Identifying Drivers of Lean Six Sigma Implementation in the Process Industries: A Case Study

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Abstract

Process Industry is rapidly growing in Bangladesh. Lean six sigma (LSS), a process improvement tool, can be applied to this sector for efficient operational performance. Since there have been manifold factors which influence and induce the process performance while implementing LSS, prevailing drivers have been sorted out from the survey on the managers of analogous companies. In the proposed framework, Interpretive structural modeling (ISM) has been applied to check the contextual relationship among the selected drivers and MICMAC analysis has been implemented to categorize the drivers according to their influence on company's performance based on the driving power and dependence on each other. The proposed model integrates ISM and MICMAC Analysis to sort the drivers from least to greatest influence it has on process performance. The focus of this paper is to aid the practitioners in prioritizing the drivers while implementing LSS in the process industry.

Keywords:

Lean Six Sigma, Drivers, Impeding factors, Limitations, Motivation factors

1. Introduction

A process industry is defined as where production process follows either a continuous system or batch production system to convert bulk resources to other products. In the case of batch production system, the batch material is identical. These types of industries generally produce high volume, low variety and inflexible products. It occurs due to the longer setup time than other industrial system (Abdulmalek, Rajgopal, & Needy, 2006). To give exemplification of process industry, it can be said that chemicals, food, beverages, pharmaceuticals, petroleum, textiles, ceramics, base metals, plastics, refined oil, gasoline, wooden and plastics product are produced in these industries.

To improve the process in efficient way, various methods are being followed. Among them Lean manufacturing system and six sigma has gained significant popularity. Lean manufacturing system assigns value to the raw material even though it reduces waste. On the other hand, six sigma drastically decreases the nonconformities of products through effective problem solving methods. But, in the recent years, shorter product life cycle demands shorter time to market which can be met by excellent implementation of lean six sigma. Implementation of these two methods is making the process a lot easier to complete than conventional process. In lean six sigma process, problem identification and process improvement is faster and more efficient because lean speeds up six sigma process (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016). It prioritizes defect prevention over defect detection to ensure customer satisfaction by reducing nonconformities, waste, and cycle time through developing work standard and balanced flow.

The drivers of lean six sigma stimulates the efficiency of organization's processes. Besides, there are inter-relationship among the drivers which have not yet been examined. Therefore, this paper focuses on determining the inter-relationship among different drivers of lean six sigma using Interpretive Structural Modeling (ISM) framework and MICMAC (Matriced' Impacts Croise´s Multiplication Applique´e a´ unClassement) analysis to establish a contextual relationship among the selected drivers and to classify the drivers according to their impact on industry's overall performance.

2. Literature Review

Implementing Lean Six Sigma is a complicated process and there is no particular way that can assure the successful implementation. There has been many roadmaps developed to assist the organizations which are willing to change the existing operations to align with lean six sigma philosophy (Salonitis & Tsinopoulos, 2016). Shingo proposed a set of procedures where he identified the key elements that need to be implemented within the first year and also identified 15 tools and techniques to aid this process (Shingo S, 1980). A 10 step approach to LSS focusing on design and layout has been suggested to attain the success (Kent Beck, n.d.). Since there are various roadmaps available to implement lean six sigma, Anvari et al. reviewed 80 of the existing and relevant study and came to a conclusion that there is no unique way to implement LSS(Anvari, Zulkifli, Yusuff, Mohammad, & Hojjati, 2011). Another model for LSS has been developed where the implementation process possess 4 phases and 22 elements (Mostafa, Dumrak, & Soltan, n.d.). Since there is no predetermined single recipe for successful implementation of LSS to the organization, it is necessary to identify the key drives of a company to engage itself to LSS for best possible outcome. Because failure in implementing LSS to the organization may have negative impact(Marvel & Standridge, 2013). A few researchers have identified some key elements that drives the company's interest to LSS. Achanga et al. (2006) marked leadership and finance as the most important driver of Lean Manufacturing (LM) (Achanga, Shehab, Roy, & Nelder, 2006). Bhasin (2012) listed four drivers through surveying 68 manufacturing industry which are - performance, competitive pressure, customer pressure and team building spirit for implementing LM (Bhasin, 2012). Strong leadership, employee involvement, change in organizational culture and employee motivation have been selected as critical factor (Bakås, 2011). Management commitment has been selected as the most important key factor for implementing LSS by Rose et al. (2010) and empirical investigations were conducted on Indian SME (small and medium sized enterprise) by Sangwan et al. (2014) to identify the drivers (Kuldip Singh Sangwan, Jaiprakash Bhamu, 2014; Rose, A.M.N. , Deros, B.Md. & Rahman, 2010). Hallgren et al. (2009) marked internal and external driving forces of an organization for further improvement (Hallgren, Olhager, & Hallgren, 2009). Salonitis et al. (2016) identified both key drivers and key success factors for implementing LSS and Sangwan et al. (2014) shortlisted drivers of ceramic industry based on literature and expert review (Kuldip Singh Sangwan, Jaiprakash Bhamu, 2014; Salonitis & Tsinopoulos, 2016). (Gandhi, Thanki, & Thakkar, 2017) identified seven significant LM drivers from literature review and expert opinion. But none of these researches have assigned importance factor to the selected driver or identified the most and least critical factors of all.

