

A CONTINGENCY-BASED DECISION SUPPORT INSTRUMENT FOR
SELECTING LEAN PRODUCTION TOOLS AND TECHNIQUES

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ABSTRACT

This study is about the development of decision support instrument for selecting lean tools and techniques based on the contingency factors to help Malaysian organizations to select the right lean tools and techniques based on their context. Most of the prior studies were found focusing on the selection lean tools but did not assess the critical contingency factors that may influence the selection of lean tools and techniques. Adding to that, there were no similar studies on the selection of lean tools and techniques within the Malaysian context. The right tools and techniques to be used may vary depending on several factors, therefore to keep away from unnecessary waste and dissatisfaction, it would be better for organization to choose the right lean tools and techniques that will fit with organization's situation and give benefits to the organization. A mixed-methods study exclusively focused on the development, evaluation, and refinement of a decision support instrument or specifically known as “**Decision Aid for Lean Tools and Techniques Selection**” (DEALS) was used. The developed decision support instrument, which incorporates 10 most widely used lean tools and techniques was emphasises the use of holistic processes which start from diagnose their current state of waste until the guidance of selecting the appropriate lean tools and techniques. Additionally, contingency factors were employed to include multifaceted viewpoints and contexts in the development of DEALS, such as the adeptness to acquire the commitment and support from the top management and the advantages of implementing lean tools and techniques. The developed decision support instrument includes two selection methods, namely (1) simple additive weighting (SAW) for basic selection and (2) analytic hierarchy process (AHP) for more advanced selection. Based on the evaluation results, all respondents (100%) agreed on the usability, accuracy, and novelty of DEALS as well as the relevance and validity of the selection and the clarity of the purpose of DEALS. The final results of

validation testing also shows less than 5% errors when comparing final results of DEALS with two established software which are Expert Choice 11 software and Super Decision Software. By having this DEALS, it expected significantly benefit to managers, practitioners, consultants, researchers, and academicians as a guidance instrument in the selection of lean tools and techniques and generally to organization to have knowledge workers.



ABSTRAK

Kajian ini adalah mengenai pembangunan instrumen sokongan bagi membantu membuat keputusan dalam memilih alat dan teknik lean berdasarkan faktor kontingensi dalam membantu organisasi di Malaysia memilih alat dan teknik lean yang tepat berdasarkan konteksnya. Sebilangan besar kajian terdahulu didapati memfokuskan pada pemilihan alat lean tetapi mengambilkira faktor kontingensi kritikal yang dapat mempengaruhi pemilihan alat dan teknik lean tersebut. Selain itu, didapati tidak ada kajian yang serupa mengenai pemilihan alat dan teknik lean dalam konteks Malaysia. Alat dan teknik lean yang betul untuk digunakan mungkin berbeza-beza bergantung pada beberapa faktor, oleh itu untuk mengelak daripada pembaziran dan ketidakpuasan yang tidak perlu, lebih baik organisasi memilih alat dan teknik lean yang sesuai dengan keadaan organisasi agar dapat memberi manfaat kepada organisasi tersebut. Kajian ini menggunakan kaedah mod-campuran, secara eksklusifnya berfokus kepada pembangunan, penilaian, dan penyempurnaan instrumen yang dibangunkan atau secara khusus dikenal sebagai “DEALS”. Instrumen ini, menggabungkan 10 alat dan teknik lean yang paling banyak organisasi di Malaysia. Instrumen ini menekankan penggunaan proses secara holistik di mana bermula dari mendiagnosis keadaan semasa sisa di organisasi sehingga panduan memilih alat dan teknik lean yang sesuai dengan mengambilkira faktor-faktor luar jangka yang mempengaruhi pemilihan alat dan teknik lean, seperti keupayaan mendapatkan sokongan dan komitmen dari pihak pengurusan atasan dan faedah yang diperolehi setelah melaksanakan alat lean yang dipilih. Dua kaedah pemilihan digunakan, iaitu (1) *Simple Additive Weighted (SAW)* bagi pemilihan asas dan (2) *Analytical Hierarchical Process (AHP)* bagi pemilihan yang lebih terperinci. Berdasarkan hasil penilaian, semua responden (100%) bersetuju ciri-ciri instrument yang dibangunkan seperti kebolegunaan, ketepatan, kesesuaian dan kesahihan pilihan. Hasil akhir pengesahan juga menunjukkan kesalahan kurang dari 5% dengan perbandingan

bersama dengan dua perisian dipasaran iaitu perisian *Expert Choice 11* dan perisian *Superdecision*. Dengan adanya *DEALS* ini, diharapkan dapat memberi manfaat yang pengurus besar pengurus organisasi, eksekutif, perunding, penyelidik, dan ahli akademik sebagai instrumen sokongan dalam membantu memilih alat dan teknik lean dan secara umumnya dapat melahirkan pekerja yang berpengetahuan di dalam organisasi.



