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Industrial Marketing Management 33 (2004) 627–641

INDUSTRIAL MARKETING MANAGEMENT

The role of learning and technical capabilities in predicting adoption of B2B technologies[†]

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Received 13 January 2003; received in revised form 12 August 2003; accepted 1 October 2003
Available online 3 December 2003

Abstract

Using the resource-based view and the learning organization as its theoretical framework, this study hypothesized that organizations which possessed not only the technical capabilities for automation but also the ability to learn and share information would be most likely to automate their supply chain processes. An empirical study with the top suppliers of a major airline supported this hypothesis. As predicted, both learning capabilities and certain technical capabilities were important in predicting the likelihood of adoption of Ariba, a web-based e-procurement tool.

Keywords: Supply chain management; Information management; Knowledge management; Resource-based view; Technology adoption

1. Introduction

In his 1997 *Computerworld* Leadership Series, Davenport (1997) offered some insights into why IT practitioners continue to develop applications that are not adopted by users. Among his laundry list of items, Davenport began with the notion that systems are largely governed around how information flows within and around an organization. To this end, antiquated frameworks of data management have proven to be dysfunctional—thereby resulting in failures to meet customer demands, challenges to internal and interface integration, extreme cost overruns, and resistance to change (Goodhue, Kirsch, Quillard, & Wybo, 1992; Truman, 2000).

As organizations strive to electronically integrate not only their immediate customers and suppliers, but multiple tiers of customers and suppliers, adoption of these new technologies across global supply chains continues to be a major barrier (Handfield & Nichols, 1999, Chap. 1). As supply chain members begin to work together, integration must occur between functions both *internal* to the organization (purchasing, engineering, manufacturing, marketing, logistics, accounting, etc.) and *external* to the organization (end customers, third-party logistics, retailers, distributors, warehouses, transportation providers, suppliers, agents, financial institutions, etc.). Each goal contains its own set of challenges. For instance, *internal strategic integration* requires that all company members have access to an integrated information system spanning multiple functions and locations. This integration is most often accomplished through a company-wide ERP (Enterprise Resource Planning) system, which links internal groups via a single integrated set of master records. *External integration* refers to the systems that link external suppliers and customers to the focal company. External integration allows all supply-chain members to share critical information such as forecast demand and inventory levels across the supply chain. Systems used to integrate supply-chain members include e-procurement and e-logistics systems, trade exchanges, network communications, and Electronic Data Interchange (EDI) (Handfield & Nichols, 1999, Chap. 1).

This study is motivated in part by the very practical concerns of a large airline as it moved forward in its supply chain automation efforts. This airline was in the processes of implementing an e-procurement system in a parallel mode. The system, Ariba, is a web-based e-procurement tool that

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[†] This effort and these results are dedicated to those airline industry employees who lost their lives on September 11, 2001 and to their families.

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doi:10.1016/j.indmarman.2003.10.004

allows users to order items directly from supplier catalogs from a secure Internet website, thereby automating the order requisition, purchase order, and accounts payable processes.

Other software alternatives to Ariba include Commerce One, Lawson, Lonesource, and other providers that provide electronic tools and documents for purchase requisition, request for quotation, approval, purchase order, and accounts payable processes. These systems do not require suppliers to make a major investment in the technology. However, the systems do require that suppliers invest in alternative businesses processes in bidding, providing requests for quotation, and invoice submittal procedures. Supplier automation systems also require some baseline level of technical expertise, as suppliers may need to submit materials via online systems, develop electronic catalogs of item availability to the customer. Once a buying company implements a system such as Ariba, it is relatively difficult to switch to another system, as the compatibility with other purchasing systems may be relatively low. Systems such as Ariba or Commerce One, are, however, compatible with many ERP systems currently in use.

In this case, as Ariba was implemented, the airline continued to use a traditional manual process for purchase orders and invoices with many of its larger suppliers. As the airline moved forward with Ariba, executives were faced with the task of selecting supplier candidates for the pilot stage of the system. Executives eliminated many suppliers based on the criteria to include only large strategic supplier partners; however, this decision still left them with a total of 96 potential suppliers. Executives noted that the success of the pilot was critical to the success of the entire Ariba implementation. If the pilot was successful, the likelihood of other suppliers "jumping on board" was more probable. The selection decision needed to be made quickly, as the time frame for implementation was perceived to be rather short.

This paper first presents several key theoretical frameworks used to develop a model for the likelihood of adoption of B2B technologies by suppliers. The literature review suggests the hypothesis that suppliers can be clustered into four groups on the basis of technological and learning dimensions, and also suggests that these clusters will vary in terms of their likelihood of adoption and cycle time improvements. This paper then discusses the constructs and scales that were developed to test these hypotheses and the methodology used to analyze the resulting data. Finally, the results and managerial implications of the study are presented.

1.1. Theoretical background

The resource-based view contends that competitive advantage is achieved by combining resources and capabilities that create value for customers and profits for the firm (De Castro & Chrisman, 1995). Firms achieve competitive advantage through heterogeneous, specific, and difficult-to-imitate resources that include intangible assets, such as customer and supplier information (Barney, 1991; Itami & Roehl, 1987, Chap. 2; Mahoney, 1995; Penrose, 1995, Chap. 2; Prahalad & Hamel, 1990). However, it is not just a firm's assets, but how they are leveraged across supply chains that provide competitive advantage (Handfield & Nichols, 1999, Chap. 1). For example, research shows that it is not the IT system itself that provides competitive advantage, but how the system is used in conjunction with complementary human resources (Hult, 1998; Powell & Dent-Micaleff, 1997).

In fact, it has been suggested that firms' ability to learn may be the only true source of long-term competitive advantage (Garvin, 1993; Sinkula, Baker, & Noordewier, 1997; Slater & Narver, 1995). Learning processes are difficult to develop in and of themselves, but the specificity and intangibility of these associated assets makes them more difficult for others to imitate, ultimately creating advantage for those with effective learning processes. As organizations seek to integrate customers and suppliers, this learning capability becomes an important asset that managers are recognizing as key to successful deployment of relationship structuring, material flows, and information system deployment (Hult, 1998; Hult, Hurley, Giunipero, & Nichols, 2000).

For example, in the customer context, the process of learning has been linked to success in the development of Customer Relationship Management (CRM) systems which store and process information about the customer so that dialogues may be developed with relevant customers (Massey, Montoya-Weiss, & Holcomb, 2001). To manage effective relationships with suppliers, certain key information from them is required as well (Monczka, Peterson, Handfield, & Ragatz, 1998). The ability of suppliers to adopt tacit information regarding customer requirements and realign their technology roadmaps has been deemed critical to success of integration in new product development processes (Handfield, Ragatz, Monczka, & Peterson, 1999).

