International Journal of Economics, Business and Management Studies
e-ISSN: 2304-6945/p-ISSN: 2226-4809
Vol. 2, No.2 (2013) 62-74
Indexing and Abstracting: Ulrich's - Global Serials Directory

Supply Chain Integration and Information Technology

Rakesh Singh
Durgadevi Saraf Institute of Management Studies, India
Email: director@dsims.org.in

Vaidy Jayraman
University of Miami, USA

Abstract

The paper reports on a study which analyzes relationships between information technology and performance of Supply Chains. The two main barriers faced in Supply Chain are Management of Inventory and the timely delivery of goods to meet the demand of customers. Hence, the performance of Supply chain is measured by the impact on the inventory turnover and lead time of goods. The transparency of demand across the Supply Chain i.e. the product visibility across the Supply Chain would lead to improvement of the performance was the expectation set by this study. Facts on the basis of responses from Industry propose that Product Visibility results in improvement of lead time of the Supply Chain. The study also shows that certain sectors, primarily FMCG goods Industry are in the forefront in using Information Technology to improve their Supply Chain. However, an important outcome of the study has been the resistance observed in the industry in implementation of technology infrastructure. Since the study is based on survey methods, the perceptions of the respondents reflect the lack of confidence in Information Technology in improving the demand visibility and hence the inventory position of Supply Chain partners.

Keywords: Information technology; supply chain; product visibility.

1. Introduction

The earliest and most pioneering work in the field of integrated supply chains was done by Forrester (1961). Over the years, numerous studies have followed on similar lines mostly on theoretical models to prove that poor Supply chain integration results in the “Bull whip” effect or the sequential build up of inventories right from the downstream partners to up the Supply chain. Quite the opposite happens with an integrated Supply chain. With the advent of Information technology in the form of Internet, seamless integration has become very common. The main need for IT results from the following characteristics businesses have acquired since the 90s (Liljenberg, 1996) which includes (i) customer expectations are rising, (ii) complex businesses are relying on skills and knowledge of people increasingly and (iii) power of IT lies in the heart of businesses. All these consequences require the modern businesses to stay closer to the customer to be proactive in satisfying his needs.

As planning instability grows backwards up the supply chain, controlling errors with the downstream partners becomes very important. The more integrated the flow of data between channel partners, the easier it is to balance the supply and demand across the entire network. An important trend in that direction is the use of internet for Supply chain integration. Pre- internet, real time demand information and inventory visibility were impossible to achieve. This has changed in the internet era and widely available web based technologies allow strong customer and supplier integration for inventory planning, demand forecasting, order scheduling and customer relationship management.

The basic notion of channel design is that efficiency can be improved sharing information among agents and plan jointly rather than distinctly (Raghunathan, 2001). In terms of relationships between manufacturers and distributors (retailers-wholesalers-distributors), in order to implement coordinating mechanisms and this attain greater efficiency in supply chain management, the partners must share information, for a number of reasons, including the following as mentioned by Cachon and Fisher (2000).

- The mechanisms allow the manufacturers to understand each customer's specific aspects and address them in a distinct manner, adding value (through services, for example) to the line of products
- Characteristics such as segmentation of the points-of-sales and types of customers along the supply chain should be taken into account, especially in decisions to launch new products and in dealing with each store's mix.

There are five innovative technologies which have had significant impact on supply chain integration seamlessly: Electronic data interchange (EDI), personal computers, artificial intelligence, communications systems, bar codes and scanners.

Greater Supply-chain visibility, as well as more accurate and timely information about supply-chain execution, allows for reduced safety stocks (thus optimizing cash-to-cash cycles and reducing inventory carrying cost) and increased on-time performance to customer commitments (thus driving additional revenue opportunities). Operating cost improves, as RFID (Radio Frequency Identification) significantly reduces the cost of cycle counting, receiving, picking and shipping.

2. Literature review

Supply chain consists of suppliers/vendors, manufacturers, distributors and retailers interconnected by transportation, information and financial infrastructure. The supply chain's objective is to provide value to the end consumer in terms of products and services and for each channel participant to garner a profit in doing so (Funda & Robinson, 2002). The last part of the definition talks of profit for channel members. With exhaustion of practices to cut down on Production and manufacturing costs and seamless integration of systems across channel partners, the new mode of efficiency improvements is through the Supply chain. Consequently it becomes essential to measure the improvements attained in Supply chain. The two main barriers faced in Supply chain are management of Inventory and the timely delivery of goods to meet the demand of customers. Hence, we define the success of a Supply chain using certain metrics which measure the performance of a Supply chain. The performance metrics of internet-enabled Supply Chains can be of two types. The first set includes the delivery times, the inventory turns and transaction costs. The second metric is the percentage of incoming procurement and outgoing finished goods transacted over the internet.

2.1Information technology and supply chain visibility

Supply chain is a linked set of resources and processes that begins with the sourcing of raw materials and extends through the delivery of end items to the final customer (Bridgefeld Group ERP/Supply Chain Glossary, 2004). While the separation of supply chain activities among different companies enables specialization and economies of scale, there are many important issues and problems that need to be resolved for successful SC operation – this is the main purpose of SCM.

