DETERMINANTS OF LEAN RESEARCH AND DEVELOPMENT SUCCESS IN MALAYSIA

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy in (Management)

Azman Hashim International Business School
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FEBRUARY 2020

DEDICATION

This thesis is dedicated to the memory of my father, Mohd Hamel bin Mamat. I miss him every day, but although he was no longer in the world, I know that he would keep supporting me to whatever I want to do especially when it was related to study. It is also dedicated and give special thanks to my beloved mother and husband who have supported me throughout the process of entire doctorate program.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, all praises to Allah for the strengths and His blessing in completing this thesis. I would like to take this opportunity to express my appreciation to many people who have provided assistance towards the completion of this Doctoral of Philosophy in a lot of ways especially to my supervisor, Dr. Tan Owee Kowang who has been giving my guidance, help, advice, critics, support and also friendship.

Besides that, I also would like to thank to all interviewees and respondents either from R&D based organization in Malaysia or other education institute who have spent some of their time to answer the questionnaire seriously even most of them been very busy with their job. They had provided us with a very useful information and feedback to our study.

Finally, I wish to thanks to my colleague in Dyson Malaysia Development Centre especially all my boss who had supporting me in giving a spare time to complete my study. I managed well to accomplish my project report. Without their help given, I would not have completed the report. My sincere appreciation also extends to my mother, husband, younger sister and children for being with me all the time during the process to complete this thesis.

ABSTRACT

Lean principle has been adapted widely across the management of manufacturing and services industries, however it is still a new concept within the scope of Research and development (R&D) environment. Empirical research found that prior studies on Lean tends to focus on exploring and confirming the application of Lean tools and techniques (T&T) as well as determinants for Lean for manufacturing and services setting. Hence, the concept of Lean for R&D domain remains ambiguous because there is no standard set of Lean T&T and determinants available for R&D. Thus, the purpose of this study is to categorize Lean T&T based on R&D setting and to identify the determinants of Lean R&D toward R&D performance. This study advances the discussion in Lean by integrating R&D process with Theory of Constraint, Resource-based View Theory and System Theory. As such Lean T&T are categorized into Design, Development and Product Testing Phase T&T based on the nature of R&D process. In addition, the study views Lean R&D determinants from Lean hard practice determinant's and soft practices determinant's perspectives, with hard R&D tools as a mediator between soft R&D and R&D based organization performance. This study targeted the R&D based organizations that implemented Lean principles in manufacturing industry within Malaysia. A total of five Lean and R&D experts were involved in the semi structured interview, and out of the total of 232 targeted respondents, 102 responded via structured questionnaire which represents a response rate 43.97%. Qualitative content data analysis was used for the analysis of semi-structured finding, while descriptive data analysis and Structural Equation Modelling were the data analysis method used for quantitative data. Findings of the study revealed that 5S, Value Stream Mapping, A3 Report, Standardized Work and Visual Management are the most common tools used across the three phases (design, development and testing) of R&D process. Findings of the study also suggest that three out of the seven Lean R&D soft practices determinant have the impact on R&D performance - managerial; employee skills and expertise; and supplier involvement. In addition, Lean R&D tools and techniques have a mediating effect on the Lean R&D soft practices determinant toward R&D performance. The findings from this study not only revealed the determinants of R&D performance but extend the knowledge of Lean through understanding the mediating effect of Lean R&D tools and techniques in organization that is based on R&D performance. Therefore, this study makes contribution in extending existing models of Lean principle and understanding beyond manufacturing and services domain hence it overcomes the weakness of the current Lean frameworks. As practical contribution, the findings of the study could deliver a usefulness message for policy makers and R&D companies to place an emphasis on in order to improve the R&D performance. In addition, this study also delivers a Lean R&D determinants framework which could be replicated to the other segments of research and development environment in Malaysia. Areas for further research were highlighted, including the need for a larger study to explore Lean implementation across the multi-national company and small medium enterprise.

ABSTRAK

Prinsip kejat telah disesuaikan secara meluas dalam pengurusan industri perkilangan dan perkhidmatan, namun ia masih merupakan konsep baru dalam lingkungan persekitaran Penyelidikan dan Pembangunan (R&D). Kajian terdahulu berkenaan kejat lebih tertumpu kepada penerokaan dan pengesahan terhadap penggunaan teknik dan alatan (T&T) yang terkandung dalam kejat beserta dengan penentu ukur kejat dalam industri pembuatan dan perkhidmatan. Oleh itu, konsep kejat di dalam R&D masih tidak jelas disebabkan oleh ketiadaan penyelarasan T&T dan penentu ukur khas untuk R&D. Oleh itu, tujuan kajian ini adalah untuk mengkategorikan T&T berdasarkan R&D dan untuk mengenalpasti penentu bagi R&D kejat terhadap prestasi R&D. Kajian ini seterusnya membincangkan kejat melalui integrasi proses R&D dengan Teori Kekangan, Model Pandangan Berasaskan Sumber (RBV) dan Sistem Teori. Dengan itu, T&T kejat dikategorikan kepada Rekabentuk, Pembangunan dan Ujian. Di samping itu, kajian ini menilai faktor penentu R&D dari perspektif penentu amalan kejat keras dan penentu amalan kejat lembut, dengan menjadikan penentu amalan kejat keras T&T sebagai pengantara antara penentuan amalan kejat keras dan prestasi organisasi R&D. Kajian ini mensasarkan organisasi yang berasaskan R&D yang melaksanakan prinsip kejat dalam industri perkilangan di Malaysia. Sejumlah 5 orang pakar dalam prinsip kejat dan R&D terlibat dalam soal selidik separa berstruktur. Manakala daripada jumlah sampel 232, hanya 102 data yang dikumpul melalui soal selidik berstruktur yang mana kadar tindak balas adalah 43.97%. Kandungan data kualitatif analisis digunakan untuk analisis soal selidik separa berstruktur, manakala analisis data deskriptif dan Model Persamaan Struktur (SEM) adalah kaedah analisis data yang digunakan untuk data kuantitatif. Hasil kajian mendapati 5S, Pemetaan Aliran yang Bernilai (VSM), Laporan A3, Keseragaman Kerja dan Pengurusan Visual adalah alat yang paling biasa digunakan dalam tiga fasa R&D (reka bentuk, pembangunan dan ujian). Hasil kajian turut mencadangkan bahawa tiga dari tujuh faktor kejayaan amalan R&D kejat mempunyai kesan ke atas prestasi R&D iaitu pengurusan; kemahiran dan kepakaran pekerja; dan penglibatan pembekal. Di samping itu, alat dan teknik R&D kejat mempunyai kesan pengantara terhadap penentu amalan kejat lembut dan prestasi organisasi R&D. Penemuan dari kajian ini bukan sahaja mendedahkan penentu prestasi R&D tetapi memperluas pengetahuan yang berkaitan dengan kejat melalui pemahaman kesan pengantaraan alat dan teknik kejat R&D dalam prestasi organisasi berasaskan R&D. Oleh itu, kajian ini memberi sumbangan dalam memperluaskan model prinsip kejat yang sedia ada dan kefahaman yang ada selain daripada industri pembuatan dan perkhidmatan seterusnya mengatasi kelemahan rangka kerja kejat yang sedia ada. Sebagai sumbangan praktikal, penemuan kajian ini dapat menyampaikan mesej berguna bagi pembuat dasar dan syarikat R&D dengan memberi penekanan bagi meningkatkan prestasi R&D. Di samping itu, kajian ini juga menyampaikan rangka kerja penentu R&D yang boleh direplikasikan kepada segmen penyelidikan dan pembangunan lain di Malaysia. Penyelidikan lanjut telah diketengahkan, termasuk keperluan untuk kajian yang lebih besar bagi meneroka perlaksanaan prinsip kejat di syarikat multinasional dan perusahaan sederhana kecil.

