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A REVIEW ON THE SELECTION OF LEAN PRODUCTION TOOLS AND TECHNIQUES

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ABSTRACT

There has been numerous published literature related to lean production. However, very limited studies have been found focussing on the selection of lean production tools and techniques especially for Malaysian context. The review is based on the contemporary literature that published between year 2004 to 2014. The main databases used were Science Direct, Scopus and Emerald. The review gives general pictures of the selection and implementation of lean tools and techniques in various industries and the factors that affect the selection process. The analysis showed that there was no study yet on the selection of lean production tools and techniques specifically in Malaysia by using rational decision making process. Therefore, this gap requires further research on the selection of appropriate lean production tools and techniques by considering several critical decision criteria.

Keywords: lean production, lean tools and techniques, selection.

INTRODUCTION

In today's business world of fierce competition, customers consistently demand higher quality product in a shorter delivery time and at a lower price. So, the organisation struggles to continuously improve their organisation. The most important questions in their mind, is 'what is the most appropriate way to improve their organisation by considering their constraint such as cost and time?' Both incremental upgrading and innovation are precious operational strategies to gain and maintain competitive advantage in the global market (Hammer, 2005; Sohal, 2001; Swinehart, 2000). Many companies facing more challenges in selecting the appropriate improvement initiatives because the number of improvement initiatives is increasing every year, which makes it even harder to select the most appropriate initiative (Baxter and MacLeod, 2008; Davenport *et al.*, 2003). "Improvement initiatives" refers to the approaches, systems, tools and/or techniques and include for example Lean Production, Six Sigma, Business Process Reengineering (BPR), Balanced Scorecard and so on. ((Mohammad, 2010).

The adoption of initiatives requires time, resources, financial and knowledge (Mohammad, 2011; N. Thawesaengskulthai, 2007). To avoid unnecessary waste and frustration, it would be better for people to select the right initiative that will fit with organisation's context and provide value to the organisation. In reality, while none of the individual initiatives can solve all problems effectively in the organisation, each initiative has a role to play towards improving organisational performance. Every initiative has its own strengths and limitations (Francis, 2010, Mohammad, 2012). The right initiatives to be used may vary depending on several contextual factors, such as: the current maturity level of an organisation, areas in which the initiatives are adopted, type or size of an organisation and the capabilities of its workforce (Benson *et al.*, 1991; Dahlgaard and Dahlgaard-Park, 2004; Mohammad, 2012). Therefore, the objective of this paper is to review the existing literature and provide a comprehensive assessment on the selection process of lean tools and techniques.

RESEARCH METHODOLOGY

The research methodology employed for investigating the lean production tools and techniques selection is literature survey. Literature has been collected primarily through journals within the area of operations management. The literature search has been conducted using electronic journal databases such as ScienceDirect, Scopus and Emerald that publish between years 2004 and 2014. The keywords for this search were "lean production", "lean manufacturing", "lean production tools and techniques", and "Toyota Production Systems". Only English articles had been counted on quantifying the common composition of lean production tools and techniques selection.

RESULTS AND DISCUSSIONS

Lean production

In the late 1980's, the term "lean production" or "lean manufacturing" was introduced by the Japanese car manufacturer Toyota in order to describe a production system conceived. Lean production is a strategy or philosophy that promotes the use of practices, such as just-in-time (JIT), kanban, and value stream mapping (VSM), in order to minimize waste and improve organization's performance (Womack *et al.*, 1990).

Lean production is also known as manufacturing without waste. The waste is consisting of non-added value to the product. There are seven type of waste such as overproduction, waiting time, transportation, inventory, inappropriate processing, excess motion and product defects (Melton, 2005; Ohno, 1988; Womack and Jones, 1996). The heart of lean production is improve the efficient use of resources through the minimization of waste. Some of the tools and techniques of lean production

include value stream mapping (VSM), 5S, kanban, kaizen, total productive maintenance (TPM), single minute exchange of dies (SMED), cellular layout and pull production system (Abdulmalek, 2007; Doolen and Hacker, 2005). Thus, the selection and the implementation of the right lean production tools and techniques is expected to result in improved the operational outcomes, such as higher quality, lower inventories, and shorter throughput times which results in the improvement of operational performance.

