Using Electronic Procurement to Facilitate Supply Chain Integration: An Exploratory Study of US-based Firms

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Abstract

With ever-increasing competitive pressures, growing numbers of firms use electronic procurement (e-procurement) in an attempt to reduce costs and increase profitability. Academicians and practitioners alike agree that one of the most important benefits of e-procurement is its ability to facilitate integration within the firm and across the supply chain. However, there is much to be discovered about the prevalence of actual implementation of e-procurement. The purpose of this study is to empirically examine the extent to which firms operating in diverse industries use nine different e-procurement tools that differ in their ability to facilitate supply chain integration. The survey data were provided by a sample of 142 members of the Institute for Supply Management (ISM). Factor analysis revealed that the group of nine e-procurement tools could be categorized into two types: basic, single-process tools and integrative tools. A t-test of the mean differences between each type of e-procurement tool revealed that firms used basic, single-process tools to a greater extent than they used integrative forms of e-procurement. To further explore firms' use of e-procurement, we attempted to ascertain whether the industry in which a firm operates impacts use. Logistic regression revealed that firm sector has an effect on the use of integrative e-procurement tools, with firms operating in the petroleum and the transportation equipment sectors being less likely to use them than their manufacturing counterparts. These findings are important, as previous research indicates that effective supply chain integration is associated with improvements in production planning, inventory management, distribution, and overall supply chain performance.

Keywords: electronic procurement, supply chain management, supply chain integration

Introduction

With increasing competitive pressures, supply chain management professionals must continually find ways to reduce costs, increase efficiency, and reduce lead time. How does today's supply chain management professional accomplish all of this? Increasing numbers of firms use e-procurement in an attempt to enhance these key business outcomes. This comes as no surprise, given one of the key competitive priorities for the 21st century is the maximization of Internet-based technologies such as e-procurement (Monczka and Morgan 2000). Among other things, Internet-based technologies assist supply chain management professionals in the sometimes arduous task of linking supply chain members, which is a necessity in increasing the speed of information transfer and reducing non-value adding processes.

Supply chain management professionals are faced with the challenge of selecting and implementing the most appropriate e-procurement tools or applications to meet the needs of their firms. Some examples of available e-procurement applications include online auctions, e-catalogs, and e-marketplaces to name a few. While these and other forms of e-procurement

can prove to be beneficial, the supply chain management professional's decision-making process can be complicated by the fact that these tools vary in many respects, including their ability to facilitate supply chain integration within and across firms. Some e-procurement tools involve applications within a single function (e.g., electronic requisitions), while some facilitate integration across multiple functions within a single firm (e.g., Enterprise Resource Planning [ERP] systems); others provide integration across organizations (e.g., Electronic Data Interchange [EDI]).

Purpose

The opening quotes of this paper underscore the importance of the use of Internet-based technologies, including e-procurement in the integration of supply chains. Although the potential of e-procurement to contribute to supply chain success has generated substantial interest, Cagliano, Caniato, and Spina (2003) noted that evidence is still lacking with regard to the prevalence of actual implementation and effectiveness of these tools in firms. Researchers have made strides in understanding these issues in European firms (e.g., Cagliano et al. 2003, Frohlich and Westbrook 2002). This exploratory study provides a first step in addressing the gap in the literature regarding e-procurement implementation issues faced by US-based firms.

The purpose of this research is to empirically assess the extent to which US-based firms use nine different e-procurement tools that differ in their ability to facilitate supply chain integration. Furthermore, this study explores the relationship (if any) between the industry in which the firm operates and the use of e-procurement applications. Specifically, this study addresses the following research questions: 1) Which type of e-procurement application is more widely used (applications that are relevant to single function/process or those that integrate processes across functions and/or firms)? 2) Is there a relationship between the industry in which the firm operates and the use of integrative e-procurement applications? It is important to answer the aforementioned questions because the concept of integration is foundational in effective supply chain management. While a supply chain consists of at least two or more distinct entities, the processes that occur between them must be seamless in order to be effective. In other words, these entities must come together and operate in a unified manner in order to satisfy customer needs. Some of the benefits that are associated with the integration of supply chain processes include increased competitive advantage, lowered operational costs, and enhanced coordination and collaboration among supply chain members (Themistocleous, Irani & Love 2004).

"While a supply chain consists of at least two or more distinct entities, the processes that occur between them must be seamless in order to be effective."

In order to examine this topic, a review of the existing literature on e-procurement and supply chain integration is presented. The literature review is followed by an explanation of the research methodology and results. The paper concludes with a discussion of the findings, conclusions, and opportunities for future research.

