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ABSTRACT

Supply chain collaboration is claimed to yield significant improvements in multiple performance areas: it is believed to reduce costs, to increase quality, to improve delivery, to augment flexibility, to cut procurement cost and lead time, and to stimulate innovativeness. Yet empirical support for the relationship between supply chain collaboration and performance improvement is scarce. Our research adds to this emerging stream of research by providing empirical evidence from the engineering/assembly industries, based on data collected through the International Manufacturing Strategy Survey (IMSS) in Europe. The study reveals that supply chain collaboration is no guarantee for success: performance improvement is only weakly related to the extent of collaboration with customers or suppliers. However, strong improvers in multiple performance areas are found to be heavily engaged in collaboration projects with customers and suppliers, through extensive information exchange and higher levels of structural coordination.

Keywords: supply chain management, collaboration, performance improvement

1. INTRODUCTION

Conventional wisdom among practitioners holds that companies enjoy significant performance improvements through supply chain collaboration. Likewise, supply chain management textbooks are singing the praises for supply chain collaboration as an important approach for boosting performance. Simchi-Levi et al. (2002, p.5) argue that "strategic partnerships between suppliers and manufacturers may have a significant impact on supply chain performance." In the preface to his book on "collaborative manufacturing", McClellan (2003) refers to supply chain collaboration as "a win/win arrangement that is likely to provide improved business success for both parties." It may even be considered a prerequisite for future competitive performance. Indeed, Poirier and Bauer (2001, p.20) maintain that "future success no longer belongs to a single firm, no matter on what scale it functions. The future belongs to networks of supply." In a similar vein, Monczka et al. (2002, p.135) recognize a "trend toward greater use of the collaborative approach."

Also, supply chain collaboration is considered an essential part of demand chain management (Selen and Soliman, 2002, p.667; Langabeer, 2001), which advocates "extending the view of operations from a single business unit or a company to the whole chain" (Vollmann et al., 2000). By meeting the needs and wants of specific customer segments and working backward to raw material suppliers, demand chain management is claimed to deliver significant performance improvements to companies successfully adopting this approach (Ghosh, 2001; Vollman et al., 2000; Doherty, 2001). Frochlich & Westbrook (2002, p.729), for instance, state that "the most admired (and feared) competitors today are companies that link their customers and suppliers together into tightly integrated networks using what is now commonly called demand chain management."

Yet some authors beg to differ. Cox (1998), for instance, promotes direct control over strategic resources as a more likely source of competitive advantage than collaborative supplier relationships. Turnbull et al. (1993) caution that weaker players are not necessarily better off in seemingly collaborative arrangements than in adversarial ones. Furthermore, case study research reveals the difficulty of implementing supply chain collaboration (Boddy et al., 2000). A study in the U.K. automobile industry (Lamming, 1994) warns that rhetoric may be stronger than reality. Indeed, while supply chain collaboration may lead to increased performance, it cannot be taken at face value (van Weele, 2002). In a case study of supply collaboration for steering assemblies between Rover and TRW, Burnes and New (1997) advocate adopting a process perspective to identify and overcome major collaboration barriers

in successful customer-supplier collaboration. Likewise, case research in Manchester, U.K., with 11 companies highlighted potential limitations of supplier partnering (Adacum and Dale, 1995).

Clearly, the cases made for increased collaboration are merely starting to increase our understanding of this complex process (e.g., Burnes and New, 1996). Is the assertion of collaboration leading to increased performance no more than a common belief or should firms evolve toward more collaboration in their buyer-supplier relationships? To what extent do empirical studies support the rhetoric?

It is the objective of this paper to empirically test the relationship between on the one hand collaboration with suppliers and/or customers, and on the other hand performance improvement. As such, the paper contributes to supply chain theory and practice by showing how the notion of collaborative buyer-supplier relationships has diffused across industries, and how it is related to success across critical performance areas.

Toward that end, the paper is organized in 6 sections. In the next section the literature is reviewed and hypotheses developed. Subsequently, the data and method are presented in section 3. Section 4 shows the results, while the discussion and directions for further research are outlined in section 5. Section 6 concludes the paper.

2. THEORY AND HYPOTHESES DEVELOPMENT

Collaborative buyer-supplier relationships are generally defined in terms of their characteristics. Monczka et al. (2002), for instance, refer to long-term, win-win, open information exchange type of agreements in which both parties engage in joint efforts to improve supplier performance and commit to quality, cooperation, and dispute resolution. Likewise, Burnes and Whittle (1995) point to the presence of a proactive, cooperative, win-win philosophy with a long-term commitment to continuous improvement, integration and performance determination for a partnership relationship to exist. In this article we keep with Burnes and New (1997) and purposely use the term collaboration instead of partnership as a way of describing buyer-supplier relationships that embrace both conflict and partnership, implying some form of mutuality without an apparent need for lifetime commitment or total openness and trust.