According to the definition of SCM by the Global Supply Chain Forum (GSCF), SCM is ''the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customer and other stakeholders'' (Chan & Qi, 2003). We can only talk about SCM, if there is a proactive relationship between a buyer and supplier and the integration is across the whole supply chain, not just first-tier suppliers (Cox, 2004). There are several important problems in SCM that need to be resolved for efficient operation. Most of those problems stem either from uncertainties or inability to coordinate several activities and partners (Turban et al., 2004).

One of the most common problems in supply chains is the bullwhip effect. Even small fluctuations in the demand or inventory levels of the final company in the chain are propagated and enlarged throughout the chain. Because each company in the chain has incomplete information about the needs of others, it has to respond with the disproportional increase in inventory levels and consequently even larger fluctuation in its demand to others down the chain (Forrester, 1961). There are many practical examples from various industries that support this finding (see e. g. Jones & Simons (2000) for an example of food industry or Naim et al. (2002) for automotive sector). It was shown however that the production peak could be reduced from 45% to 26% by transmitting the information directly from the customer to the manufacturer (Forrester, 1961; Holweg & Bicheno, 2002).

Another problem is that the companies often tend to optimize their own performance, disregarding the benefits of a supply chain as a whole (local instead of global optimization). Additionally, human factors should also be studied: decision-makers at various points in the supply chain are usually not making perfect decisions (due to the lack of information or their personal hindrances). Those two problems are also interconnected as employee reward systems often focus simply on growing sales or on gross margins (McGuffog & Wadsley, 1999).

Over a period of time, there has been increase in the IT investments of various companies across various industries and a major portion of which has been in the Supply chain domain. Integrated control of Multi Company networks have been postulated to offer significant benefits (Cooper et al. 1997; Burgess, 1998; Leeuw et al. 1999). The utilization of information technology (IT), in turn, is considered an imperative requirement for managing these networks, and has been associated with significant supply chain efficiency improvements (Lee & Billington, 1992; White & Pearson, 2001). Studies conducted on small scale supply chains have broadly been conducted on two lines, one of two-echelon supply chains with one product, Gavirneni et al. (1999), Lee et al (2000) and Raghunathan (2001) and the other being on a model which consists of four echelons Evans et al. (1993). These studies show that the sharing of demand information in supply chains increases the performance of the supply chain by increasing availability and reducing inventory related costs (Evans et al. 1993; Gavirneni et al. 1999; Cachon & Fisher, 2000; Lee et al., 2000).

E-business can be defined as the term covering both e-commerce (buying and selling online) and the restructuring of business processes to make the best use of digital technologies. Internet and e-business offer many possibilities for effective information sharing that enable seamless flow of transactions in the supply chain. They can also facilitate relationships by their ability to transfer information (Wagner et al., 2003). Newly developed relationships can drastically change the underlying business processes and different new approaches are emerging, such as vendor managed inventory (VMI), computerized point-of-sale (POS) systems, material requirements planning (MRP), manufacturing resource planning (MRP II) etc. (see Turban et al., 2004 for more details).

However it should be noted that information technology alone is not a panacea for all SC problems. Even more: the most often quoted problems of online purchasing are not related to technology but rather to logistic and supply chain problems (Hoek, 2001). This is even truer for traditional companies that are usually even less prepared for new e-commerce related challenges. The efficiency of supply chains can generally be improved by e.g. reducing the number of manufacturing stages, reducing lead-times, working interactively rather than independently between stages, and speeding up the information flow (Persson & Olhager, 2002). It was shown that electronic data interchange (EDI) could reduce swings in inventory and safety stock levels. The simulation results showed that (among other improvements) the standard deviation of the stock level was reduced from 749 to 272 tons, leading to 400,000 $ annual savings (Owens & Levary, 2002).

The benefits of information sharing have been proposed to depend on the predictability of demand. Information sharing seems to be of greater value in situations with unknown demand, for example, early sales of new products or promotion situations. Also, the proposed information sharing can be less beneficial in situations where demand is predictable, and where past demand can be used to form a reasonably accurate demand forecast. Another interesting finding which comes our way in this regard is that the benefits of IT use are more due to positive effects of IT on transaction processing efficiency potentially leading to shorted lead times and smaller batch sizes than to sharing of inventory and demand information. However, Evans et al. (1993), in turn, maintains that the feeding of actual demand information forward in the supply chain provides greater benefits than lead time reductions.

The following papers show how sharing demand and inventory data can improve the supplier's order quantity decisions in models with known and stationary retailer demand: Bourland et al. (1996), Chen (1997), Gavirneni et al. (1999). Lee et al. (2000) use shared information to improve the supplier's order quantity decisions in a serial system with a known autoregressive demand process. Liljenberg (1996) studies how to use shared information to improve the supplier's allocation of inventory among the retailers.

