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CONCEPTUAL EVOLUTION OF LEAN MANUFACTURING

A REVIEW OF LITERATURE

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Abstract

Unlike certain scientific theories which remain unchallenged over time, the most of management theories have evolved over time with new insights, and so as the theories related to manufacturing management. The theory of lean manufacturing has been built on the Toyota Production System which was initially learnt from the Ford's Production System. Therefore, the production philosophy and basic management principles adopted by the Toyota Production System and the Ford's Production System can be recognized as the fundamental theories contributed to the development of lean manufacturing philosophy. The main purpose of this paper is therefore to recognize and to comprehend the historical manufacturing philosophies contributed to the current knowledge on lean manufacturing. It also covers the state-of- the art of understanding on lean manufacturing in terms of definitions, generally accepted principles, tools and techniques of lean manufacturing.

Keywords: Lean Best Practices, Lean Implementation, Lean Manufacturing, Lean Principles, Production Philosophy, Seven Types of Wastes, Waste Reduction

INTRODUCTION

Today, the production philosophies have to evolve with new innovations due to technological advancement and unlimited demands of customers in the manufacturing industry. Lean manufacturing is one such renowned philosophy currently adopted by the manufacturing industry. This concept focuses on key processes of manufacturing systems and improves the organizational performance in financial and non-financial terms. Lean manufacturing is about doing more with less; it involves a never-ending effort to reduce waste and non-value-added

activities. In advance, lean manufacturing leads to improved quality, visual and easy management, increased efficiency, manpower reductions, total company involvement, problem elimination, reduced space, safer work environment and improved employee morale. Rose et al. (2011) explained that lean manufacturing has been proved as the best manufacturing system in the 21st century. Therefore it is timely in need to study this field so that the conceptual knowledge of the lean researchers and the practitioners can contribute to the successful implementation of lean manufacturing.

Lean manufacturing encompasses a wide area in manufacturing context. Thus, understanding and implementing lean strategy has become more difficult than other productivity improvement strategies. Denton and Hodgson (1997) also identified the difficulty in implementing lean manufacturing. This situation can be well addressed by confirming lean fundamentals and their applications through further researches. Therefore this literature review supports in understanding the concepts, tools and techniques of lean manufacturing.

HISTORICAL BACKGROUND

Lean concept was originated with thinking of waste reduction. Pre- 20th century highlights the contribution given by Benjamin Franklin for waste reduction thinking. Sparks (1836) noted the guidelines related to this concept provided by Benjamin Franklin through the essay titled as "The Way to Wealth".

The scientific management then came into play in waste reduction in 20th century. Frederick Winslow Taylor who was the father of scientific management emphasized the importance of work standardization. He suggested replacing existing procedures with new or improved procedures so that all non-value added activities and time wastes could be eliminated. Further studying the work with efficiency calculations, Frank Gilbreth recognized wastes built into the jobs. Then he introduced predetermined motion time systems (PMTS) which enabled any organization to improve the performance of its workers.

These studies encouraged further development of many theories related to the manufacturing management. This was evident in the Ford's production philosophy which was then built by using fundamentals of the Taylor's management theory.

Ford's Production System (FPS)

Henry Ford had an automobile assembly plant in mass scale using skilled labourers. That was time consuming and very expensive. Then he applied the theory of Taylor and streamlined his assembly process. The Taylor's management theory stated that the individual worker was more productive if he was assigned tasks properly suited to his capabilities and strengths. It

supported Ford to identify the unnecessary physical motions of workers being in groups so that productivity could be increased by eliminating such waste. Simultaneously the time taken for the whole assembly process could be minimized avoiding wasted time. These tactics helped Ford to develop the mass assembly manufacturing system of his motor company to operate more efficiently.

Further Ford looked at the motor parts motion and their poor arrangement in the work place. Then he could realize that the time and labour waste could be reduced by keeping heavy parts to be stationary while the light parts were moved. Further streamlining the motor assembly system, Henry Ford converted manufacturing of cars to a paced assembly line.

Ford (1922) described the entire concept of waste in his “My Life and Work”. He had identified the waste motion, waste effort etc. of the average farmer, closely looking at his activities and attitudes. Mentioned in the same paper, Design for Manufacturing (DFM) was another Ford’s concept in mass production which was based on standardization of parts. Henry Ford's proven methods were for mass-production of any product or delivery of any service cheaply but went well beyond the synergistic and mutually supporting techniques (Levinson 2002).

