

# Lean Supply-Chain:A State-of-the-art Literature Review

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## ABSTRACT

Lean practices are meant to reduce the unwanted activities from a system and use only as much resources as are necessary for that matter. In today's world, the manufacturing organisations are trying tooth and nail to get an edge over their competitors. This makes them obligatory to improve their production process which in turn requires a very effective and efficient supply chain system. It has made the researchers focus on this area of manufacturing and add some valuable contributions towards the betterment of manufacturing industry and the society as a whole. Review papers provide a great help to researchers in identifying the areas that need improvement and avoid redundancy of the efforts. Although a wide range of researches has been done on lean and supply chain separately, the integrated view of lean and supply chain is still suffering to receive the attention of a large stream of researchers. In the same context, to help researchers, this paper tries to identify the important researches and also find some key aspects that need to be explored. As, to the knowledge of the researchers, there are no review papers on lean supply chain till now, this paper assumes a greater relevance. The literature on the lean supply chain is exhaustively covered under the limitations of the resources, is classified on the bases of year, country, industry and journal and discussed lucidly followed by findings and conclusion. The literature identifies three phases of researches and highlights future research avenues.

**Keywords:** Lean, Agile, Lean Supply Chain, Leagile, Supply Chain Network

## INTRODUCTION

Literature is continuously being published and therefore added to the base of existing knowledge (Mollenkopf, Stolze, Tate, & Ueltschy, 2010). Enterprises are continuously paying attention in responding to the customer demand for maintaining a competitive advantage over their rivals (Agarwal, Shankar & Tiwari, 2006). Supply chain management (SCM), nowadays, has become one of the most significant innovations among business managers (Behrouzi & Wong, 2011). Supply Chain Management (SCM) has gained attention as it focuses on material, information and cash flows from vendors to customers or vice-versa. A key feature of present day business is the idea that it is supply chains (SC) that compete, not companies (Christopher & Towill, 2001), and the success or failure of supply chains is ultimately determined in the marketplace by the end consumer. The focus of the lean approach has essentially been on the elimination of waste or *muda*. Lean is about doing more with less. Leanness in a supply chain maximizes profits through cost reduction. Lean thinking is a current popular paradigm (Naylor, Naim & Berry,

1999). According to literature the term lean means getting rid of what is unneeded, in other words is to cut fat, for manufacturing environment, lean means to keep inventory, waste, defects, and time required, at the minimal level. Today lean tools are used to reduce wasteful activities across the supply chain (Sezen & Erdogan, 2009). Lean processes create value through the elimination of "waste" in the supply chain (Disney, Naim & Towill, 1997). Lean processes reduce waiting time, rectify mistakes, excess processing, movement, transport, and stock (Jones & Hines, 1997). Lean supply is closely associated with enabling flow and the elimination of wasteful variation within the supply chain (Stratton & Warburton, 2003). With the introduction of lean manufacturing, excess inventory is quickly reduced to the point where the remaining inventory levels act to smooth out the effect of the various sources of fluctuation process variation, set-up delays, and plant reliability, etc., are identified as wasteful and targeted and hence the improvement in the supply chain making it lean. The lean supply paradigm has taught us the importance of reducing variation and enabling flow, so reducing the need for protective inventory and capacity. However, with the growth in

product innovation and demand uncertainty, supply chains now need to strategically locate inventory and capacity to enable flow. Supply chain management is a business term that has emerged in the last few years and is gaining in popularity. In modern business environments, an effective supply chain management (SCM) is crucial to business continuity (Cabral, Grilo & Cruz-Machado, 2012). Today, in order to have a competitive product in the marketplace, it is fundamental to have a competitive supply chain (SC). Effective SCM is one of the keys to survival in a market that is increasingly volatile and turbulent. Supply chain management (SCM) enhances competitiveness of a firm and its supply chain, if appropriate supply chain strategy (SCS) is chosen (Soni & Kodali, 2012). The term “lean” means a series of activities or solutions to eliminate waste, reduce non-value added (NVA) operations, and improve the value added (VA). This VA and NVA concept were derived mainly from TPS (Wee & Wu, 2009). Over the past two decades, the theory and practice of supply chain management (SCM) has received considerable attention from academics and practitioners alike (Agus & Hajinoor, 2012). The pursuit for quality product and waste reduction are driven by the need to survive and remain competitive. Lean and agile supply chain managements, as well as the hybrid forms (leagile supply chains), are popular and relatively widely discussed in literature (Konecka, 2010).

