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*RESEARCH ARTICLE*

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# ISM APPROACH IDENTIFICATION OF KEY BARRIERS AFFECTING LEAN MANUFACTURING SYSTEM DESIGN AND IMPLEMENTATION

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***Abstract***

Lean manufacturing is said to be a manufacturing culture that is rapidly expanding. Due to intense competition, the businesses are compelled to outperform their rivals. Only those businesses that can use cutting-edge technologies like lean can expand more quickly and keep their place in this cutthroat market. Because management strategies can change and businesses must adopt them based on client demands, they are inherentl y challenging and uncertain. Lean's primary objective is to fulfill the needs and fulfill the wishes of the consumer. Lean manufacturing is a combination of policies and a culture that may be put into place with the help of management directives. Respect for the employees and waste elimination are the two core principles of lean manufacturing. Once implemented, these elements can enhance effective leadership during implementations.In-depth discussion is provided on the advantages of utilising lean techniques in conception and execution, as well as how managers can engage with questions of culture and leadership.The analysis revealed that changing an organization's culture is just as important as implementing technical tools.The links between the identified lean barriers are developed in this research. Understandin g the reciprocal effects of barriers also requires the capacity to identify barriers, such as the driving barrier, that support other barriers and those barriers which are most influenced by other barriers are called dependent barriers. The methodology of ISM is utilized to develop the relationships between these barriers. Based on their driving and dependent powers, lean manufacturing has been categorized. Analyzing the influence of barriers driving and dependent forces in the goal of classification.



**Introduction:-**Lean Production is another name for Lean Manufacturing. The goal of this collection of devices and techniques is to continually get rid of all the waste produced. The main benefits are increased productivity, lower production and shorter lead time, shorter lead times, lower production costs and increased productivity.

**Lean Manufacturing's goals:**

- **Defects and unnecessary physical waste** - It reduces flaws and unneeded physical waste, such as excessive inputs of raw materials, defects that could have been avoided, processing costs for damaged goods, and superfluous product features that customers don't desire.
- **Cycle Times** - It cuts down on the amount of time needed for process setup and product model conversion, as well as the amount of time spent waiting between different processing phases.
- **Inventory levels** - During all manufacturing phases, especially those that are still in progress in between stages, it lowers inventory levels. Working capital requirements are also decreased when inventory are reduced.
- **Labor productivity** - It raises labour productivity by cutting down on idle time and ensuring that workers are as productive as possible when they are working.
- **Utilization of resources and space** - the least amount of machine downtime possible while improving output rates using already available equipment to make optimum use of resources and manufacturing space.
- **Flexibility** - Lean manufacturing expands the flexible product range with the least amount of changeover time and expense.
- **Production** - LM will boost businesses' output from their current facilities by reducing cycle times, increasing labour productivity, eliminating bottlenecks, and minimizing machine downtime.

Most of these advantages result in lower unit production costs, such as lower depreciation costs per unit produced from better equipment and space utilization, lower labour expenses per unit produced from better labor utilization, and decreasing cost of products sold from lesser faults. According to a 2004 Industry Week Magazine survey, that the American businesses using lean manufacturing claimed median COGS savings of 7% as a result of using LM. Another advantage of LM is that it requires fewer resources overall than other techniques, such as less machine time, less time space, less amount of labour, less space, less amount of money, and less materials, to get the same outcomes. The above improvements over the batch-based process in 1991 were reported by Lantech, a U.S. equipment maker, when they had finished implementing lean in 1995.

• A 45% reduction in manufacturing space was made per machine.

• 90% fewer defects were found.

• The production cycle was cut in half, going from 16 weeks to 14 hours and 5 days.

• The wait time for product delivery was shortened from 4 to 20 weeks to 1-4 weeks

## 1. Literature review

**Ford & Crowther, 2006** Sakichi Toyoda, a self-taught inventor, created and patented a manually operated loom that would turn off when a thread broke while weaving fabric in the early 1890s. This markedly increased worker productivity and halted the creation of defective cloth. Ohno, 2008 Due in part to these developments, Toyota's early management practices had as their main objectives to improve production efficiency by constantly and completely eliminating waste and "the equally vital consideration for humanity."

