

The Impact of Enterprise Systems on Corporate Performance: A Study of ERP, SCM and CRM System Implementations

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ABSTRACT

This paper documents the effect of investments in Enterprise Resource Planning (ERP), Supply Chain Management (SCM), and Customer Relationship Management (CRM) systems on a firm's long-term stock price performance and profitability measures such as return on assets and return on sales. The results are based on a sample of 186 announcements of ERP implementations; 140 SCM implementations; and 80 CRM implementations. Our analysis of the financial benefits of these implementations yields mixed results. In the case of ERP systems, we observe some evidence of improvements in profitability but not in stock returns. The results for improvements in profitability are stronger in the case of early adopters of ERP systems. On average, adopters of SCM system experience positive stock returns as well as improvements in profitability. There is no evidence of improvements in stock returns or profitability for firms that have invested in CRM. Although our results are not uniformly positive across the different enterprise systems (ES), they are encouraging in the sense that despite the high implementation costs, we do not find persistent evidence of negative performance associated with ES investments. This should help alleviate the concerns that some have expressed about the viability of ES given the highly publicized implementation problems at some firms.

1.0 Introduction

Enterprise systems (ES) represent an important technology investment option for operations managers, and have been acclaimed in the practitioner and academic literature for their potential to improve business performance (Akkermans et al. (1999), Davenport (1998)). For the purposes of this research, ES includes one or more of the following applications: Enterprise Resource Planning (ERP); Supply Chain Management (SCM); and/or Customer Relationship Management (CRM) systems. Firms have invested heavily in ES. AMR Research estimates that investment in ES amounted to more than \$38 billion in 2001 (Krause and O'Brian (2002)). Forecasters predict continued high growth in the level of investments in ES (AMR Research (2004)). Given the significant level of investments in ES, a relevant issue is whether investments in ES affect corporate performance.

Most empirical evaluations of the benefits of ES assume that a successful implementation of ES will have a positive impact on operational performance metrics, which in turn will improve financial performance. However, little empirical research has been done to link investments in ES to financial performance using objective data. We are aware of only two such studies that have analyzed investments in ERP systems. Hitt et al. (2002) analyze a sample of SAP's ERP implementations using accounting and stock market based performance measures. Although they find evidence of improved financial performance during implementation, they are unable to estimate the long-run impact of ERP systems due to a lack of post-implementation data at the time they conducted their study. Ranganathan and Samarah (2003) find that the stock market reacts positively to announcements of ERP investments. Compared to ERP systems, the evidence on the impact of investments in SCM and CRM on financial performance is even more limited. Dehning et al. (2004) study the effect of investments in SCM systems on accounting

based performance metrics and find that such investments improve profitability. We are not aware of any academic study that has analyzed the effect of CRM systems on firm performance.

This paper documents the effect of investments in ERP, SCM, and CRM systems on long-run stock price and profitability performance. By estimating the long-run financial effects of investments in ES, we shed light on the value of these systems. The results of this paper are based on an analysis of a sample of 186 announcements of ERP implementations, 140 SCM implementations, and 80 CRM implementations at publicly traded firms. Performance effects are examined over a five-year time period for ERP implementations and a four-year time period for SCM and CRM implementations. Performance effects are also examined for both the implementation and post-implementation periods.

There are a number of differences between our study and other studies that have focused on publicly traded firms (Dehning et al. (2004), Hitt et al. (2002), Ranganathan and Samarah (2003)). First, previous studies have focused on a specific type of ES such as ERP or SCM. In contrast, we analyze the impacts of ERP, SCM, and CRM - three types of commonly used ES. Second, unlike previous studies, we examine the effect of ES on both stock price and profitability to examine the consistency between different measures of performance. In the long-run both the stock price changes and profitability changes should point to the same conclusion about the effect of ES on performance. Third, unlike other studies, we examine performance effects for both the implementation and the post-implementation periods. Finally, to isolate the effect of ES on performance, we use recently developed methodologies that are the current standards in the literature (Lyon et al. (1999), Barber and Lyon (1997), Kothari and Warner (1997), Barber and Lyon (1996)).

The paper is organized as follows: Section 2 briefly reviews the rationale behind the

belief that investment in ES will improve financial performance. The contribution of this paper is a rigorous validation of this premise. We do not develop a theory of how this value is realized. Instead we establish whether or not ES adoption is associated with improvements in financial performance. Section 3 describes the sample collection. Section 4 describes the methods used to estimate the long-run stock price and profitability effects of the sample firms. The empirical results are presented in Section 5. Section 6 compares our results with other studies that have examined the performance effects of ES. Section 7 discusses these results in the context of theories on how firms develop competitive capabilities and develops suggestions for future research on the operational mechanisms by which ES systems can improve performance.

2.0 Benefits of Enterprise Systems

Information integration is a key benefit of ES. This integration can replace functionally oriented and often poorly connected legacy software, resulting in savings in infrastructure support costs. Furthermore, improvements in operational integration enabled by ES can affect the entire organization and therefore can positively impact firm performance. As discussed below, ERP systems also provide benefits in the area of transaction automation, SCM systems provide more sophisticated planning capabilities, and CRM systems facilitate customer relationship management.

2.1 ERP Systems

ERP systems replace complex and sometimes manual interfaces between different systems with standardized, cross-functional transaction automation. Order cycle times (the time from when an order is placed until the product or service is delivered) can be reduced, resulting in improved throughput, customer response times and delivery speeds (Cotteleer (2002), McAfee (2002)). Similarly, automated financial transactions can reduce cash-to-cash cycle times and the

time needed to reconcile financial data at the end of the quarter or year (Mabert et al. (2000, 2003), McAfee (1999), Stratman (2001)). The result is a reduction in operating capital and the headcount of the financial area.

Another benefit of ERP systems is that all enterprise data is collected once during the initial transaction, stored centrally, and updated in real time. This ensures that all levels of planning are based on the same data and that the resulting plans realistically reflect the prevailing operating conditions of the firm. For example, a single, centrally developed forecast ensures that operational processes remain synchronized and allows the firm to provide consistent order information to customers (Bancroft et al. (1998)).

Taken together, the standardized firm-wide transactions and centrally stored enterprise data greatly facilitate the governance of the firm (Scott and Vessey (2000), McAfee and Upton (1996)). ERP reports provide managers with a clear view of the relative performance of the various parts of the enterprise, which can be used to identify needed improvements and take advantage of market opportunities (AT Kearney (2000), Boston Consulting Group (2000)).