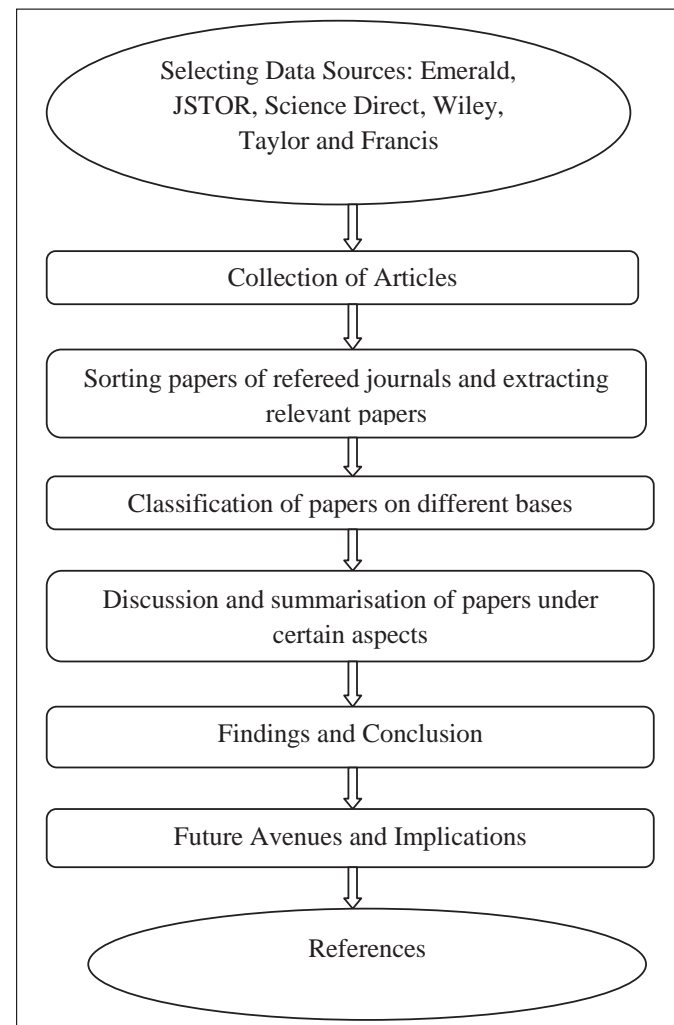
Leanness has become a prime area of concentration for researchers in present era and it has become the most popular concept of research. Leanness refers to reduction of all kinds of waste during any process and using as much resources as are necessary for that matter. The concept has been much talked about in manufacturing and supply chain context by succeeding in drawing the attention of researchers to this area. Moving a step forward there have been review papers on lean and lean manufacturing but in that context to the knowledge of researcher, no review paper has been found on lean supply chain. It makes this paper quite relevant and gives us immense motivation to write this review paper in order to assist the researchers to have a clearer idea of the researches on lean supply chain.

## METHODOLOGY

An extensive literature survey of various publishers like Emerald, science direct, Taylor and Francis, Nature and JSTOR was done with the key words “lean supply chain” to collect papers and articles that were published in peer reviewed refereed journals. Keywords, how many articles yield, how many reviewed and how many found relevant. Then sorting of these papers was done to find out relevant

papers which included “lean” and supply chain/ supply in their topic. Then a final sorting of papers was done to finally find 59 relevant papers on lean supply chain to be considered for the study. A line graph regarding the publications in different years can be drawn. Then, said papers were classified in different categories to give a clear view of the works done on lean supply chain. Only those papers were considered to which we had access. Then a critical study of the selected papers was done to get a clear view of the works done on Lean Supply Chain. Some aspects that seem to have not found due attention were also identified and discussed. An attempt was made to classify them in a chronological sequence according to a trend along with highlighting the unexplored points. Then some possible avenues for future research were identified too followed by conclusion and recommendation. The methodology is depicted in Figure 1.

**Figure 1: Methodology of Research**



## CLASSIFICATION OF PAPERS

**Table 1: Year wise**

Year	No of Papers
1996	1
1997	2
1998	1
1999	4
2000	4
2001	4
2002	0
2003	2
2004	2
2005	3
2006	3
2009	3
2010	8
2011	7
2012	6
2013	9
Total	59

**Table 2: Country wise**

Country	No of Papers
UK	15
USA	8
India	3
Taiwan	2
Malaysia	3
Brazil	2
Hong Kong	2
Portugal	2
Turkey	2
Spain	2
Poland	2
Italy	2
Sweden	2
China	1
Iran	1
Denmark	1
Japan	1
Jordan	1
Pakistan	1
Canada	1
Indonesia	1
Worcester	1
Australia	1
Egypt	1
Ireland	1
Total	59

**Table 3: Industry wise**

Industry	No of Papers
Manufacturing	33
Textiles	3
Food	4
Apparel	1
Construction	2
Healthcare	3
Automobile	2
Automotive	4
Pork	1
NGO	1
Municipal	1
Electronics	2
Polish	1
Aerospace	1
Total	59

