

# LEAN IN THE SUPPLY CHAIN: A LITERATURE REVIEW

Paschal Ugochukwu, Jon Engström, Jostein Langstrand

*Linköping University, Institute of Technology, Department of Management and Engineering, Sweden*

**Corresponding author:**

*Paschal Ugochukwu*

*Linköping University*

*Institute of Technology*

*Department of Management and Engineering*

*Quality Technology and Management*

*SE-581 83 Linköping, Sweden*

*phone: +46 739-848-131*

*e-mail: paschalug@gmail.com*

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**ABSTRACT**

“Lean” is a management philosophy that enhances customer value through waste elimination and continuous improvement in a system, by applying lean principles, practices and techniques. The focus on lean implementations and research had been on a single company without extension to the entire supply chain. When the lean concept is implemented across the entire supply chain, however, it is referred to as a lean supply chain. The purpose of this paper is to review literature on lean in the supply chain and identify research trends and issues within the field. The paper involves a comprehensive review of articles on lean in the supply chain using structured content analysis. The reviewed articles were classified based on the basic characteristics and contextual issues of the articles. The researchers in the field agree that the identified benefits of lean in the supply chain, which include reduced cost, improved quality, faster delivery and flexibility, are linked to the implementation of certain lean principles, practices and techniques in the supply chain. Most of the reviewed articles are case studies, and evidence for the benefits of lean in the supply chain is anecdotal. While the empirical work done in the field is encouraging, quantitative studies to substantiate the claims for the efficiency of lean in the supply chain are lacking. In the reviewed articles, the manufacturing sector received much attention, while the service sector received little attention from researchers in the field. It was generally suggested that the supply chain members, suppliers and manufacturers should be considered in the implementation of lean in the supply chain, while the inclusion of distributors and end customers was not discussed in detail in many of the reviewed articles.

**KEYWORDS**

Lean, supply chain, literature review, principles, practices, techniques.

## Introduction

As a result of increasing global business competition, many organizations are looking for ways to gain competitive advantage. Vonderembse et al. [1] observe that competition has shifted from company orientation to supply chain orientation, thus supply chain improvement has become a necessity for survival. Researchers increasingly propose the implementation of lean in the supply chain as a way to achieve the required competitive advantage [2–5]. Agus and Hajinoor [6] argue that lean is the very basis of supply chain management. There are several

case examples on how implementation of lean in the supply chain has resulted in important improvements [7–10]. Extending lean, which is rooted in automotive manufacturing and shop floor operations, to the entire supply chain and other industry sectors requires extensive research and adaptation. Lean is an evolving concept [11] with rapidly increasing popularity as a supply chain management approach. Hence, it is important to understand researchers’ views of what makes a lean supply chain, i.e., lean principles, practices, techniques and benefits regarding the implementation of lean in the supply chain. The above observations call for a comprehensive review of pub-

lications in the field. The review will help to ascertain the extent and trend of research on the implementation of lean in the supply chain.

### Lean concept

The lean concept originated with Toyota and helps companies achieve more with less human effort, time and cost [5]. Lean, which was popularized by Womack et al. [12] in their book *The Machine that Changed the World*, was earlier solely implemented on the manufacturing shop floor and usually referred to as “lean production” or “lean manufacturing.” Today, the lean concept is applied across various industrial sectors and beyond the shop floor of single companies [11]. There is no generally accepted definition for the lean concept. Instead there is a great variation of what lean is and what it is not [13–14]. Shah and Ward [15], however, describe lean as a management philosophy that is concerned with identification and elimination of waste within and beyond organizations’ product value chain. It is a way to achieve cost reduction, quality and efficiency improvement with less effort [16]. The desired improvement can be achieved by appropriate implementation of lean tools and techniques, practices and principles. In the same way that Dean and Bowen [17] claim that total quality is a management philosophy that can be characterized by its principles, practices and techniques, Shah and Ward [15] claim that lean can be understood as a set of principles, practices and techniques. Womack and Jones [18] articulated comprehensive business logic on lean management, which is called lean thinking or lean principles. The five lean principles according to Womack and Jones [18] include:

*Specify value from the end customer view:* Find out what the customers desire in a product or service.