**Ford & Crowther, 2006** the author who had the most impact on readers was Henry Ford, who wrote the novels my work, my life, today, and tomorrow. Huntzinger, 2003 “A standardized four-step program called "Training within Industry Service" (TWI) is used to teach manufacturing employees, especially supervisors.

**Mejabi, 2003** Western industrial management practices undoubtedly have an impact, but it is important to recognize that this influence is also rather limited. Due to the purposeful efforts of Toyota managers over many generations, industrial management practices have undergone multiple notable breakthroughs. Ohno, 2008 In line with the dual goals of "production efficiency by continuously and completely removing waste" and "the equally crucial respect for humanity."

**Taj & Berro, 2006** The Toyota Way 2001, a business internal document released by Toyota Motor Corporation in 2001, lists these two goals as the top-level company principles. They are "continuous improvement" and "respect for people." Emiliani, 2006 At the very least, management must accept and put into practice the two ideas of "continuous improvement" and respect for people in order to properly implement Toyota's management method, known as Lean management. However, the first principle, "continuous improvement," is rarely put into practice by managers, which significantly reduces the amount of progress that can be made.

**Imai, 2007** the eight basic categories of waste that the Lean manufacturing system detects are used to create structured processes, support tools, and improved time-based competitiveness. Routines for internal and external organizational capability building are established as a result of effective Lean management implementation. Bhasin and Burcher, 2006 although there are generic lean procedures that apply to all businesses, each one should navigate its way through its own notions of lean manufacturing.

**Womack and Jones, 1996** only 41% of auto manufacturers, in their estimation, had a high level of lean implementation. In order to adopt the proper implementation and modifications through incremental improvements and stepwise projects by the reciprocal engagement with employees until the conclusion of implementation, it is crucial to have a strong understanding of lean tools and be familiar with lean culture. Sheridan, 2000 According to this, before lean implementation is complete, it takes three years to become adept in using tools like set-up reduction, standard work, or cell construction, and five years to gradually instil a firm belief in all the procedures. Chase, 1999 implementing lean manufacturing, according to the author, "also means that the firm is scrutinized in its whole, including how orders are processed, how supplies are purchased, and how manufacturing is carried out."

## 2. The difficulties in implementing lean manufacturing effectively

- Scope and the absence of a strategic viewpoint
- Human dimensions
- Absence of backup
- Variability in Copying
- Lean and the Shop Floor
- Opposition to Change
- Philosophy's Roots and Branch
- Inadequate Planning
- Reluctance to See and Learn

## 3. ISM METHOLOGY AND MODEL DEVELOPMENT

The ISM methodology aids in establishing direction and order in interactions between complex system pieces. It is interpretative since the group's opinion determines how the variables relate to one another. It is structural because an overall structure is produced from a complicated set of variables based on relationships. Since the precise relationships and general structure are prepared in a graphical model, it is a modelling technique.

**The ISM approach entails a number of processes, including:**

(1) Identifying the elements that are important to the issue, this could be done through a survey.
(2) Creating a context in which items are related to one another and with which to compare elements in pairs.
(3) Assembling elements to form a structural self-interaction matrix (SSIM) that displays the connections between system parts in pairs.
(4) Build a reach ability matrix and check its transitivity using the SSIM as a starting point. The essential premise of ISM is that if element A is related to element B and element B is related to element C, then A is related to C.
(5) The reach ability matrix is divided into various tiers.
(6) Drawing a directed network (digraph) based on the relationships shown in the reach ability matrix, then deleting the transitive linkages.
(7) Substituting the Statements for the element nodes in the resulting digraph to create an ISM-based model.
(8) Review the model, make the required adjustments, and look for conceptual inconsistencies.
The following steps illustrates the numerous phases that led to the development of the ISM model.

### 1 Structural self-interaction matrix (SSIM)

In order to determine the nature of contextual linkages among the barriers, a group of specialists from the academic community and the business world were interviewed. For the examination of obstacles in creating SSIM, the following four symbols have been utilised to show the direction of relationships between barriers (x and y)
A - Barrier x will make barrier y possible.
B - Barrier y will make barrier x possible.
C - X and Y barriers will work together to overcome one another.
D - X and Y-barriers are unrelated.