Literature Review

E-procurement

While a number of definitions of e-procurement exist, Min and Galle's (2003, 227) definition of electronic procurement as "business-to-business purchasing practice that utilizes electronic commerce to identify potential sources of supply, to purchase goods and services, to transfer payment, and to interact with suppliers" was adopted for this research because it is comprehensive. Many agree that the intensely competitive nature of today's business environment makes the effective use of e-procurement an operational necessity for firms; it is an important issue that must be confronted by purchasing/supply management decision-makers now and into the future (Dooley and Purchase 2006; Davilia, Gupta & Palmer2003; Carter et al. 2000). Some of the noted benefits of e-procurement include increased collaboration between buyers and suppliers, reduced personnel requirements, improved coordination, reduced transaction costs, shorter procurement cycles, lower inventory levels, and greater transparency (Dooley and Purchase 2006; Davila et al. 2003; Min and Galle 2003; Turban et al. 2002; Osmonbekov, Bello & Gilliland 2002; Rajkumar 2001; Carter et al. 2000).

Giunipero and Sawchuck (2002) noted that the Internet can be used as a research tool, allowing the purchasing professional to "shop around" and compare suppliers' capabilities and to peruse online catalogs. Second, the Internet can be used to generate savings. Purchasing via the Internet is an effective way to reduce otherwise high transaction costs for low-value items such as maintenance, repair, and operating items. Third, Internet-based procurement tools can be used not only to reduce transaction costs, but as a means of reducing prices paid for purchased goods/services. The buying firm can use the Internet to solicit bids from a wider range of potential bidders than is possible using traditional methods. This could increase the firm's chances of getting a better price. Fourth, the buying firm can use an e-marketplace and participate in online auctions, both reverse (where a buying firm makes its purchase needs known online) and forward (where a selling firm puts goods/services up for sale on-line). Finally, e-

procurement can be used as part of an effort undertaken by the entire supply chain, from the final customer back to a firm's suppliers.

The Importance of Integration in Effective Supply Chain Management

In order to understand the importance of integration in effective supply chain management (SCM), one must first examine how SCM has been conceptualized and defined. The term SCM first emerged in the literature in the early 1980s and has gained increasing prevalence over the last two decades. Pagh and Cooper (1998) described SCM as a method of integrating and performing logisitics and manufacturing activities. Tan et al. (1999) defined SCM as "the simultaneous integration of customer requirements, internal processes, and upstream supplier performance". Finally, Lambert and Cooper (2000, 66) defined SCM as "the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders". Although SCM has been defined differently among scholars, a common theme clearly exists: the importance of integration.

Internal and external integration are fundamental to superior supply chain performance. Firms achieve internal integration by effectively coordinating processes on an enterprise-wide basis. The ability of distinct functions working together to create seamless interfaces across processes is fundamental to firm and supply chain success (Narasimhan and Kim 2002). This requires decision-makers to reject the traditional school of thought in which the various functional-level managers' primary concern focuses on their own departments (Rajagopal 2002). External integration entails recognizing suppliers as an integral part of the supply chain and engaging in collaborative efforts with these firms (Narasimhan and Kim 2002). Integration at this level is imperative because it increases the overall performance of the supply chain (Speckman, JW & Myhr 1998; Gattorna 1998).

The Role of IT in Integrating Supply Chains

The use of IT provides the basis for supply chain integration by providing efficient, timely, and transparent business information to the appropriate parties (Cagliano et al. 2003). Some of the relevant types of information include operations, logistics, and strategic planning information. Sharing of this information enables multiple firms to engage in synchronous decision making and can lead to improvements in production, planning, inventory management, and distribution (Sanders 2005). Due to its ability to provide vital information to the appropriate parties, Sanders (2005) dubbed IT the "backbone of supply chain business structure."

Zeng and Pathak (2003) suggested that supply chains advance when they progressively integrate multiple functions into the process. This progression is driven by the development, advancement, and implementation of IT, which allows coordination of activities and processes between supply chain members (Zeng and Pathak 2003). In addition, Daugherty, Germain, and Droge (1995) assert that the greatest value associated with the use of IT may be its ability to allow users to develop networks that reach beyond the borders of the individual firm.

Categorizing Types of E-procurement Applications

A number of researchers have developed classification schemes or taxonomies to categorize Internet-based tools (e.g., DeBoer, Harink & Heijboer 2002; Kehoe and Boughton 2001; Whitaker et al. 2001; Brynjolfsson and Smith 2000). This categorization is necessary because e-procurement tools differ in many respects including costs, benefits, goals, and as previously noted - integrative ability.