Lean production tools and techniques

There are various lean production tools and techniques have been used by many industries depending on the size of the industries. Based on the compilation from recent research (Arunagiri and Gnanavelbabu, 2014; Khusaini *et al.*, 2014; Matt and Rauch, 2013), there are more than 50 lean production tools and techniques widely used by industries as shown in Table-1.

Table-1. List of lean production tools and techniques widely used by industries.

No	Lean Production Tools and Techniques	(Matt & Rauch, 2013)	(Arunagiri & Gnanavelbabu, 2014)	(Khusaini et al., 2014)
		Italy	India	Malaysia
1	**5S**	**√**	**√**	**√**
2	Cellular Manufacturing (Cell Layout)	√	√	√
3	Kaizen	√	√	√
4	Poka-yoke (Mistake proofing)	√	√	√
5	Setup Time Reduction (SMED)	√	√	√
6	Standardization	√	√	√
7	Value Stream Mapping (VSM)	√	√	√
8	Jidoka (Zero Defect)	√	√	√
9	Autonomation	√	√	
10	Overall Equipment Effectiveness (OEE)	√	√	
11	Quality Function Deployment (QFD)	√	√	
12	Six-Sigma	√	√	
13	Statistical Process Control (SPC)	√	√	
14	Andon (Lighting Signal)			√
15	Group Technology			√
16	Heijunka			√
17	Just in Time	√		√
18	Kanban		√	√
19	One piece flow	√		√
20	Plan Do Check Act (PDCA)			√
21	Root Cause Analysis			√
22	Takt Time		√	√
23	Total Productive Maintenance (TPM)	√		√
24	5 Whys		√	
25	8 Step Practical Problem Solving (PPS) Method		√	
26	Analysis of Variance (ANOVA)		√	
27	Autonomous work groups	√		
28	Benchmarking	√		

29	Continuous Flow		√	
30	Continuous Improvement		√	
31	Design for Six Sigma (DFSS)		√	
32	Economic (optimal) lot size	√		
33	Elimination of Waste		√	
34	Failure Mode Efffect Analysis (FMEA)	√		
35	First in first out (FIFO)	√		
36	Fishbone Diagrams		√	
37	Idea Management	√		
38	Job rotation	√		
39	Just in Sequence	√		
40	Lean Office (Administration)	√		
41	Line Balancing and Muda Reduction	√		
42	Milkrun	√		
43	Optimization of the supply chain	√		
44	Pareto Analysis		√	
45	PPS Simulation software	√		
46	Preventive maintenance	√		
47	Process Mapping		√	
48	Production Leveling		√	
49	Quality Circles	√		
50	Quick and Easy Kaizen		√	
51	Simulation software	√		
52	Supplier Development	√		
53	Total Quality Management (TQM)	√		
54	Visual Controls		√	
55	Visual Management	√		
56	Voice of Customer (VOC)		√	
57	Work Simplification		√	
58	Work station design	√		

Matt and Rauch (2013) have clustered 36 numbers of lean production tools and techniques at Italy. Meanwhile, Arugunagiri and Gnanavelbabu (2014) have listed 30 lean production tools and techniques that currently used by organisations in India. Khusaini *et al.* (2014) listed 18 lean production tools and techniques that widely used by Malaysian companies such as automotive, electrical and electronics. It was found that less than 10 lean production tools and techniques similarly used by industries at three different countries (Italy, India, and Malaysia) such as 5S, Cellular Manufacturing, Kaizen, Poka-yoke (mistake proofing), Setup Time Reduction, Standardization, Value Stream Mapping (VSM), and Jidoka (Zero Defect).

Selection of lean production tools and techniques

The researchers have not found the guidance for the selection specifically on lean production tools and techniques. However, there are numerous literatures suggested the decision makers to make the rational decision with regards to the selection and adoption of proper improvement initiatives such as (Miller and Hartwick, 2002; Mohammad, 2012; Natcha Thawesaengskulthai, 2007). Regarding to Bazerman and Moore (2009), a rational decision making is " logically expected to lead to the optimal result, given an accurate assessment of the decision maker's values and risk preferences".

