Lean Implementation Barriers and Their Contextual Relationship in Contract Manufacturing Machining Company

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Abstract: The objective of this paper is to identify critical lean implementation barriers within a Small and Medium Scale Enterprise (SME) and their contextual relationship. Identifying these will be the key success factor towards implementing green practices in a manufacturing environment. Through extensive literature review, 15 identified barriers are discussed and shortlisted. Using Interpretive Structural Modelling (ISM) methodology, the underlying subtlety between the barriers are analysed and a model is generated. This model can be considered by the management as a guideline to tackle lean implementation barriers as part of the overall lean management strategy. To determine the driving barriers and dependence power which influence the implementation, the Impact Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) analysis is used. From the output of ISM and MICMAC analyses, a firm understanding of the barriers that effect lean implementation and their interrelationship within an SME Contract Manufacturing Machining Company is obtained. 15 barriers are classified into 10 levels to be tackled. Their driving and dependence power are analysed and classified. Barrier 15 which is "*Roles and Responsibility is not defined in Lean Implementation"* at level 1 has the highest dependence power. The most significant barriers are barrier 4 which is "*Lack of Long-Term Commitment to Change and Innovation*" and barrier 5 which is "*Individual Attitude*" at level 10. Typically, barriers 4 and 5 display weak dependence power and strong driving power. Thus, these 2 barriers are identified as "*Independent Factors*" of lean implementation barriers within the organisation.

Keywords: Lean Implementation; Lean Management; Interpretive Structural Modelling (ISM); Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC)

1. Introduction

Lean implementation in manufacturing industries has evolved from a manufacturing optimization approach to a continual improvement-based administration philosophy. Many corporations globally apply lean management and has accomplished boundless progresses not only in term of cost saving, but more importantly in terms of green and sustainable environment through elimination of wastes. Many studies on managing green and sustainable environment have been reported such as in Hashemzahi et al.[1)] on green supplier selection and order allocation, Shahriari[2)] on systematic review on green human resource management, Deb[3)] on factors influencing choices of smartphone, Madyaningarum[4)] on strategic project planning model in radioactive plant, and Dwiki[5)] on the development of environmental policy. This study targets barriers on lean implementation in a Small and Medium Scale Enterprises (SME), namely, a contract manufacturing machining industry, and proposes a structured formal model of barrier relationship with defined levels to approach.

The SMEs are the core contributors to many national economies. To maintain market share and be relevant, SMEs are extremely competitive in their pricing mechanism. One of the approaches is Lean Manufacturing (LM) implementation into the organization operations and productivity activities. However, due to multiple barriers faced in the lean policy implementation, the implementation fails to achieve its intended target and benefits[6)]. As such, this study investigates the barriers SMEs face in their lean implementation and the underlying barrier relationships between the organizations. The purpose is to investigate barriers of LM that are implemented in machining companies. Also, this paper outlines a strategy for firms to address and overcome the barriers faced to implement lean culture. The understanding of this will support senior administrators on how to execute LM. This study focuses on the barriers faced to a successful LM implementation in contract manufacturing machining industry and their inter-relationship. The proposed implementation plan is targeted to provide operation management an effective way to tackle lean implementation barriers with targeted focus on high impact barriers. These barriers, if handled poorly may have a potentially disastrous impact on the organization productivity and staff.

2. Methodology

This study uses Interpretive Structural Modelling (ISM) and Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) for data analysis. ISM method converts qualitative mental systems to quantified models with numerous application benefits[7-9]. ISM is also applicable for direct and indirect links between multiple variables. MICMAC technique employs cross-impact matrix multiplication method to examine and classify indirect relationships between variables[10]. This is a form of structural prospective analysis