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LIST OF ABBREVIATIONS

CREST	-	Collaborative Research in Science, Engineering and Technology
ECRS	-	Eliminate, Combine, Rearrange, Simplify
FMM	-	Federation of Malaysian Manufacturers
GERD	-	Gross Expenditure on R&D
JIT	-	Just in Time
LRDTT	-	Lean R&D Tools and Techniques
LTT	-	Lean tools and Techniques
MASTIC	-	Malaysia Science and Technology Information Centre
MIDA	-	Malaysian Investment Development Authority
MNC	-	Multinational Companies
MOSTI	-	Ministry of Science, Technology and Innovation
MSC	-	Multimedia Super Corridor
NEM	-	New Economic Model
R&D	-	Research and Development
RBV	-	Resource-based View
SEM	-	Structural Equation Modelling
SME	-	Small-medium Size Enterprises
SMED	-	Single Minute Exchange of Die
SPSS	-	Statistical Package for the Social Sciences
TOC	-	Theory of Constraint
TOC	-	Theory of Constraint
TPM	-	Total Productive Maintenance
TQM	-	Total Quality Management
UTM	-	Universiti Teknologi Malaysia
VSM	-	Value Stream Mapping
WIPO	-	World Intellectual Property Organization
5W1H	-	Why, When, Where, What, Who, How

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Research and development (R&D) have been growing in all sizes in manufacturing industries. The heaviest R&D activities take place in computers and electronics, transportation equipment and chemicals (Nasho-Hoff, 2014). R&D is essential for the long-term growth of any manufacturer to continuously innovate their product and service, as well as to increase and sustain the competitive advantage by offering the customer a great value of product and/or service including improvement on the process, adding the new innovation feature or benefits with an affordable prices (Larsson, 2007; Nivoix and Nguyen, 2012).

1.1.1 Importance of Research and Development

R&D is recognized widely by prior researchers (Kevin P., 2012; Freel M., 2018, Cleb F., 2019) as important entity that drives organizations innovativeness, creativity, human resource capability toward the direction of achieving competitive advantage in the market place. R&D activities are essential by essence as they embody the overall process leading to innovation. According to Nasho-Hoff (2014), R&D function is to provide a platform for creativity and innovation to improve the organizational performance. Even though R&D activities require a lot of money due to the investment either on equipment, people, technology or training, the investment in R&D will allow the organization to acquire future capabilities and technologies, which can then be converted to new products, processes or services (Freel M., 2018).

According to Kevin P. (2012), R&D activities allowed to create new ideas or concept which could be converted to product or services and can be potential value to

marketplace and increase the competitive advantage. Next, the organization acquire new patents for new products development to ensure that the organization gain sustainable competitive advantages and positioning an organization in an extremely comfortable situation within market and therefore benefit from long term profits. Prior researcher claimed that the R&D activities able to help an organization reduce manufacturing cost and improve processes thus, provide less costly processes to manufacture the products (Caleb F., 2019). For example, using robots alongside humans in factories can reduce production time. Similarly, using self-driving trucks to deliver products can reduce the likelihood of damage and reduce delivery time. As such, R&D activities to create new technology can help increase manufacturing productivity, improved the safety of manufacturing sites and work hourly.

R&D activities also able to increase the human capability by encourage an engineer to have knowledge and skills in line with the current economic situation. According to Freel M. (2018), organizational competitive advantage is determined by organizational efficiency, the ability of the workforce among the engineer, manager, analyst or researcher whereby they make became major contributions to the organization. Besides that, R&D is a necessary step forward furthering the organization vision and goals by offering the new or improve innovative products or services to customer which can change the economy, strength and vitality as well (Kevin, P, 2012). Therefore, an organization able to provide at more competing price to customer or increase the profit margin. As such, R&D activities are very important as it can sustained economic growth and increase knowledge of innovation as the new initiative in the organization.

1.1.2 Research and Development in Malaysia

Reports from the Multimedia Super Corridor (MSC) stated that Malaysia has a world-class of R&D environment and services industry due to the business environment, people skills, financial attractiveness, and availability. It has been proven by A.T. Kearney Global Services Location Index^{TM} report 2016 that Malaysia is the third most financial attractive location in the world, as shown in Figure 1.1 whereby

foreign investor interest in using Malaysia as their regional operational hub to tap into the growing opportunities in emerging Asia. Therefore, it is well known as one of the top most preferred offshore development centres. In addition, Malaysia has constantly been generating and establishing new sources of economic growth in order to remain competitive in the world economy. The application and development of innovation, technology and science through R&D can enhance the country's capabilities. Additionally, Malaysia has a stronghold in the manufacturing sector which will provide ample opportunity for R&D growth in the country.

