

**LONG TERM LEAN IMPLEMENTATION: A CASE
STUDY AT JOB SHOP PRODUCTION
ORGANISATION IN MALAYSIA**

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by

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LIST OF ABBREVIATIONS

CAD	Computer aided drafting
CAM	Computer aided machining
CNC	Computer numerical control
EDM	Electro-discharged machining
FOT	First of trial
HSM	High speed milling
HVLV	High volume low variety
LVHV	Low volume high variety
ODM	Original design manufacturer
OEM	Original equipment manufacturer
PSA	Process sample approval
PPMX	Product-process matrix
RBV	Resource-based view
RBT	Resource-based theory
SMED	Single minutes exchanged dies
TSA	Trial shot analysis
VRIN	Value, Rareness, Inimitable, Non-substitutable
VRIO	Value, Rare, Imitate, Organised

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Appendix A	Permission from organisation for case study conduct
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**PELAKSANAAN KEJAT JANGKA PANJANG: SATU KAJIAN KES DI
ORGANISASI PENGELUARAN *JOB SHOP* DI MALAYSIA**

ABSTRAK

Tujuan kajian kes kualitatif ini adalah untuk memahami pengurusan “sisi lembut” bagi pendekatan organisasi terhadap pelaksanaan kejut dan kesan kepada prestasi operasi jangka panjang di organisasi pembuatan yang berorientasikan kedai kerja di Malaysia. Objektif kajian ini adalah untuk meneroka faktor-faktor yang menghalang pelaksanaan kejut yang telah lama ditubuhkan daripada mengekalkan prestasi kompetitif bagi organisasi kedai kerja untuk jangka masa yang panjang. Isu kes bagi satu organisasi yang dipilih bagi kajian ini adalah pelaksanaan kejut yang dilaksanakan sejak awal tahun 2000 tidak dapat menyokong organisasi kedai kerja untuk mengekalkan prestasi kompetitif untuk jangka panjang. Hasil daripada analisis tematik telah mengenal pasti 3 tema utama iaitu pudar rutin operasi, daya maju asset yang tidak mencukupi dan beralih dalam langkah-langkah operasi. Akhirnya, tema yang diperolehi memberikan makna bahawa kecekapan sumber operasi bagi organisasi tersebut tidak lagi cekap untuk mengekalkan prestasi sebelumnya dan juga menyumbang kepada peningkatan prestasi operasi untuk jangka panjang. Kajian ini memberikan pemahaman mendalam melalui pengalaman langsung mengenai perspektif operasi terhadap pelaksanaan kejut jangka panjang terutamanya di dalam persekitaran pengeluaran kedai kerja. Penemuan yang diperolehi dari kajian ini tertakluk kepada konteks kajian dan aplikasi metodologi dan tidak bertujuan untuk digeneralisasi ke industri lain.

LONG TERM LEAN IMPLEMENTATION: A CASE STUDY AT JOB SHOP ORGANISATION IN MALAYSIA

ABSTRACT

The purpose of this qualitative case study is to understand the management of soft side of organisational approach to Lean implementation and the impact on long term operational performance in a job shop production oriented manufacturing organisation in Malaysia. The objective of this study was to explore the factors that hinder the long established Lean implementation from retaining competitive performance of job shop organisation in the long run. The case issue of the one selected organisation for this study is that the Lean implementation implemented since the early of 2000s has not been able to support the job shop organisation to retain competitive performance for the long term. The results of the thematic analysis have identified 3 overarching themes namely fade of routine engagement, inadequate assets viability and shift in operating measures. Finally, the themes obtained give the meaning that the operational resources competencies for the organisation no longer competent to retain previous performance and also contribute to the improvement of operational performance for the long run. This study provides an in-depth understanding through direct experience of the operational perspective on long term Lean implementation especially in the job shop production environment. The findings obtained from this study are subjected to context of the study and application of methodology and are not intended to be generalized to other industries.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides information about background of the research. The chapter began with background of study that briefly explain about context of knowledge and gap that lead to problem statement. Next, followed by research objective and research question to portray intended goal and anticipated outcome. Then, scope of research defines the research boundary while significant of research explain the rationale of this study. Finally, this chapter ended with definition of terminology.

