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# Empirical Progression of Lean Manufacturing: Literature Review

**Dilanthi M.G.S.**
Department of Industrial Management, Faculty of Applied Sciences,
Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka.

shanikadilanthi@gmail.com

***Abstract: Lean manufacturing has evolved over time devising with thinking of waste reduction. Many researchers have studied in this field and have tried to define the concept and to evaluate its performance. Therefore the main purpose of this paper is to recognize the conceptual evolution and to comprehend such empirical work related to lean manufacturing.***

***Keywords: Waste Reduction, Lean Manufacturing, Production Philosophy, Operational Performance, Lean Best Practices***

## I. Introduction

Lean manufacturing is one of prominent philosophies in the manufacturing context focusing the improvements in its processes. Rose et al. (2011) have noted lean manufacturing to be the best manufacturing system in the 21st century. It facilitates managers to do their duties easily while improving the quality of products and increasing the efficiency of manufacturing processes, ensuring a safe work environment with improved employee morale. Zayko (1997) has identified 50 percent reduction in human effort, manufacturing space, tool investment and product development time, and 200-500 percent improvement in quality through lean manufacturing.

The major concern of this concept is to reduce waste and non-value added activities. Literature says that this concept was created before the twentieth century. Lean manufacturing has a long history where the origin stands up with thinking of waste reduction. Early authors have explained the lean concept in philosophical perspective and practical perspective (Womack and Jones 1996, Spear and Bowen 1999). They have shown that the theory of lean manufacturing has evolved over time related to different manufacturing philosophies. The knowledge gained through these philosophical perspectives has encouraged practitioners and researchers to further expand the concept and its applications. Therefore it is very important to consider the history and the evolution of lean manufacturing based on related empirical literature.

## II. Historical Overview of Waste Reduction

Benjamin Franklin in 1758 contributed well in advance for thinking of waste reduction. He provided some important guidelines for this concept based on work ethic themes and frugality. Sparks (1836) has highlighted this explaining the essay on "The way to wealth" written by Franklin.

In the twentieth century, the contribution of scientific management was significant in evolution of waste reduction. The father of scientific management: Frederick Taylor introduced work standardization and the best practices deployment to identify non-value added activities done by the workers. In order to eliminate those wastes, he emphasized them to adopt new methods and practices instead of the existing procedures.

Frank Gilbreth also contributed to reduce wasted time and labour by explaining his studies on motion efficiency. He established fundamentals for predetermined motion and time systems (PMTS) after having a deep investigation on the performance of workers.

## III. Initiated Empirical Wok in Japan

The economy of Japan collapsed after the Second World War so that they had to face shortage in raw material, financial resource and human resource. Therefore the Japanese managers needed to device new methods to remain in the market. This caused an outstanding progress in the studies done in Japan related to the production philosophy. This progression was based on "Today and tomorrow" written by Henry Ford in 1927 explaining the Ford's Production System (FPS). Therefore the Ford's production philosophy became more credited among early researchers.

One such a study was done by Ohno (1937) together with Toyoda cousins of Kaiichi and Eiji in Toyota Motor Company where the Toyota Production System (TPS) was evolved (Shah and Ward 2007). They further studied FPS and principle concepts and tools of TPS. The knowledge gained through this study helped Ohno to publish the book called "Toyota Production System" in 1988. As mentioned in this book, the primary goal was to eliminate wastes by producing only the units needed, at the time needed and in the quantities needed. This idea led the Just In Time (JIT) philosophy. The same idea can be mapped with the conceptual definition for JIT given by Sugimori et al. (1977). He defined JIT as "only the necessary products, at the necessary time, in the necessary quantity". This production philosophy therefore emphasizes fewer inventories which are more related with the lean concept.

## IV. Integration of Lean in United States

There was an oil crisis in United States in 1973. In order to successfully withstand this challenge, many of their firms adopted toward JIT which was a Japanese production

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philosophy. They had to gain the conceptual knowledge on the Japanese manufacturing and management practices through numerous publications such as academic and practitioner books and articles (Sugimori et al. 1977, Mondon 1981b). These publications provided the knowledge on Kanban and JIT production systems, production smoothing and level loading. Gathering of such knowledge was facilitated by publishing the books called "Ohno's Toyota Production Systems" and "Mondon's Toyota Production Systems" in English in mid 1980s according to the reviews of Shah and Ward (2007).