3. Methodology:

To recognize the potent drivers of implementing LSS in process industries, numerous online surveys were conducted among IE experts, academic experts & expert executives of process industries along with current literature reviews. After identifying the puissant drivers with the assistance of expert opinion and literature reviews, ISM technique was used to develop framework. The MICMAC analysis was applied to illustrate the hierarchical relationship among these drivers associated with the implementation of LSS. With the knowledge of interrelation among these puissant drivers, effectual implementation of LSS in process industries may be possible.

3.1. Interpretive Structural Modelling (ISM)

Interpretive Structural Modelling is an intuitive learning process(Tiwari, 2013). Sometimes it becomes very tough to understand a system when there are many interrelated elements present in the framework. Presence of direct and indirect interaction among these elements increase the complexity of any process. Therefore, ISM ameliorates insights into collective understandings of these relationship. This zero-information added powerful systematic model transform unclear & poorly articulated models of system into visible & well-defined models(Tiwari, 2013). The various steps involved in ISM technique are-

Step 1: Identification of the potent drivers in implementing LSS in process industries with the assistance of expert opinions & literature reviews.

Step 2: A contextual relationship was established among the identified drivers (in Step 1), with the pairs of examined drivers. Numerous online surveys were directed to find the contextual relationship(T, Radhika, & Pramod, 2014).

Step 3: A structural self-interaction matrix (SSIM) was created. It expresses the pair-wise association between the drivers. With the assistance of existing contextual interaction between two drivers (*i* & *j*), the related direction of relationship was questioned(Attri, Dev, & Sharma, 2013). Four images were utilized to recognize the course of connection between two elements (*i* & *j*). (a) V for the connection from factor i to factor j (i.e., factor i will impact factor j) (b) A for the connection from factor j to factor i (i.e., factor i will be affected by factor j) (c) X for both bearing relations (d) O implies no connection between the components (i.e., drivers i and j are not related).

Step 4: A reachability matrix was created from the SSIM & checking the matrix for transitivity. An essential supposition in ISM is Transitivity which expresses that if B is identified with A and A is identified with C, at that point B will be fundamentally identified with C. For creating the reachability matrix 0 and 1 were used for replacing the symbols of SSIM (V, A, X, O). The systems for this replacement were as follows: (a) 1 was used for and 0 was used for (*j*, *i*) when V was used in SSIM for (*i, j*). (b) 0 was used for (*i, j*) and 1 was used for (*j*, *i*) when A was used in SSIM for (*i, j*). (c) 1 was used for both (*i, j*) and (*j*, *i*) when X was used in SSIM for (*i, j*). (d) 0 was used for both (*i, j*) and (*j*, *i*) when O was used in SSIM for (*i, j*)(Attri et al., 2013).

Step 5: The reachability and predecessor set for every driver were found from the last reachability grid. At that point the convergence of the sets was advanced for all drivers. The best level driver is meant in the ISM chain of command when the component for the reachability and convergence sets were same. When the top-level driver was denoted, it was removed from alternate drivers. With the same system, the following level of driver was found. For creating the diagraph and final model, the denoted levels were used. This iteration was rehashed till the levels of each driver are decided.

