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ANALYSIS OF MANAGEMENT STRATEGIES AND PRACTICES TO ACHIEVE WORLD CLASS MANUFACTURING

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Abstract

The recent advances in technologies and globalization have pushed the manufacturing entities of the world into a competition zone where survival exists for the fittest one. Traditional practice of having a few products for a longer shelf life and very little competition has been replaced with short product life cycle, global competition and fast changing consumer taste. As consumers are pampered with variety of choices available at competitive price, manufacturing entities need to change their strategies to stay in the market. As such they have to think and deploy strategies with an eye on the future while fulfilling the current need of the consumers. The management strategies and practices that can be employed to achieve World Class Manufacturing has been analyzed in this paper using Interpretive Structural Modelling (ISM).

Keywords- *World Class Manufacturing, Management Strategies& Practices for Manufacturing, Interpretive Structural Modelling (ISM)*

1 Introduction

The economic wealth of a nation is dependent on the manufacturing excellence achieved by it. The fact has been proven historically with industrial revolution in its backdrop. While Britain once pioneered the industrial revolution, its competitive edge was lost due to failure to upgrade its manufacturing technologies. European Countries and USA built factories using prevalent technologies with scientific research. Globalization along with advances in technologies had a cascading effect on manufacturing industries the world over, who didn't upgrade in time. Many firms were out of business due to resistance to adapt to the fast changing scenario. There are many instances to support this fact. A few of them has been compiled in table 1.

Table 1: List of companies that failed to adapt

S.No.	Name of the Company	Product(s)	Reason for Failure
1	Kodak	Camera, items related to photo developing process	Founded in 1888, failed to adapt to changing consumer demand of instant/digital photography
2	Nokia	Telecommunications, Mobile Phones	Largest manufacturer of mobiles in 1998, the company introduced the term smartphone in 2002, but failed to see the changing consumer demand. Rise of iphones and android based smartphones and the reluctance to embrace newer user-friendly operating system proved catastrophe for Nokia.

3	Pacific Gas and Electric Co.	Natural Gas and Electricity Generation	Established in 1905. Due to deregulation of electricity, sold its natural gas plants and only retained the hydroelectricity plants. The electricity generating capacity of the company declined leading to bankruptcy in 2001.
4	Delta Airlines	Airline operations	The rising fuel prices and stiff competition from low cost airlines proved fatal to the airlines. This clubbed with the non-availability of concessions and higher labour costs led to the company filing for bankruptcy in 2005.
5	Abercrombie & Fitch (A&F)	Cloths for kids and teenagers	They were not able to adapt to changing needs of consumers. Rather than understanding customer desires, they found it offensive for being suggested by consumers on current trends. Being out of touch with the consumers made them out of business by 2009.

Hayes and Wheelwright (1984) used the concept 'world class manufacturing' in his book 'Restoring Our Competitive Edge: Competing through Manufacturing'. Since then, the concept 'world class manufacturing' has been broadened and enhanced by various authors with relevancy of time. World Class Manufacturing (WCM) is 'continual and rapid improvement' of a manufacturing entity (Schonberger, 1986). According to him continual improvement in quality, cost, lead time, customer service and flexibility will ultimately lead to 'World-Class' status.

2 Literature Review

To attain manufacturing excellence the focus should be on 'value-added manufacturing'. Anything that does not add value to the product or service, whether material, equipment, space, time, energy, systems, or human activity of any sort should be discarded (Hall, 1987).

Seven categories of wastes have been described that does not add value to the product or service. These are waste of overproduction, waiting, transportation, processing itself, stocks, motion, making defective parts (Shingo & Dillon, 1989).

According to Gunn (1988), World-Class manufacturing rests on three pillars: computer integrated manufacturing (CIM), total quality control (TQC) and just-in-time (JIT) production methods.

With the rise of European and Japanese companies increasing attention has been given to the excellence at the operational level. To achieve World-Class competitive position in the manufacturing sector, it is now an accepted fact that a good quality management team with understanding of concerned attributes is necessary. Many awards created over the last 40 years promote total quality management as the means of achieving manufacturing excellence, and thus reaching World Class status. The first was the Deming Prize in Japan, created in 1951. The Malcolm Baldridge National Quality Award, established in 1987, is the best known and most comprehensive award in the US.

