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An Empirical Study of Operational Performance Convergence Following Enterprise-IT Implementation

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Abstract

This paper presents an empirical investigation into the influence of enterprise-level software package implementation on operational performance. It seeks to determine whether, as some suggest, the implementation of these technologies leads to convergence in operational performance. The potential for performance convergence is important because if it occurs, then the use of packaged software applications may act as a leveler of competitive performance, rather than as a tool to promote competitive differentiation.

This paper investigates operational performance change and convergence within three geographically defined operating regions of a single firm. Operational performance is measured using order lead-time – the elapsed time between when an order is received and when it is shipped to the customer. The firm implemented Enterprise Resource Planning (ERP) across its global operations, simultaneously in all regions, using single installation of the applications.

Findings suggest that convergence may be an initial characteristic of initial operating performance following ERP deployment. However differences in rates of performance change following deployment led to divergence in operating performance. This suggests that convergence is not a long-run characteristic of post-ERP performance.

1. Introduction

The productivity paradox of information technology is largely resolved. Properly implemented information technology can be an effective tool for firms' use in pursuit of improved performance. The efficacy of information technology has been demonstrated at the level of the economy (Dewan et al. 1998), the industry (Weill 1992), and the firm (McAfee 2002), using measures that include GNP, productivity, consumer surplus, and operational performance. Yet as the issues of general effectiveness recede, new questions emerge.

One such question concerns the influence that the use of enterprise-level packaged software applications has on firms' ability to competitively differentiate themselves from one another. The importance of this question derives from the increasing use of these technologies. In 2001, firms were expected to invest more than $47 billion on enterprise systems (ES) packages (AMR 2001). Billions of additional dollars were invested in the services and computer hardware required to implement and maintain these systems (Mabert et al. 2000; Willcocks et al. 2000). One leading ES vendor, SAP, reported in June of 2001 that it alone accounted for more than 36,000 software installations in 15,000 companies, spread across 120 countries.

Both proponents and critics of ES investment view the technology as an enabler of standardization in business process execution and performance. Proponents view this standardization as a positive outcome, leading to process improvability and consistently high operational performance across the firm. Critics argue that the standardization imposed by these technologies is a path to competitive parity and is therefore, non-strategic. Lacking on both sides of the debate is a clear understanding of whether ES implementation actually leads to a convergence in operational performance. Contributing to the development of that understanding is the objective of this paper.

This paper investigates the influence of ES software package implementation on operational performance convergence in the context of three geographically defined operating regions of a single firm. Operational performance is measured using order lead-time – the elapsed time between when an order is received and when it is shipped to the customer. The analysis takes place in the context of a computer peripherals manufacturer for whom order lead-time represented a key criteria upon which competitive success was determined.[1] This firm deployed an Enterprise Resource Planning (ERP) software package across its global operations, simultaneously in all regions, using single installation of the applications.

Findings demonstrate convergence in operational performance immediately following deployment of the new ES. While all regions showed some level of improvement, the convergence was for the most part achieved through the improvement of the region that had been performing the worst prior to deployment. In the period following deployment, rates of performance change differed significantly, eventually leading to divergence in lead-time performance.

Findings suggest that the deployment of enterprise systems like ERP may, in fact, enable a certain level of initial convergence in business process performance. However, the paper suggests that these systems do not deterministically control performance to the extent that implementing sites can maintain this convergence in the face of other managerially relevant factors.

The rest of the paper proceeds as follows. Section 2 presents a brief overview of the literature that is relevant to the discussion of information technology-enabled improvement and performance convergence. Section 3 presents the data used for the study. Section 4 presents a statistical analysis of the data. Section 5 discusses the analysis. Section 6 provides some conclusions from the analysis and discusses several of the study's limitations.

2. Enterprise Systems, Performance, and Convergence

Traditional research on information technology value has established that, in general, firms benefit from information technology investment (Brynjolfsson et al. 1998; Dewan et al. 1998; Hitt et al. 1996). More recent research has extended this understanding to the influence of ES on business performance. These studies have suggested that ES technologies offer the potential for firms to improve productivity, stock market premiums, and operational performance. In particular, Hitt (2002) performs an industry-level econometric analysis that compares ERP adopters with non-adopters. Findings indicate that ERP implementation leads to improvements in productivity, and in Tobin's *q*, a measure of surplus stock market returns. These findings are consistent with firm-level research that demonstrates improvements in operational performance (McAfee 2002).

