ADVANCING THE ADOPTION OF LEAN IN SMES' SUPPLY CHAINS

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ABSTRACT

While traditional lean manufacturing focuses on the activities within a single organization, lean supply chain consists of the same processes, but it views these processes over multiple organizations. This research addresses an important yet under-studied area – lean supply chain management in small organizations, especially small manufacturing firms. The study examines driving factors of lean supply chain management, focus of lean supply chain practices, and major supply chain and information technology solutions applied in these companies. The study has provided important insights into the current status of lean supply chain practices and related implementation issues in small businesses.

Keywords: Lean, Lean manufacturing, Supply Chain Management, Just-in-Time

INTRODUCTION

Lean is a systematic approach to identify and eliminate non-value-added activities or waste through continuous improvement process. The practice of "lean manufacturing" originated from Toyota that used names such as "Just-in-Time" manufacturing or "Toyota production system" (TPS) in the 1950. The main goal of TPS was to reduce costs and improve productivity by eliminating wastes or non-value activities (Womack et al., 1991). Lean is regarded as "continuous flow" to the assembly line process with a focus on cost reduction, quality improvement, and throughput, which is recognized as the most advanced manufacturing process by both practitioners and academicians.

Initial lean efforts were made to reduce wastes within organizations. In the early manufacturing stage, lean initiatives were focused on specific areas and functions within the firm, such as engineering, production, inventory, and quality control. While implementing lean programs and tools in these areas, firms found that close intra-organizational and cross-functional collaborations were necessary and important to the success of lean. As a result, lean efforts were

gradually expanded to full organizations in the process of waste reduction and value creation, aiming to become lean enterprises. Firms are not only required to monitor their internal operations, but their partners' as well so as to achieve lean in the whole process. In fact, as lean evolves from lean manufacturing, to lean enterprise, and eventually to lean supply chain, many organizations have become to realize that optimizing a part of the process is different from optimizing the whole. If real changes were to take place, they had to include their business partners in the supply chain system.

A supply chain is a complex system consists of organizations, people, technology, activities, information and resources. Wastes in the interaction points of these entities and activities are generated. These wastes are resulted from external factors that the manufacturer has less control. The end result of these wastes in the supply chain would be amplified at downstream customer who would experience higher costs or lowered quality of the product. Clearly, there are a limited number of things a single unit can do to eliminate the wastes in the entire system. To effectively remove wastes and gain value, every entity throughout the supply chain must contribute and accept others as its partners.

While traditional lean manufacturing focuses on the activities within a single organization, lean supply chain consists of the same processes, but it views these processes over multiple organizations. Hence, the former is internally focused; the latter is externally focused. With increased competition and customers' requirement, along with the growing trend of globalization, more and more companies are implementing lean in supply chain management. Furthermore, as supply chain system extends, many small (manufacturing) companies become important partners in the system. Small organizations have attempted to implement or have already implemented lean in their practices. Some companies have implemented a few lean tools and techniques, while others have implemented a whole spectrum of lean programs in the supply chain. Therefore, it becomes very difficult to gauge which firm has really embraced the lean philosophy and where it stands in comparison with other organizations.

The lack of research in the area of lean supply chain, especially among small firms motivates us to provide a holistic framework that help to have a better understanding of lean supply chain practice. The objective of this research is to investigate the adaptation of lean supply chain and its current state of practice in small organizations through a research questionnaire.

This rest of article is organized as follows. In the second section, we provide a review of relevant literature about lean and supply chain management and their applications. In the third section, we describe research methodology employed and how it was conducted. Section four is devoted to analyzing lean supply chain by investigating some specific areas such as lean tools and programs, supply chain solutions, and information technology. The final section summarizes the research study and concludes with a discussion of its limitations and future directions.