The extensive literature review was carried out to identify management strategies and practices necessary to achieve World Class Manufacturing as shown in table 1.

Table 1: List of Management Strategies and Practices to achieve World Class Manufacturing

Code	Management Strategies and Practices
M1	Business Process Orientation
M2	Leagile Manufacturing
M3	Employee Management
M4	Supply Chain Management
M5	Customer Segmentation
M6	Total Quality Management
M7	Globalized Operations

3 Research Method

Interpretive Structural Modelling (ISM) is one of the techniques that can be used to evaluate criteria's based on their interactions. ISM is an advanced interactive planning methodology that allows a group of people, working as a team, to develop a structure that defines the interrelationships among a set of elements. The structure is obtained by answering a set of simple questions. The elements to be structured such as objectives, barriers, activities, practices etc. are defined by the group at the beginning of the ISM planning session. The group also specifies a relational statement that defines the type of relationship desired such as "aggravates", "enhances", "contributes to", "precedes", etc.

ISM is a very efficient structuring technique. If there are N elements in the set that needs to be structured, the group would have to answer N x (N - 1) questions in order to fully define the relationships. Using the mathematics of ISM the group can fully define all the interrelationships by answering a much smaller number of questions.

ISM was developed by Prof. John N. Warfield, Director of the Institute for Advanced Study of George Mason University in Fairfax, Virginia, when he was at the University of Virginia and at Battelle Memorial Institute. (http://www.gwu.edu/~asc/warfield/)

Table 2 List of some of the fields in which ISM has been employed

S. No.	Field	Paper	Author(s)
1.	Six Sigma	Analyzing Lean Six Sigma enablers: a hybrid ISM-fuzzy MICMAC approach	Yadav&Desai (2017)
2.	Solar Energy	Identification and analysis of barriers in implementation of solar energy in Indian rural sector using integrated ISM and fuzzy MICMAC approach	Sindhu, Nehra& Luthra (2016)
3.	Waste management	Analysis of key factors for waste management in humanitarian response: An interpretive structural modelling approach	Trivedi, Singh, & Chauhan (2015)
4.	Quality Management	Understanding complex relationship among JIT, lean behaviour, TQM and their antecedents using interpretive structural modelling and fuzzy MICMAC analysis	Dubey& Singh (2015)
5.	Green supply chains	Multi-objective decision modelling using interpretive structural modelling for green supply chains	Mangla, Madaan, Sarma, & Gupta (2014)
6.	Information Security	Modeling of information security management parameters in Indian organizations using ISM and MICMAC approach	Chander, Jain&Shankar (2013)
7.	World-class manufacturing	Analysis of critical success factors of world-class manufacturing practices: an application of interpretative structural modelling and interpretative ranking process	Haleem, Sushil, Qadri, & Kumar (2012)
8.	Technology transfer in industry	An evaluation framework for technology transfer of new equipment in high technology industry	Lee, Wangand Lin (2010)
9.	automobile manufacturer–distributor partnership	A systematic procedure to evaluate an automobile manufacturer–distributor partnership	Chen and Wu (2010)
10.	Government's purchasing and bidding	The Application of ISM to Re-designing of Government's Purchasing Process	Zhang, Gu, Fang, Zhang and Xu (2009)
11.	Battery Manufacturing Industry in India	A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider	Kannan, Pokharel and Kumar (2009)
12.	E-learning	Analysis of e-learning influencing factors based on ISM	Wang (2009)

