

Supply chain practice and information quality: A supply chain strategy study



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ABSTRACT

There is a wide acceptance of the strategic importance of integrating up-to-date information technology with effective supply chain practice. However, little is known about how the alignment between information technology and supply chain practice impacts business performance. This paper investigates two supply chain practices (i.e. sourcing practice and delivery practice) and information quality. Scales measuring sourcing practice, delivery practice, and information quality were developed. Four strategic clusters of companies, using alternative supply chain strategies, are identified. In three of the strategic clusters, the level of supply chain practice is consistent with the level of information quality. The fourth strategic cluster has a high level of information quality but a low level of effective supply chain practices. In this study, the fourth strategic cluster performed consistently worse than the other three strategic clusters. The performance measures consist of sales revenue and profitability. This study shows that firms need to align supply chain practice with the level of their information quality in order to achieve good overall business performance. Implications of our findings and future research opportunities are addressed.

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1. Introduction

Effective supply chain practices and integrated information technology (IT) are two approaches to improve business performance. It is important to integrate supply chain practices with information technology decisions in operations/supply chain management. As an example, Dell Computer positioned itself to take advantage of the Internet to build information partnerships, both with their suppliers and customers. Covisint was another good example of leveraging information technology in supply chain management. As an electronic marketplace for the auto industry, Covisint provided on-line purchasing services and promoted supply chain collaboration between major direct suppliers and automakers.

In this study, we consider two types of supply chain practices: sourcing practice and delivery practice. A company is considered to have effective supply chain practice if selected best practices are used. By using sourcing practices and delivery practices, both the incoming and outgoing portions of the supply chain are represented. As for information technology, this study measures information quality. *The question facing companies is how the alignment*

between information quality and effective supply chain practice impacts firm performance.

In the literature, few supply chain strategy studies have empirically analyzed the integration of information technology with supply chain practices in supply chain management (Fisher, 1997; Frohlich and Westbrook, 2001; Towill and Christopher, 2002; Harrison and New, 2002; Vickery et al., 2003; Millet et al., 2009; Li, 2012; Ulmer et al., 2013). Supply chain strategies are usually dichotomized into two groups: lean/efficient supply chain strategy versus agile/responsive supply chain strategy (Fisher, 1997; Towill and Christopher, 2002). However, recent business environment development requires firms to be not only “lean” but also “agile”. Firms are interested in knowing whether they can be responsive while still being efficient. The previous studies have never explored such a supply chain strategy that is both lean and agile. A recent study (Ward and Zhou, 2006) addressed the importance of balancing the Just-in-time production practices and information technology. However, no study has used supply chain practices and the information technology to characterize supply chain strategy. Therefore, the purpose of this study is to (1) cluster alternative supply chain strategies on the basis of supply chain practices and information quality, and (2) to identify which alternative supply chain strategies are consistent with good business performance.

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In this study, sourcing practice, delivery practice, and information quality are used to cluster a sample of 125 North America manufacturing firms into four strategic clusters. Each cluster represents a specific supply chain strategy. The business performance of the four strategic clusters is compared to identify the most desirable supply chain strategy.

In the next section, the literature on sourcing practice, delivery practice, information quality, and business performance will be reviewed. Based on the literature review, the research hypotheses are generated. The research methodology and scale development are presented in [Section 3](#). [Section 4](#) contains a discussion of the analysis results and provides the managerial implications of the findings. [Section 5](#) concludes the study and suggests future research possibilities.

2. Literature review and research hypotheses

In this section, we review the literature in sourcing practice, delivery practice, information quality, and business performance. A summary of the literature is in [Appendix A](#). Based on the literature review, the research hypotheses are developed. The survey questions are listed in [Appendix B](#).

2.1. Sourcing practice

Sourcing practice connects manufacturers with suppliers and is critical for manufacturing firms, because manufacturing firms often spend a significant portion of its revenue on purchasing materials and services ([Benton, 2006](#)). The extant literature shows that sourcing practice has a significant impact on business performance ([Benton, 2006](#); [Watts et al., 1992](#); [Narasimhan and Das, 2001](#)).

In the sourcing literature, several sourcing practices have been identified as best practices. First, it is important to have a designated purchasing team ([Ellram and Pearson, 1993](#); [Trent and Monczka, 1994](#); [Johnson et al., 2002](#)). Such cross functional teams facilitate the timely completion of purchasing activities. The purchasing team organizes the necessary resources to achieve specific company objectives.

Second, establishing long-term supplier–buyer relationship and reducing the supplier base are good sourcing practices. The role of key suppliers in a supply chain should be assured through long term relationship ([Benton, 2006](#); [Li et al., 2005](#)). [Hahn et al. \(1983\)](#) showed that companies' benefits gained by giving larger volume of business to fewer suppliers using long-term contracts outweigh the costs. By reducing the supplier base, economies of scale based on order quantity can be realized. Moreover, it is less costly to manage a smaller supplier base than a larger supplier base in terms of account management and other managements costs ([Treleven, 1987](#)). Therefore, reducing the supplier base is a good sourcing practice. Another benefit of long term supplier–buyer relationships is early supplier involvement in product development. According to [Kamath and Liker \(1994\)](#) and [Womack et al. \(1990\)](#), Toyota's first tier suppliers are involved in Toyota's new product development, which reduce the length of the product development cycle. [Hartley et al. \(1997\)](#) found a significant relationship between the supplier's involvement in product development and overall product development delays. They showed that in order to reduce product development delay, the suppliers should be involved early in the design process.