Different levels of collaboration in customer-supplier relationships are identified in the literature (Lamming, 1994). While operational collaboration is geared towards transaction efficiency improvements, collaboration at the strategic level requires shared or matching

objectives, either by coincidence or design. Burnes and New (1997, p.12) have shown that even strategic collaboration needs to be endorsed at the operational level for its objectives to be achieved and that "different forms of relationships can exist at these different levels." A basic form of collaboration involves the exchange of information to the joint benefit of the buyer and supplier. Information may be shared at all relevant levels of the planning and control process, that is in forecasting phase, in the actual planning phase, as well as in the execution or replenishment phase (Vollmann et al., 2005). For instance, rather than treating buyer-supplier interactions at arm's length, the sharing of inventory data can preclude information distortion (bullwhip effect) forestalling extra costs, excess inventories, slow response, and lost profits (Lee et al., 1997). Likewise, combining information captured in the supply chain with analysis of customer demand can augment the accuracy of production planning and demand forecasting, enhancing performance in the whole chain (Costello, 2001; Zellen, 2001; Selen and Soliman, 2002). Also, many companies foster information exchange with a single or dual source of supply through long term contracts to seek supplier improvements in delivery frequency and cost (Ansari and Modarress, 1990, Handfield, 1993; Grout 1998; Krausse et al., 1998).

A more pronounced form of collaboration occurs at a structural level when information exchange is embedded in standardized systems geared toward process integration. Through joint planning and synchronization of business processes, buyer-supplier dyads go beyond passive information exchange and engage in proactive collaboration (Jagdev and Thoben, 2001).

As the concept of supply chain management was introduced in the 1980s the increasingly collaborative nature of Japanese-inspired trading relations was highlighted (Dyer et al., 1988). Various forms of collaboration practices emerged, ranging from Efficient Consumer Response (ECR) (Salmon, 1993), over related practices such as Vendor Managed Inventory (VMI) (Cooke, 1998) and Continuous Replenishment (CR), to Collaborative Planning, Forecasting, and Replenishment (CPFR) (Skjoett-Larsen et al., 2003). At the same time, process models were developed as guidelines for supply chain collaboration (e.g., the Voluntary Inter-Industry Commerce Standards (VICS) process model and the Supply-Chain Operations Reference (SCOR) model (http://www.supply-chain.org).

Other systems and processes fostering structural coordination include kanban and plant colocation (Leenders et al., 2002). Provided they are used in the broader context of the Just-in-Time philosophy, kanban systems are a powerful way of linking the supplier's and customer's planning systems, by pulling demand through the supply chain (Vollmann et al.,

2005). The increasing rate of adoption of lean practices in the supply chain, which has been described in particular in the automotive industry, has created a need for geographical proximity of the supplier to the assembler. In some cases it has led to the establishment of supplier parks, where the supplier is co-located with the assembler (Doran, 2001; Liker, 2000).

Successful collaborative customer-supplier relationships are claimed to yield significant benefits: inventory reduction, better quality, improved delivery, reduced costs, compressed lead times, faster product-to-market cycle times, higher flexibility, increased responsiveness to market demands and customer service, and market share increases (Anderson and Lee, 1999, Corbett et al., 1999; Mentzer et al., 2000; McLaren et al. 2002). Moreover, through "pie expansion" mutually beneficial buyer-supplier collaboration may offer significant opportunities for the creation of competitive advantage and extraordinary financial performance (Jap, 1999, 2001). Also, companies able to effectively collaborate both with their suppliers and customers are believed to outperform companies not effectively managing supply chain collaboration (Christopher, 1999; Frochlich and Westbrook, 2002). High levels of collaboration, both with suppliers and customers, are believed to lead to significant overall performance improvements, making a company world class.

It is important to note here that not all collaboration is successful. Burnes and New (1997) stress that only companies that effectively turn declared working partnerships with their customers or suppliers into mutually beneficial collaboration will reap performance benefits. Likewise, various authors in the field of demand chain management indicate that world class companies use real time customer information, collaborate with trading partners, and invest in web-enabled technology to close the loop between supply and demand chains (Doherty, 2001; Selen and Soliman, 2002).