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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Fundamentally, organisations need to fulfil the needs and demands of all relevant stakeholders (e.g. customers, employees, shareholders, supply chain partners, and communities) in order to remain competitive and relevant in this unpredictable market [1]–[6]. The growing demands for high-quality products and services within a shorter period of time at lower cost have highlighted the need for the organisations to constantly improve their performance. Therefore, organisations need to efficiently and effectively identify the best approach in terms of time and cost without compromising their commitments and circumstances.

Some of the key operational methodologies for organisations to increase and maintain their playing point in the global business market involve incremental redesigning and development [7]–[9], which highlight the significance of implementing “improvement initiatives” at the organisational level. Examples of improvement initiatives (in the forms of approaches, systems, tools, and/or techniques) include business process re-engineering, environmental management system, lean production, six sigma, and product life cycle management [3], [10].

In this study lean production was selected to be focused on the selection of appropriate lean tools and techniques. The increasing number of lean tools and techniques in the market for selection has become a challenge for numerous organisations [11]–[16]. Moreover, adequate time, financial capability, and knowledge are necessary for organisations to select the most beneficial and appropriate lean tools and techniques [3], [17]–[19] according to the organisational goals, available resources, and circumstances.

Furthermore, there is no single lean tools and techniques that can holistically address all issues within an organisation [3], [15], [17], [20], [21], as each lean tools and techniques has its own strengths and limitations and can differently influence the performance of the organisation [22]. There are various aspects that influence the selection of the appropriate lean tools and techniques, such as staff competence, areas in need of improvement, and organisational size and age [3, 15, 16].

The need of lean tools and techniques in waste elimination or reduction can be seen in several studies and the research interest to lean tools and techniques is at the increasing trend. It tallies with the searching results by using keyword “lean tools” in Science Direct search engine by filtering publication in 2010 to 2020 as shown in figure 1.1. It shows that, lean tools are very significant field to be explored by focusing on different perspectives.