Third, Just-In-Time (JIT) delivery from suppliers is considered a good sourcing practice. The benefits of JIT delivery are widely documented ([Dong et al., 2001](#); [Benton, 2006](#)). As an example, [Dong et al. \(2001\)](#) found that JIT purchasing directly reduced the buyer's logistic costs. Elements of JIT purchasing are found in

various studies ([Hahn et al., 1983](#); [Schonberger and Ansari, 1984](#)). Typically, JIT purchasing reduces order size, reduces lead-time, and improves product quality.

Fourth, doing suppliers' performance evaluations and providing feedback is a good sourcing practice. [Carr and Pearson \(1999\)](#) tested the relationship among the supplier evaluation system, supplier–buyer relationship, and firm financial performance. According to the authors, supplier evaluation systems have a direct positive impact on buyer–supplier relationship, and an indirect impact on firm financial performance. More recently, [Prahinski and Benton \(2004\)](#) studied the role of communication in supply chain management. They found that executives at buying firms need to incorporate indirect influence strategy, formality and feedback into supplier development programs.

The literature review for sourcing has established the importance of following sourcing practices: (1) a designated purchasing team; (2) long-term supplier–buyer relationships and a reduced supplier base; (3) JIT delivery; and (4) suppliers' performance evaluation and feedback.

2.2. Delivery practice

The delivery process starts with order inquiry processing and finishes with customer invoicing. It includes processing inquiries, entering orders, consolidating orders, routing shipments, selecting carriers, transporting products, and so on.

The extant literature and anecdotal evidence show that a good delivery system has a significant positive impact on a firm's overall business performance. According to [Johnson and Davis \(1998\)](#), poor ordering processes cost Hewlett Packard a million dollars a day. Whereas, the cross docking technique used by Wal-Mart, using its warehouse as a switching station rather than a stocking place, reduced inventory carrying costs and the number of docking spaces ([Stalk et al., 1992](#)). [Gurin \(2000\)](#) described how Ford partnered with UPS to develop and implement an Internet-based delivery process, significantly improving Ford's delivery performance. [Ahmad and Schroeder \(2001\)](#) identified several factors that affect delivery performance. The factors include just-in-time management, quality management, production instability, and so on.

Best delivery practices include direct delivery, cross docking, JIT delivery, outsourcing of logistics services, and so on. [Goldsby and Stank \(2000\)](#) reviewed the world class logistics competencies and capabilities. One capability is sharing information with supply chain partners, which increases the real time visibility of order tracking. Agility is also an important competence of world class logistics. In this study, JIT delivery is used to measure the agility of a supply chain. Dell computer uses JIT delivery. The majority of Dell's suppliers are located within 15 min of a Dell assembly facility. Airborne Express or UPS serves as Dell's logistics department and has resulted in improved responsiveness and higher customer satisfaction. Other best delivery practices identified by the Supply Chain Operational Reference (SCOR) model ([Supply Chain Council, 2010](#)) include a single contact point for all order inquiries, order consolidation, and the use of automatic identification. The bar code technology significantly improves the relationship between suppliers and buyers and allows some emerging inventory management programs such as vendor managed inventory program.

2.3. Information quality

Information quality measures the degree to which the information exchanged between organizations meets the needs of the organizations ([Petersen, 1999](#)). A number of researchers have identified important characteristics of information quality. [Tushman and](#)

Nadler (1978) defined information as accurate, timely, and concise data. DeLone and McLean (1992) and Seddon (1997) suggested that information relevance, timeliness, and accuracy are concerns of an effective information system. McCormack (1998) measured information by accuracy, frequency, credibility, and availability of forecast. Petersen (1999) measured information quality by currency, accuracy, and completeness. Chopra and Meindl (2012) suggested that information shared among supply chain partners must be accurate, accessible in a timely manner and correct. Li et al. (2005) measured information quality by timeliness, accuracy, completeness, adequacy, and reliability.

Information quality is an important determinant of the usefulness of the information system. McGowan (1998) argued that only when the information is high quality, readily accessible, accurate and relevant, would the information system be perceived useful. Sum et al. (1995) found that data accuracy is critical in affecting operating efficiency and customer service. This study measures information quality on nine aspects: accuracy, availability, timeliness, internal connectivity, external connectivity, completeness, relevance, accessibility, and information update frequency.

2.4. Business performance

Performance measures have been linked to strategies in numerous extant studies. Ward and Duray (2000) tested the impact of manufacturing strategy and business strategy on performance measures such as sales growth. Miller and Roth (1994) used annual sales revenue and net profit as performance measures. This study measures business performance by sale revenue and profitability. The profitability is measured by return on sales.

Performance data can be categorized as perceptual data (e.g. business performance relative to competitors) versus objective data (absolute operating profit margin). This study chooses to use performance relative to competitors as previous studies did (Ward et al., 1994; Boyer et al., 1997; Prahinski and Benton, 2004), because relative measures diminish the industry effect as respondents compare their firm's performance to their competitors in the same industry.