2.2 SCM Systems

The primary benefit of SCM systems is better operational and business planning. The MRP II and ERP systems of the nineties usually included only rough-cut capacity planning logic, with basic finite capacity planning functionality limited to key work centers (Vollmann et al. (2005)). SCM systems use finite-capacity planning algorithms that do not require iterative adjustments to the master schedule (Raman and Singh (1998)), and real-time planning capabilities allow firms to react quickly to supply and demand changes. Coordinated planning and flow of materials and information among supply chain partners can mitigate the “bullwhip effect” (Lee et al. (1997)). There is a rich literature in OM on the benefits of better supply chain

planning and coordination (Cachon and Fisher (2000), Cheung and Lee (2002), Milner and Kouvelis (2002)). Recent empirical research has demonstrated that reducing forecasting and planning errors that result in supply chain disruptions avoids value destruction (Hendricks and Singhal (2003)). Increased revenue, increased productivity, operational cost savings, lower inventory, and reduced order-to-fulfillment cycle time are some of the benefits from SCM system implementations (Nucleus Research (2003a)).

2.3 CRM Systems

CRM is a synthesis of many existing principles from relationship marketing (Jancic and Zabkar (2002), Sheth et al. (2000), Morgan and Hunt (1994)), and the broader issue of customer-focused management. CRM systems provide the infrastructure that facilitates long-term relationship building with customers. Some examples of the functionality of CRM systems are sales force automation, data warehousing, data mining, decision support and reporting tools (Katz (2002), Suresh (2004)). CRM systems also reduce duplication in data entry and maintenance by providing a centralized firm-wide database of customer information. This database replaces systems maintained by individual sales people, institutionalizes customer relationships, and prevents the loss of organizational customer knowledge when sales people leave the firm. Centralized customer data is also valuable to firms managing multiple product lines. In many cases customers will overlap across different lines of business, providing an opportunity for increasing revenues through cross-selling.

Based on the above review and discussion of the literature we hypothesize:

H1 (2 and 3): Investments in ERP (SCM and CRM) systems lead to improvements in financial performance as measured by stock returns and profitability.

3.0 Sample selection procedure and data description

Business Wire, Dow Jones News Service, PR Newswire, and the Wall Street Journal are

our primary sources for collecting the sample of firms that have invested in ES. We started with the set of all announcements during 1991-1999 that mention ES providers by name. Although more than 25 providers are used in our search, the major ones are SAP, Oracle, JD Edwards, and Peoplesoft for ERP systems; i2 Technologies, Manugistics, Aspen Technology, American Software, and Logility Inc for SCM systems; and Siebel and SCT Corp for CRM systems. These announcements mentioned firms that have invested in ES. To be included in the final sample a firm must have stock price information on the Center for Research on Security Prices (CRSP) database and accounting information on the COMPUSTAT database. Nearly 98% of the announcements were made during 1995 to 1999.

Our sample consists of 406 firms with the following breakdown: 186 announcements of investments in ERP systems; 140 in SCM systems; and 80 in CRM systems. Panel A of Table 1 presents statistics on the sample based on the most recent fiscal year completed before the date of the announcement of investing in ES. The mean (median) ERP observation represents a firm with annual sales of nearly \$6,956 million (\$1,679 million) and total assets of \$10,330 million (\$1,461 million). SCM observations represents firms with mean (median) annual sales of nearly \$10,020 million (\$4,089 million) and total assets of \$13,735 million (\$3,253 million) whereas CRM observations represent firms with mean (median) annual sales of nearly \$9,609 million (\$2,879 million) and total assets of \$25,199 million (\$3,404 million). Overall, it appears that larger firms have invested in ES. Furthermore, the size of firms that invest in SCM and CRM applications is larger than those that invest in ERP applications. This may be because SCM and CRM applications are relatively new compared to ERP applications.

Our sample has two distinct sets of announcements. One set indicates that the firm has started or plans to start the implementation of an ES application. The other set indicates that the

firm has completed the implementation of an ES application. Of the 186 ERP announcements, 35 are on completed implementations; of the 140 SCM announcements, 12 are on completed implementations; and of the 80 CRM announcements, 5 are on completed implementations.

4.0 Methodology for estimating performance effects of investments in ES

This section describes our methodology including the period over which the performance effects are measured and the approach used to estimate the long-term stock price and profitability effects of investments in ES.

4.1 Choosing the period over which to measure performance impacts.

In deciding the period over which to measure performance changes, we focus on longer periods to fully capture the performance effects of ES. We also examine the performance during the implementation period as well as the post-implementation period. Based on the evidence in the literature, we use a two-year implementation period for ERP systems. O’Leary (2000) and McAfee (1999) report that ERP installation takes between 1 and 3 years, with an average of 21 months. Stratman (2001) collected detailed timeline information from 43 respondents, and estimates that the average time from start of installation to live is 17.1 months. The weighted average implementation time from the survey of 479 U.S. manufacturing firms by Mabert et al. (2000) is about 17.5 months. Given the above evidence, we choose to use a two-year implementation period.

The evidence on the time required to implement SCM and CRM applications is limited. Compared to ERP systems, SCM and CRM systems are less complex and easier to implement. Raman and Singh’s (1998) case study on i2 Technologies indicated that implementation of SCM systems can take about 6 to 12 months. Nucleus Research (2003a, 2003b) reports a 1.5-year implementation period for SCM systems. Our discussion with an SCM expert at SAP suggests

that a 12-month implementation period seems reasonable. We are unable to find much information about implementation time for CRM. A summary of white papers found at crmguru.com indicated that 50% of the projects get a payback within 18 months, suggesting that implementation time might be short. Based on the above evidence, we choose to use a one-year implementation period for SCM and CRM systems.

The existing literature provides little guidance on what should be the appropriate length of the post-implementation period over which one should measure the benefit of investments in ES. There does seem to be an agreement that the benefits will be felt over a long time period. Given this, we choose a three-year post implementation period for ERP, SCM, and CRM applications. Overall, we examine the changes in financial performance over a five-year period for ERP systems (a two-year implementation period and a three-year post-implementation period), and a four-year period for SCM and CRM systems (a one-year implementation period and a three-year post-implementation period).

For sample firms that plan to implement ES, the five-year period in the case of ERP systems (four-year period in the case of SCM and CRM systems) starts on the announcement date. For sample firms that have announced they have completed the implementation of an ES application, we set the starting date back by two years (one year) relative to the announcement date of completion of the implementation of ERP system (SCM and CRM systems), and use these reset dates to measure the five-year and four-year periods. This adjustment of dates allows us to align the starting time for both the planned and completed implementations.