Yet there is a paucity of empirical studies supporting the claims made for performance improvement through collaborative customer-supplier relationships. In a study of 98 US manufacturing and retail firms involved in CPFR, Stank et al. (1999) failed to verify the existence of broad-based performance enhancements related to implementation of CPFR. Only firms engaging in high levels of CPFR were found to have significantly reduced overall costs. Significant improvements in customer service, reduced stockouts, less instances of damaged, returned, and refused goods, and lower inventory levels with faster turns were not observed. Stronger empirical support was found by Frohlich and Westbrook (2001).

In a global sample of 322 manufacturers, Frohlich and Westbrook (2001) found that manufacturers focusing on strong integration with either suppliers or customers, the so-called supplier-facing and the customer-facing companies, demonstrated improved performance across all measures, a finding in line with the results of previous research investigating the link between either strong upstream (Chapman and Carter, 1990; Akinc, 1993; Lawrence and Hottenstein, 1995; Choi and Hartley, 1996; Germain and Droge, 1998; Tan et al., 1998; Carr and Pearson, 1999; Essig and Arnold, 2001) or downstream (Clark and Hammond, 1997; Narasimhan and Jayaram, 1998; Lummus et al., 1998; Daugherty et al., 1999; Gilbert and Ballou, 1999; Waller et al., 1999) connections in the supply chain and performance. Moreover, Frohlich and Westbrook (2001) observed that companies with the highest degree of integration in the direction of both customers and suppliers, the so-called outward facing companies, enjoyed the largest rates of performance improvement across multiple marketplace (market share, profitability), productivity (cost, lead time) and non-productivity (customer service, quality, delivery) measures (Voss, 1988). While these are encouraging results, it is important to note that the empirical work of Frohlich and Westbrook (2001) also highlighted the absence of significant differences in performance improvement across manufacturers engaging in either extensive supplier- or customer-facing integration and their low supplier and customer integration counterparts, the so-called inward- and periphery facing companies. Indeed, while the former did enjoy percentage improvements in each performance measure in the range of 6.6% to 18.8%, the latter exhibited similar improvement rates (7.5% to 18.2%).

In this study we follow up the generalizations and hypotheses made in previous research with empirical research. In keeping with the extant literature, we hypothesize the following:

Hypothesis 1a: Information exchange with suppliers is positively related to performance improvement.

Hypothesis 1b: Structural coordination with suppliers is positively related to performance improvement.

Hypothesis 2a: Information exchange with customers is positively related to performance improvement.

Hypothesis 2b: Structural coordination with customers is positively related to performance improvement.

Hypothesis 3a: Companies engaged in information exchange both with suppliers and customers have the largest rates of improvement.

Hypothesis 3b: Companies engaged in structural coordination both with suppliers and customers have the largest rates of improvement.

Hypothesis 4: Companies reaching strong performance improvement show higher levels of information exchange and structural coordination than the other companies.

3. DATA AND METHOD

In this section, we discuss the data set, the operationalization of constructs and the data analysis.

Data

This study uses the data of the International Manufacturing Strategy Survey (IMSS) 2001. IMSS is a global research network collecting data on the manufacturing and supply chain strategies, practices and performance of companies in the Engineering / assembly industries (ISIC 38). This includes manufacturing of metal products, machinery, electrical equipment, transportation equipment, and measuring and controlling equipment. The data has been collected in the period 2000-2002, in 16 countries worldwide. Information about the survey administration is available in Voss and Blackmon (1998) and Frohlich and Westbrook (2001). The data set consists of 474 companies, 79 % of which are located in Europe. The other companies are scattered across multiple countries in widely dispersed regions (14 in Argentina, 40 in Australia, and 30 in China). Therefore, the focus of our research is on the European subset of countries. Our sample thus includes 374 companies (after omission of outliers and incomplete cases) from 11 European countries: Belgium, Denmark, Germany, Hungary, Italy, Ireland, the Netherlands, Norway, Spain, Sweden, and the United Kingdom. On average, a company in the data set employs 825, has a turnover of 260 million USD, buys from 212 suppliers, and delivers its goods to 762 customers.

Operationalization of constructs

In keeping with the literature, the survey identifies several collaboration practices as variables. These variables are listed in Table 1 and Table 2. Both the information exchange and the structural coordination variables are present in the questionnaire. The extent to which the respondents are involved in each of these collaboration practices, with their key suppliers and customers, has been measured through five-point scales (1 = no adoption, to 5= high level of adoption). Factor analysis (Principal Component Analysis and Varimax Rotation) has been applied to this list of 6 variables. The results of the factor analysis are reported in Table 1 for collaboration with suppliers and in Table 2 for collaboration with customers.