The factors in the organization contributing to the product visibility would be the extent of implementation of the following practices:

- Advanced planning and scheduling
- Bar coding
- Computer aided design(If manufacturing enterprise)
- Computer integrated manufacturing (If manufacturing enterprise)
- Computerized maintenance management
- Enterprise resource Planning(ERP)
- Forecast/demand management software
- Manufacturing execution systems
- MRPII
- Product data management
- Transportation management systems

2.2Lead time and product/supply chain visibility

As a result of the focus on fast response to customers in many markets, lead-time reduction has been a common focus for performance improvement efforts (Treville et al., 2004). Lead time can be measured in a number of ways, including manufacturing lead time (Jayaram et al., 1999) and customer lead time (Duenyas & Hopp, 1995). Customer lead time is defined as "the time elapsed from receipt of an order until the finished product is either shipped or delivered to the customer" (IndustryWeek's Census Glossary, 1999).

2.2.1IT integration and lead-time reduction

There is positive belief that there exists a relationship between IT integration and Lead time (Devaraj & Kohli, 2003). Studies done, in this regard conclude investments in IT lead to improved performance (Small, 1999; McAfee, 2002). In fact, reducing lead times has been cited as an important reason for adopting IT integration programs (Attaran, 1989; Schlie & Goldhar, 1995; McAfee, 2002). Because key differences exist between internal (within-firm) and external (between-firm) information systems integration (Bergeron & Raymond, 1992), we discuss them separately. However, integration of IT has been classified based on whether the process is done internally or externally.

2.2.2Internal IT integration

Internal Integration is defined as the process of connecting different function in a firm such as manufacturing, purchasing and materials management (Ward & Zhou, 2006). For example, ERP systems are a form of internal integration of processes (Davenport, 1998). Furthermore, these information systems aid in generating information and facilitating information sharing within the firm which can enhance a firm's production capabilities (e.g., Schlie & Goldhar, 1995; Small, 1999).

2.2.3External IT integration

External integration refers to information systems that connect a firm with its suppliers and customers (Ward & Zhou, 2006). IT integration with suppliers and customer has been found to impact firm performance positively Frohlich (2002) and Subramani (2004). There are other studies too, which suggest that IT integration contributes to reduction of Lead times. Lead time in a supply chain is classified as material movement Lead time and information movement Lead time (Jones & Towill, 1999). The supply chain thus developed is called Information enriched Supply chain. In an information-enriched supply chain, firms are more closely connected both internally and externally because of information sharing resulting in reduced information lead time and reduced total lead time in a supply chain. Another impact of External IT integration has been found to be the decision making process time. Data integration serves to make the data available in a standard format which is understandable to all the stakeholders (Galbraith, 1973). At the same time insufficient data integration leads to delays, decreases in communication and greater distortion of meaning (Huber, 1982). Between-firm integration aids supply chain partners in reaching joint decisions by facilitating information exchange, recollection, and standardization (Dennis, 1996).

Analytical studies provide evidence that between-firm IT integration reduces lead time. Cachon and Fisher (2000) find that sharing demand and inventory data can shorten the order processing lead time. Lee et al. (2000) study information sharing in a two-level supply chain and show that sharing the current demand variation information leads to significant inventory reduction, which is generally associated with reduced lead times. While, the performance enhancement through inventory reductions has been explored in most of the works, the impact on Lead time is not of particular interest. This study aims at focusing on the impact Information technology and consequently Supply chain visibility will have on Lead time, the reason being the need of Supply chain to manage the demand of products. Inventory reductions improve the costs of the channel partners; however, the increase in customer coverage occurs only through demand fulfillment and demand generation. Hence, this study hypothesizes that,

> H_1: Product visibility will reduce the Lead time of an organization and consequently improve the Supply chain performance.

2.3Product visibility and inventory turnover

Demand volatility is the key problem facing most supply chains, eroding both customer service and product revenues. Ordering patterns may be aggravated by demand (Waller et al., 1999) uncertainty in general, conflicting performance measures, planning calendars used by buyers, buyers acting in isolation, and product shortages that cause order inflation. And thus inventory management has to account for such variation of demand at the same time optimizing the inventory levels to drive down costs to the organization. Waller et al. (1999) explain various strategies viz. Automatic replenishment programs such as continuous replenishment planning, efficient consumer response, quick response and vendor managed inventory which involve information sharing among channel partners. They also explain of the importance of information accuracy and delay as important factors for the success of a vendor managed inventory as these are the challenges which can result in increased inventories and hence lesser inventory turnovers which indirectly affect the holding costs.

According to a survey Friedman (2001) nearly three quarters of the retailers surveyed choose to share information with their vendors to improve inventory management; 28% are not providing information and may be content to manage their inventory alone. Among the companies that choose to share information with vendors, just over one third share between three and five types of information-sales, inventory, sales forecast, margin, and by store. Also, compared to last year's survey, the percentage of retailers sharing margin information has increased from 25% to 33%. Not only are more retailers recognizing the importance of sharing margin information, nearly 60% believe that they achieved higher profit margins from their merchandise vendor base last year-good news in an otherwise gloomy retail environment.