Step 6: With the assistance of clustering drivers in a similar level of rows and columns of the final reachability matrix, a conical matrix was derived(Tiwari, 2013). Drive power and dependence power are two important key elements of this matrix. The drive intensity of a factor was figured by including the quantity of 1s in the rows and dependence intensity by including the quantity of 1s in the columns. The ranking arrangement of these drive power and dependence power was computed with the quantity of 1s in the rows and columns individually.

Step 7: Digraph of the drivers for implementing LSS represents the association between the drivers. From the final reachability matrix, the systematic model was created by methods for vertices or hubs and lines of edges. The bolt which indicates from i to j demonstrates the connection between the drivers i and j. As direction is presented in this graph so it is known as directed graph or digraph(Tiwari, 2013).

Step 8: The ISM model was developed from this digraph by replacing node with statement(Attri et al., 2013).

3.2. MICMAC Analysis

The expansion of MICMAC is Matrice d'Impacts croises-multiplication appliqúe an classment (cross-impact matrix multiplication applied to classification)(Attri et al., 2013). Analyzing drive power and dependence power is the primary objective of MICMAC analysis. Multiplication property of matrix is the basic foundation of MICMAC principal. With the assistance of drive power and dependence power the drivers are divided into four clusters.

Autonomous drivers: Weak drive and weak dependence power are the criteria for autonomous drivers. This type of drivers is generally separated from the framework. These drivers have least power to influence other drivers of the system.

Linkage drivers: Strong drive power and strong dependence power are the criteria for linkage drivers. These drivers are known as unstable driver(Attri et al., 2013).

Dependent drivers: Weak drive power but strong dependence power are the criteria for dependent drivers.

Independent drivers: Strong drive power but weak dependence power are the criteria for independent drivers.

Which driver has strong drive power is known as key driver. Based on this criteria linkage drivers and independent drivers are key drivers.

4. Case Study

4.1 Application of Interpretive Structural Modeling(ISM) Method

The developed ISM methodology has been used to rank the drivers of the Lean six sigma implementation and this has been followed by a hierarchy of these drivers. Among all the potential drivers, twenty has been shortlisted though expert opinion. This survey has been done on the experts who are closely related to process industries. ISM methodology has been applied to this case study to find out the interrelationship between the drivers and to provide a multi-objective decision model using ISM based approach which can successfully initiate Lean Six Sigma in the process industries.

4.2 Interpretive Structural Model Development

Contextual relation between the drivers of LSS

Many drivers of lean six sigma implementation in different types of industries have been identified and through literature review and expert feedback, only twenty of them has been selected. These drivers are interrelated and influence each other in an effective manner which encouraged to develop the contextual relationship between the selected drivers.

Table 4.1: Identification code of the drivers of lean six sigma

Identification code	Driver of Lean Six Sigma
ED1	Highly responsive suppliers
ED2	Reduce lead time
ED3	No frequent changes in supply schedule by customers
ED4	Good quality material or parts supplied by suppliers
ED5	Following standard operating procedures
ED6	Strong process control
ED7	Stable customer order
ED8	Low product variety
ED9	Low scrap/ rework / rejection.
ED10	Low labor cost
ED11	Availability of skilled workers
ED12	Strong workplace organization & house keeping
ED13	Global competition
ED14	Advances in manufacturing technology & Advances in information technology
ED15	Customer wants reliable and prompt deliveries
ED16	Employee training
ED17	Less machine breakdowns
ED18	Organization culture
ED19	Cost savings
ED20	Government legislation

Developing Structural Self-Interaction Matrix (SSIM)

Through expert opinion taken on a survey sheet which contained the drivers of LSS implementation, the contextual relationship of the drivers of LSS has been marked in four different criteria. This four criteria are denoted through four different standard symbols, which also define the direction of the relationship between variables (Singh, Garg, & Deshmukh, 2007).