Frohlich and Westbrook (2002) surveyed a sample of UK-based firms in order to investigate the extent to which they used Internet-based technologies to integrate supply chain activities such as inventory planning, order taking, and demand forecasting. The authors categorized the respondents' usage into four groups:

1. web-based, low integration (Internet-enabled focus on the firm only)
2. web-based supply integration (Internet-enabled integration between the firm and its suppliers)
3. web-based demand integration (Internet-enabled integration between the firm and its customers)
4. web-based demand chain (Internet-enabled integration between the firm, its suppliers, and its customers)

Frohlich and Westbrook (2002) found that the majority of firms (63%) engaged in web-based, low integration. The web-based demand chain group was the smallest segment, with only 4% of the respondents in this category.

Cagliano et al. (2003) conducted a study on a sample of European manufacturing firms and identified four clusters of respondents based on their use of Internet-based technologies. The authors categorized the firms in the following manner: *traditionalists* (55% of the sample) did not use Internet-based technologies within the supply chain, *e-sellers* (23% of the sample) used Internet-based technologies for sales and customer care only, *e-purchasers* (14% of the sample) employed Internet-based technologies extensively, but only for

the purpose of making purchases from suppliers. Finally, *e-integrators* (7% of the sample) used Internet-based technologies in every aspect of their supply chain processes. This included use in internal operations, procurement, and sales.

Previous research has established that e-procurement tools can be classified on the basis of a number of characteristics, including an ability to facilitate integration. Based on the findings of Frohlich and Westbrook (2002) and Cagliano et al. (2003), the following is proposed:

P1: *The use of less integrative e-procurement applications will be more prevalent among the sample firms than the use of e-procurement applications that facilitate integration across departments and/or firms.*

The Relationship between Firm Sector and the Use of E-procurement Applications

In an attempt to further understand e-procurement use, the authors examined previous research on the relationship between firm sector and the adoption of technology. The results of a multi-sample survey of Spanish firms operating in various sectors, which was conducted by Ortega, Martinez, and DeHoyos (2006), provided support for the premise that the sector in which a firm operates plays a role in the acceptance of technologies. Ortega et al. (2006) found there were factors that influenced technology adoption such as perceived ease of use and usefulness of the technology, but their effect was contingent upon the sector in which the firm operated. Specifically, the authors found that firms operating in the IT industry not only perceived on-line management applications (the technology in question) to be more useful and easier to use; they also had higher adoption intentions and intensity of use than firms operating in the primary, industrial, and services sectors.

While a number of studies suggest that firm sector plays a role in technology adoption, researchers have taken somewhat different approaches to explaining this relationship. Ortega et al. (2006) noted that some industries are characterized by greater experience in technology use, which facilitates the adoption of additional technological applications (including e-commerce).

Additional research suggests that industries that are more technologically advanced promote greater and more effective use of the appropriate technologies (Chewlos, Benbasat & Dexter 2001; Dyer, Cho & Chu 1998; Goodacre and Tonks 1995). Thatcher and Foster (2002) support this notion in their analysis of how information technology has evolved in firms operating in various industries. The authors noted, for example that industries such as textiles tend to be less technologically advanced than other sectors such as electricity companies, which tend to be in the forefront of technology adoption.

Motiwalla, Khan, and Xu (2005) undertook a study to identify the factors that impact the adoption/use of e-business across three different sectors. The researchers concluded that similarities in the level of IT adoption were identified within sectors because engaging in a particular activity prompts firms to develop similar behavior patterns. This would explain why firms engaged in information-intensive activities are more likely to accept new techno-

Table 1
Survey Items and Descriptive Statistics

We use Internet-based technologies to:	Mean	Standard Deviation
Plan and schedule production	2.80	1.16
Collaborate with suppliers on product design issues	2.88	1.21
Place orders on suppliers' web sites	2.91	1.21
Search for suppliers that will help us differentiate our offerings	2.94	1.19
Achieve cross-functional coordination	3.08	1.06
Check suppliers' finances	3.31	1.16
Develop an integrated supply chain	3.32	1.08
Access electronic marketplaces	3.33	1.12
Use the software services of an electronic purchasing solutions provider	3.44	1.14
Search for low-cost suppliers	3.62	1.10
Access on-line catalogs	3.63	1.10
Visit suppliers' web sites	3.85	1.03

1 = strongly disagree, 5 = strongly agree

logical innovations. These firms do so primarily because using advanced technologies provide greater strategic benefits for them (Yap 1990; Min and Galle 2003).