The most common method of sharing information with vendors is the telephone (82%), followed by fax (77%) and email (70%), EDI (38%), Internet (29%), and systems integration (23%). It's not surprising that the respondents continue to rely on phone, fax, and e-mail to do business with the small number (less than 30) of their key vendors. The larger retailers in the survey (greater than $500 million in sales) are more likely to communicate with their vendors using EDI (52%) or integrated systems (32%).

Certain works have analyzed the effect of information sharing on inventory management (Cachon & Fisher 2000). They try to develop an algorithm and model to find out the relationship among them and find that lead time has decreased although the inventory management with respect to demand has not changed. There are also works which explain the development of networked inventory management information systems (NIMIS) (Verwijmeren et al., 1996). According to the same, the driving forces of inventory management are increasing customer requirements, the need for networked organizations and opportunity of networked inventory management. They propose certain systems in light of the same for implementation of NIMISs.

The measurement of Inventory management is mostly through mathematical models which primarily use Safety stock determination through demand variability across the Supply chain partners. Researchers have used two to four echelon models for measuring this variability. However, the impact of information technology on inventory management depends on the amount of comfort/resistance the users (Channel partners' employees) have in the use of the technology. This would in turn result in better usage of technology to improve the visibility of information of channel partners across the supply chain in turn resulting in managing the inventory better. Hence, this study hypothesizes that,

H_2: Product Visibility will have a positive impact on the Inventory Turns.

3. Method

The methodology of establishing the aforementioned hypotheses is by development of a survey tool. This survey tool is in the form of a questionnaire which is administered to a set of respondents who are part of organizations and work with technologies for interaction with the channel partners. The development of the questionnaire involved evaluation of the technologies and methodologies used in the industry for e-integration. Considering the same, a primary focus of the study was to focus on the demand visibility for channel partners. An important strategy in that direction is "Collaborative planning, forecasting and replenishment".

> *"Collaborative Planning, Forecasting, and Replenishment (CPFR) is a concept that aims to enhance supply chain integration by supporting and assisting joint practices. CPFR seeks cooperative management of inventory through joint visibility and replenishment of products throughout the supply chain. Information shared between suppliers and retailers aids in planning and satisfying customer demands through a supportive system of shared information. This allows for continuous updating of inventory and upcoming requirements, making the end-to-end supply chain process more efficient. Efficiency is created through the decrease expenditures for merchandising, inventory, logistics, and transportation across all trading partners". (Source: Wikipedia)*

As earlier researchers have focused on mathematical models for research on performance enhancement of Supply chain, the survey tool method has not been prevalent in practice. There has been a significant research by Gonzaga University in this respect. The survey tool is based on a tool developed by the university's academicians. With questions based on the uses, implementation of CPFR, the questionnaire reflects the importance of Information Technology in enhancing the Supply chain.

This data was administered to a mix of respondents from Industry and academicians. The sample size for the study was thirty. GlaxoSmithKline consumer health care and Marico Industries were two of the organizations mainly involved in this study from whose employees a major chunk of the industry related response was elicited.

There have been several studies as mentioned in the literature review, which have relied on mathematical modeling for the analysis of performance enhancement effects of Information technology and Supply chain integration. However, the exact nature of value addition through Information technology is qualitative and cannot be measured only by the investments made on Information technology infrastructure or the types of technologies used in the organization. There have been cases in literature review when authors have mentioned about the widespread view that Information technology has made the functions difficult for the execution and there has been considerable resistance to the same. It has been proven that resistance to implementation of Information technology infrastructure is a major deterrent in improving the performance of Supply chains (Frohlich, 2002). Hence, the instead of using the explicit values of the variables of Study, the data was measured on a 5-point Likert scale from 1- Strongly disagree to 5- Strongly agree. The questions were mainly used to measure the perceived benefits (in the form of inventory turns and Lead time reduction) through the employment of Information technology infrastructure. This would aid in obtaining insight into the prospects of Information technology usage in organizations as the complexity of the Supply chain grows.

The data obtained were fed into SPSS for analysis. The analyses included Chronbach alpha estimation to ascertain the validity of data, the correlation calculation to find any relation between the variables, regression testing to analyze the impact of independent variables on dependent variable and also to analyze any mediation between the variables. The final analysis was to find out if there was any impact on the third variable through a mediating variable. This was done primarily to estimate the impact of "Product visibility" on "Lead time" through the impact "Product visibility" had on "Inventory turnover. The same was carried out for the "Vice versa" case.

4. Results

As mentioned earlier, the two main problems faced by Supply chains are demand uncertainty (Turban et al., 2004) and integration of Supply chain (Cooper et al. 1997; Burgess, 1998; Leeuw et al. 1999). The end result is the Lead time increase and inventory build-up. Product visibility was postulated as a factor to reduce the impact on Lead time and inventory turnover. The first step was to analyze the validity of responses obtained. As the results shown in the tables of Lead Time, Inventory Turnover and Product Visibility (table no. 3, 4, 5), considerably prove that accuracy was obtained for each of the three variables, (0.7 for Inventory turnover, 0.6 for Lead time, and 0.8 for Product visibility).

