International Journal of Engineering & Technology, 7 (3.25) (2018) 316-320

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



A Conceptual Framework for the Lean Research and Development

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Abstract

Both lean R&D soft practices success factor and lean R&D tools and techniques are the improvement strategies to reduce cost, increase speed and deliver superior quality in R&D organization. In order to achieve higher performance, an R&D organization needs to adopt both lean R&D soft practices success factor, and lean R&D tools and techniques. Therefore, the main objective of this paper is to review the relationship among lean R&D soft practices success factor, lean R&D tools and techniques, and R&D based organization performance. After an extensive review of literature, a new lean R&D model in R&D based organization is developed with an objective of developing a theoretical knowledge for R&D based organization in order to understand more systematically the relationship among lean R&D soft practices success factor, lean R&D tools and techniques, and R&D based organization performance. The proposed model examines the impact of lean R&D tools and techniques as the mediating effect between lean R&D soft practices success factor and R&D based organization which has not been evaluated earlier. The paper also includes a review to identify existing theoretical perspectives that could be considered as a basis for the creation of a new conceptual framework of lean R&D.

Keywords: *Research and Development, Lean, Success Factor, Performance, Improvement Tools, Soft Practices, Hard Practices*

1. Introduction

Nowadays, research and development (R&D) activities have been growing in the manufacturing industries especially in the computers and electronics, transportation equipment and chemical industries [1]. Due to rapid changes in technology and globalization trade, most manufacturers initiated R&D activities to ensure their products or services are continuously innovated to increase and sustain the competitive advantage [2]. As such, R&D success factors such as managerial factor, capital, technology, and employee involvement are essential to the manufacturer in order to gain sustainable competitive advantage. However, applying R&D success factors only to R&D activities can cause financial devastation, supply disruption, waste overproduction, and excess high technology due to overinvestment [3]. A study conducted by Skaife, Swenson and [4].Suggested that overinvestment in R&D results in a more severe decline in organization performance compared to underinvestment in R&D. Therefore, lean R&D implementation is an important strategy to improve R&D activity. The literature review found that there are very few empirical studies that examine the lean R&D implementation compared with the studies on lean manufacturing [5]. Based on the Theory of Constraint introduced by Eliyahu M. Goldratt (1984), then it could also be applied in R&D as the objectives of TOC and the lean itself are similar which is to increase the profit of an organization.
There are two practices for lean R&D implementation, namely the lean R&D soft practices success factor, and lean R&D tools and techniques (LRDTT). Lean R&D soft practices success factor is concerned with the social aspect that involves human relations such as the managerial factor; supplier and customer involvement; skills and expertise; financial capability; and technology whereas the lean R&D hard practices success factor refers to lean tools and techniques [5]. Successful implementation of lean is not merely due to hard lean elements but it must be supported by soft practice to achieve superior performance [6]. Based on the theory of Resource-based , the competitive advantage can be achieved and sustained when an organization employs tangible and intangible resources whereby the tangible resources refer to technical practices such as tools and techniques while intangible resources are anything related to human practices such as commitment, culture, and knowledge. Therefore, the research explores the relationship among the lean soft practices success factor, lean tools and techniques (LTT), and R&D based organization performance. Based on these three factors, the lean soft practices success factor is extremely influential to the success and survival of R&D organization but still insufficient in today's business[7]. Besides, numerous studies have discovered positive relationship between LTT and organization performance [8]. However, all the studies mentioned are focused mainly on direct relationship. According to the System Theory introduced by Bertalanffy L. V. (1968), a complex problem could be reduced to a set of simpler problems by addressing each process in the system since it is easier to control any potentially confounding influence. Hence, this paper aims to close the literature gap by proposing LRDTT as the potential mediator between lean R&D soft practices success factor and R&D organization performance.