Insert Table 1 and Table 2 About Here

The results of the factor analysis are in accordance with the two types of collaboration identified in the literature:

- The first type of collaboration is related to the exchange of information. More specifically it consists of making delivery agreements, and exchanging information on inventory levels, production planning decisions and demand forecasts. In what follows, we label this factor as "*information exchange*". The cronbach alpha for information exchange with suppliers is 0.70. The cronbach alpha for information exchange with customers is 0.75. Both reliability measures can be considered acceptable (Nunnally, 1978; Sekaran, 2000).
- The second type of collaboration is related to structural coordination by setting up systems to collaborate in a standardized way: the use of kanban systems, the co-location of plants, and Vendor Managed Inventory. In what follows, we label this factor as "*structural coordination*". The cronbach alpha for structural coordination with suppliers is 0.51. The cronbach alpha for structural coordination with customers is 0.63. We acknowledge that both reliability measures are rather low, especially the structural coordination with suppliers measure which is below the generally acceptable rate of 0.6 (Sekaran, 2000). Yet, in view of its theoretical basis we continue to hold on to this measure in the remainder of this study. It is important to note that correlations for instruments with modest reliabilities are highly likely to be attenuated by measurement error, resulting in conservative correlation estimates (Nunnally, 1978).

Performance improvement has been measured by a set of 17 performance variables, representing improvements in various operational areas (Hill, 1994). While many performance frameworks have been advanced in the literature on operations management, advocating the use of various performance measures, cost, quality, flexibility, and delivery are widely regarded as constituting the major operational performance variables (e.g., Voss, 1995; Spring and Boaden, 1997; Schroeder et al., 2002). Therefore, our study highlights performance measures in these four respective areas. In addition, other performance measures in both productivity and non-productivity performance improvement areas are included for analysis (Voss, 1988). The degree of improvement on each of the performance dimensions has been measured by five-point scales (1= strongly deteriorated, 5 = strongly improved). The 17 performance variables are listed in Appendix 1. Factor analysis was conducted to discern the underlying dimensions of the variables. Four variables have been omitted from the analyses since the factor load proved to be too small (<0.50): product customization, environmental performance, manufacturing lead time, and time to market. Overhead costs has been omitted from the analyses because of the substantial increase in cronbach alpha of the corresponding factor. This results in a set of 12 variables, which fall into 5 different factors. These factors prove to be stable: in factor-analyzing the original 17 variables and the final 12 variables, all remaining variables loaded on the same factors. The factor loadings are shown in ***Table 3***.

Insert Table 3 About Here

The factor analysis thus results in 5 performance improvement factors, with acceptable reliability (Sekaran, 2000):

- delivery performance: delivery speed, customer service, delivery reliability (cronbach alpha = 0.75)
- cost: labour productivity, capacity utilization, inventory turnover (cronbach alpha = 0.61)
- procurement performance: procurement cost, procurement lead time (cronbach alpha = 0.67)
- flexibility: volume flexibility, mix flexibility (cronbach alpha = 0.68)
- quality: product quality, manufacturing conformance (cronbach alpha = 0.70)

This factor analysis results in the traditional measures of performance, as mentioned in the manufacturing strategy literature (Hill, 1994), together with a procurement performance measure. However, a measure of innovativeness is lacking. Given that time to market is the only measure of innovativeness included in the survey, it was not expected to load on any of the factors, and it will be treated as a separate performance improvement measure in our analyses. Consequently, we have added time to market as the sixth performance improvement measure in our analyses.

4. RESULTS

In this section we present the results of our analyses per hypothesis.

Hypothesis 1

Hypothesis 1a and Hypothesis 1b that collaboration (information exchange and structural coordination respectively) with suppliers is positively related to performance improvement were evaluated through Pearson Correlations. These correlations are shown in Table 4.

Insert Table 4 About Here

Table 4 shows positive correlations between both types of collaboration with suppliers and all performance improvement factors. Most of the correlations are significant. However, the correlations are low, indicating only weak support for Hypothesis 1a and Hypothesis 1b.

Hypothesis 2

Hypothesis 2a and Hypothesis 2b that collaboration (information exchange and structural coordination respectively) with customers is positively related to performance improvements were evaluated through Pearson Correlations. These correlations are shown in ***Table* 5**.

