ERP Architectural / Operational Alignment for Order-Processing Performance

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Abstract

The selection of an appropriate Enterprise Resource Planning (ERP) solution remains a complicated task. Since the fundamental role of an ERP solution is to support corporate operations, a key consideration is its alignment with the process requirements of the firm. This work is an investigation into the impact that this alignment has on perceived operational performance. Data is collected using a survey administered to representatives of the machine manufacturing industry. Our findings suggest that the alignment of ERP solutions with operational needs is crucial to perceived ability to deliver orders on time and to general satisfaction with the ERP solution.

Key words: ***Management of Technology, ERP, Alignment, Performance***

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1. Introduction

Vendors of comprehensive systems designed to improve business process efficiency use the term Enterprise Resource Planning (ERP) in many different ways. For our purposes, ERP is a term that describes an integrated software approach designed to efficiently manage the transactions and track the status of a company's day-to-day activities. Companies seeking to fully integrate business functions beginning with back office operations such as accounting and purchasing, through manufacturing and conversion processes, and finally to sales tend to be those most interested in ERP system technology. Such firms recognize that benefits may be gained from the elimination of redundant processes, increased information accuracy, and quicker response to customer requirements (Sarkis and Sundarraj 2000, and McAfee 2002). In a recent paper, we describe fertile areas for research related to ERP systems (Jacobs and Bendoly 2003). This paper centers on one of the areas identified.

Modern ERP packages permit wide variation in implementation both in terms of how systems from various vendors are mixed and in how transaction processes are implemented. For some firms, a single ERP package may be inadequate in providing an effective solution to their operating needs. This is especially true when competitive advantage may be compromised by the reengineering needed to use the processes available from a single package. Such is often the case with large global enterprises concerned with many geographically disperse and unique markets. As an option for such firms, ERP software solutions can be "built" using multiple software systems and databases. These components may still originate from a single vendor, but often multiple software vendors are involved. A multi-system or multi-structure solution may give a firm the opportunity to purchase "best in class" versions of each operating module. At the same time, this tactic comes at the expense of increased monetary investments and resource allocations needed to implement and integrate functional modules.

Accordingly, the selection of an appropriate ERP system strategy is not a simple one. Since the fundamental role of an ERP solution is to support corporate operations, one key consideration that would seem necessary is the alignment of the ERP solution's capabilities with the operational goals of the firm. Questions faced by IT decision include whether or not all of the necessary day-to-day processes will be accounted for, whether the types of processes that form the core of the business can be dealt with appropriately, the appropriate concentration of centralized versus decentralized control, and whether the distinct needs of the various market interests will be met. The underlying issue is one of alignment between corporate operating functionality and IT architecture.

While the concept of strategic alignment has been looked at in various ways in the past, the performance implications of alignment, both within operational and ERP contexts and between the two contexts, has not been adequately considered. In this work we provide an investigation of the customer order-processing tasks supported by ERP system processes. Specifically, we evaluate the operational flexibility provided in these tasks by the system. In addition, we consider how the ERP system has been implemented using a continuum that spans a single vendor centralized system, to the use of multiple vendor decentralized systems. We study the impact of the alignment of ERP system architectures with operational flexibility requirements on on-time delivery performance and user satisfaction with ERP systems.

2. Operational and IT Alignment

Terms such as alignment, fit and congruence have been used for several decades to describe the extent to which decisions or characteristics support and promote each other. Such concepts have proven critical to the development of research areas such as strategic management (Miles and Snow, 1978; Snow

and Miles, 1983). Venkatraman (1989) outlined a classification system identifying six perspectives of the alignment concept: moderation, mediation, matching, gestalt, covariance or profile deviation. Each of these interpretations holds theoretical and analytical implications, although both "matching" and "profile deviation" are defined with regards to the effects that measurable differences between comparable elements can have on performance. Because of the intuitive nature of such definitions these two interpretations of alignment have seen perhaps the greatest application.

In particular, a considerable amount of literature has utilized these interpretations to assess the alignment of operating strategies and environments within which such strategies are set. For example, Venkatraman and Prescott utilized such an interpretation in their study of alignment between an 8-environment typology based on Porter (1980) and specific facets of operating strategy (e.g price, vertical integration, product breadth, etc.). Their results revealed that the profile alignment between strategy and its context has significant positive implications for performance and hence subsequent strategic decisions (Venkatraman and Prescott, 1990). Similar studies have focused on the alignment between operational strategies and the needs of the surrounding market (Staughton and Williams, 1994), operating costs/constraints (Ward et al., 1995), and corporate strategy (Smith and Reece, 1999).