**Table 4: Journal wise**

Name of the Journal	No of Papers Published
Economic Geography	1
American Journal of Agricultural Economics	1
Journal of Purchasing & Supply Management	1
European Management Journal	1
Int. J. Production Economics	4
European Journal of Operational Research	1
Expert Systems with Applications	1
Journal of Cleaner Production	2
European Journal of Purchasing & Supply Management	3
International Journal of Logistics: Research and Applications	2
International Journal of Production Research,	5
Production Planning & Control: The Management of Operations	1
Enterprise Information Systems	1
Logistics Information Management	1
Supply Chain Management: An International Journal	10
International Journal of Physical Distribution & Logistics Management	3

Name of the Journal	No of Papers Published
International Journal of Quality & Reliability Management	1
International Journal of Operations & Production Management	3
Electronic Scientific Journal of Logistics	1
International Journal of Lean Six Sigma	3
Integrated Manufacturing Systems	2
Scientific Research and Essays	1
International Business Research	1
California Management Review	1
International Journal of Agile Management Systems	1
Benchmarking: An International Journal	1
Journal of Global Strategic Management	1
Journal of Economics and Behavioral Studies	1
Qualitative Research in Accounting & Management	1
Journal of Humanitarian Logistics and Supply Chain Management	1
Journal of Small Business Management	1
Strategic Outsourcing: An International Journal	1
Total	59

## PHASES OF RESEARCH

Closer observation lead to identification of three phases of research viz. Phase I (1996-2001) Network Management Phase; Phase II (2003-2009) Lean Environment Phase and Phase III(2010-2013) Leagality Phase. These phases are well depicted in Table 5.

### Phase I (1996-2001) Network Management Phase

During this phase the focus of researchers was on managing the supply chain network by maintaining a good relationship among the supply chain agents, integrating the whole network.

### Supply Chain Network

Naylor *et al.* (1999) suggested that manufacturers should not be looking at operations in isolation from the rest of the supply chain. Whether to develop an agile capability or a lean manufacturing structure will be dependent upon where in the supply chain the members are located. This total supply chain perspective is essential and companies should be striving for leagility that is carefully combining both lean and agile paradigms. Kinsey (2000) links between economic agents known as food manufacturers, wholesalers, and retailers are complex, ill understood, changing rapidly, and decreasing in number. Therefore wastes are rampant in these links and lean supply chain

**Table 5: Phases of Lean Supply Chain**

Phase Period	Phase I (1996-2001)	Phase II (2003-2009)	Phase III (2010-2013)
Phase	Network Management Phase	Lean Environment Phase	Leagality Phase
No. of Papers	16	13	30
Examples	Naylor <i>et al.</i> (1999), Mason-Jones, Naylor and Towill (2000), Mentzer, DeWitt, Keebler, Min, Nix, Smith and Zacharia (2001), Francis (1998), Disney <i>et al.</i> (1997), McCullen and Towill, (2001), Das and Handfield, (1997), Christopher and Towill (2000), Arkader (2001), Lamming (1996), Kinsey (2000).	Dayna and Damien (2005), Wee and Wu (2009), Cox and Chicksand (2005) Fearne and Fowler (2006), Sezen and Erdogan (2009), Cagliano, Caniato and Spina (2004) Goldsby, Griffis and Roath, (2006), Mistry (2005)	Manzouri, Rahman, Saibani and Zain (2013), Smadi (2012), Cudney and Elrod (2012), Wong (2011), Hong, Dobrzykowski and Vonderembse (2010), So and Sun (2011), Hajmohammad, Vachon, Klassen and Gavronski (2013), Arlbjörn, Freytag and Haas (2011), Agus and Hajinoor (2012), Fuentes, Di'az and Jurado (2012), Aronsson, Abrahamsson and Spens (2011), Eriksson (2010), Chen, Cheng and Huang (2013)

can be used to remove them, also talked about direct store delivery (DSD). DSD vendors are manufacturers that deliver their own products directly to individual stores and arrange it on the shelves. Advocated the use of efficient consumer response (ECR) and electronic data interchange (EDI) system to improve grocery supply chain. Concluded that role of UCC (Uniform Code Council) to design and to set up compatible systems with optimum size are promising and are consistent with the criteria needed for success. The question of optimum network size is barely addressed in the literature but is worth contemplating.

### Relationship and Information Exchange in Supply Chain

Not all consumers desire the type of food or shopping experience delivered by a fast and lean distribution system. Retailers and producers who cater to the specialized needs of consumers may prove effective. The use of either paradigm has to be combined with a total supply chain strategy particularly considering market knowledge and positioning of the decoupling point as agile manufacturing is best suited to satisfying a fluctuating demand and lean manufacturing requires a level schedule. This view is supported by consideration of a PC supply chain case study (Naylor *et al.*, 1999). Nellore *et al.* (2001) explained that both the lean supply model and the global purchasing process have certain advantages and disadvantages and the global purchasing process affects different aspects of lean supply in a negative way, they also indicated that global sourcing based on price is not compatible with the lean supply model, and should therefore, be applied with extreme caution. The above discussion shows that the lean supply model has never really been challenged. They also denied the requirement of lean supply when the manufacturer knows exactly what it wants from the suppliers and is able to give detailed specifications.