With this much of knowledge on the Japanese manufacturing and management practices, many United States firms implemented JIT in mid 1980s. Thereby, TPS arrived in United States challenging the managers there. TPS was not an easy task to grasp for them because it was a multifaceted approach. Then these managers could realize the components of TPS and hence the lean concept was popular among the academic and business publications as an extended production philosophy.

## V. Academic Progression in Lean Thinking

In 1988, Krafcik used the term "lean" at first to describe the manufacturing system used by Toyota (Shah and Ward 2007). He used this term arguably in his master's thesis and published the article titled as "Triumph of the Lean Production". This article supported to overturn the myth about the auto industry: the location of assembly plant decides the level of productivity and the quality of the industry. Since this work was very interested, it was continued and published in the book called "The machine that changed the world" by Womack, Jones and Roose in 1990. The term "machine" established "lean production" stating TPS.

Starting with this point, Shah and Ward (2007) reviewed and mentioned the articles related to JIT measurements (Sakakibara et al. 1997, Flynn et al. 1995b, McLachlin 1997), Total Quality Management (Ross 1993, Dean and Bowan 1994, Sitkin et al. 1994, Flynn et al. 1995a), their interrelationships (Flynn et al. 1995a, Sakakibara et al. 1997) and the impact of other organizational variables on their implementation.

Extending the philosophy and guiding the principles of lean production toward the enterprise level, Womack and Jones published the book called "Lean Thinking" in 1994. Furthermore, the academics and the practitioners (Krafcik 1988, McDufie 1995, Pil and McDuffie 1996, Shah and Ward 2003, Wood et al. 2004) accepted and explained the superior performance and the provided competitive advantages through lean production.

## VI. Applications, Case Studies and Performance Evaluations of Lean Philosophy

The proper guidance given by the academics and the practitioners led further innovative studies related to the lean philosophy. The literature found number of applications, case studies and performance evaluations done by different researchers coming up with important findings related to the lean concept.

The authors (Sugimori et al. 1977, Mondon 1981b, Hall 1987, Ross 1993, Sitkin et al. 1994, Dean and Bowan 1994, Flynn et al. 1995, McLachin 1997, Hopp and Spearman 2004, Bhasin and Burcher 2006, Nash, Poling and Ward 2006, Shah and Ward 2007, Ghosh 2013) have studied the lean concept and defined it incorporating different applications of the concept as per the empirical literature. But some authors (Pettersen 2009, Karlsson and Ahlstrom 1996, Shah and Ward 2007) have seen the lack of clarity of the definition of lean manufacturing. Shah and Ward (2007) further emphasized this saying "however, any discussion of lean production with managers, consultants or academics specializing in the topic points to an absence of common definition of the concept". Therefore they have tried to some extent to define lean manufacturing through their studies.

Literature could be found explaining several studies on the lean practices and its performance. According to Shah and Ward (2003), lean production is a multi-dimensional approach including variety of management practices focused toward quality, superior management and less wastage. It consists with number of lean practices which ensure a good implementation and a longer existence. The studies done by many authors found different lean practices which showed positive relationship with the operational performance of the concept (Caglino et al. 2004, Rahman et al. 2010, Kuo et al. 2008, Ghosh 2013, Taj 2007, Nair 2006, Sila 2007,Papadopouloand Ozbayrak 2005, Bonavia 2006, Simpson et al. 1998, EPA, 2003, Oliver et al. 1993).

Relating to the case studies, few researchers (Flynn et al. 1995, McKone and Weiss 1999, Osterman 1994) have investigated the implementation and the performance relationships of lean manufacturing. As a result of these attempts, one research done by Galbraith (1977) found the success of implementingthe management practices to be frequently depended upon the organizational characteristics and that was not same for all organizations.

- Operational Performance Measures

Measuring of the operational performance is still discussed by researchers and practitioners. That might have been caused by the revolution in measuring of the performance as shown by Neely et al. (2005). He notified this revolution in pure financial focus. Lean manufacturing is mostly applied in the work floor linking with the manufacturing processes. Further Neely et al. noted that the practitioners argued in some areas to be measured related to the performance of any business, but they could give a little guidance on those measurements. In order to measure the performance at operational level, the measures should be defined in non-financial terms rather than the financial terms as Neely et al. noticed, and also should be related to the lean practices.