Still other researchers have concentrated on the alignment between multiple operating strategies. One of the most famous frameworks for such considerations has been the Product-Process Matrix introduced by Hayes and Wheelwright (1979a, b). A comprehensive empirical analysis of this framework is provided by Safizadeh, et al. (1996). These authors show that operational alignment has observable positive effects on overall performance. Similarly, in the development of their IT efficiency metrics, Mirani and Lederer (1998) also suggest that alignment should constitute a relevant factor with respect to the

measurable benefits of information systems. Yet an understanding of what exactly is meant by alignment in an IT context remains fuzzy.

2.1. Flexibility and Decentralization

Recently Jacobs and Whybark (2000) presented a research framework suggesting that the fit between certain dimensions of ERP solution strategies may have implications on system performance. The specific structure of the framework, utilizing Flexibility and Decentralization as orthogonal taxons, was selected because of its ability to logically distinguish ERP adoption strategies of firms. An adaptation of their framework is provided in Figure 1.

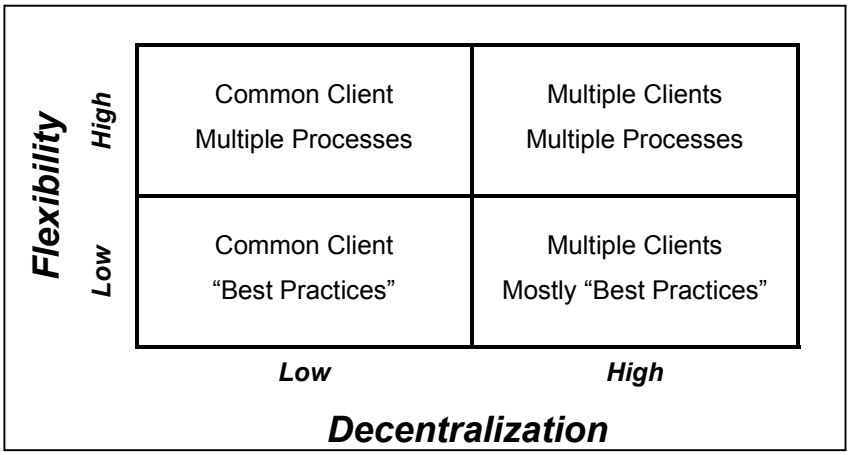

Figure 1. Alignment in ERP Solution Strategies

High flexibility, in the context of this framework, refers to the incorporation of a variety of alternative transaction and documentation routines / processes within the ERP solution, capable of catering to a wide range of disparate operational practices. Low decentralization refers to the use of a single central accounting system structure or database. Given these definitions, the "low flexibility – low decentralization" box represents a solution where all entities use the same processes and are each linked to a single centralized database. This extreme case is often associated with high levels of BPR (Business Process

Reengineering) during implementation, due to requisite convergence on standardization and central control in contrast to the diversity of business-unit-specific legacy systems that can characterize pre-ERP settings.

In contrast, the “low flexibility – high decentralization” box represents the use of standardized routines across business entities, but the use of multiple decentralized databases and accounting system structures. Firms operate in the “high flexibility – low decentralization” box when they choose to make use of single database, but retain multiple processes, perhaps tailored to the needs of each location. Such cases are often referred to as Federalist operating policies (Davenport, 1998). The “high flexibility – high decentralization” box represents the case in which all transactions and accounting measures remain relatively unique and restricted to each entity.

Jacobs and Whybark’s framework suggests a mechanism for studying the alignment between IT strategy and operational strategy since its dimensions are applicable across both operational and IT contexts. From an operational standpoint, process flexibility refers to the ability to continue functioning effectively in response to a wide range of operating requirements (Ramasesh and Jayakumar, 1991). Several specific dimensions of such flexibility have been the focus of research for some time now (Swamidass and Williams, 1988). Similarly, from an IT standpoint process flexibility refers to the ability of a corporate information system to manage a wide array of potential transaction and documentation procedures and formats. Flexibility in both contexts therefore refers to the adaptability of a “system” to a range of changing internal and external conditions.

Decentralization on the other hand relates to control structures established by the firm and accountability practices. A decentralized operation refers to one in which decisions can be made independently by a wide array of business units associated with an enterprise. IT decentralization on the other hand deals with

the use of a wide array of information system structures, perhaps catered to meet the various independent demands of a highly dispersed enterprise. While the birth of large ERP systems was fostered by the perceived need to consolidate systems and standardize processes, excessive controls and flexibility jeopardize existing operational advantages if not aligned with operational requirements, and therefore may not be effective in certain relevant cases.

The importance of alignment between IT capabilities and operational requirements can be viewed through the perspective of combinative capabilities (Kogut and Zander 1992). In this context, the term "capabilities" relate to how well the set of transactions supported by the IT system efficiently support operational requirements. The most common repetitive transactions, for example, should be supported by quickly executed and simple processes. This concept suggests that firms can benefit by seeking out capabilities that are cumulative and complementary. Such a view provides a convenient fit to Porter's (1996) argument that multiple distinct competencies may provide gains that outweigh tradeoffs in diversity or what had previously been associated with a lack of competitive focus. Therefore, congruence both between and within IT capabilities and operational requirements should result in superior performance for firms able and savvy enough to make such alignment a reality.