1.2 Background of study

1.2.1 Lean manufacturing implementation in Malaysia

The early implementation of Lean manufacturing (Lean) in Malaysia was begun in the automotive manufacturing sector (Abd Hamid, Hassan & Agus, 1987). The implementation was introduced during Proton partnership with Mitsubishi Motor Corporation in national car manufacturing project. The implementation was focused on JIT approach with the aim of streamlining production line activities and supply chain supports (Simpson, Sykes & Abdullah, 1998). At that time, Lean implementation was at introductory phase and organisations were focused on improving operational performance due to economic slowdown (Puvanasvaran, Tan, Megat, Tang, Muhammad & Hamouda, 2008). In the following years, Lean implementation was seen to be increasingly implemented in manufacturing industries with more application of various tools and techniques introduced to improve

operational productivity and performance.

Extant studies of Lean implementation in Malaysia exhibit that automotive-related industry has led the implementation development while others are followed with slower traction. The studies show that automotive related industries have continuous development progress to explore the next phase of Lean implementation such as post-implementation evaluation (Mohd. Salleh, Kasolang & Jaafar, 2012; Ghobakhloo & Tang, 2014) and expansion of concepts application for sustainable organisational performance (Shamsudin, Mohd Radzi, & Othman, 2016; Dhiravidamani, Ramkumar, Ponnambalam & Subramanian, 2017; Habidin, Hibadullah, Mohd Fuzi, Salleh & Md Latip, 2017). Apparently, the successful of Lean implementation in automotive related industries has brought up dissemination to other industries. Extant literatures reported the implementation had disseminated in industries such as colour processing (Rohani & Zaharee, 2015), electronic and electric (Wong & Wong, 2011), halal food (Manzouri, Ab-Rahman, Che Mohd Zain, & Jamsari, 2014), plastic moulding injection (Rosnah & Othman, 2012), large-scale metalworking (Benjamin, Murugaiah & Marathamuthu, 2013) and furniture manufacturing (Abu, Gholami, Mat Saman, Zakuan & Streimikiene, 2019)

The successful of Lean implementation in automotive related industries has brought up wide dissemination to industries with similar manufacturing environment. The reason lies on production operational concept as Lean was originated from car assembly which applies assembly line of manufacturing process type (Peças & Henriques, 2003). Apparently, industries that operate in similar manufacturing environment typically associated with mass production and were found well adapted to the implementation approach. This includes electronics (Wong & Wong, 2011), Halal food (Manzouri et al., 2014), plastic moulding injection (Rosnah & Othman,

2012) and large scale metalworks (Benjamin et al., 2013). However, other manufacturing process types such as job shop, batch, continuous flow line and project based on PPMX framework (Helkio & Tenhiala, 2013; Mohamed & Khan, 2012) have shown lack of presence in extant studies.

Statistic of 32 case studies of Lean implementation in Malaysia denoted that 78.1% were conducted in assembly line, 9.3% in project, 6.3% in job shop, 6.3% in batch and none for continuous manufacturing environment. The statistics exhibited Lean implementation in Malaysia predominantly adopted by mass production or assembly line production type of industries and dissemination to other types are fewer. This perhaps explained by the rise in mass production oriented operations with the emergence of multinational corporations (MNC) since late 1990s and early 2000s (Gamble, Morris & Wilkinson, 2007). The MNCs bring the concept of 'transplant transfer' which denotes transfer of technology and operational practices from their origin (Boscari, Danese & Romano, 2016).

However, the degree of transfer might well suit for industry specific, for example production process in electronics is less complex and has been largely automated, routinised and deskilled. In such position, Japanese MNCs have great influence to disseminate the Lean concept into its supply chain streams operation. Thus, postulates Lean implementation progress for other industries other than mass production or assembly line manufacturing process types are still lagging behind and the implementation development gaps can be noticed. The gap in the adoption of Lean implementation between industries in Malaysia explains that Lean penetration in Malaysia is still at a slow pace (Shamsudin et al., 2016).

Despite many studies on Lean implementation in Malaysia report the successful implementation at the early adoption phase or introduction into the

organisations, it is the least to found studies that assess the implementation progress after certain duration of time. This postulates level of knowledge of Lean implementation performance post to adoption phase still lacks. That raises an interest whether the implementation is well nurture or able to sustained in specific organisation environment in generating performance after certain duration of time.

With the volatility of business performance in the manufacturing industry at regional and global levels, industry practitioners face various challenges to leverage the impact on their operations (Deflorin & Scherrer-Rathje, 2012). Despite the rapid adoption of Lean in organisations, what matters is the extent to which it has been implemented (Corbett, 2007). Therefore, the study of long term Lean implementation in the Malaysian manufacturing industry provides insights on implementation sustainability and operational caveat for the organisation's sustainable performance. That became motivation for this study to further revisit Lean implementation at the post adoption phase especially in industries that have low implementation adoption.