4.2 Methodology for estimating the long-term stock price effects

We estimate the long-run buy-and-hold abnormal returns using daily returns. An abnormal return is the difference between the return on a stock and the return on an appropriate

benchmark. There has been considerable discussion in the literature on the appropriate methodology for computing long-run abnormal returns (Lyon et al. (1999), Fama (1998), Barber and Lyon (1997) and Kothari and Warner (1997)). This discussion has focused on two issues. The first issue is the appropriate factors that should be controlled for in computing long-run abnormal returns. The current consensus seems to be that abnormal return computations should control for size, market-to-book ratio of equity, and prior performance. The second issue is the interpretation of the statistical significance of long-run abnormal returns. Barber and Lyon (1997) and Kothari and Warner (1997) report that test statistics from many commonly used methods are misspecified because these methods do not adjust for cross-sectional dependency. Barber and Lyon (1997) and Lyon et al. (1999) find that abnormal returns using matching portfolios of similar firms give well-specified tests. We implement this approach as follows:

Step1: In each month, all eligible NYSE firms are sorted into deciles according to their market value of equity. Next all AMEX and NASDAQ firms are placed into the appropriate size portfolio. The smallest size decile portfolio is further divided into quintiles, resulting in 14 size portfolios. Each portfolio is further divided into quintiles according to their market-to-book ratio of equity, resulting in 70 portfolios. Each portfolio is further divided into three portfolios based on the stock price performance of firms in that portfolio over the previous year, resulting in 210 portfolios for each month where firms in each portfolio are similar in terms of size, market-to-book ratio, and prior performance. Over 300 months, the mean (median) number of firms over 63000 portfolios is about 22 (21).

Step 2: We identify the portfolio that a sample firm is assigned to in the first month of the start of the sample firm's measurement period. Since all other firms in this portfolio are similar to the sample firm on size, market-to-book ratio, and prior performance, all these firms can be

considered as benchmarks for the sample firm. For example, Allied Signal announced on October 7, 1998 that they plan to implement an ERP system. In this case we search the 210 portfolios for August 1998 and identify the portfolio that includes Allied Signal. Suppose that Allied Signal is in portfolio #20, which also includes 25 other firms. These 25 firms then become the benchmark against which Allied Signal's performance is evaluated.

Step 3: A sample firm's abnormal return is the difference between its buy-and-hold return and the average of the buy-and-hold returns of all other firms that belong to the sample firm's portfolio (see Hendricks and Singhal (2005) for more details). For example, in the case of Allied Signal, we compute the buy-and-hold return of Allied Signal and the 25 other firms that belong to portfolio #20. If Allied Signal's return over a particular period is say 25%, and the average return of the 25 other firms in portfolio #20 is 15%, then Allied Signal's abnormal return is 10%.

Step 4: Statistical inference is based on a simulation approach (see Lyon et al. (1999)). The idea is to compute an empirical distribution of abnormal returns for a portfolio that has similar characteristics to those of the sample portfolio, and compare where the abnormal return of the sample portfolio falls on this distribution. To achieve this we create a pseudo-sample where for each sample firm we randomly select, with replacement, a firm that belongs to the portfolio assigned to the sample firm. This randomly selected firm is assigned the same announcement date as that of the sample firm. Thus, in the case of Allied Signal, we would select one of the 25 firms that belong to portfolio #20 and assign it the date of October 7, 1998. Once this is done for all sample firms, the mean abnormal performance for this pseudo-sample is computed using the portfolio approach discussed in Step 3. This results in one observation of the mean abnormal performance from a pseudo-sample. We repeat this process 1000 times to obtain 1000 mean abnormal return observations.

Step 5: The empirical distribution of the mean abnormal returns from 1000 pseudo-portfolios is used to test whether the mean abnormal return for the sample portfolio is significantly different from zero. We compute the p-value as the fraction of the 1000 pseudo-samples with mean abnormal returns less than the mean abnormal return of the sample portfolio. For example, if 600 pseudo-samples have mean abnormal returns above the mean abnormal return of the sample, then the p-value is 0.400. Using the empirical distribution to compute p-values explicitly accounts for cross-sectional dependencies, which has been a major source of concern about the validity of p-values from conventional test-statistics (Lyon et al. (1999)).

To pool observations across time, for each sample firm, we translate calendar time to event time as follows. The announcement date is day 0 in event time, the next trading date is day 1, and trading day after that is day 2, and so on. Since a year typically has 250 trading days, the implementation period for ERP systems (SCM and CRM systems) span event days 0 to 500 (0 to 250) and the post-implementation period spans event days 501 to 1250 (251 to 1000).

4.3 Methodology for estimating the long-term operating performance effects

To estimate the profitability effects of investments in ES, we analyze changes in operating return on assets (ROA) and operating return on sales (ROS). ROA (ROS) is the ratio of operating income to book value of total assets (sales), where operating income is defined as sales less cost of goods sold, and selling, general, and administrative expenses. We focus on operating income over other income measures (for example, net income or earnings per share) because it is a cleaner measure of performance as it is not obscured by special items, tax considerations, or capital structure changes.

To control for various factors unrelated to investments in ES that could affect the performance, we compare the performance of each sample firm against an appropriately chosen

comparison group. We estimate abnormal performance as the change in the sample firm's performance minus the change in the median performance of the comparison group. More formally, let PI_{t1} and PI_{t2} be the performance level in year $t1$ and $t2$ (where $t2 > t1$), respectively, for the sample firm I . Let PC_{t1} and PC_{t2} be the median performance level in year $t1$ and $t2$, respectively, for the comparison group for sample firm I . Then API , the abnormal performance of sample firm I is

$$API = (PI_{t2} - PI_{t1}) - (PC_{t2} - PC_{t1})$$

In earlier studies of operating performance the choice of the comparison group was generally based on industry and size. Furthermore, some researchers used a single firm as the basis for comparison while others used a portfolio of firms as their comparison group. More recently, Barber and Lyon (1996) develop robust guidelines on selecting comparison groups that give well specified and powerful test statistics. They emphasize the importance of selecting comparison groups that have similar prior performance as that of the sample firms as well as using a portfolio of firms as the comparison group. We implement the findings of Barber and Lyon (1996) using a four-step procedure.

Step 1: For each sample firm we identify all firms that have the same two-digit SIC code as that of the sample firms and whose ROA (ROS) in the starting year of the measurement period is within 90% to 110% of the sample firm. All firms that meet these criteria are considered part of the comparison group for the sample firm. The 90% to 110% filter on performance is used because this range yields well specified test statistics (Barber and Lyon (1996)).

Step 2: If we do not find any firms in Step 1, then we attempt to match performance within the 90% to 110% filter using all firms in the same one-digit SIC code.