2.2. Research Hypotheses

Based on the framework of Figure 1 and the associated theories of aligned and combinative capabilities, the current study considers two general research issues. The first is the impact that the alignment between flexibility and decentralization within a specific context (either operational or IT) has on performance. Since operational flexibility and decentralization can have very broad interpretations and definitions, we restrict our investigation to one specific aspect of operations linked directly to common ERP capabilities: order-processing (APICS 2002). Furthermore, although interpretations of ERP

flexibility and decentralization may vary, we focus only on those attributes described in the framework of Jacobs and Whybark (2000), the number of systems, structures or clients and the number of processes, as they apply to order-processing functions. The first hypotheses associated with the alignment of flexibility and decentralization in order-processing is as follows:

> *H_1: Strong matches between levels of order-processing flexibility and order-processing decentralization are associated with high levels of performance.*

Beyond support from the current framework, the intuitiveness of this relationship follows relatively simplistic assumptions. Specifically the capability for customization made possible by increased process flexibility is strategically complemented by an ability to retain market focus at local levels. On the other hand, low flexibility environments often justified through standardization may be further justified based on economies made available through centralized management.

Similar assumptions can be applied in the IT context. In the IT context however, the case-based framework of Jacobs and Whybark (2000) provides the primary and sufficient motivation behind the hypotheses.

> *H_2: Strong matches between the number of ERP processes and the number of ERP systems are associated with high levels of performance.*

The second issue we consider involves the impact that the alignment between comparable operational and ERP strategic dimensions (either flexibility or decentralization decisions) has on performance and draws more heavily on the concept of combinative capabilities. The formal hypotheses associated with these relationships are as follows:

H_3: Strong matches between levels of order-processing flexibility and the number of ERP processes are associated with high levels of performance.

H_4: Strong matches between levels of order-processing decentralization and the number of ERP systems are associated with high levels of performance.

As stated earlier, it is the goal of this work not only to test these hypotheses but also to provide an investigation into the simultaneous consideration of these various alignment issues.

3. Methods and Data

To capture the effects of alignment, we developed an electronic survey instrument consisting of questions felt to be indicative of both the flexibility and decentralization dimensions of operational and ERP strategies. Recent research into the use of electronic surveys has shown that they can provide response rates comparable to traditional surveys while providing added advantages of greater clarity for respondents through access to definitional hyperlinks and other forms of help tools (Boyer, Olson and Jackson 2001, White and Jacobs 1998). In the design of our questionnaire we take advantage of this approach. The highly context specific nature of the survey items, focusing on the order-processing functions of an operation, follows Gerwin's (1993) suggestion regarding future research in the area of operational flexibility.

3.1. Independent Variables

The first two items (see Table 1) relate to the firm's demand for customization and modification capabilities with regards to customer orders. These questions help characterize how responsive the system must be to unique customer requests in order-processing. Such responsiveness is analogous to flexibility questions used by Safizadeh et al. (1996) in their earlier benchmark study. Following past recommendations by survey instrument designers, a percentage scale was used here to help ensure uniformity in the units of the responses, facilitate the completion of the survey and ultimately increase the response rate (Nunally 1994, Dillman 2000).

(1) Percentage of all orders needing customized processing / documentation
(2) Percentage of all orders needing due-date, quantity or other changes
(3) Percentage of all orders for which tracking is handled locally
(4) Percentage of all orders for which resource scheduling is handled locally
(5) Percentage of all orders for which transport planning is handled locally
(6) Percentage of all orders for which promise-dates are determined locally
(7) Percentage of all orders for which materials procurement is handled locally
(8) Number of distinct ERP system structures used by firm for managing orders
(9) Number of distinct ERP processes available throughout firm for managing orders

Table 1. Independent items used in the questionnaire

Keeping with the theme of order-processing, items 3 through 7 deal with whether order-processing is managed locally or from a centralized function. The five separate items characterize the degree of local control over the tracking of orders, scheduling of local resources, handling of transportation and distribution, determination of delivery dates, and the procurement of material. These questions capture whether a local group makes critical operational decisions or whether this is a centralized function within the organization.

The last two independent items relate specifically to the characteristics referred to by Jacobs and Whybark's framework (2000). These questions describe features of the current information architecture(s) used by the organization. The actual number of separate system structures in place is critical

to embodying the extent to which the basic design of the architecture follows a centralized planning scheme (Jacobs and Whybark, 2000). Similarly the number of processes has often been referred to as mitigating the degree of flexibility inherent to ERP architectures and subsequent decisions regarding adoption (Davenport, 1998).