1.2.2 Job shop production and mould making operation

Most of Lean studies focus on the mainstream production environment; the assembly line or also well known as mass production. This is because Lean originated from Toyota manufacturing plant that operates in such production environment. Mass production focuses on high volume manufacturing output with constant variables in the process operation (Slomp, Bokhorst & Germs, 2009). Therefore, the implementation concept and practice philosophy can be applied directly due to the production environment characteristic have similarities to be adapted. However, job shop production is another manufacturing environment that produces small or medium range of output and deal with high customisation of product design (Helkio & Tenhiala, 2013; Mohamed & Khan, 2012). This type of

production is associated with low volume and high variety (LVHV) product mix. Such characteristics explain that the shop floor operates with non-constant variables that influence the process operations.

The job shop manufacturing environment is in contrast from mass production (Helkio & Tenhiala, 2013; Mohamed & Khan, 2012). It originates from craft production that is associated in producing a unique customisation products and producing in low output. Shop floor operations are typically make to order basis, involving highly skilled workmanship on design and fabrication activities held in specific layout as contrast to cellular layout in mass production (Mohamed & Khan, 2012). It has no production line but has a production area. The shop floor operation works based on arrangement of machines or equipment in the designated work centres according to specialised operating tasks.

Mould-making is among shop floor operations that are classified as job shop production due to its manufacturing environment is based on make to order basis and the products produced are highly customised as specified by customer. The nature of mould making process depends on the distinctive product design and technical approach used (Altan, Blaine & Yen, 2001). Each product design is unique and its fabrication processes is distinctive. That explains for low volume of production as the product produces according to specified parameters. High variation in design results in a variety of variables in the manufacturing processes that consequence frequent changes or updates. Apparently, that requires high degree of flexibility on resource operation that feasible and capable to accommodate with such operational requirements (Gurumurthy & Kodali, 2008; Slomp et al., 2009).

Job shop production operation has stark contrast at fundamental level compared to mass production. The operations outcomes are geared towards

craftsmanship performance as opposed to mass production which emphasises on volume performance. Differences in anticipate outcome raise concern over compatibility and feasibility when adopting any operation strategy in long term. In that sense, a long term review of operation strategy from mass production to job shop production able to provide insights into operational behaviour and caveats that beneficial for industry practitioners.

1.3 Problem statement

Lean has been demystified as manufacturing strategy that can be applied across production environments out of car manufacturing work system (Womack, Jones & Ross, 1990). However, early practitioners had portrayed sceptic view about the feasibility of adopting Lean concept into job shop oriented industry such as mould making (Peças & Henriques, 2003) and machine tool (Eswaramoorthi, Kathiresan, Prasad & Mohanram, 2011). Several critiques later emerged with considering caveats at fundamental level in job shop operations such as process response to low volume, process flexibility on product variation and operational response to agile market (Bong & Chong, 2014; Khaw, Zailani, Iranmanesh & Heidari, 2019). However, such critiques have least emphasis in extant literatures thus portray Lean implementation approaches in job shop is likely similar to other production type and the myth of instant success subsequent to the implementation can be directly obtained.

In the context of Malaysian manufacturing industries, Lean implementation is predominantly implemented in mass production or assembly line process type of production. This includes automotive sector (Shamsudin et al., 2016; Dhiravidamani et al., 2017; Habidin et al., 2017), electronics (Wong & Wong, 2011), Halal food (Manzouri et al., 2014), plastic moulding injection (Rosnah & Othman, 2012) and

large scale metalwork (Benjamin et al., 2013). However, other manufacturing process types such as job shop have shown lack of presence in extant studies. This brings several notions about knowledge gap of Lean implementation in job shop in Malaysia. First, whether the dissemination of Lean knowledge is lack among practitioner thus adoption population might be very small. Second whether practitioner acknowledge the caveat of implementation feasibility thus divert to other manufacturing system approach. Third whether the organisation averse to embark the initiative investment as business size of the industry is typically small to medium enterprise which revenue turnover is longer and tend to leverage the operational performance with minimal investment. Apparently, extant literatures indicate all those notions are relative to lack of dissemination of Lean implementation in job shop production oriented industries in Malaysia.