A major problem faced by executives is the ability to accurately assess these "soft" criteria associated with knowledge management, which are not readily quantifiable. For example, the number of engineers on staff or the number of training hours received by employees is not necessarily a good representation of the degree of learning present in an organization. Yet, the importance of assessing these skills is believed to be a critical determinant associated with successful implementation of new supply chain information systems. Another important variable associated with implementation success is the strength of the relationship between parties (Vlosky & Wilson, 1994). Just as companies seek to develop strong relationships with their industrial customers (in the relationship marketing literature), they now seek to develop these relationships with their suppliers (Morgan & Hunt, 1994; Walter, Ritter, & Gemunden, 2001; Whipple &

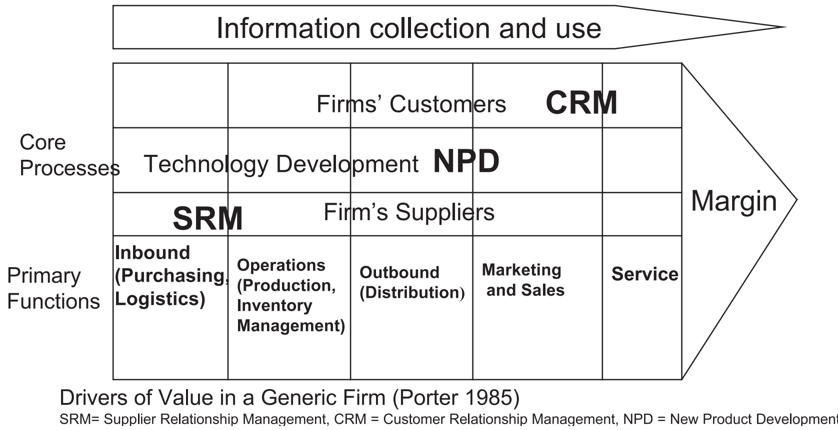

Fig. 1. Value activities, core processes and the value chain.

Frankel, 2000). Further, improving supplier relationships can create improved efficiencies which positively impact customer relationships (Sheth, 2001).

Even among suppliers that are deemed strategic to the airline in question, it is unlikely that all of these companies would be progressing along the same lines toward automation. Market segmentation theory would predict that just as not all customers are equal, not all suppliers are equal (Monczka et al., 1998). Porter (1980, Chap. 2, 1985, Chap. 2) suggests that these distinguishing variables will span both technical as well as information processing or learning activities, since both are critical to value chain operations (Fig. 1). There is much to be gained by the supplier when the buying firm in turn creates valuable relationships with its suppliers. One of the goals of this study was to create categories of suppliers using as an analogy the categories of customers referred to in the relationship marketing and segmentation literature.

1.2. Hypotheses development

Interviews with key airline supply chain executives suggested the application of a measurement framework that addressed the learning ability and information-processing capabilities of suppliers. Executives at the airline partner were very interested in specifically addressing the technical capabilities of suppliers within this context. Scales were developed over the course of several weeks based on these discussions, and several hypotheses emerged regarding the expected relationships between the capabilities of the suppliers, their likelihood of adopting Ariba and the benefits to be achieved from this adoption.

First, it seemed that the relationships between the two general categories of capabilities studied would look something like that pictured in Fig. 2, creating four different clusters varying along both technical and learning dimension. That is, it was predicted that the airline could prioritize the pilot with selected suppliers in a hypothesized "early adopter" group. If an early adopter group was found, these early adopters would be characterized by both high learning and high technological capabilities and would be most likely to adopt new B2B technologies. As shall be seen, both of these sets of capabilities (learning and technology) proved important in the segmentation process.

In addition, the categories varying on technical and learning dimensions would not be expected to contain the same number of suppliers, but rather would be expected to approximate the adoption categories as discussed by Rogers (1995, Chap. 7), with some suppliers adopting the technology early and some later (Fig. 3). Rogers' framework classifies those who adopt new technologies into different segments based on the time frame in which they are likely to adopt these technologies. Innovators typically are the first to have new technologies, followed by early adopters. Early majority and late majority individuals typically wait for a technology to be proven before they come on board with the technology, and laggards are the last to adopt. As these terms suggest, the early and late majority categories comprise the largest number of adopters.

Because the technology is not in a "test" or exploratory phase, it is unlikely there would be true innovators in the sample. The Rogers framework is an application of concepts

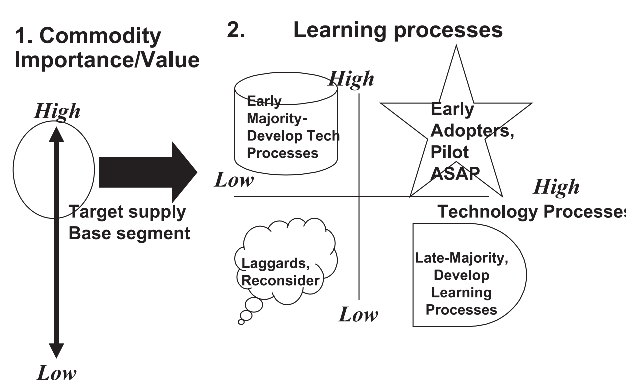

Fig. 2. Choosing suppliers for B2B integration.

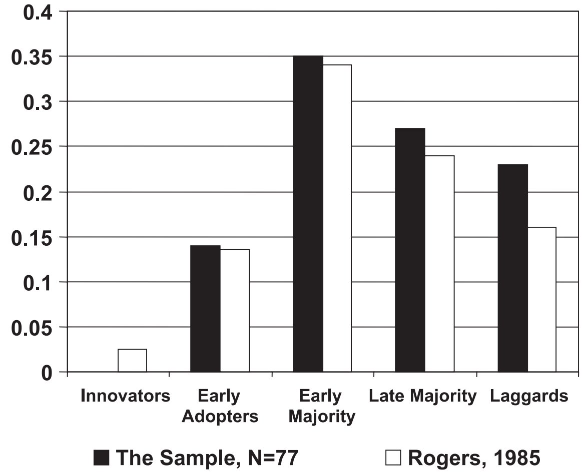

Fig. 3. Percentage of suppliers. Open to adopting B2B technologies (cf. Rogers, 1985).

related to adoption of new technologies by individuals. The ideas in this case are applied to the adoption rate by companies of an e-procurement technology, which also relies extensively on the need for communication. The framework was originally designed for individuals, but recent work in social networks and the diffusion of innovations indicates that this framework can be adapted to the company setting. Interpersonal networks can work within and between firms to spread new ideas and the willingness to adopt technology (Rogers, 1995).