McIvor (2001) found the presence of some of the principles associated with lean supply in areas such as higher levels of customer and supplier integration in the new product development process and high levels of information exchange in the supply chain, but not the total 'leanness' along these dimensions. Found the evidences of barriers in the requirement of equality between partners and the mutual sharing of benefits and customer enjoys the majority of benefits that accrue from their relationship. Francis (1998) studied the information domain and found that the "Five Lean Principles" were equally applicable in the information domain also found significant levels of waste were found, major sources of those wastes were

identified to be lying in the areas of the dependent decision cycles, unsynchronized push-pull triggers and complex external supplier relationships. This it concluded that a supply chain's ability to effectively manage the power of material will ultimately be constrained by its ability to manage information.

### Supply Chain Environment

Mason-Jones *et al.* (2000) talked about the effect of the marketplace environment on strategy selection to ensure optimal supply chain performance. They did case studies in the mechanical precision products, carpet making, and electronic products market sectors and found a matching for different supply chain paradigms viz. Lean, Agile and Leagile for different sectors according to needs of the sectors. The matches were as mechanical precision products (lean); carpet manufacture (agile); and electronics products (leagile). Taylor (1999) described the Parallel Incremental Transformation Strategy (PITS), an approach to triggering and sustaining the supply chain improvement process. It is described in two scenarios viz. a global supply chain in the footwear sector and the upstream automotive component supply chain in the UK. PITS is a methodology which has been developed to address these issues and create a supply chain improvement programme in such a way as to educate, involve and enthuse personnel from all levels and parts of the supply chain. The PITS approach addresses the transformation process through six initiatives viz. Education and awareness Initiative, Waste analysis, Creating an appropriate organisational structure, Value stream mapping Initiative, Incremental improvement Initiative, and Evolutionary development of supply chain strategy, that, once started, proceed in parallel towards the goal of a lean supply. The widespread acceptance of lean supply chain practices and the growing pressure for environmental management guide firms to incorporate environment friendly practices in their waste reduction procedure. Lean processes create value through the elimination of "waste" in the supply chain (Disney *et al.*, 1997).

Lean processes reduce waiting time, rectify mistakes, excess processing, movement, transport, and stock (Jones & Hines, 1997). McCullen and Towill (2001) validated the importance of four material flow principles in supply chain viz. appropriate control systems, time compression, information transparency and echelon elimination. They concluded that agile manufacturing eliminates the sources of variability induced wastes, particularly inventory if manufacturing is viewed in context of the supply chain. Another prerequisite is developing a supply chain

orientation (SCO), which requires a shift from functional to process thinking (Mentzer *et al.*, 2001). MacDuffie and Helper (1997) discussed the importance of lean suppliers to raise the production level with the help of lean supply chain. It takes a JIT approach to supply chain management (Das & Handfield, 1997). It focuses on specific functional areas of the supply chain including lean logistics (Disney *et al.*, 1997).

### Agility in Lean Supply Chain

Leanness may be achieved by eliminating non-value added time; agility usually requires the additional reduction of value-added time. Adopting “leagile” approach to supply chain re-engineering will ensure the improved customer service levels and reduced lead times and costs. Within the leagile supply chain the market winner is availability, hence the prime requirement for agility. However, cost, lead-time, and quality are market qualifiers. There is need for lean production to be engineered into the supply chain (Mason-Jones *et al.*, 2000). Christopher and Towill (2000) show how the lean and agile paradigms may be selected according to marketplace requirements. These are distinctly different, since in the one case the market winner is cost, whereas in other the market winner is availability. So there is need of agile supply chains that are market sensitive and nimble. The challenge of lean supply is redesigning it, sharing of responsibility and recognizing the impacts of decisions in one part of supply chain in other. Though leadership and initiative are necessary parts of continuous improvement, preconceived, intransigent ideas of who should play such roles are not productive in the long term in a supply relationship (Lamming, 1996). Michaels (1999) studied the deployment of lean production in an aerospace machined parts supply. Factors identified to be the greatest obstacles were past business practices, poor alignment, confusion over roles and responsibilities, the independent mindset of the owners of the machining suppliers and the batch and queue system. Arkader (2001) worked on perspective of auto parts suppliers in Brazilian auto industry on advances and barriers to renewed buyer supplier relations under lean production practices in form of a case study research. He found that suppliers perceive advances in the relationships as far as operational issues were concerned, but less so in terms of strategic issues. He also found both organisational firm specific barriers and environmental barriers originating in the peculiarities of the local economic and business environment. He also identified that buyers reduced waste by adopting lean practices in supply chain and main suppliers delivered on just in time basis with increasingly adopting lean

practices. But suppliers were found to be lacking in lean supply model. He considered that main missing element in achievement of lean supply objectives was strategic vision of role of suppliers.