In addition, most of the Lean implementation studies in Malaysia are in context of reporting the successful implementation of Lean applications into the organisation at early phase of adoption. However, least has reported extended studies at post-implementation after long duration of implementation. Apparently, the studies also found focused at mainstream type of production; a mass production and automotive related companies. Mohd Salleh et al. (2012) studied on companies that established from mid 1980s and 1990's while Ghobakhloo & Tang (2014) studied at companies that have minimum 5 years of Lean implementation experience. This bring notion that extended studies at post-implementation of Lean in Malaysian manufacturing industries is lacking especially for job shop type of production. Apparently, lack of extant Lean implementation studies at post-implementation denotes least knowledge about long term feasibility of Lean in job shop production. That postulates feasibility and related operational issues of long term Lean

implementation in job shop production industries in Malaysia is arguably available. In that sense, this study is attempting to fill this gap as to explore long term Lean implementation in job shop production environment.

Equally important, extant studies denote that successful adoption at early implementation phase in the job shop is arguably viable for long term as operational issues continue to develop along the implementation journey (Tyagi, Cai, Yang & Chambers, 2015). Practitioners seem to be eager about embracing the concept as a strategy to improve operation performance and address emerging issues that plague their business performance (Bhasin & Burcher, 2006). However, the implementation initiatives are threatened for practice derailment or faded in long run due to unseen factor during initial setup phase (Turesky & Connel, 2010). In that sense, the organisation will continue to improve but the changes made may not last long.

Considering the critiques of concept adoption, operation caveat, knowledge dissemination gap and long term feasible ambiguity of Lean implementation in job shop production, the researcher believed that a job shop organisation is having great challenges to maintain its operation performance or generate a competitive advantage in the long run despite series of improvement initiatives and long operating experience. With insufficient knowledge and misleading understanding of implementation approach, the Lean implementation begin to loss performance traction and organisation faces less significant impact on contributing long term competitive operational performance (Verma & Sharma, 2017).

The reflection of above statements from extant literatures was found reflected in the case operation namely SAS Tool Room. The case operation's shop floor exhibited operational performance was declining even though the organisation had been implementing Lean implementation since the early 2000s. Despite possessing

long duration of Lean implementation experience, the shop floor recently seems unable to retain its previous operational performance although series of improvements have been initiated over the years. Previous performance indicates that Lean implementations succeed to shorten mould fabrication lead time and increase the productivity of the operation thus fabricate of more moulds. However, the shop floor facing operational issues like long mould approval lead time and process non-conformances which depicted the Lean implementation does not support shop floor operation in generating performance. Therefore, this brings a problem statement that *“the long established Lean implementation does not warrant the job shop organisation able to retain its previous competitive performance in the long run”*.

1.4 Research objective

The problem statement portrayed that long established Lean implementation does not warrant a job shop organisation to retain its competitive performance in the long run. The statement also denotes nature of the job shop operation has influences the Lean implementation thus could jeopardise organisation’s competitive performance. The intent of this study was to explore the Lean implementation to find out the factors that hinder the long established Lean implementation to generate operational performance. Therefore, research objective for this study was *“to explore the factors that hinder the long established Lean implementation from retaining competitive performance of job shop organisation in the long run”*.

1.5 Research question

The Problem statement and research objective led to a notion that long established Lean implementation does not warrant the job shop organisation to retain competitive performance thus result operational performance eventually declined

overtime. Despite numerous of Lean improvements have been implemented in the past, the organisation supposedly able to retain its operational performance. Therefore, the research question of this case study is “*what are the factors that hinder the long established Lean implementations from retaining competitive performance of job shop organisation in the long run?*”

1.6 Scope of research

This study emphasis to understand the management of soft side of long term Lean implementation operations and impacts to operational performance in the job shop production work environment qualitatively. It was assumed that long established Lean implementations are significantly developed to accommodate current changes in operational requirement. The contributions of all progressive development of Lean practices to the improvement of operational performance were studied. Contextualised this study in Malaysian manufacturing environment, a qualitative case study was concerned to an organisation that operating in a job shop production environment. Such production environment was selected because of the lack of knowledge related to Lean implementations in extant studies. In addition, long term review of Lean implementation studies in such types of production environments is least to be found.

This qualitative case study was conducted in a Tool Room of a manufacturing company which has long experience of Lean implementations and eventually able to achieve the anticipated objective at one time. However, the performance unable to be retained despite capacity utilisation of the organisation was reduced. Therefore, this study does not intent to reassess the operation of established Lean implementation procedures and approaches. This is because the Lean implementations that have long been developed and established have been proven to

operate in a job shop oriented organisation work environment. It also signifies the procedurals and approaches imposed can be implemented to lead the organisation to achieve the anticipated objective. Past records show the gradual improvement of the shop floor was relative to the improvement of operating performance. Therefore, the scope of this study instead was to focus on the soft side of Lean implementations for selected organisation to understand long term Lean implementations and its impact on operational performance.