2.5. The theoretical background and research hypotheses

Given the increasing evidence that effective supply chain practice and up-to-date information technology lead to improved business performance (Frohlich and Westbrook, 2001; Vickery et al., 2003), it is important for a firm to develop an appropriate supply chain strategy that aligns effective supply chain practices with information quality. Several organizational theories support the argument that aligning effective supply chain practices with information quality is crucial for business success (Williamson, 1975; March, 1991; Barney, 1991). First, transaction cost theory suggests that collaborations among supply chain partners are limited by the transaction costs of managing the collaborations (Williamson, 1975). As firms increase the information quality, several transaction costs such as information gathering, negotiation, and monitoring cost can be reduced. Therefore, having better information quality can motivate firms to implement effective supply chain practices. Furthermore, by sharing more information among supply chain partners, firms can develop a higher level of trust, which is a key driver to motivate supply chain collaboration.

Second, organizational learning theory supports the importance of balancing effective supply chain practices with information quality (Kiesler and Sproull, 1982; Weick and Westley, 1996). The quality of information is an indicator of companies' ability to assimilate information from external and internal supply chain environment, which acts as an exploration role. Meanwhile, supply chain practices are the means to routinize processes, which act as an exploitation role. As March (1991) argued, it is critical for

a firm to balance its exploration activities and exploitation activities in order to achieve superior business performance.

Third, from the resource based view perspective (Barney, 1991), aligning effective supply chain practices with information quality can link the supply chain processes across firm boundaries and thus create sustainable competitive advantages for firms. As Porter (1996) argued, linked activities and processes in the supply chain are hard for competitors to imitate while isolated activities are easier to duplicate. Integration among supply chain partners occurs at two levels: strategic level and operational level. At operational level, effective supply chain practice and information sharing help firms to achieve higher level of operational efficiency such as reduced lead time and reduced total cost. However, operational efficiency is necessary but not sufficient for a good supply chain strategy (Porter, 1996). At the strategic level, firms need to think about how other supply chain members should involve in their supply chain activities and how much information they should share with other supply chain members.

2.5.1. Supply chain strategy framework and configuration approach

In the supply chain strategy literature, several conceptual studies and empirical studies have proposed supply chain strategy frameworks. Fisher (1997) pointed out that supply chain strategy should depend on the product type. An efficient supply chain is desirable for functional product while a responsive supply chain is preferred for innovative product. Towill and Christopher (2002) prescribed two similar supply chain strategies, named "lean" supply chain strategy versus "agile" supply chain strategy. Frohlich and Westbrook (2001) characterized supply chain strategies by the different "arc of integration" on both supplier side and customer side. Their study suggested five supply chain strategies: inward-facing, periphery-facing, supplier-facing, customer-facing, and outward-facing. However, Frohlich and Westbrook (2001) did not address the importance of the alignment between effective supply chain practice and information technology. Vickery et al. (2003) considered the influence of integrative supply chain practices and information technology on customer service and financial performance by using a structural equation model. Their study did not categorize firms' supply chain strategy according to integrative supply chain practice and integrative information technology.

Configuration approach has been used in many operations strategy and supply chain strategy studies (Ward et al., 1996; Flynn et al., 2010). Configuration theory (Miller, 1986) is a useful tool to handle the alignment of several variables. Venkatraman (1989) describes the way of checking the alignment of more than one variables as "fit as gestalts" (p. 432). In this study, we use clustering analysis to empirically categorize 125 North America manufacturing firms into four groups (i.e. gestalts) according to supply chain practices and information quality. In addition, this study examines the impact of the alignment between supply chain practices and information quality on business performance. To our best knowledge, this is the first empirical study that proposes supply chain strategy framework based on the alignment between effective supply chain practice and information quality.

As shown in Fig. 1, this study classifies supply chain strategies into four strategic clusters based on the alignment between the level of effective supply chain practice and the level of information quality. As suggested by previous literature (March, 1991; Rondeau et al., 2000), effective supply chain practice is a means to standardize and exploit the efficiency of supply chain processes. Thus, strategy 2 in Fig. 1 is similar to the "lean" supply chain strategy in Towill and Christopher (2002). Meanwhile, the quality of information is an indicator of firms' ability to explore and absorb the dynamics in business environment and make firms

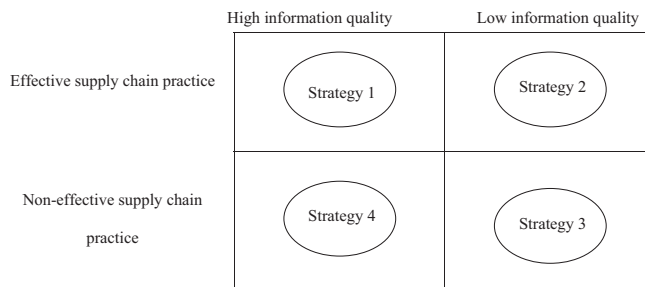


Fig. 1. Hypothesized four supply chain strategy clusters.

more responsive. Thus, the strategy 4 in Fig. 1 is similar to the “agile” supply chain strategy in Towill and Christopher (2002). Strategy 1 in Fig. 1 suggests that the firms are not only “lean” but also “agile”. This supply chain strategy has not been identified in previous studies (Frohlich and Westbrook, 2001; Towill and Christopher, 2002; Harrison and New, 2002). Strategy 3 in Fig. 1 suggests that the firms are neither “lean” nor “agile”, which has not been addressed in previous studies either. The formal research hypothesis is as follows.