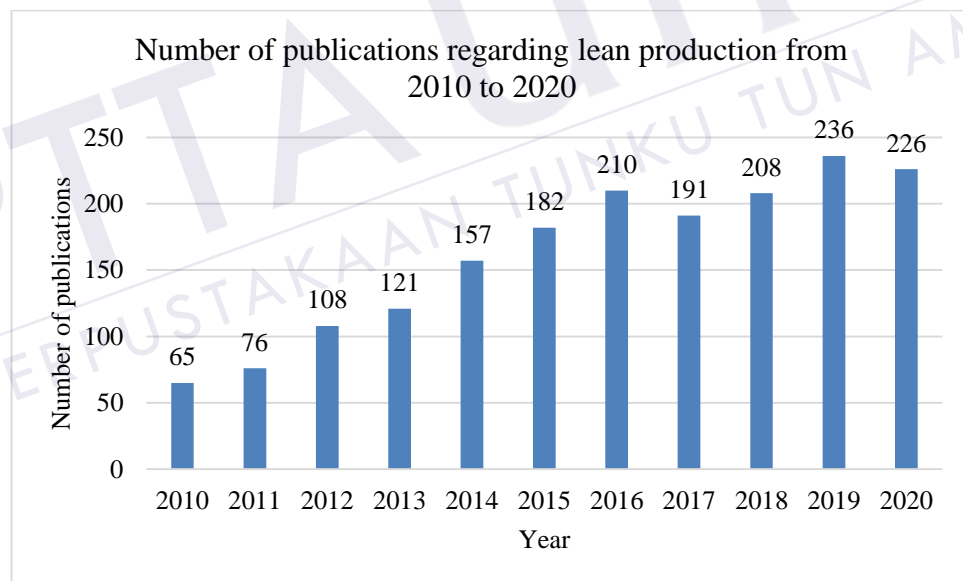


Figure 1.1: Number of publications using keyword lean tools in 2010-2020

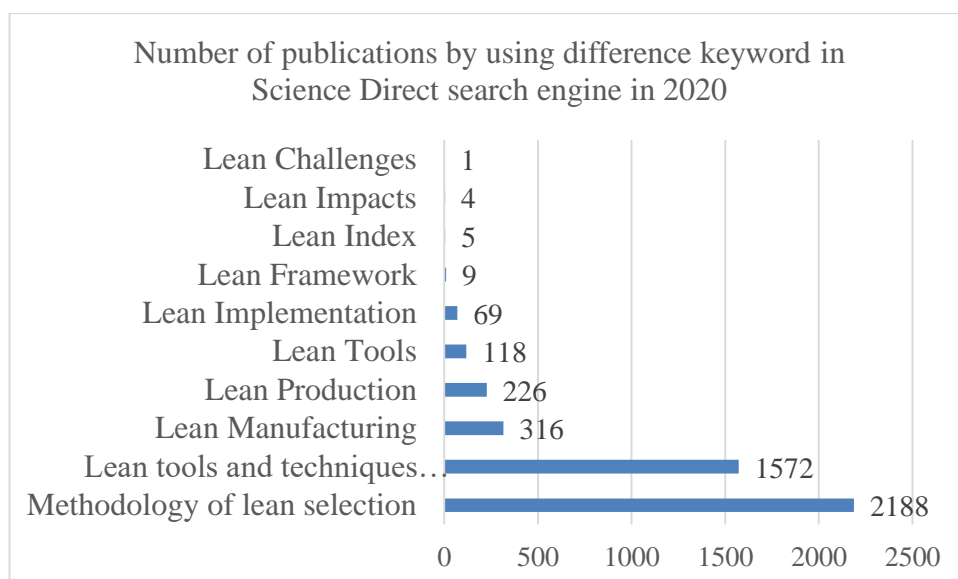


Figure 1.2: Number of publications by using difference keyword in Science Direct search engine in 2020

Figure 1.2 shows that, by using few keywords downloaded on January 2021, there is a huge number of documents found the Science Direct search engine. When arranging the number of documents, it shows that keyword of methodology of lean selection is the highest number of publications followed by the lean tools and techniques selection and others.

In view of the above, the current study very significant to be explored and exclusively focused on the following lean tools and techniques selection based on interview with lean experts: (1) 5S; (2) cellular manufacturing (CM); (3) Kaizen; (4) poka-yoke (mistake proofing); (5) standardised work; (6) value stream mapping (VSM); (7) Jidoka; (8) Kanban; (9) plan-do-check-act (PDCA); (10) total productive maintenance (TPM).

1.2 Problem Statement

Most organizations face difficulties to select appropriate lean tools and techniques due to numerous tools available [11]. Current studies show that, there are more than 50 lean tools and techniques that are widely used, depending on the size of the industries such as 5S, Kanban, Kaizen, Cellular Manufacturing, Value Stream Mapping and others [25]. In Malaysia, various studies were found related to lean production tools

and techniques adoption and implementation especially in automotive [26]–[28], electrical and electronic [29] and food and beverage industries [30] in order to achieve higher performance improvement. Each lean tools and techniques also has its own purpose, strengths and limitations. There is no one best lean tools and techniques that can solve all organisational problems [3], [31]. The most appropriate lean tools and techniques selection depends on the context or factors in which it is adopted. Selection and implementation of lean tools & techniques also required time, resources, financial and knowledge [3], [31]. Therefore, to keep away from unnecessary waste and dissatisfaction, it would be better for organizations to choose the right lean tools that will fit with organization's situation such as availability of resources and others and give benefits to the organization.

However, to date, the selection of lean tools and techniques using a rational decision-making process within the Malaysian context has been less explored. Focusing on that, this study aimed to develop a decision support instrument for the selection of appropriate lean tools and techniques using simple additive weighting (SAW) for basic selection and Analytical Hierarchical Process (AHP) for more advanced selection.

1.3 Aim and Objectives of the Research

The general aim of this study was to develop a decision support instrument for the selection of appropriate lean tools and techniques. The specific objectives of this study are as follows:

- i. To identify the critical contingency factors that influence the selection of lean tools and techniques.
- ii. To explore the currently available decision support instruments for the selection of lean tools and techniques.
- iii. To propose and evaluate a decision support instrument for the selection of lean tools and techniques.
- iv. To validate the proposed decision support instrument with the existing established software.

1.4 Scope of the study

Firstly, this study exclusively focused on 10 main lean tools and techniques that are widely used in the Malaysian manufacturing sector because of the technical constrains. Secondly, the selection of appropriate lean tools and techniques in this study was performed, with the inclusion of 10 contingency factors that influence the selection. With respect to the objectives of this study, the rational decision making of selecting appropriate lean tools and techniques was explored, which did not include the adoption and maintenance of lean tools and techniques. Additionally, the development of the proposed decision support instrument in this study specifically made use of both SAW (for basic selection) and AHP (for more advanced selection).

1.5 Research Questions

With respect to the objectives of this study, the following research questions were addressed:

- i) What are the critical contingency factors that influence the selection of lean tools and technique?
- ii) What are the currently available decision support instruments for the selection of lean tools and techniques?
- iii) What are the strengths and limitations of the currently available decision support instruments?
- iv) What are the strengths and limitations of the proposed decision support instrument in this study?
- v) How are the design, steps, and content of the proposed decision support instrument?
- vi) How can the proposed decision support instrument be improved?
- vii) How does the proposed decision support instrument perform against other decision support instruments available in the market?