**TABLE 1 Structural Self-Interaction Matrix**

| Barrier Number | Barrier description | Barrier Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** |
| **1** | Scope and the absence of a strategic viewpoint | **A** | **A** | **A** | **A** | **A** | **A** | **A** | **A** |
| **2** | Human dimensions | **A** | **A** | **A** | **A** | **A** | **B** | **B** | |
| **3** | Absence of backup | **A** | **A** | **A** | **A** | **A** | **D** | | |
| **4** | Variability in Copying | **A** | **A** | **A** | **A** | **A** | | | |
| **5** | Lean and the Shop Floor | **A** | **A** | **A** | **A** | | | | |
| **6** | Opposition to Change | **A** | **A** | **A** | | | | | |
| **7** | Philosophy's Roots And Branch | **C** | **A** | | | | | | |
| **8** | Inadequate Planning | **B** | | | | | | | |
| **9** | Reluctance To See And Learn | **D** | | | | | | | |

**Reach ability matri**

The SSIM has been transformed into a binary matrix known as the initial reach ability matrix, where A, B, C, and D have been changed to 1 and 0 as necessary (see Tab. 1). The use of 1s and 0s in substitution is subject to the following rules:

If the (x, y) item in the SSIM is A, the (x, y) entry in the reach ability matrix becomes 1 and the (y, x) entry becomes 0.

If the (x, y) entry in the SSIM is B, the (x, y) and (y, x) entries in the reach ability matrix become 0 and 1, respectively.

If the (x, y) entry in the SSIM is C, both the (x, y) and (y, x) entries in the reach ability matrix become 1.

If the (x, y) entry in the SSIM is D, the (x, y) and (y, x) entries in the reach ability matrix both become 0.

The original reach ability matrix will be used for the subsequent calculations because there is no transitivity in this scenario. The impact and reliance of each barrier are shown in. The total amount of barriers, including those it may be a part of, is what drives each barrier. Dependence is the entire number of barriers that could make something possible, including itself

**Table 2 Initial Reach ability Matrix**

| Barrier no. | Barrier description | Barrier Number | | | | | | | | | Driving power |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| 1 | Scope and the absence of a strategic viewpoint | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 |
| 2 | Human dimensions | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 6 |
| 3 | Absence of backup | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 |
| 4 | Variability in Copying | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 |
| 5 | Lean and the Shop Floor | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| 6 | Opposition to Change | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 4 |
| 7 | Philosophy's Roots And Branch | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| 8 | Inadequate Planning | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 9 | Reluctance To See And Learn | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| Dependence Power | | 1 | 4 | 3 | 3 | 5 | 6 | 7 | 9 | 7 | |

**Level partitions**

The final reach ability matrix is used to determine the reach ability and antecedent set for each barrier. The reach ability set consists of the element and any further elements that it might help attain, whereas the antecedent set consists of the element and any additional elements that might assist gain it. Then, for each barrier, the intersection of these sets is identified. Barriers for which the intersection and reach ability sets are equivalent are those at the top of the ISM hierarchy. The element at the top of the hierarchy wouldn't help the components below it advance. It is then possible to identify the top-level element and separate it from the remaining elements. Repeating the process results in the discovery of the components at the subsequent level. This procedure is continued up until the level of each element is learned. These levels support the creation of the diagraph and the final model.

**Table 3 Artition Of Reach ability Matrix: First Iteration**

| Barrier Number | Reachability Set | Antecedent set | Intersection | Level |
|---|---|---|---|---|
| 1 | 1,2,3,4,5,6,7,8,9 | 1 | 1 | |
| 2 | 2,5,6,7,8,9 | 1,2,3,4 | 2 | |
| 3 | 2,3,4,5,6,7,8,9 | 1,3,4 | 3,4 | |
| 4 | 2,3,4,5,6,7,8,9 | 1,3,4 | 3,4 | |
| 5 | 5,6,7,8,9 | 1,2,3,4,5 | 5 | |
| 6 | 6,7,8,9 | 1,2,3,4,5,6 | 6 | |
| 7 | 7,8 | 1,2,3,4,5,6,7 | 7 | |
| 8 | 8 | 1,2,3,4,5,6,7,8,9 | 8 | I |
| 9 | 8,9 | 1,2,3,4,5,6,9 | 9 | |