Insert Table 5 About Here

As can be seen from Table 5, positive correlations between both types of collaboration with customers and all performance improvement factors were observed. Also, most of the correlations are significant. However, the correlations are low, indicating only weak support for Hypothesis 2a and Hypothesis 2b.

Hypothesis 3

In order to understand the impact of collaboration (for information exchange and structural coordination respectively) both with suppliers and customers on performance improvement (Hypothesis 3a and Hypothesis 3b), we have split the sample into four categories, based on the direction of collaboration (upstream with suppliers versus downstream with customers) and the level of collaboration (low versus high). The median has been used as the cut-off value to distinguish low from high levels of collaboration. Respondent companies that fell on the median for any or both of the dimensions were dropped from the analysis. The four resulting categories are shown in ***Figure 1***.

Insert Figure 1 About Here

Table 6 summarizes the mean performance improvement levels per supplier/customer collaboration category for information exchange. As can be seen from Table 6, companies showing high levels of information exchange both with suppliers and customers show significantly higher cost, flexibility, quality, and procurement improvement vis-à-vis their low information exchange counterparts. However no significant differences were observed vis-à-vis companies in categories 2 and 3.

When looking at the mean performance improvement levels per supplier/customer collaboration category for structural coordination (see Table 7), significant differences are only observed for flexibility and procurement improvement for companies showing high levels of structural coordination both with suppliers and customers vis-à-vis their low structural coordination counterparts. No other significant differences are found.

Insert Table 6 and 7 About Here

A similar classification scheme has been proposed by Frohlich and Westbrook (2001) who suggest an arcs of integration approach, in which the direction of the collaboration (towards suppliers and/or customers) and the extent of collaboration are used to represent the strategic position of each company with respect to supply chain development. In lieu of a median split, Frohlich and Westbrook identified five categories of collaboration based on a quartile split of direction and extent of collaboration, with at the extremes inward and outward facing companies. The category of inward facing companies can be considered a subgroup of our Category 1. Likewise, the category of the outward facing companies can be considered a subgroup of our Category 4. A comparison of the performance improvements for both information exchange and structural coordination across the inward and outward facing categories corroborates the results of the analyses reported in Table 6 and Table 7.

In summary, partial support was found for Hypothesis 3a and Hypothesis 3b.

Hypothesis 4

It may be that the relationship between supplier and customer collaboration and performance improvement is more complex than we can determine by comparing categories of collaboration against each of the performance improvement measures separately. An overall implementation of supply chain collaboration may well coincide with an overall performance improvement, as stated in Hypothesis 4. One may indeed expect that companies able to collaborate in an effective and coherent way both with suppliers and customers outperform competition on multiple dimensions simultaneously, thus gradually reaching world class performance. If this holds true, we should observe a high level of collaboration for the subset of companies with a high level of overall performance improvement vis-à-vis the other companies in the data set.

In order to evaluate Hypothesis 4 we split the sample in three groups according to their level of overall performance improvement. Using a cycling metaphor, we have labeled the strong improvers as the “head” category, the weak improvers as the “tail” category, and all other companies as the “pack” category.

We have classified a company in the “head” category if it shows performance improvement in the upper quartile for at least three of the six performance improvement factors. A company is classified in the “tail” category if it shows performance improvement in the lower quartile for at least three of the six performance factors. All other companies are classified in the “pack” category. As a result, the “head” category consists of 45 companies,

the “tail” category consist of 58 companies, and the “pack” category consists of 271 companies. Table 8 and Figure 2 summarize the average improvement level for each of the measures, for the three categories. Conform to our categorization, the companies in the “head” category show on average a significantly higher level of performance improvement on all measures than the ones in the “tail” category; companies in the “pack” category score in between on all performance improvement variables.

Insert Table 8 and Figure 2 About Here

In order to evaluate Hypothesis 4 we compared the degree of supplier and customer collaboration (for information exchange and structural coordination respectively) of the companies in the “head” category with the ones in the “tail” category and the “pack” category. The results are summarized in Table 9 and Figure 3. The analysis reveals that the “head” category is indeed characterised by a higher level of collaboration, both in terms of information exchange and structural coordination, both with suppliers and customers, than the “tail” and the “pack” category. Hence, we find strong support for Hypothesis 4.

Insert Table 9 and Figure 3 About Here

It is of interest to note that companies in the “head” category show high mean levels of information exchange both with suppliers and customers, whereas they show rather low mean levels of structural coordination, both with suppliers and customers.