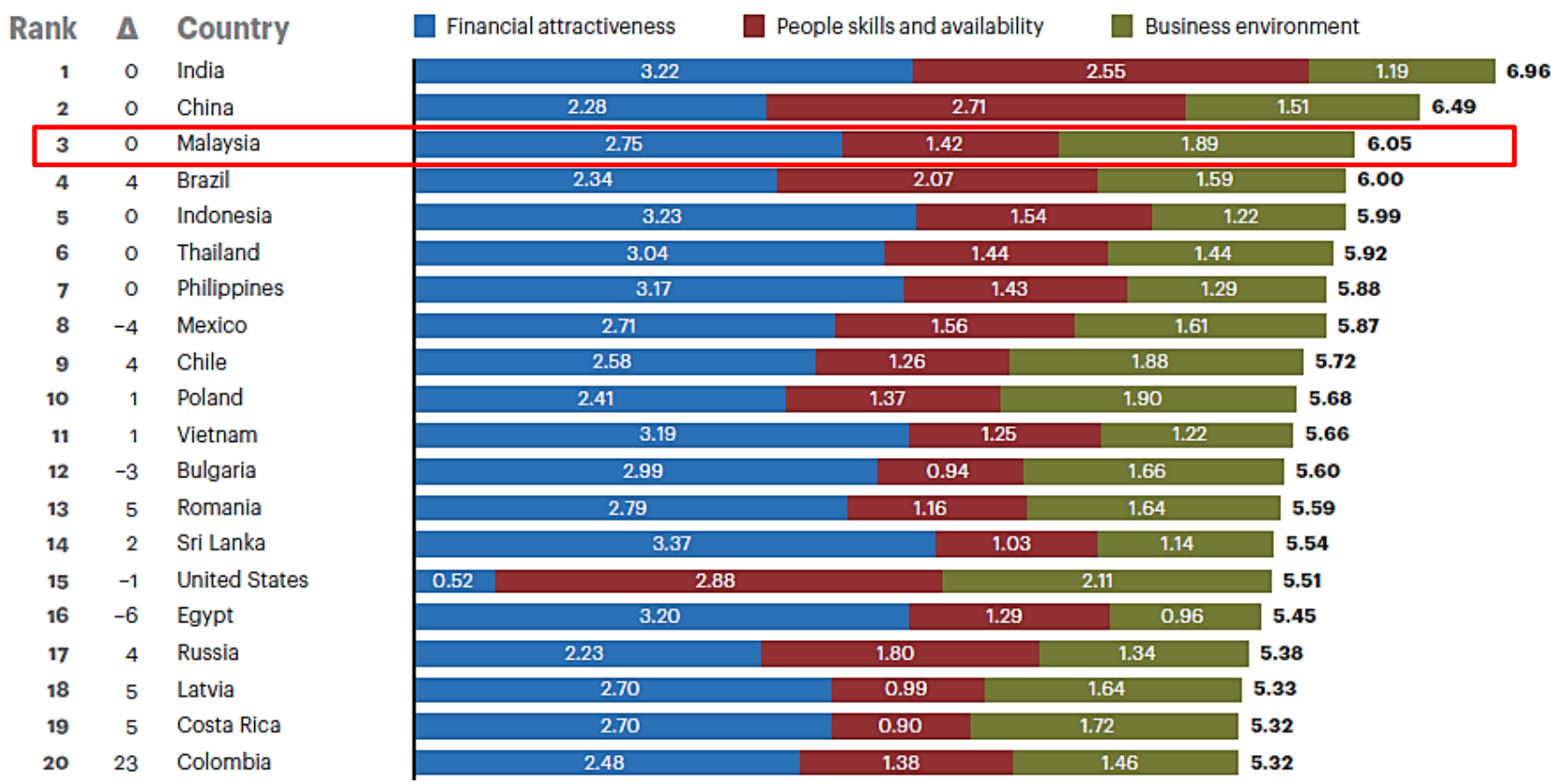


Figure 1.1 T. Kearney Global Services Location Index™ Top 20 (Sethi and Gott, 2016)

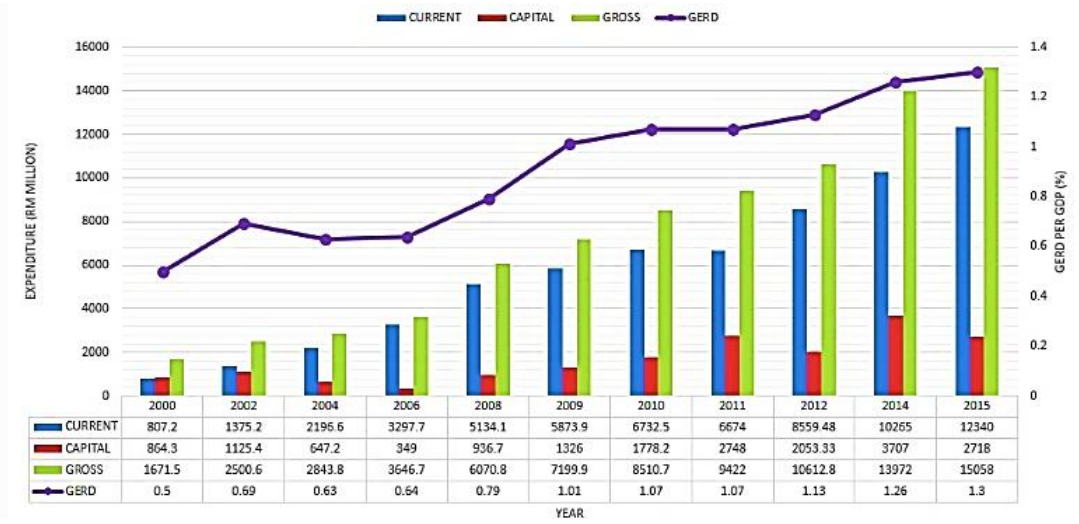
Investment in R&D will increase the appointment of researchers, increase design and patent registration and ultimately contribute to higher R&D spending in the country. The involvement of the Malaysian Government in promoting R&D activities has started in the Fifth Malaysia Plan, 1986 – 1990 with the introduction of Intensification of Research in Priority Areas (IRPA) grant (Jalil *et al.*, 2015). Beginning with the Seventh Plan, R&D activities began to be seen as a potential source of income that can contributed significantly to the country's economy. Therefore, the Malaysian Government feels the need to encourage researchers to engage in R&D activities whereby the results can then be converted into commercialized products.

Many initiatives have been undertaken by the Malaysian government in order to achieve R&D intensity of at least 20% by 2020. One of it was by expanding the organizations that function as moderators for the R&D growth such as the Federation of Malaysian Manufacturers (FMM) and Malaysian Investment Development Authority (MIDA). The Malaysian government has introduced various science and technology programs to promote R&D and technology innovation to acquire and develop technological capabilities (Jalil *et al.*, 2015). For example, the Innovation design academy mooted by Collaborative Research in Science, Engineering and Technology (CREST) aims to enhance local design outsourcing capabilities. Through this program, local design talent groups and companies will be able to develop solutions for MNC's globally and locally.

Besides this, the Malaysian government also announced various initiatives and incentives such as a double deductions for the use of approved research facilities/companies, financial donations for research institutions, cash donations to research institutions, revenue expenditure for research projects and exempted on import duty, and excise sales taxes and duty and sales taxes on raw materials, machine/equipment materials, components parts and samples used for R&D activities (Jalil *et al.*, 2015).

Based on the survey done by the Malaysian Science and Technology Information Centre, the R&D spending in Malaysia has increased since 2000. In 2015, Malaysia recorded the highest Gross Expenditure on R&D (GERD) at RM12,058

million, an increase of 148.04% over the GERD value in 2008 which was RM6, 070.80 million (Figure 1.2). However, from the perspective of intellectual properties, which is one of the measures to assess R&D output the number of patents granted in Malaysia recorded the lowest number compared to other countries in 2016, which was only 3324 even though there was an increase in R&D spending over time (Figure 1.3). Hence, the review and analysis of problems faced by R&D based companies in Malaysia in implementing and maintaining their performance requires further investigation. With a better overview of these issues, the determinant for R&D success can be identified and the framework for an effective Malaysian R&D company can be developed with the increasing manufacturer performance even though the use of R&D expenditure is already at optimum level.