Table 1 shows the correlations between the three variables in consideration. As the values show, there is a significant influence of "Product visibility" on "Lead time" (sig<0.05). On the other hand "Product visibility" does not have a similar impact on Inventory turnover (sig>0.05). However, there seems to be a relation between the Lead time and Inventory turnover. The mode of impact, reduction of Lead time, would have on Inventory turnover is not very clear. While, there is no mention of this effect in the literature review, this may be an indirect impact of reduction of Lead time, as the number of times the inventory would be replenished may increase. To analyze the same, an analysis was carried out to investigate whether there was a significant impact on inventory turnover due to Lead time and vice versa. The results of the analysis are mentioned in the Figure 2 and 3.

The program tried to analyze the impact of a variable on another through a mediating variable. The same has been depicted in Figure2 and 3. The impact of Lead Time on Inventory turnover and vice versa is ruled out. The results show that the significance level is about 0.17 or 83% confidence interval for the case when "Inventory turnover" is used as a mediating variable and 0.09 with 91% confidence interval for "Lead time" as a mediating variable. Each of these cases doesn't fit the required confidence interval of 95%.

Hence, the next step was to analyze the impact of Product visibility on Inventory turnover and Lead time.

The results show that "Product visibility" does impact Lead time as exhibited by the significance values (sig<0.05). However, the same is not observed about the "Inventory turnover" variable (sig>0.05).

5. Discussion

The results as shown in the previous section show that Product visibility does have a performance enhancing impact. The impact it has on "Lead time" is proven by the significance values (sig<0.05 just about 0.01). However, the other result shows that there is no impact of Lead time on Inventory turnover which is evident from the significance value greater than 0.05 and lesser than the 95% confidence interval. This result is in line with the observations of certain studies done earlier. As mentioned earlier, reducing lead times has been cited as an important reason for adopting IT integration programs (Attaran, 1989; Schlie & Goldhar, 1995; McAfee, 2002).

On the other hand the impact of Product Visibility on Inventory turnover is not very clear. While, the final results show that the significance values are much higher than 0.05 and hence don't fit in the confidence interval. Consequently, the improvement of demand information visibility across the Supply chain does not affect the inventory turnover of the Supply chain. The opposite has been the result of earlier studies based on mathematical models. It was shown that electronic data interchange (EDI) could reduce swings in inventory and safety stock levels. The simulation results of a study (Owens & Levary, 2002) showed that (among other improvements) the standard deviation of the stock level was reduced from 749 to 272 tons, leading to 400,000 $ annual savings. Also, the study on Bullwhip effect (Cachon & Fisher, 2000), shows that there is a considerable decrease in inventory build-up due to the visibility of demand information across the supply chain. The main feature of this study has been the mathematical modeling technique with four echelons built in the Supply chain. Similar models have been used in other studies too (Verwijmeren et al., 1996) to ascertain the performance enhancing effects of demand/product visibility on Inventory turnover.

At the same time the secondary impact of inventory turnover on Lead time due to improvement of "Product visibility" is also ruled out, thus, eliminating any mediation effect (sig>0.05).

Conclusion

The main focus of this study has been improvement of the performance of supply chain. The metrics chosen were Inventory turnover and Lead time. The transparency of supply chain i.e. the product visibility across the supply chain would lead to improvement of the performance was the expectation set by this study. The study proposes that product visibility or transparency of demand across the supply chain results in improvement of lead time of the supply chain. The same has been put forth by earlier works based on Supply chain performance improvement. The result thus, ascertains these stated facts on the basis of responses from Industry. While, there have been widespread awareness and research in this area in US, Europe and other industrially developed nations, Asia has been growing its industries lately with reforms in the economic set up and governance. Hence, the percolation of Supply chain enhancements has taken time to set foot here. However, this study shows that certain sectors, primarily, FMCG goods industry are in the forefront in using technologies primarily Information technology to improve the Supply chain. The use of third party logistics and MIDAS software for vendors and wholesalers and SAP for the company operations by Marico Industries is a case in point. Similarly, the use of PDAs by HUL salesmen to transfer point of sales data to the head office for demand estimation is another example.

On the other hand, the other finding has been that the impact is not adequate of Information technology on Inventory turnover. While, this is in contrast to earlier studies, the same is not evident by the study, the enhancement effects on inventory turnover through Information technology cannot be brushed aside. The usage of technology to develop accurate demand forecasts results in improvement of inventory management (Verwijmeren et al., 1996). However, an important outcome of the study has been the resistance observed in the industry in implementation of technology infrastructure. Since, the study is based on survey methods, the perceptions of the respondents reflect the lack of confidence in Information technology in improving the demand visibility and hence the inventory position of Supply chain partners.

References

Attaran, M. (1989). The automated factory: Justification and implementation. *Business Horizon, 32*(3), 80-86.

Bergeron, F. & Raymond, L. (1992). The advantages of electronic data interchange. *Data Base, 23*(4), 19-31.