All these are case based and provide evidences for steady state environment; therefore Ford’s philosophy cannot be applied to dynamic situations. Therefore Ford’s concept requires further improvements to become more sustainable and relevant.

Toyota Production System (TPS)

During the Second World War, the economy of Japan collapsed and Japanese manufacturers had to device new methods to reduce costs and remain in the market. They developed some concepts focusing on waste minimization (Levinson 2002) so that unnecessary costs were to be reduced. The philosophy of the Toyota Production System consists of continuous improvement of products, processes or activities in the manufacturing system according to set standards for minimizing the waste together with the participation of all employees. Therefore this philosophy gives the responsibility to all in the work place for each and every aspect inside the organizational boundary.

In the Toyota Production System house, Just in Time is one pillar which is a famous concept. It emphasizes the delivery of right product, at the right time in the right quantity to the customers using minimum necessary resources. This approach therefore creates a minimum level of inventory leading to a minimum level of inventory handling cost. But in most cases, the organizations are facing problems and creating disruptions in the work floor by keeping additional amounts of inventory.

The other pillar is called Jidoka which means that the machines work automatically with human touch according to the Toyota Production System principles. Improvements of the quality should be done with this approach while minimizing human touch. The Toyota Production System suggests in advance that whenever there is an error, the machine should identify any error itself and stop further processing without noticing by any worker. In continuous run of such machines, the quality of the output will be enhanced with minimized waste.

Apart from minimizing the waste, Japan made efforts to improve the quality of their products by using statistical quality control methods. The foundation of the Just In Time house therefore is composed with production leveling, continuous improvement and standardized work. By smoothing production, customers can be delighted with better quality products as they require.

Also Just In Time concerns on continuous improvement which is not related only to the production floor but also to the other processes and activities as well. Goforth (2007) mentioned that Deming achieved prominence in the field of continuous improvement by providing effective training to engineers, managers and scholars focusing on three major areas in using the PDCA cycle, the importance of understanding the causes of variation and process control through the use of control charts. The Deming's view reviewed that the management must be responsible for quality which related to the lean principle of Hoshin Planning or policy deployment. Therefore everyone should be responsible in continuous improvement so that waste can be completely eliminated. In the practical situation, each and every worker is not working with the same attitude and the skills. They may reluctant to contribute to do changes. That leads the Toyota Production System to fail.

Three sub-goals to achieve the primary goal of cost reduction (waste elimination) are quantity control, quality assurance, and respect for humanity. Goforth (2007) has identified several authors such as Ohno (1988), Monden (1983), Shingo (1989) who have provided extended reviews of the Toyota Production System. These reviews aimed at minimizing waste.
Based on these theoretical reviews, the lean concept was originated with the main purposes of minimizing waste of the manufacturing processes and adding value to the customers.

GENERAL PRINCIPLES OF LEAN MANUFACTURING

Definitions

Different authors have defined lean manufacturing in different ways. In order to gain the success and the sustenance of the lean concept, it is very important to review these different definitions. Whatever the industry is related to manufacturing sector, the primary focus is to improve

operations so that the profit is increased. Most researchers argued that the lean is also a paradigm for operation in manufacturing (Bhasin and Burcher 2006).

The famous authors Shah and Ward have seen the lack of clarity of defining the term “lean manufacturing”. Therefore they studied substantive literature and addressed the confusion and inconsistency of the concept. They have noted that the related discussions on lean manufacturing with several managers, specialized persons and academics pointed out this absence of a common definition. Based on the multi-dimensional structure of lean manufacturing, Shah and Ward (2007) proposed the definition as “lean production is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability”.

Also Nash, Poling and Ward (2006) have defined lean as a systematic approach to identify and to eliminate waste through continuous improvement by following the product or the service at the pull of the customer in pursuit of perfection.

Whoever defined lean manufacturing, they have centered the concept as to minimize the waste by considering the value of the customer and have helped to fill the conceptual gap in lean manufacturing.

Seven Types of Wastes

Waste is a central term in classical lean literature (Schonberger, 1982; Krafcik, 1988; Ohno, 1988; Imai, 2001). Wastes create unnecessary costs and time losses while leaving the customers as well. Any non- value added activity or movement in the work floor causes creating wastes. The Toyota Production System has defined three broader types of wastes (Ohno 1988). They are;

1. Muda (Original wastes created in the work floor)
2. Muri (All unreasonable work done by workers and machines due to the poorness of the organization)
3. Mura (Unevenness of the work/process)

Iarnien and Vienaindien (2012) have mentioned that two basic concepts in lean thinking are to eliminate waste and to create value. In order to improve the overall value to the customer, the lean concept focuses waste reduction. As Toyota noted, in many lean implementations, the above types of wastes shrink to the first category.

