

011-0464

**Supply Chain Agility, Collaboration, and Performance:
How do they Relate?**

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POMS 20th Annual Conference
Orlando, Florida U.S.A.
May 1 to May 4, 2009

Abstract

Business managers are concerned with what factors influence the degree of supply chain collaboration and what moderates supply chain collaboration's effect on supply chain performance? This proposed study examines how supply chain agility acts as a moderator between supply chain collaboration and supply chain performance. Furthermore, the presence of environmental uncertainties will be shown to influence the degree of collaboration and the degree of collaboration will be shown to influence the supply chain performance.

1. Introduction

Supply chain collaboration is often defined as “two or more chain members working together to create a competitive advantage through sharing information, making joint decisions, and sharing benefits which result from greater profitability of satisfying end customer needs than acting alone” (Simatupang & Sridharan, 2005; Whipple & Russell, 2007). This paper will focus on the inter-firm collaboration efforts of manufacturing chain members and their interactions with retailers.

Identified benefits of collaboration include: revenue enhancements, cost reductions, operational flexibility to cope with demand uncertainties (Fisher, 1997; Lee, Padmanabhan, & Whang, 1997; Simatupang et al., 2005); increased sales, improved forecasts, more accurate and timely information, reduced costs, reduced inventory, improved customer service, (Barratt & Oliveira, 2001; Whipple et al., 2007); division of labor, exchanges of knowledge about products and processes (Kotabe, Martin, & Domoto, 2003) and cost and/or problem avoidance (Whipple, 2007). Identified risks of collaboration include: difficulty of implementation, failure to differentiate with whom to collaborate (Sabath & Fontanella, 2002); and opportunism (Hoyt & Huq, 2000). Although the number of “potential” benefits cited in the literature outnumber the “potential” risks, several authors have indicated that efforts to collaborate between firms is not always successful (Simatupang & Sridharan, 2002; Whipple, 2007). The literature on supply chain management does not adequately explain under what conditions collaboration is effective and what factors influence its effect on supply chain performance.

We propose that when a supply chain is “agile” and environmental uncertainties exist, collaboration will have a greater influence on supply chain performance. This research examines how supply chain agility acts as a moderator between supply chain collaboration and supply

chain performance. Furthermore, the presence of environmental uncertainties and their influence on the degree of collaboration and the degree of collaboration and its influence on supply chain performance will be examined.

This paper is organized as follows. The next section reviews previous literature on supply chain collaboration. Next, the theoretical foundation, conceptual development and hypotheses are presented. Then, the methods section follows outlining the proposed methodology. Following the methods section, a discussion of expected results and their implications for practice and research are presented. Finally, concluding remarks and directions for future research are provided.

2. Literature Review

2.1 Collaboration

Whipple and Russell (2007) identified three “types” of collaboration. These types of collaboration were segregated based on ten factors: (1) people characteristics; (2) process characteristics; (3) technology characteristics; (4) degree of involvement in decision making; (5) collaboration focus; (6) time horizon; (7) classification of return on relationship; (8) organizational level; (9) information domain; and, (10) knowledge level. Within each of these ten factors, the authors were able to describe three different levels of development to correspond with their three different types of collaboration: Type I – collaborative transaction management; Type II – collaborative event management; and, Type III – collaborative process management. Whipple and Russell (2007) posit that the number of collaborative relationships will decrease as the Type increases from I to III. Additionally, they posit that the sustainable payoffs from collaborative relationships will increase as the Type increases. In other words, these authors predict there will be more of a sustainable payoff from a Type III collaborative relationship than a Type I. The “types” identified by Whipple and Russell (2007) are progressive. A supply chain

relationship could move along a continuum from Type I to Type III rather than the “types” denoting a categorical location separate and distinct from each of the other levels.