1.6 Significance of the research

The need to select appropriate lean tools and techniques was deemed significant due to several reasons. Firstly, the selection of appropriate lean tools and techniques can prevent any wastage of resources and guarantee satisfaction in terms of organisational performance considering the extensive amount of time and resources (e.g. financial resources and knowledge) involved in determining appropriate improvement initiatives for implementation [3], [17]. Secondly, the number of available lean tools and techniques continue to increase annually. With the wide availability of these tools and techniques in the market, organisations need a reliable and valid decision-making aid or support to select appropriate lean tools and techniques [3], [17] according to the existing organisational contexts and circumstances [3], [32]–[34]. However, only a few prior studies focused on the selection of lean tools and techniques [3], [17], particularly within the Malaysian context, which highlighted the significance of the current study.

1.7 Thesis Outline

As illustrated in Figure 1.1, this thesis consists of six chapters, which are organised as follows:



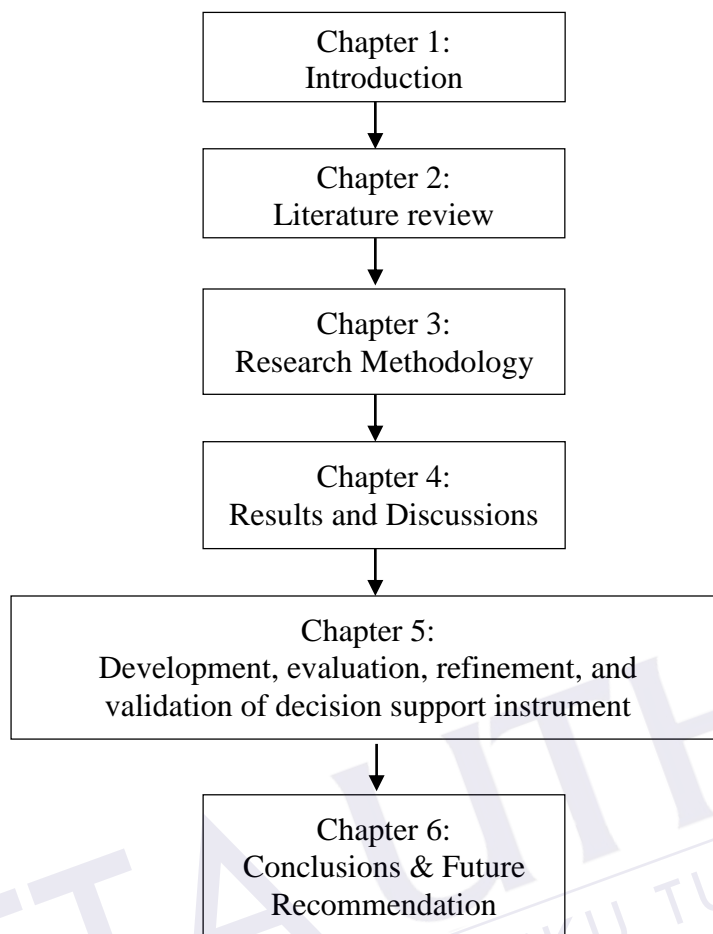


Figure 1.3: Thesis Outline

Firstly, Chapter 1 presented the background of study and problem statement. This chapter also described the objectives of this study as well as the scope and significance of this study.

Following that, Chapter 2 reviews relevant literature on lean production and its principles as well as common lean tools and techniques. Apart from the types of wastes in different manufacturing organisations, this chapter also includes the discussion of the rational decision making using SAW and AHP. Besides that, this chapter also reviews the contingency factors that influence the selection of lean tools and techniques. In addition, this chapter reviews prior studies on the selection of lean tools and techniques to aid the development of a decision support instrument for manufacturing organisations.

Chapter 3 specifically describes the employed research design and data collection in this study. In particular, this chapter justifies the adopted methods in the different stages of this study. Besides that, this chapter also describes the validation of the developed decision support instrument in this study.

Meanwhile, Chapter 4 presents the demographic profile of the survey respondents and discusses the obtained results of the exploratory survey. This chapter also presents the results of the semi-structured interviews. The results specifically include the profile of interviewees, interview findings, key factors of the selection of appropriate lean tools and techniques, and the types of waste versus lean tools and techniques based on the interviewees' experiences also had been discussed.

In addition, Chapter 5 discusses the development, evaluation, refinement, and validation of a decision support instrument in selecting appropriate lean tools and techniques. Apart from that, this chapter also presents the interface of decision support instrument that incorporates both SAW and AHP. Basically, the proposed decision support instrument was developed, evaluated, refined, and validated as a decision-making tool in this study for the manufacturing organisations to select appropriate lean tools and techniques based on their available resources and constraints.

Last but not least, Chapter 6 is the final chapter that presents the summary of main findings with respect to the objectives of this study. This chapter also describes the contributions and limitations of this study. Several recommendations for future research are also presented in this final chapter.



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