Thawesaengskulthai (2010) explains that the rational selection of improvement initiatives is associated with a structured and systematic processes that consider

the organization's direction and context. Decision making involved numerous alternatives and assessment criteria. When making decision, the difficulties arise in choosing the most appropriate alternative or solution. One of the ways that help the decision maker to choose an appropriate solution is by using Multiple Attribute Decision Making (MADM) technique. The MADM is a part of Multiple Criteria Decision Making (MCDM) technique (Yoon and Hwang, 1995). MADM can be defined as "making preference decisions, evaluation, prioritization and selection over the available alternative that are characterized by multiple, usually conflicting, attributes". The common characteristic of MADM include a finite number of alternative are screened, prioritized, selected or ranked (Yoon & Hwang, 1995). There are several methods that can be used within the MADM technique such as Weighted Sum Model (WSM) or Simple Additive Weighting (SAW), Weighted Product Model (WPM), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) method.

As shown in Table-2, there are several studies have been found related to the selection of improvement initiatives which include Bendell, (2005); Mohammad, (2012); Thawesaengskulthai, (2007); Wieleman, (2011) Thawesaengskulthai, (2007) was focused on the selection of approaches (e.g. TQM, Six-Sixma, Lean, BPR, BE) and system (ISO9000), and (Wieleman, 2011) focusing on the approach (e.g. TQM, Six-Sigma, BPR, Lean, Business Process Improvement) of improvement initiatives. Meanwhile, Mohammad (2010) focuses on 30 main organisational improvement initiatives that could be implemented to improve organisational performance according to the common enabling criteria of Business Excellence Frameworks and organisational maturity.

Unfortunately, only Pangsri, (2014), Matt and Rauch, (2013) and Arunagiri and Gnanavelbabu, (2014) focusing on the selection of lean tools and techniques. Pangsri, (2014) produced the decision framework in product design and process improvements based on lean production using Analytical Hierarchical Process (AHP) at Thailand, but the research has not stated the number of lean production tools and techniques used in product design and process improvement and the critical factors of selection was also not discussed. While Matt and Rauch, (2013) only focus on 16 lean production tools and techniques used in Italy without discussing how the selection process and decision making technique used. Arunagiri and Gnanavelbabu (2014) analyzed 30 lean production tools and techniques using the weighted average techniques for the selection of most effective lean production tools and techniques, and focuses on automotive industries in India. Arunagiri and Gnanavelbabu (2014) only studied five main lean production tools and techniques and its effect to the productivity.

Table-2. Related study on the selection of initiatives improvement.

Authors (Year**)**	**Improvement Initiatives**				**Decision Matrix**			**Origin**
	Approach	**Management System**	**Technique**	**Tool**	**SAW**	**WPM**	**AHP**	
(Natcha Thawesaengskulthai, 2007)	√	√	x	x				Thailand
(Wieleman, 2011)	√	x	x	x	√			India
(Mohammad, 2012)	√	√	√	x	√			Worldwide especially in New Zealand, Singapore, Malaysia
(Bendell, 2005)	√	√	√	√	√			United Kingdom
(Radziwill *et al.*, 2008)	√	√	√	x		Not stated		United State
(Matt and Rauch, 2013)	x	x	√	√			Not stated	Italy
(Pangsri, 2014)	x	x	√	√			√	Thailand
(Arunagiri and Gnanavelbabu, 2014)	x	x	√	√	√	Not stated		India
(Khusaini *et al.*, 2014)	x	x	√	√				Malaysia
Legend: SAW - Simple Additive Weighting WPM - Weighted Product Model AHP - Analytical Hierarchical Process								

No study were found on the selection of lean production tools and techniques specifically in Malaysia by using rational decision making process. Therefore, it shows that, there is a need of study to help Malaysian industries to select the right lean production tools and techniques by considering the critical factors for selection in order to gain the benefits of implementing lean production.