The following hypothesis describes these relationships.

Hypothesis 1: Candidate suppliers for adoption of B2B technologies will vary along technological as well as learning dimensions to create distinct cluster groupings of suppliers, early adopters, early majority, late majority, and laggards.

In addition, these supplier groups, once defined, would be expected to vary both in terms of likelihood of adoption and higher potential for cycle time performance. Moreover, a proclivity to adopt new innovations based on technological and learning dimensions is likely to result in a greater willingness to adopt new technologies (Hult et al., 2000). As suppliers adopt new B2B technologies, the cycle-time capabilities will improve as suppliers integrate e-procurement activities into their daily operations (Hult et al., 2000; Monczka et al., 1998). In other words, early adopters are expected to demonstrate cycle time improvements, as cycle time reductions have been positively related to learning in the past. Objective and subjective measures of cycle time from prior research were used in the study (Hult, 1998; Hult, Ketchen, & Slater, 2002).

Hypothesis 2: The supplier groups will vary in terms of likelihood of adoption of B2B technology as follows: early adopters>early majority>late majority>laggards.

Hypothesis 3: The supplier groups will vary in terms of order delivery cycle time as follows: early adopters < early majority < late majority < laggards.

1.3. Independent variables

1.3.1. Learning

Because of a perceived tight time frame for implementation, limited time was available to pretest the survey. Therefore, scales were developed from existing research. The development of each particular scale and its theoretical foundations are discussed in turn.

Performing the segmentation required developing constructs and scales that would distinguish between suppliers along the key dimensions of learning and technology. For the scales associated with learning, both items which would indicate a learning orientation, as well as items to assess the capabilities to process specific information were included. Both types of learning were related in prior research, with organizational learning shown to have a positive effect on information processing capabilities (Hult et al., 2000). For the specifics of a highly complex and detailed Ariba implementation, the details of information processing might be just as important as the overall learning orientation.

In fact, many organizations are reforming themselves along the lines of learning organizations (Slater & Narver, 1995) for the specific purpose of improved performance in every area. Recently, this concept of the learning organization has been studied in the context of the strategic sourcing function of another air-based service, Federal Express (Hult, 1998). Therefore, the suppliers' ability to learn should be a strong predictor of its likelihood of adoption of the Ariba system. Here, a four-dimensional construct of organizational learning (team orientation, systems orientation, learning orientation, and memory orientation) was found to influence customer satisfaction, relationship commitment, and cycle time in the sourcing process. Team orientation (shared learning) and systems orientation scales were used and supplemented with specific information-processing capabilities scales adapted from Hult (1998) and Kohli, Jaworksi, and Kumar (1993) and Zahay and Griffin (2002). These specific information-processing capabilities are related to the firm's learning orientation (Hult et al., 2000).

Information-processing systems as described below contribute to the formation of knowledge (Day, 1994; Pentland, 1995; Sinkula et al., 1997; Slater & Narver, 1995) and consist of four capabilities:

1. *Generation (get or acquire)*: processes and systems to collect information (Kohli et al., 1993).
2. *Memory (store)*: processes and systems to store information for future use, new scale, developed with corporate partner, based on "shoppable Internet catalog (SIC) capabilities".

3. *Dissemination (move)*: processes and systems for diffusing information horizontally and vertically throughout the organization Kohli et al., 1993.
4. *Interpretation (use)*: processes that give information one or more commonly understood (shared) meanings that are used in that organization, new scale, based on prior work in this area (Zahay & Griffin, 2002).

All four of these information-processing capabilities, worded for context, are applicable to the implementation of Ariba or a similar system. The constructs of acquisition and dissemination are based on the work of Kohli et al. (1993) as adapted by Hult et al. (2000). The construct of memory was operationalized as database skills in the form of a SIC capability, such as the ability to process returns easily and look at the entire inventory in an integrated format. The airline executives involved in this study contributed to all scales but particularly the development of the SIC scale.

The shareability or ''use'' construct was operationalized as sharing specific information such as safety stock, plant capacity utilization. These questions represented an entirely new set of scales. Some prior work has operationalized intraorganizational knowledge sharing (Calantone, Cavusgil, & Zhao, 2002; Hult & Ferrell, 1997) but no work has operationalized the sharing of specific types of information necessary for this study. However, the inspiration for the scales came from prior work in the area of sharing customer, not supplier, information (Zahay & Griffin, 2002), as well as conversations with the airline partner to this study.

1.3.2. Technology capabilities

The technology scale focused on the selected technical capabilities of suppliers and associated technological capabilities of their workers. The technical capabilities of suppliers were developed directly from working with the airline and its needs in implementing Ariba. Questions centered around the ease with which orders could be accessed electronically by customers and changed easily, as well as other technical capabilities associated with the order fulfillment system. These technological capabilities included the ability to process orders and change orders electronically, provide available to promise information and implement an MRP (Material Requirements Planning) System.

On the insistence of the airline partner in this study, another set of technology items was developed. This scale centered on the technology capabilities of workers, that is whether workers in the company felt comfortable working with a web browser and in a Windows environment required to implement these systems.

1.3.3. Relationship priority

Because of the importance of the overall business relationship in relationship marketing, another scale was included to inquire about the priority in which the individual relationship was held by the supplier. As firms seek to develop long-term relationships with their key customers (Dwyer, Schurr, & Oh, 1987; Morgan & Hunt, 1994), it makes sense that they would seek to develop relationships with strategic suppliers. The relationship priority scale was based upon a scale previously developed by Vlosky and Wilson (1994) to measure relationship commitment. This scale was shown in later research to be positively related to the level of communication, satisfaction, and trust in the industrial buyer–seller relationship (Fontenot, Vlosky, Wilson, & Wilson, 1997).

Since the sense in which the relationship is held to be a priority has been associated with firm performance (Fontenot et al., 1997), it also made sense that relationship priority would be associated with the dependent variables of decreased cycle time (Hult, 1998) and commitment to automation. Decreased cycle time and automation are both activities which should lead to overall firm performance by decreasing the amount of inventory and providing for smoother handling of invoices and purchase orders. The relationship priority scale is more appropriate in this specific context of the relationship between the airline and its key suppliers than the more general Hult et al. (2000) relationship commitment scale. Implementation of systems such as Ariba requires not jut a commitment, but also establishing the implementation as a priority in the organization.