ISM method can be employed as per the following explanation[11]. Barriers identified relevant to the context are itemized. A contextual relationship is determined amongst the paired variables. Based on the established contextual relationship, Structural Self-Interaction Matrix (SSIM) is formulated. It shows the relationship associations between all the barriers under review. Based on the SSIM, the Reachability Matrix (RM) is generated. Two forms of RM are obtained which are the Initial Reachability Matrix and the Final Reachability Matrix. Direct relationships are considered during the formation of Initial Reachability Matrix. This is the raw data input as per consultation with organization management and stakeholders. Based on this, contextual relationships are established in the form of Final Reachability Matrix where indirect relations are indicated as “1*”. To generate Final Reachability Matrix from the Initial Reachability Matrix, transitive checks between the barriers are performed. Through this, additional subtle relationship can be detected. Some “0” set value will be converted to indicate as 1* (to denote transitive relation). As shown in Figure 1 below. If variable A influences variable B which in turn influences variable C, then variable A is said to influence variable C through transitive relations.

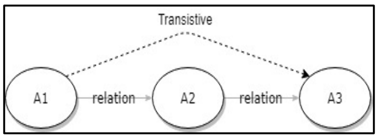

Fig. 1: Transitive Relation

After formation of the Final Reachability Matrix, the ISM model is generated through level partitioning. The level partitioning iterations must be carefully done by considering all the reachability set (RS), antecedent set (AS), and the intersection set (IS), which are determined through the Final Reachability Matrix. Firstly, RS must be completed for all barriers, followed by AS and finally IS. The IS will consist of common barriers between RS and AS. When more than one barrier has identical RS and IS, the same level will be assigned to these barriers. This analysis will be repeated until all barriers are assigned levels accordingly. Level assignment is considered done after all intersection set are determined.

MICMAC technique employs cross-impact matrix multiplication method to examine and classify indirect relationships between variables as a form of structural prospective analysis. Based on the drive power and dependence power, the factors are classified into 4: Autonomous, Linkage, Dependent and Independent.

This method of analysis and classification matches ISM since ISM also considers transitive interrelationship between barriers of the system under review for driving and dependence power calculation. MICMAC investigation generates a graph that organizes variables founded on driving power and dependence power. In this case study, MICMAC analysis is applied to categorize the 15 barriers and authenticate the ISM Model.

3. Barriers of Lean Implementation

Although many success stories are often associated with lean manufacturing implementation, there are also a few failures in lean implementation programs. Although they are low in number, these issues must be addressed since the manufacturing sector is a prime contributor to the economy. Based on literature review, some of the identified barriers are as follows:

i. Poor Top Management Direction and Support

Most staff are quite new to implementing lean manufacturing tools and techniques at their workplace. Based on Hartinia and Ciptomulyonob[12], organisation culture is crucial for successful lean implementation. The management should implement lean policy based on the need to improve company’s performance and not due to client pressure or request. The managers must have ample knowledge and training in driving the lean implementation. Organisations that are only profit driven tend to overlook company and staff enrichment policies. In the study, it was found that lean implemented companies have better turnaround compared to non-practitioners of lean management. Based on a study done by Moeuf et al.[13], administration direction plays a main role in driving successful lean implementation. Most SME organisations expect short and immediate results for lean implementation. They do not allocate time for trial-and-error. Sufficient time must be allocated for proper understanding and implementation. Organisations that do not have clear procedures result in staff that find it difficult to adapt.

ii. Language and Communication

Based on Moeuf et al.[13)], communication among staff and management must be improved. The management should allow staff to effectively communicate on any queries and ideas in improving the lean implementation. This is crucial as most companies tend to implement all lean tools and expect immediate successful results. Older staff might have problem adapting to changes in the new management direction. This was also discussed by Rose et al.[14)], and Bianca et al.[15)], where lean understanding and the actual lean implementation at workplace varies a lot. As a result of the staff not understanding the concept properly and the management being too strict on the policy as per the rule book, lean implementation is regarded as ineffective. Lean concept is a dynamic philosophy which can be modified to suit the workplaces and industries. The tools and techniques must be chosen based on suitability to the tasks.