### PhaseII (2003-2009) Lean Environment Phase

During this phase major researches aimed at maintaining a good environment and applying lean models in the supply chain.

### Supply Chain Environment

Dayna and Damien (2005) investigated the relationship between a supplier and firm’s level of environmental management activity and the structure of the customer supplier manufacturing relationship. They also found that efforts to improve or influence a supplier’s environmental management practice raises critical issues of transaction costs and efficacy of approach for the buyer and developed a model for approaching issues of supplier environmental performance through lean supply. First transition to a lean manufacturing models resulted primarily in cost savings related to capital and carrying cost savings, while the second transition to an integrated lean and agile supply chain resulted in improved efficiencies as well as cost savings (Mistry, 2005). The issues of lean supply chains present are more project-centric and less process-centric. some of discrete applications of “lean thinking” in the supply chain cause difficulties with regard to project delivery but in some other areas ‘lean’ enables the projects to proceed more effectively (Fearne & Fowler, 2006). Companies in the textiles and apparel sector utilise aspects of both agile and lean perspectives. Extended relationships with suppliers are keys to supply chain management. It can be argued that the textiles and clothing industry does not neatly fit into either a lean or agile paradigm, but instead it is a combination of the two driven by low margins and volatility of demand (Bruce, Daly & Towers, 2004). As a lean strategy lean production system fits to supply chain management that focuses to optimize the efficiency in the work progress (Sezen & Erdogan, 2009).

### <Lean Models in Supply Chain

Barla (2003) studied the supplier selection and evaluation for a manufacturing company under lean philosophy. In order to reduce the supplier base, the supplier selection

and evaluation study is conducted by multi-attribute selection model (MSM) in five basic steps. Cagliano *et al.* (2004) claimed the existence of four clearly differentiated supply strategies, adopted by manufacturing firms. Two of them, Leanness and Agility, are the most advanced strategies, characterised by the use of a wide set of supplier selection criteria and the adoption of integration mechanisms, in the context of long-term partnerships. On the other hand, there are two more traditional strategies, which focus on short-term selection criteria and no or partial use of information integration mechanisms. A third conclusion, besides lean and the agile models, is that there is no clear evidence of the dominance of one model on the other. Both strategies perform better than the remaining strategies, but neither of them is clearly the best. Finally, the paper also shows that even less advanced strategies can lead to relatively good performance, at least on certain dimensions, like delivery and manufacturing lead time. Cox and Chicksand (2005) analysed the current crisis of profitability and competitiveness in the UK food industry and red meat supply chains. The study shows that, while aspects of lean thinking may be appropriate internally for all participants in beef supply chains, the ability to extend this way of thinking beyond the boundaries of the firm into the extended supply chain for fresh/frozen beef is much more problematic. Agarwal *et al.* (2006) advocated for the use of The ANP methodology. The ANP methodology is a robust multi-attribute decision-making technique for governing the SC performance.

Wee and Wu (2009) followed a four-step problem solving process to demonstrate how lean supply chain affects product cost and quality. Different indices of quality enhancement and lead time reduction were depicted. They also provided some recommendations and basic principles to implement VSM successfully through P-D-C-A improving cycle. This study shows how VSM supports the lean supply chain and identifies potential opportunities for continuous improvement to eliminate waste. Culture change was found to be the foundation of many companies to sustain success. Lean supply chain literature highlights the managerial application of lean practices (Manrodt, Vitasek & Thompson, 2008), integrates lean and agile operations (Mason-Jones *et al.*, 2000; Goldsby *et al.*, 2006).

### Phase III (2010-2013) Leagility Phase

The most important phase from the lean supply chain point of view advocated the combination of the concepts of Lean and Agile in the supply chain for better performance.