Despite these findings, it is still unclear whether ERP confers long-term competitive advantage to the firm. ERP implementation, while widespread, is not yet ubiquitous. Even among firms that have made ERP investments, many are either incomplete or not fully deployed (Deloitte 1998). Therefore, despite operational improvements, the surplus stock market returns that have been identified may be transitory in nature, owing to a sort of early-mover advantage rather than to sustainable competitive advantage. This view would resolve potential inconsistencies with prior industry-level studies of information technology that show it delivers improvements in productivity and consumer surplus, but not in profitability (the anticipation of which is a key antecedent of positive Tobin's *q*) (see, Hitt et al. 1996).[2] The question of whether the implementation of ES like ERP can lead to sustainable competitive advantage is still an open one.

ES Technology Characteristics and the Standardization of Business Process

The ability for firms to derive sustainable competitive advantage from the implementation of ERP may be complicated by both system characteristics and the reasons for which ES is implemented. Researchers have noted that ES software package developers embed a set of assumptions about the way business processes should work (Austin et al. 1998; Davenport 1998; Davenport 2000; Upton et al. 2000). These assumptions represent vendor-determined best practices for business processes, and act as templates (also called reference models) around which firms may be predisposed to build their business processes (Scheer et al. 2000). If the implementation of ES technology such as ERP predisposes a firm to adopt a particular business process approach, then the potential for performance convergence may emerge.

There are at least two reasons why performance convergence may be particularly prevalent in the case of ERP deployment. First, employees may have little choice but to use the software in the conduct of their jobs because ERP supports the core business processes of the firm (Davenport 1998). Employees who refuse to use the technology may simply be unable to fulfill the demands of their organizational roles. Second, ERP is routinely characterized as monolithic and inflexible. Some have likened its implementation to "pouring concrete over your business plan" (Carson 1998). Thus, when using the applications, employees may have little alternative but to do so in the manner prescribed by the software. The notion that implementation of ES technologies like ERP leads to a standardization of business processes execution (if not performance) has been born out in case-based research on the subject (Davenport 2000).

Managerial Intent and the Standardization of Business Process

The standardizing influence of ERP may be magnified by managerial intent. Standardization of business process is commonly identified as one of the key goals of managers leading ERP implementations (Austin et al. 1999; Deloitte 1998). Advocates of process standardization argue that it can form a major component of a firm's operations strategy by promoting the development of deep knowledge and understanding of the way processes should unfold (Hayes et al. 1988). Standardization facilitates cross-site learning by allowing distributed sites to learn from each other's experiences (Pisano et al. 2001). One mechanism through which it does so may be through the ability of the firm to embed important operational knowledge in process and technology. Knowledge embedded in process and technology has been identified as an enabler of the transfer of organizational learning across the firm (Darr et al. 1995; Epple et al. 1991; Epple et al. 1996). Process standardization also promotes the ability to measure, compare and improve performance. These abilities represent precursors to process improvement (Garvin 1998).

Critics argue that process standardization suppresses local adaptation and learning (Pisano et al. 2001). Lacking the opportunity to adapt to local conditions, firms may be overtaken by competitors. Standardization has also been viewed as an enabler of process duplication by competitors. The structuring of a business process in such a way that it is repeatable within the firm may also make it repeatable outside the firm. Packaged information technology implementation has been singled out for particular criticism in this regard. The broad availability of these technologies and their associated implementation services makes them readily available to competitors. Because of this, investment in these kinds of technologies and services has been viewed as non-strategic (Porter 1996). The most dire predictions suggest that investments in these technologies may evolve into a parity move within an industry, rather than a step toward competitive differentiation (Davenport 2000).

Factors Mitigating Convergent Performance

Research in other operational contexts may raise doubts about the extent to which an ES or any other technology can lead to convergence in performance. For example, Hayes & Clark (1986) demonstrate that despite similarities in products and technologies, different manufacturing plants owned by the same company demonstrate significantly different levels of total factor productivity. Analysis reveals a variety of managerially oriented factors that contributed to these differences, including the management of, waste, WIP, and engineering change orders. Quality studies have yielded similar results. Plants using similar processes to manufacture similar products have been shown to deliver very different quality outcomes (Garvin 1988). Garvin's research identified a different set of levers that contributed to superior results, including alternative engineering practices, supplier management, data analysis, and production management. Beyond identifying specific drivers of differential performance, these studies argue that the capacity of technology to determine performance outcomes is limited.