Bourland, K. E., Powell, S. G., Pyke, D. F. (1996). Exploiting timely demand information to reduce inventories. *European Journal of Operational Research. 92*(2), 239-253.

Burgess, R. (1998). Avoiding supply chain management failure: lessons from business process re-engineering. *International Journal of Logistics Management, 9*(1), 15-23.

Cachon, G. & Fisher M. (2000). Supply chain inventory management and the value of shared information. *Management Science, 46*(8), 1032-1048.

Chan, F. T. S., Qi, H. J. (2003). An innovative performance measurement method for supply chain management. *Supply Chain Management: An International Journal, 8*(3), 209 -223.

Chen, F. (1997). Optimal policies for multi-echelon inventory problems with batch ordering. *Working paper*, Columbia University, New York.

Cooper, M. C., Lambert, D. M., & Pagh J. D. (1997). Supply chain management: more than a new name for logistics. *International Journal of Logistics Management, 8*(1), 1-13.

Cox, A. (2004). The art of the possible: relationship management in power regimes and supply chains. *Supply Chain Management: An International Journal, 9*(5), 346 - 356.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Business review, 76*(4), 121-131.

Dennis, A. (1996). Information exchange and use in group decision making: You can lead a group to information, but you cannot make it think. *MIS Quarterly, 20*(4), 433-457.

Devaraj, S. & Kohli, R. (2003). Performance impact of information technology: Is actual usage the missing link? *Management Science, 49*(3), 273-289.

Duenyas, I., & Hopp, W. J. (1995). Quoting customer lead times. *Management Science, 41*(1), 43-57.

Evans, C. N., Naim, M. M & Towill, D. R (1993). Dynamic supply chain performance: Chain strategies. *Management Science, 45*(1), 16-24.

Forrester, J. W. (1961). *Industrial Dynamics*. Portland, OR: Productivity Press.

Friedman, L. (2001). *Overview: Inventory management*. Chain Store age, 34.

Frohlich, M. (2002). E-integration in supply chain: Barriers and performance. *Decision Sciences, 33*(4), 537-556.

Funda, S., Robinson. E. P. (2002). Flow Coordination and Information Sharing in Supply Chains: Review, Implications, and Directions for Future Research. *Decision Sciences, 33*(4), 505-536.

Galbraith J. (1973). *Designing complex organizations*. Reading, MA: Addison Wesley.

Gavirneni, S., Kapuscinski, R. & Tayur, S. (1999). Value of information in capacitated supply chains. *Management Science, 45*(1), 16-24.

Hoek, R. (2001). E-supply chains – virtually non-existing. *Supply Chain Management: An International Journal, 6*(1), 21 - 28.

Holweg, M. & Bicheno, J. (2002). Supply chain simulation - a tool for education, enhancement and endeavour. *International Journal of Production Economics, 78*(2), 163-175.

Huber, G. (1982). Organization information systems: Determinants of their performance and behavior. Management Science, 28(2), 138-155.

Industry Week's census Glossary (1999), available from Industry Week

Jayaram, J., Vickery, S. K., & Droge, C. (1999). An empirical study of time based competition in North American automotive suppliers industry. *International Journal of Operation and Production Management, 19*, 1010-1023.

Jones, D. T., & Simons, D. (2000). Future directions for the supply side of ECR. *ECR in the Third Millennium—Academic Perspectives on the Future of Consumer Goods Industry*. ECR Europe, Brussels, 34–40.

Jones, M. R. & Towill D. (1999). Total cycle time compression and the agile supply chain. *International Journal of Production Economics, 62*(1/2), 61-73.

Lee, H. & Billington, C. (1992). Managing supply chain inventory: pitfalls and opportunities. *Sloan Management Review, 33*(3), 65-73.

Lee, H., So K. & Tang C. (2000). The value of information sharing in a two level supply chain. *Management Science, 46*(5), 626-643.

Leeuw, D. S., van Goor, A. R & van Amstel, R. P (1999). The selection of distribution control techniques. *International Journal of Logistics Management, 10*(1), 97-112.

Liljenberg, P. (1996). The value of centralized information in a two-echelon inventory system with stochastic demand. Working paper, Lund University, Lund, Sweden.

McAfee, A. (2002). The impact of enterprise information technology adoption on operation performance: An empirical investigation. *Production and Operations Management, 11*(1), 33-53.

McGuffog, T., & Wadsley, N. (1999). The general principles of value chain management. *Supply Chain Management: An International Journal, 4*(5), 218 - 225.

Naim, M. M., Disney, S. M. & Evans, G. N., (2002), "Minimum reasonable inventory and the bullwhip effect in an automotive enterprise; a "Foresight Vehicle" demonstrator. *SAE Transactions Journal of Materials and Manufacturing, 3*, 196-203.

Owens, S. F., & Levary, R. R. (2002). Evaluating the impact of electronic data interchange on the ingredient supply chain of a food processing company. *Supply Chain Management: An International Journal, 7*(4), 200 - 211.