### Leagility in Supply Chain

In the lean drive the distributor tries to reduce its inventory from levels resulting from high agility to more appropriate lean levels, eliminating wastes. Then the firms' strategy could be described as supplying the customers with what they needed, when they needed it but in perfect way, hence acting in a lean way. Hence, firms can change from one supply chain approach to another and should do so when circumstances change (Kisperska & Haan, 2011). The proportions between lean and agile elements in operations of a single company or the whole supply chain might be changing all the time and only very seldom find an example of pure leanness and pure agility in real business can be found. Such patterns of operation based on "leagile" approach require further research both in theoretical and practical terms. There does not seem to be any clear distinction between leanness and agility. They also compared the lean and agile manufacturing paradigms, highlighting the similarities and differences. Neither paradigm is better nor worse than the other, indeed, are they complementary within the correct supply chain strategy. Cabral *et al.* (2012) Lean, Agile, Resilient and Green (LARG) paradigms are advocated as the foundation of a competitive SCM. Effective SCM is one of the keys to survival in a market that is increasingly volatile and turbulent. They emphasised the importance of decision-making in selecting the appropriate strategies/practices/KPIs by SC managers in supply chain performance and proposed an integrated LARG analytic network process (ANP) model to support decision-making in choosing the most appropriate practices and KPIs to be implemented by companies in an SC with the help of a case study.

Soni and Kodali (2012) proposed a framework for lean, agile and leagile supply chain by evaluating reliability and validity of lean, agile and leagile supply chain. They established the constructs of lean, agile and leagile supply chain for Indian manufacturing industry. Vinodh and Aravindraj (2013) in their article presented the conceptual model of leagility imbued with lean and agile principles. A fuzzy logic approach had been used for the evaluation of leagility in supply chains. This was to compute the performance of supply chains using both lean and agile concepts as leagility supply chains using a fuzzy logic approach. Rahimnia and Moghadasian, (2010) studied the role of lean and agile in supply chain of professional services in context of the healthcare industry. The specific condition of the patients forces the hospital to be highly agile and at the same time it can benefit from lean strategies. Argued that role of human resource is very important in leagility. Quick delivery of required services is very necessary

for effectiveness of the treatment process. Mollenkopf *et al.* (2010) claimed certain barriers and contradictory points across the three supply chain strategies viz. lean agile and leagile. Managerial aspects are to be given due attention across these three strategic interfaces. Integrated life cycle management was suggested as a framework for measurement application across the three supply chain strategies. A recently introduced term SCRM (Supply Chain Risk Management) emphasizes the importance of the risk management in supply chains. A significant part of the papers concerns the identification of risks related to supply chain management. However, the concepts of lean and agile management are often discussed due to the fundamental determiners of the functioning of a supply chain. They suggested that the factors of supply chain should be viewed under the purview of supply chain risk management (Konecka, 2010).

Scholten Kirstin *et al.* (2010) explored the concept of agility in the context of supply chains of humanitarian aid (HA) organisations, mainly non-government organisations (NGOs). Agility when responding to disaster relief holds strong potential for increasing efficiency and effectiveness, but there are barriers of absence of supporting information technology (IT) and ignorance of supply chain management (SCM) by NGOs. They also found that those NGOs which embrace technology and along with effective supply chains will be better positioned to win the donations of sponsors. Success of lean and agile practices needs many diverse factors such as implementation of technical tools, transformation of organisational culture, modifications throughout the value chain of the organisation. Leagile has major strategic significance importance and edge (Amir, 2011). Sukwadi, Wee and Yang (2013) studied the impact of lean-agile operations and supplier-firm partnership on garment small and medium enterprise supply chain performance. They found that agile supply chain and partnership strategy are critical for garment SMEs supply chain performance but leanness strategy is not. Cozzolino, Rossi and Conforti (2012) studied the humanitarian logistics process to identify the need of agile and lean principles. There must be proper combination of the agile and lean principles in disaster relief phases which must be based on the coincidence of the objectives that arises in every stage and that each principle is capable of achieving.

### Technology and VSM in Supply Chain

Chen *et al.* (2013) showed that total operation time can be saved significantly from current stage to future stage with the integration of RFID and lean. They advocated

the use of RFID technology to reduce the cost of labors along with maintaining the service capacity in the supply chain and also applying it to the transportation system to increase the traceability of deliveries. They used VSM to analyse the factors leading to insufficient supply chain operations and applied both lean production and RFID technology to improve supply chain efficiency and effectiveness. Dües and Tan (2013) found the importance of applying lean and green practices in supply chain to make it more effective. They found a positive relationship between the lean environment and the green implementation mentioning that lean environment acts as a catalyst for implementation of green. Integration of lean and green practices would be beneficial for effectiveness of the supply chain. This integration is not prevalent but is also not impossible to do so. Hajmohammad *et al.* (2013) indicated that supply management and lean activities provide means by which resources are invested in environmental practices. The empirical analysis also confirms that the impact of lean management, and to a lesser extent supply management, on environmental performance is mediated by environmental practices. So and Sun (2011) proposed and tested a theoretical model based on the innovation diffusion theory (IDT) and used IDT to explain lean production adoption with the influence of electronic-enabled manufacturing supply chain (EMSC). They found that IDT can explain lean production adoption; and electronic-enabled supply chain integration positively influences the perceived relative advantage of lean production and consequently leads to its long-term adoption. Perez, Castro, Simons and Gimenez (2010) found that the pork sector has actively adopted the productive techniques associated with lean management and the structure of the specific chain in the studied pork sector is suitable to implement lean supply chain strategies according to the presented model. They negated the fluctuations in raw material prices and advocated the use of support mechanisms to increase the sustainability of lean. Arlbjørn *et al.* (2011) outline a model that illustrates under which conditions lean is deemed most appropriate according to the type of service delivered. The surveys and case studies show that lean is mainly implemented as “toolbox lean,” such as with value stream mapping, kaizen and information boards. In addition, the analyses show that the lean philosophy can be used by the public sector to be more effective in terms of cost reduction and service improvements if the assumptions for implementing lean exist. Thus, there is a belief that lean is a means of developing the organisation, which can take place through value stream mapping exercises and kaizen events. This has been confirmed through the three case studies.