3.2. Measures of Performance

The first two performance factors considered were to be administered to representatives involved with order-processing tasks. One described the percentage of orders delivered on time. Although the relative percentile nature of this question has the potential of masking very low occurrences of lateness, we preferred this to an absolute measure of the 'number of orders late' to ensure comparability among responses from firms that regularly deal with very different order levels on average. For the same reason, as well as issues with transportation/logistical differences, we preferred such a metric to average lateness estimates. The second measure, "personal satisfaction", used a five-point index scaled from "very unsatisfied" to "highly satisfied". While participants were again expected to provide objective responses to the percentage of orders delivered on time, their response to this last question was designed to elicit entirely subjective responses.

A third metric-set, administered to higher level managers overseeing the order-processing function utilized Mirani and Lederer's (1998) instrument for gauging the efficiency of the ERP architecture. This measure required the use of ten items (Table 2) and subsequent confirmatory factor analysis to describe three dimensions of the transactional efficiency construct originally detailed by earlier authors (Turner and Lucas 1985; Williamson 1985). The measure itself was specifically chosen based on its appropriateness in capturing dynamics common to the order-processing environment, where transaction costs are often directly attributable (Weil 1992).

(1) Save money by reducing travel costs
(2) Save money by reducing communication costs
(3) Save money by reducing system modification or enhancement costs
(4) Allow other applications to be developed faster
(5) Allow previously infeasible applications to be implemented
(6) Provide the ability to perform maintenance faster
(7) Save money by avoiding the need to increase the workforce
(8) Enhance employee productivity or business efficiency
(9) Speed up transactions or shorten product life cycles
(10) Increase return on financial assets

Table 2. Transactional efficiency items used in the questionnaire

Additional data viewed as relevant controls in our analysis was drawn both from the electronic surveys and Compustat. The number of ERP sites managed by the firm and the number of databases maintained were provided by the managers involved in our study. Archival data from Compustat provided the last year's figures of firm size (number of employees), sales level in dollars, capital investments in plant/property/equipment, and dollars held up in WIP.

3.3. Survey Data Collection

Specified in the introductory letter, participants were asked to base their responses from data provided by documented corporate reports when available. If objective data was not available, the respondents were asked to leave the associated fields of the questionnaire blank. To ensure a common understanding of the survey questions, detailed descriptions of the key terms were provided through hyperlinks. The terms described in greater detail through this method are provided in Table 3. Definitions drew upon those provided in common Operations Management and Information Systems texts (Chase, Aquilano and Jacobs 2001, Laudon and Laudon 1996). Respondents were asked to read through these definitions before responding to the survey items.

Term	Hyperlinked Definition
Customized	Processing steps or documentation that is not commonly handled for other orders of a particular type. Resulting in the creation of non-standard records and special handling of materials.
Locally	Not handled by a central processing unit of the organization; Handled by decentralized business units specifically associated with the regional origin or nature of the order.
Resources	Employees, Equipment, Vehicles, Computer systems, Capacitated units, etc.
System structures	Specific ERP packages, versions, clients and implementations used across all departments, units and plants managed by your firm.
Processes	Distinct accounting procedures and protocols supported by your ERP systems. Specifically, the number of total unique order-entry sequences available.

Table 3. Hyperlinked term definitions provided to participants

To provide an appropriate focus in our study, the survey population consisted of small- to medium-sized U.S. firms in the machine tool manufacturing industry that possessed ERP systems in-house. Small- to medium sized enterprises (SMEs) were particularly intriguing given the growth potential of this sector and the large number of low-end ERP vendors currently providing catered and partial-system offerings (Demery 2001, Boudette 2002). Although it would be difficult to assess exactly how many of such firms actually exist without first performing an exhaustive preliminary survey of this industry, a sub-population of these firms that actively discuss issues of interest to this study was made available through Manufacturing.net, an on-line host site for manufacturer contact-information, interaction and publication. This sub-population consisted of 453 firms, all of which were targeted as our sample population.

All participants contacted for this survey were order-management representatives. At every firm, individuals specifically involved in order-processing were asked to provide responses to the questions regarding each of the independent variables and the first two performance measures (satisfaction and orders-on-time). The introductory message sent to each participant requested that responses only be provided if such participants possessed

working experience on order-processing implementation projects involving ERP in-house systems. Because of this requirement, a reduced response rate was anticipated, as a trade-off for the accuracy and validity of each individual response. Supervisory managers overseeing these representatives were asked to provide responses to the transactional efficiency questions and to describe the two non-Compustat controls. In return for their participation, a summary report of the data analysis and statement as to their firm's position relative to the rest of the respondents was offered.