Persson, J. F. & Olhager, J. (2002). Performance simulation of supply chain designs. *International Journal of Production Economics, 77*(3), 231-245.

Raghunathan, S. (2001). Information sharing in a supply chain: A note on its value when demand is non-stationary. *Management Science, 47*(4), 605-610.

Schlie, T., & Goldhar, J. (1995). Advanced manufacturing and new direction for competitive strategy. *Journal of Business Research, 33*(2), 103-114.

Small, M. (1999). Assessing manufacturing performance: An advanced manufacturing technology portfolio perspective. *Industrial Management and Data Systems, 99*(6), 256-267.

Subramani M. (2004). How do suppliers benefit from information technology use in supply chain relationships? *MIS Quarterly, 28*(1), 45-73.

Treville, S., Shapiro, R. D., & Hameri, A. (2004). From supply chain to demand chain: The role of lead time reduction in improving demand chain performance. *Journal of Operation Management, 21*(6), 613-627.

Turban, E., McLean, E. & Wetherbe, J. (2004). *Information technology for management, transforming organizations in the digital economy.* Hoboken: John Wiley.

Verwijmeren, M., Vlist, P., & Donselaar, K. (1996). Networked inventory management information systems: materializing supply chain management. *International Journal of Physical Distribution & Logistics Management, 26*(6), 16 - 31.

Wagner, B. A. Fillis, I., Johansson, U. (2003). E-business and e-supply strategy in small and medium sized businesses (SMEs). *Supply Chain Management: An International Journal, 8*(4), 343 - 354.

Waller, M., Johnson, M., & Davis, T. (1999). Vendor managed inventory in the retail supply chain. *Journal of Business Logistics, 20*(1), 183-203.

Ward, P., & Zhou, H. (2006). Impact of information technology integration and lead/just-in-time practices on lead time performance. *Decision Sciences Institute, 37*(2), 177.

White, R. & Pearson, J. (2001). JIT, system integration and customer service. *International Journal of Physical Distribution & Logistics Management, 31*(5), 313-333.