LITERATURE REVIEW

The well-known Toyota Production System (Ohno 1988) was introduced to the U.S. as lean manufacturing in the 1990s, during which many transformations of traditional manufacturing into the lean approach occurred. Lean practice applies pull production concepts, linking the shop floor to the customer, thereby greatly reducing inventory and lead times. It enables manufacturers to add more value to meet customer requirements while still largely being dependent on standardized processes (Womack et al. 1991). Achanga et al. (2006) argued that the success of lean implementation depends on four critical factors: leadership and management; finance; skills and expertise; and supportive organizational culture of the organization. Other researchers classified the lean tools and techniques based upon the area of implementation – internally and externally oriented lean practices (e.g. Panizzolo, 1998 and Olsen, 2004).

Researchers tend to agree that the concept of lean has evolved from a shop floor waste reduction strategy to an allover continuous improvement strategy, affecting everyone from suppliers to customers in the supply chain. Panizzolo (1998) divided the lean practices into six areas: process and equipment; manufacturing; planning and control; human resources; product design; supplier relationships; and customer relationships. The first four areas are grouped as internal oriented lean practices, whereas supplier relationships and customer relationships are obviously external oriented lean practices.

The change from traditional manufacturing to lean manufacturing and to lean supply chain is not an easy task. While the huge benefits gained from lean implementation are widely recognized, in reality many manufacturing firms have experienced various problems and issues in lean practices (Balle, 2005; Papadopoulou and Ozbayrak, 2005). Womack et al. (1991) investigated the difference between lean and non-lean firms by the number of suppliers they had. They showed that non-lean firms had 67% more suppliers than their lean counterparts. Optimizing and reducing the number of suppliers lead to more reliable sources of materials and supplies. Ansari and Modarress (1988) argued that involving one supplier, rather than many, provides the opportunity for mutually collaborative ventures that otherwise would not be possible.

A growing number of firms have expressed keen interest in jointly forecasting customer demand and co-managing business functions. Such interest sparked the rapid development and implementation of Collaborative Planning, Forecasting and Replenishment (CPFR) that was proven to be successful in minimizing safety stocks, improving order fill rates, increasing sales, and reducing customer response time (Min and Yu, 2008). Various supply chain information systems and technologies such as Enterprise Resource Planning (ERP), Warehouse Management System (WMS), Customer Relationship Management (CRM), e-Procurement, are also employed to facilitate communication and collaboration among organizations.

A company must keep its efforts for an effective communication process at all levels in order to be successful in lean implementation (Puvanasvaran et al., 2009). However, a focus on simply

improving all internal operational processes does not make a firm lean; a focus on those outside the bounds of the direct manufacturing operation needs to be factored in. A lean supply chain identifies all types of wastes in the systems and seeks to eliminate them (Wee and Wu, 2009).

RESEARCH METHODOLOGY

A research questionnaire was developed and distributed to collect related data and information. Our research population is small business in the manufacturing industry. We selected the samples of organizations from various regional chapters of Association for Operations Management (APICS). We found that this selection is both convenient and relevant to our research problems, since APICS is the leader and premier source of the body of knowledge in supply chain and operations management, including production, inventory, materials management, purchasing, and logistics. The association has more than 43,000 individual and corporate members in more than 10,000 companies and its members include managers and owners of many small and medium-sized firms across the nation.

The survey questions were stored in a website for a period of 6 weeks. Then emails that contained a link to the survey website were sent to these respondents to request their participation of the study. The emails and survey were sent to senior management of these companies such as managers, managing directors, vice president of operations, and companies' owners, who should be considered to be the best people that are likely to be the leaders in charge of lean implementations in their supply chains if any.

The research questionnaire included two major parts that cover different interested aspects. The first part of the questionnaire collects the primary information related to the organization and respondent, such as name of the firm, operating locations, type of industries, type of ownership, number of employees, sales data, job title, etc. The background information provided a general picture of the respondents. The second part focused on collecting information about lean practices in supply chains in the respondent companies. Especially, research questions were classified into six areas with a total of 45 elements.

"Motivation of applying lean in supply chain management" is this first area that aims to reveal the triggers for implementing lean in the supply chains. The second area, "Coordination within the organization", investigates the level of communication and collaboration among different functional areas within the firm. The third area, "Supply chain solutions applied", intends to discover SCM programs and methods employed by the firms in the process. The fourth area, "Successfulness of lean SCM", measures the extent of successfulness of lean SCM in the respondents companies. And the last area, "Future SCM/IT plans", deals the future implementation plans of SCM related technology and programs.

