* = \frac{\hat{\beta}_j^- + \hat{\beta}_j^0 + \hat{\beta}_j^+}{1 + 2\hat{\rho}_m} \tag{A.7}$$

where:

$\hat{\alpha}_j$ = The Scholes-Williams OLS intercept estimator;
$\hat{\beta}_j^-$ = The slope estimate from the OLS regression of R_{jt} on R_{mt-1};
$\hat{\beta}_j^0$ = The slope estimate from the OLS regression of R_{jt} on R_{mt};
$\hat{\beta}_j^+$ = The slope estimate from the OLS regression of R_{jt} on R_{mt+1}; and
$\hat{\rho}_m$ = The estimated first order autocorrelation of R_m.

As another test of robustness, we use generalized autoregressive conditional heteroskedasticity (GARCH) and exponential generalized autoregressive conditional heteroskedasticity (EGARCH) models. With GARCH and EGARCH models, returns continue to follow the form $R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt}$; however, they differ in the assumption of the behavior of the error term. In GARCH and EGARCH, $\varepsilon_{jt} \left| \Psi_{t-1} \sim (0, h_{jt}) \right.$ and Ψ denotes all information available at time t-1. Using maximum likelihood to estimate the parameters, the conditional variance for the GARCH model is

$$h_{jt} = \omega_j \delta_j h_{jt-1} + \gamma_j \varepsilon_{jt-1}^2$$

with:

$\omega_j > 0$, $\gamma_j > 0$, $\delta_j \geq 0$; and
$\gamma_j + \delta j < 1$.

The conditional variance for the EGARCH model is:

$$\log h_{jt} = \omega_j + \delta_j \log h_{jt-1} + \gamma_j |z_{jt-1}| + \phi_j z_{jt-1}$$

where:

$$z_{jt} = \varepsilon_{jt} \Big/ \sqrt{h_{jt}} \;.$$

Boehmer, Musumeci, and Poulsen (1991) report that if an event causes event induced variance, commonly used tests reject the null hypothesis too frequently. Their corrected test requires the residuals to be standardized by the estimation period standard deviation before using the ordinary cross-sectional technique.
Formally, the standardized cross-sectional test statistic, Z_t, is

$$z_t = \frac{TSAR_t}{N^{\frac{1}{2}}\left(S_{SAR\bullet t}\right)} \tag{A.8}$$

where:

$TSAR_t$ = Average event period standardized residual for event day t;
N = Number of firms in the sample; and
$\sqrt{(N^*S_{SAR\bullet t})}$ = The contemporaneous cross-sectional standard error.

$TSAR_t$ is

$$TSAR_t = \sum_{j=1}^{N} SAR_{jt} \tag{A.9}$$

where:

SAR_{jt} = The standardized error for firm j on day t.

$S^2_{SAR_{\bullet t}}$ is

$$S^2_{SAR_{\bullet t}} = \frac{1}{N-1} \sum_{i=1}^{N} \left(SAR_{it} - \frac{1}{N} \sum_{j=1}^{N} SAR_{jt} \right)^2 . \tag{A.10}$$

The standardized cumulative abnormal return, SCAR, for stock j is

$$SCAR_{T_{1j},T_{2j}} = \left(CAR_{T_{1j},T_{2j}} \Big/ S_{CAR_{T_{1j},T_{2j}}} \right) \tag{A.11}$$

and $S_{CAR_{T_{1j},T_{2j}}}$ is

$$S^2_{CAR_{t_{1J},t_{2J}}} = S^2_{A_j}\left\{L_j\left[1+\frac{L_j}{D_j}+\frac{\left(\sum_{t=T_{j1}}^{T_{2j}} R_{mt} - L_j\overline{R}_m\right)^2}{\sum_{k=1}^{D_j}\left(R_{mt}-\overline{R}_m\right)^2}\right]\right. \tag{A.12}$$

where:

$$S^2_{A_j} = \frac{\sum_{k=T_{D_b}}^{T_{D_e}} A^2_{jk}}{D_j - 2} \tag{A.13}$$

D_j is the number of trading day returns in the D-day interval, T_{D_e} through T_{D_b}, that are utilized to estimate firm j's parameters. L_j is length of the trading-day event period and $\overline{R}_m$ is the average market return over the estimation period.

The standardized cross-sectional test statistic is

$$z_t = \frac{\sum_{i=1}^{N} SCAR_{T_{1j},T_{2j}}}{N^{\frac{1}{2}}\left(S_{SAR\bullet t}\right)} \tag{A.14}$$

where:

$$s^2 SAR{\cdot}t = \frac{1}{N-1}\sum_{i=1}^{N}\left(SCAR_{T_{1i},T_{2i}} - \frac{1}{N}\sum_{j=1}^{N} SCAR_{T_{1j},T_{2j}}\right)^2 . \tag{A.15}$$

To enhance the robustness of our results, we use several nonparametric tests to confirm parametric results. The generalized sign Z-test that examines the number of securities with positive and negative average abnormal returns during estimation and event periods under the null hypothesis that the fraction of positive returns during the event period is the same as the fraction of positive returns during the estimation period. The fraction of positive returns under the null hypothesis is

$$\hat{\rho} = \frac{1}{N}\sum_{j=1}^{N}\frac{1}{T_j}\sum \varphi_{jt} \tag{A.16}$$

and the test statistic is

$$Z = (w - n\,\hat{\rho}\,)/\sqrt{\left[n\hat{\rho}\left(1-\hat{\rho}\right)\right]} . \tag{A.17}$$

Corrado (1989) developed the rank Z-test that treats the combined estimation period and event period as a single set of returns and assigns a rank to each daily return for each firm. K_{jt} represents the rank of abnormal return of stock j during the combined estimation and event period, $D_j + E_j$, respectively. The average rank across the combined estimation and event period is

$$\tilde{K} = \frac{D + E + 1}{2} . \tag{A.18}$$

The rank Z-test statistic for days T_1 through T_2 is

$$Z_r = (T_2 - T_1 + 1)^{1/2} \left\{ \frac{\overline{K_{T_1,T_2}} - \tilde{K}}{\left[\sum_{t=1}^{D+E} \left(\overline{K_t} - \tilde{K} \right)^2 \Big/ (D+E) \right]^{\frac{1}{2}}} \right\}, \tag{A.19}$$

where:

$$\overline{K_{T_1 T_2}} = \frac{1}{T_2 - T_1 + 1} \sum_{t=T_1}^{T_2} \frac{1}{N} \sum_{j=1}^{n} K_{jt} . \tag{A.20}$$