Table 4 SECOND ITERATION

| Barrier Number | Reachability Set | Antecedent Set | Intersection | Level |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | VII |
| 2 | 2 | 1,2,3,4 | 2 | V |
| 3 | 3 , 4 | 1,3,4 | 3,4 | VI |
| 4 | 3, 4 | 1,3,4 | 3,4 | VI |
| 5 | 5 | 1,2,3,4,5 | 5 | IV |
| 6 | 6 | 1,2,3,4,5,6 | 6 | III |
| 7 | 7 | 1,2,3,4,5,6,7 | 7 | II |
| 8 | 8 | 1,2,3,4,5,6,7,8,9 | 8 | I |
| 9 | 9 | 1,2,3,4,5,6,9 | 9 | II |

**Categorization of barriers**

All barriers have been categorised into four classes based on their ability to drive and be driven: autonomous barriers, dependent barriers, linked barriers, and independent barriers. These obstacles have been grouped in a similar way as Mandal and Deshmukh. The driving power and dependent power diagram for obstacles is shown.

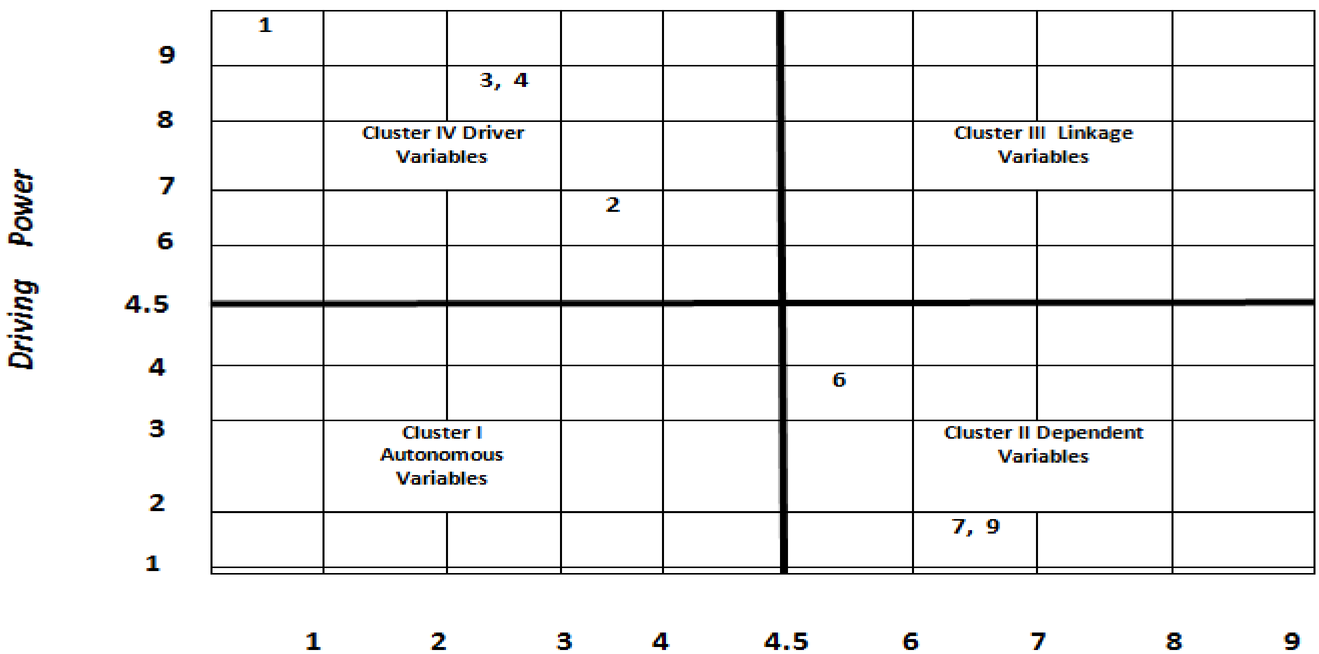


**Figure 1: Categorization of barriers**

Given that it has a driving power of 6 and a dependency power of 4, Barrier 2 is located in a location that corresponds to those values, as shown in Fig (see Tab. 4). The objective of the classification of barriers is analysis of the driving and supporting forces. The first cluster of obstacles in this classification are autonomous barriers with low driving and reliance strengths. Generally speaking, the autonomous barriers are not connected to the system. There are no autonomous boundaries in this situation. Dependent barriers with strong dependency and modest driving strength make up the second cluster. In this instance, barriers 5, 6, 7, 8, and 9 can be classified as dependent barriers. Linkage barriers with a lot of driving and dependent power make up the third grouping. Any action taken to overcome these obstacles will have a ripple effect that affects the other obstacles as well as the original obstacles. There are no connectivity hurdles in this situation. Independent barriers with high driving power and low dependence power make up the fourth cluster. In this instance, barriers 1, 2, 3, and 4 are considered independent barriers.

**5 ISM digraph and model formation**

The structural model is generated from the initial reach ability matrix (see Tab. 4). Whether there is a connection between barrier I and barrier j can be seen by an arrow pointing from one to the other. This graph is an initial directed graph, often known as an initial digraph. When the transitivities are eliminated (see step 4 of the ISM technique), the final digraph is produced (Fig. 2). The final digraph is modelled using the ISM (Fig. 3

