RELATIONSHIP AMONG PRINCIPLES OF LEAN MANUFACTURING, SUPPLY CHAIN CHARACTERISTICS, MANUFACTURING STRATEGIES AND PERFORMANCE

THESIS

Submitted in fulfilment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

J.C. BOSS UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA

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DECLARATION

I hereby declare that the thesis entitled '**RELATIONSHIP AMONG PRINCIPLES OF LEAN MANUFACTURING, SUPPLY CHAIN CHARACTERISTICS, MANUFACTURING STRATEGIES AND PERFORMANCE'** by **RAJENDER KUMAR,** being submitted in the fulfillment of the requirements for the Degree of Doctor of Philosophy in **MECHANICAL ENGINEERING** under Faculty of Engineering & Technology, J.C. Boss University of Science & Technology, YMCA, Faridabad, during the academic year 2019, is a bonafide record of my original work carried out under guidance and supervision of **Dr. VIKAS KUMAR** (Professor, Mechanical Engineering Department, J.C. BOSS University of Science and Technology, YMCA, FARIDABAD and **Dr. SULTAN SINGH**, Joint Director, Directorate of Technical Education, Panchkula, Haryana.

I further declare that the thesis work has not been presented elsewhere. In addition, the work carried out by me doesn't contain any work which has been submitted for the award of any degree either in this university or in any other university.

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CERTIFICATE

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We further declare that to the best of our knowledge, the thesis does not contain any work which has been submitted for the award of any degree either in this university or in any other university.

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ABSTRACT

The product's features and parameters (variety in the products) demanded by the customer in the present scenario are reducing the organization's competencies to compete nationally as well as globally. Due to this, the organizationsfail to manage its equipment and facilities in anoptimal manner. This further leads to the infrastructural adequaciesand inabilities to capture the market and cater the customer demand in-time.

The present government of India has the motto to enhance the efficiency and effectiveness of the manufacturing context. Also the Indian entrepreneurs are looking for their share in the global market. The literature published earlier depicts that the Indian manufacturing industry performance has huge affection by the socio-cultural behavior among employees and employers i.e. affected communication channel, the work culture, and environment etc.

The present study discusses the relationship between the lean principles, supply chain characteristics, organizational performance and the manufacturing strategy. The study also discusses the leanness of the supply chain i.e. coupling of two different approaches with variation in perspectives, results in providing the pull-production (what the customers want at the best in class cost) instead of push-production (for which customer never wants to pay). As the literature reveals that the lean manufacturing approach supports the manufacturer's perception (results in significant increases in productivity and quality) whereas the supply chain management supports the customer's and supplier's perceptions (gradual reduction in the process lead-time).

This research study integrates the two approaches and depicts their combined effect on manufacturing organizational outcomes. The work includes the design of the theoretical model using the Structural Equation Modeling approach that explains the lean manufacturing and the supply chain characteristics have the impact on the organizational performance. The evaluation of the model is done in AMOS 20 software using the data collected through the survey questionnaire from the industry experts.

In addition, the Interpretive Structure Modeling approach is used to establish the contextual relationship (based on causal approach) among the variables identified for lean manufacturing, supply chain characteristics performance,and the workculture. The ISM approach reveals the researcher/practitioners to understand the relationship and help them to identify the variable based upon the contribution in the final cause. The MICMAC Analysis analyzed the behaviors of all the variables identified and categorized the variables in the dependence/driving/independence/autonomous zones.

The main aimto establish this relationship is to set- out the focus of all entrepreneurs oncustomer satisfaction and at thelowest cost of the product.This study provides the valuable insights for the researchers and the practitioners whose research, especially seeks in the area of improvement in organizational performance. The present work reveals the impact on organizational performance by coupling the lean manufacturing approach in the organizational supply chain, i.e. operational excellence; enhance customer services; optimum resource utilization and ultimately, the strategic excellence etc. to prosper and indeed survive on the organizations in the present competitive environment.

TABLE OF CONTENTS

Candidate's Declaration	i
Certificate of the supervisor	ii
Acknowledgement	iii
Abstract	iv-v
Table of Contents	vi-ix
List of Tables	x-xi
List of Figures	xii-xiv
List of Abbreviations	xv

Chapter No.		Description	Page No.
1		**Introduction**	1-22
	1.1	Introduction	1
		1.1.1 What is manufacturing process?	2
		1.1.2 Journey of the manufacturing context	3
		1.1.3 Basic consideration of the manufacturing process	4
		1.1.4 Concept of lean manufacturing in the manufacturing context	6
		1.1.5 Concept of supply chain management in the manufacturing context	11
	1.2	Problem formulation	14
	1.3	Motivation of the work	16
	1.4	Objectives of the study	17
	1.5	Significance of the study	18
	1.6	Summary of the Dissertation Report	19
	1.7	Chapter summary	21
2		**Literature Review**	23-53
	2.1	Introduction	23
	2.2	Lean Manufacturing: An Overview	24