*Map value streams:* Identify the value stream starting from activities on the suppliers side to the end customers and expose waste.

*Establish flow:* Organize the system to avoid delays, down time, scraps. Batch production should be avoided.

*Let the customer pull the products:* Provide exact amount of what is required by the customer only when it is needed.

*Strive for perfection:* Improve the system continuously. Always search for problems and solve them when identified.

Each lean principle is implemented by applying certain practices. These practices, which are activities used to improve organizations, are implemented by a set of techniques [17, 19]. Techniques are

detailed approaches on how to implement practices effectively. Some of the widely acknowledged lean techniques/tools include: poka yoke, just-in-time (JIT), setup time reduction (SMED), kanban/pull system, production leveling, standardized work, 5S/housekeeping, small lot size, total productive maintenance (TPM), supplier involvement, employee involvement, root cause analysis (5Whys), customer involvement, value stream mapping (VSM), cellular manufacturing, kaizen/continuous improvement, and statistical quality control [2, 13]. Hines et al. [11] explain that lean has two levels: strategic and operational. The authors argue that the strategic level, which involves the five lean principles or lean thinking, addresses issues of value creation and better understanding of customer value and has unlimited applications. They argue that the operational level, which involves lean tools, addresses issues on waste elimination, and is mostly applicable to the shop floor.

### Supply chain concept

A supply chain is a network of facilities and activities that performs the function of product development, procurement of materials between facilities, manufacturing of products, and distribution of goods to customers [20]. Supply chain scopes or members include: suppliers, manufacturers/focal organization, distributors and end customers [20–22]. Suppliers are the supply chain members who supply raw materials or components to the manufacturers or focal organizations for value creation. Manufacturers or focal organizations are the supply chain members that produce the core values or products for the end customers. Distributors ensure delivery of products from the focal organizations to the customers. End customers are the end users or beneficiaries of value created by focal organizations.

Previous research on supply chains suggests that quality, cost, flexibility and delivery are considered very important issues in the supply chain [6, 23, 24]. In order to perform the activities identified in the above definition better, supply chain managers and coordinators have been thinking of approaches to adopt in order to achieve reduced cost, efficient delivery, high quality and flexibility with the supply chain.

### Lean in the supply chain

The focus on lean implementation and research had been within shop floor or core process of single organizations, not extending to the whole supply chain. Large companies found that it was not enough to improve performance only within organi-

zations. Improvement must be extended across the entire supply chain [23]. Considering the benefits, lean as a management approach [6, 15] has been projected by many researchers as a way to make supply chain management more effective. Womack et al. [12] describe lean as a close alignment from raw material to customer through cooperation. Thus, lean management can be adopted by organizations seeking to integrate their supply chain members and activities. When lean is implemented across the entire supply chain, the supply chain is referred to as a lean supply chain (LSC).

### Research Purpose

The purpose of this paper is to review literature on the implementation of lean in the supply chain. The objectives of the paper include: First, to summarize the existing articles in the field by identification of patterns and issues on research in the field. Second, to create a structure for quick overview and evaluation of research in the field. Third, to uncover the need for further research in the field. In order to actualize the research aim and objectives, the paper focuses on characteristics of lean supply chains, benefits, research approach and lean management approach in the supply chain.

### Methodology

The research is based on comprehensive review of literature on lean in the supply chain. A four-step process model proposed for content analysis in literature reviews (Mayring, 2003, p. 54) cited in [25] is adopted for this review. The four steps are: material collection, descriptive analysis, category selection and material evaluation. Material selection involves definition and delimitation of materials to be collected and search for relevant literature. At the descriptive analysis step, basic characteristics of the selected materials such as publication distribution across journals, research methods, and number of publications per year were examined. Decision on the choice of categories and dimensions to be used in structuring the collected materials was made at the category selection stage. Category selection was followed by material evaluation, which involved review and classification of the selected materials according to the chosen structural dimensions and categories. Only journal articles published from 1990 to 2012 that discussed lean in relation to the supply chain were considered. Books, reports and conference papers were not considered. Since Womack et al. [12] popularized lean in 1990, all predating papers were excluded. Articles that did not contain detailed discussion on lean

implementation beyond the production/core process area of focal organizations were not considered (only articles that discussed lean in relation to at least two members of the supply chain were considered).