iii. Economic

Based on Konstantinos et al.[16)], Kumar and Kumar[17)] and AlManei et al.[18)], the implementation of lean requires costs, such as the need to provide training. Managements need to allocate proper budget to prepare equipment and lean concept training to all employers. Most companies tend to reduce the available funds and avoid any work stoppage for staff training. As such, the staff do not get the proper time to adapt and understand lean methodologies which can potentially be beneficial in the long term. As common in lean implementation planning, experts and field specialists are often contracted to assist. They offer advice on the knowledge and barriers faced. Since the cost factor is involved, the management try to force quick implementations and force changes. A realistic successful lean implementation takes a longer period. The management must take this into account and plan ahead so that the benefits are not short term.

iv. Lack of Long-Term Commitment to Change and Innovation

SME organisations are primarily profit driven and strive to achieve short lead time delivery dates. Based on Rahman et al.[19)], most firms focus on cost-effectiveness of the projects and abandon culture of continuous improvement. This is normally practised after the target profits have been achieved. No further company or staff improvement study is done as current method is deemed suitable to achieve company's profit target. Lean philosophy emphasizes on continuous improvement culture, as reported by Sim[20)]. Research and improvement are a long-term investment and commitment process. The short-sighted vision of SME firms to ignore continuous improvement is set as a known barrier to effective lean implementation.

v. *Individual Attitude*

Personal commitment also plays a vital role in successful lean implementation. Based on the finding by Rahman et al.[19)], individual commitment and attitude such as lack of team commitment spirit, lack of self-improvement, and poor direction and leadership are the potential obstruction of the execution of lean in manufacturing. AlManei et al.[18)], found that other individual attitudes, such as fear of the unknown and fear of failure, are also part of the barriers.

vi. Lack of Training

Newall and Dale[21)], Ljungström and Klefsjö[22)], Kumar and Kumar[17)], and Jadhav et al.[23)] attested insufficient training and exposure as one of the key barriers in execution of quality value development plans. According to Jayaram et al.[24)], trainings are a serious factor of Just-In-Time (JIT), which emphasises on lean implementation. The initial phase is to lift operational excellence through application of quality development activities. Absence of formal and well-defined training plan will disrupt the improvement activity[25)].

vii. *Poor Facility Layout*

Lean manufacturing utilizes efficient and maximum machine utilization coupled with a flexible production flow movement to fulfil demand fluctuations especially in contract manufacturing business. Sule et al.[26)], advised that an unoptimized factory production layout will lead to failure in JIT implementation. A bad factory layout will increase material management expenses, build up unnecessary work-in-progress (WIP) inventories, and cause unstable machine usage resulting in high operational costs. Poor facility layout as a barrier in the successful lean implementations were also reported by Jadhav et al.[23)] and Wong et al.[27)].

viii. Lack of Proper Execution Plan

The objective of lean production is to minimalize or remove non-value-added activities. Lean management stresses precise manufacture scheduling and productivity in all relevant scopes involved. Suitable availability of resources with skilled manpower is crucial for the success of lean implementation. Planning schedulers must be aware with the production methods and machine capabilities with consideration of changeover timings and lead times. Lack of proper arrangement by top administration will affect quality development activities [28, 29)].

ix. Organizational Cultural Difference

Typically, most firms will have employees who prefer to retain existing company's practices without striving for improvement[30)]. This resistance will be present regardless of the potential benefits of improvements demonstrated to the workforces since it requires a change in mind-set and developing possible new work cultures. This is further extended to current operations and productivity scope. Ultimately lean implementation is targeted to fulfil customer's quality and design demand with the removal of non-value-added activities. Since each company's culture and activity is unique to each firm, there is no universal accepted method for lean implementation[31)]. This is even more important since contract manufacturing is a fast driven and high-pressure work industry.

x. Lack of Information and Data Sharing

Resource availability and availability of data are two major factors in lean implementation. Inaccurate flow of information can seriously disrupt the established system. According to Moorthi et al.[32], proper communication flow is crucial to JIT sustainability. Vokurka and Lummus[33] mentioned it is highly beneficial to involve customers and vendors in open communication sharing throughout the supply chain.