An examination of the literature raises a question about the extent to which the relative operational performance of ES implementation sites should converge following deployment. This paper attempts to address this question *by investigating whether ES implementation has led to convergence in operational performance across the distributed operating regions of one firm*. The results of this investigation will be important to both advocates and critics of business process standardization and ES implementation because of the role business process standardization and performance convergence are seen to play in promoting the competitive success of firms.

3. Context and Measurement of Operational Performance.

Ideally, the question of whether ES implementation leads to convergence in operational performance would be addressed by looking across many firms. The limitations of this study prevent this approach. Instead, this study takes a first step toward understanding the influence of ES implementation on convergence by looking at operational performance in the context of three geographically defined operating regions of a single firm. Despite the limitation of the use of a single firm, this approach has the advantage of controlling for uniqueness in the specific ERP package selected as well as for the characteristics of the implementation. For example, research has shown that firms may employ different deployment strategies (e.g., phased rollout vs. "big bang") and technology platforms for their ERP implementations (Markus et al. 2000). Selection of a single firm for study eliminates these factors as potential explainers of subsequent operational performance. The result may be a more conservative analysis in which the emergence of convergent performance should be highly visible. Alternatively, where convergence in performance is detected, future study would be required to determine whether it extends beyond the boundaries of a single firm.

The paper focuses on operational performance in the order management process. Order management has been a primary target of ERP implementations (Austin et al. 1999; Deloitte 1998; Mabert et al. 2000). There is also good reason to expect that ERP implementation might affect order management process performance. First, ERP solutions explicitly target the order management process, including functionality for order generation, planning, production scheduling, inventory allocation, order picking, and shipping (Davenport 1998). Second, ERPs are intended specifically to link together business processes and information in order to improve communication and visibility (McAfee 1999). For example, in the firm studied, "available-to-promise" functionality was intended to give visibility into the internal supply network (distributed production and finished goods) to allocate and ship inventory rapidly.

Order management process performance is measured using order lead-time, the elapsed time between the date an order is received by the firm and the date the product is shipped to the customer. Lead-time has established roots as a measure of order management and supply-chain performance, having been used in multiple studies of related phenomena (Hult et al. 2002; Mabert et al. 2000; McAfee 2002). The importance of cycle time has also been demonstrated in studies of customer service (Stalk et al. 1990) and manufacturing performance (Hayes et al. 1988). Finally, order lead-time reductions are valuable to firms as a source of overall business cycle reduction and working capital release. In the case of the firm studied, each day's reduction in order lead-time was estimated to be worth approximately $11 million in freed working capital.

4. Analysis of Operating Data

Lead-time data were collected for sales orders processed both before and after ERP deployment. The data included information necessary to calculate order lead-time, as well as related information that allowed transactions to be sorted by operating region and classified in other ways including transaction date, order quantity and order amount. The variables used in the analysis are defined in Table 1. Summary statistics are provided in Table 2.

Table 1: Model variable definitions

Variable Name	Definition
leadtime	Elapsed time between the order booking date and the date it was recorded as shipped to the customer.
month	A time index variable used to capture the number of months prior to, or after ERP deployment that a transaction was executed.
europe, **asia**	Indicator variables that identify the operating region in which a sales order was generated. Transactions that originated in North America were identified where both **europe** and **asia** were set equal to zero.
daycount	The total number of order transactions that were processed within the operating region on the day the order was taken. A measure of business intensity.
ordqty	The total number of product units (in thousands) associated with the order. A measure of order size.
ordvalue	The total dollar value (in thousands) of the sales order. A measure of order value.

Table 2: Summary of Analysis Variables

Variable	N	Mean	Std. Dev.	Min	Max
leadtime	112818	33.44	35.65	0	434
month	112818	9.39	9.90	-12	24
europe	112818	0.29	0.45	0	1
asia	112818	0.19	0.40	0	1
daycount	112818	94.58	90.29	1	833
ordqty	112818	0.64	1.86	0	116
ordvalue	112818	262.61	1728.00	0	126000

Approximately 113,000 pre- and post-deployment order records were used in the analysis. These records cover a period beginning 12 months prior to deployment and extend 24 months following deployment.[3]

The data were analyzed using the following model.

$$
\begin{aligned}
&leadtime_i = \alpha + \beta_1 daycount_{ij} + \beta_2 ordqty_i + \beta_3 ordvalue_i + \beta_4 europe_i + \beta_5 asia_i + \\
&\beta_6 europe_i * daycount_{ij} + \beta_7 asia_i * daycount_{ij} + \beta_8 europe_i * ordqty_i + \beta_9 asia_i * ordqty_i + \\
&\beta_{10} europe_i * ordvalue_i + \beta_{11} asia_i * ordvalue_i + \beta_{12} month_i + \beta_{13} europe_i * month_i + \\
&\beta_{14} asia_i * month_i + \beta_{15} month2_i + \beta_{16} europe_i * month2_i + \beta_{17} asia_i * month2_i + \varepsilon
\end{aligned}
\qquad \textbf{(1)}
$$

Where "*i*" represents the customer order and "*j*" represents the operating region from which the order was placed.