Table 4.2: Structural Self-Interaction Matrix

	ED1	ED2	ED3	ED4	ED5	ED6	ED7	ED8	ED9	ED10	ED11	ED12	ED13	ED14	ED15	ED16	ED17	ED18	ED19	ED20
ED1	X	V	A	A	O	O	O	O	O	O	O	O	V	A	A	O	O	A	V	O
ED2		X	O	A	A	A	O	A	O	O	A	A	V	A	A	A	O	O	V	O
ED3			X	O	O	V	V	A	V	O	O	O	O	O	O	O	O	O	V	O
ED4				X	A	V	O	V	V	O	O	O	V	O	V	O	V	O	V	A
ED5					X	V	O	O	V	O	A	V	V	O	O	V	V	V	V	V
ED6						X	O	O	V	O	A	V	V	O	O	A	V	O	V	A
ED7							X	V	V	O	O	O	O	O	V	O	O	O	V	O
ED8								X	V	V	O	O	O	O	V	V	V	O	V	O
ED9									X	O	A	V	O	A	O	A	O	O	V	O
ED1										X	A	O	O	O	O	O	V	O	V	A
ED1											X	V	V	V	V	V	V	O	O	O
ED1												X	V	O	O	A	O	A	V	O
ED1													X	A	A	A	O	A	A	O
ED1														X	V	A	V	O	V	A
ED1															X	A	A	O	V	O
ED1																X	V	V	V	O
ED1																	X	O	V	O
ED1																		X	O	V
ED1																			X	O
ED2																				X

Developing the initial and final reachability matrix

The SSIM developed is converted into a binary matrix by substituting the letters used (V, A, O, X) with only 1 and 0 per case. This substitution is done maintaining the conditions and the outcome has been show below.

Table 4.3: Initial Reachability Matrix

	ED1	ED2	ED3	ED4	ED5	ED6	ED7	ED8	ED9	ED10	ED11	ED12	ED13	ED14	ED15	ED16	ED17	ED18	ED19	ED20
ED1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
ED2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ED3	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0
ED4	1	1	0	1	0	1	0	1	1	0	0	0	1	0	1	0	1	0	1	0
ED5	0	1	0	1	1	1	0	0	1	0	0	1	1	0	0	1	1	1	1	1
ED6	0	1	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	1	0
ED7	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	0
ED8	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	1	0
ED9	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0
ED1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0

ED1	0	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0
ED1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0
ED1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
ED1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0
ED1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
ED1	0	1	0	0	0	1	0	0	1	0	0	1	1	1	1	1	1	1	1	0
ED1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
ED1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
ED1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
ED2	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1

In next table, driving power and dependence have been denoted by D1 and D2 respectively.

Table 4.4: Final Reachability Matrix

	ED1	ED2	ED3	ED4	ED5	ED6	ED7	ED8	ED9	ED10	ED11	ED12	ED13	ED14	ED15	ED16	ED17	ED18	ED19	ED20	D1
ED1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	4
ED2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
ED3	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	6
ED4	1	1	0	1	0	1	0	1	1	0	0	0	1	0	1	0	1	0	1	0	10
ED5	0	1	0	1	1	1	0	0	1	0	0	1	1	0	0	1	1	1	1	1	12
ED6	0	1	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1	0	1	0	7
ED7	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	0	5
ED8	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	0	1	0	8
ED9	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	3
ED1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	3
ED1	0	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	12
ED1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	4
ED1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
ED1	1	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	8
ED1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	5
ED1	0	1	0	0	0	1	0	0	1	0	0	1	1	1	1	1	1	1	1	0	11
ED1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	3
ED1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	4
ED1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
ED2	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	4
D2	6	11	1	2	2	7	2	3	10	4	1	7	12	4	8	4	9	3	16	2	114

Level Partitioning of the Final Reachability Matrix

For dividing the drivers into different sets, reachability and antecedent set is identified first. To get the reachability matrix, every column that contains 1 in the row of the considered driver is grouped together as reachability matrix. Again, to get the antecedent set, every row that contains 1 in the column of considered driver is grouped together. The intersection of these two set is named as intersection set. When the intersection set is equal to the reachability set, that driver is marked with a level and excluded from the further iterations.