The following information sources were searched for articles on lean in the supply chain: Emerald, ScienceDirect, Scopus, Springerlink, Ebscohost, Wiley, ISI, Business Source Premier, and Google Scholar. The reference lists of articles found were also scanned for more relevant articles. The following keywords were used for the search: “lean supply chain”, “lean management”, “lean enter prise”, and “lean implementation”. The initial search with keywords resulted in more than 1000 hits. After limitation of the initial search to articles with both lean and supply chain mentioned in their abstract and titles, the number of articles was drastically reduced. Articles with perceived irrelevant titles were excluded. The process was repeated for different keywords and databases. At a certain stage in the search, it was found that the same set of articles kept reappearing, and the search process was stopped. A total of 136 perceived relevant articles were selected from the search process. Further screening of the articles was made by scanning through the abstracts, introduction and body contents, and articles which did not discuss lean in relation to at least two supply chain members were removed. Thus, the number of articles was reduced from 136 to 64. After detailed reading of the 64 articles and removal of articles which did not contain a good amount of relevant discussion on the lean supply chain, a total of 40 articles were finally selected for the review.

In the review, nine dimensions relating to the articles’ basic characteristics and main ideas were identified and organized in two groups. The articles were classified and analyzed based on the nine dimensions. The two groups and the nine dimensions are presented below:

*Basic descriptive characteristics of the reviewed articles:* research methods, journal names, industry sectors, publication time and research objectives. The analysis here focuses on research methods used for exploration of lean in the supply chain by authors, insights into distribution of articles across journals, distribution of articles across time, widely adopted research objectives or purposes and research methods used to achieve them.

*Authors’ views on lean in the supply chain:* This covers benefits of lean in the supply chain, characteristics of lean supply chain, lean supply chain management approach (principles, practices and techniques) and supply chain members involved. The analysis here focuses on what many of the authors acknowl-

edge as the benefits of lean in the supply chain and characteristics of a lean supply chain. It also involves the study of the extent of research on lean implementations across various supply chain members and authors' emphasis on lean principles, practices and techniques in the implementation of lean in a supply chain.

## Findings

### Descriptive characteristics of the reviewed articles

This section describes the findings on the basic characteristics of the reviewed articles. The characteristics include: research methods, journal names, industry sectors, research objectives and publication time.

### Research methods

Kotzab et al. [26] identify different research methods that can be applied in various types of research. The methods are: case study, modeling (mathematical and simulation), conceptual and survey. These methods can be further classified into empirical, theoretical, qualitative and quantitative research [27]. Case study research is the most widely used research method on lean in the supply chain, followed by the conceptual and survey approaches. Modeling is sparingly used in research work done in this field. However, some authors combined two methods, with one method serving as the main approach and the other as supporting approach. Case study and surveys were used as supporting approaches as well as the main approach; see Table 1. Table 1 below also shows the reviewed articles and the corresponding research methods used in each article.

### Distribution of articles across journals

The articles were found in 27 different journals. Seven articles were found in Supply Chain Management: An International Journal (SCM: IJ) and five were found in the International Journal of Operations Management (IJOPM). Two articles each were found in the European Journal of Purchasing and Supply Management (EJPSM), International Journal of Physical Distribution and Logistics Management (IJPDLM) and Integrated Manufacturing. Other journals have one article each. The wide range of different journals that contain articles on lean in the supply chain shows that it is a diverse and important research field. The highest number of articles found in SCM: IJ is an indication that supply chain management (SCM) pays attention to the lean management approach.