	2000	2002	2004	2006	2008	2009	2010	2011	2012	2014	2015
CURRENT	807.2	1375.2	2195.6	3297.7	5134.1	5873.9	6732.5	6674	8559.48	10265	12340
CAPITAL	864.3	1125.4	647.2	349	936.7	1326	1778.2	2748	2053.33	3707	2718
GROSS	1671.5	2500.6	2843.8	3646.7	6070.8	7199.9	8510.7	9422	10612.8	13972	15058
GERD	0.5	0.69	0.63	0.64	0.79	1.01	1.07	1.07	1.13	1.26	1.3

Figure 1.2 R&D spending in Malaysia, 2000 – 2015

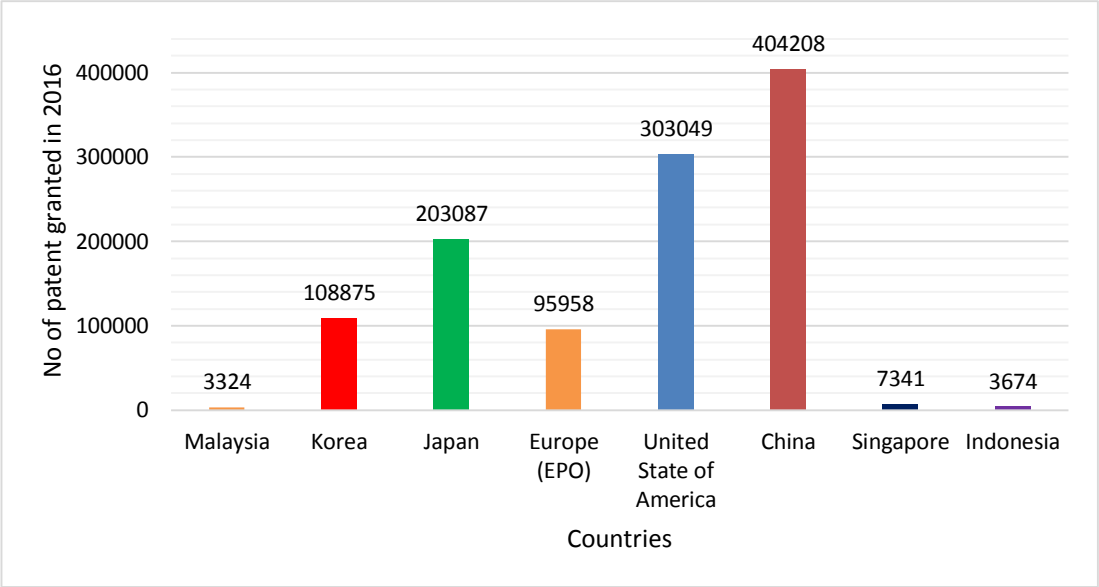


Figure 1.3 Patents granted by countries in 2016 compiled by researcher from Statistics Database World Intellectual Property Organization (WIPO) 2017

1.1.3 Issues in Research and Development

Research and development (R&D) is leading factor affecting performance in term of productivity and growth for every innovative company. However, R&D can be expensive and is often associated with risk of financial devastations, supply disruptions, producing much waste and excess high technology (Kovacheva, 2010; Scottish, 2013). A study done by Skaife, Swenson & Wangerin (2013) suggested that overinvestment in R&D results in a more severe decline in organization performance compared to underinvestment in R&D. Many failures derived from the standpoint of emerging technologies, where the introduction of the most innovative technical features in new product development is computed to meet customer demands. The result of this is an inefficient use of resources and waste in the form of excessive investment on unwanted features and failure to "do the right thing" (Bianchi *et al.*, 2011). Resource allocation is one of the ways that R&D activities are enhanced whereby the resources refer to employees, knowledge, skills, finances, and time that represent the company's strengths and can be used to assist in concept and the implementation of strategies (Kahn and McGourty, 2009; Adegorite, 2013;

Oyedolapo, 2014). Hence, appropriate allocation of resources and optimization of resources are essential to the survival and organization's success.

In conjunction with this, one of the strategies that can be used for achieving superior R&D performance is via the adoption of lean practice into R&D process. Lean is a widespread strategy for reducing waste; improving products and/or quality and is thus increase the competitive advantages. According to Womack and Jones (1996), the lean system was introduced by Toyota Production System with aim of improving the manufacturing process by reducing or eliminating non-value-added activities. Lean can yield very dramatic improvements in innovation, customer satisfaction and financial performance (Pearce and Pons, 2013). Previous study found that the lean system has been applied in the manufacturing industries and showed the positive impact to the overall efficiency of the company (Andersen, Belay & Seim, 2012; Bhamu & Sangwan, 2014; Gutter, 2014). As R&D activities was appeared one of the entities in the manufacturing industries, therefore lean system can be implemented as well in the R&D activities with the similar objective which is reduce or eliminate the waste and non-value added activities.

Even so, many organizations cannot turn themselves into a lean implementation organization towards creating the world class companies that concerning customer demand in the quality looked for zero waste (Hibadullah *et al.*, 2014). Baker (2002) reports that the percentage of success of UK organizations on lean implementation is less than 10% thus affecting the manufacturer performance in terms of productivity and profits. A large survey conducted by Industry Week 2007, reported that only 2% of organizations that have implemented lean practices fully achieved their goals and less than a quarter of all organizations (24%) reported achieving significant results. This leaves 74% of organizations responding that they are not making good progress with lean practices (Pay, 2008). According to Chong, Cheah, Wong, & Deng (2012), the complexity and challenges of implementing lean principles have affected the success rate of organization adopting lean practices such as limited training for human resource development, limited funds, lack strong leadership commitment, lack of lean tools and techniques, and miscommunication between supplier and customer.

1.2 Problem Statement

There are four gaps been addressed by the researcher. The first gap is regarding the lean for R&D setting, followed by lean R&D tools and techniques, lean implementation and the measurement of R&D based organization performance. The last gap is regarding the relationship among lean R&D tools and techniques, lean R&D soft practices determinants and R&D based organization performance. All the gaps will be discussed at the next session in details.

1.2.1 Gap 1: Lean for R&D Setting

The manufacturing industry has changed its business model and now spends more than 5% of its total expenses on R&D. Since 1995, technology industry spend more than 10% of expenses on R&D which show that was the most dramatic change. The fastest growing industry in the last three decades has shifted its focus away from marketing towards innovation and product development (Vijay Govindarajan et. al., 2019). Concurrently, many companies have been carried out research today in order to achieve the best performance through implementing lean manufacturing. According to Padilla & Pekmezci, (2011); Pearce & Pons (2013) lean practice could help to improve organization performance as the lean goal is to eliminate all waste that adds costs without adding to value hence improving efficiency due to a reduction in lead time whilst quality increases and the cost of quality decreases. However, Baker (2002) reported that the success percentage of UK organizations on lean implementation is less than 10% thus affected the manufacturer performance as well in term of productivity and profits. A large survey conducted by Industry Week 2007, reported that only 2% of organization that have implement lean practices fully and achieved their objectives, meantime less than a quarter of all organization (24%) reported achieving significant result. That leaves 74% of responding organization admitting that they are not making good progress with lean practices (Pay, 2008).

According to Abdulmalek, 2006 & Brady, 2014, R&D activities can add value to various functions of business by gaining knowledge to develop, design, enhance and

modify company's product thus increase the market participation. Yet, there are challenges like high cost, increases timescales, unknown results, etc need to overcome to ensure the company achieved their mission and vision. Several researchers found that most of manufacturing industry has improve their product by conducting a massive ongoing R&D investment that leads to negative cash flow for a long time. According to Manyika *et al.* (2012); Hemlin *et al.* (2013) , the R&D activity could be the major reason operational performance in an organization does not show a good result or any improvement after the lean implementation as the non-value added mostly coming from R&D activity.