## Supply Chain Network

Ma Jinping *et al.* (2011) worked on the modelling and analysis of the cross-organisational workflow systems in the context of lean supply chain (LSC) using Petri nets, assumed conditions of cross organisation workflow net. They defined the concept of Labelled Time Petri Nets (LTPNs) through combining labelled Petri nets with time Petri nets, and the concept of Labelled Time Workflow Nets (LTWNs) is also defined based on LTPNs. Cross-organisational labelled time workflow nets (CLTWNs) are then defined based on LTWNs. Finally, the article illustrated how to use the proposed method. Lean-related aspects mostly focused on increasing the cooperation among supply chain actors, for which the pilot project is very helpful. Although there are a lot of other things to be done but pilot project acts as starting point to develop lean construction. Increased cooperation among supply chain actors is, however, a prerequisite and an appropriate starting point for a further development of the lean concept (Eriksson, 2010). When asked how the municipalities interpret lean, there is a predominant agreement that lean is about eliminating waste, mapping workflows and a focus on continuous improvement. Supply chain management has potential to work well as a philosophy for patient flow in the healthcare sector by organizing for quick response and flexibility in a hybrid strategy through combining lean and agile process strategies. This can be done by a systems approach together with a strategic orientation with cooperative efforts to synchronize and converge operational as well as strategic capabilities into a unified whole by the supply chain members (Aronsson *et al.*, 2011).

There exists a strong association between lean production, product quality performance, and business performance. "Reduced setup time" appears to be of primary importance in the linkage between lean production, product quality performance and business performance (Agus & Hajinoor, 2012). Fuentes Jose *et al.* (2012) examined the impact of the level of cooperation of both suppliers and customers in the supply chain on lean production (LP) adoption. Found that greater levels of cooperation with suppliers do not impact on the intensity of LP adoption but greater levels of cooperation with customers do have a significant effect. Also, greater cooperation with customers along with more information integrated with them, leads to the higher intensity of LP adoption. Cudney and Elrod (2012) studied the effectiveness, applications and the performance of lean techniques in the supply chain. They found that training their suppliers in lean methodologies provided significant time and financial benefits for organisations. Behrouzi

and Wong (2011) identified four underlying lean supply chain performance components including quality, cost, flexibility, and delivery and reliability and related measures with a focus on small and medium enterprises. Smadi (2012) studied the extent of applying lean supply practices in the Garments manufacturing companies with the help of five variables representing the lean supply concept. These variables are, Supplier feedback, Just in time delivery by suppliers, Supplier development, Customer involvement, and Facilitation of just in time production. The study revealed that the Garments Manufacturing Companies in Jordan adoption to the lean supply practices is considerably high at all aspects, except for supplier development which was given average rating. Lean practices can reasonably predict MC (mass customisation) performance and e-commerce and e-procurement appear to be reasonable predictors of MC performance in product manufacturers, while ERP is not (Hong *et al.*, 2010).

Manzouri *et al.* (2013) assessed the implementation of lean practices in the Halal food supply chain and found that lean is not a popular thing in this supply chain but they need implementation of it on an urgent basis. Market competition and uncertainty was highlighted as an important barrier in implementing LSC among the lean firms but in contrast, lack of customer awareness of LSCM practices was recognised as a major barrier in non-lean firms. Supplier partnership fully mediates the relationship between lean supply chain strategy and supply chain responsiveness, and that postponement partially mediates the relationship between agile supply chain strategy and supply chain responsiveness. And supply chain responsiveness is associated with enhanced firm performance (Qrunfleh & Tarafdar, 2013). Shamah (2013) developed an instrument to measure the impact of lean thinking on supply chain value in Egyptian industrial sector and indicated that they are willing to go lean. Guimarães and Carvalho (2013) studied the healthcare supply chain and found an alignment between SCM thinking in healthcare and lean thinking. In SCM decision, lean practices serve not only strategic intent but also solve operational efficiency. There is a match between different outsourcing drivers (transactional, strategic and transformational) and lean maturity levels. The main constraint to deployment of both lean and outsourcing practices are cultural differences (Guimarães & Carvalho, 2013).