These various aspects were evaluated on a Likert type scale. Potential answers were measured with a five-point scale, anchored at, for instance, 5 "strongly agree," 4 "agree," 3 "neutral", 2 "disagree," and 1 "strongly disagree." This design of the survey instrument can also keep it short and help the respondents to answer them in less time. A pilot study was conducted during the survey development process. Lean and supply chain management experts from both industries (3 practitioners) and academics (4 academicians) were consulted. Comments and feedbacks from these experts were generally favorable and some modifications were made to alter and eliminate some variables and improve readability.

Reliability and validity tests were carried out to ensure that the questionnaire is both reliable and valid. Reliability measurement is an indication of the stability and consistency of the instrument applied. Cronbach's Alpha is used to gauge the reliability of the six major areas of the study. Cronbach's Alpha with a minimum value of 0.60 is acceptable, as it is generally agreed that a value of 0.60 is satisfying for exploratory research. Validity test is achieved through principle components test. Kaiser-Meyer-Olkin (KMO) Bartlett's test of sphericity are employed to measure the sampling adequacy. A summary of the reliability and validity test results is provided in Table 1. It is observed that all the results of the six areas have very high internal consistency with Cronbach's Alpha values varying from 0.87 to 0.98, which are significantly greater than the threshold value and hence they are reliable. Also, it is noted that there is one item deleted in the "Motivation of lean SCM" category so as to achieve a satisfying Cronbach's Aphla. In the validity test results, KMO values of the six areas are all exceeding the minimum score of 0.5, demonstrating that all these areas and factors are valid. In addition, Bartlett's test results also show that they are all significant with $p = 0.00$. In summary, it can be concluded that all the areas of interests in the study are reliable and valid, hence suitable for further analysis.

Table 1. Reliability and validity tests

Areas	*Cronbach's Alpha*	*No. of Items*	*Item Deleted*	*KMO Value*	*Bartlett's Test Sig.*
Motivation of lean SCM	0.92	8	1	0.82	0.00
Coordination within the organization	0.92	7	None	0.73	0.00
SCM IT solutions applied	0.93	10	None	0.84	0.00
Successfulness of lean SCM	0.98	14	None	0.90	0.00
Future SCM plans	0.87	6	None	0.70	0.00

FINDINGS AND DISCUSSION

The first area of research interest was the general background information of the small companies involved in this study, including for instance, type of industry, type of ownership, number of locations, number of years of lean implementation, number of employees, and job title of personnel answered the survey. The key descriptive statistics with respect to company profiles is provided in Table 2.

Among the survey respondents, private firms account for 82.4%, while public companies account for 17.6%. In terms of the type of industry of the respondents, 85.3% of the respondent companies are in manufacturing business, such as assembly, metal and chemical goods, electronic components, machinery, and pharmaceuticals. The rest of the respondents are in the service or distribution industry. Obviously, there are more manufacturing firms engaged in lean activities. In terms of operating locations, 91.2% of the respondent firms operate in less than 3 locations, and 8.8% have more than 7 business locations. Apparently, most firms are smaller scale firms that have limited number of business locations.