Table 4.5: Level partition Iteration 1

Drivers	Reachability Set	Antecedent Set	Intersection Set	Level
ED1	ED1,ED2,ED13,ED19	ED1, ED3, ED4, ED14, ED15, ED18	ED1	
ED2	ED2,ED19	ED1, ED2, ED4, ED5, ED6, ED8, ED11, ED12, ED14, ED15, ED16	ED2	
ED3	ED1,ED3,ED6,ED7,ED9,ED19	ED3	ED3	
ED4	ED1,ED2,ED4,ED6,ED8,ED9, ED13,ED15,ED17,ED19	ED4, ED5	ED4	
ED5	ED2,ED4,ED5,ED6,ED9,ED12 ,ED13,ED16,ED17,ED18,ED1 9,ED20	ED5, ED11	ED5	
ED6	ED2, ED6, ED9, ED12, ED13, ED17, ED19	ED3, ED4, ED5, ED6, ED11, ED16, ED20	ED6	
ED7	ED7, ED8, ED9, ED15, ED19	ED3, ED7	ED7	
ED8	ED2, ED8, ED9, ED10, ED15, ED16, ED17, ED19	ED4, ED7, ED8	ED8	
ED9	ED9, ED12, ED19	ED3, ED4, ED5, ED6, ED7, ED8, ED9, ED11, ED14, ED16	ED9	
ED10	ED10, ED17, ED19	ED8, ED10, ED11, ED20	ED10	
ED11	ED2, ED5, ED6, ED9, ED10, ED11, ED12, ED13, ED14, ED15, ED16, ED17	ED11	ED11	
ED12	ED2, ED12, ED13, ED19	ED5, ED6, ED9, ED11, ED12, ED16, ED18	ED12	
ED13	ED13	ED1, ED4, ED5, ED6, ED11, ED12, ED13, ED14, ED15, ED16, ED18, ED19	ED13	**I**
ED14	ED1, ED2, ED9, ED13, ED14, ED15, ED17, ED19	ED11, ED14, ED16, ED20	ED14	
ED15	ED1, ED2, ED13, ED15, ED19	ED4, ED7, ED8, ED11, ED14, ED15, ED16, ED17	ED15	
ED16	ED2, ED6, ED9, ED12, ED13, ED14, ED15, ED16, ED17, ED18, ED19	ED5, ED8, ED11, ED16	ED16	
ED17	ED17, ED19	ED4, ED5, ED6, ED8, ED10, ED11, ED14, ED15, ED16, ED17	ED17	
ED18	ED1, ED12, ED13, ED18	ED7, ED16, ED18	ED18	
ED19	ED13, ED19	ED1, ED2, ED3, ED4, ED5, ED6, ED7, ED8, ED9, ED10, ED12, ED14, ED15, ED16, ED17, ED19	ED19	
ED20	ED6, ED10, ED14, ED20	ED5, ED20	ED20	

Following the process stated above, all the drivers has been divided into 11 levels which is summarized below through the final list of level partitions.

Table 4.6: Final list of Level Partition

Level	Drivers No	Drivers
I	ED13	Global competition
II	ED19	Cost savings
III	ED2	Reduce lead time
	ED17	Less machine breakdowns
IV	ED1	Highly responsive suppliers
	ED10	Low labor cost
	ED12	Strong workplace organization & house keeping
V	ED9	Low scrap/ rework / rejection
	ED15	Customer wants reliable and prompt deliveries
	ED18	Organization culture
VI	ED6	Strong process control
	ED14	Advances in manufacturing & information technology
VII	ED16	Employee training
	ED20	Govt. legislation
VIII	ED8	Low product variety
IX	ED4	Good quality material or parts supplied by suppliers
	ED7	Stable customer order
X	ED3	No frequent changes in supply schedule by customers
	ED5	Following standard operating procedures
XI	ED11	Availability of skilled workers