5. DISCUSSION AND AVENUES FOR FURTHER RESEARCH

The empirical findings presented in this study support the claim for a concerted approach to collaboration both with suppliers and customers in order to reap maximum performance improvement benefits. Indeed, while separate collaboration efforts with suppliers or with customers were shown to provide only minor performance improvements, collaboration both with suppliers and customers was found to have the largest rates of improvement, especially for information exchange.

Also, when separating the strong improvers on multiple performance areas from companies in the pack and tail, a consistently strong level of support for both supplier and customer information exchange and structural coordination was observed, supporting the rhetoric of increased performance through supply chain collaboration.

Even though our results suggest that collaboration may be an important development for manufacturers, the results may also indicate that supply chain collaboration efforts may be too modest and un-orchestrated in many companies. If this holds true, the absence of supply chain collaboration and the lack of coherence in supply chain projects could be hiding the expected relationship between collaboration and performance improvement. While companies pursuing high levels of information exchange and structural coordination, upstream as well as downstream, stand to gain the most, companies approaching collaboration in a piecemeal manner may well forego any significant and substantial performance improvement. Therefore, our results suggest that the latter should go beyond mere information exchange and embark on structural coordination in a concerted manner both with suppliers and customers.

Given the above, a key implication of this study for managers that set out to reap the benefits from supply chain collaboration is the need to consider a large scale effort in which supplier and customer collaboration are approached in a concerted manner involving both information exchange and structural coordination. In addition, practitioners also need to be aware that a possible explanation for the weak relationship between performance improvement and supply chain collaboration may be the low absolute level of supply chain collaboration. Indeed, it may well be that many companies may not have reached a minimum threshold in supply chain collaboration, necessary to show substantial improvements. Therefore, as supply chain collaboration becomes more common and increasingly intense, the relationship between supply chain collaboration and performance improvement may become more prevalent in future research.

More research is needed to address some limitations of this study. First, this study is cross-sectional in nature and does not offer a longitudinal perspective on the relationship between collaboration and performance improvement. Especially in the area of structural coordination, a significant time lag between the development of collaboration systems and their full-blown use may well obscure the relationship between collaboration and subsequent performance improvement. Second, the results of our study are limited by the availability of data. In the absence of absolute performance measures and financial performance data, the demonstrated impact of supply chain collaboration is limited to improvement measures. That is, our study demonstrates a relationship between supply chain collaboration and the

(perceived) degree of performance improvement. It is not capable of demonstrating a relationship between supply chain collaboration and the absolute level of performance. Third, the unit of analysis in our research is the respondent's company in relation to its suppliers and its customers. While our study provides important insights, these could be enhanced by studying overall supply chain collaboration, from end customer to raw material, in line with the demand chain management and networks of supply literature streams (Selen and Soliman, 2002; Poirier and Bauer, 2001). Such a study could then survey supply chain improvement, i.e., performance improvement for every collaboration partner in the supply chain, and identify "multiple-win" incidences, rather than focusing on performance improvement for any principal firm alone.

Another important extension to the current work would be the study of the impact of Internet technology and electronic business practices on the relationship between supply chain collaboration and performance improvement. Frochlich and Westbrook (2001, p.196), for instance, point to the importance of the Internet in facilitating information exchange and collaboration, asserting that "the ultimate arc of integration is a web-enabled supply chain." In a similar vein, Frochlich (2002) and Frochlich and Westbrook (2002) note that the Internet resolves traditional supply chain integration tradeoffs and allows all supply chain partners to exchange rich information at low cost over long distances. In an empirical study of 187 manufacturers in the UK, Frochlich and Westbrook (2002) found that a high degree of web-based supply and demand integration led to the highest levels of operational performance for manufacturers in terms of faster delivery times, reduced transaction costs, greater profitability, and enhanced inventory turnover. Frochlich and Westbrook (2002) also found that manufacturers showing high levels of either web-based supply or demand integration significantly outperformed manufacturers adopting a low web-based integration strategy. Likewise, in a sample of 486 UK manufacturers, Frochlich (2002) found a positive link between e-integration (i.e., broad upstream and downstream supply chain integration using the Internet) and operational performance measures (faster delivery times, reduced transaction costs, enhanced inventory turnover). Clearly, future research should investigate the use of web-based supply and demand collaboration practices and systems to further increase researchers' and practitioners' understanding of the relationship between supply chain collaboration and performance improvement.