2. Literature Review

Lean principles have been applied across a wide range of manufacturing industries including the food and beverage sector; rubber and plastic sector; metals sector; textiles sector; chemical sector; communication and electronic equipment sector; automotive sec-

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tor; and medical equipment sector [9]. This suggested that the lean transformation to the manufacturing industry is well established; however, it is relatively new and has limited reported benefits and approaches. The best practice was inherited from the manufacturing industry; when applied to R&D based organizations it can generate large economic and financial results as well as increase process efficiency. Therefore, there is still a great need to explore the determinants of lean R&D success to the R&D based organization performance. Although most of the findings of lean soft practices success factors provided by previous studies focused on the manufacturing industry, they can also be used in an R&D environment since it is one of the entities in the manufacturing industry.

2.1. Lean R&D Soft Practices Success Factor

Lean soft practices success factors are associated with the intangible resources that have no physical presence but can still be owned by the R&D organization [10]. Based on the literatures, lean soft practices success factors are the main resource of sustainable competitive advantage [11]. The lean R&D soft practices success factors are defined as the determinants of R&D success which is related to non-technical practices that directly influence the R&D based organization performance. The common sets of lean R&D soft practices success factors suggested by prior researchers are summarized in Table 1.0 which consist of managerial factor; supplier and customer involvement; skills and expertise; financial capability; technology; and transformational leadership.

2.2. Lean R&D Tools and Techniques

Generally, the implementation of LRDTT can help organization maximize profits by removing waste, variability, and overburden; and delivering improvements in specific areas [10]. Prior research suggested that lean tools and techniques can be categorized into three phases of R&D activities: design, development, and validation. Different sets of LRDTT are required for each phase to reduce the misuse of LRDTT or the misapplication of tools in improper activities or for improper purposes [12]. Table 2.0 summarized the LRDTT category based on R&D activities.

2.3. R&D Based Organization Performance

Organization performance refers to how well an organization is doing to reach its vision, mission, and goals. The success of an organization can be evaluated by a variety of performance measurement frameworks [13]. Numerous studies have been conducted to investigate the R&D based organization performance such as competencies of the team members, stakeholder satisfaction, effectiveness of the operational procedure, and capability of delivering output [14]. Although most of the findings of R&D based organization performance have been provided by previous studies, they can be used in the R&D environment as well since the R&D environment is one of the entities in the manufacturing industry. Different variables of organization performance have been identified by prior researchers as illustrated in Table 3.

3. Theoretical Framework Discussion

Theoretical framework can be used as a guide for logically developing and understanding the interconnection of each part or variable of the literature review and ultimately help to improve the ability for predictions [15]. Based on the literature review, it is proposed that a lean R&D model can be considered from three possible theory, which are theory of constraint, resource-based view, and system theory.

3.1. Theory of Constraint

At the starting point, the Theory of Constraint (TOC) is used to understand how the lean is influenced by and how it influences the manufacturing companies as well as how they interact within the R&D environment. The theory proposed that since every system has at least one constraint or bottleneck that stands in the way of achieving a goal, profit can be increased by increasing throughput in the process [16]. The lean R&D concept is to increase profit, eliminate waste and add value by considering the entire process, operation or supply network from the customers' perspectives [17]. Therefore, TOC can be adapted in the lean concept as the goals of lean R&D since they have similar goal which is to increase profit but by using different approaches. Table 4 summarized the similarities of TOC and Lean R&D.

Table 1: Similarities of TOC and Lean R&D

Similarities	Theory of constraints	Lean R&D
Overall objectives	To increase profit by increasing the throughput of a process or operation	To increase profit by adding value from a customer perspective
Measures of effectiveness	- Throughput - Inventory - Operating expense	- Cost - Throughput time - Value-added efficiency
Achieve improvement by …	Focusing on the constraints (the weakest links) in the process	Eliminating waste and adding value by considering the entire process, operation or supply network
How to implement?	A five step, continuous process emphasizing acting locally	Continuous improvement emphasizing the whole supply network

As such, it can be said that lean could be applied in R&D based organization to create competitive advantages.