1.7 Significant of research

Specifically, this study attempted to ascertain the understanding of Lean implementation and operational performance in job shop production work environment. It was hoped this study may enlarge the knowledge and theories on long term Lean implementations and impacts to operational performance in long run. This study tried to provide the view of case study experience of one of the job shop production oriented manufacturing organisations in Malaysia on long term Lean implementation. This study is important and contributes significantly from a theoretical and practical perspective.

1.7.1 Theoretical perspective

In relation to the body of knowledge, this study hoped to contribute significantly in the process of understanding the long term Lean implementations and job shop operational performance from the theoretical lens of Lean, job shop production operation and resource-based theory.

This case study is centred on Lean and job shop production environment with emphasis on generating operational performance and practice feasibility to the production environment. The general proposition of Lean implementation concept

postulates the philosophy can be universally adopted into various types of manufacturing environments following Womack and Jones (1996) notion of demystification out of car manufacturing environment. Apparently, the theoretical notion of demystification of implementation operations is too generic to other manufacturing environment. As explained by the PPMX framework, each manufacturing environment has distinctive differentiation with 2 baselines; volume and process flexibility (Hayes & Wheelwright, 1979). That postulates job shop production has different operational characteristic than the origin of Lean which is assembly line. In that sense, the central tenet of operational characteristic become caveats in Lean implementation design considerations. With the lack of such discussion in extant literatures, this study highlighted the importance of such theoretical notion to make Lean implementations sustainable and operational performance improved in the long run.

In addition, this study also contributes to body of knowledge on theoretical proposition of Lean philosophy and RBT to explain resource positioning in long term operational performance. This study is centred on the implementation of Lean in organisational operations which postulates Lean also as a resource for organisation to generate operational performance. The central philosophy of Lean implementation is about waste elimination from the internal organisation's environment to improve operational performance (Shah & Ward, 2007). The philosophy manifests waste is consequences of resource's action on operation activities that reduces operational performance (Womack et al., 1990; Hj. Bakri, Abd Rahim, Yusof & Ahmad, 2012; Shah & Ward, 2017).

Apparently, RBT shows its theoretical proposition in line with Lean philosophy with 3 notions. First, RBT is in line with Lean that emphasis internal

resource as source for organisation to generate competitive advantage. Second, RBT is in line with central tenet of Lean that centred to similar area that is the internal environment of the organisation. Third, RBT is in line with Lean that emphasising on operation strategies to make the organisation's performance relevant to be sustainable and competitive in near future. The notions denote that competitive performance will improve when Lean implementation and resource developments are relative to the improvement of organisation experience. However, organisation experience does not warrant viable organisational operations to support resource actions on operational activity. The Lean philosophy suggests waste can be eliminated when the organisation's internal resources are competence and effective in avoiding unwanted results from operational activities. Therefore, this study provides insights on the long term organisational experience of job shop production operations on resource attributes that impact the feasibility of Lean implementations in long run to generate competitive performance.

1.7.2 Practical perspective

This study serves as an important reminder for practitioners to understand the job shop production operational characteristic and caveats in enduring sustainable Lean implementations and generating operational performance for long term. This study may be instrumental in outlining the long term Lean implementation with central operation of the specific types of manufacturing environment in fostering operational performance. This study was significant in understanding how organisations are unable to retain its previous competitive performance despite having long duration experience in Lean implementation. Routine operation, resource viability and managerial insight are the anticipated avenues that have a significant effect on long term Lean implementations. Further, this study may permit

organisation to recognise that Lean journey places much emphasis on its resource competency. In addition, this qualitative review may allow organisations that have implemented Lean to understand why it is vital to continue to equip its work environment with competence resources in responding to changes in the upcoming business environment.

Businesses are pressured to do more with less, provide faster service, minimise costs and increase productivity in the face of intense competition in a period of economic instability. Finding explored the factors that hinder an organisation to retain its previous competitive performance despite having long Lean implementation experience. The illumination of this study may be advantageous in gaining a large amount of information while simultaneously influencing future research opportunities relating to the impact after implementing Lean. Furthermore, the results of this study provided views on the myth of instant success subsequent to the implementation of Lean. Consequently, the information and findings associated with this study were for research purposes and did not constitute consultation for Lean-related business decisions.