Dyer et al. (1998) found that firms operating in a particular sector require similar levels of efficiency of managers, which can be facilitated by various levels of technology use. Similarly, Premkumar and Roberts (1999) examined the intensity of competitive pressure within the firm's sector as a determining factor in the adoption of technologies. The authors maintain that firms that engage in more competitive economic activities are driven to employ increasingly sophisticated tools. Consequently, the adoption/use of higher levels of technology has become strategically vital for firms belonging to sectors such as telecommunications or distribution (Premkumar and Potter 1995).

Based on previous research, which suggests that the industry in which the firm operates impacts the adoption of technology in general and e-commerce specifically, the following is proposed:

P2: *A significant relationship will exist between firm sector and the use of integrative e-procurement applications.*

Table 2
Respondents' Demographic Information

	N	Min.	Max.	Mean	Standard Deviation
Number of years employed in purchasing/supply management	140	1.00	31	11.68	7.65
Annual business unit revenues*	128	4.50	45,000	5,487.35	7,104.88
Dollar amount of purchases for which respondent is responsible*	126	1.00	17,000	516.98	1,568.63

Ten Most Frequently Reported Position Titles (N = 140)

Title	Percentage
Purchasing Manager	19.7
Senior Buyer	14.8
Director	14.1
(Strategic) Sourcing Manager	8.5
Commodity Manager	7.7
Vice President	5.6
E-procurement Manager	5.6
Buyer	4.9
Supply Chain Manager	3.5
Supply Manager	2.8

* in millions of dollars

Methodology

Survey Participants and Mailing

The Institute for Supply Management provided a list of potential survey participants in eleven different standard industrial codes. The industries were: food products, paper products, chemicals, petroleum, rubber, primary metals, transportation equipment, fabricated metals, computer equipment, measuring and analyzing instruments, and electrical equipment. One thousand, twenty-five surveys were mailed to purchasing/supply management professionals with a cover letter explaining the objective of the research and a postage-paid return envelope. Follow-up postcards were sent to all potential participants two weeks later in an attempt to increase the response rate.

The Instrument

The instrument contained basic demographic questions and items intended to assess e-procurement tool use. The scale to assess "e-procurement tool use" was developed by the researchers. The survey items reflected Internet-based activities discussed in the SCM literature and the popular business press, along with general suggestions by Porter (1980, 1985) in a discussion of ways to achieve competitive advantage (applied in the context of Internet-based technologies). The scale was anchored with the statement "we use Internet-based technologies to..." followed by a list of e-procurement applications. The e-procurement applications assessed were as follows: plan and schedule production, collaborate with suppliers on product design issues, place orders on suppliers' web sites, search for suppliers that will help us differentiate our offerings, achieve cross-functional coordination, check suppliers' finances, develop an integrated supply chain, access e-marketplaces, use the software services of an e-purchasing solutions provider, search for low-cost suppliers, access on-line catalogs, and visit suppliers' web sites. Each item was measured on a Likert

scale ranging from 1 = "strongly disagree to 5 = "strongly agree". Table 1 contains the scale items along with descriptive statistics.

Response Rate and Sample Demographics

Of the 1,025 surveys mailed, a total of 142 useable surveys were received – resulting in a 14 percent response rate. While this response rate may appear somewhat low, Min and Emam (2003) note that response rates less than 20 percent are not uncommon in the supply chain management literature when the research method involves mail surveys (see Petersen, Ragatz & Monczka 2005; Claycomb and Frankwick 2004; Wisner 2003; Carter and Narasimhan 1996). It is possible that the response rate was impacted by the fact that the survey was only relevant to firms that use at least one type of e-procurement application listed. If a firm did not use any of the nine e-procurement applications listed on the survey, it could not be included in the sample.

In order to assess the potential of non-response bias, the researchers implemented a commonly used technique advanced by Armstrong and Overton (1977). Multivariate t-tests were performed on each item to determine if there were statistically significant differences between early and late respondents. The first twenty questionnaires received were considered early responses and the last twenty received were considered late. No statistically significant difference existed between early and late respondents. Thus, non-response bias did not pose a threat to the study results.