Simatupang and Sridharan (2005) developed a collaboration index that measures the level of collaboration in a supply chain relationship based on three factors: (1) information sharing; (2) decision synchronization; and (3) incentive alignment. Appendix B provides the underlying items for each of the three factors. Our research will utilize this scale to measure the level of collaboration within a manufacturer and retailer supply chain relationship.

2.2 Supply Chain Environmental Uncertainties and Collaboration

Chen and Paulraj (2004b) indicate that uncertainty in the environment is one of the key external driving forces instrumental to the development of supply chain management. These authors indicate that the uncertainty surrounding supply chains can be attributed to three sources: supplier uncertainty; demand uncertainty; and technology uncertainty.

Collaboration in supply chain relationships is becoming more prevalent because of its ability to reduce uncertainty (Hoyt et al., 2000; Monczka, Petersen, Handfield, & Ragatz, 1998; Peters & Hogensen, 1999).

Hypothesis 1: As uncertainty in the environment increases, collaboration in the supply chain relationship increases.

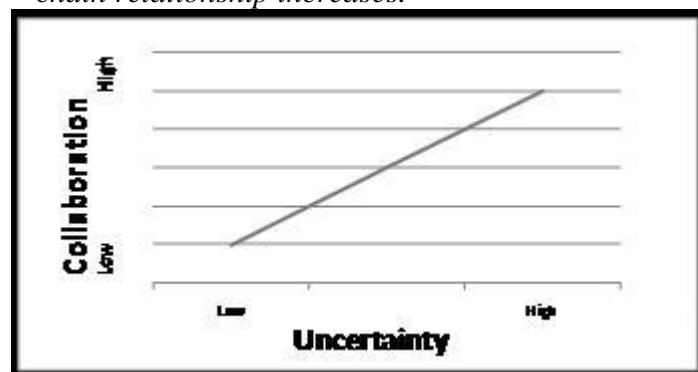


Figure 1 – Hypothesized relationship between Uncertainty and Collaboration in the Supply Chain

2.3 Supply Chain Performance and Collaboration

“Traditional measures of supply chain performance included lead times, inventory turns, weeks of stock, defect rates, and service levels” (Ramdas & Spekman, 2000: 4). These traditional measures focus on reducing costs for transactions, or improving efficiency. However, they do not measure the advantages related to end-customer satisfaction (Ramdas et al., 2000). Simatupang and Sridharan (2005) build from Ramdas et al. (2000) and suggest that supply chain performance criteria should include fulfillment, inventory measures and responsiveness measures. A supply chain performance measurement that focuses only on operational items or only on finance items is not sufficient (Chen et al., 2004b). Chen and Paulraj (2004a) indicate supply chain performance may be measured based on supplier operational performance, buyer operational performance, and buyer financial performance. The specific measures associated with Chen and Paulraj (2004a) are included in Appendix C. However, this scale will need modification as it includes items that represent flexibility. For the purposes of our study, flexibility will be separated from supply chain performance as discussed below in the supply chain agility section.

Competitive supply chains that are able to integrate supply and demand through collaboration, deliver significantly improved performance (Barratt, 2004). Increased collaboration generally has a positive effect on the supply chain performance. However, at a certain point, further collaboration ceases to generate benefits for the supply chain. The resources invested in collaboration could be better spent on other projects or activities.

Hypothesis 2a: As collaboration increases, supply chain performance will also increase up to a “tipping” point.

Hypothesis 2b: Once the “tipping” point has been reached, as collaboration increases, supply chain performance will decrease.