One week after the initial requests were mailed out, a follow-up e-mail was provided to those not yet responding. Out of the 453 firms contacted, a total of 143 (31.6%) provided responses. Of these, 78 were complete, for a fully useable response rate of 17.2%. This response rate is comparable to recent research in developing application research and, given the knowledge required to representatively complete the survey, well within our expectations (Kathuria 2000). Those providing complete responses represented a range of machine manufacturers that included firms specializing in drilling (17%), cutting (23%), machining and milling (20%), bending and forming (12%) and machine tool attachments and accessories (28%). The average number of sites managed was 2.58 with a range of 1 to 6 and a standard deviation of 0.86. Only a moderate correlation (0.12, insignificant at the 5% level) was found between the number of sites and the number of system structures in place. Overall firm sizes ranged from 91 to 1379 employees. A summary of the means and correlations of key independent items under investigation is provided in Table 4.

	Mean (Stdev)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Percentage of all orders needing customized processing / documentation	37.7 (18.5)								
(2) Percentage of all orders needing due-date, quantity or other changes	35.1 (17.4)	***0.71***							
(3) Percentage of all orders for which tracking is handled locally	83.3 (24.2)	0.16	-0.17						
(4) Percentage of all orders for which resource scheduling is handled locally	35.9 (25.0)	0.14	-0.11	***0.67***					
(5) Percentage of all orders for which transport planning is handled locally	38.5 (23.6)	0.04	-0.09	-0.02	***0.83***				
(6) Percentage of all orders for which promise-dates are determined locally	35.4 (23.0)	0.02	-0.08	***0.31***	***0.77***	***0.78***			
(7) Percentage of all orders for which materials procurement is handled locally	35.1 (22.8)	-0.15	0.03	0.20	***0.70***	***0.67***	***0.74***		
(8) Number of distinct ERP system structures used by firm for managing orders	2.65 (1.05)	-0.08	0.15	-0.07	-0.16	-0.21	-0.14	-0.21	
(9) Number of distinct ERP processes available across firm for managing orders	6.51 (3.10)	0.14	0.00	-0.04	-0.08	-0.11	-0.01	-0.01	***0.25***

Numbers in bold-italics: Correlation is significant at the 0.01 level (2-tailed)

Table 4. Means and Correlations for the Independent items

Regardless of our belief that the respondents provided a representative sample of the sub-population under consideration, two tests for non-response bias were performed. The first involved a comparison of the completed responses received to those of the 65 non-completed responses. Since many non-responses may have been due to a lack of sufficient knowledge regarding the questions posed, and since those providing incomplete responses may have had similar reasons, the incomplete responses provide a loose representation of the non-respondents in the survey sample. For items provided, t-Tests and Mann-Witney non-parametric comparisons were performed. No significant differences between complete responses and incomplete responses were detected for any of the survey items.

A second test followed the model of Lambert and Harrington (1990) and considered differences between late and early providers of complete responses. The assumption behind such an approach is that late respondents can to some degree characterize the views of non-respondents who just never 'got-around-to'

filling out the questionnaire (Armstrong and Overton 1977). As with the previous test, no significant differences were detected between the two sub-samples. These results encouraged the use of the set of complete responses as a representative sample in our analysis.

3.4. Factor Analysis

Our overall approach to analyzing the data collected was motivated by the tactics of Safizadeh et al. in their 1996 empirical investigation of the Product-Process Matrix (Safizadeh, et al., 1996). The existence of several significant correlations among the first seven items collected suggested that a similar data reduction scheme would be appropriate. Subsequently, principle components analysis performed on the normalized data was used to reduce the number of factors under consideration and help reduce collinearity. For clarity varimax rotation was applied and an eigen-value criteria of '1' used during the extraction. Factor loadings from this procedure are given in Table 5, along with the percentage of variance accounted for by each extracted factor.

	OrdFlex	OrdDec
Percentage of all orders needing customized processing / documentation	**0.85**	-0.05
Percentage of all orders needing due-date, quantity or other changes	**0.77**	0.08
Percentage of all orders for which tracking is handled locally	-0.43	**0.78**
Percentage of all orders for which resource scheduling is handled locally	0.08	**0.92**
Percentage of all orders for which transport planning is handled locally	0.07	**0.87**
Percentage of all orders for which promise-dates are determined locally	0.17	**0.90**
Percentage of all orders for which materials procurement is handled locally	0.23	**0.79**
Total variance accounted for by factor	*30.6%*	*45.8%*
K-S Tests for deviation from normality (p<...)	*0.122*	*0.590*

Chi-square goodness of fit: p<0.566

Table 5. Factor Loadings for Order-processing functions

All items loaded roughly as would have been expected on factors connoting either order-processing flexibility (OrdFlex) or decentralization (Ord Dec). In the interest of comparison, only standardized forms of both the derived factors and the last two items referring to the number of system structures (SNumSys) and number of processes (SNumPrc) were used in subsequent analysis. Since the impact of all four factors on performance would ultimately be considered, Kolmogorov-Smirnov goodness of fit tests were used to determine whether any of them violated normality assumptions. No significant violations were detected.