Hypothesis 1. *There exist four different supply chain strategies as shown in Fig. 1. Firms using strategy 1 have both effective supply chain practice and high information quality. Firms using strategy 2 have effective supply chain practice and low information quality. Firms using strategy 3 have no effective supply chain practice and have low information quality. Firms using strategy 4 have no effective supply chain practice but have high information quality.*

2.5.2. Supply chain strategies and business performance

Using the four alternative supply chain strategy clusters in Fig. 1, business performance associated with each strategy will be investigated. Numerous studies have suggested that effective supply chain practice and high information quality will lead to improved business performance (Vickery et al., 2003; Supply Chain Council, 2002; Frohlich and Westbrook, 2001; Zhou and Benton, 2007). Furthermore, studies show that effective supply chain practice and high information quality complement each other in supply chain management. For example, high quality information provides accurate and timely information that an effective supply chain practice such as JIT delivery requires. As H5a in Zhou and Benton (2007) states, “increases in the information quality improve delivery performance”. On the other hand, an effective supply chain practice can provide high quality information that supports the supply chain. Automatic identification techniques that track order status are good examples.

Shaw (2000) explored the impact of emerging manufacturing technologies on supply chain activities and supply chain structures. It investigated manufacturing technologies that are driven by information systems, such as EDI and ERP software. They found that those web-based emerging manufacturing technologies make the information transmission among the supply chain partners much easier and many have a big influence on supply chain processes. Verstraaten (2000) suggested that the implementation of online purchasing can reduce costs by 80%. Frohlich and Westbrook (2001) provided the evidence that information integration with suppliers and customers has positive influence on performance improvement. Spring and Sweeting (2002) synthesized the themes in supply chain management, information and customer relationships. It showed that the use of ERP profoundly changes the supply chain relationships. Vickery et al. (2003) showed the positive influence that information technology and supply chain integration have on customer service and financial performance.

The literature review suggests that (1) firms that have a high level of either effective supply chain practice or information quality perform better than those firms having neither effective supply chain practice nor high information quality, and (2) firms that have a high level of effective supply chain practice and high information quality perform better than those firms having either effective supply chain practice or high information quality. Therefore, we propose the following hypotheses.

Hypothesis 2(a). *Firms using either strategy 2 or 4 in Fig. 1 have superior business performance compared to those firms using strategy 3.*

Hypothesis 2(b). *Firms with strategy 1 in Fig. 1 have superior business performance compared to those firms using strategy 2 or strategy 4.*

3. Research methods and scale development

3.1. The survey

The survey used for this study is the same as the one used for Zhou and Benton (2007). The survey involves two data collection stages: pilot survey and large-scale survey. The pilot survey is designed to test the viability of the study and purify the data collection instrument. Four academic researchers and three industry experts were asked to critique the research instrument in order to ensure the relevance and clarity of the research instrument. The questionnaire for the large-scale study was developed based on the pilot study feedback. There were minor changes made to the large-scale study. A total of 745 surveys were mailed. 125 useable responses were received. The response rate was approximately 18%. The data analysis is based on the 125 useable responses, which were from 125 different companies.

3.2. The sample

The respondents were senior executives and held titles such as CEO, President, Vice President, Director, and so on. The average number of employees in the respondents' firms was about 5000. Eight companies had more than 10,000 employees. The median annual sales value, as reported by the respondents, was between \$100 million and \$500 million dollars. Five companies had annual sales of more than \$5 billion.

To minimize the non-response bias, multiple contacts were utilized in order to maximize response rate (Dillman, 2000). After the responses were received, the responses of those who returned early were compared with those who returned late to determine if there are any statistical differences (Lessler and Kalsbeek, 1992). There were no statistical differences between the early and late responses.

3.3. Measurement scales

The survey questions and the descriptive statistics for each measurement scale are in Appendix B. This section first describes the process and multiple criteria that are used to validate the measurement scales. Then, the results of the measurement scale analysis are presented.

3.3.1. Scale validity

The measurement scale development process supports the validity of the measurement scales. The content validity of the scales was established by the literature. In addition, both academic and practitioner experts assessed the survey questionnaire content validity before the surveys were conducted. Construct validity

ensures that the conceptual constructs are operationalized in the appropriate way. In order to ensure the construct validity, factor analysis is used. According to [Carmines and Zeller \(1979\)](#), the factor loadings need to be at least 0.3. Only one factor in each construct can have an eigenvalue that is larger than 1 and the variance explained by the first factor in each construct is at least 40%. The results of measurement scales analysis are shown in [Table 1](#). All factor loadings meet the criterion of larger than 0.3. The factor analysis results from [Table 1](#) also show that all constructs satisfy the unidimensionality requirement. For all scales except “Delivery Practice”, only one eigenvalue is larger than 1.00 and the variance explained by the largest eigenvalue is larger than 40%. For the construct “Delivery Practice”, the second largest eigenvalue is slightly larger than 1.00. The largest eigenvalue explains more than 40% of the variance of that construct. The scree test also suggests that one factor is the most appropriate for this set of measurement items. Therefore, “Delivery Practice” is determined to be unidimensional. However, the factor analysis of the 11 supply chain practices measurement items does not satisfy the unidimensionality requirement. The largest five eigenvalues are 4.21, 1.37, 1.14, 1.04, and 0.73. Therefore, this study does not combine sourcing practice and delivery practice into one latent variable when confirmatory factor analysis (CFA) was conducted below.