1.8 Definition of terminology

To clarify the language used in this study, the key terms were defined as follows. Several terminologies definitions were taken from earlier study as it meant the similar meaning which fit to be used in the context of this study.

i. Job shop production (job shop)

“[...] which is basically a craft manufacturing establishment. Job shop organisation typically requires many ad hoc adjustments and control is exerted at low level of flexibly fulfil the required tasks.” (Gelders & Van Wassenhove, 1981; Cusmano, 1991)

ii. Lean implementation

[..] is based on the application of the complete set of Lean principles (Rafique, Ab Rahman, Saibani, Arsad, & Saadat, 2016).

iii. Long established Lean implementation

A set of Lean principles applications that have been developed and practiced since the beginning of Lean implementation in the shop floor of the case organisation.

iv. Operating caveat

A notion of cautions, conditions or limitations that becomes concern to the operationalisation of organised and concerted activity of the case organisation.

v. Organisational performance

Relates how successfully an organised group of people with a particular purpose perform a function of Lean implementations.

vi. Operational performance

Comprises actual outputs of operations strategies employed which is influenced by operating conditions and represents some internal properties of manufacturing system.

vii. Resource

“[...] includes all assets, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness” (Barney, 1991). In this study, it refers to shop floor member, management insights, machines & and equipment, operating facility, manufacturing process technique, operating routine, work procedures, skills

and workmanship, production control, operating fund and shop floor relationship in the case organisation.

viii. Resource capability

“Capabilities are the kind and amount of resources in place with which a firm can supports its current competitive actions, respond to market change, and maintain growth” (Teece, 1984).

ix. Resource competency

“[...] is the ability of an organization to sustain coordinated deployment of resources in ways that promise to help that organization achieve its goals” (Sanchez & Heene, 1997).

x. Shop floor

“[...] a space for manufacturing activities” (Chiarini, 2014). In this study, it refers as production floor where the activities of machining, bench work and mould assembly are conducted of the case organisation.

xi. Shop floor member

Refers to all employees in the organisational structure hierarchy of the case organisation that including management and operations divisions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the philosophical and arguments in the perspective of Lean implementation in job shop production operation and operating environment from extant literatures related to the objective of this study. The review begins by providing an overview of extant Lean studies in 3 avenues; general studies, Malaysian industry and job shop production operation. The intention is to display key notes on the development of Lean implementation in the manufacturing industry environment and several statistics are presented. Moreover, it will also exhibit the overall idea about adoption penetration of Lean in manufacturing industry from extant studies. Further, a review on the understanding of the job shop production concept that is the context of production environment for this study. Next, to review resource-based theory as the underpinning theory to understand and resource-based perspective on long term Lean implementations. Finally, this section ended with a discussion of operational caveats for long term Lean implementation.

2.2 Lean studies overview in manufacturing

To gain a better overview of Lean studies in manufacturing environment, this review was organised in 3 avenues of studies. General studies analyse Lean adoption dissemination in a perspective of overall manufacturing sector. Malaysian studies analyse in context of manufacturing industries in Malaysia. Job shop studies analyse Lean implementations in job shop production environment. All 3 avenues of studies were reviewed with purpose of gaining existing research interest and to scrutinise

research trends over the decades of Lean concept demystification especially in manufacturing sector. As for Malaysian study, this was to view at the dissemination of Lean implementation development into domestic industries environment.

The literatures on Lean in manufacturing industry were searched from 5 main databases that commonly used by scholars in social science studies; Science Direct/ Elsevier, Emerald Insight, Taylor & Francis Online and Research Gate. All selected databases provided wide choice of suggestions of literatures related to Lean studies. However, the researcher found the selected databases provided extensive suggestions of the searched literatures that matched the desired search keyword especially “Lean manufacturing”, “Lean implementation” and “Lean job shop”. Therefore, each database browsed the top 300 literatures from selected keywords to filter out those relevant to a specific manufacturing industry. The purpose was to gain insights of Lean implementation on a specific manufacturing industry perspective rather than a general overview.

Table 2.1 Research gap from extant literatures of Lean studies from selected 4 databases.