Table 1.1 and Figure 1.4 shows the 10 most innovative companies against the R&D spending in US Dollar. By referring to Figure 1.4, the bar chart shows the fluctuation in the number of R&D spending in 2013 across the 10 most innovative company. Apple was established as the most innovative companies with R&D spending about $3.4 Billion only while Samsung was the most companies that invest in R&D but at the Rank 3 compare to Apple and Google Inc. However, Microsoft Inc. yet not at the 5 most innovative companies as they were invest the second most R&D investment after Samsung.

Table 1.1 10 Most Innovative Companies by B. Jaruzelski, Staack, & Goehle, (2014)

Rank	Company	2013 R&D Spending ($B)	Spending Rank	R&D/Revenue (Intensity)	Industry
1	Apple Inc.	$3.4	43	2.2%	Computing & Electronics
2	Google Inc.	$6.8	12	13.5%	Software & Internet
3	Samsung	$10.4	2	5.8%	Computing & Electronics
4	Amazon.com Inc.	$4.6	30	7.5%	Software & Internet
5	3M Corp.	$1.6	85	5.5%	Industrial
6	General Electric Co.	$4.5	31	3.1%	Industrial
7	Microsoft Corp.	$9.8	5	13.3%	Software & Internet
8	IBM	$6.3	16	6.0%	Computing & Electronics
9	Tesla Motors Inc.	$0.3	377	66.3%	Auto
10	Facebook Inc.	$1.4	101	27.5%	Software & Internet
	Total R&D Spending	$49.1B			

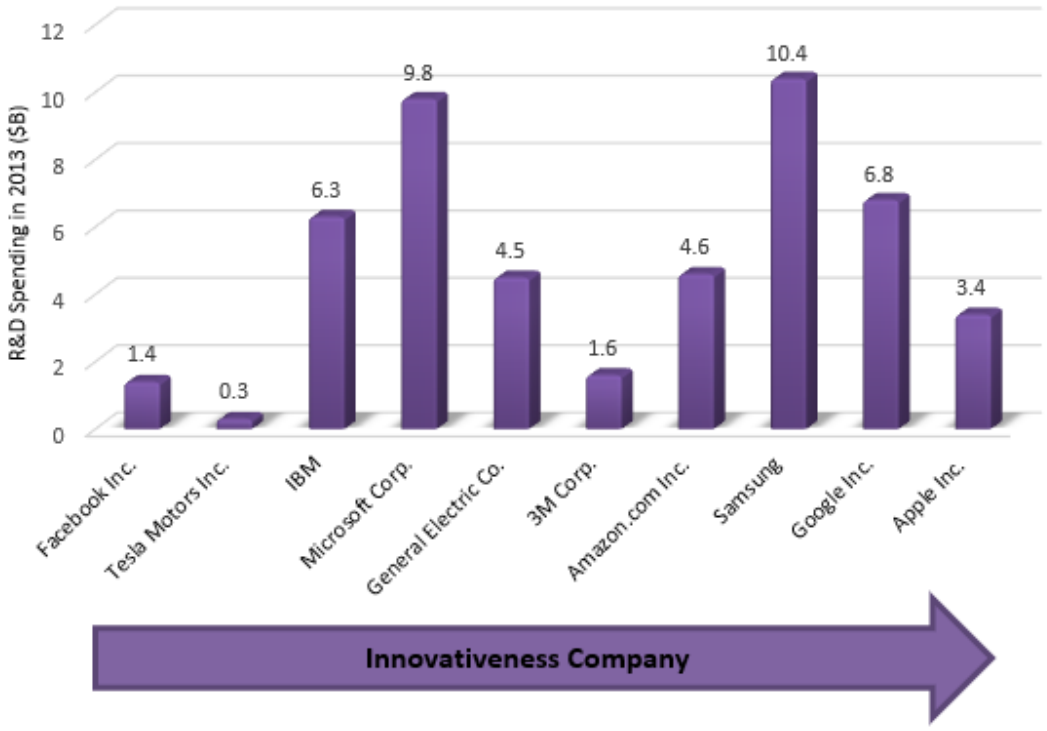


Figure 1.4 10 Most Innovative Companies in 2013 compiled by researcher from Table 1.1

The empirical evidence strongly supports that the investment into R&D has led to a significant amount of output in the form of patents which positively impacts company performance (Czarnitzki and Hussinger, 2004; Finger, 2008; Santamaría *et al.*, 2009; Hunady and Orviska, 2014; Koh and Reeb, 2015). Contrary to this traditional view, Costa-Campi, Duch-Brown, & García-Quevedo (2013); Evangelista, Perani, Rapiti, & Archibugi (1997); Horton & Kinezos (2010); Klodt (1987) and Sharma (2003) argue that the investment on R&D has not giving a significant result towards the organizational performance. The consistent result of an organization performance indicates that there is gap exist in between the lean implementation in manufacturing industry which is indirectly implement in R&D environment. Hence, it is necessary to conduct the study of lean implementation on R&D setting.

1.2.2 Gap 2: Lean Tools and Techniques

1.2.2.1 Gap 2a: Lean Tools and Techniques for R&D Setting

There are numerous lean tools and techniques developed by previous researched based on manufacturing environment which allows the improvement of production by eliminating all waste occurring on the production (Amin and Karim, 2012). According to Higor R. L. & Guilherme E. V. (2015), lean tools and techniques could be applied as well to other sector instead of manufacturing environment as the waste was basically produce in every activity either in manufacturing or non-manufacturing, either from big company to small company. However, the use of lean tools and techniques for manufacturing cannot be fully utilized in R&D environment as the manufacturing was about mass production or large-scale production of standardized products while R&D was about producing prototype in few quantities for testing purpose (Paulina R., Przemyslaw C., Justyna T., 2016). For example, one of lean manufacturing tools was Poka yoke whereby used to determine the mistake done by operator in the production which involves a high-volume production (Sissonem, 2008) and therefore not suitable to implement in the R&D environment. There are very

few empirical studies related on the lean tools and techniques in R&D setting (Paschkewitz, J. J., 2011; Edison T., 2015; Neha, Singh, Simran & Pramod, 2013). Furthermore, the right lean tools and techniques to be used may vary depending on several contextual factors such as the current maturity level of an organisation, areas in which the lean tools and techniques are adopted, type or size of an organization and the capabilities of its workforce Benson et al, 1991; Dahlgaard & Dahlgaard-Park, 2004; Mohammad, 2012; Shahir Y. et. al, 2016). As such, this research attempt to fill the gap by identifying the lean tools and techniques for R&D setting.

1.2.2.2 Gap 2b: Categorization of Lean Tools and Techniques based R&D Process

There are over 100 lean tools and techniques available and applied in manufacturing industry (Mwacharo, 2013; Pavnaskar, Gershenson, & Jambekar, 2003), hence causing confusion and diminishing focus on activities. R&D based organization, which plans to implement the lean, must determine how to make it work under their organization's circumstances. However, there are lacks study focus on how to put the lean tools and techniques in place within R&D environment. There are several approaches in categorizing the lean tools and techniques proposed by previous researcher in order to assist the organization on selecting an appropriate lean tools and techniques such as methodology-based, a manufacturing-based categorization, a waste application-based, a resource performance-based and a characteristic-based categorization (Pavnaskar *et al.*, 2003; Abdulmalek *et al.*, 2006; Larteb *et al.*, 2015).