Much research on the service sector is concentrated on focal organizations without extension to other supply chain members. Only very few articles discussed implementation of lean beyond the focal organizations of service industries. The reviewed articles worked on tourism and humanitarian services. The articles on construction considered civil and mechanical engineering projects. Attention is given to design, material procurement and core construction activities. It is surprising that despite the importance and size of the health care industry, it did not receive any attention from the researchers.

### Distribution of articles across time

In the article search, publications from 1990 were considered, but the first relevant article appeared in 1993 and the increase over the subsequent years was small and fluctuating. More than half of the reviewed articles were published from 2005 to 2012 with the highest number of articles published in 2009 and 2011 respectively. The year 2005 marked the extension of lean to service and agri-food supply chain. Lean became popular in 1990, but implementation of lean in the supply chain only gained more attention in 1997. The attention may be attributed to the publication of the book *Lean Thinking* by Womack and Jones [18]. The book advocates implementation of lean across the entire supply chain. Also, the rise in the attention given to lean in the supply chain in 2009 may be attributed to the search for survival strategies in the face of the global economic crisis which started in 2008.

### Research objectives

Descriptive, exploratory, explanatory, and predictive research are different types of research objectives or purposes [28, 29]. Usually, the research objective affects the choice of research methods. Explanatory research looks for explanations of the nature of relationships between different variables and explains cause-effect relationships and how activities take place. Exploratory research involves identification of key issues and variables, operational definitions such as more efficient approaches to handling issues and tests for possibility of more extensive study on an issue. Descriptive research provides accurate systematic information or description of an observation or phenomenon within its context. Predictive research tries to predict or forecast short and long term outcome, or behavior as a result of certain actions taken in a system. Table 1 above shows various research objectives of the reviewed articles and the corresponding research methods used in actualizing the objectives. Case study, survey and concep-

Table 1  
 Articles and the corresponding supply chain scopes, industry sectors, research objectives and methods.