CFA was used to test convergent and discriminant validity ([O’Leary-Kelly and Vokurka, 1998](#)). In the convergent validity test, each item was linked to its corresponding construct and the covariance among the constructs was freely estimated. The model fit indices ($\chi^2=317.69$, d.f.=167, RMSEA=0.080, NNFI=0.93, CFI=0.94) indicated that the model was acceptable ([Hu and Bentler, 1999](#)). In addition, all factor loadings had *t*-values greater than 2.0, and all factor loadings were higher than 0.50, which confirmed the convergent validity of the scale ([Chau, 1997](#)). For discriminant validity testing, we built a constrained CFA model for each possible pair of latent constructs, in which the correlation between the paired constructs was fixed to 1.0 ([O’Leary-Kelly and Vokurka, 1998](#)). The results were compared with those of the original unconstrained model, in which the correlations were freely estimated. A significant difference in the chi-square statistics between the fixed and unconstrained models indicates high discriminant validity ([Bagozzi et al., 1991](#); [Chen and Paulraj, 2004](#)). In this study, all chi-square differences were found to be larger

than 5, which were all significant at the 0.05 level. Therefore, discriminant validity was achieved.

3.3.2. Scale reliability

Reliability is defined as the extent to which the measures can yield same results on other replication studies ([Carmines and Zeller, 1979](#); [Hair et al., 1998](#)). The internal consistency method is used to measure the construct reliability in this study. Internal consistency in this study is measured by Cronbach’s alpha. The lower limit of 0.7 is considered acceptable for established scales ([Nunnally, 1994](#)). [Table 1](#) shows that all scales have Cronbach’s alpha values of 0.7 or higher. Therefore, all three constructs are determined to be reliable.

4. Analysis results and implications

4.1. Supply chain strategy clustering analysis

In order to perform further analysis, we first imputed the missing data for the 20 measurement items (i.e. nine information quality items, six sourcing items, and five delivery items) that we used to conduct clustering analysis. Among these 20 measurement items, 35 data values were missing across 10 firms. The mean of each item was used to replace the missing data. Then, we took the average of the nine items in information quality scale to create a composite score for information quality and took the average of 11 items in sourcing and delivery scales to create a composite for

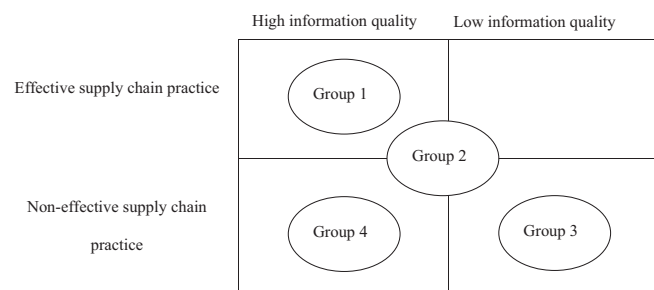


Fig. 2. Four company clusters from clustering analysis.

Table 1
Final results of measurement validation.

Scale name	Variable name	Factor loading	Scale statistics
Sourcing practice	VIA1	0.54	Cronbach's alpha: 0.77 Largest eigenvalue (variance explained): 2.87 (48%) Second largest eigenvalue (variance explained): 0.86 (14%)
	VIA2	0.59	
	VIA3	0.59	
	VIA4	0.65	
	VIA5	0.85	
	VIA6	0.86	
Delivery practice	VIB1	0.58	Cronbach's alpha: 0.74 Largest eigenvalue (variance explained): 2.45 (49%) Second largest eigenvalue (variance explained): 1.04 (21%)
	VIB2	0.67	
	VIB3	0.81	
	VIB4	0.74	
	VIB5	0.68	
Information quality	VIC1	0.72	Cronbach's alpha: 0.89 Largest eigenvalue (variance explained): 4.987 (55%) Second largest eigenvalue (variance explained): 0.991 (11%)
	VIC2	0.82	
	VIC3	0.76	
	VIC4	0.64	
	VIC5	0.56	
	VIC6	0.80	
	VIC7	0.84	
	VIC8	0.70	
	VIC9	0.79	

Table 2
Characteristics of the four groups of companies.

Group	Number	Information quality	Supply chain practice
1 (Effective supply chain practice, high information quality)	51	5.93 (2, 3, 4)	5.54 (2, 3, 4)
2 (medium level of effective supply chain practice, medium information quality)	42	4.72 (1, 3, 4)	4.55 (1, 3, 4)
3 (non-effective supply chain practice, low information quality)	10	3.04 (1, 2, 4)	2.90 (1, 2)
4 (non-effective supply chain practice, high information quality)	22	5.50 (1, 2, 3)	3.10 (1, 2)
<i>F</i> -statistic (<i>P</i> value)		97.904 (<i>P</i> < 0.001)	113.742 (<i>P</i> < 0.001)

Numbers in the parentheses indicate the group numbers from which his group was significant at 5% level according to Tamhane's comparison procedure.

supply chain practice. Then, we used the two composite scores for supply chain practice and information quality as the independent variables to cluster the companies into four strategic clusters as hypothesized in Fig. 1. The initial clustering centers are the centers of the four quadrants in Fig. 2. The clustering results are shown in Fig. 2 and Table 2.

As hypothesized, Fig. 2 shows one strategic cluster with both high information quality and effective supply chain practice, one strategic cluster with low information quality and no effective supply chain practice, and another strategic cluster with high information quality and no effective supply chain practice. However, Fig. 2 does not represent the strategic cluster with low information quality and effective supply chain practice as hypothesized in Fig. 1. Instead, Fig. 2 shows a cluster (i.e. cluster 2) with medium information quality and medium level of effective supply chain practice. Therefore, Hypothesis 1 is only partially confirmed. As shown in Fig. 2, three supply chain strategies (clusters 1, 2, and 3) align the level of effective supply chain practice with the level of information quality while one supply chain strategy (cluster 4) has a high level of information quality but low level of effective supply chain practice.