xi. Slow Market Response

In the execution of lean implementation, the top management should be aware of a few critical issues which are the rapid market demand changes, customer delivery requirement changes, delivery timeline and inconsistent market movements[26, 34]. These will lead to sluggish feedback towards the industry. This factor heavily influences contract manufacturing industry due to unpredictability of market order supply and demand. Rapid changes to customer design disrupt pre-set manufacturing process and require time to relook and revise established processes.

xii. Poor Sales Forecast

Market demand changes and industry improvements are major concerns addressed by contract manufacturing firms[32]. Poor sales and market prediction will affect company's ability to meet customer and market supply and demand requirements[23]. Rapid market downturns are always an element of surprise to managements and direction.

xiii. Lean not focused continuously

The management must recognize the administrative resources that are required in sustaining and driving lean implementation within the firm[35]. That driving force must be supplemented by all relevant executives and operations' workforce. This will result in improved knowledge and skills of the workforce. This enhancement must be continuous and not on as-required basis[28]. As this is closely related to financial investment cost of lean implementation and time spent on providing awareness, the relevant firm administration must take this factor into consideration.

xiv. Wrong Selection of Lean Tool

Implementation of lean improvement activity through proper usage of lean methodologies is crucial for successful implementation. Examples of lean practices are: Value Stream Mapping (VSM), 5S work culture, JIT system, Kanban, and Total Production Maintenance (TPM). Wrong usage of tools at wrong scope targeted for improvement is the main reason for lean implementation failures[36]. VSM technique for example, focuses to map out the processes involved with consideration to time taken to perform the activities involved. This however does not address on product non-conformance that happens in production[37].

xv. Roles and Responsibility Not Defined in Lean Implementation

Proper roles and responsibilities assignment play a major role in the success of lean implementation[29]. Lean implementation must not be considered solely as a managerial task. It should involve all staff. Several workers assumed that "lean was not part of their job" and will be addressed only by the managers for productivity improvement. Management must spend time to provide awareness on lean concepts and the benefits of implementation to all relevant staff[38]. Combining both, collaboration with employees in position along with their respective staff, will greatly improve the success rate of lean implementation to the firm.

4. Data Analysis

4.1 ISM Model Development

The first sequence of ISM methodology is the formation of Structural Self Interaction Matrix (SSIM). This is done through discussion with stakeholders and establishes direct relationship between the 15 selected barriers. The following are four symbols used to denote the direction of relationship amongst the 15 barriers.

- V: "barrier i" influences "barrier j"
- A: "barrier i" influenced by "barrier j"
- X: "barrier i" and "barrier j" influence in both ways to each other.
- O: "barrier i" and "barrier j" do not influence each other and they are unrelated.

Table 1 shows the developed SSIM based on this relationship. Table 2 shows the rules of transformation as a guide on converting the V, A, X, O data to generate initial reachability matrix which is shown in Table 3. Table 4 shows final reachability matrix generated. "1*" is used to denote barriers with contextual relationship between the barriers. Through this relationship, the driving power changes noticeably as underlying barrier is considered.

Table 1. Structural Self Interaction Matrix (SSIM)

SN	Barriers to Lean Implementation	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	Poor top management direction and support	V	O	V	V	A	V	V	V	V	V	A	A	A	O	
2	Language and communication	V	V	V	A	A	A	A	X	V	A	O	O	A		
3	Economy	V	V	V	V	V	V	V	V	V	V	A	A			
4	Lack of long-term commitment to change and innovation	O	O	O	V	V	V	V	O	O	V	X				
5	Individual attitude	O	O	O	V	V	V	V	V	V	V					
6	Lack of training	V	V	V	V	X	V	A	A	A						
7	Poor facility layout	V	V	V	V	X	V	V	V							
8	Lack of proper execution plan	V	O	O	O	O	A	A								
9	Organizational culture difference	V	O	O	V	A	V									
10	Lack of information and data sharing	V	O	V	V	A										
11	Slow market response	O	V	V	V											
12	Poor sales forecast	V	V	V												
13	Lean not focused continuously	V	V													
14	Wrong selection of lean tools	V														
15	Roles and responsibility is not defined															