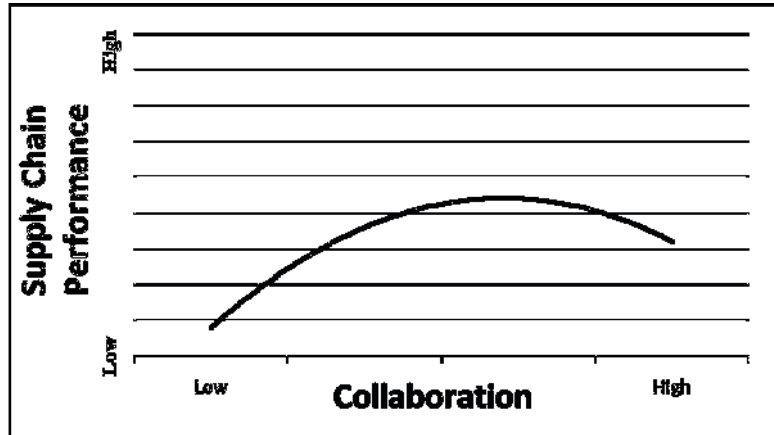


Figure 2 – Hypothesized relationship between Collaboration and Supply Chain Performance

2.4 Supply Chain Agility and Collaboration

Supply chain agility has been defined as, “an externally focused capability that is derived from flexibilities in the supply chain processes” (Swafford, Ghosh, & Murthy, 2006: 172). It is important to note the difference between agility and flexibility. Agility is an outwardly focused capability, while flexibility is an inwardly focused competency. This perspective of a capability being derived from a competency is consistent with the strategy literature (Prahalad & Hamel, 1990; Roth & Jackson, 1995; Teece, Pisani, & Shuen, 1997).

Prior research indicates that flexibility comprises four elements: range-number, range-heterogeneity, mobility and uniformity (Koste & Malhotra, 1999; Koste, Malhotra, & Sharma, 2004; Slack, 1983, 1987). Swafford et al., (2006) reduced the number of dimensions from four as described by Koste et al., (2004) to two dimensions to measure manufacturing flexibility. Swafford et al., (2006) focused on range as it relates to existing resources as their first dimension. Their second dimension was adaptability, the ability to change within a given state (Swafford et al., 2006). Manufacturing flexibility and sourcing flexibility were then measured on these two dimensions (range and adaptability) and empirically supported as antecedents to supply chain agility (Swafford et al., 2006).

Supply chain agility is a measure of how rapidly the supply chain can respond. (Swafford et al., 2006). This measure is unique from the supply chain performance measure as the supply chain performance measure captures the level of attainment of supply chain performance outcomes. Supply chain agility is a measure of the supply chain responsiveness capability (the speed), not the supply chain performance capability (Swafford et al., 2006).

While an increase in supply chain collaboration is generally expected to have a positive effect on supply chain performance, introducing supply chain agility into the relationship increases the opportunity for firms to take advantage of the benefits of collaboration and improve the supply chain's performance.

Hypothesis 3a: Higher levels of supply chain agility will positively moderate the collaboration and supply chain performance relationship.

Hypothesis 3b: The "tipping" point influence will be delayed in the collaboration and supply chain performance relationship.

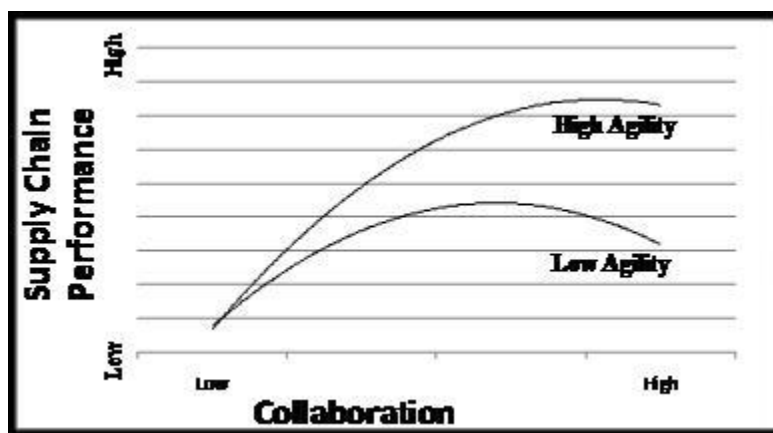


Figure 3 – Hypothesized moderating effect of Agility on the relationship between Collaboration and Supply Chain Performance