1.4. Dependent variables

1.4.1. Likelihood of adoption

Likelihood of adoption was a self-reported variable consisting of four items in which suppliers essentially reported their commitment to automation. Suppliers were asked to rate how likely they were to supply electronic catalogue information to customers and to work with them to implement electronic order fulfillment systems, as well as their belief that these systems will decrease expediting and increase order delivery time.

1.4.2. Cycle time improvement

In addition to likelihood of adoption, the literature suggested that there would be support for decreased cycle time as a result of electronic integration (Handfield & Nichols, 1999, Chap. 1; Vloskey & Wilson, 1994). Specifically, early adopters would be more likely to demonstrate cycle time improvements, as cycle time decreases have been positively related to learning in the past. Objective and subjective measures of cycle time from prior research (Hult, 1998; Hult et al., 2002) were used. The entire survey is in Appendix 1.

2. Method

2.1. Data collection

Data collection was a joint effort between the airline and the research team. The airline provided the contact names, phone numbers, and email addresses of their top

96 suppliers and implemented the final online survey of 75 questions. Data collection methodology was modeled after the method of Dillman (1999, Chap. 4) and adapted to the use of new technology of email instead of mail communication and online survey instead of paper and pencil. Three waves of emails were sent to all of these suppliers over the course of 4 months, following up with phone calls when necessary. The emails included an active link to the online survey. Eight of these contacts were unresponsive after repeated attempts, bringing the total universe of suppliers to 88.

The terrorist attacks of September 11 occurred approximately 6 weeks into data collection. These attacks made it difficult to make phone calls into companies associated with this sensitive industry. With permission from the airline partner, research assistants making calls were instructed to continue calling but to exhibit sensitivity for the situation. The response rate by November of 2001, at which point data collection ceased, was 77 out of 88 responses, or 87% (77 out of the original 96).

2.2. Refining measures

Exploratory factor analysis is useful to discover patterns in exploratory data (Bollen, 1989, Chap. 6) such as the data in this study. PCA was selected instead of CFA due to the sample size of less than 100 (Hinkin, 1998). The EFA used principal components analysis with a Varimax rotation and a cutoff of 0.5 for individual item factor loadings (Hair, 1979) and 1 for factor eigenvalues. In general, factors had eigenvalues of greater than 1 and usually accounted for greater than 10% of the explained variance in the sample. Correlation analysis was used to establish discriminant validity (Hinkin, 1998). Correlations, descriptive statistics, and coefficient alphas are reported in Table 1.

The relationship priority, likelihood of adoption, and subjective cycle time measures loaded as predicted, with some items eliminated. The two components of learning orientation that were used, team processes and systems orientation, loaded on one factor and were called learning ability.

Shareability, a difficult construct to measure, was divided into three parts by the factor analysis. Three of the shareability items, those related to sharing information on customer materials lists and sharing order status and shipping status with customers, loaded on information processing. Thus, the final information-processing factor consists of acquisition, dissemination, and sharing of order processing information. Two items, sharing warehouse information with customers and sharing replenishment information with customers, loaded on a factor called sharing distribution information with cus-

Table 1
Construct descriptive statistics and correlation matrix

	Information processing	"Shoppable" Internet Catalog	Share distribution information	Share manufacturing information	Technical capabilities	Learning ability	Relationship priority	Cycle time	Likelihood of adoption
Information Processing (Acquisition, dissemination and share order processing) coefficient α=.91	1.775 (0.729)								
"Shoppable" Internet Catalog (Memory) α=.92	.227* (.047)	3.672 (1.310)							
Share distribution information α=.57	.229** (.008)	.266* (.019)	2.532 (1.173)						
Share manufacturing information α=.71	.475** (.000)	.037 (.746)	.141 (.222)	2.461 (1.242)					
Technical capabilities α=.84	.488** (.000)	.426** (.000)	.203 (.077)	.123 (.283)	2.424 (1.121)				
Learning ability α=.88	.621** (.000)	−.060 (.602)	.246* (.031)	.217 (.058)	.286* (.012)	1.516 (0.493)			
Relationship Priority α=.60	.098 (.394)	−.052 (.656)	.007 (.954)	.246* (.031)	.005 (.965)	.054 (.641)	1.956 (0.748)		
Cycle time α=.88	.502** (.000)	.100 (.386)	.139 (.227)	.165 (.152)	.257* (.024)	.590** (.000)	.143 (.216)	2.277 (1.018)	
Likelihood of Adoption α=.89	.455** (.000)	.461** (.000)	.192 (.094)	.242* (.094)	.452** (.000)	.119 (.302)	.032 (.782)	.197 (.086)	2.344 (1.224)

N=77; Correlations: two-tailed significance.
Numbers on the diagonals are means and (σ). All variable ranges are 1–5, 1=Strongly Agree, 3=Neither, 5=Strongly Disagree.
* P<.5 level.
** P<.01 level.

tomers. An additional two items, sharing plant capacity utilization with customers and sharing engineering requirements with customers, loaded on a factor called sharing manufacturing information. The SIC (originally memory capability) loaded separately from any other learning factor and because of its correlation with specific technical capabilities, this factor was categorized as a technology variable.

Interestingly, neither the objective measures for cycle time, in spite of being developed in a prior survey, nor the specific technical capabilities of workers, a new scale for this survey, loaded on any particular factor. Whether due to the small sample size or the inappropriateness of the questions for this group of firms, the objective measures of cycle time were unusable in the final data analysis. Also, the specific technical capabilities of workers did not explain the variance among firms in this sample, which indicated that these capabilities need not be of such concern in predicting supplier adoption as the airline research partner had thought. It appears an organization's overall ability to learn means it can also teach its employees to use new systems.

Descriptive statistics for all variables, including correlations, means, standard deviation, and coefficient alphas, are included in Table 1. Coefficient alphas were in general excellent, between .8 and .9, far above the standard for exploratory research. As Table 1 indicates, only two variables (information processing and learning ability), were correlated more than .6 (.621), reducing concerns of discriminate validity. Interestingly, only two of the variables considered, information-processing capabilities [information processing (acquisition, dissemination, and sharing of order-processing information], and sharing of manufacturing information, not the overall learning ability, correlated with the self-reported likelihood of adoption. Specific technical capabilities also correlated with information processing and likelihood of adoption, whereas the other variables, including relationship priorities, did not. Again, it appears that the SIC variable, because it is more highly correlated with specific technologies than information processing or learning ability (.49 vs. .23 and .00), might actually be measuring a technical capability.