Step 3: If we do not find any firms in Step 2, then we attempt to match performance within the 90% to 110% filter without regard to SIC code.

Step 4: If we do not find any firms in step 3, then we chose the firm that is closest in performance without regard to SIC code.

The mean (median) number of firms in the comparison groups is 20 (14) for the ERP sample, 17 (12) for the SCM sample, and 28 (18) for the CRM sample. To test the sensitivity of our results from the above approach, we create a second comparison group, which takes the firms identified in the first comparison group and includes only those firms whose total assets are within a factor of 10 of the total assets of the sample firm. Since these results are very similar to the first comparison group, we only report the results from the first comparison group.

Abnormal performance can be reported as the change in the level of performance or as the percent change in the level of performance. To see the difference between these two methods, consider a sample firm where the ROA has changed from 3% to 5%. In this case the change in the level of ROA is 2%, whereas the percent change in ROA is 66.66%. If the starting ROA is negative, then percent change calculations are nonsensical. Therefore, basing results on percent change require that we exclude firms (sample or comparison group firms) that have negative starting ROA. This not only diminishes the power of statistical tests, but can also lead to biases in test statistics. Because of these issues with the percent change method, we report abnormal performance based on the change in the level of performance.

To pool observations across time, for each firm in our sample, we translate calendar year to event years as follows. The year of the announcement date is year 0 in event year, the next year is year 1, and year after that is year 2, and so on. For ERP systems (SCM and CRM

systems) the implementation period spans year 0 to 2 (0 to 1) and the post-implementation period spans year 2 to 5 (1 to 4).

5.0 Empirical Results

Outliers can influence the mean values of long-term performance effects. To control for outliers, all abnormal stock return results are reported after capping the data at the 1.0% level in each tail. Outliers are a more serious problem with accounting data. To control for outliers all profitability results are reported after capping the data at the 2.5% level in each tail. Even with capping, outliers can still influence the mean values of long-term performance effects. Therefore, we will put more emphasis on non-parametric statistics such as median and percent of sample firms with positive abnormal performance. In addition to reporting the parametric tests on changes in the mean, we report two non-parametric tests. The Wilcoxon sign rank test is used to test whether the median of the changes is significantly different from zero, and the binomial sign test is used to test whether the percent of sample firms experiencing positive abnormal performance is significantly different from 50%. Consistent with our hypotheses, we measure statistical significance using one-tailed tests.

5.1 Results for investments in ERP systems

Table 2 presents results for the sample of firms that invested in ERP systems. During the two-year implementation period, the stock price performance of the sample firms fared poorly relative to the benchmark portfolios. The mean (median) abnormal return during this time period is -11.96% (-23.04%). A p -value of 0.064 indicates that the mean abnormal return of the sample firm is lower than the mean abnormal returns of 936 out of the 1000 pseudo-portfolios abnormal returns. Of the 186 sample firms, only 40% of the sample firms do better than the median return of the firms that belong to their assigned portfolios, significantly lower than 50% (p -value $\leq$

0.01). The abnormal stock price performance during the implementation period is negative and statistically significant.

The results for the three-year post-implementation period are mixed. The mean abnormal return of 10.97% is statistically significant (p -value = 0.043) and similar in magnitude to the loss experienced during the implementation period. However, the median abnormal return is -1.03%. Only 51.07% of the firms do better than the median return of the firms that belong to their assigned portfolio, insignificantly different from 50%. Overall, only one of the three statistics suggests positive abnormal performance.

When the performance is examined over the full five-year period (the combined implementation and post-implementation periods), there is no evidence of abnormal performance. The mean abnormal return is -5.06%, insignificantly different from zero (p -value = 0.41). The median abnormal return is -11.39%. Nearly 52% of the sample firms do better than the median return of the firms that belong to their assigned portfolio, insignificantly different from 50%. The evidence suggests that over the five-year period, the stock price performance of firms that invest in ERP systems is no different from that of their benchmark portfolios.

The results on changes in profitability (Panel B of Table 2) provide some evidence of improvements in profitability. The mean and median changes in ROA are positive for the implementation, post-implementation, and the combined implementation and post implementation periods. The positive changes in ROA during the implementation period are statistically significant at the 5% level. Although the changes in ROA during the post-implementation period are positive, none of the changes are statistically significant. However, during the combined implementation and post-implementation periods the median change of 1.03% in ROA is significantly different from zero (p -value ≤ 0.01), and nearly 58% of the

sample firms experienced positive abnormal change in ROA, significantly different from 50% ($p\text{-value} \leq 0.025$). The evidence suggests that ERP adopters show an improvement in ROA.

When ROS is used as the performance metrics, 8 of the 9 performance metrics (3 for each time period) are positive but only three changes are statistically significant at the 5% level. These are the median change during the post-implementation period, the percent of sample firms that experience positive abnormal change during the post-implementation period, and the percent of sample firms that experience positive abnormal change during the combined implementation and post-implementation periods. Although there is some evidence of positive abnormal changes in ROS, the results are not as strong as that of the changes in ROA.

Overall the evidence suggests that although firms that invest in ERP systems do not experience a statistically significant increase in stock returns, there is some evidence to suggest that profitability improves over the combined implementation and post-implementation periods. To examine the ERP results in more detail, we segment the sample into four different subsamples. We briefly summarize these findings. The detailed results are available from the authors.

To estimate the effect of ERP systems during the post-implementation period more precisely we examine the results only for those announcements that indicated that the firm has completed the implementation of an ERP system. In this case we know when the implementation was completed, and hence the time period after the completion would more accurately represent the performance effects during the post-implementation period. The results for this subsample are very similar to the overall sample.

We also examine the results for those announcements that indicated that the firm has started or planned to start the implementation of an ERP system. In this case we know when the

implementation was started but not necessarily when it was completed. By examining the performance of these firms over the five-year period, we shed some light on the payback from ERP systems over a five-year period. Again the results for these subsamples are very similar to the overall sample.

We also segment our sample into manufacturing and service firms to see if the benefits from investments in ERP systems are more or less for manufacturing or service firms. We did not find any evidence to suggest that the benefits of ERP implementation are different for manufacturing or service firms. Basically, the results for these two subsamples are very similar to those for the full sample.

5.2 Results for investments in SCM systems

Table 3 presents results for the sample of firms that invested in SCM systems. During the one-year implementation period, the mean abnormal return is -1.46%, insignificantly different from zero (p -value = 0.624). The median abnormal return is -8.11%. Of the 140 sample firms, about 45% of the sample firms did better than the median return of the firms that belong to their assigned portfolios, insignificantly different from 50%. Basically, the abnormal stock price performance during the implementation period is not statistically significant.