13.	Flexible Manufacturing System	An ISM approach to analyse interaction between barriers of transition to Flexible Manufacturing System	Raj, Shankar and Suhaib (2009)
14.	Knowledge management	Knowledge management barriers: An interpretive structural modelling approach	Singh &Kant (2008)
15.	Corporate governance	An interpretive structural model of corporate governance	Grover, Shankarand Khurana (2007)
16.	Engineering education system	ISM-CMAP-Combine (ICMC) for hierarchical knowledge scenario in quality engineering education	Upadhyay, Gaur, Agrawal and Arora (2007)
17.	University-Industry alliance partner selection	University-Industry Alliance Partner Selection Method Based on ISM and ANP	Ningand Xue-wei (2006)
18.	Supply chain management	Supply chain risk mitigation: modelling the enablers	Faisal, Banwet, and Shankar (2006)
19.	Logistics	Analysis of interactions among the barriers of reverse logistics	Ravi and Shankar (2005)

Interpretive Structural Modelling (ISM) can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue (Sage, 1977 and Warfield, 1974). ISM provides us means by which order can be imposed on the complexity of such variables (Mandal and Deshmukh, 1994). Table 2 enlists some of the fields in which ISM methodology has been employed.

To understand and simplify the complexity in a subject under study requires a methodical, systematic, and logical approach to find interrelationships between various elements of the subject. Interpretive structural modelling (ISM) is a qualitative tool that was developed by Warfield with the objective of understanding the complex relationships among elements related to a subject. The process starts with the identification of elements in a system, their prioritization and categorization through an understanding of their primacy, precedence, and causality over and among each other through independent and dependent linkages that are represented through a multi-level structural model [Warfield (1976), Gorvett and Liu (2006)].

The ISM methodology is interpretive from the fact that the judgment of the group decides whether and how the variables are related. It is structural too, as on the basis of relationship; an overall structure is extracted from the complex set of variables. It is a modelling technique in which the specific relationships of the variables and the overall structure of the system under consideration are portrayed in a digraph model. ISM is primarily intended as a group learning process, but it can also be used individually. The various steps involved in the ISM methodology are as follows:

Step 1: List all the variables affecting the system under consideration. Variables can be Objectives, Actions, and Individuals etc.
Step 2: Establish contextual relationship among variables identified in step 1 with respect to each other.
Step 3: A Structural Self-Interaction Matrix (SSIM) is developed for variables, which indicates pair wise relationships among variables of the system under consideration.
Step 4: Reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a variable A is related to B and B is related to C, then A is necessarily related to C.
Step 5: The reachability matrix obtained in Step 4 is partitioned into different levels.

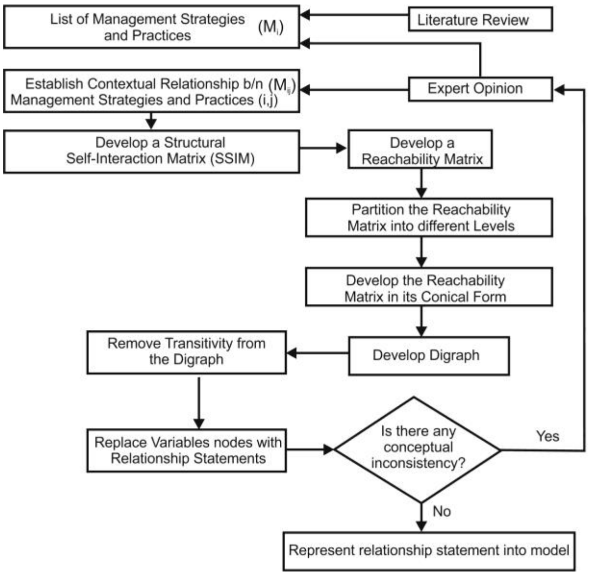

Fig. 1 Methodology for development of ISM model

Step 6: Based on the relationships given above in the reachability matrix, a directed graph is drawn and the transitive links are removed.
Step 7: The resultant digraph is converted into an ISM, by replacing variable nodes with statements.
Step 8: The ISM model developed in Step 7 is reviewed to check for conceptual inconsistency and necessary modifications are made.
These steps of ISM modelling are illustrated in Figure 1.
As per step 1, Management Strategies and Practices to achieve World Class Manufacturinghave been designated in Table 1.

