

The Impacts of Enterprise Resource Planning Systems on Firm Performance: An Empirical Analysis of Chinese Chemical Firms

Lu Liu, Rui Miao and Chengzhi Li

School of Economics and Management, Beihang University, Beijing 100083, P.R. China
liulu@buaa.edu.cn miaorui@sem.buaa.edu.cn lichengzhigg@sohu.com

Abstract. Chinese firms heavily invest in enterprise resource planning systems (ERP) in recent years and expect that ERP can help them gain superior financial performance. Given the high costs and high risk of ERP investments, to quantify the financial benefits of ERP implementation is an important research issue. This paper empirically examines the impacts of ERP implementation on firm performance using the financial data from 50 Chinese chemical firms that implemented ERP. The firms' abnormal performance during the two-year implementation period and three-year post-implementation period was analyzed based on the guideline of Barber et al. on event studies. The results find no significant performance improvement during the implementation period and the three-year post-implementation period and a decline in performance in the first two years after implementation. However, a slight performance improvement in the third year after implementation may indicate that the financial benefits of ERP may show after a long-term ERP use. These results provide insight for Chinese firms that want to invest in ERP.

Keywords: *Enterprise resource planning systems (ERP), Financial performance, Chinese chemical firms, ROS, ROA, COGS*

I. INTRODUCTION

With the development of information technology, Chinese firms begin to realize that a firm's competitive advantages do not only depend on traditional manufacture capabilities but also depend on IT applications in today's highly competitive market. Hence, many firms heavily invest in IT applications and expect that IT can help them enhance the firms' competitive advantages. Taking the Chinese chemical firms as an example, the Chinese chemical firms invested RMB 371 millions on information systems in 2005 and RMB 148 millions out of those investments are invested in enterprise resource planning systems (ERP) [1]. Industry and professional reports often claim that the basic drivers motivating firms to invest in ERP include: more accurate and timely information, high quality decision-making, cost reduction, improved efficiency, reduction of order cycle time and improved customer satisfaction.

However, ERP is an investment with high costs and high complexity. The firms need to commit significant resources to ERP implementation and face with a great

deal of difficulty in integrating ERP with their operations. Those make quantifying the financial benefits of ERP implementation an important research issue. To examine the impacts of ERP implementation on firm financial performance can shed light on the value of ERP systems and provide beneficial guidance on ERP investments.

The issue of whether ERP is associated with improved financial performance has been studied by a great deal of literature, but there is relatively little literature to investigate the relationship between ERP implementation of Chinese firms and firm performance using objective financial data. Therefore, this paper also contributes to the literature on the impacts of ERP implementation on firm performance in China.

This paper selects the publicly traded Chinese chemical firms that implemented ERP between 1998 and 2005 as the sample and empirically examines the impacts of ERP implementation on firm performance. The paper is organized as follows. Section 2 reviews the literature on the relationship between ERP implementation and firm performance. Section 3 briefly illuminates the benefits of ERP and proposes the research hypothesis. Section 4 describes sample selection and the method used to estimate the change in financial performance of the sample firms after ERP implementation. The results of this study are presented in Section 5. Section 6 discusses the results and suggests the direction of future research.

2. LITERATURE REVIEW

The existing literature using objective financial data to examine the relationship between ERP implementation and firm performance provides ambiguity for the impacts of ERP on firm performance, while some studies indicate that the firms adopting ERP can acquire better performance, other evidence suggests that there are little relationship between ERP implementation and firm performance.

Poston and Grabski use paired t-test to compare the performance ratios in the year before ERP implementation with the performance ratios after implementation and find no significant improvement in the ratio of residual income and selling, general and administrative expenses (SG&A) in each of the three years after adoption [2]. The research of Hunton et al. indicates that there is no significant pre- and post-adoption performance improvement for ERP adopters, but the performance of non-adopters decline significantly comparing to ERP adopters [3]. Hitt et al. analyze the data of firms that implemented SAP systems and the results show that the firms implementing ERP show higher performance in different financial ratios. Although there is a slow down in performance and productivity shortly after implementation, the financial markets consistently reward the ERP firms with higher market value [4]. Nicolaou studies 247 public traded firms and finds that the ERP firms show higher performance only after two years of use. In addition, controlling for vendor selection, implementation goals, modules implemented and implementation time period helps explain the effects of ERP implementation on firm performance [5]. Hendricks et al. investigate the effects of investing in ERP, SCM and CRM on a firm's stock price, return on assets and return on sales and provide insufficient evidence to support a positive relationship between firm performance and the investments of ERP, SCM and CRM [6].