3. Method

3.1 Unit of Analysis

The constructs in this study (collaboration, uncertainty, supply chain performance, and supply chain agility) focus on the supply chain and its environment. The core of supply chain is the relationship between the buyer and the supplier firms (Chen et al., 2004a), therefore, the unit

of analysis for this study is the dyadic relationship between the buyer and the supplier. In this study, survey participants will be asked to respond to the survey questions based upon their business unit and its buyer-supplier relationships. In the field of operations management, surveying buying firms' top purchasing and supply management executives to study the buyer-supplier relationship has been widely practiced (Bozarth, Handfield, & Das, 1998; Carr & Pearson, 1999; Chen et al., 2004a; Hartley, Zirger, & Kamath, 1997; Krause, 1999; Shin, Collier, & Wilson, 2000; Tan, Lyman, & Wisner, 2002).

3.2 Measures

Each of the scales to measure the four constructs (environmental uncertainty, collaboration level, supply chain performance, and supply chain agility) will be derived from existing literature. Modifications are expected to be made to each scale in order to fit the context of the current study.

As previously stated, Chen and Paulraj (2004a) identified three sources of environmental uncertainty: supply uncertainty, demand uncertainty and technology uncertainty. Appendix A details the factors, items and Likert scale that Chen and Paulraj (2004a) found to meet established criteria for internal consistency, construct validity, unidimensionality, criterion related validity and discriminant validity. The scale to measure environmental uncertainty in our study will be adapted from the one shown in Appendix A. Currently, there are only two items underlying the measurement for supply uncertainty. Our survey will include additional items in an effort to strengthen the reliability and validity of the supply uncertainty measurement.

This study will utilize the index Simatupang and Sridharan (2005) developed to measure supply chain collaboration which is based on information sharing, decision synchronization, and incentive alignment between buyers and their suppliers. Appendix B details the factors, items and Likert scale from Simatupang and Sridharan's (2005) Collaboration Index.

Chen and Paulraj (2004a) developed a Supply Chain Performance Measurement Scale based on three factors: (1) Supplier operational performance; (2) Buyer operational performance; and (3) Buyer financial performance. Appendix C details the factors, items and Likert scale that Chen and Paulraj (2004a) developed to measure supply chain performance. Adaptations to this scale for this study will include modifying the seven-point Likert scale which utilized end points of “decreased significantly” and “increased significantly”. Chen and Paulraj’s (2004a) article does not provide the specific context that this Likert scale was utilized. The Likert scale will be modified to a seven-point scale with end points of “strongly disagree” and “strongly agree”. In the case of supplier operational performance the items will be restated to coordinate with the revised anchors. As an example, volume flexibility will be restated in the survey as, “Our suppliers provide a high degree of volume flexibility.” The items for buyer operational performance and buyer financial performance will be restated to indicate, “Our business unit leads our major competitors in ...” The survey respondent will be asked to indicate his or her business unit’s operational performance and financial performance relative to their major competitors’ performance.

Swafford, Ghosh, and Murthy (2006) developed a Supply Chain Agility Measurement Scale. Appendix D details the factors, items and scale they developed to measure agility. Sourcing flexibility and manufacturing flexibility have been shown to be antecedents to supply chain agility (Swafford et al., 2006). Incorporating the measurements for manufacturing and sourcing flexibility would generate thirty-one additional items on the survey. Due to the length of the survey, we have elected to measure only supply chain agility and build on Swafford, Ghosh, and Murthy’s (2006) research which identifies manufacturing and sourcing flexibility as antecedents to supply chain agility.