Final Diagraph

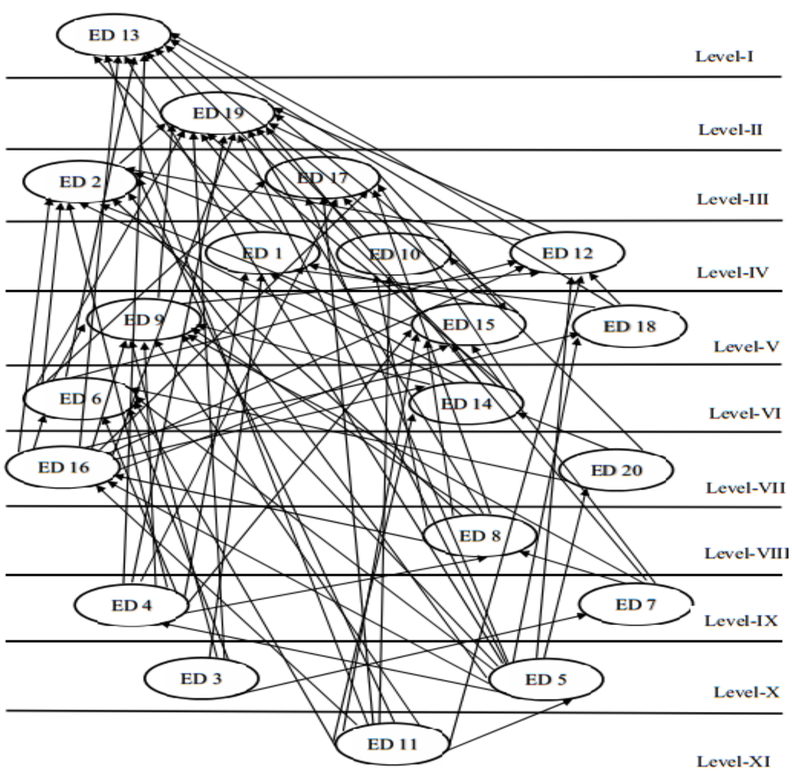

Figure 4.1: Final Diagraph of LSS Drivers

4.3 Proposed ISM Model

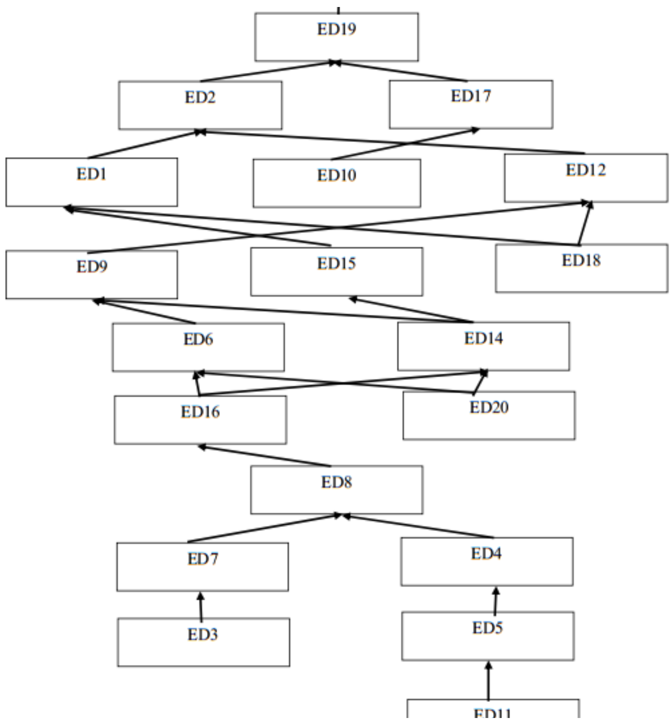

Figure 4.2: Proposed ISM Model

5. Results Obtained from Micmac Analysis

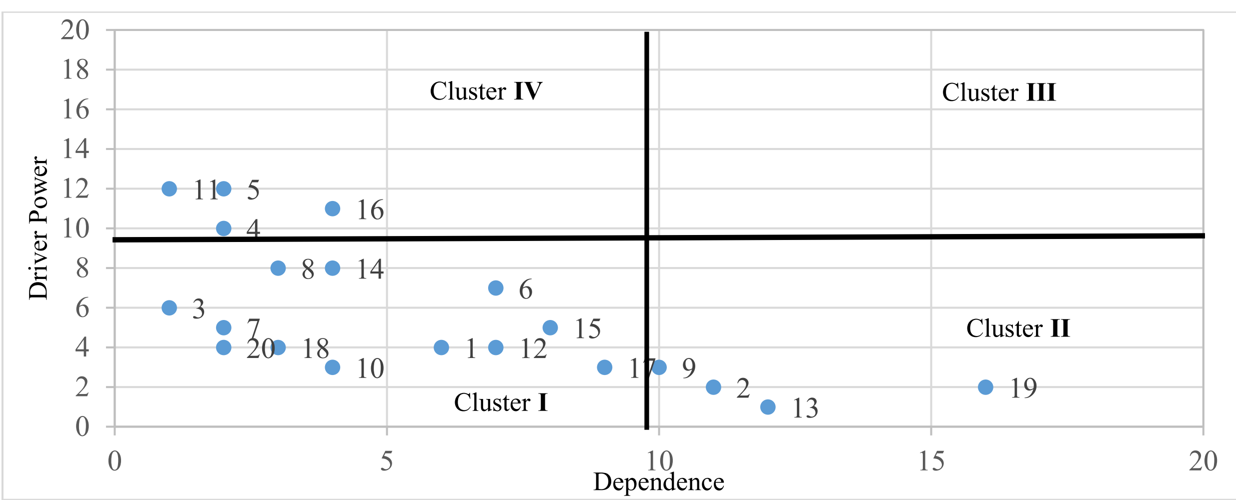

Figure 4.3: MICMAC Analysis of LSS Drivers

The purpose of MICMAC analysis is further analysis of the drivers of LSS. It is done by putting dependence and driver power in X and Y axis respectively. Here cluster I represents "autonomous driver". Among 20 driver, 12 drivers have been found in this cluster. These selected autonomous factor for LSS are: ED1, ED3, ED6, ED7, ED8, ED10, ED12, ED14, ED15, ED17, ED18 and ED20. Cluster II represents "dependent driver". Manager should take special care of these drivers for successful implementation. Four drivers have been found as dependent factors. These are ED2, ED9, ED13 and ED19. Cluster III represents "linkage driver" which is highly unstable. Any action on this factor can imply effects on others, also there will be feedback on themselves. Among our selected drivers none has showed this unstable nature. Lastly, cluster IV represents "independent driver". This factor is called key factor as it plays vital role for the implementation of the system. Here we have found ED4, ED5, ED11, and ED16 as independent factors.

6. Result & Discussion

To fully understand the importance of the drivers of LSS is essential for the proper implementation of LSS in the process industry. From the ISM diagraph we have found that among our selected 20 drivers, availability of skilled workers (ED11) was found playing the vital role. It is one the key factor in LSS system having higher driver power. So it is placed in the bottom of hierarchy. Other key factors such as following standard operating procedures (ED5) and employee training (ED16) are in the lower part of hierarchy having higher level in ISM as well as they have higher driver power. Besides, some drivers have strong links to the system though they have lower driver power. These are: no frequent changes in supply schedule by customers (ED3), stable customer order (ED7), low variety of product (ED8) and govt. legislation (ED20). Global competition (ED13) driver positioned in level 1 in ISM hierarchy needs least attention for the LSS system. In level 2, Cost savings (ED19) is placed. Reducing lead time (ED2) is placed in level 3 along with less machine breakdowns (ED17). Highly responsive suppliers (ED1), low labor cost (ED10) and strong workplace organization and housekeeping (ED12) are in level 4. In level 5, there are low scrap/ rework / rejection (ED9), customer wants reliable and prompt deliveries (ED15) and organization culture (ED18) drivers. Strong process control (ED6) and Advances in manufacturing & information technology (ED14) are in level 6. Employee training (ED16) and Govt. legislation (ED20) are in level 7. These drivers have impact in the framework and need special care. Then, low variety of product (ED8) in the next level. Good quality material or parts supplied by suppliers (ED4) and stable customer order (ED7) are in level 8. No frequent changes in supply schedule by customers (ED3) and Following standard operating procedures (ED5) are in next level. Availability of skilled workers (ED11) is in the highest level 11 which has great impact on the framework.

7. Conclusion

Interpretive Structural Modelling (ISM) helps us to develop a systematic and directional structure for a complex system along with a practical picture of the system. It indicates the direct and indirect association among the critical drivers of implementing LSS in process industries. It also provides different levels of the potent drivers. With the help of these levels of the drivers, a structural framework is developed. With the help of these framework and knowledge of different levels of different drivers, a decision maker can easily co-ordinate among these drivers which will accelerate the process of implementing LSS in process industries. MICMAC analysis provides four different cluster through drive power and dependence power. From this ISM method and MICMAC analysis we find the critical drivers and co-relation among them which will accelerate the process of implementing LSS in process industries.

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