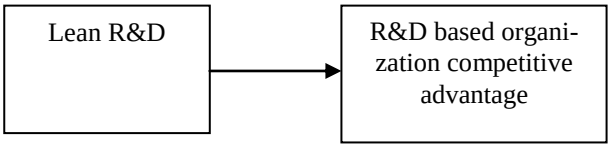


Fig. 1: Application of theory of constraint in Lean R&D

3.2. Resource-Based View

The next level of theory is related to how an organization execute their business and is more focused on the tactical element in helping companies achieve higher organizational performance. For this, Resourced-based View (RBV) addressed two resources, namely the tangible resources and intangible resources. Tangible resources are physical things such as land, building, machinery, equipment, and capital. The physical resources can easily be bought in the market so they can confer little advantage to the companies in the long run because rivals can soon acquire identical assets. Intangible resources are everything else that has no physical presence but can still be owned by the company such as brand reputation, trademarks, and intellectual property. Unlike tangible resources, the intangible resources are built over a long time which companies cannot buy from the market. Usually intangible resources stay within a company and are the main resource of sustainable competitive advantage. This theory is particularly relevant to the lean R&D model as it utilized the common resources that help an organization in the manufacturing industry to generate maximum profits. In the lean R&D model, the intangible resources refer to lean R&D soft practices success factors while the tangible resources refer to lean R&D tools and techniques. Since all the organization's goals in the manufacturing industry are to achieve and sustain the competitive advantage, eventually this competitive advantage leads to improved business performance. In conclusion,

the theory can be applied in the lean R&D model as shown in Figure 2.

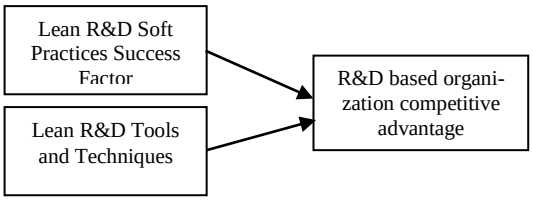


Fig. 2: Application of resource-based view theory in Lean R&D

3.3. System Theory

At the most detailed level, the lean R&D model could be researched using a system theory which seeks to explain the whole system with a particular focus on the interaction of the system within the system. System theory is an interdisciplinary theory about the nature of complex systems in nature, society, and science and is a framework by which one can investigate and/or describe any group of objects that work together to produce some results [18]. The fundamental system-interactive paradigm of organizational analysis features the continual stages of input, throughput (processing), and output which demonstrate the concept of openness and closeness. A system is an organized collection of independent but interrelated elements or components to accomplish an overall goal. The researcher has defined an organization as a system which has various inputs that are processed to produce outputs. The inputs include resources such as lean R&D success factors. Inputs are processed to produce the output of the organization. Outputs can be goods or services which result from the system's throughput or processing of technical, social, financial, and human input [18]. Throughput is the process used by the system to convert inputs from the system that are usable by either the system itself or the environment such as diagnosing, planning, decision-making, and tools [18]. In the lean R&D model, lean R&D soft practices success factor refers to inputs while lean R&D tools and techniques refer to throughput. This makes sense as the lean R&D tools and techniques could not be properly utilized unless the practitioner knows how the lean R&D tools and techniques are utilized, whereby the know-how factor is one of the lean R&D soft practices success factors. From this review, it can be concluded that the system theory is included in the proposed conceptual framework (Figure 3).



Fig. 3: Application of system theory in Lean R&D

4. Research Hypotheses

4.1. The Relationship between lean R&D Soft Practices Success Factor and R&D based Organization

Most of the researchers found that the lean soft practices success factors were significantly correlated with organization performance [11, 15]. In contrast, other studies showed that the lean soft practices success factors did not improve organization performance [20, 21]. Other findings show a partial correlation between lean soft practices success factor and organization performance. This research argued that the non-significant relationship drawn by prior researcher were because the studies only covered limited factors of lean soft practices success factor [22]. Thus, organizations need to find and implement a suitable soft practice success factor in order to sustain excellent performance. Based on the discussion above, the hypothesis of this study is indicated below: -

H_1: Lean R&D soft practices success factor is positively correlated with R&D based organization performance

4.2. The Relationship between Lean R&D Soft Practices Success Factor and Lean R&D Tools and Techniques Resource-Based View