All the categorization approaches are having a limitation thus unable to implement well in R&D environment. For example, Larteb et al., (2015) proposed to divide the lean tools and techniques into hard practices and soft practice. However, the categorization is too simple as both practices have interrelated each other. Similarly, the categorization approaches by Abdulmalek et al. (2006); Abdulmalek & Rajgopal (2007) which is manufacturing-based and characteristics-based could not be adopted directly to R&D environment as the lean tools and techniques specified are focused on manufacturing environment. Waste-application based is over-focused on the reduction or elimination waste while resource performance-based is depend on the user

perception whereby it is very subjective. Therefore, the selection of appropriate lean tools and techniques for R&D improvement together with their applicability and acceptance within each R&D activity remains a major problem for any R&D based organizations as the categorization approaches that developed by prior researches were based on manufacturing environment. Based on 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 whereby it is easier to control for potentially confounding influences. Therefore, to overcome the aforementioned and in line with the system theory, this research going to close the gap by categorizing the lean tools and techniques based on R&D processes.

1.2.3 Gap 3: Lean Implementation for R&D Setting

A study conducted by previous research shows that the lean is less focused on R&D due to inadequate way of implementing lean practices in R&D activities in the manufacturing industry (Flinchbaugh, 1998; Yamashita, 2004; Christodoulou, 2008b; Farhana Ferdousi, 2009; Agyei-Boahene, 2010; Amin and Karim, 2012; Attané, 2012). Hence, to select and implement lean practices directly to R&D is a challenging task because the issues addressed by R&D are not compatible with the manufacturing environment. Considering the determinant of lean implementation within the organization which are top management, culture, training, knowledge, lean tools and techniques, there are many previous study can be found related to this topic (Hibadullah *et al.*, 2013; Larteb *et al.*, 2015; Netland, 2015).

Based on Resource-based View Model introduced by Wernerfelt (1984) stated that the competitive advantage achieves and sustain when the organization employ the tangible and intangible resources whereby the tangible resources is referring to technical practices which is tools and techniques while intangible resources are anything related to human practices such as commitment, culture, knowledge, etc. Hence, the determinant of lean R&D could be split into two practices which are lean soft practices determinant and lean tools and techniques. As such, this research

attempts to fill the gap by further study on both of lean determinant which is lean soft practice determinants and lean tools and techniques in the context of R&D.

1.2.3.1 Gap 3a: Implementation of Lean Soft Practice Determinants

Lean is considered appropriate to adopt to various sector of manufacturing industry including R&D environment with the aim to improve the quality and operational performance as the lean have been successfully applied in manufacturing (Russle & Taylor, 2009; Scherrer-Rathje et. al, 2009). Previous researcher has pointed out that implementing lean soft practice determinant to other sector such as R&D environment may confront with difficulties regarding the standardizations of operations, overlooking of people issues, operating times, which are all subjected to a variability of R&D activities which is much higher than of manufacturing operations (Paulina R et. al, 2016; Higor R. L., 2015). Hence, it is interesting to understand the lean soft practice determinant for improving operational performance in R&D context. From the literature review, it is evident that there exist many common lean soft practices determinants in manufacturing industry that lead to successful implementation and these factors include top management commitment, technology, communication, collaboration, etc. However, these common lean soft practice determinants may or may not be appropriate across the R&D environment.

In the meanwhile, previous researcher found that, most of company in manufacturing industries have been implemented lean soft practice determinant to some extent (Scherrer-Rathje et. al, 2009). However, findings based on manufacturing industries do not indicate the holistic perspective of lean soft practice determinant implementation in R&D. Furthermore, implementation of lean soft practice determinants has motivated many industries to improve quality, improve productivity, reduce cost and customer satisfaction although there are many industries that often fail to implement lean (Scherrer-Rathje et. al, 2009). Several researchers stress that most of the barriers towards lean implementation in manufacturing are related to resistance from people, leadership failures, identity of improvement team members, weak links between improvement program and strategy, lack of resources, poor communication

which known as lean soft practice determinants (de Souza & Pidd, 2011; Erik D., 2014; Radnor et. al., 2006). Hence, this research going to identify and obtained the lean soft practice determinant implementation level for R&D setting.

1.2.3.2 Gap 3b: Implementation of Lean Tools and Techniques

Most of the companies in manufacturing industries found to have a good understanding of lean tools and techniques, and since its implementation, they have gained many benefits such as reduced cost and improved productivity. Previous researcher found that most of companies in manufacturing industry are "moderate-to-extensive" adopters of lean tools and techniques among organization. However, several researchers noticed that the implementation of the lean tools and techniques are not uniform throughout the industrial activity, ranging from full enactment to a few lean technique utilization (Godinho F. & Fernandes, 2004). Hence, this research analyses to what extent the R&D industries in Malaysia have been adopting the lean tools and techniques in R&D environments. According to Ruchira K. (2018), there are different types of lean tools and techniques deployment to bring in improvement process in the final output, while it is no a static model which makes it more important for the organizations in R&D environment to explore lean deployment. This is a research gap and the importance of probing the lean implementation in R&D environment hence forth becomes more pertinent now.

1.2.4 Gap 4: Relationship Among Lean R&D Soft Practices Determinants, Lean R&D Tools and Techniques and R&D based Organization Performance

According to Rui, Filipa & Sousa (2015), the implementation of lean is not straightforward process, numerous obstacles possibly emerged such as refusal to contribute suggestion for improvement, resilience to change, lacking motivation and knowledge of the lean philosophy and its tools, if not properly planned. Previous researchers argue that there has been no systematic study done on lean tools and techniques affecting the strength of lean soft practices determinant and organization

performance (Kayakutlu, & Karakadılar, 2015; Farhana Ferdousi, 2009; Fricke, 2010; Chakravorty & Hales, 2013; Sundar, Balaji, & Kumar, 2014; Buller & McEvory, 2012). Hence, Mamat, Md Deros, Ab Rahman, Omar, & Abdullah (2015) proposed for more comprehensive empirical studies on the top management and employee involvement which also known as lean soft practices and the relationship with organization performance with intervening variables of lean tools and techniques. Details of each relationship in R&D setting to be discuss in next session.

1.2.4.1 Gap 4a: Relationship between Lean R&D Soft Practice Determinant and R&D based Organization Performance

Many empirical studies supported the positive relationship between lean soft practices determinant and organization performance (Maleyeff, 2007; Jozaffe, 2008; Neyogi, 2009; Daraei et. al., 2015). However, there are several research found that there are no sufficient significant positive effect on the organization performance from the increase of lean engineer and high technology implementation (Shahram Taj, 2005; Sasidharan *et al.*, 2014). Other than that, there are some research evidence demonstrates that lean soft practice determinant has not diffused across all manufacturing industry which is R&D environment (Bortolotti, 2010; Neagoe & Klein, 2009; Ospina & Perez, 2016; Sabry, 2014; Shah & Ward, 2003). The inconsistencies on the finding of attribution for lean soft practices implies that there is no common agreement or finding by prior research on the lean soft practice determinants for organization performance, hence there is no single set of lean soft practices determinant within manufacturing environment that could be brought across and adopted in R&D environment. Buller and McEvory (2012) suggested that a bundle of lean soft practice determinant should generate greater effects, in contrast to individual lean soft practice determinant. Therefore, this study attempts to fill the gap by integrating multiple lean soft practices determinant to provide empirical evidence of the lean soft practice determinants on organization performance within R&D environment.