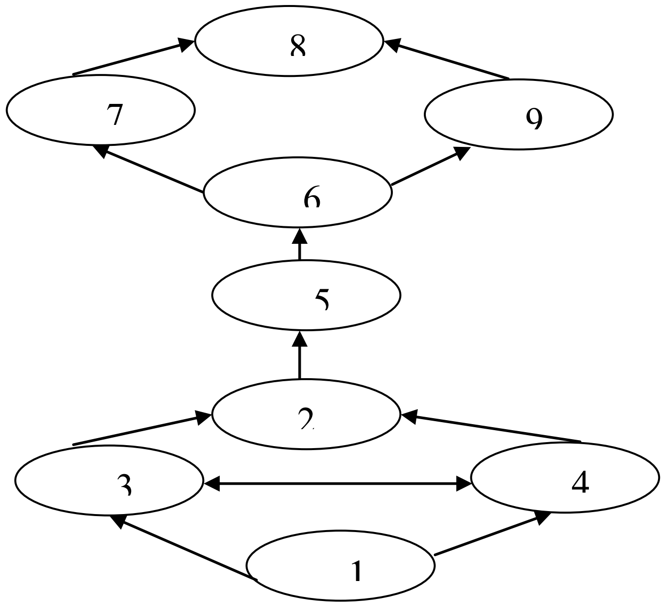


**Figure 2: ISM digraph and model formation**

## Discussion:-
For a LEAN deployment to be successful, it is essential to comprehend the many sorts of hurdles. The biggest obstacle to implementing lean is a lack of scope and a lack of a strategic perspective because of its strong driving force and low dependence. Survey results from the past can attest to this. In the ISM-based paradigm, this barrier is at the bottom of the hierarchy. Due to its strong reliance and weak driving, the ISM-based approach has the highest level of barrier unwillingness to insufficient planning. "Strategic barriers" are located in the fourth and third layers of the model with the strongest driving force. Collaboration, knowledge sharing, communication, as well as the pursuit of knowledge and information, require the removal of these barriers. The top management needs to give these issues more consideration. The driving power and dependence power diagram provides some helpful information regarding the interdependencies and relative relevance of the obstacles. According to the driving force and dependency diagram, effective LEAN is not hindered by autonomous systems. Weak dependents and weak drivers define autonomous barriers. The LEAN system is not significantly impacted by these difficulties. The lack of autonomous barriers in this study supports the finding that all barriers have an impact on knowledge management's success. Therefore, it is crucial that management thoroughly assesses all LEAN barriers.

**Conclusion and suggested next steps**

The LEAN implementation technique takes the severity of the obstacles into account. In addition, three barriers—lack of scope and strategic perspective (barriers 1), absence of backup (barriers 3), and variability in copying (barriers 4)—can be seen in Fig. 1. These barriers are demonstrated to have a high driving power and a low reliance power. As a result, these obstacles can be regarded as crucial LEAN obstacles. We may infer from the explanation above that each of the nine hurdles is crucial—albeit to varied degrees—for the successful adoption of LEAN. In this study, the ISM model was developed using only nine LEAN barriers.