A similar factor analysis was performed for the dimensions of transactional efficiency, outlined by Mirani and Lederer's (1998) instrument and collected through managerial responses in this study (Table 6). Factor loadings were analogous to those previously observed with all three factors providing eigen-values greater than '1'.

	ComEff	DevEff	BusEff
Save money by reducing travel costs	**0.70**	0.11	0.11
Save money by reducing communication costs	**0.51**	0.10	-0.02
Save money by reducing system modification/enhancement costs	-0.01	**0.38**	0.01
Allow other applications to be developed faster	-0.17	**0.91**	0.10
Allow previously infeasible applications to be implemented	-0.09	**0.45**	0.10
Provide the ability to perform maintenance faster	0.02	**0.37**	-0.03
Save money by avoiding the need to increase the work force	0.18	-0.18	**0.72**
Enhance employee productivity or business efficiency	-0.03	0.07	**0.46**
Speed up transactions or shorten product cycles	-0.10	0.10	**0.36**
Increase returns on financial assets	0.10	0.19	**0.61**
Total variance accounted for by factor	13.5%	23.4%	22.1%
K-S Tests for deviation from normality (p<...)	0.324	0.411	0.298

Chi-square goodness of fit: p<0.681

Table 6. Factor Loadings for Transactional Efficiency dimensions

Along with later use of control data drawn from the Compustat database, these factors not only provided the opportunity for greater performance detail but, due

to their sources, also had the added advantage of helping to reduce concerns of common-source bias.

4. Results and Discussion

A first look at the role that these factors might have on performance began with descriptive factor-effect assessments including a consideration of correlations between the performance measures and alignment variables were derived with this in mind (Table 7).

	AccOnT	Satisfact	ComEff	DevEff	BusEff
OrdFlex	0.005	0.136	-0.210	**-0.242**	-0.034
OrdDec	0.104	0.049	0.008	0.191	0.089
SNumPrc	0.130	**-0.248**	**-0.354**	**-0.378**	0.002
SNumSys	**-0.339**	**-0.396**	**-0.476**	**-0.412**	**-0.252**

Table 7. Main Factor Correlations with Performance Measures

Only two factors were consistently associated directly with perceptions of performance: SNumPrc and SNumSys. Firms with more independent system structures and ERP processes had users and managers that were generally less satisfied with their ERP solutions. Consistent support for the direct impacts of order-processing flexibility or decentralization among the performance measures was not observed. This of course does not imply that operational decisions were irrelevant to the firms surveyed, but rather that firms in diverse operational settings could attain equivalent levels of performance and satisfaction if appropriate ERP solution strategies were selected. These pre-tests did lead us to believe that alignment measures involving the number of processes and system structures might not sufficiently predict performance if absolute levels of these factors were not also considered. This provided impetus for the structure of the regression analyses to be presented later.

4.1. Discrete Scale Analysis

In accordance with the Safizadeh et al. methodology, for all factor pairs of interest (e.g. order-processing flexibility and number of ERP processes), formal testing of the proposed hypotheses began with a comparison of relatively "aligned" and "misaligned" firms. The splitting of sample population into these two categories involved first the creation of 2-dimensional factor matrices, with each dimension consisting of 5 discrete bins covering the full range of factor values observed. This framework mimics that of Safizadeh et al. (1996) and is illustrated in Figure 2.

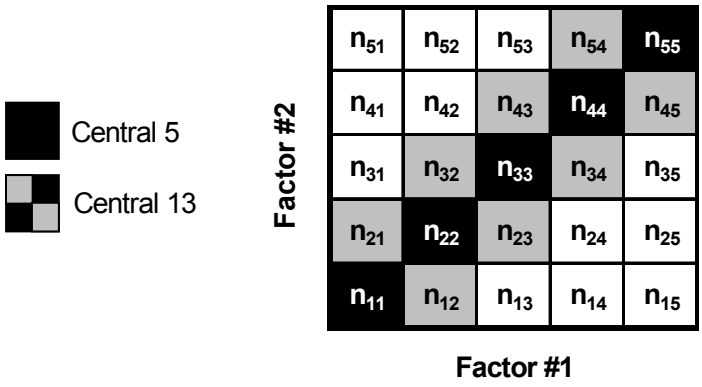

Figure 2. Two Discrete Specification Methods for Aligned vs. Non-Aligned Firms

"On-diagonal" cells were interpreted to contain sub-populations with relatively high levels of factor alignment, whereas "off-diagonal" cells contained firms with relatively low alignment. The major issue was determining the appropriate "width" of such a diagonal, particularly since certain factor pairs had already been shown to be highly correlated while other pairs were described by firms that were, again, "all over the map". Because of the subjectivity inherent to this approach, two diagonal widths were used. The first interpreted only those firms lying on the central 5 cells of the matrix diagonal to be representative of "aligned" firms. The second method labeled those firms lying on the central 13 cells of the matrix diagonal as such. t-Tests comparing the performance of

"aligned" and "misaligned" firms by both categorization methods were then performed.