3.3 Data Collection

A multi-page questionnaire will be utilized to measure the environmental uncertainties, level of collaboration, supply chain performance, and supply chain agility between a buyer and supplier firms. Similar to Chen and Paulraj (2004), the target sampling frame will be members of the Institute for Supply Management (ISM) drawn from firms covered under the two-digit SIC codes between 34 and 39. Respondent titles are expected to range from vice president of purchasing, materials management, and supply chain management or director/manager of purchasing and material management.

The survey will utilize several techniques to motivate respondents (Dillman, 1978). The survey will be accompanied by a cover letter explaining the intentions of the study and the contributions it makes to supply chain collaboration research. All respondents will be guaranteed anonymity and a summary report of the results in exchange for their participation will be offered. Finally, a pre-addressed stamped envelope will be provided to encourage the respondents to complete and return the questionnaire. Those respondents not returning their survey within four weeks will be mailed a reminder letter and another copy of the questionnaire.

3.4 Reliability and Validity

A pilot test of the measurement instrument will be conducted with a panel of academicians and industry experts. The measurement items will be refined and improved based upon the feedback from the panel. The pilot test and the feedback from the panel will contribute to enhanced content validity.

Once the data have been collected, the constructs and their associated items will be analyzed through the continuous improvement cycle as depicted by Chen and Paulraj (2004a). The first stage identified by Chen and Paulraj (2004a) draws upon Flynn, Schroeder and Sakakibara's (1994) three-step approach for testing internal consistency using Cronbach's alpha.

First in this approach, constructs are accepted if the Cronbach's alpha value is greater than 0.7. Second, other constructs with a Cronbach's alpha value of at least 0.6 will be evaluated for possible improvement. Items within the construct that contribute the least to internal consistency will be reviewed for possible elimination. The item inter-correlation matrix will be utilized to determine the items that contribute the least and thus would be the best candidates for deletion. Third, other constructs with a Cronbach's alpha value of below 0.6 will be evaluated in a similar manner. Constructs failing to achieve a Cronbach's alpha value of at least 0.6 will be discarded.

The second stage identified by Chen and Paulraj (2004a) involves testing for construct validity using exploratory factor analysis using principal component analysis. Items that do not load on the factor they intended to measure, but on factors they did not intend to measure, will be deleted from consideration (Chen et al., 2004a).

The final stage identified by Chen and Paulraj (2004a) involves using confirmatory factor analysis in evaluating unidimensionality and construct validity. LISEREL measurement models will be evaluated. Those measurement models that have a proportion of variance (R^2) less than .30 will be eliminated from further consideration. Chen and Paulraj's (2004a) three-stage continuous improvement process will be repeated until the theoretical constructs exhibit acceptable levels of reliability, validity, and unidimensionality. If the construct measures meet the established criteria, we will continue on to test the data for the hypothesized relationships.

3.5 Hypotheses Testing

The unit of analysis will be the supply chain dyadic relationship between a manufacturing firm and an associated supplier. The hypotheses will be tested through appropriate multivariate analysis techniques including multiple regression and structural equation modeling.