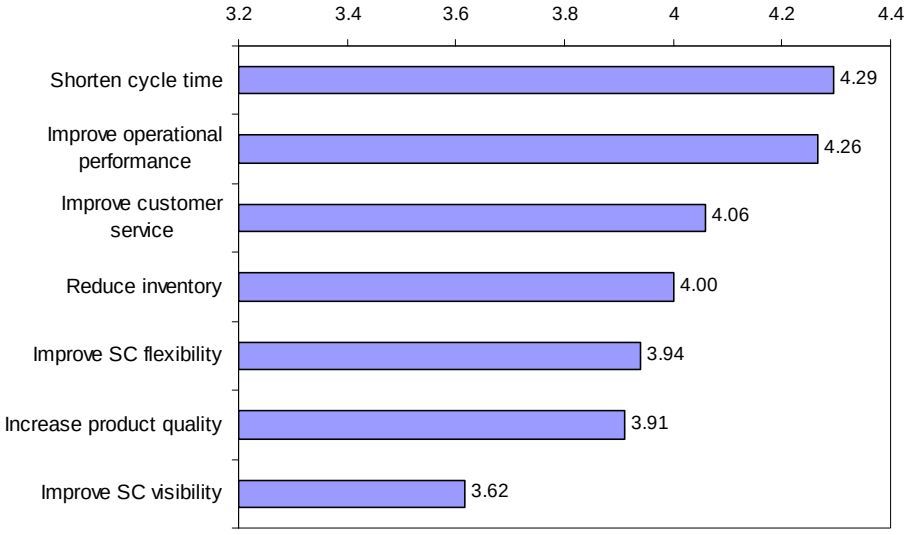
Lastly, we obtained the information with respect to the personnel involved in the survey. As can bee seen in the table, 52.9% of the personnel are managers and executives (such as vice president of operations, chief executive officer, etc.) of the firms. Quality assurance or control personnel account for approximately 21%. Together, these two categories account for more than 70% of the personnel responded the survey. We believe that these respondents have the necessary experience and knowledge of their companies, especially on the implementation of lean and supply chain management and their answers are reliable and helpful to the study.

Table 2. General background of the respondent companies

Type of Ownership	***No. of Companies***	***Percentage***
Private	28	82.4%
Public	6	17.6%
Type of Industry		
Manufacturing	29	85.3%
Service/Distribution	5	14.7%
No. of Operating Locations		
1 – 3	31	91.2%
4 – 6	0	0.0%
>= 7	3	8.8%
Title in the Company		
Manager or Executives	18	52.90%
QA or QC Personnel	7	20.60%
Other	9	26.50%

Understanding the driving factors of applying lean in supply chain is very important and they directly affect lean decision, application and results. To identify primary reasons for small manufacturing firms to apply lean in supply chains, respondents were asked to rate the relative importance of seven elements that are believed to be the driving forces of lean practices in supply chains. The average mean values were computed and presented in Figure 1.

Figure 1. Triggers for applying lean in supply chains



As can be seen in the figure, the top three reasons for applying lean in the respondents' supply chains are: "shorten cycle time", "improve operational performance", and "improve customer service", with mean values of 4.29, 4.26, and 4.06, respectively. Clearly, these factors are all closely related with lean. Especially, it seems that SMEs place high priority on both internal operations and external customers' requirements, which are keys to establishing effective and efficient supply chains. Further, "reduce inventory" is another major reason for adopting lean supply chain with a mean score of 4.0. We also provide two explicit supply chain management elements to the respondents and both of them received above-average mean scores. In particular, "improve supply chain flexibility" received a mean score of 3.94 and "improve supply chain visibility" had a lower score of 3.62.

In an attempt to identify where small manufacturing firms have applied lean in their supply chains, respondents were asked to indicate the areas that lean efforts have been concentrated (seven areas were provided). Table 3 presents a summary of the findings. "Inventory management and control" and "manufacturing and supply chain flexibility" were the highest ranked areas, where 59.82% and 52.94% of the respondents indicating that they have focused lean. This shows that in general, effective and efficient inventory management and flexible manufacturing and supply chain systems are primary concerns. Obviously, lean practices help to improve decision making process and business performance in such areas. Hence, it is not surprising that SMEs focus on using lean to reduce inventory costs and improve flexibility in their supply chains. The respondents seem to emphasize on using lean to enhance customer value-adding activities in the supply chains. 44.12% of the respondents indicate that it is the third most important areas where lean has been implemented. Interestingly, only 26.47% stated that they have been using lean to establish customer demand-driven supply chain processes.