The respondent possessed considerable experience in purchasing/supply management and had significant responsibilities within their firms. The mean dollar amount of purchases for which the respondent was responsible and the respondents' annual business unit revenues varied widely. The respondents were em-

Table 3
Respondents' Primary Line of Business

Industry	Frequency	Percent
Manufacturing	28	19.7
Food	12	8.5
Automotive parts	11	7.7
Petroleum/gas	10	7.0
(Tele)communications	8	5.6
Chemicals	7	4.9
Transportation equipment	7	4.9
Pharmaceuticals	7	4.9
Metals/mining	6	4.2
Paper/paper products	4	2.8
Consumer products/packaged goods	3	2.1
Lawn and garden	3	2.1
Electronics	3	2.1
Consumer plastics	3	2.1
Inertial instruments	3	2.1
Medical equipment	3	2.1
Self-test diagnostic systems	2	1.4
Utility/power	2	1.4
Aircraft	2	1.4
Optical components	2	1.4
Semi-conductor	2	1.4
Industrial equipment	2	1.4
Tires	2	1.4
Computer (hardware and software)	2	1.4
Office equipment	2	1.4
Personal care	1	.7
Convenience store	1	.7
AC/CE equipment	1	.7
Agricultural products	1	.7
Heating, ventilation, and air conditioning	1	.7
Cans	1	.7
Total	**142**	**100.0**

Table 4
Rotated Component Matrix

SURVEY ITEM We use Internet-based technologies to:	Component	
	1	2
Develop an integrated supply chain	.70	.28
Plan and schedule production	.70	.06
Collaborate with suppliers on product design issues	.85	-.03
Achieve cross-functional coordination	.81	-.02
Search for suppliers that will help us differentiate our offerings	.62	-.10
Search for low-cost suppliers	-.14	.68
Visit suppliers' web sites	-.10	.77
Access on-line catalogs	-.01	.88
Place orders on suppliers' web sites	-.04	.64

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Total Variance Explained

Component	Eigenvalues		
	Total	% of Variance	Cumulative %
1	3.10	25.80	25.80
2	2.97	24.75	50.55

Extraction Method: Principal Component Analysis

ployed in thirty-three different industries, with manufacturing being the most commonly reported. The extent to which each industry reported was representative of the number of surveys mailed varied widely, with a low of 4 percent for paper and allied products to a high of 20 percent for both transportation equipment and measuring/analyzing instruments. The mailing resulted in no responses from those employed in the "fabricated metals" industry. Table 1 contains a summary of the respondents' demographic information and Table 3 lists the respondents' primary line of business.

Data Analysis

In order to test the first proposition that the use of less integrative e-procurement tools would be more prevalent among the sample firms than the use of integrative e-procurement tools, the data were analyzed using the Statistical Package for the Social Sciences (SPSS 13.0). When the "e-procurement tool use" scale was developed, it was believed that firms used two general types of e-procurement applications: applications that are relevant to one function/process or applications that help firms integrate across functions and/or firms. This suggested the scale would be composed of two underlying factors. Contrary to that presumption, the initial exploratory factor analysis (EFA) on the 12-item scale revealed three factors. The first factor was composed of five items with factor loadings ranging from .59 to .84. Four items comprised the second factor, with factor loadings ranging from .61 to .86. The third factor only contained two items, "we use Internet-based technologies to: access e-marketplaces" and "use the software services of an e-purchasing solution provider". The items had factor loadings of .90 and .66 respectively. Using Tabachnick and Fidell (1996) as a guide in approaching two-item factors, correlations were examined. The correlation between the aforementioned items did not exceed .7 (r = .44), nor were they relatively uncorrelated with the other items. Consequently, the items were deleted. An additional item, "we use Internet-based technologies to check suppliers' financial status," failed to load on any factor, with factor loadings of only .16, .28, and .29. According to Comrey and Lee (1992), factor loadings less than .45 are considered poor; therefore this item was also deleted.

Factor analysis was performed on the remaining nine-item scale. The rotated solution revealed two factors. The first factor was composed of five items and had factor loadings ranging from .62 to .85. Four factors comprised the second factor and had factor loadings ranging from .64 to .88 (see Table 4).

Next, an attempt was made to label the factors. The first factor, which included items such as, "we use Internet-based technologies to: achieve cross-functional coordination and collaborate with suppliers on design issues," was labeled "*integrative e-procurement tools*". The second factor, which included items such as, "we use Internet-based technologies to: search for low-cost suppliers and visit suppliers' web sites," was labeled "*basic, single-process e-procurement tools.*"

In order to determine if each of the aforementioned sets of items could be treated as distinct scales, discriminant validity was tested. Within each set, the items exhibited significant correlations (ranging from .27 to .69) and were uncorrelated across sets. This suggested that discriminant validity existed. In addition, both sets of items were found to be reliable based on the assessment of Cronbach's alpha (Cronbach 1951). Cronbach's alpha for the "basic, single-process e-procurement tools" scale was .77; it was .80 for the "integrative e-procurement tools" scale.