Factors to be considered when selecting lean production tools and techniques

There is no one best initiatives that can solve all organizational problems because each initiative has its own purpose, strengths and limitations (Mohammad, 2012). In order to select the right lean production tools and techniques for the right situation, managers and/or practitioners in the organization should consider several factors as shown in table 3 below. Referring to Table-3, most of the researchers (Mohammad, 2012; Saunders and Mann, 2007; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008) agreed that, the top management commitment is the most important factor for the selection of the lean production tools and techniques. Without this factors, the selection and implementation of lean production tools and techniques will not be successed due to the decision of budget allocation are from top management. The workforce capability also effect the decision of lean production tools and techniques selection (Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008).

The workforce factors such as the number of workforce available in the industry, the level of education for each workforce that effect the time of understanding the implementation of lean production tools and techniques, and the age of workforce also should be considered. Besides that, the expected cost, time and resources also affect the selection process (Dale, 2007; Mohammad, 2012). Before implementing the lean production tools and techniques, the decision makers should know the expected benefit that company will gained when implement the selected lean production tools and techniques (Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008). Therefore, this factor also important to the decision makers in order to select the right lean production tools and techniques.

CONCLUSIONS

This paper presents a literature review on the selection of lean production tools and techniques from year 2004 to 2014. The review gives general pictures of the selection and implementation of lean tools and techniques in various industries. The analysis showed the gaps that require further research related to selection of lean production tools and techniques and the factors that affect the decision making.

Table-3. The factors that affect the selection of lean production tools and techniques.

Factors affects the selection	Authors(year)
1. Top management commitment	(Mohammad, 2012; Saunders and Mann, 2007; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
2. Workforce capability	(Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
3. Expected costs, time and resources needed for the successful implementation.	(Dale, 2007; Mohammad, 2012)
4. Expected value/ benefit of using the initiatives	(Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
5. Organizational culture	(Sousa and Voss, 2008; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
6. Direction, strategic plan and goals of the organization	(Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
7. The external environment in which the organizations operate	(Mohammad, 2012; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)
8. Level of organization maturity	(Dahlgaard and Dahlgaard-Park, 2004; Mohammad, 2012; National Institute of Standards and Technology (NIST), 2010)
9. Ability if the initiatives to “fit in with, complement”, integrate, and/or “support” other initiatives “already in place, and might be used in the future”.	(Dale, 2007)
10. Area in which the initiatives will be used.	(Mohammad, 2012; Saunders and Mann, 2007)
11. Types (e.g. public, private or non-profit) and size (e.g. small, medium or large) of the organization.	(Dahlgaard and Dahlgaard-Park, 2004; Mohammad, 2012; National Institute of Standards and Technology (NIST), 2010; Natcha Thawesaengskulthai, 2007; Thawesaengskulthai and Tannock, 2008)

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REFERENCES

Abdulmalek, F. A. a. R., J. 2007. Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a process sector case study. International Journal of Production Economics. 107(1), 223-236.

Arunagiri, P. and Gnanavelbabu, A. 2014. Identification of High Impact Lean Production Tools in Automobile Industries using Weighted Average Method. Procedia Engineering. 97(0), 2072-2080.

Baxter, L. F. and MacLeod, A. M. 2008. Managing performance improvement. New York: Routledge.

Bendell, T. 2005. Structuring business process improvement methodologies. Total Quality Management and Business Excellence. 16(8-9), 969-978.

Benson, P. G., Saraph, J. V. and Schroeder, R. G. 1991. The effects of organisational context on quality management: An empirical investigation. Management Science. 37(9), 1107-1124.

Dahlgaard, J. J. and Dahlgaard-Park, S. M. 2004. The 4P quality strategy for breakthrough and sustainable development. European Quality. 10(4), 6-20.

Dale, B. G. 2007. Tools and techniques: An overview. In B. G. Dale, T. Van der Wiele and J. Van Iwaarden (Eds.), Managing quality (5th ed., pp. 336-381). Malden, MA: Blackwell Publishing.

Davenport, T. H., Prusak, L. and Wilson, H. J. 2003. What's the big idea? Creating and capitalizing on the best management thinking. Boston: Harvard Business School Press.

Doolen, T. L. and Hacker, M. E. 2005. A review of lean assessment in organizations: an exploratory study of lean practices by electronics manufacturers. Journal of Manufacturing Systems, 24(1), 55-67.