Taxonomy	Research gap
Population	<p>Studies of Lean in manufacturing is predominantly centred to high volume low variety (HVLV) compared to low volume high variety (LVHV).</p> <p>Assembly line process type seems become main stream for researcher interest.</p> <p>Lean penetration in Malaysian industry predominantly at automotive related industries while other industry still in slow pace</p> <p>Lean implementation in job shop production environment is still limited especially in Malaysia.</p>
Knowledge	<p>Limited discussions from extant literatures about long term Lean implementation that discuss extended development progress of the implementation among industries.</p> <p>Studies of Lean in job shop production centred at initial experience of implementation.</p>

Apparently, the review from extant literatures provided several research gaps which motivate for this study. Based on Miles (2017) taxonomy, the research gaps

for this study were identified according to taxonomy of population and knowledge. The research gap is summarised in table 2.1 and further highlights are presented in following sections.

2.2.1 General studies

Stone (2012) had established 5 themes of Lean evolvement phase from 4 decades of literature review beginning with discovery phase (1970-1990), dissemination phase (1991-1996), implementation phase (1997-2000), enterprise phase (2001-2005), and performance phase (2006-2009). The 5 phases postulate Lean concept implementation that has long been evolved for industry applications and has matured in industrial environment practice. Moreover, the fifth phase manifested a Lean dissemination concept that has been expanded and adopted by practitioners. Apparently, the surge of Lean implementation development into other sectors was influenced by the success of Toyota Motor Corporation displacing General Motor as the leading automotive manufacturer in the world in 2006 (New, 2007; Takeuchi, Osono & Shimizu, 2008). Since then, Lean has been promoted as a strategic solution that improves firm's performance by various fields of academicians and practitioners in their studies. Thus, the concept applications began to widely disseminate across in non-automotive related industries with motivation from successful model application at Toyota.

Analysing the dissemination of implementation in the industry could indicate on the extent of concept penetration in manufacturing sector (Shamsudin et al., 2016). It provides a coherent map of practitioner's participation in embracing Lean into their manufacturing industry environment. In that sense, it also indicates the anticipation of practitioners from the implementation of Lean in the current manufacturing environment while focusing on improving lead time and reducing

costs as well as providing faster and efficient services. The Lean demystification out of automotive industry (Womack et al., 1990) and the recent performance phase (Stone, 2012) lead to the notion that Lean studies dissemination shall be increasingly widespread across industries in manufacturing sector. Thus, both Womack et al. (1990) and Stone (2012) notions elevate large traction in recent Lean studies and participation from various industries in manufacturing sector.

To gain insights on Lean dissemination in manufacturing sector, a brief statistical analysis is presented from extant literatures with reference to specific industries in the manufacturing sector. The specific manufacturing industries were classified base on product-process matrix (PPMX) framework developed by Hayes and Wheelwright (1979) then later adapted by Ahmad and Schroeder (2002), Evans and Collier (2007) and Goldense (2015). The framework postulates there are 2 main production environments mixed in tmanufacturing environment namely high volume low variety (HVLV) and low volume high variety (LVHV). HVLV is applied to modern mass production concept that produces high volume of yield and low customisation of product. It is commonly found in assembly line or repetitive, process batch and continuous manufacturing process productions. In contrary, LVHV is found to deal with low volumes of yield with high customisation of product differentiations which commonly found in make-to-order (MTO) setup such as job shop and batch production (Haider & Mirza, 2015).

The analysis outcome (Table 2.2) exhibited HVLV attracted intense interest of the researchers (77.4%) and showed significant variances of the published literatures compare to LVHV (22.6%). This explained that the Lean principle adoption has been successfully embedded into HVLV type of production mixed industry originated from mass production setup as demystified by Womack et al.

(1990). As for LVHV, Lean adoption still needs to be refined according to industry as product variation is being considered as main factor to justify with production volume (Eswaramoorthi et al., 2011). Such proposition indicates the nature of production environment that favours the interest of researchers and practitioners to adapt the Lean concept with reference from vast exposure in past studies.

Table 2.2 Availability of Lean studies on specific PPMX classification from 1990s to early 2020 extracted from selected 4 databases.