Table 2 shows the number of companies in each group and the mean score of each independent variable for each group. 51 companies have high scores on both effective supply chain practice and high information quality. 42 companies have medium scores on both effective supply chain practice and information quality. 10 companies have low scores on both effective supply chain practice and information quality. 22 companies have a high score on information quality but low scores on effective supply chain practice.

After clustering the companies into four strategic clusters, a one-way ANOVA was conducted to assess the differences among the four groups. Then, a Tamhane's pairwise comparison test was performed to test the pairwise differences of the variables in the four clusters. The results are presented in Table 2. The *F*-statistics are significant at $p < 0.001$ level for both information quality and supply chain practice variables. The numbers in the parentheses indicate the cluster numbers from which that cluster is significantly different from at 5% level according to Tamhane's pairwise comparison test. For example, (2, 3, 4) at the intersect of group 1 and information quality means that the information quality of group 1 is significantly different from group 2, 3, and 4 according to Tamhane's pairwise comparison test.

Two checks were performed to help ensure that the clustering result in Fig. 2 is appropriate. First, we used the *K*-mean clustering analysis again with different *K* values. When we tried $K = 3, 5, 6$, all results had one cluster that had no effective supply chain practice but high information quality. Except for that strategic cluster, all

Table 3
Classification results for discriminant analysis for four groups of companies.

Group	No. of cases	Predicted group membership			
		Group 1	Group 2	Group 3	Group 4
1	51	50	1	0	0
2	42	0	42	0	0
3	10	0	0	10	0
4	22	0	0	0	22

other strategic clusters aligned the level of effective supply chain practice with the level of information quality. No analysis ($K = 3, 5$, or 6) identifies any strategic cluster with effective supply chain practice but low information quality.

Second, a discriminant analysis was run. Information quality and supply chain practice were entered as independent variables along with the membership from Table 2 (cluster 1, 2, 3, and 4) as the dependent variable. In the discriminant analysis, we predicted the membership of a company by the discriminant function drawn from all other companies (except that particular company). For example, when we predicted the membership of company X, we use the discriminant function drawn from all other 124 companies except company X. In this way, the discriminant function has much larger predictive power. The results in Table 3 show that only one company among the 125 companies was misclassified, i.e. 99.2% of the cross-validated grouped cases were correctly classified.

The results from the clustering analysis contribute to the literature by providing a supply chain strategy framework that enriches the existing supply chain strategy frameworks (Fisher, 1997; Frohlich and Westbrook, 2001; Towill and Christopher, 2002; Harrison and New, 2002). This marks the first empirical study that has used the alignment between supply chain practice and information quality to classify supply chain strategies. In addition to the classical two supply chain strategies (lean/efficient supply chain versus agile/responsive supply chain), this study suggests a strategic cluster that has both effective supply chain practices and high information quality, which can make firms both efficient and responsive. The large number of companies in this category suggests that being either lean or agile is not sufficient for many firms. Firms need to be efficient as well as responsive. Therefore, the characteristics of this strategic cluster deserve more attention from academics. Also it is interesting to find that there is no cluster that has low information quality and effective supply chain practice.

4.2. Supply chain strategy and business performance

After clustering the companies, we compared the business performance of the four strategic cluster groups. The results are in Table 4. The one-way ANOVA test results show that the sales revenues are significantly different among the four strategic clusters. Looking further into the mean of the four clusters in sales revenue, we noticed that cluster 2 and cluster 4 have significantly lower sales revenue than cluster 1 and strategic cluster 3. For the return on sales measure, the ANOVA test did not show significant difference. The descriptive statistics in Table 4 show that cluster 4 did have a lower return on sales than all other three strategic clusters. Therefore, Hypothesis 2(b) is confirmed while Hypothesis 2(a) is not confirmed.

The results provide several insights about the relationship between supply chain strategy and business performance. First, it is shown that for both sales and return on sales, firms that align the level of effective supply chain practice with the level of information quality (clusters 1, 2, and 3) perform better than the firms with high information quality but no effective supply chain practice (cluster 4). It is interesting to notice that firms with medium level of effective supply chain practice and medium information quality perform worse than the firms with either high level of effective supply chain practice and high information quality or low level of effective supply chain practice and low information quality. As can be seen in Table 4, cluster 3 has significantly higher sales revenue than cluster 2 while keeping a high return on sales. This suggests that some other variables might affect whether firms should have effective supply chain practice and high information quality. What is important to firm

performance is the alignment between supply chain practices and information quality, not necessarily high or low information quality and/or effective supply chain practice.

Second, this study provides the evidence that good information quality alone is not enough to improve business performance. Firms need to align effective supply chain practices with information quality. Otherwise, high information quality is not likely to pay off. While it is relatively easier for companies to buy a suite of IT solutions for improving information quality, it is difficult for companies to change their supply chain processes to leverage the benefits of IT solutions. In a Supply Chain Council study (2002), an Intel manager stated, “The biggest challenge is changing the process, not changing the technology”.