Most of the above literature chooses some financial ratios as performance indicators, while some also considers the firm's gains on stock market. Some of the literature uses non-adopters as control group matched by size and industry, but little eliminates the influence of macro-economy and other factors unrelated to ERP implementation.

3. BENEFITS OF ERP AND RESEARCH HYPOTHESES

A key benefit of ERP is that all the enterprise data are collected immediately during the initial transaction, stored and processed centrally and updated in real time. This ensures that the employees can share information and the managers can acquire more comprehensive, accurate and timely information to support their decision-making. Therefore, this improves the decision-making quality and the firm's capability to take advantage of market opportunity. Information transferring costs and opportunity costs due to poor decision-making are reduced and the profitability is improved.

Second, ERP realizes the standardization and automation of business process and tracks down the employees' responsibility electronically. This facilitates the governance of the firm, reduces human errors and the monitoring costs, increases the efficiency and makes the management process more transparent. Further, ERP can be integrated with the firm's e-business and supply chain management systems. The integration with other systems automates the purchase and order management process, reduces the order cycle time, the transaction costs and the inventory holding costs, quickens the response time to customer demand and improves customer satisfaction.

Taken together, ERP systems can reduce the firm's costs and boost the profitability. Hence, the following hypothesis is advanced:

H1. ERP implementation leads to improvement in financial performance.

4. SAMPLE SELECTION AND METHOD

4.1 Sample Selection

The sample was selected by identifying public traded Chinese chemical firms that publicly disclosed ERP implementation between 1998 and 2005. The reason of selecting chemical firms as the sample is that there is a heat wave of ERP investments in the chemical industry in China in recent years. An initial sample was identified by searching the firms' news and reports with the keyword as "the firm name ERP implementation" for each firm using searching engines such as Google, Baidu and Yahoo. Then, the initial sample was reduced to 50 firms using the following filter conditions:

1. There is specific year when the firm's ERP implementation was started;
2. The financial data before and after the ERP implementation was available;
3. ERP implementation must have begun before December 2005.

The distribution of the sample firms by implementation year and the descriptive statistics of the sample firms are shown in Table 1 and Table 2.

Table 1. The Distribution of the Sample Firms by Implementation Year

Implementation year	Number of implementations	Percent
1998	2	4.0
1999	1	2.0
2000	3	6.0
2001	10	20.0
2002	11	22.0
2003	6	12.0
2004	9	18.0
2005	8	16.0
Total	50	100.0

Table 2. The Descriptive Statistics of the Sample Firms in the Year before ERP Implementation

	Mean	Median	S. D.	Maximum	Minimum
Total assets (¥ million)	2183.18	1278.75	4054.03	27580.83	114.22
Sales (¥ million)	1777.65	810.48	4364.61	29567.14	123.16
COGS (¥ million)	1483.74	668.07	3739.18	25242.21	82.01

4.2 Choosing the Period over Which to Measure Performance Impacts

To better understand the impacts of ERP implementation on firm performance, this paper examines the financial performance during the implementation period as well as the post-implementation period. 16 adopting firms, nearly one third of the firms in the sample, disclosed both the start and ending dates for their ERP implementation. Based on the detailed timeline information from those firms, we estimate that the average time from start of implementation to live is 17.5 months, which is close to the results of Mabert et al. [7]. Given the above evidence, a two-year implementation period is chosen. As the benefits of ERP seem to be shown only after a long time of continue use, a three-year post-implementation period, and overall a five-year period is chosen to measure the financial performance impacts of ERP. This paper uses T_0 , T_1 to

denote the two years in the implementation period and $T2, T3, T4$ to denote the three years in the post-implementation period. Then the year before implementation is coded as $T - 1$.

4.3 Research Method

In order to analyze the impacts of ERP implementation on financial performance, this paper selects return on assets (ROA), return on sales (ROS) and the ratio of costs of goods sold (COGS) to sales as performance indicators. ROA is the ratio of pre-tax income to total assets, and ROS is the ratio of operating income to sales, where operating income is defined as sales less COGS and SG&A. These two indicators are the measures of firm's profitability, while the ratio of COGS to sales is a measure of the firm's operating efficiency. The financial data needed to calculate the three indicators is collected from WIND database.