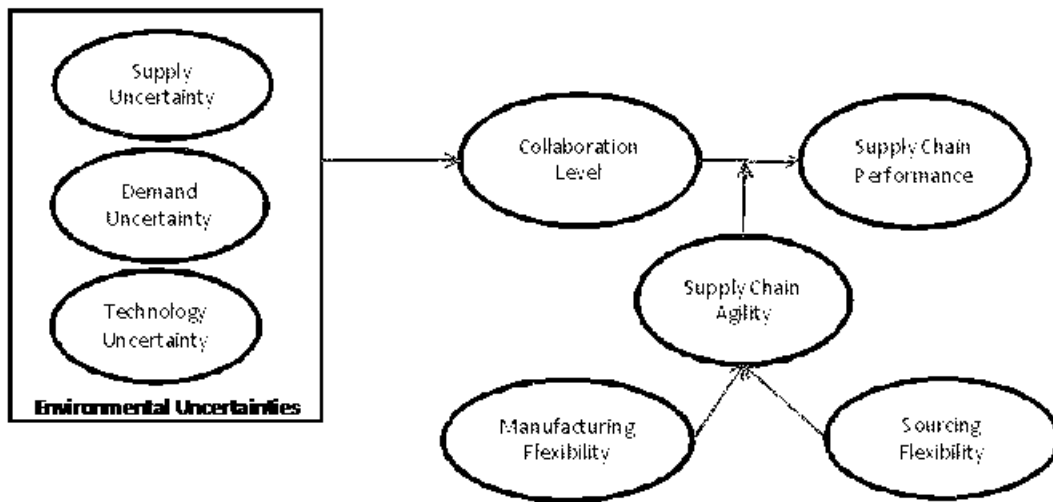


Figure 4 – Research Model

4.0 Discussion

A review of the supply chain collaboration literature revealed that while the “potential” benefits from collaboration cited in the literature outnumber the “potential” risks cited in the literature, supply chain collaboration has not always lived up to its expectations (Bowersox, Closs, & Stank, 1999; Sabath et al., 2002). One of the challenges with supply chain collaboration is determining the appropriate partners for collaboration (Barratt, 2004; Sabath et al., 2002). This study suggests collaboration provides greater benefits to the supply chain when environmental uncertainties exist and an agile supply chain is present.

The authors propose that when environmental uncertainties exist, collaboration increases to offset the effect of the uncertain environment. Additionally, the increased collaboration generally has a positive effect on the supply chain performance. However, at a certain point, further collaboration ceases to generate benefits for the supply chain. When an agile supply chain is present, the benefits from collaboration are further amplified and generate a positive effect on supply chain performance. Furthermore, through the scale development and refinement process, this research is also expected to strengthen and improve the constructs measured in the

model: environmental uncertainties; collaboration level; supply chain agility; and supply chain performance.

4.1 Managerial Implications

This research will assist practitioners in discerning situations in which collaboration will generate greater benefits to the supply chain. When firms in a supply chain are experiencing an uncertain environment and are collaborating, their supply chain performance is expected to be greater than the supply chain performance of their competitors.

This research also addresses how supply chain agility moderates the effect of collaboration on supply chain performance. Agility is an outwardly focused capability, while flexibility is an inwardly focused competency. If as suspected, agility positively moderates the effect of collaboration on supply chain performance, practitioners will be able to develop a more agile supply chain by understanding how different flexibilities influence the agility of the supply chain and developing their supply chain accordingly.

4.2 Limitations

The generalizability of this study will extend only to those firms who are represented by the ISM database and the selected SIC codes. Further studies should expand the scope to a wider range of firms. Another limitation of this study derives from the collection of the manufacturer-retailer dyadic relationship information. The information will be collected from the manufacturer only to simplify the data collection. The positions of the respondents, as well as steps in collecting data and analyses argue against serious effects of bias and common method variance (Swink, Narasimhan, & Wang, 2007). Future research should consider utilizing matched pairs from both the buyer and supplier to allow for a cross-check of the data. Ideally, this data would also be collected from multiple respondents at both the manufacturer and the retailer to further increase the validity of the data.

5. Conclusion

Modern competition is being fought “supply chain versus supply chain” rather than “firm versus firm” (Boyer, Frohlich, & Hult, 2005; Ketchen & Guinipero, 2004; Ketchen & Hult, 2007). This shift of focus from individual firms competing to supply chains competing has been one of the most significant paradigm shifts in business management (Chen et al., 2004a; Lambert & Cooper, 2000). Some authors have shown that collaboration efforts have improved supply chain performance while others posit that efforts to collaborate between firms are not always successful (Simatupang et al., 2002; Whipple, 2007).