| Author (s)                        | Publication year | Supply chain scope |             |              |              | Industry sectors |              |         |           |         | Research methods |            |        |           | Research Objectives |             |             |            |
|-----------------------------------|------------------|--------------------|-------------|--------------|--------------|------------------|--------------|---------|-----------|---------|------------------|------------|--------|-----------|---------------------|-------------|-------------|------------|
|                                   |                  | Supply             | Manufacture | Distribution | End customer | Manufacturing    | Construction | Service | Agri-food | General | Case study       | Conceptual | Survey | Modelling | Explanatory         | Exploratory | Descriptive | Predictive |
| Oliver [3]                        | 1993             | x                  | x           | x            | x            | x                |              |         |           |         | x                |            |        | x         |                     |             |             |            |
| Karlsson & Norr [32]              | 1994             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        | x         | x                   |             |             |            |
| Womack & Jones [5]                | 1994             | x                  | x           | x            |              | x                |              |         |           | x       |                  |            |        | x         | x                   |             |             |            |
| Lamming [33]                      | 1996             | x                  | x           |              |              |                  |              |         | x         |         |                  |            |        | x         | x                   |             |             |            |
| Karlsson & Ahlström [19]          | 1997             | x                  | x           | x            | x            | x                |              |         |           | x       |                  |            |        |           | x                   |             |             |            |
| Levy [34]                         | 1997             | x                  | x           | x            | x            | x                |              |         |           | x       |                  |            |        |           | x                   |             |             |            |
| New & Ramsay [35]                 | 1997             | x                  | x           |              |              |                  |              |         | x         |         | x                |            |        |           | x                   |             |             |            |
| HUallacháin & Wasserman [36]      | 1999             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        |           |                     | x           |             |            |
| Michaels [37]                     | 1999             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        |           |                     | x           |             |            |
| Taylor [9]                        | 1999             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        |           |                     | x           |             |            |
| Arkader [38]                      | 2001             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        |           |                     | x           |             |            |
| Pheng & Chuan [39]                | 2001             | x                  | x           |              |              |                  | x            |         |           |         |                  | x          |        |           | x                   |             |             |            |
| Arbulu et al [40]                 | 2003             | x                  | x           |              |              |                  | x            |         |           | x       |                  |            |        |           | x                   |             |             |            |
| Wu [41]                           | 2003             | x                  | x           | x            |              | x                |              |         |           |         |                  | x          |        | x         |                     |             |             |            |
| Mohan & Sharma [14]               | 2003             | x                  | x           |              |              |                  |              |         | x         |         | x                |            |        |           |                     | x           |             |            |
| Cox & Chicksand [42]              | 2005             | x                  | x           | x            | x            |                  |              |         | x         |         | x                |            |        | x         | x                   |             |             |            |
| Mistry [43]                       | 2005             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        | x         | x                   |             |             |            |
| Simpson & Power [44]              | 2005             | x                  | x           |              |              | x                |              |         |           | x       |                  |            |        | x         |                     |             |             |            |
| Taylor [45]                       | 2005             | x                  | x           | x            | x            |                  |              |         | x         |         | x                |            |        |           | x                   |             |             |            |
| Cagliano et al [46]               | 2006             | x                  | x           |              | x            | x                |              |         |           |         |                  | x          |        | x         |                     |             |             |            |
| Taylor [4]                        | 2006             | x                  | x           | x            | x            |                  |              |         | x         |         | x                |            |        |           |                     | x           |             |            |
| Cox et al [47]                    | 2007             | x                  | x           | x            | x            |                  |              |         | x         |         | x                |            |        | x         | x                   |             |             |            |
| Eisler et al [48]                 | 2007             |                    | x           |              | x            | x                |              |         |           |         | x                | x          |        |           | x                   |             |             |            |
| Matson & Matson [49]              | 2007             | x                  | x           | x            | x            | x                |              |         |           |         |                  | x          |        |           |                     | x           |             |            |
| Julien & Tjahjono [50]            | 2009             | x                  | x           |              | x            |                  |              | x       |           |         | x                |            |        |           |                     | x           |             |            |
| Jorgensen & Emmitt [51]           | 2009             | x                  | x           |              | x            |                  | x            |         |           |         | x                |            |        | x         | x                   |             |             |            |
| Sezen & Erdogen [16]              | 2009             | x                  | x           |              | x            |                  |              |         | x         |         | x                |            |        | x         |                     |             |             |            |
| Taylor & Pettit [52]              | 2009             | x                  | x           | x            | x            |                  |              | x       |           |         | x                |            |        |           | x                   |             |             |            |
| We & Wu [10]                      | 2009             | x                  | x           | x            | x            | x                |              |         |           |         | x                |            |        |           |                     | x           |             |            |
| Eriksson [7]                      | 2010             | x                  | x           |              | x            |                  | x            |         |           |         | x                |            |        |           |                     | x           |             |            |
| Perez et al [8]                   | 2010             | x                  | x           |              | x            |                  |              |         | x         |         | x                |            |        |           |                     | x           |             |            |
| So & Sun [53]                     | 2010             | x                  | x           |              |              | x                |              |         |           |         | x                | x          |        | x         | x                   |             |             |            |
| Behrouzi & Wong [23]              | 2011             | x                  | x           |              | x            | x                |              |         |           |         |                  | x          |        |           | x                   |             |             |            |
| Cudney & Elrod [2]                | 2011             | x                  | x           |              |              | x                |              |         | x         |         |                  | x          |        | x         | x                   |             |             |            |
| Kisperska-Moron & Haan [54]       | 2011             |                    | x           | x            | x            | x                |              |         |           |         | x                |            |        |           | x                   |             |             |            |
| Ma et al [55]                     | 2011             | x                  | x           | x            |              | x                |              |         |           |         | x                |            | x      |           |                     |             | x           |            |
| Zarei et al [56]                  | 2011             | x                  | x           |              |              | x                |              |         |           |         | x                |            |        | x         | x                   |             |             |            |
| Zhou & Kelin [57]                 | 2011             |                    | x           | x            | x            | x                |              |         |           |         | x                |            | x      |           |                     |             | x           |            |
| Agus & Hajinoor [6]               | 2012             | x                  | x           |              | x            | x                |              |         |           |         | x                |            | x      |           | x                   |             |             |            |
| Baladhandayuthan & Venkatesh [58] | 2012             | x                  | x           |              |              |                  | x            |         |           |         | x                |            |        | x         | x                   |             |             |            |
| <i>Total number of articles</i>   | 40               | 37                 | 40          | 15           | 19           | 23               | 5            | 2       | 5         | 5       | 26               | 7          | 8      | 2         | 17                  | 22          | 10          | 2          |