This mixture of technical capabilities and learning activities in the final scales allowed for testing the initial hypothesis that both learning and technical variables would aid in understanding the adoption process. The data, although differing slightly from normal, did not differ so much that the analysis could not proceed. The final set of variables used in the analysis is reported as Appendix 2.

2.3. Cluster analysis

Three separate clustering methods were applied. The first method displayed excessive chaining; the second provided cluster groupings that did not make sense on a theoretical basis. The third, k-means clustering, provided groups that were aligned with the theoretical structure and had enough group members to conduct comparison tests of the dependent variables. While several different cluster procedures were explored as recommended by Ketchen and Shook (1996), the k-means procedure for four clusters produced the best result in terms of group size equivalency and minimizing chaining effects.

The three, four, five, and six solution clusters were compared, with the five-cluster solution contributing little additional information to the work. Since very few companies were included in the fifth cluster, a meaningful com-

Table 2
Final cluster centers (1 = Strongly Agree, 3 = Neither, 5 = Strongly Disagree)

Total $N = 77$	Early adopter	Early majority	Late majority	Laggards
N (Percentage)	11 (14%)	27 (35%)	27 (21%)	23 (18%)
Independent variables				
Technology capabilities				
"Shoppable" Internet Catalog (Memory function)	2.05	3.04	4.51	4.64
Specific technology	1.62	1.88	2.75	3.28
Learning ability (team and systems processes)	1.64	1.37	1.63	1.95
Information management capabilities				
Information processing activities (acquisition, distribution and sharing order processing)	1.63	1.37	1.65	2.51
Sharing information with distribution	2.18	1.74	3.45	2.86
Sharing information with manufacturing	3.94	1.56	1.83	3.68
Relationship priority	2.13	1.89	1.60	2.21
Dependent variables				
Cycle time	2.33	1.90^{+}	2.28	2.50
Likelihood of adoption	1.80**	1.70**	2.50^{+}	3.20

Two-tailed significance, $+P < .10$ level, $*P < .05$ level, and $**P < .01$ level.
Result of Paired t tests (significant relationships): Cycle Time Improvements: Early majority>Laggards (**) Likelihood of Adoption: Early majority>Late majority (**) Early majority>Laggards (**) Early adopters>Late majority (**) Early adopters>Laggards (**) Early majority>Late majority (*) Late majority>Laggards (+).

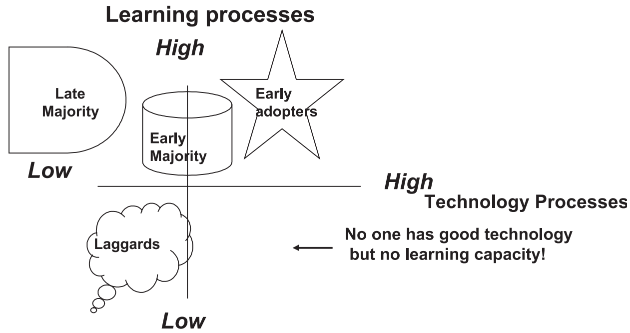

Fig. 4. Final k-means clusters. Learning processes.

parison was not possible. Final cluster groupings are reported in Table 2. Descriptions of the clusters are included in Table 2 and are shown graphically in Fig. 4.

3. Results

The final solution, as Table 2 indicates, supported the notion of the differences in groups based on likelihood of adoption. The sample was classified as 14% early adopters and 35% early majority, very close to the original 13.5% and 34% predicted by Rogers. The late majority of 27% was somewhat smaller than the 34% predicted by Rogers and the 23% of laggards was somewhat larger than the 18% predicted by Rogers (see two sets of figures in Fig. 2). Overall, the categories fit quite well.

Table 2 also shows the final k-means clusters as reported by group membership. These results largely support Hypothesis 1, with one exception. As can be seen in this table and in Fig. 4, no single group had high-technology processes but low learning capability, indicating a strong linkage between technology and learning. In fact, all groups except the laggards were very close in terms of learning ability and information processing. The difficult to achieve ability to share information across organizations appeared to contribute more to the differences between groups than learning or information processing (with the exception that the laggard group seems to uniformly have the worst scores in all aspects of learning and information processing). The group classified as laggards clearly possessed a lower level of capability on both the critical learning functions and technology functions as well.

The late majority's technical capabilities were lacking even more than its ability to acquire, store, process, and share information. The early adopter and early majority categories were similar except for the key technology function of the SIC, in which the early adopters were clearly superior. Since the airline partner thought that SIC was most important in making this designation, suppliers with highest SIC capabilities were classified as early adopters. In fact, these functions as operationalized in the SIC exhibited significant variation between groups, with the early adopters clearly having a superior capability. (It is interesting to note, however, that early adopters were less likely to share manufacturing information with their customers then the early majority group).

After obtaining a consensus as to group membership, Hypotheses 2 and 3 were tested. These hypotheses stated that early adopters would have higher likelihood of adoption scores (Hypothesis 2) and improved cycle time scores (Hypothesis 3) than the early majority group, and that the relationships would be similar throughout the learning hierarchy of other groups. The results did not support Hypothesis 3, which predicted that cycle time performance would vary across the groups (although the early majority are more likely to have cycle time improvements than laggards). Although cycle time improvements in the data are associated with learning ability and information processing capabilities, the dependent variable of cycle time was not helpful in the analysis of adopter groups.

However, the likelihood of adoption variable displayed considerable variation across the groups, supporting Hypothesis 2. Differences are particularly striking between the two early categories on the adoption curve. Early majority and early adopters were more likely to adopt than late majority or laggards, early majority more likely to adopt than late majority and late majority more likely to adopt than laggards. The results of the supporting *t* tests (applicable because of the small sample sizes) are reported in Table 2 and in Fig. 5. (Note, as before, that early adopters and early majority groups were very similar in their likelihood to adopt.)

Relationship priority was not significantly different across the clusters, perhaps because the study focused on the airline's largest suppliers. The exception was that the late majority rated the airline relationship as a higher priority to them than the early adopters did (*t* test significant at $P<.05$).