1.2.4.2 Gap 4b: Relationship between Lean R&D Soft Practice Determinant and Lean R&D Tools and Techniques

Locher D. (2013) study commented that the lean tools and techniques only do not always lead to organizational effectiveness but more on the management responsibility to ensure the lean tools and techniques are utilized properly within the organization. According to Daraei, Hosseini, Niksirat, & Kianbakhsh (2015); Vijayakumar & Robinson (2016), the management staff need to ensure that the utilization of lean concepts and lean tools and techniques in proper way in order to get the long term prosperity and sustainability of the lean tools and techniques. From the available literature it is identified that management involvement, employee involvement, communication, lack of training and culture issue are identified as the determinant of lean tools and techniques implementation success but which of these are relevant in R&D environment is certainly not clear (Chakravorty and Hales, 2013; Sundar *et al.*, 2014; S.D. *et al.*, 2015). Hence, there is a need to study the relationship between lean tools and techniques and lean soft practice determinant in R&D environment within Malaysia.

1.2.4.3 Gap 4c: Relationship between Lean R&D Tools and Techniques and R&D based Organization Performance

Lean tools and techniques (LTT) which also known as lean hard practices are able to help maximize a firm's operational efficiency and become competitive. According to Bortolotti (2010); Büyüközkan et al. (2015); Farhana Ferdousi (2009); Fricke (2010); Kovach et al. (2011); Vijayakumar & Robinson (2016), various lean tools and techniques can help the industry eliminate waste, improve productivity and product quality, reduce lead time and obtain better operation performance. In summary, lean tools and techniques can be viewed as important determinant of organization performance. However, the link between lean tools and techniques and organization performance has remained controversial and ambiguity about the strength of lean tools and techniques and organization performance relationship (Fricke, 2010; Kovach et al., 2011; Vijayakumar & Robinson, 2016). The number of available lean

tools and techniques for the improvement of operational performance is growing rapidly, yet the companies attempted to use them failed to produce significant results (Milita V. & Ramune C., 2013). This indicate that the adoption of lean tools and techniques across manufacturing has struggled with the lack clarity on how to make lean tools and techniques implementation more successful.

Previous study suggested that in the study of LTT and the relationship with organization performance, LTT should not be viewed or grouped as single and identical entity that applied across the whole system or process (Fricke, 2010; Kovach et al., 2011; Vijayakumar & Robinson, 2016). As such, the types or category of LTT used at every sub-system or sub-process need to be identified, assessed, follows by studying the impact of each category of LTT toward organizational performance. In conjunction with this, this study closes the LTT literature gaps by exploring the relationship of LTT with organizational performance at different stage of R&D process.

1.2.4.4 Gap 4d: Mediating Effect of Lean R&D Tools and Techniques between Lean R&D Soft Practice Determinant and R&D based Organization Performance

Gap 4a – 4c showing that there are mainly focused on direct relationship. For example, the studies on lean practices have primarily focused on the lean soft practices determinant in association with organization performance (Alaskari. *et al.*, 2012; Punnakitikashem and Chen, 2013; Sventelius and Ohrstrom, 2013; Hibadullah *et al.*, 2014). Besides that, many studies have found a positive relationship between lean tools and techniques and organization performance (Farhana Ferdousi, 2009; Bortolotti, 2010; Fricke, 2010; Kovach *et al.*, 2011; Büyüközkan *et al.*, 2015; Vijayakumar and Robinson, 2016; Nabila *et al.*, 2018). Other than that, the management, lean expertise and technology which is lean soft practice determinant were the reason why the lean tools and techniques implementation success (Daraei et. al, 2015; Vijayakumar & Robinson, 2016).

Although the relationship among the lean soft practice determinants, lean tools and techniques and organization performance has been investigated in directly effect, not much work is available by considering the determinant of R&D success as intervening variable either lean soft practices or lean hard practices. Furthermore, a mass study done by prior researchers' show that most lean soft and hard practices focus on the manufacturing environment and there is limited evidence to show that all lean soft and hard practice are involved in R&D activity (Deif & ElMaraghy, 2014; InnovationInsight, 2009; Padilla & Pekmezci, 2011; Shah & Ward, 2003. Becker and Gerhart (1996) strongly suggested that it is important to consider the intervening variables in lean implementation analysis which may offer highest potential leverage on the lean soft practice determinant and organization performance relationship. Therefore, this research aims to investigate the mediating effect of lean R&D tools and techniques between relationships of the lean R&D soft practices determinants and R&D based organization performance in Malaysia.

1.3 Significance of the Research

The principal significance of this study is to explore the R&D based organization performance by creating the understanding of the awareness, usage, effectiveness and perceived need of R&D based organization towards lean implementation. This study also will contribute in terms of filling the gap to the literature pertaining to lean practices determinants in research and development. A major gap in the literature is the lack of research pertaining determinant of lean tools and techniques as a mediator between lean soft practices determinant and organization performance since most of the studies focused on the relationship of lean determinant and organization performance. Meanwhile, this study provide guideline for selection lean tools and techniques based on process in the R&D environment that can assist managers, engineers and lean practitioners in the organization to select the appropriate tools in each process of R&D.

The results of the study will give a great benefit to R&D based organizations in Malaysia when implementing lean R&D and improving their R&D based

organizations performance as well as assisting the Malaysian government in reassuring the organizations to adopt lean R&D practices for policy setting. This in turn will enhance and support the Malaysian economy performance. As this is preliminary Malaysian study, it should prove to be the basis for future research on R&D research and the findings of the research would provide evidence for further research work. Finally, the findings will provide evidence for further research work.

1.4 Research Objectives

This study aims to explore the R&D based organization performance by identifying all the determinant of lean R&D success in Malaysia which is lean R&D soft practices determinant and lean R&D tools and techniques that also known as hard practices, assessing the determinant's implementation level and evaluate the current R&D based organization performance in Malaysia, thus investigate the relationship between the lean determinant and R&D based organization performance including by considering the mediating effect of lean R&D tools and techniques among lean soft practices determinant and R&D based organization performance. Therefore, the objectives of this research can be summarize as below:

RO1 : To identify and categorize lean tools and techniques for research and development setting in Malaysia

RO2 : To assess the implementation level of lean tools and techniques within R&D based organizations in Malaysia

RO3 : To assess the implementation level of lean R&D soft practice determinants within R&D based organizations in Malaysia

RO4 : To assess the performance level of R&D based organizations in Malaysia

RO5 : To explore the relationship between lean R&D soft practice determinants and organization performance within R&D based organizations in Malaysia

RO6 : To explore the relationship between lean R&D soft practice determinants and lean R&D tools and techniques within R&D based organizations in Malaysia

RO7 : To explore identify the relationship between lean R&D tools and techniques and organization performance within R&D based organizations in Malaysia

RO8 : To investigate the mediating effect of lean R&D tools and techniques between the relationships of the lean R&D soft practices determinants and organization performance within R&D based organizations in Malaysia

1.5 Research Questions

Base on the above discussion in problem statements, the research questions that will drive the research are as follows:

RQ1 : How to determine and categorize the lean tools and techniques based on R&D setting in Malaysia?