tual methods were used by various authors to actualize different research objectives such as a sex planatory, exploratory and descriptive research. Predictive objective was achieved using modeling; however, predictive research is not popular in the field (Table 1). The argument by Woodside et al. [29] that case study research method can be used to achieve explanatory, exploratory and descriptive research objectives is supported by the findings. The review result shows that many of the exploratory research objectives were achieved using the survey research method.

### **Authors' views on lean in the supply chain**

This section presents the authors' views on what characterizes a lean supply chain, benefits of lean in a supply chain and approach to lean in a supply chain in terms of lean principles, practices and techniques. It also studies the extent of research on lean implementations across various supply chain members.

### **Characteristics of lean supply chain**

The following are widely acknowledged characteristics of a lean supply chain by many authors of the reviewed articles: Integrated supply chain members (mentioned in 24 articles); effective communication and information sharing (mentioned in 13 articles); effective demand management (mentioned in seven articles); end customer focus (mentioned in five articles); continuous improvement (mentioned in six articles); low inventories and few suppliers (mentioned in four articles each); and continuous flow and long-term contracts between supply chain members (mentioned in five articles each). Only characteristics acknowledged by at least four authors were selected. However, integrated supply chain members, effective demand management (demand pull), and effective communication and information sharing are very popular among the authors. The popularity of integrated supply chain members among the characteristics is in agreement with the description by Womack et al. [12] of lean as a close alignment from raw material to customers through cooperation. The authors emphasized that the identified characteristics are the requirements for attaining the desired benefits in lean supply chain management. From the authors' descriptions of the characteristics, it is interesting to note that there is strong linkage or dependency among the identified characteristics. They explain that supply chain integration involves dealing with other supply chain members as extended parts of the focal organization. The integration, which may involve signing long-term contracts with other supply chain members by the focal organization, will help

to facilitate effective communication and information sharing. Also, in order to achieve an integrated supply chain, effective communication and information sharing, there is a need to have few suppliers. The idea of keeping few suppliers will help for effective communication and coordination across the entire supply chain. Some of the authors explain that supply chain integration, effective communication and information sharing are the basis to achieve continuous flow, low inventory, end customer focus and effective demand management.

### **Supply chain members involved**

According to Stevens [21], supply chain scope or members are: suppliers, manufacturers, distributors and end customers. Only very few of the articles discussed lean in the supply chain in relation to all supply chain members. About half of the articles discussed lean in the supply chain in relation to only two out of the four identified members of a supply chain (see Table 1). The supply chain scope, supply and manufacture were extensively discussed in many of the reviewed articles while distribution and end customers were not discussed in detail in many of the articles. The discussion on manufacture centered on waste reduction, problem search and problem solving by applying lean techniques/tools such as TPM, small lot size, 5S, cell manufacturing, employee involvement, VSM and 5Whys. Discussion on supply centered on using supplier integration and JIT to achieve waste reduction, effective communication and information sharing, and a strong and effective relationship. The scant discussion on distribution called for efficient delivery, cost and waste reduction in transportation and warehousing. Emphasis was on the appropriate choice of transportation modes, lot size, warehouse locations, number and size. Many authors acknowledged the importance of focusing on end customers, but did not discuss this in detail. Some of the authors argue that through customer involvement such as market research on customer needs and value chain analysis, customer-oriented process and products will be achieved. Table 1 above shows the supply chain members or scope covered by various authors in their discussions on the implementation of lean in the supply chain.