4. ISM Methodology and Model Development

4.1 Structural Self-Interaction Matrix

ISM methodology suggests the use of the expert opinions based on various management techniques such as brain storming, nominal technique, etc., in developing the contextual relationship among the strategies. Thus, in this research for identifying the contextual relationship among the strategies, experts from the industries and academia having an average experience of more than 20 years were consulted.
Keeping in mind the contextual relationship for each strategy, the existence of a relation between any two strategy (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the strategies (i and j):
V: Strategy i will help in achieving strategy j;
A: Strategy j will help in achieving strategy i;
X: Strategy i and j will help in achieving each other; and
O: Strategy i and j are unrelated.

Table 3 Structural Self-interaction Matrix (SSIM)

	M2	M3	M4	M5	M6	M7
M1	X	O	V	A	O	A
M2		X	A	A	X	X
M3			A	O	A	V
M4				A	A	A
M5					O	A
M6						X

Table 3 shows the use of symbols V, A, X, and O in formation of SSIM.

4.2 Reachability Matrix

To convert the SSIM into the binary reachability matrix with the dependence and enabling power all V, A and X is replaced by a digit 1 and O by 0 (zero). The substitution of 1s and 0s are according to the following rules.
- If the (i,j) entry in the SSIM is V, the (i,j) entry in the reachability matrix becomes 1 and the (j,i) entry becomes 0.
- If the (i,j) entry in the SSIM is A, the (i,j) entry in the reachability matrix becomes 0 and the (j,i) entry becomes 1.
- If the (i,j) entry in the SSIM is X, the (i,j) entry in the reachability matrix becomes 1 and the (j,i) entry also becomes 1.
- If the (i,j) entry in the SSIM is O, the (i,j) entry in the reachability matrix becomes 0 and the (j,i) entry also becomes 0.

The initial reachability matrix developed on the basis of the above procedure is presented in Table 4.

Table 4 Initial Reachability Matrix

	M1	M2	M3	M4	M5	M6	M7
M1	1	1	0	1	0	0	0
M2	1	1	1	0	0	1	1
M3	0	1	1	0	0	0	1
M4	0	1	1	1	0	0	0
M5	1	1	0	1	1	0	0
M6	0	1	1	1	0	1	1
M7	1	1	0	1	1	1	1

The final reachability matrix is obtained by incorporating the transitivity's as enumerated in Step 4 of the ISM methodology. This is shown in Table 5. In this table, the driving power and dependence of each strategyis shown. The driving power of a particular strategy is the total number of

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strategies (including self) which it may help achieve. The dependence is the total number of strategy which may help achieving it. These driving power and dependencies will be used in the MICMAC analysis, where the strategies will be classified into four groups of excluded, dependent, relay, and influential (driver) strategies as detailed below.

Table 5 Final Reachability Matrix

	M1	M2	M3	M4	M5	M6	M7	Driver Power
M1	1	1	1	1	0	1	1	**6**
M2	1	1	1	1	0	1	1	**6**
M3	1	1	1	1	1	1	1	**7**
M4	1	1	1	1	0	1	1	**6**
M5	1	1	1	1	1	1	1	**7**
M6	1	1	1	1	0	1	1	**6**
M7	1	1	1	1	1	1	1	**7**
Dependence	**7**	**7**	**7**	**7**	**3**	**7**	**7**	

Excluded Strategies – These strategies are close to the origin of the matrix having low driving power & low dependency. Also called Independent strategies or autonomous strategies, they have a weaker link to the system and do not influence future of the system.
Dependent Strategies – Also known as resultant strategies, these strategies have low driving power & high dependency and are influenced by both influential strategies and relay strategies.
Relay Strategies – These strategies have high influence and high dependency and are unstable. Also known as linkage strategies, any actions towards these strategies may relay back through other strategies.
Influential Strategies – These strategies have high driving power & low dependency.