Such a technique was first applied in comparing within-context alignment effects on performance. The results of these comparisons are provided in Table 8. As shown in the first two columns of this table, the alignment of the number of ERP system structures and the number of ERP processes are relevant to a large fraction comparisons considered (5 out of 10). The same could be said for the alignment between order-processing flexibility and decentralization (5 out of 10). Specifically, this suggested that such misalignment was associated with lower levels of both accuracy and satisfaction. These findings therefore provided early partial support for hypotheses H_2 and H_4.

		Performance t-Test for Central-5 vs. Outer 20 (p<...)	Perfirmance t-Test for Central-13 vs. Outer-12 (p<…)	Correlation of Performance with Abs Difference Measures
AccOnT	OrdFlex vs. OrdDec	**0.042**	0.178	-0.132
	SNumPrc vs. SNumSys	**0.051**	**0.003**	**-0.314**
	OrdFlex vs. SNumPrc	**0.088**	0.147	0.082
	OrdDec vs. SNumSys	0.990	**0.042**	**-0.397**
Satisfact	OrdFlex vs. OrdDec	**0.053**	0.123	-0.108
	SNumPrc vs. SNumSys	0.574	**0.074**	**-0.231**
	OrdFlex vs. SNumPrc	0.445	**0.049**	0.067
	OrdDec vs. SNumSys	0.747	**0.067**	**-0.328**
ComEff	OrdFlex vs. OrdDec	**0.003**	0.139	**-0.383**
	SNumPrc vs. SNumSys	0.649	**0.044**	**-0.416**
	OrdFlex vs. SNumPrc	0.466	**0.089**	0.107
	OrdDec vs. SNumSys	0.723	**0.049**	**-0.369**
DevEff	OrdFlex vs. OrdDec	0.232	0.820	0.103
	SNumPrc vs. SNumSys	0.571	**0.018**	**-0.248**
	OrdFlex vs. SNumPrc	0.470	0.117	-0.112
	OrdDec vs. SNumSys	**0.050**	**0.051**	**-0.413**
BusEff	OrdFlex vs. OrdDec	0.110	0.803	-0.139
	SNumPrc vs. SNumSys	0.655	**0.075**	-0.189
	OrdFlex vs. SNumPrc	0.470	0.175	0.142
	OrdDec vs. SNumSys	0.178	0.241	**-0.443**

Table 8. Diagonal t-Tests and Correlations with Abs Difference Measures

4.2. Continuous Scale Analysis

Although suggestive, the discrete nature of this bin comparison technique warranted the use of additional analytical testing. In a second approach to effect assessment, continuous measures of misalignment for each factor pair were constructed. Specifically, these measures were based on the absolute differences between any two factors (eg. $\left| SNumPrc - SNumSys \right|$). Such an approach mimicked that of Venkatraman and Prescott (1990). Correlations between these derived measures and the performance measures provided additional consistent support for H_2 (4 out of 5 significant correlations) but very limited support for H_1 (only 1 out of 5). These results are given in the last column of Table 8.

An identical set of steps was utilized in the cross-context analysis of operational and ERP alignment. Table 8 provides these results as well. Here, both the t-Test approach of Safizdeh, et al. and the continuous measure of alignment between the measure of order-process decentralization and SNumSys seemed to be consistently correlated with performance (5 out of 10 significant t-Test results; 5 out of 5 significant correlations). Specifically, increases in such misalignment seemed to be associated with decreases in all performance measures. Subsequently, these results granted strong early support for H_4. Very little support for H_3 could be found through a similar analysis however.

Given the ability of continuous alignment measures to capture results similar to discrete approach, the measures were included along with the main factors in step-wise regressions for each of the performance measures. This last analysis was intended to provide insights into the impact that certain types of alignment may have on performance irrespective of the direct effects of the main factors.

	AccOnT	Satisfact	ComEff	DevEff	BusEff
Coefficient	**96.42** *(1.75)*	**4.57** *(0.20)*	--	--	--
OrdFlex	--	--	--	**-0.21** *(0.04)*	--
OrdDec	--	**-0.29** *(0.14)*	--	--	--
SNumPrc	**7.90** *(1.35)*	**0.42** *(0.13)*	--	**-0.37** *(0.12)*	--
SNumSys	**-10.96** *(1.30)*	**-0.68** *(0.13)*	**-0.17** *(0.03)*	**-0.24** *(0.06)*	**-0.27** *(0.01)*
| SNumPrc - SNumSys |	**-10.99** *(1.81)*	**-0.71** *(0.18)*	**-0.40** *(0.11)*	**-0.22** *(0.08)*	--
| OrdDec - SNumSys |	**-4.43** *(0.89)*	**-0.47** *(0.12)*	**-0.32** *(0.06)*	**-0.25** *(0.09)*	**-0.19** *(0.03)*
R^2	0.598	0.473	0.418	0.521	0.207

Table 9. Step-wise Regressions of Main Factors and Misalignment Measures on Performance

As shown in Table 9, the alignment of SNumPrc and SNumSys, as well as that of OrdFlex and SNumSys, are consistently relevant with respect to various measures of performance, even when the direct effects of main factors are considered. Moreover, these types of misalignment appear to be more relevant than many of the main factors considered in isolation.