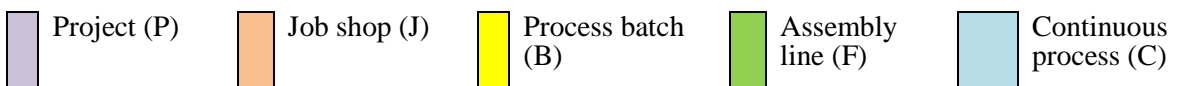
PPMX classification		Year												Total	
		1990s	2000s	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019		2020
Volume and process flexibility	LVHV	1	11	2	2	1	3	2	8	3	4	4	5	5	51
	HVLV	2	12	6	9	5	12	17	27	15	15	14	15	26	175
	Total	3	23	8	11	6	15	19	35	18	19	18	20	31	226
Process type	Project (P)	1	4	2			1		3	1	2	2	2	2	20
	Job shop (J)		7		2	1	2	2	5	2	2	2	3	3	31
	Process batch (B)							2	1	1			2	3	9
	Assembly line (F)	2	11	6	9	5	12	14	25	14	14	12	13	23	160
	Continuous process (C)		1					1	1		1	2			6
	Total	3	23	8	11	6	15	19	35	18	19	18	20	31	226

In term of the type of manufacturing process, assembly line is exhibited as the most being studied with wide margin compared to other process types. Looking at the industry perspective (Table 2.3), automotive-related industry shows consistent research participation every year and prominent contribution to Lean knowledge over time. However, job shop production and other productions still lacking thus requiring more researcher and practitioner participation in related industry. Stone (2012) notion of theme performance postulates development of literatures across disciplines with focus on measuring Lean implementation performance. However, the

performance phase seems to manifest the most contribution of the literatures from assembly line production type compare to others.

Table 2.3 Availability of literatures on specific manufacturing industry environment from 4 selected databases.

Industry	Year													Total
	19 90s	20 00s	20 10	20 11	20 12	20 13	20 14	20 15	20 16	20 17	20 18	20 19	20 20	
Automotive component (F)		2	1	2	4	6	3	7	2	5	3	2	5	42
Automotive assembly (F)	2	1	1	1	1	2		7	2	2			2	21
Textile & apparel (F)		1	1					3	4	4	2	2	5	22
Aerospace component (P)	1	4	1			1		3		1	1	1	1	14
Electronic products (F)		4	1				1		2	1	1	1	1	12
Food processing (F)				1		2	1	4				1	2	11
Metal works (F)		2	1			1		2				2		8
Machine tools (J)				1		2	1	1		1	1		1	8
Electrical product (F)		1		1					1			1	3	7
Furniture (J)		3			1		1					2		7
Packaging & printing (F)						1			1	1	1		2	6
Mechanical/electronic instrument (F)				2			1				2			5
Pharmaceutical (F)				1				1			3			5
Metal works (J)		1								1		1	1	4
Machinery (J)								2			1		1	4
Heavy machineries assembly (F)						2			1			1		4
Machinery assembly (F)			1						1				1	3
Mechanical/electronic instrument (J)		1						1	1					3
Motorcycle assembly (F)							2					1		3
Ceramic & tile (F)					1	2								3
Maritime components (P)			1						1		1			3
Mining processing (C)								1			2			3



While the automotive related industries dominated the progress, several industries such as textile and aerospace industries showed increasing participation following year 2015. It was noticed many literatures emerged from new industries after year 2015 as well. However, the literatures largely discuss the early phase adoption and introducing Lean into industry environment. The aim is to disseminate

the philosophy feasibility in the respective industry environments as part of strategic manufacturing methodology. In that sense, Lean adoption is portrayed still in infancy in certain industries and Lean dissemination is not widespread or widely embraces. That postulates adoption progress stills at a slow pace (Eswaramoorthi et al., 2011; Shamsudin et al., 2016). Thus, studies from non-automotive related and non-assembly line production type industry were seen as a contribution to exaggerating the Lean knowledge dissemination in the manufacturing sector.

2.2.2 Malaysian studies

The early study of Lean practices found in Malaysia was from the automotive sector (Abd Hamid et al., 1987). Proton the national automotive manufacturing company had ventures with Mitsubishi, the Japanese car maker that initially focused on JIT approach to streamline production line activities and supply chain support (Simpson et al., 1998). However, it was noticed there's a literature gap between year of 1998 and 2008. That may be explained by the low adoption and Lean was still in introductory phase. Thus, companies focus on improvement due to the period of economic slowdown at that time (Puvanasvaran et al., 2008). Later studies exhibited Lean implementation in Malaysian manufacturing industries was centred on adopting various tools and techniques to improve productivity and operational performance. That includes studies on operation management (Puvanasvaran et al., 2008) and interaction with stake holders in the supply chain network (Boyle, Scherrer, Rathje & Stuart, 2011; Manzouri et al., 2013).

Case studies of Lean that mentioned explicit industry in Malaysian manufacturing environment contributes 14.6% of available literatures from the specified data bases (Table 2.4). Two-decades of Lean research in Malaysia exhibited similar development pattern to what have found at the general studies level.