Model selection was theoretically motivated by the literature on learning curves, which posits that performance following the implementation of new process and/or technology will improve nonlinearly but monotonically with time or experience as a function of learning-by-doing (see Dutton et al. 1984; Yelle 1979 for comprehensive reviews of the learning curve literature). Typical learning curve specifications utilize models that relate the log of performance to the log of either elapsed time or cumulative experience. In this case, however, the existence of zero values for the performance measure (i.e., when the order was booked and shipped on the same day) prompted a search for alternative specifications.

Visual inspection of the data raised the concern that the improvement function was non-linear in time. Specifically, it appeared that a performance dip might exist following initial ERP deployment. In order to capture this characteristic of the data, and to accommodate zero values in the dependent variable, various exponential functions were tested for use in the model. These alternatives included transformations of the dependent and independent variables according to Neter (1990).

The final functional form was selected based on model fit and use in prior, related research (see, McAfee 2002). Models were also evaluated that controlled for calendar month, quarter, and quarter ends. Finally, analysis was completed using an enhanced model for the post-deployment period. This model included data on sales channel, and product type. Different modeling alternatives reported similar results. The model presented was selected on grounds of fit, parsimony, and interpretability. As a final test, models were run assuming both constant and differing levels variation across operation regions. Findings were identical using both models.

OLS results for the analyses are presented in Table 3. Models 1a and 1b include only the main effects for the combined pre- and post-deployment periods. These models establish baseline lead-time performance over the entire period studied and the contribution of the control variables to the explanatory power of the model. Model 1a does so by assuming a linear relationship between lead-time and operating month. Model 1b repeats this analysis with the addition of **month2,** which accommodates an apparent non-linear relationship between lead-time and operating month. We note the significance ($p<.001$) for each of the variables in the main effects models.

Model 2 and Model 3 facilitate the analysis of operating region effects through the inclusion of **europe** and **asia** and their interactions with each of the variables in the main effects models. The models focus respectively on pre- (Model 2) and post-deployment (Model 3) periods in order to facilitate the interpretation of operating region effects through avoidance of three-way interactions.

Table 3: Summary of OLS pre- and post-deployment lead-time performance (standard errors in parentheses).