6. CONCLUSION

Companies engage in two different forms of collaboration. Collaboration can be focused on the exchange of information on forecasts, planning, inventory and delivery. It may also be geared toward setting up more structural coordination, such as installing Kanban systems, initiating Vendor Managed Inventory or even co-locating plants. In this study, a positive relationship was hypothesized between each of these forms of collaboration and a widely accepted set of performance improvement measures (i.e., the four traditional areas of delivery, cost, quality, and flexibility, as well as two additional areas: procurement (cost and lead time), and innovativeness (time to market)). However, we found only weak support for the hypothesized relationships. While our empirical findings do show that increased collaboration goes hand in hand with higher performance improvement in most areas, the improvements are minor, and not always significant. At best, the results allow us to conclude that supply chain collaboration has no adverse impact on operational performance improvement.

Clearly, supply chain collaboration is not a guarantee for success. Modest collaboration efforts with customers or suppliers deliver at best piecemeal improvements in performance on isolated performance measures. Yet a coherent supply chain strategy, consisting of both information exchange and structural coordination with suppliers as well as customers is observed in companies that reach major performance improvements on multiple performance measures simultaneously. Stated differently, supply chain collaboration is a valuable approach for reaching world class operational performance.

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APPENDIX 1

Performance improvement variables

manufacturing conformance

product quality and reliability

product customization ability

volume flexibility

mix flexibility

time to market

customer service and support

delivery speed

delivery reliability

manufacturing lead time

procurement lead time

procurement costs

labor productivity

inventory turnover

capacity utilization

overhead costs

environmental performance

TABLE 1

Factor analysis of degree of collaboration with suppliers

Collaboration with supplier	Factor 1	Factor 2
Information sharing about inventory levels	**.670**	.419
Information sharing about production planning decisions and demand forecast	**.848**	4.9E-02
Agreements on delivery frequency	**.766**	.135
Co-location of plants	.173	**.586**
Use of Kanban systems to acquire materials	.225	**.663**
Manage or hold inventories of materials at own site	3.2E-04	**.814**
Eigenvalue	2.42	1.06
Percentage of Variance explained	40.4	17.6

TABLE 2

Factor analysis of degree of collaboration with customers

Collaboration with customer	*Factor 1*	Factor 2
Information sharing about inventory levels	**.769**	.292
Information sharing about production planning decisions and demand forecast	**.878**	.129
Agreements on delivery frequency	**.687**	.228
Co-location of plants	.193	**.693**
Use of Kanban to deliver your products	.308	**.664**
Supply customer to consignment stock and/or VMI	.127	**.821**
Eigenvalue	2.81	0.92
Percentage of Variance explained	46.8	15.4

TABLE 3

Factor analysis of performance improvement

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
	delivery	cost	procurem.	flexibility	Quality
delivery speed	**.839**	.117	7.0E-02	.178	-.011
delivery reliability	**.794**	9.8E-02	.179	.218	.165
customer service	**.700**	.146	3.6E-02	-.116	.274
labour productivity	.232	**.669**	.104	9.6E-02	.120
capacity utilization	3.2E-03	**.816**	-.025	7.5E-02	.117
inventory turnover	.108	**.641**	.186	6.4E-02	7.6E-03
procurement costs	1.9E-02	8.5E-02	**.819**	5.4E-02	.129
procurement lead time	.200	-.023	**.795**	.144	7.3E-02
overhead costs	4.6E-02	.349	**.582**	-.116	-.076
volume flexibility	.175	.193	-.007	**.809**	.129
mix flexibility	4.83E-02	2.5E-02	9.3E-02	**.859**	7.5E-02
manufacturing conformance	.138	5.1E-02	5.5E-02	.217	**.828**
product quality	.172	.148	7.8E-02	1.0E-02	**.837**
Eigenvalue	3.564	1.514	1.261	1.237	1.098
Percentage of Variance explained	27.4	11.6	9.7	9.5	8.4

TABLE 4

Performance improvement versus supplier collaboration

	cost	flexibility	quality	delivery	procure-ment	time to market
H 1a: supplier information exchange	0.134 *	0.264 **	0.282 **	0.060	0.281 **	0.176 **
H 1b: supplier structural coordination	0.062	0.183 **	0.097	0.105	0.181 **	0.127 *

** *Correlation is significant at the 0.01 level.*
* *Correlation is significant at the 0.05 level.*

TABLE 5

Performance improvement versus customer collaboration

	cost	flexibility	quality	delivery	procure-ment	time to market
H 2a customer information exchange	0.084	0.114 *	0.148 **	0.164 **	0.119 *	0.154 **
H 2b customer structural coordination	0.176 **	0.183 **	0.307 **	0.058	0.103	0.132 *