### **Benefits of lean in the supply chain**

The following are the widely acknowledged benefits of lean in the supply chain by many authors of the reviewed articles: Low inventories (mentioned in 20 articles); customer satisfaction (mentioned in 12 articles); optimized efficiency (mentioned in four articles); high quality (mentioned in 22 articles); reduced

cost and improved delivery regarding time, quantity and quality specifications (mentioned in 26 articles each); and high flexibility (mentioned in ten articles). Many of the authors agree that the identified benefits are linked to lean management practices such as value chain analysis, waste elimination, system organization, end customer focus, problem solving, and strong and effective relationships. Improved delivery, which involves delivery of exact customer specifications in terms of quantity and quality at the required time, is possible through the implementation of lean practices. Through implementation of just-in-time and pull production, accumulation of inventories in the system is avoided, hence cost of holding inventories is reduced. Besides reduction of lead time by avoiding unnecessary processes, waste elimination has also helped in cost reduction by avoiding overproduction, unnecessary transportation, inventory and processing. By focusing on the end customers and application of value chain analysis across the entire value chain, waste and value-adding activities are identified. Identification of value-adding activities and waste elimination helps in the achievement of customer satisfaction. Continuous problem search and solutions help to increase operational efficiency and quality of products or services. The improvement can be achieved by implementation of some lean techniques such as TPM, 5Whys, VSM and employee involvement. Few authors acknowledged poka yoke, visual control and statistical quality control (SQC) as ways to achieve high quality, but many of the authors emphasized supplier involvement as a way to achieve high quality. They suggest that supplier involvement in the early design stage and thorough screening of suppliers' operations will help to improve quality. The authors view flexibility as the ability to respond to the dynamic market situation in terms of volume, product mix and delivery. They identified three major areas of flexibility (volume, product mix, and delivery flexibility) and argue that flexibility is required at both focal and supplier organizations.

From the reviewed articles, it is found that the identified areas of flexibility can be achieved by implementation of lean techniques and practices such as small lot size, supplier relations or involvement, pull production, effective communication and information sharing. Only benefits acknowledged by at least four authors were selected. However, the listed benefits were acknowledged by at least ten authors.

#### Lean management approach: principles, practices and techniques

About half of the authors gave explicit consideration to some of the five lean principles in their

discussion. Only a few authors considered all five principles in their discussion. Map the value stream of products and establish flows are the principles most often considered. The implementation of principles requires implementation of some practices [17, 19]. From the reviewed literature, the practices, tech-

Table 2

Lean principles with corresponding practices and techniques.

| Principles                                  | Practices   | Techniques                             |
|---|---|--|
| 1. Specify value from the end customer view | Source information on customer need                 | Customer involvement                   |
|   | Value chain analysis and end customer focus         | Value stream mapping (VSM)             |
| 2. Map value to expose and eliminate waste  | Value chain analysis                                | VSM                                    |
|   | Waste reduction                                     | JIT, TPM, small lot size, 5S, SMED     |
| 3. Establish flow                           | System organisation                                 | 5S, cellular manufacturing             |
|   | Strong and effective relationship                   | Supplier integration                   |
|   | Waste reduction                                     | JIT, small lot size, TPM, and 5S, SMED |
| 4. Let the customer pull the products       | Production of exact customer needs only when needed | JIT, pull/kanban system                |
|   | Strong and effective relationship                   | Supplier integration                   |
| 5. Strive for perfection                    | Problem search                                      | VSM, 5Whys, employee involvement       |
|   | Problem solving                                     | Training, 5Whys, employee involvement  |

niques and tools shown in Table 2 below for the implementation of various lean principles were selected based on acknowledgement by at least three authors. Strong and effective relationships, value chain analysis and waste reduction are the most acknowledged practices for implementation of lean in the supply chain. Implementation of practices requires arrays of techniques or detailed processes [17, 19]. JIT, VSM and supplier integration are very popular techniques in the implementation of lean in a supply chain. Table 2 below shows the five lean principles and the corresponding practices and techniques for the implementation of the principles as perceived by different authors of the reviewed articles. The table presents a summary of the findings from the reviewed articles as regards the implementation of Womack and Jones' [18] five lean principles in the supply chain.