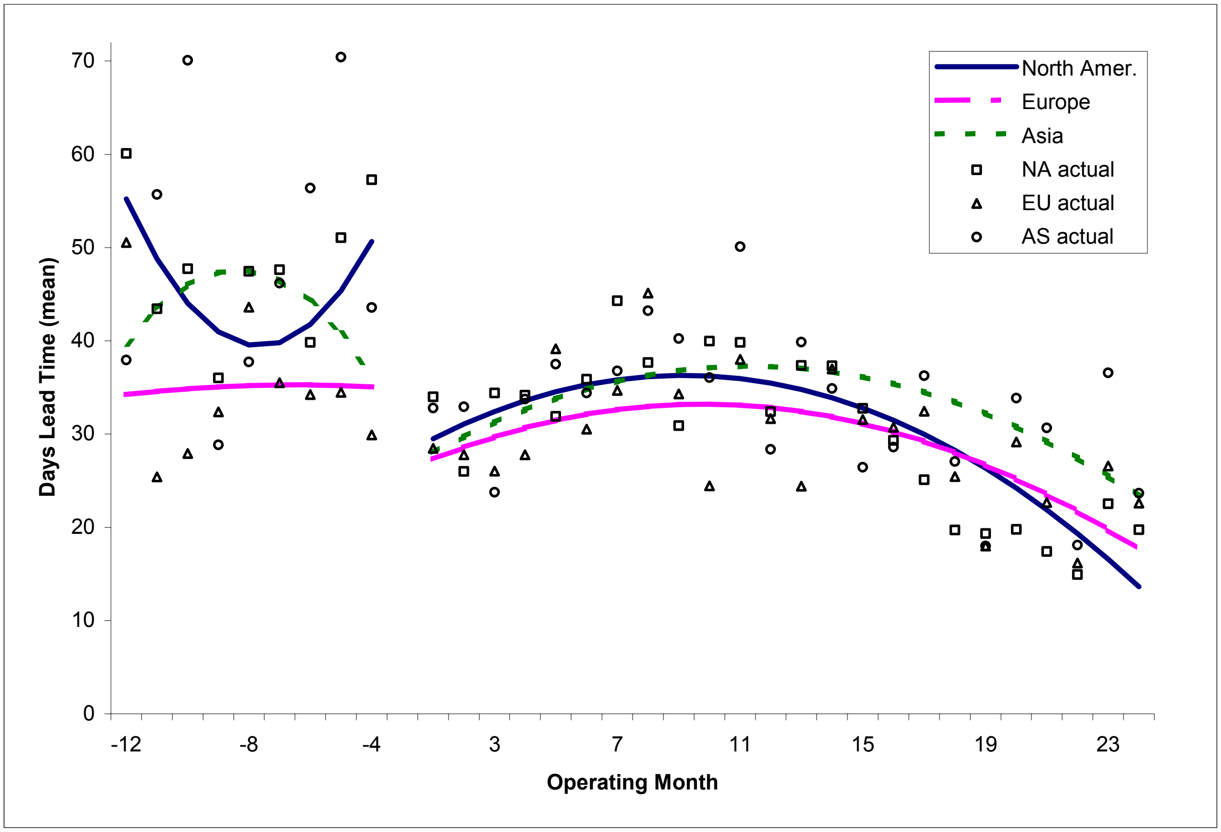
Deployment Period: Model:	Pre- & Post- Model 1	Pre- & Post- Model 1	Pre- Model 2	Post- Model 3
constant	36.6418*** (0.1915)	36.8841*** (0.2017)	72.1573*** (3.3427)	25.7695*** (0.6215)
daycount	0.0348*** (0.0012)	0.0347*** (0.0012)	0.1595*** (0.0055)	0.0246*** (0.0015)
ordqty	-0.4160*** (0.0559)	-0.4214*** (0.0559)	-0.7090*** (0.2296)	-0.5222*** (0.1069)
ordvalue	-0.0002*** (0.0001)	-0.0002*** (0.0001)	0.0174*** (0.0015)	-0.0044*** (0.0009)
month	-0.6585*** (0.0106)	-0.6052*** (0.0175)	12.8035*** (0.8679)	1.8776*** (0.0979)
month2		-0.003883*** (0.0010)	0.8358*** (0.0540)	-0.1027*** (0.0037)
europe			-49.1323*** (13.5041)	-7.5153*** (0.9576)
asia			-78.0025*** (24.6277)	-1.3665 (1.0482)
europe*daycount			0.6629*** (0.1063)	0.0882*** (0.0040)
asia*daycount			1.7929*** (0.1676)	0.0132*** (0.0029)
europe*ordqty			-1.6593 (5.9740)	0.3818* (0.2083)
asia*ordqty			-24.8945* (14.6772)	0.4077*** (0.1420)
europe*ordvalue			-0.0123 (0.0177)	-0.0033** (0.0016)
asia*ordvalue			0.1307 (0.0861)	0.0040*** (0.0009)
europe*month			-13.2358*** (3.3564)	-0.3707*** (0.1508)
asia*month			-22.8255*** (6.1189)	0.0886 (0.1699)
europe*month2			-0.8692*** (0.2011)	0.02562*** (0.0058)
asia*month2			-1.4350*** (0.3629)	0.01599*** (0.0065)
R-Square (adj.)	0.0459	0.0461	0.0807	0.0456
N	112818	112818	18277	94541
Prob. > F	0.0000	0.0000	0.0000	0.0000

Table 4 presents prototypical order lead-times based on these results for each month using median values for each of the other independent variables. Also included in Table 4 are calculations of the instantaneous rate of lead-time performance change for each operating month, and a calculation of the absolute difference in predicted lead-time between each operating region.[4] Prototypical lead-time performance is graphically depicted in Figure 1. The figure presents prototypical plots for all regions overlaid with actual monthly performance data for each region.

Table 4: Summary of prototypical lead-times, estimated rate of performance change, and estimated days of lead-time difference from North America, by operating month and operating region.