4. Additional analysis

A regression of the full set of independent variables run on the dependent variable of likelihood of adoption revealed that three significant variables in this equation were information processing capabilities (acquisition and generation and sharing of order-processing information), the specific technology capabilities of the supplier, and the technical processes of the SIC (adjusted R^2=.31, F(sig.) = 12.362 (0.00), variables significant at $P<.05$). This result also confirmed the importance of both technology and learning in the prioritization of suppliers for automation. An additional regression analysis supports the conclusions of earlier research that learning orientation (here team processes and systems orientation) as well as information-processing capabilities (acquisition, dissemination, and sharing), can help predict cycle time improvements (adjusted R^2=.36, F(sig.) =

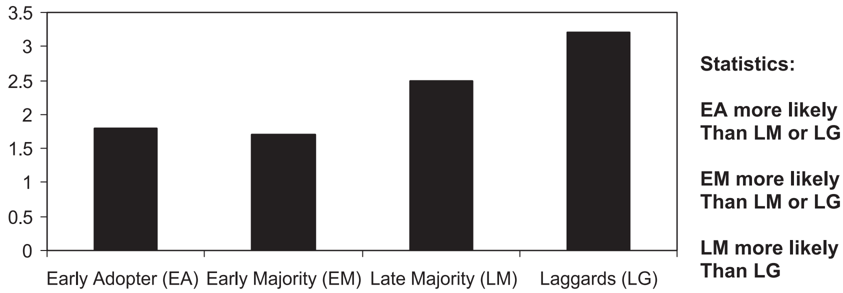

Fig. 5. Likelihood of adoption (1 is highest).

22.474 (0.00), information processing significant at $P<.10$, learning ability significant at $P<.01$).

Another analysis of the timing associated with adoption is also included in Table 3. Although the original survey included questions which asked about the timing of adoption of various technical features and learning capabilities, the small number of responses to these questions made it difficult to perform any meaningful statistical analysis on these cases. Either the respondents were reluctant or unable to answer these questions. In addition, the fact that respondents did not have to complete these questions to complete the survey may have contributed to the low response rate on these questions. Table 3 illustrates the set of questions to which received the most responses, the timing of when invoices would be transmitted electronically, by the final cluster membership of the respondents. Since the electronic transmission of invoices is critical to the type of systems implementation reported here, the responses to these questions by cluster category are of interest. Percentages are reported here because of the difficulty of performing other types of analysis due to the small sample size and missing data.

These descriptive and admittedly, post hoc, results indicate that the cluster categories as estimated are reasonably robust. Only one respondent out of 26 indicated that invoices would be processed electronically by the end of the year in which the survey was asked, and this respondent, as might be predicted, was in the early adopter category. The distribution of those who thought they would have electronic invoicing capability by the end of the following year reasonably approximates initial cluster membership and that predicted by Rogers. Among those who predicted adoption of electronic invoice processing in 2 years, the results are more mixed. Only one early adopter, five early majority and no late majority suppliers are in this group, where late majority and laggards might be predicted. More consistent with expectations, three out of the four laggards that responded to this question predicted electronic invoicing 2 years in the future. It seems that these cluster membership categories may be less reliable for predicting future behavior as time frames farther in the future are considered.

Although few control variables could be included in the survey due to time pressures and the desire to keep the survey short, an analysis of differences in likelihood of adoption and cycle time between the major industry groupings in the sample (defined as those with at least five companies in the industry group) was performed. These groups were, broadly categorized, electronics, aircraft manufacturing, aircraft service, aircraft engine manufacture and repair, and aircraft equipment. An ANOVA with post hoc Scheffé tests revealed that there was no significant difference in either likelihood of adoption or cycle time between the industry groups. Because of the small group sizes, independent sample t tests were also run and revealed no significant differences. This result is consistent with learning organization theory, which does not suggest that learning is necessarily confined to one industry or group of companies.

Table 3
Responses to questions of WHEN the majority of invoices will be transmitted electronically by cluster membership [N (Percentage)]

Cluster membership	By the end of this year	By next year	In 2 years
Early adopter 5 (19%)	1 (10%)	3 (19%)	1 (11%)
Early majority 10 (39%)	None	5 (31%)	5 (56%)
Late majority 5 (19%)	None	5 (31%)	None
Laggards 6 (23%)	None	3 (19%)	3 (33%)
Total $N=26$	TOTAL $N=1$	TOTAL $N=16$	TOTAL $N=9$

5. Discussion

These results build on prior research, which suggests that a learning orientation (represented in part here by learning ability), is associated with the information processing capabilities of firms, in conjunction with specific technical capabilities, particularly in the supply chain context (Hult et al., 2000). This research shows that these information-processing and technical capabilities can in turn be related to likelihood of adoption in a field setting and used to guide the implementation process of an actual supply chain automation tool at a major company. The contribution of this research is in applying these concepts to a real-life implementation problem, whereby the results can be used to determine which firms are the most likely candidates for automation of supply chain functions. In addition, this research indicates that both learning and technology capabilities can combine to create meaningful groups of suppliers and that technology development alone cannot exist without a learning context.

The results of the study suggest the airline focus on early adopters and the early majority in terms of implementation of Ariba. Helping the late majority to become ready for Ariba might be as simple as introducing them to the existing technology. However, given the personality type of those in the late majority, the companies in this group might succumb more to peer pressure from other of the airline's suppliers (at a company-wide conference for example) than just being exposed to the Ariba technology (Rogers, 1995). Given the traditional views and scarce resources of the "laggard," the airline research partner might be better served to focus on the other three groups in terms of prioritization for Ariba adoption (Rogers, 1995).

6. Managerial implications

This research had a direct and specific managerial implication for the airline involved. First, it reinforced to the airline the importance of not looking at just specific technologies but at learning and information-processing abilities of suppliers in selecting candidates for automation. Second, the airline allowed the partner to choose among suppliers, all of whom are seen as key suppliers, and focus on implementing Ariba first among those classified as early adopters and early majority. These two groups have the capabilities for automation and any pilot studies should be concluded within them. The group labeled laggards clearly needs to be reexamined by the airline and the group labeled late majority needs some specific assistance on technical capabilities before it can be said to be ready to move forward with automation.

The results also have some important implications for supply managers in the area of supplier evaluation, supply base rationalization, and supplier development. The majority of the literature in this area has focused on improving suppliers' manufacturing capabilities through the use of *kaizen* improvements and six sigma "black belt" training, (Handfield, Krause, Scannell, & Monczka, 1998; Tan, Handfield, & Krause, 1998). These results suggest that managers may need to devote additional resources to assess the level of information processing, particularly information sharing, in their supply base, as well as their predisposition to adopt new technologies. As organizations move into the future and compete on the basis of their entire supply chain as the unit of analysis, the assessment of these "soft skills" will prove to be important in distinguishing the winners from the losers. In fact, organizations are only as strong as the customers and suppliers that they partner with, in harnessing a truly competitive advantage and delivering greater value to the end customer (Handfield & Nichols, 1999, Chap. 1).