Third, this study shows that firms do not have to tradeoff different business performance metrics, because the supply chain strategy that performs well on the sales dimension also performs well on the profitability dimension. In the literature, there are two major opinions about the relationship among different performance dimensions. One research stream argues for the tradeoff model, i.e. companies have to sacrifice certain performance dimensions in order to improve other performance dimensions (Skinner, 1974; Hayes and Wheelwright, 1984). The other research stream argues for the sand cone model, i.e. firms may be able to improve certain performance dimensions without sacrificing other performance dimensions (Roth and Miller, 1992; Noble, 1995). Although the literature focuses on operational performance such as quality and cost, the same concept applies to business performance. Some firms believe that obtaining a higher level of sales revenue might require sacrificing overall profitability. The finding in this study suggests more evidence for the sand cone model in the supply chain environment. Aligning effective supply chain practice and good information quality seems to improve business performance on different dimensions simultaneously.

Table 4

ANOVA results for performance measures by four groups of companies.

Performance	Group 1	Group 2	Group 3	Group 4	F-statistic	P value
Sales revenue	4.96	4.14	5.11	3.88	4.222	0.007
Return on sales	4.64	4.29	4.78	4.13	1.019	0.388

Table 5

Two way ANOVA results.

Dependent variable	Main effect	F-statistic	P value
Information quality	anova2info	135.135	0.000
	anova2prac	9.230	0.003
Supply chain practice	anova2info	0.066	0.798
	anova2prac	162.844	0.000

Table 6

Characteristics of the four groups of companies (after deleting missing data).

Group	Number	Information quality	Supply chain practice
1 (Effective supply chain practice, high information quality)	47	5.94 (2, 3, 4)	5.56 (2, 3, 4)
2 (medium level of effective supply chain practice, medium information quality)	40	4.71 (1, 3, 4)	4.55 (1, 3, 4)
3 (non-effective supply chain practice, low information quality)	8	2.81 (1, 2, 4)	2.88 (1, 2)
4 (non-effective supply chain practice, high information quality)	20	5.38 (1, 2, 3)	3.05 (1, 2)
F-statistic (P value)		90.731 (P < 0.001)	101.459 (P < 0.001)

Numbers in the parentheses indicate the group numbers from which his group was significant at 5% level according to Tamhane's comparison procedure.

4.3. Discussion

To reveal further insights and test the robustness of the findings, we conducted further analysis. First, a two way ANOVA analysis was conducted. The results are in Table 5. We sorted the information quality composite scores from low to high and then assigned value 0 to the lower 50% scores and value 1 to higher 50% scores. We named this categorical variable as “anova2info”. Similarly, we sorted the supply chain practice composite scores from low to high and then assigned value 0 to the lower 50% scores and value 1 to higher 50% scores. We named this categorical variable as “anova2prac”. The two way ANOVA used the two categorical variables (i.e. anova2info and anova2prac) as independent variables and used the information quality composite score and supply chain practice composite score as dependent variables. The results

show that when information quality composite score is the dependent variable, both main effects are significant at 0.05 levels. When supply chain practice composite score is the dependent variable, only main effect of anova2prace is significant at 0.05.

Second, we deleted the 10 firms which had missing data values in twenty measurement items (i.e. nine information quality items, six sourcing items, and five delivery items) that we used to conduct clustering analysis and then repeated the following analysis. The results are in Tables 6 and 7. The results in Table 6 are similar to the results in Table 2, except that each group has a fewer cases. Among the four groups in Table 6, three groups (groups 1, 2, and 3) align the level of information quality with the level of effective supply chain practice. Similarly, group 4 has high information quality and low effective supply chain practice. The results in Table 7 are similar to the results in Table 4, i.e. group 4 has lower sale revenue and return on sales than all other three groups.

Third, instead of using simple average, we used the factor loading scores in Table 1 to calculate the composite scores for information quality and supply chain practice, and then conducted further analysis. The results are in Tables 8 and 9. The results in Table 8 are similar to the results in Table 2. Among the four groups in Table 8, three groups (groups 1, 2, and 3) align the level of information quality with the level of effective supply chain practice. Similarly, group 4 has high information quality and low effective supply chain practice. The results in Table 9 are similar to the results in Table 4, i.e. group 4 has lower sale revenue and return on sales than all other three groups.

4.4. Managerial implications

Executives in pursuit of improved business performance often choose effective supply chain practice and/or good information systems as a means to the end. Our research provides two significant managerial insights about the role of effective supply chain practices and good information systems in improving business performance.

First, the most important message of this study is that firms need to align effective supply chain practices with the level of information quality. The study shows that the strategic cluster of

firms that does not align the level of effective supply chain practices with the level of information quality performs consistently worse than the other three strategic clusters.

Second, this study shows that it is not necessary for all firms to pursue a high level of effective supply chain practices and high information quality. Our study shows that a group of firms (cluster 3) with low level of effective supply chain practices and information quality performs well on both sale revenue and return on sales revenue. It suggests that what firms really need to pursue is the desirable level of effective supply chain practices and information quality. The desirable level is not necessarily a high level.

5. Conclusion and future research

This study marks the first empirical effort to examine supply chain strategy according to the alignment between supply chain practice and information quality. It clusters 125 North America manufacturing companies into four strategic clusters according to their supply chain practice and information quality. Four alternative supply chain strategies are identified. The business performances of the four supply chain strategies are compared.

This paper provides the following findings: (1) firms should align the level of effective supply chain practice with the level of information quality in order to achieve superior business performance, (2) no such strategic cluster of firms having low information quality but high level of effective supply chain practice exists, (3) firms can perform well at different business performance dimensions simultaneously, and (4) firms with high information quality but no effective supply chain practice tend to perform the worst among all four supply chain strategic clusters. This study provides a significant extension to Zhou and Benton (2007) in that this study shows how the alignment between supply chain practice and information quality impacts business performance.