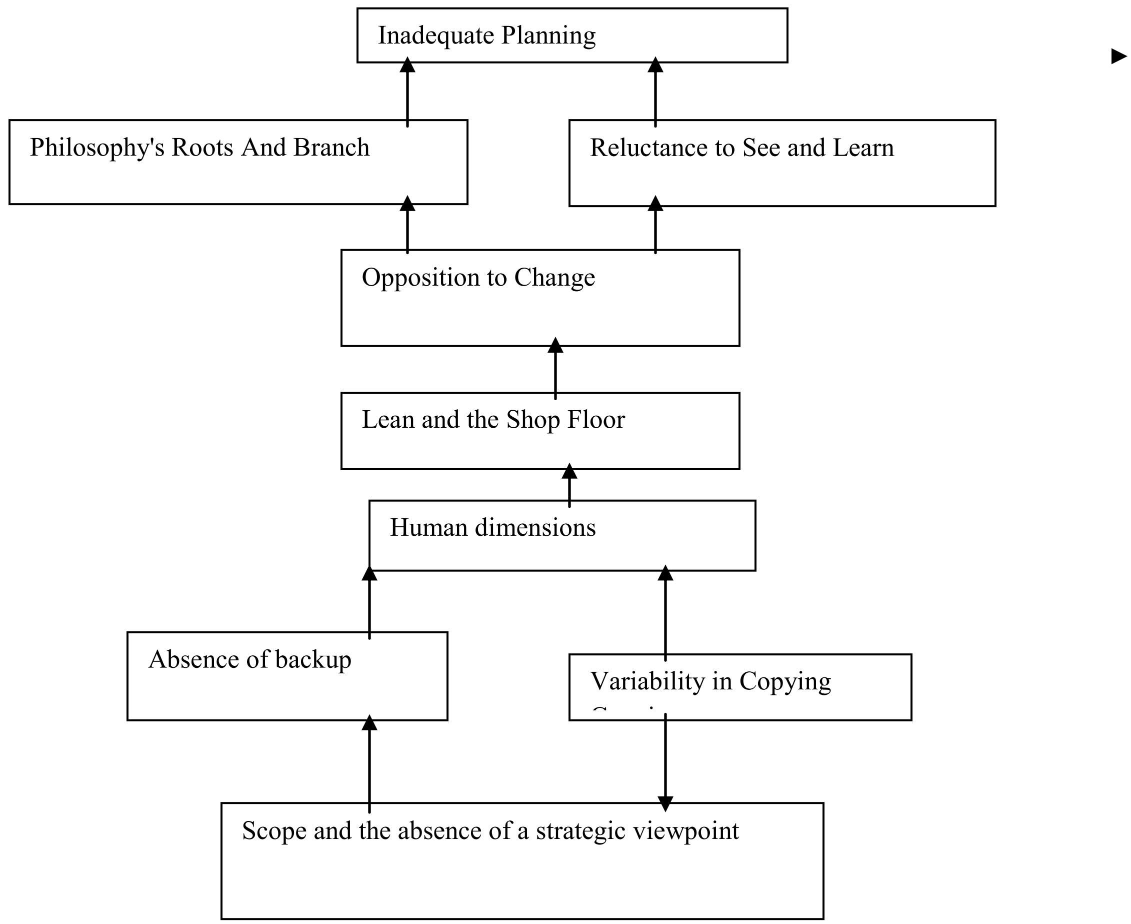


**Figure 3: Dependent and Independent Variables**

But by employing the ISM methodology, more LEAN barriers can be added to improve their relationship with one another. Additionally, there is no statistical support for the relationship model between the identified LEAN barriers in this study. Structural equation modeling (SEM), sometimes referred to as the linear structural connection approach, can be used to assess the veracity of such hypothetical models. In order to verify that this model is accurate, future research can employ this strategy.. While SEM can statistically test an already constructed theoretical model, ISM is a tool that can be used for developing an initial model. Therefore, it has been proposed that future study may focus on creating the initial model by ISM and then testing it through SEM. In order for lean to be implemented successfully and for the firm to benefit from it, the management needs consider the various types of barriers and take the required steps to remove them.

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