RQ2 : What are the implementation levels of lean tools and techniques within R&D based organizations in Malaysia?

RQ3 : What are the implementation levels of lean R&D soft practice determinants in R&D based organizations in Malaysia?

RQ4 : What are the performance levels of R&D based organizations in Malaysia?

RQ5 : What are the relationships of lean R&D soft practice determinants and R&D based organization performance in Malaysia?

RQ6 : What are the relationships between lean R&D soft practice determinants and lean R&D tools and techniques in Malaysia?

RQ7 : What are the relationships between lean R&D tools and techniques and R&D based organizations in Malaysia?

RQ8 : Do lean R&D tools and techniques mediate the relationship between lean R&D soft practice determinants and R&D based organization performance in Malaysia?

1.6 Scope of the Research

The scope of this research is to perform detail study of lean R&D implementation in manufacturing industry within Malaysia. In this scope, the researcher aims to measure the implementation level of lean soft practice determinant, lean tools and techniques and organization performance in R&D environment followed with the further study on the relationship among the variables and examined the mediating effect of lean tools and techniques between lean soft practice determinant and R&D based organization performance. Lean tools and techniques have been implemented in various other field in manufacturing industry including R&D in the range of start implemented to fully implemented (Selim Z. & Ebru A., 2014).

There are many other lean soft practice determinants that would also affect the degree of R&D based organization performance. However, the focus of this research is the seven core dimensions of lean soft practice determinant which are managerial, employee skills and expertise, financial capability, technology, leadership transformation, supplier and customer involvement. Other than that, this research will focus on ten (10) leans tools and techniques that have potentially either directly or indirectly affect the R&D based organization performance. The key measurement key for R&D based organization performance are limited to 5 attributes which are financial performance, time, product quality, organization capability and customer satisfaction. Further, the study incorporated a framework for conceptual insight are based on underpinning theory: Theory of Constraint, Resource-based View Model and System Theory. The proposed conceptual model has been tested to verify the direct relationship among the variable and mediating effect of lean tools and techniques in the model.

The research would be done through the utilization of semi-structured interview to the experts and self-administered questionnaire to the R&D based organization which represent as unit of analysis. The researcher choose to use any organization with R&D entity in the manufacturing industry either its existence is formal or informal within Malaysia to ensure that all determinants of R&D success

which is lean soft practice determinants and lean tools and techniques, together with R&D based organization performance indicator.

The sample population for R&D based organization is restricted to the manufacturer which conducted lean and R&D activities in Malaysia during year 2017 - 2018. The Malaysia was selected because it represents a developing country that offer many opportunities to multinational companies (MNC) such as low cost skilled manpower, low cost infrastructure and low cost logistics with appropriate technology in line with New Economic Model (NEM) that have been introduces by the Malaysian government to achieve economic growth (Jones, 2010; World Bank, 2014). Furthermore, the Malaysian Government has provided various grants and incentives to encourage companies in various industries to start R&D activities in the manufacturing sector. Malaysian Investment Development Authority (MIDA) is the country's leading investment promotion agency, who responsible to review and give approval to any R&D project that beneficial to the country. Malaysian Investment Performance Report 2017 show the total investment in the manufacturing sector was about RM63.7 billion, increasing 8.9% from RM58.5 billion in 2016. Those numbers indicate that the R&D activities have been widespread in Malaysia over the years in every sector such as chemical and chemical products; electronics and electrical products; transport equipment; scientific and measuring equipment; food manufacturing; machinery and equipment; and non-metallic mineral products. This can be illustrated clearly in Figure 1.5. In view of the statistics and considerations above, R&D based organization in Malaysia is thus chosen as the research scope of this research.

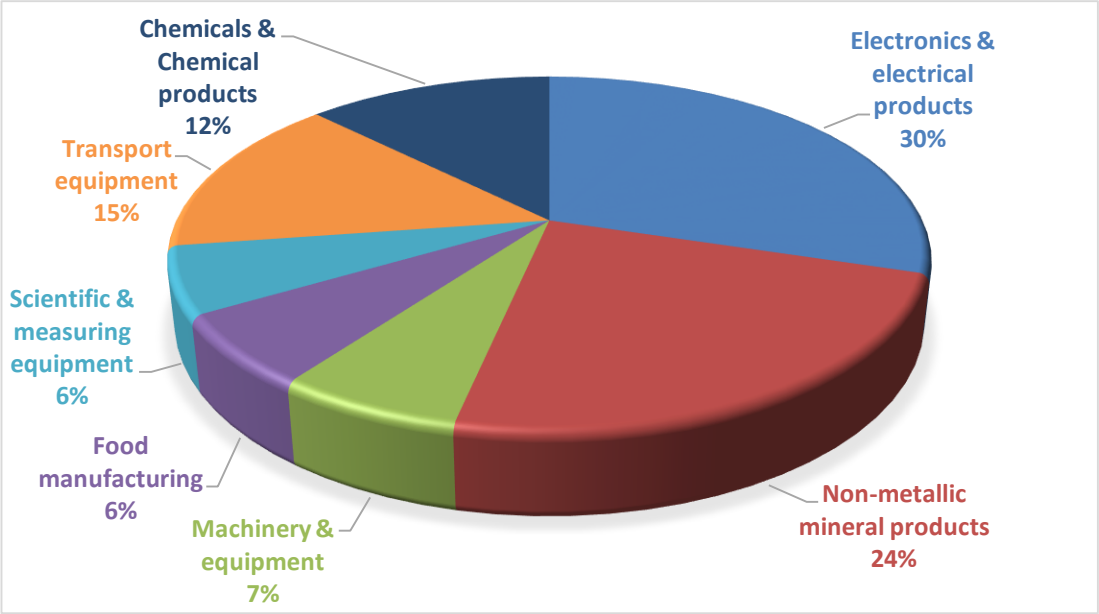


Figure 1.4 Total Investment by Industry compiled by researcher based on Malaysia Investment Report, 2017

1.7 Operational Definition

The operational definitions of terms used throughout this research are provided to clarify the context of this research.

Research and development (R&D)	:	A systematic process that combines basic and applied research to solve any problems or create new good knowledge. Results from the R&D activity can become an ownership of intellectual property such as patents.
R&D based organization	:	A company in manufacturing industry that conducted R&D activity either formal or informal within the organization.

Lean R&D	:	A strategy to reduce costs, increase speed and deliver superior quality in R&D process by integrating both lean R&D tools and techniques and lean R&D soft practice determinants.
Lean soft practices determinant	:	The determinants of lean R&D success which is related to non-technical practices such as employee skills and expertise, transformational leadership, customer involvement, managerial, supplier involvement, technology and financial capability that directly influence the R&D based organization performance
Lean R&D tools and techniques	:	The systematic methods introduced to support the lean transformation in lean system to remove waste, variability, an overburden and deliver improvements in R&D process.
R&D based organization performance	:	The accomplishment or the ability of R&D based organization to perform in term of customer satisfaction, product quality improvement, organization capability, financial performance and time performance.

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