## Conclusions

This literature review provides some insights about research on lean in supply chain as regards the amount of works already done, research approach, trend and authors' views on certain issues in the field. Lean approach to supply chain management has become very popular since 1997, following the publication of *Lean Thinking* by Womack and Jones [18]. However, there is still a limited number of journal articles in the field and no review of the field has been made. Distribution of articles across various industry sectors shows that the authors agree on the arguments by Cudney and Elrod, and Womack et al. [2, 12] that lean has no boundary in terms of industry sectors. Concentration of the research work on the manufacturing sector, especially automotive, and use of single case study may negatively affect research development in the field. Besides, the popularity of single case study in the field will make it difficult to generalize research results from other industry sectors and subsectors like automotive in particular.

Case studies help in gaining insight into a little known situation or concepts, and are good to use in exploring implementation issues and theory building [27–29]. Thus, the popularity of the case study research method in the field indicates the authors' effort to present in-depth knowledge of the field and build a theory base for research development in the field. Yin [30] argues that case study helps in the provision of illustrative evidence of an issue. However, most of the reviewed articles are case examples without illustrative evidence, which is required to substantiate the claimed benefits of lean in the supply chain. Reiner [31] argues that empirical quantitative research helps in the development of policies, strategies and actions for improvement of situations or process. The empirical work done in the field is quite encouraging, but there is more concentration on qualitative approach and little attention to quantitative research approach.

Lean suppliers, logistics and distribution are the major requirements to become a lean enterprise [23]. Concentration of many of the articles on only two supply chain scopes, supply and manufacture (core process), and neglect of others may hamper fast development in the field. The review indicates that research on lean in the supply chain has not given adequate attention to full implementation of lean in the supply chain. To get maximum benefit from lean implementation, it should go beyond the internal activities of the focal organization to suppliers and distributors [14]. Hence, full implementation of lean in the supply chain is necessary so as to help in the adequate assessment of the benefits. The reviewed

articles show that lean principles (map value stream, establish flow) and lean techniques (JIT, VSM) and supplier integration are very important in the implementation of lean in the supply chain. Many of the authors considered lean implementation in the supply chain from principle down to application of appropriate practices and techniques. Thus, strategic and operational levels of lean [11] are found in the implementation of lean in the supply chain.

The review helped in the identification of what many researchers in the field view as benefits of lean in the supply chain and what makes a lean supply chain. Thus, the information will be of immense help to researchers and organizations implementing lean in their supply chain. The authors agree that the identified benefits are linked to the implementation of lean principles, practices and techniques in the supply chain. However, little effort was made by the authors to illustrate how the benefits can be achieved.

## Future research

As a result of the findings from the reviewed articles, it is recommended that future research in the field consider conducting more empirical quantitative researches, like surveys and modeling. The research approach will help in the development of more policies and strategies for improvements in the field and can also help to substantiate claims about the benefits of lean in the supply chain. Also, more use of the case study research method based on illustrative evidence and predictive research using modeling (mathematical and simulation) will help to substantiate claims about the benefits of lean in the supply chain. There is need to extend more research to other industry sectors such as the agri-food, construction and service sectors, especially the health care industry which was completely left out by the researchers in the field. Full implementation of lean in the supply chain will help in the appropriate evaluation of the benefits. Thus it is important to encourage organizations to embrace full implementation of lean in their supply chains by extending more research to other supply chain members like distributors and end customers. Finally, case study research to compare the findings in this review with practices in industry will help to further align the research in the field to industry needs.

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