The next step in testing P1 was to ascertain which type of e-procurement tool use was more prevalent. To accomplish this, summated scales were developed for each set of items and t-tests were conducted to determine if significant differences existed. The data indicated that significant differences existed between the means of the "basic, single-process e-procurement tools" and the "integrative e-procurement tools" (means = 3.50 and 3.01 respectively, t = -6.77, p<.0001). Table 5 contains the data related to this analysis.

Table 5
Test for Equality of Means

Construct	N	Mean	Standard Deviation
Single-process e-procurement tools	141	3.50	.85
Integrative e-procurement tools	141	3.01	.85

Mean Difference (single-process vs. integrative)	t	df	Sig.
.49	-6.77	140	p<.0001

In order to test P2, that firm sector has an effect on the adoption of integrated e-procurement applications, it was first necessary to categorize the firms included in the study according to their e-procurement usage. Cluster analysis was selected as the appropriate method for categorization, as it is commonly used to group individual observations into clusters characterized by high homogeneity based a set of relevant characteristics (Hair et al. 2006).

Hair et al. (2006) recommend using both empirical analysis and theoretical judgment to determine the proper number of clusters in the solution. It was proposed that two groups were present in the sample collected for this study: 1) Firms that use e-procurement applications primarily for basic processes within a single function and 2) Firms that use e-procurement applications for the purpose of integration across multiple, internal functions and/or across firms. To test this proposition, we clustered observations using Ward's linkage, a hierarchical clustering method, with squared Euclidean distance as the measure of similarity. Ward's linkage was selected because it is recommended as an initial step for determining the proper number of clusters and generating cluster seeds for use in non-hierarchical methods (Johnson and Wichern, 2002). This is consistent with the combination (hierarchical/non-hierarchical) method of generating clusters recommended by Hair et al. (2006). This method begins with each of n observations as its own cluster, and in stepwise fashion, combines observations based on the similarity measure until all observations are combined into a single cluster. Each step s represents a solution of $n - s$ clusters. Results of this analysis suggested that a two-cluster solution was appropriate. The Calinski/Harabasz pseudo-F (a ratio of within cluster similarity to between cluster similarity) was used as the deciding criterion. Higher values indicate superior separation and uniqueness of clusters. The two-cluster solution had a Calinski/Harabasz pseudo-F = 32.12, the highest value within the range of theoretically feasible solutions (1 to 4 clusters).

The centroids (i.e., mean vectors) of the two-cluster solution were checked to evaluate the interpretability of the resulting clusters, and found to be consistent with our hypothesized groupings (see Table 6, panel A).

The next step in establishing clusters involved using a non-hierarchical clustering method to optimize the grouping of observations (Hair et al. 2006). We employed K-means clustering, which uses the centroids generated from the hierarchical approach as starting points, then systematically assigns observations to the cluster whose centroid is nearest (Johnson and Wichern, 2002). The method further optimizes grouping by reassigning observations, as necessary, based on updated centroids that are recalculated as observations are added to existing clusters. Application of this method resulted in our final cluster solution (see Table 6, panel B). The first cluster, labeled "Basic E-procurement Tool Users", consists of 66 firms who average moderate to high usage of basic, single-process e-procurement tools, but low usage of integrative e-procurement tools. The second cluster, labeled "Integrative E-procurement Tool Users," consists of seventy-four firms who average moderate to high usage of both basic, single-process and integrative e-procurement tools.

With validated groups in place, we were able to proceed with our ex-

Table 6
Cluster Centroids

Variable	Panel A			Panel B		
	Cluster 1 (n = 44)	Cluster2 (n=96)	Diff.	Basic Tool Users (n=66)	Integrative Tool Users (n=74)	Diff.
Search for low cost suppliers	4.00	3.45	0.55***	3.62	3.62	0.00
Visit suppliers' Web sites	4.09	3.73	0.36**	3.82	3.86	0.04
Access on-line catalogs	3.75	3.56	0.19	3.48	3.74	0.26
Place orders on Web sites	2.91	2.92	0.01	2.86	2.96	0.10
Develop integrated SC	2.77	3.58	0.81***	2.70	3.89	1.19***
Plan and schedule production	1.84	3.26	1.42***	2.08	3.47	1.39***
Collaborate with suppliers on product design	1.75	3.41	1.66***	1.89	3.77	1.88***
Achieve cross-functional coordination	2.20	3.50	1.30***	2.35	3.76	1.41***
Search for suppliers to differentiate	2.34	3.20	0.86***	2.33	3.46	1.13***