This research can be extended in several directions. First, when supply chain partners gain benefits from good information quality and effective supply chain practice, it is not necessary that each supply chain member benefits equally. Therefore, it is important to study how supply chain partners should share the total benefits from cooperation and collaboration. For example, should the

Table 7
ANOVA results for performance measures (after deleting missing data).

Performance	Group 1	Group 2	Group 3	Group 4	F-statistic	P value
Sales revenue	4.98	4.06	4.86	4.00	3.791	0.013
Return on sales	4.64	4.24	4.71	4.13	0.983	0.404

Table 8
Characteristics of the four groups of companies (using factor loading scores).

Group	Number	Information quality	Supply chain practice
1 (Effective supply chain practice, high information quality)	48	4.41 (2, 3)	3.84 (2, 3, 4)
2 (medium level of effective supply chain practice, medium information quality)	46	3.50 (1, 3, 4)	3.12 (1, 3, 4)
3 (non-effective supply chain practice, low information quality)	12	2.40 (1, 2, 4)	1.95 (1, 2)
4 (non-effective supply chain practice, high information quality)	19	4.19 (2, 3)	2.10 (1, 2)
F-statistic (P value)		104.262 (P < 0.001)	112.907 (P < 0.001)

Numbers in the parentheses indicate the group numbers from which his group was significant at 5% level according to Tamhane's comparison procedure.

Table 9
ANOVA results for performance measures (using factor loading scores).

Performance	Group 1	Group 2	Group 3	Group 4	F-statistic	P value
Sales revenue	4.93	4.20	4.82	4.00	2.742	0.047
Return on sales	4.59	4.36	4.64	4.15	0.518	0.671

benefits sharing be contractual or should supply chain members form certain strategic alliances (either equity based or non-equity based) to share the benefits?

Second, a longitudinal study can explore the impact of improved information quality and effective supply chain practice on objective financial performance such as stock price or firm value. It is important for firms implementing information systems and/or effective supply chain practice to have financial justification.

Appendix A. Literature review taxonomy

Authors and year	Sourcing practice	Delivery practice	Information quality	Business performance
Ahmad and Schroeder (2001)	*			
Benton (2006)	*			
Carr and Pearson (1999)	*			*
Chopra and Meindl (2012)			*	
DeLone and McLean (1992)			*	
Dong et al. (2001)	*		*	
Ellram and Pearson (1993)	*			
Frohlich and Westbrook (2001)	*	*		*
Goldsbey and Stank (2000)		*		
Gurin (2000)		*		*
Hahn et al. (1983)	*			*
Hartley et al. (1997)	*			*
Johnson et al. (2002)	*			
Johnson and Davis (1998)		*		*
Kamath and Liker (1994)	*			
Li et al. (2005)	*	*	*	
McCormack (1998)			*	
McGowan (1998)			*	
Miller and Roth (1994)				*
Narasimhan and Das (2001)	*			*
Petersen (1999)			*	
Prahinski and Benton (2004)	*			
Schonberger and Ansari (1984)	*			
Seddon (1997)			*	
Stalk et al. (1992)		*		*
Supply Chain Council (2002)	*	*	*	*
Sum et al. (1995)			*	
Treleven (1987)	*			*
Trent and Monczka (1994)	*			
Tushman and Nadler (1978)			*	
Vickery et al. (2003)	*			*
Ward et al. (1994)				*
Ward and Duray (2000)				*
Watts et al. (1992)	*			*
Womack et al. (1990)	*			*

Appendix B. Survey Questions and Descriptive Statistics

Survey question	Mean	S.D.
To what extent have the following sourcing practices been implemented in your company [1=Not Implemented, 7=Extensively Implemented]		
VIA1. Designated procurement teams	4.36	2.05
VIA2. Long-term relationships with strategic suppliers	5.51	1.52
VIA3. Reduction in the number of suppliers	4.69	1.87
VIA4. Just-in-time delivery from suppliers	4.29	1.92
VIA5. Frequent measurement of suppliers' performance	4.75	1.83

VIA6. Frequent performance feedback to suppliers 4.44 1.94

To what extent have the following delivery practices been practiced in your company
[1=Not practiced, 7=Extensively practiced]

VIB1. Product delivery to major customer on a just-in-time basis 4.82 2.07

VIB2. A single point of contact for all order inquiries 5.12 1.82

VIB3. Real time visibilities of order tracking 4.41 2.17

VIB4. Order consolidation by customers, sources, carriers, etc. 4.59 2.03

VIB5 Automatic identification during the delivery process to track order status 3.26 2.19

Assess your firm's information system capability in the following dimensions:
[1=Not capable, 7=Highly capable]

VIC1. Information accuracy 5.62 1.23

VIC2. Information availability 5.36 1.32

VIC3. Real-time information 4.88 1.55

VIC4. Internal connectivity 5.33 1.49

VIC5. External connectivity 4.75 1.60

VIC6. Updating information frequently 5.27 1.22

VIC7. Information completeness 5.24 1.23

VIC8. Information relevance 5.48 1.09

VIC9. Information accessibility 5.02 1.40

The following questions relate to the performance of your firm. Compared to your competitors, please indicate your position on the following dimensions. [1=Significantly lower, 4=Equal, 7=Significantly higher]

1. Sales revenue 4.54 1.45

2. Return on sales 4.46 1.31

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