Table 2. Rules of transformation

RULES OF TRANSFORMATION		
The (I,J) entry in the SSIM	Entry in Initial Reachability Matrix	
	(I,J)	(J,I)
V (Barrier i influences barrier j)	1	0
A (Barrier j influenced by barrier i)	0	1
X (Barrier i and j influence each other)	1	1
O (Barrier i and j do not influence each other and are unrelated)	0	0

Table 3. Initial reachability matrix

SN	Barriers to Lean Implementation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	DRIVING POWER (Y)
1	Poor Top Management direction and support	1	0	0	0	0	1	1	1	1	1	0	1	1	0	1	9
2	Language and communication	0	1	0	0	0	0	1	1	0	0	0	0	1	1	1	6
3	Economic	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	13
4	Lack of Long-Term Commitment to Change and Innovation	1	0	1	1	1	1	0	0	1	1	1	1	0	0	0	9
5	Individual Attitude	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	11
6	Lack of training	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1	8
7	Poor Facility Layout	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	10
8	Lack of Proper Execution Plan	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	4
9	Organisational Cultural Difference	0	1	0	0	0	1	0	1	1	1	0	1	0	0	1	7
10	Lack of information and data sharing	0	1	0	0	0	0	0	1	0	1	0	1	1	0	1	6
11	Slow Market Response	1	1	0	0	0	1	1	0	1	1	1	1	1	1	0	10
12	Poor Sales Forecast	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	5
13	Lean not focused continuously	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3
14	Wrong selection of Lean Tool	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
15	Roles and Responsibility is not defined in Lean Implementation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	DEPENDENCE POWER	5	8	3	2	2	9	6	8	7	9	6	10	9	8	12	

Table 4. Final reachability matrix

SN	Barrirers to Lean Implementation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Driving Power(Y)
1	Poor Top Management direction and support	1	1*	0	0	0	1	1	1	1	1	1*	1	1	1*	1	12
2	Language and communication	0	1	0	0	0	1*	1	1	1*	1*	1*	1*	1	1	1	11
3	Economic	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	13
4	Lack of Long-Term Commitment to Change and Innovation	1	1*	1	1	1	1	1*	1*	1	1	1	1	1*	1*	1*	15
5	Individual Attitude	1	1*	1	1	1	1	1	1	1	1	1	1	1*	1*	1*	15
6	Lack of training	1*	1	0	0	0	1	1*	1*	1*	1	1	1	1	1	1	12
7	Poor Facility Layout	1*	1*	0	0	0	1	1	1	1	1	1	1	1	1	1	12
8	Lack of Proper Execution Plan	0	1	0	0	0	1	1*	1	0	1*	1*	1*	1*	1*	1	10
9	Organisational Cultural Difference	0	1	0	0	0	1	1*	1	1	1	1*	1	1*	1*	1	11
10	Lack of information and data sharing	0	1	0	0	0	1*	1*	1	0	1	0	1	1	1*	1	9
11	Slow Market Response	1	1	0	0	0	1	1	1*	1	1	1	1	1	1	1*	12
12	Poor Sales Forecast	0	1	0	0	0	0	1*	1*	0	0	0	1	1	1	1	7
13	Lean not focused continuously	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3
14	Wrong selection of Lean Tool	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
15	Roles and Responsibility is not defined in Lean Implementation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Dependence Power (X)	7	12	3	2	2	11	12	12	9	11	10	12	13	14	15	