***p<0.01 **p<0.05

amination of the influence of industry on the use of basic versus integrative e-procurement tools. We began by constructing a dummy variable representing group membership (*1=Integrative Tool Users; 0=Basic Tool Users*). Next, the thirty-three industries represented in the study were collapsed into fifteen industries, using broader SIC designations. This was followed by construction of a set of fourteen dummy variables to represent the fifteen industries present in the sample (*Manufacturing* was designated as the reference group). Given the dependent variable is binary, logistic regression was selected as the method of analysis. Unlike linear regression, which evaluates the effect of marginal changes in independent variables on the *value* of the dependent variable, logistic regression evaluates the effect of marginal changes in the independent variables on the *probability* of the presence of a certain attribute, condition, or state (Gujarati 2003; Kutner, Nachtsheim & Neter 2004). Additionally, it is customary to report odds ratios in logistic regression, as opposed to regression coefficients typically reported in linear regression.[1]

Results of logistic regression of firm sector on group membership are listed in Table 7 . The model is significant, with a Likelihood Ratio Chi-Square statistic of 19.00 (p = 0.04). Results indicate that firm sector has an effect on the use of integrative e-procurement applications, with evidence of statistically significant differences between both the *petroleum* and *transportation equipment* sectors with the reference group, *manufacturing* at a significance level of 0.05. Odds ratios suggest that firms in the petroleum industry are 15 percent as likely to use integrative e-procurement applications as manufacturing firms, while firms in the transportation equipment sector are only 12.5 percent as likely to use integrative e-procurement tools as manufacturing firms.

Discussion and Conclusions

The survey data indicated that, of the nine e-procurement applications explored, responding firms were least likely to use e-procurement applications to plan and schedule production. On the other hand, the firms' most prevalent use of e-procurement was visiting suppliers' web sites. These data are reflective of the finding that firms in the sample used basic, single-process e-procurement applications to a greater extent than they used integrative e-procurement tools. This finding is consistent with previous research conducted with European firms (e.g., Cagliano et al. 2003; Frohlich and Westbrook 2002). Specifically, respondents in this study indicated that they used Internet-based technologies to search for low-cost suppliers, visit suppliers' websites, access on-line catalogs, and place orders on suppliers' websites to a greater extent than they did to develop an integrated supply chain, plan and schedule production, collaborate with suppliers on product design issues, or achieve cross-functional coordination.

The primary benefits associated with the use of these basic, single-process e-procurement applications stem from lower administrative costs and purchase prices. While reducing these costs is important, previous research indicates that using integrative e-procurement applications not only has the potential to lower costs and

Table 7
Logistic Regression Results

Dependent Variable is Group (1= Integrative Tools; 0 = Basic Tools)
Manufacturing is the reference group for Industry Dummy Variables

No. of obsv.† =	135
LR $\chi^2(10)$ =	19.00
Prob > χ^2 =	0.0402
Pseudo R^2 =	0.1019
Log likelihood =	-83.77

Independent Variable (Industry)	Odds Ratio	Std. Err.	z	p-value	95% Conf. Interval	
Chemicals	.2625	.1827203	-1.92	0.055	.0670853	1.027144
Electronics	.56	.4029888	-0.81	0.420	.1366608	2.294733
Food	.7	.4914265	-0.51	0.611	.1768163	2.771237
Measuring and Analyzing Instruments	1.05	.9734601	0.05	0.958	.1706225	6.461634
Paper	.1166667	.1441289	-1.74	0.082	.0103605	1.313751
Petroleum	.15	.122693	-2.32	**0.020****	.030189	.7453055
Primary Metals	.175	.1699264	-1.80	0.073	.0260924	1.173713
Rubber	.525	.5318306	-0.64	0.525	.0720913	3.823274
Transportation Equipment	.125	.0851731	-3.05	**0.002****	.0328787	.4752324
Wholesale	.4666667	.3248361	-1.09	0.274	.1192627	1.826034

†Five observations/industries could not be analyzed due to low representation (≤ 2 firms)
**p<0.05

increase profitability, but also to increase operational agility and contribute to superior product design (Folinas et al. 2004). It is probable that the latter outcomes will prove to be more enduring and influential with respect to *overall* supply chain performance than mere cost reductions to the buying firm alone.

Of the ten broad industries examined in this study, two exhibited significant differences with respect to their likelihood to adopt integrative e-procurement applications relative to the "manufacturing" reference group. Specifically, the data indicated that respondents whose firms operated in the petroleum and the transportation equipment industries were less likely to adopt integrative e-procurement applications than were those in the manufacturing sector.