Operating	Predicted Values			Rate of Perf. Change			Days Diff from NA	
Month	NA	EU	AS	NA	EU	AS	EU	AS
-12	55.19	34.24	39.67	-7.26	0.37	4.36	-20.96	-15.52
-11	48.77	34.57	43.43	-5.58	0.30	3.16	-14.20	-5.34
-10	44.03	34.84	45.99	-3.91	0.24	1.96	-9.18	1.97
-9	40.95	35.04	47.36	-2.24	0.17	0.76	-5.91	6.41
-8	39.54	35.18	47.52	-0.57	0.10	-0.43	-4.36	7.98
-7	39.81	35.25	46.49	1.10	0.04	-1.63	-4.56	6.68
-6	41.75	35.25	44.25	2.77	-0.03	-2.83	-6.50	2.50
-5	45.36	35.19	40.82	4.45	-0.10	-4.03	-10.17	-4.54
-4	50.64	35.06	36.19	6.12	-0.16	-5.23	-15.58	-14.45
1	29.49	27.28	28.00	1.67	1.35	1.79	-2.20	-1.49
2	31.06	28.56	29.71	1.47	1.20	1.62	-2.50	-1.35
3	32.42	29.68	31.24	1.26	1.04	1.45	-2.74	-1.18
4	33.58	30.65	32.60	1.06	0.89	1.27	-2.93	-0.98
5	34.53	31.46	33.79	0.85	0.74	1.10	-3.07	-0.75
6	35.28	32.12	34.80	0.65	0.58	0.93	-3.16	-0.48
7	35.83	32.63	35.64	0.44	0.43	0.75	-3.20	-0.19
8	36.16	32.98	36.30	0.23	0.27	0.58	-3.19	0.14
9	36.30	33.18	36.80	0.03	0.12	0.41	-3.12	0.50
10	36.22	33.22	37.12	-0.18	-0.03	0.23	-3.00	0.89
11	35.94	33.11	37.26	-0.38	-0.19	0.06	-2.84	1.32
12	35.46	32.84	37.23	-0.59	-0.34	-0.11	-2.62	1.77
13	34.77	32.42	37.03	-0.79	-0.50	-0.29	-2.35	2.26
14	33.88	31.85	36.66	-1.00	-0.65	-0.46	-2.03	2.78
15	32.78	31.12	36.11	-1.20	-0.80	-0.63	-1.66	3.33
16	31.47	30.24	35.39	-1.41	-0.96	-0.81	-1.23	3.92
17	29.96	29.21	34.50	-1.61	-1.11	-0.98	-0.76	4.53
18	28.25	28.02	33.43	-1.82	-1.27	-1.15	-0.23	5.18
19	26.33	26.67	32.19	-2.02	-1.42	-1.33	0.35	5.86
20	24.20	25.17	30.78	-2.23	-1.57	-1.50	0.97	6.57
21	21.87	23.52	29.19	-2.43	-1.73	-1.67	1.65	7.32
22	19.33	21.72	27.43	-2.64	-1.88	-1.85	2.39	8.09
23	16.59	19.76	25.49	-2.84	-2.04	-2.02	3.17	8.90
24	13.64	17.64	23.39	-3.05	-2.19	-2.19	4.00	9.74

Figure 1: Prototypical lead-time values and plot by operating month.



5. Discussion

The goal of this paper has been to investigate the relationship between the deployment of enterprise-level information technology, such as ERP, and convergence in operational performance. In this regard, the most significant findings from this study have less to do with exact rates or amounts of operational performance change, than with the fact that these changes occurred differentially across operating regions and sites, ultimately leading to changes in relative performance among operating regions. Initially, convergence was apparent. However, after allowing time for performance effects to unfold, results differed significantly across regions. Convergence in operational performance was not sustained.

Initial Convergence Following ERP Deployment

The period that immediately followed ERP deployment was marked by improvements in order lead-time for each of the operating regions studied. In particular, the North American region realized dramatic lead-time performance improvement, falling nearly 42 percent from 50.6 to 29.5 days. The relatively smaller magnitudes of lead-time performance improvement in Europe and Asia allowed for North America to "catch up", converging in performance on the other two regions.