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Literature explains the existing measures for the operational performance of lean manufacturing (Abdallah& Matsui 2007, Ahmed et al. 2003, Bhasin 2008, Chong et al. 2001, Fullerton & Wempe 2009, Gosh 2013, Matsui 2007, Perera & Perera 2012, Rahman et al. 2010, Sakakibara et al.1997, Shah & Ward 2007, Schronberger 2007). They have used different sets of performance measures in a broad range of manufacturing environment and based on different business strategies. The following five measures were identified in the literature as they were commonly used by different authors to measure the operational performance of lean manufacturing.

i. First pass quality yield
ii. Inventory reduction
iii. Time to respond the customer
iv. Productivity
v. Unit cost reduction

- Best Practices of Lean Manufacturing

In the phase of practices, the lean practices are generally shown to be associated with high performance in a number of studies of world class manufacturing (Sakakibara et al. 1997, Giffi et al. 1990). Pavnaskar et al. (2003) identified more than one hundred lean practices available in the industrial practice.

Several studies have shown the direct relationship between the lean manufacturing practices and the improved performance (Nair 2006, Sila 2007). Empirical literature identified the best practices of lean manufacturing in different perspectives. The following best practices as mentioned in Table 01 were identified through the substantive literature, which have been widely used by many researchers in their studies.

Table 01

| Se. No. | Lean Best Practice/ [References] |
|---|---|
| i | Continuous Improvement/ [1, 2, 3, 4, 5, 7, 8, 9, 10, 11] |
| ii | Quick Setup/ [1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12] |
| iii | Just In Time Deliveries/ [2, 3, 4, 5, 6, 7, 8, 9, 10, 11] |
| iv | Implementation of Kanban/ Pull System/ [1, 2, 3, 4, 6, 7, 8, 9, 10, 12] |
| v | Use of Error Proofing Techniques/Poka yoke/ [1, 2, 3, 7, 8, 9, 10, 11, 12] |
| vi | Production Leveling/ Heijunka/ [1, 2, 3, 7, 8, 11] |
| vii | Small Lot Production/ [3, 4, 5, 6, 7, 8, 9, 10, 11, 12] |
| viii | Time/Work Studies/ [1, 2, 3, 7, 8] |
| ix | Waste Elimination/ [1, 2, 7, 8, 9, 10, 11, 12] |
| x | TPM/ Preventive Maintenance/ [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12] |
| xi | Use of New Process Technology/ [4, 5, 10, 12] |
| xii | Removing Bottlenecks/ [10, 12] |
| xiii | Use of Flexible Resources/ [2, 3, 4, 5, 6, 7, 9] |
| xiv | Inventory Reduction/ [2, 7, 8, 9, 10, 11, 12] |
| xv | Lead Time Reduction/ [2, 12] |
| xvi | Cycle Time Reduction/ [4, 5, 12] |
| xvii | Total Quality Management/ [4, 5, 6] |
| xviii | Cellular Manufacturing/ [4, 5, 6, 12] |

**References:** 1- Basu (2009), 2- Blanchard (2007), 3- Bruin (2006), 4- Chang et al. (1990), 5- Flynn et al. (1999), 6- Fullerton & Mc Waters (2001), 7- Guptha & Brennan (1995), 8- Hopp and Spearman (2008), 9- Karim (2009), 10- Kovacheva (2010), 11- Koycheve (2011), 12- Rahman et al. (2010)

Table 01 reviewed that no any common set of lean best practices could be recommended according to the relevant empirical literature since the business strategy and the manufacturing environment determine which best practices to be used. But this summary shows the widely used best practices in lean manufacturing so that they could be primarily considered in implementing the concept.

## VII. Conclusion

Based on the two philosophies of the Ford's Production System and the Toyota Production System, lean manufacturing was conceptualized with the main focus of waste reduction. These philosophies led researchers and practitioners in the fields of applications, case studies and the performance evaluation of lean manufacturing. Literature suggested widely used lean best practices and some common measures for the operational performance of lean manufacturing.

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