7. Conclusions and limitations

This research provides a piloted methodology to segment an organizational supply base into clusters that have

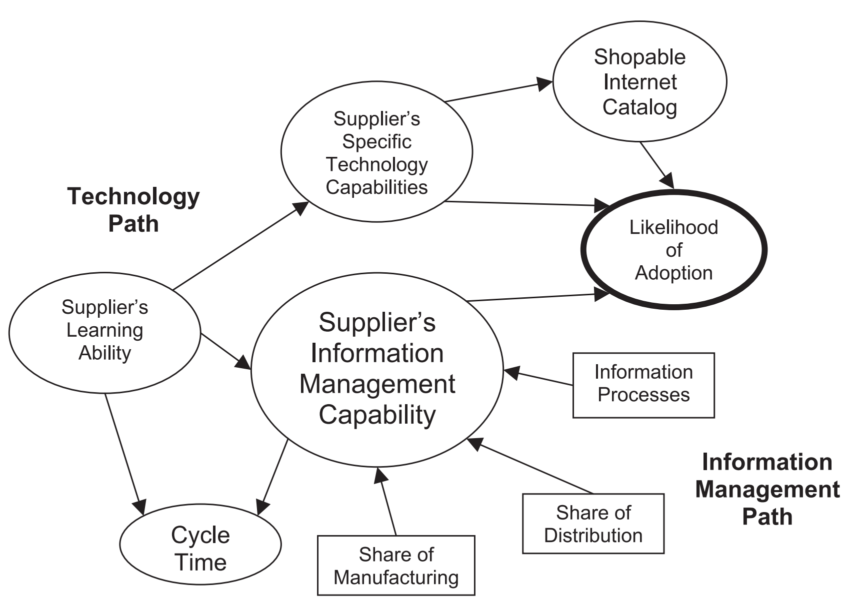

Fig. 6. Suggested theoretical model.

a high potential for success in implementing B2B technology pilot implementations. The methodology has been applied in a real-world setting to evaluate high-potential suppliers for a pilot implementation of Ariba, an e-procurement methodology. From a theoretical standpoint, the research, in part, replicates prior results on organizational learning and information processing in the supply chain in a specific company context. This study also documents the importance of considering learning, information processing and technology capabilities in conducting supplier analysis and selection processes in managing supply chain initiatives, something managers are prone to overlook in their rush to get suppliers to adopt new technology. This research has some limitations as to the generalizability of the results, since the analysis was conducted in one company's supply base, but holds rich promise for future research in this area.

Fig. 6 illustrates the results of examining the correlation matrix and performing regression analysis (not reported here in detail) to determine the relationship between the variables as they might be studied in a structural equation model in the next phase of the research with a larger sample. (Please note that this figure represents the relationships in the data and has not been subjected to tests for model identification and other rigors of structural equation modeling). Overall, these data reinforce the relationship between learning orientation and cycle time improvements (Hult, 1998; Hult et al., 2000), aided by information management capability (Hult et al., 2000). These results in fact indicate that the ability to share specific types of information with manufacturing and distribution might be more important to distinguish between suppliers in an implementation effort than general learning capabilities.

Interestingly, these results also indicate that technical capabilities themselves are not associated with improvements in cycle time, but are associated with likelihood of adoption, through the development of capabilities such as the SIC. In addition, these data support relationships between learning ability, information-processing capabilities and technology capabilities, indicating that technology improvements are difficult to sustain without a learning orientation and the ability to manage information in the firm. Supply chain managers might consider helping their suppliers become learners rather than helping them to improve their specific technologies, if they wish to have successful partner relationships.

Supplementing the self-reports of the likelihood of adoption with the independent assessments of the commodity managers on the likelihood of adoption would improve the validity of the study. Also, a larger number of suppliers would be a wonderful way to support the results of this work, which at this stage must be considered exploratory. This methodology can be replicated and extended in other industries to improve both generalizability and sample size. Memory constructs in the research need to be improved in that the SIC scale is associated more with the technical capabilities scale than learning ability or information-processing capabilities scales (Table 1). An expanded study with inclusion of two additional scales, memory orientation, and learning orientation (1998) might also lend more depth to the study. Refining the relationship priority scale or substituting relationship commitment might also lead to the ability to detect differences among groups. Finally, the prediction of cluster membership could be enhanced by including the timing of adoption, as the descriptive analysis of some of the timing data collected has indicated.

Acknowledgements

This research was funded by a grant from the Supply Chain Research Consortium at North Carolina State University and is dedicated to the memory of those in the airline industry who lost their lives on September 11, 2001.

Appendix A.

Respondents were asked to use the following scale in answering these questions (1 = Strongly Agree, 3 = Neither, 5 = Strongly Disagree)

SYSTEMS PROCESS (Hult, 1998)

a. All activities that take place in the order fulfillment process are clearly defined
b. We understand how our work fits into Generic Airlines' value chain
c. We have a good sense of the interconnections in the order fulfillment process
d. We understand how all our activities fit into the order fulfillment process
e. We involve Generic Airlines into our order fulfillment process
f. Our order fulfillment planning processes are automated

TEAM ORIENTATION (Hult, 1998)

a. A team spirit pervades the ranks in our customer order fulfillment process
b. Cross-functional teamwork is the common way of working in the order fulfillment process
c. There is a commonality of purpose in the order fulfillment process
d. There is total agreement on our organizational vision in the order fulfillment process
e. We are committed to sharing our vision with each other in the order fulfillment process

INFORMATION PROCESSING (ACQUISITION, DISSEMINATION, MEMORY AND SHARING) (Hult, 1998; Kohli et al., 1993)

ACQUISITION

a. We are quick to detect fundamental shifts in our environment
b. We regularly meet with our customers to decide what products or services they need in the future
c. We are quick to detect changes in our customer's product and service information
d. We do a lot of in-house research on products or services our customers may need

DISSEMINATION

a. Data on customer purchase patterns are disseminated at all levels on a regular basis
b. Personnel regularly exchange customer information with other departments
c. Our business unit periodically circulates documents internally that provide information on our customers
d. When something important happens to a major customer of ours, the whole business unit knows about it within a short period

SHOPPABLE INTERNET CATALOG (MEMORY) (New Scale from Generic Airlines; Sinkula et al., 1997; Slater & Narver, 1995)

a. Most of the items for sale are in the catalog
b. Returns made are handled easily
c. The process for updating the catalog is smooth and efficient
d. Our catalog is available in many formats