In concepts of the Toyota Production System and lean manufacturing, these three types of wastes are linked together. First Muri focuses preparation and planning of work or processes and then Mura focuses how that plan can be implemented by eliminating fluctuations at the scheduling or operational level. After all, Muda shows the output of these two stages through

the identified wastes. The value to the customer then can be enhanced with the feedback gained through this link.

There are seven types of wastes identified in the lean concept and called it as muda (Ohno 1988, Shingo 1989). Womack et al. (2003) have described the original seven wastes as:

1. Transport (moving products that are not actually required to perform the processing)
2. Inventory (all components, work in process and finished product not being processed)
3. Motion (people or equipment moving or walking more than is required to perform the processing)
4. Waiting (waiting for the next production step, interruptions of production during shift change)
5. Overproduction (production ahead of demand)
6. Over-processing (resulting from poor tool or product design creating activity)
7. Defects (the effort involved in inspecting for and fixing defects)

Among these wastes, inventory and work in progress (WIP) are generally classified as the key elements in lean manufacturing which cannot be separately considered. WIP can visualize the level of waste contained in a system. Therefore lean concept has identified WIP to be the mirror of system imperfections.

Later, Womack et al. (2003) added an eighth type of waste describing the manufacturing goods or services which do not meet the requirements of the customers. But many authors have named it as unused human talent/ creativity (Philbrick 2008, Duray 2013, Liker 2003, Magee 2007).

Lean Dimensions

Many authors have studied and presented their findings related to lean manufacturing as case studies which were done in the manufacturing industry. These literatures suggested different lean dimensions but not unique. Shah and Ward (2003) have presented lean production to be multi-dimensional focusing toward better quality, superior management and less wastage. Relying on these findings on lean dimensions, researchers and practitioners have been encouraged to evaluate the performance of lean manufacturing in the work floor. According to the literature, their studies have presented evidences for the significant relationship between these lean practices and the performance of lean manufacturing.

Pavanskar et al. (2003) have mentioned that there are more than one hundred of lean practices identified by different authors and practitioners. Several literatures have been summarized as in Table 1.

Table 1: Summary of Reviewed Best Practices in Related Literature

Lean Best Practice	Reference No.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Continuous Improvement	x	x	x	x			x	x	x	x	x	x	X
2. Set up Time Reduction	x	x	x	x	x	x	x	x	x		x	x	X
3. Just In Time Deliveries			x	x			x	x	x		x	x	X
4. Kanban/ Pull System	x		x	x		x	x	x	x		x	x	
5. Use of Error Proofing Techniques/Poka yoke	x		x	x			x	x	x		x	x	X
6. Production Leveling/ Heijunka	x		x	x			x	x	x				X
7. Standardized Work	x	x	x	x			x	x	x	x	x		
8. Visual Control and Management	x	x	x	x			x	x	x		x		X
9. 5S/ House Keeping	x		x	x		x	x	x	x	x	x		
10. Small Lot Production				x	x	x	x	x	x	x	x	x	X
11. Time/Work Studies	x		x	x			x	x	x				
12. Waste Elimination	x		x				x		x		x	x	X
13. TPM/ Preventive Maintenance	x	x	x	x	x	x	x		x		x	x	
14. Use of New Process Technology												x	
15. Use of Quick Change Over Techniques												x	
16. Team Work			x	x			x		x				
17. Employee Involvement			x					x					
18. Education/ Cross Training		x		x	x	x	x				x		
19. Autonomation			x				x	x			x		X
20. Inventory Reduction			x				x	x	x		x	x	X
21. Quality Circle		x			x	x							
22. Lead Time Reduction			x					x					

Sources: (1)Basu (2009); (2) Bhasin and Burcher (2006); (3) Blanchard (2007); (4) Bruin (2006); (5) Gamage et al. 2012; (6) Giffi et al. (1009); (7) Guptha and Brennan (1995); (8) Gympah and Gargeya (2001); (9) Hopp and Spearman (2008); (10) Imai (2001); (11) Karim (2009); (12) Kovacheva (2010) ; (13) Koycheve (2011)

Table 1 does not suggest any common set of lean practices. Some practices have been widely used and some other practices have rarely used. The lean practices that are adopted by different manufacturing organizations are decided by the business strategy and the applied manufacturing environment. Therefore it is not easy to propose unique set of practices in the lean conceptual space.