According to previous results, there are positive relationships between lean soft practices success factor and lean tools and techniques [23]. Organizations are unable to move forward until the management staff understand the concept of lean manufacturing and how they will be implemented [24]. Furthermore, one of the major reasons for the unsuccessful implementation of lean manufacturing is the typical behaviour exhibited by people in the workplace who are known to be incapable of developing trust and gaining commitment [25]. Several researchers emphasized that the full benefits of a set of lean tools and techniques cannot be experienced in the business sector until all soft practices success factors associated with the implementation of the techniques are recognized, fully understood and addressed [26,24]. Based on the discussion above, the hypothesis of this study is suggested below:-

H_{2a}: Lean R&D soft practices success factor is positively correlated with lean tools and techniques.

4.3. The Relationship between LRDTT and R&D Based Organization Performance

Lean tools and techniques are selected to improve the process as well as to increase the quality by reducing the rework and scrap rate; labour costs; material costs; and overhead cost which will ultimately decrease the product costs and increases revenue [27, 28, 29]. As stated by [27], the adoption and effective implementation of lean tools and techniques shall enhance organization performance. Although most of the studies of lean tools and techniques are focused on the manufacturing environment, there are certain lean tools and techniques that are applicable to the R&D environment. Therefore, it is important to explore deeper to identify the relationship of lean R&D tools and techniques with R&D based organization performance. Based on the discussion, the hypothesis is therefore suggested below: -

H_{2b}: Lean R&D tools and techniques is positively correlated with R&D based organization performance

4.4. Mediating Effect of Lean R&D Tools and Techniques between Lean R&D Soft Practices Success Factor and R&D Based Organization Performance

The implementation of the lean tools and techniques can simultaneously decrease costs and increase quality. Thus, lean management which refers to lean soft practices success factor is supposed to be a high-class method for improving the whole organization performance. There are no empirical studies to indicate that lean tools and techniques is the mediator between lean soft practices success factor and organization performance. However, a study performed by [30, 6] suggested that an organization must consider and be rational when integrating hard lean practices and soft lean practices despite the extremely influential role and contribution of soft lean practices to the success and survival of lean implementation. This is supported by [31] who emphasized that employee engagement and empowerment are critical even though technical aspects are relevant and act as drivers for an initial process innovation using lean tools and techniques in maintaining process innovation. According to [21], an effective interaction between lean and sustainable efforts enables the manufacturing organizations to explore new ways of improving operational and environmental performance. Some of the issues that need contemporary focus include active involvement of staff in planning and imple-

menting lean events with environmental opportunities; and eliminate environmental waste using lean process involvement tools. Meanwhile, [32] hypothesized that a mediation has occurred when all the relationships between each variable in the system were found statistically significant. This has been supported by the underlying theory in the formulation of proposition regarding the effect of lean R&D success factor; lean R&D tools and techniques; and R&D based organization performance, which are Theory of Constraint, Resource Based View Model, and System Theory. Based on the discussion, the hypothesis is therefore suggested below:

H_3: Lean R&D tools and techniques in R&D activity is a mediator between lean R&D soft practices success factor and R&D based organization performance

5. Conceptual Framework

The research conceptual model is presented in Figure 4. The model has been developed based on the literature review on lean tools and techniques between lean soft practices success factor and organization performance. LRDTT is a supporting practice for lean R&D soft practices success factor associated with R&D based organization performance. A structural equation modelling (SEM) techniques is employed to examine the relationships between various-model latent.