SHARE INFO WITH CUSTOMERS (New scale from our own prior research on Customer Information Management; Sinkula et al., 1997; Slater & Narver, 1995)

a. We routinely share replenishment cycle information with our customers
b. We routinely share information on shipping status with our customers
c. We routinely share safety stock levels with our customers
d. We routinely share forecasted inventory levels by location and quantity with our customers
e. We routinely share information on order status with our customers
f. We routinely share plant capacity utilization information with our customers
g. We routinely share information on engineering requirements with our customers
h. We routinely evaluate customer materials lists and make recommendations to our customers about any possible standard part substitutions
i. We routinely share information on forecasted demand with our customers
j. We routinely share information on historical sales patterns with our customers
k. We routinely share warehouse information/storage location with our customers

SPECIFIC TECHNOLOGY (New Scale from Generic Airlines, supply chain literature)

a. We can process change orders electronically
b. Our customers can easily access the status of their orders
c. The majority of our invoices are processed electronically
d. The majority of our invoices are transmitted electronically
e. We provide our customers "available to promise" information on a regular basis
f. We provide our customers access to inventory information/stock on hand
g. We are able to track where any given item is physically located (transit, customs, supplier, etc) and where it was used
h. We have or plan to have an Enterprise Resource Planning (ERP) system (If so-what type of ERP system? ______________________)
i. We develop forecasts and identify exceptions electronically with our customers on a monthly basis
j. We easily process orders electronically
k. We have a fully implemented materials requirements planning MRP system
l. We routinely exchange order fulfillment information with our customers
m. When orders need to be expedited, they are processed electronically

TECHNOLOGY-PEOPLE SKILLS (New Scale from Generic Airlines)

a. Most of our people regularly access an information system to do their work
b. Our people feel comfortable working with a Web browser
c. Our people feel comfortable working in a Windows environment
d. When new information systems are implemented in our organization, they are adopted easily
e. When new information systems are implemented in our organization, there is very little resistance to change

RELATIONSHIP PRIORITY (Vlosky & Wilson, 1994)

a. Generic Airlines are important to us because they buy a significant volume of product from us
b. We are committed to having a long-term relationship with Generic Airlines
c. In the short term, we have a better relationship with Generic Airlines than our other customers
d. We are more inclined to share production forecasts with Generic Airlines than other customers
e. We are likely to accommodate requests from Generic Airlines

f. In general, we trust the people we work with at Generic Airlines
g. Generic Airlines is important to us for our future business plans
h. We make an important investment every year in technology or equipment to serve our customers

LIKELIHOOD OF ADOPTION (EOFS is *Electronic order fulfillment system)* (New scale from supply chain literature and Generic Airlines)

a. It is important that we supply web-based catalogue information to our customers
b. EOFS will help us decrease expediting
c. EOFS will help us decrease order delivery cycle time
d. We are committed to working with our customers to implement EOFS

CYCLE TIME (OFP is *Order Fulfillment Process*) (Hult, 1998)

a. The OFP is likely to get shorter with a web enabled e-Procurement system (Ariba)
b. We are currently satisfied with the speediness of the OFP
c. Based on our knowledge, we think the OFP is short and efficient
d. The OFP could be much shorter than it is today

OBJECTIVE MEASURES (Hult, 1998)

a. The average length of our order fulfillment process with Generic Airlines from initiation to completion is (business days)
b. Actual on time delivery record for our Generic Airlines orders (% of time)
c. What percent of orders are expedited to our Generic Airlines (% of total orders)
d. Total amount of inventory we hold within our facility in anticipation of Generic e. Airlines orders (days of inventory)
e. Investment in Generic Airlines-specific technology or equipment (percentage of annual sales with our Generic Airlines)
f. A team spirit pervades our ranks in the customer order fulfillment process

Appendix B. Final scales and items

(1 = Strongly Agree, 3 = Neither, 5 = Strongly Disagree)

LEARNING ABILITY (COMBINES SYSTEMS PROCESS AND TEAM ORIENTATION):

a. All activities that take place in the order fulfillment process are clearly defined
b. We understand how our work fits into Generic Airline's value chain
c. We understand how all our activities fit into the order fulfillment process
d. We involve Generic Airlines into our order fulfillment process
e. Cross-functional teamwork is the common way of working in the order fulfillment process
f. There is a commonality of purpose in the order fulfillment process
g. There is total agreement on our organizational vision in the order fulfillment process

We are committed to sharing our vision with each other in the order fulfillment process

INFORMATION PROCESSING (ACQUISITION, DISSEMINATION, AND SHARING ORDER PROCESSING)

a. We are quick to detect fundamental shifts in our environment
b. We regularly meet with our customers to decide what products or services they need in the future
c. We are quick to detect changes in our customer's product and service information
d. We do a lot of in-house research on products or services our customers may need
e. Personnel regularly exchange customer information with other departments
f. Our business unit periodically circulates documents internally that provide information on our customers
g. When something important happens to a major customer of ours, the whole business unit knows about it within a short period
h. We routinely share information on order status with our customers
i. We routinely share information on shipping status with our customers
j. We routinely evaluate customer materials lists and make recommendations to our customers about any possible standard part substitutions

SHARING MANUFACTURING INFORMATION

a. We routinely share plant capacity utilization information with our customers
b. We routinely share information on engineering requirements with our customers

SHARING DISTRIBUTION INFORMATION

a. We routinely share warehouse information/storage location with our customers
b. We routinely share replenishment cycle information with customers

"SHOPPABLE" INTERNET CATALOG (SIC)

a. Most of the items for sale are in the catalog
b. Returns made are handled easily
c. The process for updating the catalog is smooth and efficient
d. Our catalog is available in many formats

SPECIFIC TECHNOLOGY

a. We can process change orders electronically
b. The majority of our invoices are processed electronically
c. The majority of our invoices are transmitted electronically
d. We provide our customers access to inventory information/stock on hand
e. We easily process orders electronically
f. When orders need to be expedited, they are processed electronically
g. Our order fulfillment planning processes are automated

RELATIONSHIP PRIORITY

a. In the short term, we have a better relationship with Generic Airlines than our other customers
b. We are more inclined to share production forecasts with Generic Airlines than other customers
c. In general, we trust the people we work with at Generic Airlines

LIKELIHOOD OF ADOPTION (EOFS is *electronic order fulfillment systems*)

a. Cycle time will be likely to get shorter with a web enabled e-Procurement system (Ariba) (From original Cycle time questions)
b. EOFS will help us decrease expediting
c. EOFS will help us decrease order delivery cycle time
d. We are committed to working with our customers to implement EOFS

CYCLE TIME (OFP is *order fulfillment process*):

a. We are currently satisfied with the speediness of the OFP
b. Based on our knowledge, we think the OFP is short and efficient
c. The OFP could be much shorter than it is today

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