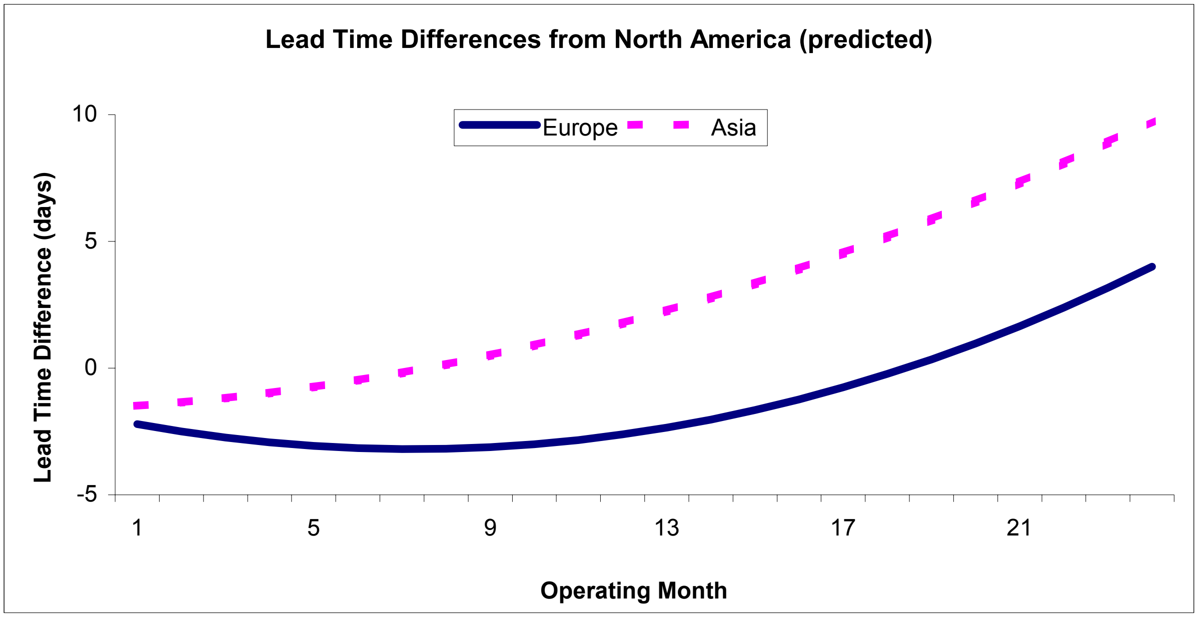
The effects of these relative performance changes are most evident in the case of North America and Asia. Prior to ERP deployment the Asian region enjoyed a significant performance advantage over North America. Immediately following deployment, the two regions were statistically indistinguishable, with Asia enjoying an estimated advantage of only 1.5 days. Convergence was also evident between North America and Europe, where the number of estimated days difference in lead-times dropped nearly 86 percent from 15.5 days to 2.2 days between the pre- and post-deployment periods. Relative performance between Europe and Asia remained quite stable between the pre- and post-deployment periods.

Divergence in Operational Performance Over Time

Despite initial levels of relative performance, convergence does not appear to be a long-term characteristic of operational performance across the regions. Differences in rates of performance change following ERP deployment almost immediately began to exert strong influence on the relative performance of the operating regions. For example, following a decline in performance shared by each of the regions, North America begins to improve sooner and improves faster than Asia, causing it to surpass Asia in lead-time performance in the eighth month following deployment. The performance gap between these two regions continued widening until, by the end of the study period, North America enjoyed a 71 percent (13.64 vs. 23.39 day) lead-time advantage over Asia.

The North American improvement rate exceeded the European rate in months 11 through 24 and the European rate exceeded the Asian rate between months 11 and 18 resulting in significant performance gaps that existed through the end of the study period. In the case of the firm studied, these rate differentials prolonged the period of convergence as the regions "traded places" in terms of their relative performance rankings. This was most obviously the case in the comparison between North America and Europe. European performance was significantly better at the start of the post-deployment period; however, by month 19 the more rapidly improving North American region had overtaken Europe in lead-time performance. Overall differences in the rate of performance change across operating regions resulted in significantly different prototypical levels of lead-time performance by the end of the analysis period. Figure 2 provides a graphical depiction of these differences over time following ERP deployment.

Figure 2: Regional differences in lead-time performance by operating month.



6. Conclusion

Researchers and managers might draw two insights from these findings. First, it should not be assumed that enterprise-level information technologies like ERP represent an effective tool for standardizing operational performance within the firm. Although some performance convergence did initially occur, it did not prove to be a long-term characteristic of relative regional performance. Findings are consistent with work in other areas (Garvin 1988; Hayes et al. 1986) in that they suggest that operational performance is determined by more than just the technology used to support it. Some of these factors were incorporated into the models that have been presented. These include measures of operational scale, order size and order value. Which other factors contribute to operational performance, and their effect on the findings in this paper, is a matter that is taken up in the discussion of this study's limitations.