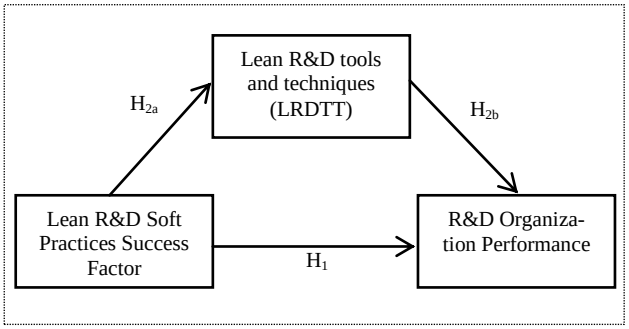


Fig. 4: Proposed conceptual model of R&D with mediation effect of LRDTT

6. Conclusion

The relationship of lean R&D soft practices success factor with LRDTT is important to provide a practical platform for Malaysia. Based on previous studies, the relationship between lean soft practices success factor and organization performance is inconsistent. However, there have been significant amount of studies conducted regarding the connection of the LTT with organization performance and the connection of the lean soft practices success factor with LTT. The review of theoretical framework, namely TOC, RBV and System Theory amplified the mediating effect of lean R&D tools and techniques between the relationship of Lean R&D soft practices success factor and R&D based organization performance. Furthermore, there have been limited research carried out on R&D activity. Therefore, there is a need to identify LRDTT as a mediator between lean R&D soft practices success factor and R&D based organization performance as the conceptual framework. There are four hypotheses regarding the relationship among the specified variables. The conceptual framework has been proposed for future work to provide researchers with an understanding of the importance of lean R&D soft practices success factor – LRDTT and to encourage manufacturers to build their competitiveness.

Acknowledgement

The authors wish to acknowledge the Malaysian Ministry of Higher Education and Universiti Teknologi Malaysia under the Research Grant 18H59 for sponsoring this publication.

References

[1] Nasho-Hoff, M. (2014). *The Importance of R&D to the Manufacturing Industry*.
[2] Larsson, A. (2007). Strategic Management of Intrafirm R&D in Process Industry. *Management*. Retrieved from http://epubl.ltu.se/1402-1544/2007/63/index-en.html
[3] Kovacheva, A. V. (2010). *Challenges in Lean Implementation : Successful Transformation Towards Lean Enterprise*. University of Aarhus.
[4] Skaife, H. A., Swenson, L. A., & Wangerin, D. (2013). A Study of Discretionary R&D Reporting. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699.
[5] Andersen, B., Belay, A. M., & Seim, E. A. (2012). Lean construction practices and its Effects : A case study at St Olav ' s integrated Hospital , Norway. *Lean Construction Journal*, 122–149. Retrieved from www.leanconstructionjournal.org
[6] Mamat, R. C., Md Deros, B., Ab Rahman, M. N., Omar, M. K., & Abdullah, S. (2015). Soft lean practices for successful lean production system implementation in malaysia automotive smes: A proposed framework. *Jurnal Teknologi*, *77*(27), 141–150. https://doi.org/10.11113/jt.v77.6910
[7] Bortolotti, T., Danese, P., & Flynn, B. B. (2016). Is there an ideal organisational culture for lean management ?
[8] Büyüközkan, G., Kayakutlu, G., & Karakadılar, İ. S. (2015). Assessment of Lean Manufacturing Effect on Business Performance using Bayesian Belief Networks. *Expert Systems with Applications*, (May). https://doi.org/10.1016/j.eswa.2015.04.016
[9] Balaguer, & Victor, R. (2012). Effectiveness of Lean Manufacturing in the Electronics and Medical Devices Operations in Puerto Rico, 9–11.
[10] Gutter, S. P. (2014). *Lean Practices in Pharmaceutical Manufacturing - An Empirical Investigation*. University of St. Gallen.
[11] Larteb, Y., Haddout, A., & Benhadou, M. (2015). Successful Lean Implementation: The Systematic and Simultaneous Consideration of Soft and Hard Lean Practices. *International Journal of Engineering Research and General Science*, *3*(2), 1258–1270.
[12] Alaskari., O., M.M, A., Dhafr, N., & Pinedo-Cuenca., R. (2012). Critical Successful Factors (CSFs) for Successful Implementation of Lean Tools and ERP Systems. *Lecture Notes in Engineering and Computer Science*, *2199*(1), 1627–1632.
[13] Kahn, C., & McGourty, S. (2009). Performance Management at R&D Organizations. *Management*, (April).
[14] Czarnitzki, D., & Hussinger, K. (2004). The Link Between R&D Subsidies, R&D Spending and Technological Performance. *ZEW Discussion Papers*, (4).
[15] Grant, C., & Osanloo, A. (2014). Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your "House." *Administrative Issues Journal Education Practice and Research*, 12–26. https://doi.org/10.5929/2014.4.2.9
[16] Kumar, S. S. G., Devadasan, S. R., & Thilak, V. M. M. (2014). Lean manufacturing through theory of constraints: An overview in literature arena, *5*(5), 163–166.
[17] Moore, R., & Scheinkopf, L. (1998). Theory of Constraints and Lean Manufacturing: Friends or Foes? *Chesapeake Consulting …*, 1–37. Retrieved from http://www.tocca.com.au/uploaded/documents/Lean and TOC.pdf
[18] Hayajneh, Y. (2007). Systems & Systems Theory, 1–5.
[19] Shah, R., & Ward, P. T. (2003). Lean Manufacturing: Context, Practice Bundles, And Performance. *Journal of Operations Management*, *21*, 129–149.
[20] Hunady, J., & Orviska, M. (2014). The Impact Of Research And Development Expenditures On Innovation Performance And Economic Growth Of the Country - The Empirical Evidence. *CBU International Conference on Innovation, Technology Transfer and Education*, (2011), 119–125.
[21] Vinodh, S., Arvind, K. R., & Somanaathan, M. (2011). Tools and techniques for enabling sustainability through lean initiatives.