The ISM model is generated through level partitioning. Reachability Set (RS) and Antecedent Set (AS) are determined through the final reachability matrix. For instance, for iteration 1: as shown in Table 5, RS for barrier 1, row 1 has influence to all barriers except barrier 3, 4 and 5. Hence the RS will contain all barriers except barrier 3, 4 and 5. For AS barrier 1; the list of barriers that may influence the barrier are barriers 1, 3, 4, 5, 6, 7 and 11. The IS will consist of common barriers between RS and AS which are barrier 1, 6, 7 and 11. In iteration 1, only barrier 15 has matching RS and IS. Hence barrier 15 is allotted Level 1 in first iteration. Barrier 15 is the highest dependent barrier in lean implementation in SME Contract Manufacturing. Barrier 15 will be eliminated from ensuing iteration for the next level partitioning process. When more than one barrier has identical RS and the IS, the same level will be assigned to them. They will be eliminated together for subsequent analysis. This analysis will be repeated until all barriers are assigned levels accordingly. Care must be taken to perform the iteration in proper order. Firstly, RS must be completed for all barriers, followed by AS and finally IS for all barriers. Level assignment is considered done after all IS are determined. Table 5 shows the example of ISM partitioning iteration Level 1. The processes are repeated until all the iterations of all levels are formulated. Table 6 show the final iteration.

Table 5. ISM Partitioning - First Iteration, Level 1

VARIABLES	RS	AS	IS	LEVEL
1	1,2,6,7,8,9,10,11,12,13,14,15	1,3,4,5,6,7,11	1,6,7,11	
2	2,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12	2,6,7,8,9,10,11,12	
3	1,2,3,6,7,8,9,10,11,12,13,14,15	3,4,5	3	
4	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	4,5	4,5	
5	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	4,5	4,5	
6	1,2,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11	1,2,6,7,8,9,10,11	
7	1,2,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12	1,2,6,7,8,9,10,11,12	
8	2,6,7,8,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12	2,6,7,8,10,11,12	
9	2,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,9,11	2,6,7,9,11	
10	2,6,7,8,10,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11	2,6,7,8,10	
11	1,2,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,11	1,2,6,7,8,9,11	
12	2,7,8,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12	2,7,8,12	
13	13,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13	13	
14	14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14	14	
15	15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	15	1

Table 6. ISM Partitioning - Final Iteration, Level 10

VARIABLES	RS	AS	IS	LEVEL
4	4,5	4,5	4,5	10
5	4,5	4,5	4,5	10

Table 7. Position Coordinates for Identified Variables

No	Factors	X	Y	Level
15	Roles and Responsibility is not defined in Lean Implementation	15	1	1
14	Wrong selection of Lean Tool	14	2	2
13	Lean not focused continuously	13	3	3
12	Poor Sales Forecast	12	7	4
10	Lack of information and data sharing	11	9	5
8	Lack of Proper Execution Plan	12	10	6
2	Language and communication	12	11	7
9	Organisational Cultural Difference	9	11	7
1	Poor Top Management direction and support	7	12	8
6	Lack of training	11	12	8
7	Poor Facility Layout	12	12	8
11	Slow Market Response	10	12	8
3	Economic	3	13	9
4	Lack of Long-Term Commitment to Change and Innovation	2	15	10
5	Individual Attitude	2	15	10

4.2 MICMAC Analysis

MICMAC analysis generates a visual graph using dependence and driving power as factor classification. The driving (Y) and dependence (X) power coordinate values are taken from the final reachability matrix, as in Table 4. The values are then tabulated as in Table 7 as position coordinates for the graph, as shown in Figure 2.

5. Result

Once all the barriers are eliminated, the ISM can be modelled. Figure 3 shows the ISM model developed through the level partitioning iteration processes. The ISM model and MICMAC output are colour coded to understand the flow of driving and dependence power proceeding from level 1 to level 10 as shown in Figure 4.

From the generated model, ISM method has transformed lean barriers from qualitative to a quantified and interrelated model structure. The identified barriers have been classified into 10 levels. These barriers can be tackled according to the ordered levels. 15 lean implementation barriers were identified through literature review and analysed using ISM technique and MICMAC analysis. As shown in the generated model, the most significant barriers are barrier 4 (lack of long-term commitment to change and innovation) and barrier 5 (individual attitude) at level 10. These barriers are the base of the ISM Model. Typically, they will display a weak dependence power and strong driving power. Barrier 15 (roles and responsibility is not defined in lean implementation) at level 1 has the highest dependence power followed by barrier 14 (wrong selection of lean tool), 13 (lean not focused continuously), and 12 (poor sales forecast). This is a progression from level 1 until level 4. Level 7 consists of barrier 2 (language and communication) and barrier 9 (organisational cultural difference). This level must be handled with consideration to the composition of the workforce. Management of the Contract Manufacturing Machining Company consists of local employees, while majority of the operation workforces are foreigners. Management must take these factors into consideration to ensure staffs have the same consensus of lean implementation activities and its benefits.