## FINDINGS AND CONCLUSION

The study brings forth a number of things in to focus that are very relevant for the researchers to conduct further

Table 6: Variables Studied

<b>Variables Classification Schema</b>	<b>Supply chain network</b> Naylor <i>et al.</i> (1999), Kinsey (2000)	<b>Waste elimination</b> Disney <i>et al.</i> (1997)	<b>Process thinking</b> Mentzer <i>et al.</i> (2001)	<b>Customer-supplier integration</b> McIvor (2001)	<b>JIT</b> Das and Handfield (1997)
	<b>Material flow</b> McCullen and Towill (2001)	<b>Marketplace environment</b> Mason-Jones <i>et al.</i> (2000)	<b>Information in SC</b> Francis (1998)	<b>Supply chain risk management</b> Konecka (2010).	<b>Agility</b> Scholten Kirstin <i>et al.</i> (2010), Soni and Kodali (2012), Christopher and Towill (2000)
	<b>Supplier-firm partnership</b> Sukwadi <i>et al.</i> (2013), Dayna and Damien, (2005)	<b>Supplier cooperation</b> Fuentes Jose <i>et al.</i> (2012), Aronsson <i>et al.</i> (2011), Eriksson (2010)	<b>Workflow systems</b> Ma Jiping <i>et al.</i> (2011) (Sezen and Erdogan, 2009).	<b>Cost reduction</b> Arlbjørnet <i>et al.</i> (2011)	<b>Innovation Theory (IDT)</b> So and Sun (2011)
	<b>Setup time</b> Agus and Hajinoor (2012)	<b>RFID and lean</b> Chen <i>et al.</i> (2013)	<b>Environmental performance</b> Hajimohammed <i>et al.</i> (2013)	<b>Mass customisation</b> Hong <i>et al.</i> (2010).	<b>Supply chain responsiveness</b> Qrunfeih and Tarafdar (2013).
	<b>Lean practices</b> Manzouriet <i>et al.</i> (2013), Hong <i>et al.</i> (2010), Cox and Chicksand (2005), Fearne and Fowler (2006)	<b>Cultural differences</b> Guimarães and Carvalho (2013)	<b>Supplier training</b> Cudney and Elrod (2012)	<b>Quality and cost</b> Wong (2011) Wee and Wu (2009)	
	<b>Agile and Lean</b> Mason-Jones <i>et al.</i> (2000), Cagliano <i>et al.</i> (2004), Cozzolino <i>et al.</i> (2012)	<b>Leagile</b> Amir (2011), Mollenkopf <i>et al.</i> (2010), Aravindraj (2013), Bruce <i>et al.</i> (2004)	<b>Green practices</b> Dües and Tan (2013)	<b>Supplier feedback</b> Smadi (2012)	

researches in the field of lean supply chain. The papers are classified on the basis of year, industry, journal, and country which gives a clear view of researches conducted in different fields. The classifications makes it evident that manufacturing industry has been the prime area of attention of researchers in lean supply chain followed by automotive and food industry. It seems that researchers of UK have most inclination towards lean supply chain followed by USA and India. A closer look on the papers, gives three phases of research viz. Phase I (1996-2001) Network Management Phase; Phase II (2003-2009) Lean Environment Phase; Phase III (2010-2013) Leagality Phase.

Among all these three phases, the third phase has been most important. Most of the researches have been done during this Phase. This makes it very lucid for the researchers to locate the papers from different areas and dealing with different set of problems of supply chain. It also indicates which aspects were emphasized in different phases and what is the direction of the current stream of researches in the field of lean supply chain. Initially there was more attention on the networks of supply chain partners and supply chain environment to achieve lean supply chain that moved towards value stream mapping and technological improvement. In the current scenario there is revolutionary importance of agility coupled with leanness in the supply chain which is growing and gaining importance in the minds of the researchers. Agility combined with lean has become order of the day and there is continuous focus on this for last three-four years.

In the same continuation this research paper provides a clearer view of previous researches in lean supply chain with a view to help researchers find out the ways to improve the supply chain of business organisations to help them flourish and hence the prosperity of the society.

### Future Avenues and Implications

This paper brings a plethora of avenues and scopes in to light for future researchers and has a wide range of implications. The classification of papers on different bases will give the researchers a clearer view of researches done in lean supply chain area. The lucid presentation of variables studied, will make the identification of research gaps easy and obvious. The exhaustiveness of the research makes it a very important source of location of researches in lean supply chain area. The phases identified make it very helpful to identify a trend in the development and progress of lean supply chain and hence the need of the hour.

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