During the post-implementation period the mean abnormal return of 18.06% is statistically significant (p -value = 0.025). However, the median abnormal return is -4.91%. Nearly 51% of the firms do better than the median return of the firms that belong to their assigned portfolio, insignificantly different from 50%. Over the full four-year period, the mean abnormal return of 18.75% is statistically significant at the 7% level. The median is -9.24%. Half the sample firms do better than the median return of the firms that belong to their assigned

portfolio. Overall, there is some evidence of positive abnormal stock price performance during the four-year period.

The results for the accounting metrics (see Panel B of Table 3) provide strong support that firms that invest in SCM systems show improvements in ROA and ROS. Improvements are observed in both the implementation and post-implementation periods, with mean and median changes in ROA and ROS generally positive and most are statistically significant at the 2.5% level or better. The results for the combined implementation and post-implementation periods indicate that the median change in the level of ROA is 1.78%. The median change in the level of ROS is 1.44%. Both these changes are statistically significant ($p\text{-value} \leq 0.01$). More than 60% of the sample firms experience positive abnormal changes in ROA and ROS during the combined implementation and post-implementation periods. All the results for the combined implementation and post-implementation periods are statistically significant at the 1% level or better. Overall the results indicate that investments in SCM systems improved profitability.

Since very few of the SCM investment announcements in our sample indicated that the firm had completed the implementation of an SCM system, it is not meaningful to analyze this subsample separately. We also segment the SCM announcements sample into those made by manufacturing firms (about 80% of the sample). The results for this subsample are generally consistent with the results for the full sample.

5.3 Results for investments in CRM systems

Table 4 presents results for the sample firms that invested in CRM systems. During the implementation period, the mean abnormal return is 6.84%, insignificantly different from zero ($p\text{-value} = 0.15$). During the post-implementation period the mean abnormal return of -3.07% is not statistically significant ($p\text{-value} = 0.617$). The percent of sample firms that do better than the

median return of the firms that belong to their assigned portfolio is insignificantly different from 50%. Overall, there is no evidence of positive or negative abnormal stock price performance during the implementation and post-implementation periods. Over the full four-year period, the mean (median) abnormal return is -15.22% (-12.41%), and nearly 53% of the sample firms do better than the median return of the firms that belong to their assigned portfolio. However, none of these performance changes are statistically significant. Basically, investments in CRM systems have had little effect on the stock returns of investing firms.

The results of abnormal stock price performance are corroborated by the results on changes in operating performance (see Panel B of Table 4). Changes in ROA and ROS are generally positive during the implementation, post-implementation, and the combined implementation and post-implementation period. Except for the mean change in ROA and ROS during the combined implementation and post-implementation periods, none of these changes are statistically significant. Overall, investments in CRM systems seem to have had little impact on profitability.

Since very few of the CRM investments announcements in our sample indicated that the firm has completed the implementation of a CRM system, it is not meaningful to analyze this subsample separately. We also segment the CRM announcements sample into those made by manufacturing firms (about 67% of the sample) and service firms (about 33% of the sample). In both these subsamples, the results are generally consistent with the results for the full sample.

5.4 Are the results driven by the control group methodology?

Before we discuss the implications of our results, we need to address an important issue that has been raised during the review process. The issue is whether our results could be driven by the control sample, as it is not clear that the controls have not invested in ES. Hence, it is

plausible that the some of the insignificant results that we find with respect to ES systems are because the controls have adopted ES systems. We certainly cannot claim that all firms in our control set have not implemented ES. However, as discussed below we believe that the chances are low that our results are driven by the possibility that a subset of control firms may have implemented ES.

First, our sample has 406 ERP, SCM, and CRM announcements. Given that at any point in time more than 5,000 firms are publicly traded, our control firms will come from a sample of more than 4600 firms. If most of these 4600 firms have adopted ES, then one would be very much concerned about our results. While we do not know what the controls have done, the chances that most of the controls have ES are quite low. The adoption of ERP systems is still limited among midsize and small firms, and the adoption is even lower for SCM and CRM systems. Furthermore, given that our last announcement is in December 1999, the adoption rate among controls in 1999 is likely to be much lower than today.

Second, even if some of the 4600 control firms have adopted ES, it should not have much of an impact on our stock price performance results because of the method used to create the 1000 pseudo samples. In each pseudo sample we use size, prior performance, and market to book ratio to select 406 firms from the sample of more than 4600 firms. We then compare the results of the sample firms against the results of these 1000 pseudo samples. If each of these 1000 pseudo samples is dominated by control firms that have implemented ES then our results would be a source of concern. While this could happen in a few of the pseudo samples, the chances of this happening in most of the pseudo samples are very low as process of creating the pseudo samples is quite randomized.

Third, in analyzing the performance effect of ES on ROA and ROS, we match each sample firm to a comparison group that consists of firms from the same industry, and which have similar performance characteristics. On average each comparison group consists of 20 firms. Furthermore, we estimate abnormal performance relative to the change in the median performance of the comparison group. The median of the comparison group is less likely to be impacted by non-identified ES adopters. For example, with this approach if more than 50% of the firms in each comparison group adopt ES, and ES adoption leads to positive results, then it would be a cause of concern as these adopters would drive the median, and negate any positive effect observed in the sample firms.

Finally, we note that our sample is based on firms that have started their implementation between 1991 and 1999. At least in the case of SCM and CRM systems our sample is likely to have firms that are early adopters, which minimizes the chances that the control firms may have also implemented SCM and CRM systems.

The above discussion provides some rationale of why the chances are low that our results are impacted by controls that may have also implemented ES. The purpose of controls is to control for broad economic and industry factors. No control process will be perfect on all dimensions. With a large sample of firms and reasonable level of randomization in the selection process, there should not be any systematic bias in the selection of controls. Nonetheless given the concerns about whether the controls are driving the results we report some additional analyses on early ES adopters to test the robustness of our results.

5.5 Analysis of the performance of early adopters of ERP

Since it is not clear that controls have not invested in ES, another way of dealing with the issue of whether this could drive our results is to examine the performance of early adopters.

While at a conceptual level the issue of controls adopting ES still remains, at a practical level the issue would be less of a concern for the early adopters. It is less likely that most of our controls are early adopters. We restrict our analysis only to the ERP sample as ERP systems have been around longer than SCM and CRM systems. We define as early adopters those firms that have made announcements of investments in ERP systems before 1998. Table 5 reports the abnormal stock price and operating performance results for the early adopter

The evidence indicates that abnormal stock price performance results of early adopters are not that different from the overall sample. The abnormal return during the implementation period is negative, and is positive during the post-implementation period. However, the mean abnormal returns over the implementation and post-implementation periods are insignificantly different from zero.