This paper analyzes the abnormal performance of sample firms in the implementation and the post-implementation period to examine the impacts of ERP implementation on firm performance. The abnormal performance of firm i in year t (AP_{it}) is defined as the real performance of firm i in year t (P_{it}) less the expected performance of firm i in year t ($E(P_{it})$), while the expected performance in year t is the expected performance of the firm i in the absence of ERP implementation. The abnormal performance in the implementation period and the post-implementation period can be expressed by the following equation:

$$AP_{it} = P_{it} - E(P_{it}), t = T0, T1, T2, T3, T4 \quad (4)$$

Based on the research of Barber and Lyon on the methods of event studies, an expectation model incorporates a firm's pre-event performance yields well-specified and powerful test statistics [8]. Therefore, this paper chooses the following expectation model to calculate the expected performance of firm i in year t :

$$E(P_{it}) = P_{i,T-1} + (PI_t - PI_{T-1}), t = T0, T1, T2, T3, T4 \quad (2)$$

Where $P_{i,T-1}$ represents the performance of firm i in the year before ERP implementation, and $(PI_t - PI_{T-1})$ represents the change of the median performance of the control group between the year before ERP implementation and the year t . The introduction of the control group eliminates the influence of macro-economy and other factors unrelated to ERP implementation. Hence, the abnormal performance can be finally expressed as follows:

$$AP_{it} = P_{it} - P_{i,T-1} - (PI_t - PI_{T-1}), t = T0, T1, T2, T3, T4 \quad (3)$$

Barber and Lyon found that selecting the control group that have similar size as that of the sample firms yields well-specified test statistics and they also emphasize

the importance of using a portfolio of firms as the control group [8]. This paper follows their findings and uses a three-step to select the control group.

1. For each sample firm, identify all firms that have the same industry code as that of the sample firm and whose sales in the year before ERP implementation is within 70%–130% of the sample firm. All firms that meet the criteria are considered part of the control group for the sample firm. The 70%-130% filter on performance is used because this range yields well-specified test statistics [8].
2. If not find any firms in step 1, identify all firms whose sales in the year before ERP implementation is within 70%-130% of the sample firm, without regard to the industry code.
3. If not find any firms in step 2, choose firms whose sales is closest to the sample firm, without regard to the industry code.

5. RESULTS

In order to test the hypothesis in this paper, a t-test for the mean is used to test whether the means of abnormal performance during the ERP implementation and post-implementation period are significantly from zero. Before t-test, the Kolmogorov-Smirnov test is used to test whether the abnormal performance distributions are normally distributed. The hypothesis can not be rejected in every case. Therefore, a t-test could be used to test the hypothesis in this paper.

Table 3. T-test Results for the Mean of the Sample Firms' Abnormal Performance

	Implementation period (T0-T1)		Post-implementation period (T2-T4)		
	T0	T1	T2	T3	T4
Year					
Number of observations ¹	50	42	33	27	16
Mean of abnormal change in ROA (%)	-0.5493 (-0.857)	-0.4697 (-0.434)	-1.8950 (-1.751) ²	-0.9723 (-0.753)	0.5789 (0.423)
Mean of abnormal change in ROS (%)	0.1754 (0.26)	0.0362 (0.037)	-0.8430 (-0.834)	0.4105 (-0.359)	-0.0866 (-0.057)
Mean of abnormal change in COGS / sales (%)	0.1122 (0.152)	0.5481 (0.569)	2.9386 (2.356) ³	2.3475 (1.532)	-0.0228 (-0.01)

As can be seen from Table 3, during the two-year implementation period and the first two years after implementation, the means of abnormal changes in ROA are negative. But only the abnormal change in the first year after implementation is significantly from zero at the 10% level ($t=-1.751$, $p=0.089$). In the third year after implementation, the mean of abnormal change in ROA is positive, but not statistically

¹ Sample size varies due to the non-availability of implementation and post-implementation data for sample firms.

² Significantly different from zero at the 10% level for two tails

³ Significantly different from zero at the 2.5% level for two tails

significant. The abnormal changes in ROS during the two-year implementation period are positive, but none are significant. During the three-year post-implementation period, the abnormal changes in ROS are negative but not significantly. During the implementation period and the first two years after implementation, the means of abnormal changes in the ratio of COGS to sales are positive, and the change in the first year after implementation is significantly from zero at the 2.5% level ($t=2.356$, $p=0.025$). In the third year after implementation, the mean of abnormal change in the ratio of COGS to sales is -0.028 , insignificantly below zero.

As outliers may influence the results of t-test for the mean, a non-parametric test, Wilcoxon sign rank test for the median is also used to test the sample. The results of Wilcoxon sign rank test are basically consistent with those of t-test. All the evidence suggests that the financial performance of firms implementing ERP is not improved significantly, and during the first two years after implementation, the financial performance declines. The hypothesis in this paper is not supported.