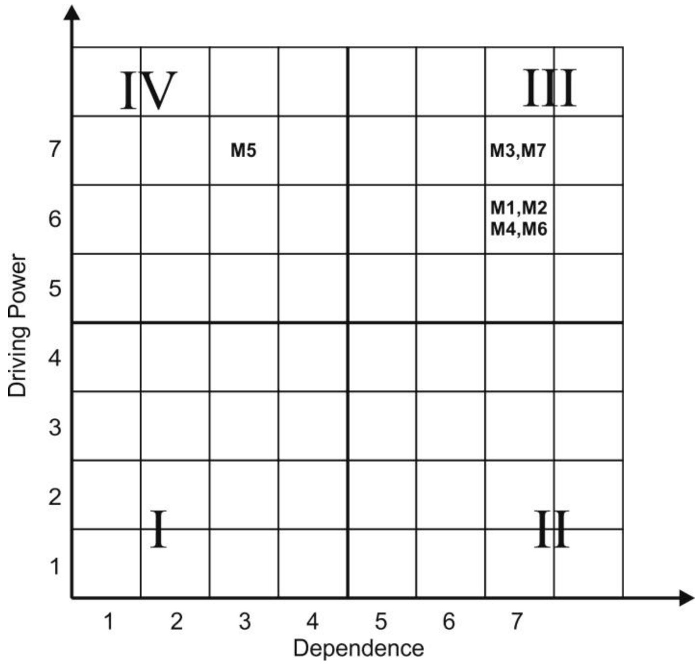

Figure 2 Driving power and dependence diagram

The various levels of this analysis involve the strategies reachability set, antecedent set and intersection set. The reachability set consists of the strategies itself and the other strategies, which it may help achieve. The antecedent set consists of the strategies itself and other strategies, which may help achieving it. Thereafter, intersection of these two sets is derived for all strategies. One by one the strategies having the same reachability set and intersection set are eliminated in each iteration. The results of the iterations are reproduced in Table 6.

Table 6 Iteration 1

Criterion	Reachability Set	Antecedent Set
M1	M1,M2,M3,M4,M6,M7	M1,M2,M3,M4,M5,M6,M7
M2	M1,M2,M3,M4,M6,M7	M1,M2,M3,M4,M5,M6,M7
M3	M1,M2,M3,M4,M5,M6,M7	M1,M2,M3,M4,M5,M6,M7
M4	M1,M2,M3,M4,M6,M7	M1,M2,M3,M4,M5,M6,M7
M5	M1,M2,M3,M4,M5,M6,M7	M3,M5,M7
M6	M1,M2,M3,M4,M6,M7	M1,M2,M3,M4,M5,M6,M7
M7	M1,M2,M3,M4,M5,M6,M7	M1,M2,M3,M4,M5,M6,M7

The levels of the strategies helps in formulating the ISM model wherein first level means topmost priority towards implementation of concerned strategy, second level means second priority towards implementation of concerned strategy and so on.
Having identified the levels of the strategies through a number of iterations, the relationship between the strategies is drawn indicating the direction of the relation with the help of an arrow. The digraph drawn thus is examined to eliminate transitivity of relationships. The final model arrived at is represented by Figure 3.

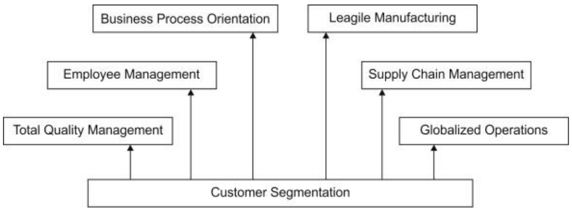

Figure 3 Driving power and dependence diagram

5. Conclusions and future scope

MICMAC analysis helps in the analysis of driver power and the dependence power of the strategies under study. The strategy of Customer segmentation has been found to be categorised in cluster IV (Figure 2). It means customer segmentation has high driving power which regulates all other strategies and practices ultimately leading to a world class manufacturing company. All other strategies fall under cluster III, which means they are highly unstable and any changes in them is reflected back with concerned changes in other strategies. It also reveals the fact that as a world class manufacturing industry one has to always keep on improving and keeping itself abreast with latest technologies to augment customer requirements within stipulated time period.
In future data from world Class Company may be collected to validate the model.

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