The profitability performance (see Panel B of Table 5) of early adopters appears to be stronger than the results for the full ERP sample (see Panel B of Table 2). Over the combined implementation and post implementation periods, the improvements in ROA and ROS are positive and statistically significant. There is some evidence of statistically significant positive changes in ROA and ROS during the post-implementation period, which is stronger than what was observed for the full ERP sample. Consistent with the results for the full sample, there is weak evidence of improvements in profitability during the implementation period. The evidence of Table 5 suggests that early adopters may have benefited more from ERP implementation when compared to later adopters.

6.0 Comparison of our results with other studies

Despite the generally positive acceptance of ERP systems in practice and the academic literature, other studies have not found overwhelmingly evidence of strong positive performance

effects from investments in ERP systems. Our results are generally consistent with these findings. For example, although Peerstone Research (Zaino (2004)) found that 63% of 215 firms gained “real benefits” from adopting ERP, they also report that only 40 percent could claim a hard return on investment (ROI). Other ROI results are reported by Cooke and Peterson (1998) in a survey of 63 companies that found an average ROI for ERP adoption of -\$1.5 million. Ranganathan and Samarah (2003) find that ERP adoption and implementation announcements are associated with a statistically significant 0.84% abnormal stock price performance improvement around announcement. Hitt et al. (2002) examine the performance effects of a sample of SAP implementations. Although they find that ERP systems positively affect performance, they are able to show this only for the implementation period.

While McAfee’s (2002) case study finds clear improvements in operational performance, broad-based survey research reports conflicting results. Mabert et al. (2003) report limited improvements in perceptual performance measures (mainly in financial close cycles and order management) but found that few firms had reduced direct operational costs. Similarly, Stratman (2001) found that manufacturing firms saw little change in operational metrics. It appears that although managers are generally satisfied with the performance of ERP, perhaps high implementation costs, together with few directly tangible performance benefits have led to limited financial returns from ERP.

The evidence is more positive regarding the value of investments in SCM systems. Although Nucleus Research (2003a) finds that 55% of 22 i2 Technologies users had not achieved a positive ROI after using their SCM system for an average of 2.2 years, other studies are in line with the results of this study. 80% of a Nucleus Research (2003b) survey of 20 Manugistics users reported a positive payback within 16 months. More recently, Dehning et al. (2004)

provide evidence on the financial benefits of SCM systems by analyzing a set of 123 manufacturing firms (SIC Codes 2011-3999) who have chosen to implement or have implemented an SCM application. They find that that these systems generally are associated with improved financial performance. Our analyses, which includes both manufacturing and service firms and uses methodology and metrics that are different from that used by Dehning et al. (2004), confirm that SCM systems have a positive impact on financial performance over a four-year period.

With respect to CRM our evidence indicates that investments in these systems do not result in statistically significant changes in stock prices or profitability. These results are consistent with that of Nucleus Research (2002), who report that 61% of the 23 Siebel customers that they surveyed did not believe they had achieved a positive ROI.

7.0 Summary and future research

Our analysis of the financial benefits of ES implementations yields mixed results. In the case of adopters of ERP systems, we find some evidence of improvements in profitability but not in stock returns. The results for improvements in profitability are stronger in the case of early adopters of ERP systems. On average, adopters of SCM system experience positive abnormal returns as well as improvements in profitability. There is no evidence of improvements in stock returns or profitability for firms that have invested in CRM. Although our results are not uniformly positive across the different ES systems, they are encouraging in the sense that despite the high implementation costs, we do not find persistent evidence of negative performance associated with ES adoption. This should help alleviate the concerns that some have expressed about the viability of ES given the highly publicized implementation problems at few firms.

Our results also add to the emerging literature on information technology (IT) and productivity. The mixed results of studies examining the financial impact of IT investments led some to propose a “productivity paradox”. Brynjolfsson and Hitt (1996) and Kohli and Devaraj (2003) argue that often the financial value of large systems was hidden from those studies because of lack of sufficient rigor. Some of the research issues that may obscure the results are: (1) the choice of the performance metrics (Bharadwaj et al. (1999)), (2) the time period studied (Devaraj and Kohli (2000)), (3) the method of analysis (Robey and Boudreau (1999)), and (4) the presence of important intermediate variables (Barua et al. (1996), Bresnahan et al. (2002)).

This study addresses the first three of the four issues. The use of both accounting data and stock returns gets at the need for financial metrics. We analyze data over a four or five-year period to capture the long-term impact of ES adoption, and our estimation procedures ensure that abnormal performance is robustly measured, and that the associated statistical tests are well specified. However, in using publicly available stock price and accounting data, we are not able to examine internal firm mediating factors that may influence the financial value from ES.

The linkage between specific internal capability factors and overall financial performance is not always clear. The resource-based view (RBV) provides a theoretical framework for evaluating the types of internal capabilities that provide a competitive advantage that can in turn lead to improvements in financial performance (Peteraf (1993), Rumelt (1984), Wernerfelt (1984, 1995)). Competitive capabilities are defined by the “VRIN” criteria of value, rarity, inimitability, and non-substitutability (Barney (1991)). Grant (1991) further classified internal firm capabilities into tangible, intangible, and personnel-based capabilities. Tangible capabilities are the hardware, software and network connections that make up the physical components of an ES. Intangible capabilities are the customer and intra-firm relationships that are used to

exchange knowledge in support of the business. Personnel-based capabilities are the managerial and technical skills of the personnel using the system.

The business integration and transaction automation offered by ES are valuable tangible capabilities. However, the other three VRIN criteria are somewhat questionable when applied to software systems that can be readily purchased (Carr (2003)). Nevertheless, the complex and expensive implementation process may serve as a barrier to competitors (Rumelt (1984), Weill and Broadbent (1998)). Sambamurthy et al. (2003) suggest that the personnel training and business process changes required to integrate the technical capabilities of these systems into the day-to-day operational practices of the firm are difficult to imitate and effectively non-substitutable. The decisions made during the adoption process are likely to differ across firms (Adner and Helfat (2003)), which implies that the outcomes may also differ. Indeed, several studies suggest that internal organizational capabilities could influence the direction and extent of financial benefits from ES adoption (Boudreau and Robey (2005), Brynjolfsson et al. (2002), (Mata et al. (1995), Melville et al. (2004), Powell and Dent-Micallef (1997)).