To assess the robustness of these effects, a similar analysis was performed in the presence of alternate objective controls drawn from Compustat data including total sales ($), number of employees, capital invested in plant/property/equipment and value of work-in-process inventories. Control data provided by managers including the number of sites operated by a firm and the number of databases managed, were introduced into the regression analysis as well. Although these controls increased the total variance accounted for, they did not significantly impact the coefficients of the measures appearing in Table 9. Furthermore, the incremental F-statistic upon the addition of these measures remained significant even in the presence of controls. These results represented strong additional support for hypotheses H_2 and H_4.

5. Conclusions

It is generally well accepted that the consideration of the alignment of certain internal processes may be important to ensuring high levels of performance within firms. This paper provides initial empirical evidence that the specific alignment within and between operational requirements and ERP system structures is critical over a range of performance measures as well. Although we must be careful to state that our results are limited to the study of order-processing, the similarity in results related to performance measures provided by both task-focused users and cost-focused managers is compelling.

Our results show that two forms of alignment play particularly crucial roles in the successful delivery of manufacturing orders and in general satisfaction with the ERP system. The first is the within-context alignment of the flexibility and decentralization dimensions of ERP solutions originally proposed by Jacobs and Whybark (2000) and represented by the number of distinct system structures and transaction routines that a firm's ERP architecture consists of. The second critical factor appears to be the between-context alignment of ERP decentralization with certain forms of order-process decentralization.

The within-context ERP alignment result raises certain interesting issues. The majority of cases studied describe benefits when the variety of transaction routines mirrors the number of system structures utilized. This would indicate that systems specialized to different transaction types (eg. perhaps on a regional basis) may be preferable. At the same time, increased ERP decentralization alone seems to be consistently associated with negative impacts on performance. This suggests that while firms operating along the diagonal may experience benefits when compared to misaligned solutions, their positions "along" this ideal diagonal are also relevant. Specifically, firms able to utilize low flexibility – low decentralization ERP solutions still posses somewhat of an upper hand to equally aligned competitors using highly flexible – highly decentralized ERP solutions.

The between-context issue of decentralization alignment between ERP solutions and actual operating policies also provides interesting strategic implications. Although anecdotal evidence may already exist, this is the first time that the relevance of this issue has been supported in the presence of other complicating effects. Simply stated, firms seem to benefit more from ERP solutions that match the extent to which order-processing is decentralized. This indicates that reengineering efforts should ensure that new operating policies are well aligned with unit requirements. In cases where unit requirements are the same, identical processes should be used, and when unit requirements differ, specialized processes implemented. In either case, misalignment across these contexts connotes weaker overall performance and satisfaction. With ERP flexibility tied to ERP decentralization, and ERP decentralization tied to order-process decentralization, one of the extended implications of these findings might be that ERP solution development on the whole is ultimately dependent on certain aspects of operational strategy.

Given a competitively advantageous level of order-process decentralization, a similar level of ERP decentralization would seem desirable, as would a well-matched level of flexibility in the ERP system design. According to our results, this is generally the case regardless of the level of order-process flexibility required. Furthermore, since direct benefits also seem to be associated with firms in the lower-left hand corner of the ERP matrix (Figure 1), we would expect that firms with lower levels of order-process decentralization would have the opportunity for greater benefits in ERP design and use. This notion is studied in the context of value change planning systems (Bendoly, Soni and Venkataramanan, forthcoming).

Aside from the strategic implications, it is also interesting to note that the same ERP design measures for which alignment seemed relevant were also the ones for which factors levels were already significantly correlated. This suggests that several firms are in fact aware of the relevance of such alignment issues.

However, the same pre-existing alignment between order-processing decentralization and ERP decentralization was not apparent, thus suggesting a gap between observed performance effects and management awareness and subsequent activities aimed towards such benefits.

Future work in this area should focus on the impact that these same measures of alignment have on alternate performance measures. If cost figures are collected, relating to alternate levels of operational and ERP flexibility and decentralization, then certain non-latent financial aspects of performance can provide an intriguing basis for analytical consideration. Specifically, the availability of such figures could open the door to optimization considerations in simultaneous operations/ERP strategic planning. Such work would likely be well received by both practitioners and researchers.

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