6. CONCLUSIONS

Based on an analysis of 50 sample firms that have implemented ERP between 1998 and 2005, this paper examines the impacts of ERP implementation on firm performance. The results find no significant improvement in ROA, ROS and the ratio of COGS to sales during the two-year implementation period and the three-year post-implementation period and a decrease in all the three performance ratios during the first two years after implementation. To fully understand the results, we discuss the findings of this study further.

First, in order to implement ERP, the firm needs to invest on software and hardware and commit a great deal of organization resources. This may raise the firm's costs and expenses. Furthermore, ERP implementation is accompanied with some integration problems, such as the integration with legacy systems, the integration with internal business process and external partners. These problems may hamper the firm's daily operation and lead to an increase in costs and a decline in financial performance. ERP may integrate with the firm's daily operation only after a long-term use and the financial benefits of ERP may show. This indicates that the impacts of ERP implementation on performance improvement have a time-lagged effect. The three-year post-implementation period used by this paper may be insufficient to capture the impacts of ERP on financial performance, but the lack of long-term post-implementation financial data for most of the samples make it infeasible to use a longer time for analysis. Future research should lengthen the time window to ensure an adequate time period for studying the impacts of ERP on firm performance.

Second, a more detailed analysis of the distribution of abnormal performance of the sample firms suggests that some firms gain superior financial performance, but some firms experience adverse financial performance. This may be because the disparities among firms in their capabilities to manage the critical factors influencing the ERP implementation. The firm's leadership, organization structure, culture, human resource and the implementation experience of IT projects and other tangible

and intangible resources could influence the successful implementation of ERP and mediate the effects of ERP on firm performance. Based on the resource-based view of the firm (RBV), Bharadwaj testifies that firms with high IT capabilities tend to show high financial performance [9]. The study of Bharadwaj provides a beneficial perspective to study what organization resources influence whether firms can realize the expected benefits from ERP use. Future research should investigate how the firms realize the expected benefits from ERP use and what organization resources influence the successful use of ERP on the basis of RBV.

Finally, this paper only chooses the sample firms in the chemical industry, and the method to identify sample firms using keywords search may exclude firms implementing ERP but not willing to make known. These firms may be included in the control group. Future research should choose sample firms from a variety of industries and identify samples using surveys or interviews to avoid the potential bias. In conclusion, this paper provides insight for the Chinese firms that want to invest in ERP. ERP does not necessarily help them gain superior financial performance especially in the years shortly after implementation. Due to the high costs of ERP implementation, firms' performance may decline in the years shortly after ERP implementation. Hence, firms should set rational implementation goal before ERP implementation and put more emphasis on managing the implementation process.

ACKNOWLEDGEMENTS

Funding for this research was supported by the National Natural Science Foundation of China under Grant No.70671007 and the PhD Program Foundation of Education Ministry of China under Contract No. 20040006023.

REFERENCES

1. Anonymous, *CCW Research data: a heat wave of software investments in the chemical industry*, CCW Research (2006).
http://cio.ccw.com.cn/data/ccw/xb/hm2006/20060427_13Q46.asp (Accessed May 19, 2007)
2. R. Poston and S. Grabski, The financial impacts of enterprise resource planning implementations, *International Journal of Accounting Information Systems*. Volume 2, pp.271-294, (2001).
3. J. E. Hunton, B. Lippincott, and J. L. Reck, Enterprise resource planning systems: comparing firm performance of adopters and nonadopters, *International Journal of Accounting Information Systems*. Volume 4, pp.165-184, (2003).
4. L. M. Hitt, D. J. Wu, and X. Zhou, Investment in enterprise resources planning: business impact and productivity measures, *Journal of Management Information Systems*. Volume 19, Number 1, pp.71-98, (2002).
5. A.I. Nicolaou, Firm performance effects in relation to the implementation and use of enterprise resource planning systems, *Journal of Information Systems*. Volume 18, Number 2, pp.79-105, (2004).

6. K.B. Hendricks, V.R. Singhal, and J.K. Stratman, The impact of enterprise systems on corporate performance: A study of ERP, SCM, and CRM system implementations, *Journal of Operations Management*. Volume 25, pp.65-82, (2007).
7. V.A. Mabert, A.K. Soni, and M.A. Venkataramanan, Enterprise resource planning survey of US manufacturing firms, *Production & Inventory Management Journal*. Volume 41, Number 20, pp.52-58, (2000).
8. B.M. Barber and J.D. Lyon, Detecting abnormal operating performance: the empirical power and specification of test statistics, *Journal of Financial Economics*. Volume 41, pp.359-399, (1996).
9. A.S. Bharadwaj, A resource-based perspective on information technology capability and firm performance: an empirical investigation, *MIS Quarterly*. Volume 24, Number 1, pp.169-196, (2000).