Through the comparison of both ISM model and MICMAC analysis output as the level 1 progresses till level 10, the driving power increases while dependence power reduces. The MICMAC output has validated the ISM model generated in terms of driving and dependence power.

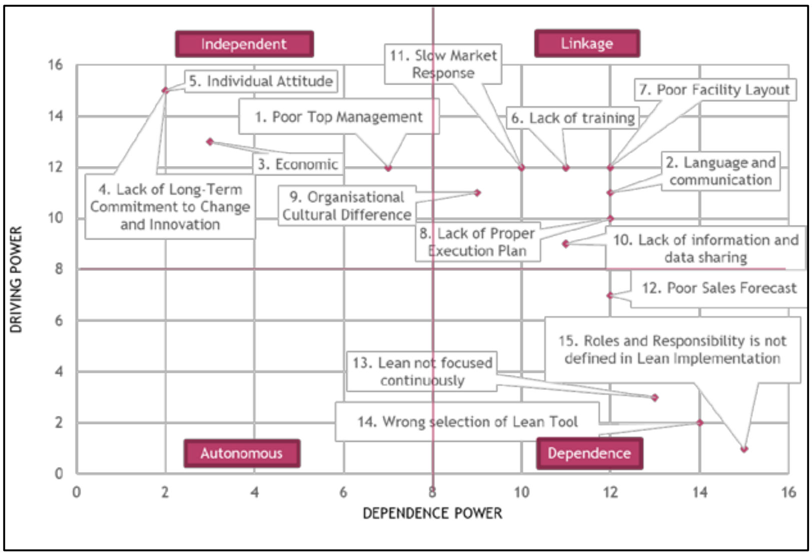

Fig. 2: Power Diagram of Barriers

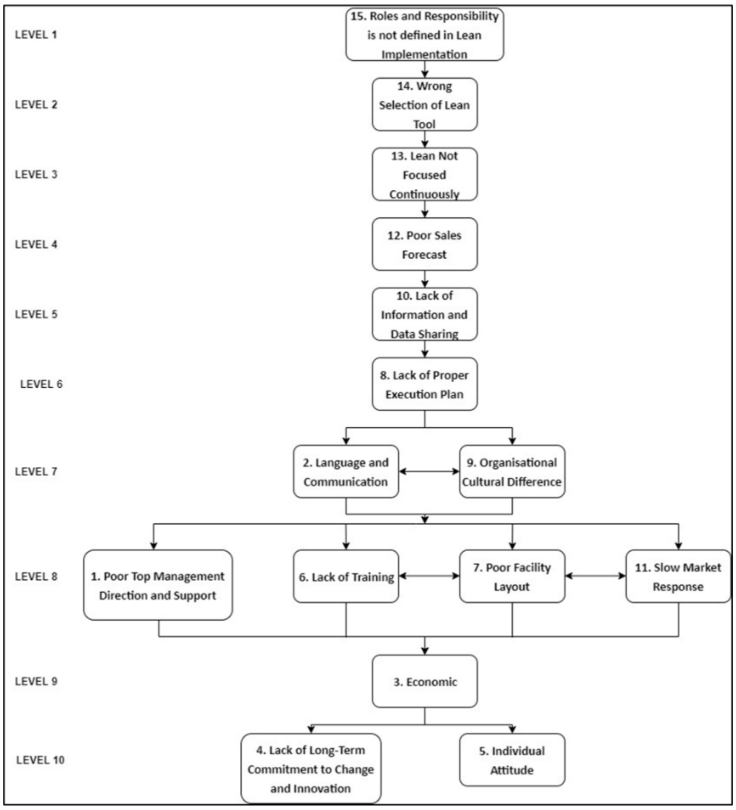

Fig. 3: ISM Model

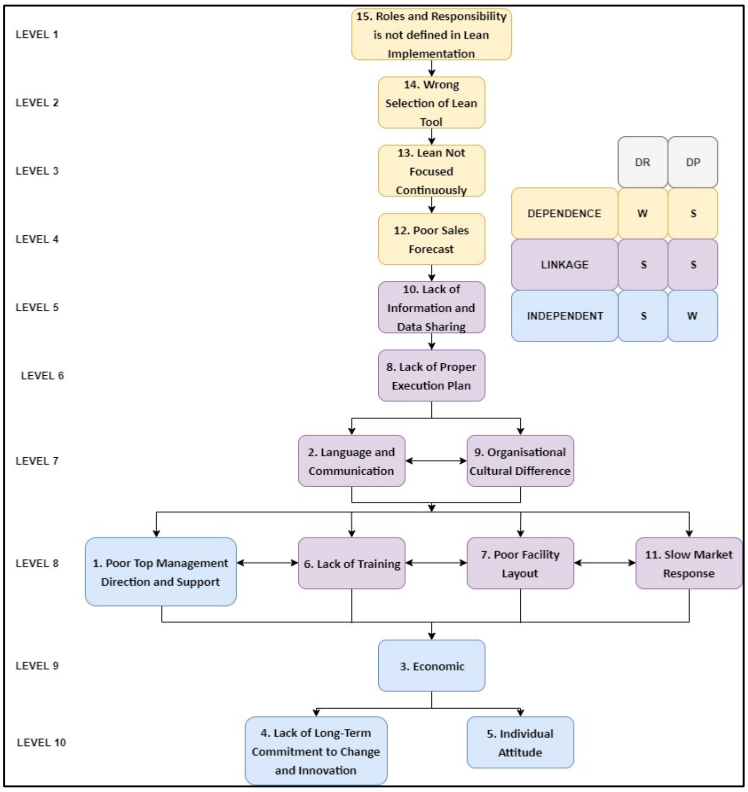

Fig. 4: ISM Model Validation

6. Conclusion

To tackle lean implementation barriers as part of the overall lean implementation strategy the ISM techniques have been employed. Based on the ISM model generated, barriers have been classified into 10 levels with some levels having multiple barriers. These show the barriers need to be tackled together with consideration to other barriers at the same level. To define these qualitative barriers into a quantitative model, ISM method is a very suitable tool. Through the generated model, a structured formal model of barrier relationship has been established with defined levels to approach. The driving and dependence power have been visually classified using Driving and Dependence Power Diagram. From the classification, they have been combined with the generated ISM model. This will help the organisation to keep in mind the driving and dependence power of each barrier. This is crucial as the driving power will determine the impact of successful lean implementation within the organisation. It can also be said that more specific implementation strategy must be discussed by the management when there are multiple barriers at the same level. More scrutiny must be placed to understand the driving and dependence power of these barriers so that the barrier concerns can be overcome.

For this case study, using the output of ISM and MICMAC analyses, a firm understanding of the barriers that effect lean implementation and their interrelationship within the company is obtained. 15 barriers are classified into 10 levels. Their driving and dependence power are analysed and classified. "*Roles and Responsibility is not defined in Lean Implementation*" at level 1 has the highest dependence power. The most significant barriers are "*Lack of Long-Term Commitment to Change and Innovation*" and "*Individual Attitude*" which are at level 10. Typically, these barriers display weak dependence power and strong driving power. Thus, they are identified as "*Independent Factors*" of lean implementation barriers within the organisation.

The study successfully proposed a structural framework for the successful implementation of LM in SME contract manufacturing machining industry, which later can be generalized to other suitable manufacturing-oriented organization, or even for service industries such as proposed by Shahriari, et al.[39]. Through lean implementation, the waste activities can be identified. The continual identification and elimination of non-value-added activities can greatly reduce operational cost for any organization. Given the current market direction towards implementing green practices with environmental effect taken into consideration, a successful lean implementation can also have positive impact towards the environment.

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