Lean Principles

Lean principles examine the business processes and identify unnecessary costs and inefficient procedures. Therefore the successful functioning of the strategy can be guaranteed by the knowledge on lean principles. Lean manufacturing was derived from the Toyota Production System together with some other concepts that explain the philosophy of process management. Lean manufacturing is underpinned by five principles (Womack and Jones 1996, Emiliani and Stec 2004, Spear 2004, Muman 2002, Hopp and Spearman 2004).

1. Identify customers and specify value (The value that customers are willing to pay).
2. Identify and map the value stream (Identifying the value added and non-value added).
3. Create flow by eliminating waste (Organizing the value stream to be continuous).
4. Respond to customer pull (Responding to downstream the customer demand).
5. Pursue perfection (Waste elimination through improvement and optimization).

These principles are explaining the way of doing things of an organization. It ensures the goal achievements driving toward the overall organizational strategy and the expected customer value. Therefore any organization can maintain its high level of service sustainably retaining in the changing environment.

Lean Implementation

Implementing lean concept is very much difficult (Denton and Hodgson 1997) because it is in multi-dimensional structure. It requires much experience and time to become very successful in a complete implementation. Still many countries are in its implementation stage. Womack and Jones (1996) have mentioned that one of main goals of implementing lean strategy is to eliminate everything that does not add value to the product or to the service. In many companies, the major focus of lean implementation is still the shop floor and their research for competitive advantage has yet to rely on the more recent lean integrative approached (Hines et al. 2004). Therefore many organizations in the manufacturing industry have already initiated lean implementation in operational level.

Implementing the lean concept in any organization can gain many advantages over the operational performance. According to the empirical literature of Rahman et al. (2010), the study done by Anand and Kodali (2009) have demonstrated that the implementation of a lean manufacturing system resulted in superior organizational performance compared to the other practices namely flexible manufacturing systems and computer integrated manufacturing systems. This has currently caused to create new trends in lean implementation.

Iarnien and Vienaindien (2012) have described the model of lean implementation process with three major steps.

1. Planning the change: It needs to define and pre identify the required change expected through lean implementation and to get the commitment of the management to do that change. Then the processes should be well identified to apply the lean concept.
2. Identifying success factors: All people should be made aware of the expected change and should involve with the process of implementation. Then the superiors should provide required tools, methods and job security to these people.
3. Implementing and measuring progress: The progress and the effectiveness of this implementation should be assessed to ensure the success. The authors suggested five dimensions to measure this progress. They are; elimination of waste, continuous improvement, continuous flow and pull driven systems, multifunctional teams and information systems.

The study done by Kovacheva (2010) has identified the following factors to be the most significant in lean implementation according to the literature.

1. Management commitment in the implementation process and communicating the vision of the improvement program
2. Necessary changes in the organizational culture
3. Employees involvement
4. Network relationships
5. Holistic strategy for integrating the system
6. Willingness to learn

Therefore in implementing the lean concept and in its operation, these factors should be collectively considered.

There is a criticism among rank-and-file workers saying that, the lean practitioners are highly focusing on the lean tools and the respective methodologies, so that they fail in the implementation process due to the poor focus on the lean philosophy. In some cases, the lean implementations look good but fail to improve. Hopp and Spearman (2008) have explained this situation seeing as a pitfall saying that management decides what solution to use without understanding the true problem and without consulting shop floor personnel.

CONCLUSION

Lean manufacturing has a long history which was initiated in Japan. This concept was originated with thinking of waste reduction evolving with the Ford's production philosophy and the Toyota Production System. Many authors have defined lean manufacturing in different terms

but their meaning was focused toward waste reduction and the value to the customers. Lean manufacturing introduced seven types of wastes created in the work floor. The related literature supported to map the current knowledge in lean manufacturing with its real-world applications. Thus many researchers have studied in this area and have found the positive impact of the concept on the organizational performance. Also they have further identified key dimensions of lean manufacturing and provided evidences for the concept to be multi-dimensional. These empirical findings have further explained the successful lean implementation procedures which make benefited to the manufacturing industry enhancing their quality and productivity.

The Way Forward

After a substantive review of literature, this paper comprehensively presents the conceptual evolution and the basic principles of lean manufacturing which is currently adopted by the manufacturing industry. Therefore, this study provides future insights to investigate on successful implementation, performance assessment and perceived benefits through the concept.

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