Hammer, M. 2005. Grounding strategy in reality. European Business Forum.

Khusaini, N. S., Jaffar, A. and Yusoff, N. 2014. A Survey on Lean Manufacturing Tools Implementation in Malaysian Food and Beverages Industry using Rasch Model. Advanced Materials Research. 845, 642-646.

Matt, D. T. and Rauch, E. 2013. Implementation of Lean Production in small sized Enterprises. Paper presented at the Procedia 8th CIRP Conference on Intelligent Computation in Manufacturing Engineering.

Melton, T. 2005. The benefits of lean manufacturing. What lean thinking has to offer the process industries. Chemical Engineering Research and Design. 83(A6), 662-673.

Miller, D. and Hartwick, J. 2002. Spotting management fads. Harvard Business Review. 80(10), 26-27.

Mohammad, M. 2012. Development of a guidance model for the selection of organisational improvement initiatives. (PhD thesis), Massey University, Palmerston North. Retrieved from http://mro.massey.ac.nz/handle/10179/3685.

Mohammad, M., Mann, R., Grigg, N. and Wagner, J. P. 2011. Selecting appropriate organisational improvement initiatives: A five steps approach. Paper presented at the Proceedings of the 15th International Conference on ISO and TQM.

Mohammad, M., Mann, R., Grigg, N. and Wagner, J. P. 2010. The right improvement initiative for the right situation: A contextual and systems approach. Paper presented at the Proceedings of the 40th International Conference on Computers and Industrial Engineering.

National Institute of Standards and Technology (NIST). 2010. 2011-2012 Criteria for performance excellence. Retrieved 23 December, 2010, from http://www.nist.gov/baldrige/publications/upload/2011_2012_Business_Nonprofit_Criteria.pdf.

Ohno, T. 1988. The Toyota Production System, English translation: Productivity Press.

Pangsri, P. 2014. A Decision Framework to Select Alternative based on Lean manufacturing Concepts in Design Processes. Journal of Industrial and Intelligent Information 2(1), 1-5.

Radziwill, N., Olson, D., Vollmar, A., Lippert, T., Mattis, T., Dewark, K. V., *et al.* 2008. Starting from scratch - Roadmap and toolkit: recipe for a new quality system. Quality Progress. 41(9), 40-47.

Saunders, M. and Mann, R. 2007. Business excellence tools: The tools used by companies at different stages of business excellence maturity. (Consultancy Report), Centre for Organisational Excellence Research, Palmerston North. Retrieved from http://www.coer.org.nz/images/files/D136-pub,%20Business%20Excellence%20Tools%20Report.pdf

Sohal, P. D. I. 2001. TQM and innovation: a literature review and research framework. Technovation. 21, 539-558.

Sousa, R. and Voss, C. A. 2008. Contingency research in operations management practices. Journal of Operations Management, 26, 697-713.

Swinehart, K. D., Miller, P.E and Hiranyavasit C. 2000. World-class manufacturing: Strategies for continuous improvement. Business Forum, winter/spring 2000, 25(1/2), 19-28.

Thawesaengskulthai, N. 2007. Selecting quality management and improvement initiatives: Case studies of industries in Thailand. (PhD thesis), University of Nottingham. Retrieved from http://etheses.nottingham.ac.uk/298/1/Natcha%27s_thesis_V16_%28submit_etheses%29.pdf

Thawesaengskulthai, N. and Tannock, J. D. T. 2008. A decision aid for selecting improvement methodologies. International Journal of Production Research, 46(23), 6721-6737.

Wieleman, B. P. 2011. Selecting business improvement methods: Towards a technique for consultants to support the selection of methods in an improvement project. (Unpublished master thesis master thesis), Eindhoven University of Technology, Eindhoven, Netherlands.

Womack, J. P. and Jones, D. T. 1996. Lean Thinking: Banish Waste and Create Wealth in Your Corporation. London: Simon and Schuster.

Womack, J. P., Jones, D. T. and Roos, D. 1990. The Machine that Changed the World. New York: Rawson Associates.

Yoon, K. P. and Hwang, C. L. 1995. Multiple attribute decision making: An introduction. California: Sage Publication Inc.