This research is expected to support the contention that in the presence of uncertain environments, supply chain collaboration is generally expected to have a positive effect on supply chain performance until the relationship reaches its “tipping” point where further collaboration consumes resources that would be better spent elsewhere. Furthermore, this research will empirically test for a moderating effect between supply chain collaboration and supply chain performance due to supply chain agility. It is expected that an agile supply chain will be better positioned to take advantage of collaboration efforts and will improve supply chain performance over and above the unmoderated relationship.

Supply chain agility is a relatively new concept within the supply chain literature. There will be a need to delve further into what other flexibilities or factors influence supply chain agility. Further understanding the contextual background (industry, culture, etc) that may influence the effect of collaboration and supply chain agility on supply chain performance will further contribute to the supply chain literature. Future research should also explore how the “tipping” point between collaboration efforts and supply chain performance is defined and what factors may influence its position.

Appendix A – Chen and Paulraj (2004) - Environmental Uncertainties Measurement Scale

Environmental Uncertainties Measurement
<i>A seven-point Likert scale with end points of "strongly disagree" and "strongly agree" was used to measure the items.</i>
1. Supply uncertainty
The suppliers consistently meet our requirements
The suppliers produce materials with consistent quality
2. Demand uncertainty
Our master production schedule has a high percentage of variation in demand.
Our demand fluctuates drastically from week to week
Our supply requirements vary drastically from week to week
3. Technology uncertainty
Our industry is characterized by rapidly changing technology
If we don't keep up with changes in technology, it will be difficult for us to remain competitive
The rate of process obsolescence is high in our industry
The production technology changes frequently and sufficiently

Appendix B – Simatupang and Sridharan (2005) - Collaboration Level Measurement Scale

Collaboration Scale
<i>A seven-point Likert scale with end points of "strongly disagree" and "strongly agree" was used to measure the items.</i>
Our business unit consistently shares the following information with our suppliers:
1. Promotional events
2. Demand forecast
3. Points of sale (POS) data
4. Price changes
5. Inventory holding costs
6. On-hand inventory levels
7. Inventory Policy
8. Supply disruptions
9. Order status or order tracking
10. Delivery schedules
Our business unit consistently incorporates our suppliers input to:
1. Jointly plan on product assortment
2. Jointly plan on promotional events
3. Jointly develop demand forecasts
4. Jointly resolve forecast exceptions
5. Consult on pricing policy
6. Jointly decide on availability level
7. Jointly decide on inventory requirements
8. Jointly decide on optimal order quantity
9. Jointly resolve order exceptions
Our business unit consistently :
1. Joint frequent shopper programs
2. Shared saving on reduced inventory costs
3. Delivery guarantee for a peak demand
4. Allowance for product defects
5. Subsidies for retail price markdowns
6. Agreements on order changes

Appendix C – Chen and Paulraj (2004) - Supply Chain Performance Measurement Scale

Supply Chain Performance Measurement	
<i>A seven-point Likert scale with end points of "decreased significantly" and "increased significantly" was used to measure the items.</i>	
1. Supplier operational performance	
	Volume flexibility
	Scheduling flexibility
	On-time delivery
	Delivery reliability and consistency
	Quality
	Cost
2. Buyer Operational performance	
	Volume flexibility
	Delivery speed
	Delivery reliability/dependability
	Product conformance to specifications
	Cost
	Rapid confirmation of customer orders
	Rapid handling of customer complaints
	Customer satisfaction
3. Buyer financial performance	
	Return on investment
	Profits as a percent of sales
	Firm's net income tax before tax
	Present value of the firm

**Appendix D – Swafford, Ghosh, and Murthy (2006) -
Supply Chain Agility Measurement Scale**

Supply Chain Agility
<i>A five-point scale with endpoints of slow and fast was used to measure the items.</i>
1. Reduce manufacturing leadtimes
2. Reduce product development cycle time
3. Increase frequency of new product introductions
4. Increase level of customization
5. Adjust worldwide delivery capacity/capability
6. Improve level of customer service
7. Improve delivery reliability
8. Improve responsiveness to changing market needs

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