A more detailed analysis of the distribution of abnormal performance of our sample firms suggests that future research should explore the relationship between internal organizational capabilities and financial performance. The abnormal stock price performance results presented in Tables 2 through 5 have mean values that are generally higher than the median values. For example, the buy-and-hold abnormal returns during the post-implementation period of firms investing in ERP systems (Table 2) have a mean value of 13.41%, but a median value of -9.52%. This suggests that some firms are achieving high returns from their ES investments. Additional support for this explanation is provided by Figure 1, which shows the distribution of abnormal stock returns during the three-year post-implementation period for our three ES samples. In the

case of the ERP adopters, nearly 20 out of 186 sample firms have abnormal returns greater than 100%. While one must be careful in drawing strong conclusions based on a small sample, it is plausible that these 20 firms may represent firms that are best able to develop the requisite internal capabilities during ES adoption. The performance improvements reported by such firms may have convinced later adopters that they can achieve similar results by purchasing ES, even though they lack the internal capabilities needed to fully leverage the potential of these systems.

Existing OM research in the area of ES has primarily focused on key factors for successful implementation (e.g., Mabert et al. (2003)) and the operational benefits, such as faster transaction processing and customer response, obtained from the use of these systems (e.g., McAfee (2002)). Researchers have started to examine organizational capabilities that influence the success of ES adoption. For example, Stratman and Roth (2002) investigate the development of internal capabilities such as the ERP competence, which is comprised of a portfolio of intangible capabilities that enable a firm to leverage its ERP technology for competitive advantage. These capabilities encompass both technical and organizational elements. Stratman (2001) found that ERP users with high ERP competence are more likely to experience a performance improvement from ERP adoption. Somers and Nelson (2003) also look beyond implementation issues to assess the fit between ERP capabilities and organizational strategies and integration mechanisms.

Future research on ES should move beyond the key factors for successful implementation to address three key issues. First, operations strategy researchers need to use resource-based theory to understand how firms realize benefits from the use of ES. Important questions such as what organizational capabilities facilitate the successful use of ES, and what types of operational processes promote the development of these capabilities, need to be addressed. This research

would logically focus on firms that have successfully implemented the software component of ES in order to avoid confounding the analyses with the organizational disruptions associated with failed software projects.

This raises an important issue related to the results of this study. We report the financial impact experienced by the average firm adopting ES. Although we do not capture details of individual firm implementation success or failure, it is likely that our sample includes some firms which had implementation difficulties or failed implementations. Although the presence of such firms would tend to attenuate the average performance benefits of ES investment, our approach allows us to assess the overall benefits and risks faced by a typical firm planning to adopt ES. Sampling only “successful” firms would tend to bias our results toward the benefits of ES and provide managers with unrealistic expectations of ES adoption. However, future research examining only firms that are actively and successfully using ES in day-to-day operations would show the potential of these systems for those adopters skilled at complex systems implementation.

Second, objective performance criteria need to be applied when assessing ES benefits. A study that combines both secondary and primary source data might provide a clearer picture of how ES influence operational, and in turn financial, performance. Primary data sources could be used to determine precise implementation timelines, as well as to collect information on specific operational practices that leverage the capabilities of ES. A study that compares and contrasts the operational practices of firms that have financially benefited from ES against those that have not could be very valuable.

Finally, the statistically significant improvement in performance of SCM adopters suggests that the benefits of these systems are also tied to the capabilities of the software. SCM

systems codify many of the optimization techniques and algorithms developed by OM researchers. Matching business characteristics such as extent of machine-paced production, environmental dynamism, location in the supply chain, market power etc., would provide validation for the applicability of OM models, as well as guidance to the most useful avenues of future theory development.

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<http://www.informationweek.com/showArticle.jhtml?articleID=18402681>.

Table 1: Description of the sample of firms that have made announcements of investing in ES**Panel A:** Descriptive statistics for the sample of ERP investment announcements

Measure	Mean	Median	Std. Dev.	Maximum	Minimum
Sales (\$million)	6958.6	1678.7	16651.8	168919.0	0.53
Total Assets (\$million)	10329.9	1461.6	36612.7	355935.0	4.00
Equity Market value (\$million)	10092.9	2002.3	2983.9	333672.0	6.01
Employment (thousands)	31.2	9.2	64.3	608.0	0.01

Panel B: Descriptive statistics for the sample of SCM investment announcements

Measure	Mean	Median	Std. Dev.	Maximum	Minimum
Sales (\$million)	10020.8	4089.0	18931.1	120279.0	0.53
Total Assets (\$million)	13735.9	3253.6	46632.2	405200.0	23.54
Equity Market value (\$million)	18882.2	3265.0	55572.1	508329.5	11.15
Employment (thousands)	38.5	16.0	59.2	340.0	0.01

Panel C: Descriptive statistics for the sample of CRM investment announcements

Measure	Mean	Median	Std. Dev.	Maximum	Minimum
Sales (\$million)	9609.5	2876.8	15431.6	99820.0	4.12
Total Assets (\$million)	25199.7	3404.1	6050.5	355935.0	5.58
Equity Market value (\$million)	27377.2	5216.9	5517.8	333672.1	5.66
Employment (thousands)	32.2	14.0	49.9	293.0	0.10

Table 2: Performance results for the sample of firms investing in ERP systems.

Panel A: Results on the mean abnormal stock return (p-value from the empirical distribution created from 1000 replications of pseudo portfolios in parenthesis), the median abnormal stock return, and the % of sample firm with returns greater than the median return of the firms that belong to their assigned benchmark portfolios (the binomial sign test Z-statistic in parentheses).

Performance measures	Implementation period (days 0 to 500)	Post-implementation period (days 501 to 1250)	Implementation and post implementation period (days 0 to 1250)
Number of observations	186	186	186
Mean abnormal return (%)	-11.96% (0.064)	10.97% (0.043)	-5.06% (0.41)
Median abnormal return (%)	-23.04%	-1.03%	-11.39%
% of sample firms with returns greater than its portfolio median	39.78% (-2.79) a	51.07% (0.29)	51.61% (0.44)

Panel B: Results on abnormal return on assets and return on sales. T-statistics for the mean, Wilcoxon signed-rank test Z-statistic for the median, and binomial sign test Z-statistic for the % positive are reported in parentheses.