Figures and tables

Figure 1: Traditional channel design Representation

Supply Chain for Physical Goods

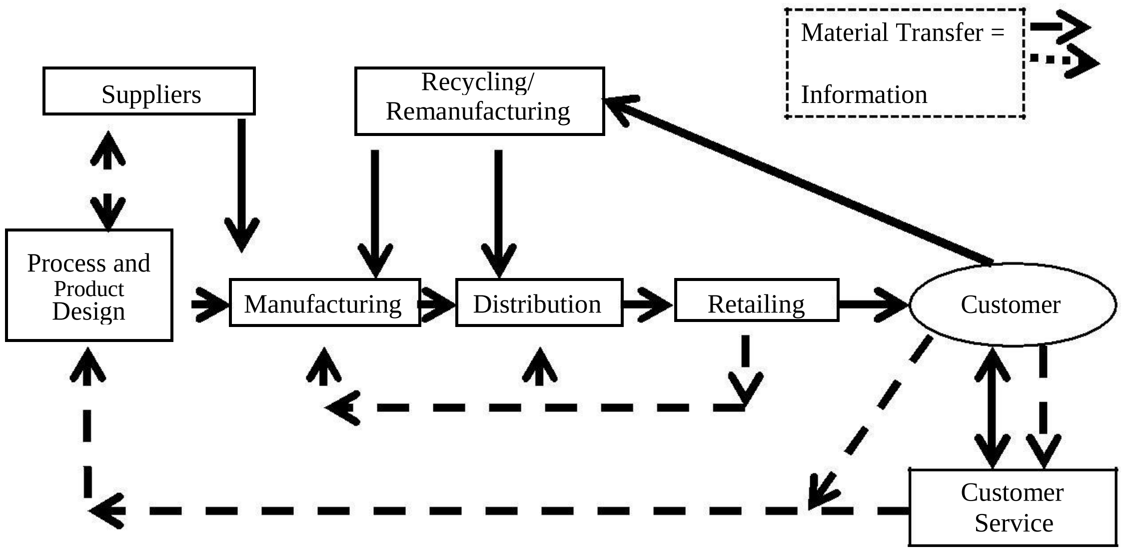

Figure 2: Med graph

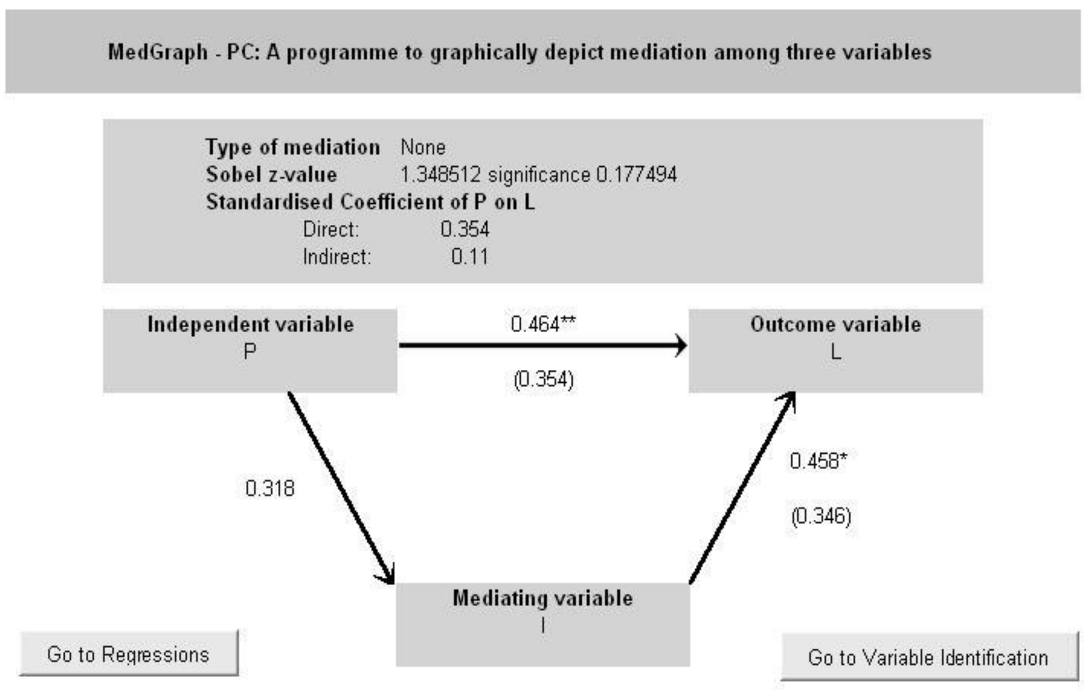

Figure 3: Med graph

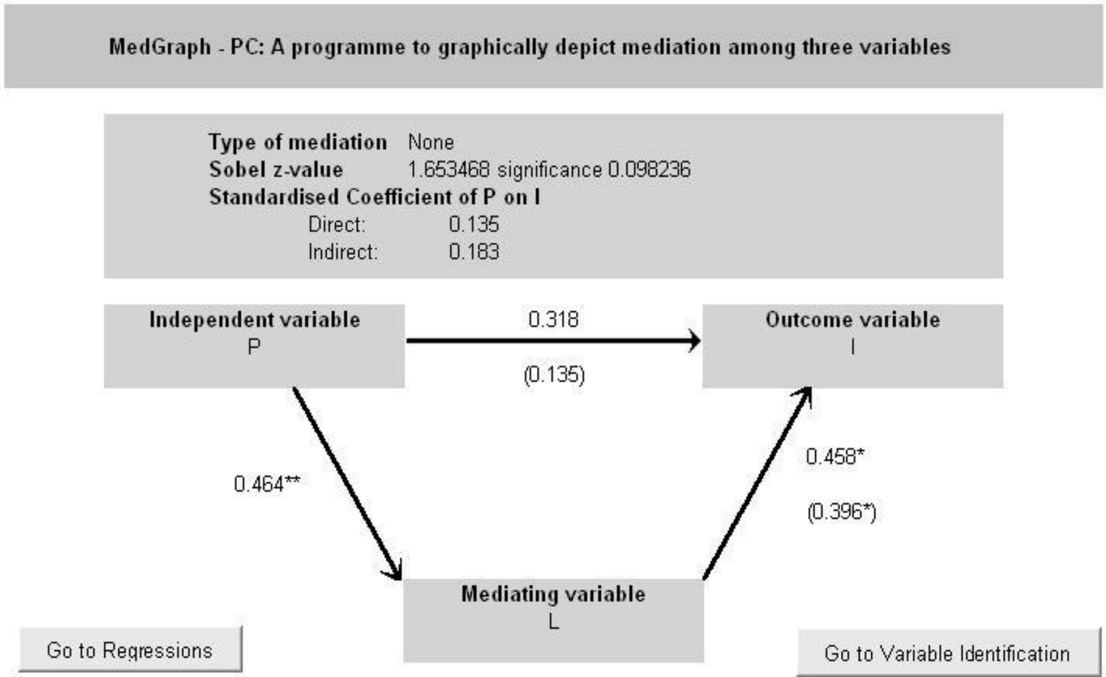

Table 1: Correlation Values

		InvMEAN	LMEAN	PMEAN
InvMEAN	Pearson Correlation	1	.458(*)	.318
	Sig. (2-tailed)		.011	.086
	N	30	30	30
LMEAN	Pearson Correlation	.458(*)	1	.464(**)
	Sig. (2-tailed)	.011		.010
	N	30	30	30
PMEAN	Pearson Correlation	.318	.464(**)	1
	Sig. (2-tailed)	.086	.010	
	N	30	30	30

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 2: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	2.375	1	2.375	7.679	.010(a)
1	Residual	8.660	28	3.09		
	Total	11.035	29			

a Predictors: (Constant), PMEAN

b Dependent Variable: LMEAN

Table 3: Cronbach's alpha values

Variable	Cronbach's Alpha	Items
Lead time	.598	10
Inventory turnover	.705	5
Product visibility	.811	16