Clean Technologies and Environmental Policy, *13*(3), 469–479.
[22] Er. Amit B. Dutta, & Er. Sneha Banerjee. (2014). Review of Lean Manufacturing Issues and Challenges in Manufacturing Process. *IMPACT: International Journal of Research in Business Management (IMPACT: IJRBM)*, *2*(4), 27–36. Retrieved from http://www.impactjournals.us/journals.php?id=78&jtype=2&page=5
[23] Bianchi, M., Richtner, A., & Modig, N. (2011). Making innovation flow : solving the trade-off between lean and innovation, 1–10.
[24] Netland, T. H. (2015). Critical Success Factors for Implementing Lean Production : The Effect of Contingencies. *International Journal Production Research*.
[25] Farhana Ferdousi. (2009). Lean Production Practices in Bangladesh : An Investigation into the Extent of Practices and the Existence of Enabling Environments for Lean Implementation. *University of Wollongong Thesis Collections*.
[26] Ferdousi, F., & Ahmed, A. (2009). An Investigation of Manufacturing Performance Improvement through Lean Production : A Study on Bangladeshi Garment Firms. *International Journal of Business and Management*, *4*(9), 106–116.
[27] Amin, M., & Karim, M. (2012). A Systematic Approach to Evaluate the Process Improvement in Lean Manufacturing Organizations. *Sustainable Manufacturing*, 65–70.
[28] Hibadullah, S. N., Habidin, N. F., Zamri, F. I. M., Fuzi, N. M., & Desa, A. F. N. C. (2014). Critical success factors of lean manufacturing practices for the Malaysian automotive manufacturers. *Int. J. Quality and Innovation J. Quality and Innovation*, *244*(3), 256–271. https://doi.org/10.1504/IJQI.2014.066382
[29] Rajenthirakumar, D., & Shankar, R. G. (2010). Analyzing the Benefits of Lean Tools : a Consumer Durables Manufacturing Company. *International Journal of Engineering*, 335–339.
[30] Kovach, J. V, Cudney, E. A., & Elrod, C. C. (2011). The use of continuous improvement techniques : A survey-based study of current practices. *International Journal of Engineering, Science and Technology*, *3*(7), 89–100.
[31] Lopes, R. B., Freitas, F., & Sousa, I. (2015). Application of lean manufacturing tools in the food and beverage industries. *Journal of Technology Management and Innovation*, *10*(3), 120–130.
[32] Baron, R. M., & Kenny, D. A. (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research : Conceptual , Strategic , and Statistical Considerations, *51*(6), 1173–1182.