Performance Measures	Implementation period From Year 0 to Year 2				Post-implementation period From Year 2 to Year 5				Implementation and post-implementation period - From Year 0 to year 5			
	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.
Abnormal change in the level of return on assets	186	1.03% (1.77) c	0.56% (1.74) c	56.45% (1.76) c	167	0.37% (0.52)	0.60% (0.81)	53.89% (1.01)	186	1.09% (1.53)	1.03% (2.49) a	57.53% (2.05) b
Abnormal change in the the level of return on sales	186	0.58% (1.28)	0.36% (1.42)	53.22% (0.88)	167	0.31% (0.38)	1.04% (1.70) c	57.48% (1.93) c	186	-0.15% (-0.18)	0.67% (1.42)	56.98% (1.90) c

a, b, and c denote significantly different from zero (50% in the case of % positive) at the 1%, 2.5%, and 5% levels, respectively, for one-tailed test.

Table 3: Performance results for the sample of firms investing in SCM systems.

Panel A: Results on the mean abnormal stock return (p-value from the empirical distribution created from 1000 replications of pseudo portfolios in parenthesis), the median abnormal stock return, and the % of sample firm with returns greater than the median return of the firms that belong to their assigned benchmark portfolios (the binomial sign test Z-statistic in parentheses).

Performance measures	Implementation Period (days 0 to 250)	Post-implementation period (days 251 to 1000)	Implementation and post implementation period (days 0 to 1000)
Number of observations	140	140	140
Mean abnormal return (%)	-1.46% (0.624)	18.06% (0.025)	18.75% (0.068)
Median abnormal return (%)	-8.11%	-4.91%	-9.24%
% of sample firms with returns greater than its portfolio median	45.71% (-1.01)	51.42% (0.34)	50.00% (0.00)

Panel B: Results on abnormal return on assets and return on sales. T-statistics for the mean, Wilcoxon signed-rank test Z-statistic for the median, and binomial sign test Z-statistic for the % positive are reported in parentheses.

Performance Measures	Implementation period From Year 0 to Year 1				Post-implementation period From Year 1 to Year 4				Implementation and post-implementation period - From Year 0 to year 4			
	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.
Abnormal change in the level of return on assets	141	0.95% (2.18) b	0.76% (2.43) a	60.99% (2.61) a	130	1.58% (2.58) a	0.71% (2.35) a	59.23% (2.10) b	141	2.98% (4.31) a	1.78% (3.59) a	60.99% (2.61) a
Abnormal change in the the level of return on sales	141	0.65% (1.80) c	0.58% (2.50) a	59.57% (2.27) b	131	0.43% (0.77)	0.94% (1.77) c	57.69% (1.75) c	141	1.33% (2.59) a	1.44% (2.78) a	62.41% (2.95) a

a, b, and c denote significantly different from zero (50% in the case of % positive) at the 1%, 2.5%, and 5% levels, respectively, for one-tailed test.

Table 4: Performance results for the sample of firms investing in CRM systems.

Panel A: Results on the mean abnormal stock return (p-value from the empirical distribution created from 1000 replications of pseudo portfolios in parenthesis), the median abnormal stock return, and the % of sample firm with returns greater than the median return of the firms that belong to their assigned benchmark portfolios (the binomial sign test Z-statistic in parentheses).

Performance measures	Implementation period (days 0 to 250)	Post-implementation period (days 251 to 1000)	Implementation and post implementation period (days 0 to 1000)
Number of observations	80	80	80
Mean abnormal return (%)	6.84% (0.152)	-3.07% (0.617)	-15.22% (0.804)
Median abnormal return (%)	-4.66%	-12.12%	-12.41%
% of sample firms with returns greater than its portfolio median	53.75% (0.67)	48.75% (-0.22)	52.50% (0.45)

Panel B: Results on abnormal return on assets and return on sales. T-statistics for the mean, Wilcoxon signed-rank test Z-statistic for the median, and binomial sign test Z-statistic for the % positive are reported in parentheses.

Performance Measures	Implementation period From Year 0 to Year 1				Post-implementation period From Year 1 to Year 4				Implementation and post-implementation period - From Year 0 to year 4			
	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.
Abnormal change in the level of return on assets	81	1.01% (0.79)	0.25% (-0.80)	56.79% (1.22)	77	0.79% (0.58)	0.02% (0.84)	50.64% (0.11)	81	2.21% (1.94) c	0.25% (1.46)	55.55% (0.99)
Abnormal change in the the level of return on sales	81	2.40% (1.57)	0.67% (1.63)	58.02% (1.44)	77	0.75% (0.57)	1.05% (0.96)	53.25% (0.57)	81	4.64% (2.25) b	1.37% (1.48)	54.32% (0.78)

a, b, and c denote significantly different from zero (50% in the case of % positive) at the 1%, 2.5%, and 5% levels, respectively, for one-tailed test.

Table 5: Performance results for the early adopters (1997 and before) ERP systems.

Panel A: Results on the mean abnormal stock return (p-value from the empirical distribution created from 1000 replications of pseudo portfolios in parenthesis), the median abnormal stock return, and the % of sample firm with returns greater than the median return of the firms that belong to their assigned benchmark portfolios (the binomial sign test Z-statistic in parentheses).

Performance measures	Implementation period (days 0 to 500)	Post-implementation period (days 501 to 1250)	Implementation and post implementation period (days 0 to 1250)
Number of observations	104	104	104
Mean abnormal return (%)	-6.48% (0.167)	14.99% (0.075)	-1.82% (0.36)
Median abnormal return (%)	-16.46%	0.23%	-13.43%
% of sample firms with returns greater than its portfolio median	40.8% (-2.04) c	52.88% (0.58)	52.88% (0.87)

Panel B: Results on abnormal return on assets and return on sales. T-statistics for the mean, Wilcoxon signed-rank test Z-statistic for the median, and binomial sign test Z-statistic for the % positive are reported in parentheses.

Performance Measures	Implementation period From Year 0 to Year 2				Post-implementation period From Year 2 to Year 5				Implementation and post-implementation period - From Year 0 to year 5			
	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.	Obs	Mean	Median	% Pos.
Abnormal change in the level of return on assets	110	1.16% (1.60)	0.45% (1.51)	54.54% (0.95)	102	0.47% (0.51)	1.22% (1.25)	59.80% (1.98) b	110	1.55% (1.59)	1.51% (2.51) a	60.91% (2.27) b
Abnormal change in the the level of return on sales	110	1.43% (1.91) c	0.66% (1.78) c	55.45% (1.14)	102	0.80% (0.52)	1.74% (2.37) a	64.71% (2.97) a	110	-0.28% (-0.19)	1.75% (2.08) b	60.91% (2.27) b

a, b, and c denote significantly different from zero (50% in the case of % positive) at the 1%, 2.5%, and 5% levels, respectively, for one-tailed test.

Figure 1: Distribution of post-implementation period abnormal returns for ERP, SCM and CRM samples