Second, critics of enterprise systems may worry less about the prospect of enterprise system implementation diluting competitive advantage. The evidence presented in this paper suggests that significant performance differentiation remains possible over time following ERP deployment. The notion that a combination of embedded business process assumptions and the wide availability of software packages leads to long-term competitive convergence is rejected, at least with regard to the outcome studied here. This finding may be particularly strong given that it occurred in the context of a single firm's ERP deployment. Given similarities in the management structure, management goals, products, and customers shared by the different operating regions, convergence might reasonably be expected. The fact that was not a stable phenomenon within a single firm casts doubt on the potential for it to promote operational convergence across separate firms.

The fact that performance both changes and diverges following implementation suggests that the implementation of ERP is not like pouring concrete on the firm's business plan or its underlying processes. Rather, the evidence suggests that different operating regions are able to alter their business process performance in different ways over time. That said, the results do show that the performance differential between the operating regions was smaller than it was prior to ERP deployment. This suggests that the technology may effectively place some bounds around the performance of business processes. Future research should consider how limiting these bounds are, particularly with regard to the ability of firms to consistently implement "best practices" across their operating regions. Alternatively, it may be that over a more extended period of time performance would have diverged to the level of previous differences. Future research could contribute in this regard by evaluating longer time periods for signs of increased divergence.

Limitations of the study

Several limitations of this study should be kept in mind when interpreting the results. First, the data do not exhaustively cover the entire study period. Characteristics of the firm's data conversion strategy led to the elimination of data for the three months prior to deployment of the ERP applications. It is therefore possible that the estimates of pre-deployment performance differences are off by a considerable margin. This limitation is particularly relevant to the evaluation of the Asian and North American regions, whose performance was changing significantly in months prior to the data cutoff. The concern is less troubling for Europe, whose pre-deployment performance seemed quite stable. Future research should seek out performance data that is not subject to the limitations of the current data set. Using such data, the level of convergence attributable to ERP deployment might be more precisely estimated.

Second, this study uses a single performance measure to gauge the influence of the information technology on performance convergence. Other performance measures are certainly important and may have exhibited different convergence patterns. Future research should seek to broaden the conception of operational performance to include other measures to see if similar patterns emerge. The current study still makes a contribution, however, in that these patterns are investigated for at least one important performance dimension. To the extent that order lead-time contributes even partially to the ability of the firm to differentiate itself from competitors, the findings suggest that the deployment of enterprise-level information technologies can contribute to performance improvement without promoting long-term competitive parity.

Third, regional affiliation, although both statistically and managerially significant, accounts for a relatively small proportion of the variation in lead-time performance. It is reasonable to suspect that many other factors contribute to order lead-time performance. It is possible that in addition to potentially explaining more about lead-time variation these other factors may be correlated with operating regions or countries. Such a correlation, although unlikely, could lead to a bias in the estimates of the relationship between deployment site and lead-time.

Future research should consider using other sets of explanatory variables in order to verify the robustness of the findings in these areas. In addition, future research should consider the specification of more robust statistical models. Tests of the data using alternative model specifications yield similar results with regard to patterns of operational performance improvement and convergence. However, other models may still yield improved results. Future research might productively focus on identifying the most appropriate functional forms for use in analyzing performance following the deployment of enterprise-level information technologies.

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Endnotes

[1] See Cotteleer (2002) for a more complete description of the firm implementation context.

[2] The differences in findings between these papers do not necessarily signal a conflict. Hitt (1996) and other studies of information technology productivity typically investigate the influence of information technology broadly defined. Within the universe of information technologies it is possible that there may be a subset that are uniquely able to confer differentiated operational improvements to implementers. The findings presented by Hitt et al (2002) may identify ERP as one of those technologies.

[3] Order transactions are excluded for the three months prior to ERP deployment. Data is excluded in order to avoid bias in estimates of order lead-time performance. This bias would have arisen because at the time of ERP implementation, all outstanding orders were reentered into the new system with order dates corresponding to the first week of ERP operation. As a result, information was not available on the full set of orders processed in the quarter prior to implementation (i.e., only orders that were taken and shipped prior to implementation would have been included in the data set). In addition, the first five days of operation following ERP deployment are excluded as all outstanding pre-deployment records were converted to the new system with booking dates during that time.

[4] Instantaneous rate of change is calculated for each region/month by taking the F.O.C. with respect to month. The calculations are used to assess the rate at which performance is converging or diverging within any given month.