** *Correlation is significant at the 0.01 level.*
* *Correlation is significant at the 0.05 level.*

TABLE 6

Information exchange versus Performance improvement

	cost	flexibility	quality	delivery	procure-ment	time to market
Category 1 n=99	3.37(4)	3.46(2,4)	3.51(4)	3.64	3.22(4)	3.39
Category 2 n=54	3.50	3.97(1)	3.77	3.67	3.34	3.41
Category3 n=35	3.41	3.57	3.74	3.71	3.19	3.48
Category 4 n=129	3.50(1)	3.82(1)	3.94(1)	3.68	3.52(1)	3.62
Significance level	0.015	0.000	0.000	0.944	0.008	0.142

Numbers in parenthesis indicate category number from which the category is different (Scheffé pairwise test with significance level 0.05)

TABLE 7

Structural coordination versus Performance improvement

	cost	flexibility	quality	delivery	procurement	time to market
Category 1 n=99	3.44	3.57(4)	3.65	3.57	3.13(4)	3.29
Category 2 n=69	3.48	3.89	3.68	3.59	3.44	3.61
Category3 n=45	3.65	3.63	3.67	3.69	3.36	3.56
Category 4 n=95	3.51	3.88(1)	3.83	3.77	3.41(1)	3.63
Significance level	0.191	0.010	0.229	0.247	0.026	0.018

Numbers in parenthesis indicate category number from which the category is different (Scheffé pairwise test with significance level 0.05)

TABLE 8

Overall Performance improvement classification

	Cost	flexibility	quality	delivery	procurem	time to market
head	3.981	4.067	4.289	4.230	3.898	3.956
pack	3.520	3.743	3.725	3.695	3.310	3.465
tail	2.991	3.138	3.181	2.971	2.922	3.035
Overall	3.491	3.684	3.708	3.645	3.319	3.458
Anova Sign. Level	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 9

Level of supplier and customer coordination

	tail (1)	pack (2)	head (3)	Sig.
supplier structural coord	1.94(3)	2.02(3)	2.35(1,2)	0.033
supplier information exchange	3.00(3)	3.25(3)	4.03(1,2)	0.000
customer structural coord	1.73(3)	1.91(3)	2.46(1,2)	0.000
customer information exchange	2.70(3)	3.08(3)	3.77(1,2)	0.000

Numbers in parenthesis indicate category number from which the category is different (Scheffé pairwise test with significance level 0.05)

FIGURE 1

Categorization of supplier/customer collaboration

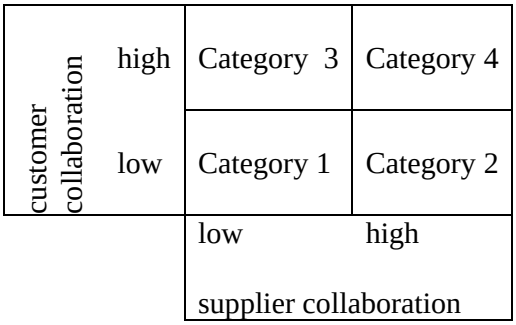

FIGURE 2

Performance improvement in head, tail and pack

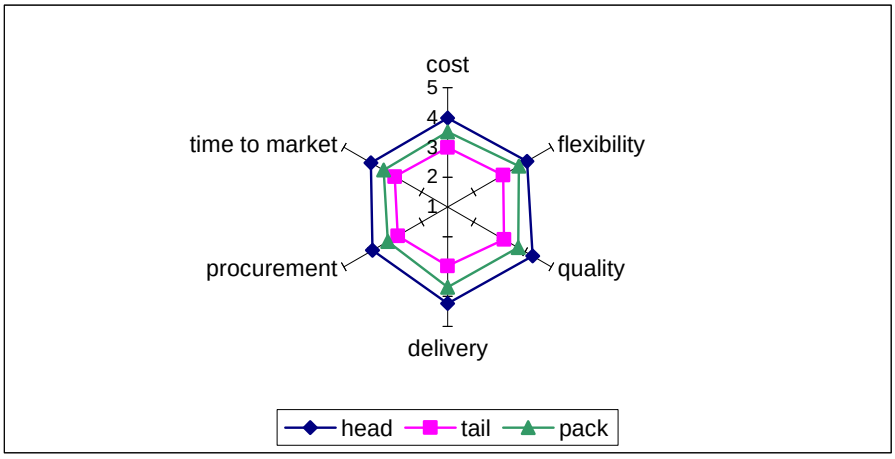

FIGURE 3

Level of supplier and customer coordination