Table 3. Areas of lean in the Supply Chain

Areas of lean in the Supply Chain	*% of respondents*	*Rank*
Inventory management and control	58.82%	1
Manufacturing and SC flexibility	52.94%	2
Customer value-adding activities in the SC	44.12%	3
Reduce non-value adding SC costs	41.18%	4
SC continuous improvement	29.41%	5
SC administrative and overhead costs	26.47%	6
Customer demand-driven SC processes	26.47%	7

The main objective of the research is to reveal the status of lean supply chains of small firms. To this end, the extent of supply chain-information technology (IT) solutions applied was explored. The questionnaire included ten commonly used SC-IT solutions such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Advanced Planning and Scheduling System (APS). Average mean values and rank are summarized in Table 4. The average mean scores were varied from 1.76 to 2.65. "Enterprise resource planning (ERP)" was shown to be the highest SC-IT solution implemented in SMEs with mean score of 2.65, followed by "sales forecasting system" (2.62) and "customer relationship management (CRM)" (2.35). The lowest ranked was "transportation management system (TMS)", indicating that is was the least applied SC-IT solutions.

Table 4. SC-IT solutions applied

SC-IT solutions applied	*Average Mean*	*Rank*
Enterprise Resource Planning (ERP)	2.65	1
Sales Forecasting System	2.62	2
Customer Relationship Management (CRM)	2.35	3
Electronic Data Interchange (EDI)	2.29	4
Warehouse Management System (WMS)	2.12	5
e-Commerce	2.03	6
Advanced Planning and Scheduling System (APS)	1.97	7
e-Procurement	1.97	8
Distribution Requirements Planning (DRP)	1.85	9
Transportation Management System (TMS)	1.76	10

An important subject worth investigation is the relation between the success of their lean supply chain management and the adoption of SC-IT solutions in the firms. Respondents were given 14 areas of that could benefits from lean supply chain practices, each with a five-point scale: very

successful, successful, natural, less successful, and not successful. Specifically, the successfulness of the lean supply chain was obtained by the overall average mean score of the 14 areas. To examine the relationship between the successfulness and each of the SC-IT solutions applied, we conducted Spearman correlation tests. Table 5 summaries the test results.

First, we observed that all the correlation coefficients have positive values, ranging from 0.331 to 0.7 (column 2). These indicate that there exists a positive relationship between successfulness of lean supply chain and SC-IT solutions applied, and as the level of application in any of the solutions increases, the degree of success of lean supply chain would increase. Second, all the p values of the 10 solutions are significant ($p < 0.05$), hence indicating that there is a significant relationship between the success of lean supply chain and the individual SC-IT solutions applied in the firms. Clearly, these supply-chain and information technologies play crucial roles in helping small manufacturing firms transforming into leaner organizations with different levels of supply chain involvements.

Table 5. Correlation between SCM-IT solutions and successfulness

SC-IT solutions applied	***Spearman's Coefficient***	***p value***
Electronic Data Interchange (EDI)	0.398	0.010
Enterprise Resource Planning (ERP)	0.362	0.018
Warehouse Management System (WMS)	0.331	0.028
Transportation Management System (TMS)	0.521	0.001
Distribution Requirements Planning (DRP)	0.403	0.009
Customer Relationship Management (CRM)	0.543	0.000
Sales Forecasting System	0.447	0.004
e-Procurement	0.700	0.000
e-Commerce	0.613	0.000
Advanced Planning and Scheduling System (APS)	0.565	0.000

CONCLUSION AND FUTURE RESEARCH

This research addresses an important yet under-studied area – lean supply chain management in small organizations, especially small manufacturing firms. The study examines driving factors of lean supply chain management, focus of lean supply chain practices, and major supply chain and information technology solutions applied in these companies. Through a research survey, the study has provided important insights into the current status of lean supply chain practices and related implementation issues in small businesses. Our results demonstrate that most of the small organizations regard lean supply chain management as an important measure to reduce cycle time, improve operational performance, and improve customer service. It is important to note that majority of the small organizations are still in the early stage of lean supply chain practices with relatively low or moderate level of application of supply chain management programs and IT solutions in their operations. This study was a preliminary step of the lean supply chain research project. It was conducted with a limited number of organizations and locations. The

generability of its findings needs to be validated through larger-scale studies. To that end, the authors are designing comprehensive surveys and more focused interviews for studies with small organizations across different geographical locations and industries.

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