Based on our findings, it appears that the petroleum and transportation equipment industries possess characteristics that make them less likely to use integrated e-procurement tools than their manufacturing counterparts. The petroleum sector is characterized by more vertical integration than most other industries in the sample, hence fewer external suppliers and less need for e-procurement applications that span organizations. In addition, the petroleum industry is relatively stable; therefore the potential for long-standing relationships and business practices exist between buying firms and external suppliers. In the same vein, relative to other sectors examined in the study, the petroleum industry, which is characterized by a limited number of firms, is not highly competitive. Consequently, firms operating in the petroleum sector might find little need to deviate from existing business practices, including the use of basic e-procurement applications. Furthermore, competitive pressures lead to the use of more sophisticated technologies (Ortega et al. 2006). In

the absence of these industry-level competitive pressures, it is quite possible that firms operating in the petroleum industry perceive less need to employ more sophisticated, integrative e-procurement applications.

Firms operating in the transportation equipment sector include companies that provide railroad equipment, aircrafts, and aircraft parts/supplies. As with the firms operating in the petroleum industry, these types of firms also face relatively low levels of competition, thus they possess less need for more sophisticated, integrative forms of e-procurement. In addition, Cagliano et al. (2005) noted that certain sectors, including the automotive industry (which encompasses the transportation equipment sector) had adopted and invested substantial resources in EDI and other proprietary infrastructures prior to the popularization of e-procurement. This might explain why the respondents whose firms operate in the transportation equipment industry are less likely to adopt more integrative (and more resource dependent) types of e-procurement.

It is possible that the use of basic, single-process e-procurement applications is more prevalent in the sample overall than the use of integrative tools because the former are easily employed, require minimal financial investment, and involve little risk. Visiting suppliers' web sites, accessing on-line catalogs, placing orders on suppliers' web sites, and searching for low-cost suppliers are all simple tools firms can use to get started with e-procurement. Conversely, achieving inter- or intra-firm integration is more complicated and risky. For example, firms looking to collaborate with suppliers on design issues face a number of challenges and risks, including uncertainty about the supplier's capabilities, sharing proprietary information, and issues surrounding intellectual property. Achieving cross-functional coordination may be challenging because it requires individuals from various departments within a single firm, with diverse perspectives to work toward a common end. Finally, developing an integrated supply chain is the most challenging because it involves multiple firms. A fully integrated supply chain is characterized by extensive sharing of information and high levels of trust (Folinas et al. 2004), which in many instances is not easily attainable, particularly when multiple suppliers and multiple customers are involved. Each of the aforementioned integrative activities is complex, even when executed by "traditional" means. When considering the use of Internet-based technologies to accomplish these activities, firms face additional challenges that may cause reluctance. These additional challenges include training of employees, incurring costs to implement e-procurement applications, willingness of trading partners to invest in technology, and security issues related to the electronic transfer of data.

"...the petroleum and transportation equipment industries possess characteristics that make them less likely to use integrated e-procurement tools than their manufacturing counterparts."

Future Research

The scope of the research is limited in that no attempt was made to examine the relationship between the use of the various e-procurement applications and business outcomes. Future research could examine the relationship between the use of integrative e-procurement applications and business outcomes such as increased communication, operational agility, improved product/service design, and overall supply chain performance. In addition, our understanding of e-procurement use could be further enhanced by the assessment of firms' motivations for adopting particular e-procurement applications over others. In other words, *why* do firms adopt certain e-procurement applications? Further, no attempt was made to assess whether firms that currently use basic, single-process e-procurement applications have plans to adopt more integrative e-procurement tools in the future. This would be helpful in assessing the rate of adoption across industries. Finally, this exploratory study relies on speculation with respect to the impact of firm sector on e-procurement use. The role of firm sector could be further examined by asking respondents to what extent industry characteristics such as competitiveness, need for efficiency, and overall technology acceptance impact e-procurement use.

Academicians and practitioners alike express great interest in the value of Internet-based technologies in improving supply chain performance. In addition, an extensive research stream regarding the essential role of inter- and intra-firm integration in effective supply chain management exists. Nevertheless, investigation of the use of Internet-based technologies to achieve supply chain integration has been primarily limited to the study of European firms. Further, previous studies on e-business resulted in classification schemes founded on a conceptual basis or on evidence from case studies. While this study is exploratory, it provides valuable, preliminary empirical data to support the notion that e-procurement tools can be categorized by their ability to facilitate supply chain integration and contributes to the literature by examining the actual e-procurement practices of US-based firms across a wide variety of industries.

Notes

1. The odds ratio is a ratio of the probability of the presence of an attribute to the probability of its absence.

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