		2.2.1 Lean manufacturing history	26
		2.2.2 Goals and objectives of lean manufacturing	28
		2.2.3 Lean manufacturing tools/techniques	30
		2.2.4 Lean manufacturing limitations	33
	2.3	Supply Chain Management: An Overview	33
		2.3.1 History of supply chain management	35
		2.3.2 Objectives of managing the supply chain	36
		2.3.3 Barriers in the supply chain	39
		2.3.4 SCM benefits	40
		2.3.5 Principles of supply chain	42
		2.3.6 Limitations of the supply chain	43
	2.4	Manufacturing strategies	43
	2.5	Performance	46
	2.6	Structural Equation Modeling	48
	2.7	Interpretive structural modeling	52
	2.8	Chapter summary	53
3		**Research methodology**	54-62
	3.1	Introduction	54
	3.2	Statement/description of the problem	55
	3.3	Research design	57
		3.3.1 Sampling frame	58
	3.4	Designing and developing the questionnaire	58
	3.5	Data collection, analysis, and validation	59
	3.6	Chapter summary	62
4		**Data analysis and interpretation**	63-142
	4.1	Introduction	63
	4.2	Lean Manufacturing in the manufacturing system	64
	4.3	Supply Chain Management in the manufacturing system	81

	4.4	Performance of the manufacturing system	97
	4.5	Validity of results analysis using Confirmatory Factor Analysis	112
	4.6	Lean Manufacturing impacts on the organizational Performance	118
	4.7	Supply Chain Management impacts on the organization Performance	124
	4.8	Structure Equation Model and result validation for the present study	130
	4.9	Path Analysis and result validation for the present study	137
	4.10	Chapter summary	142
5		**Research Study Validation using Interpretive Structure Modeling**	143-174
	5.1	Introduction	143
	5.2	Interpretive structure modeling (ISM)	143
	5.3	Implementing ISM approach on lean manufacturing benefits	147
	5.4	Implementing ISM approach on supply chain characteristics	159
	5.5	Implementing ISM approach on performance measures	167
	5.6	Chapter summary	174
6		**Relationship between Lean, Supply Chain and Performance: a model**	175-196
	6.1	Introduction	175
	6.2	Need to call the changes in manufacturingcontext	175
	6.3	Identification of commonalities among lean manufacturing and the supply chain	177
	6.4	Establishing the relationship among lean principles, supply chain characteristics, manufacturing strategy and performance	189
		6.4.1 Benefits of establishing relationship	180
	6.5	Work culture in manufacturing context	182
		6.5.1 Importance of work culture	183
		6.5.2 Identification of work culture enablers	183
	6.6	Work-culture enablers contributing in lean manufacturing and the supply chain	185
	6.7	Implementing ISM approach on work culture enablers	188
	6.8	Chapter summary	195
7		**Results, Conclusion and Future Scope of the Work**	197-204

7.1	Introduction	197
7.2	Summary of research work	198
7.3	Specific contribution of the research work	200
7.4	Limitations of the research work	202
7.5	Scope for future work	203
7.6	Chapter summary	203
	References	205-224
	Publication Details	225
	Annexure-I: Questionnaire	226-229

LIST OF TABLES

Table No.	Description	Page no
2.1	Lean objectives and process requisites	29
2.2	SCM objectives and process requisites	39
2.3	SCM Benefits	42
2.4	Manufacturing Strategies Model	44
4.1	Statements for the construct Lean Manufacturing	66
4.2	Reliability analysis for the construct Lean Manufacturing	68
4.3	Descriptive analysis of the construct Lean Manufacturing	69
4.4	Frequency distribution table for the construct Lean Manufacturing	72
4.5	Analysis summary for the construct Lean Manufacturing	77
4.6	Statistical analysis for the construct Lean Manufacturing	81
4.7	Identification of Supply Chain Characteristics	82
4.8	Statements for the construct Supply Chain Characteristics	83
4.9	Reliability analysis of the construct Supply Chain Characteristics	84
4.10	Descriptive analysis for the construct Supply Chain Characteristics	85
4.11	Frequency Distribution table for the Construct Supply Chain Characteristics	89
4.12	Analysis summary for the construct Supply Chain Characteristics	93
4.13	Statistical analysis of the construct Supply Chain Characteristics	97
4.14	Statements for the construct Performance	98
4.15	Reliability analysis for the construct Performance	100
4.16	Descriptive analysis of the construct Performance	101
4.17	Frequency distribution table for the construct Performance	104
4.18	Analysis summary for the construct performance	108
4.19	Statistical analysis of the construct Performance	112
4.20	Confirmatory factor analysis results for CFA	118
4.21	Regression results of SEM for Lean manufacturing impact on Performance	122
4.22	Statistical fitness analysis for Lean manufacturing impact on performance	124
4.23	Regression results of SEM for supply chain impact on performance	127
4.24	Statistical fitness analysis for Supply Chain impact on performance	130
4.25	SEM results for the present study	135
4.26	SEM goodness fit indices for the present study	137
4.27	Path analysis results for the present study	140
4.28	Path analysis goodness fit indices for the present study	141
5.1	Example for Contextual relation establishment	144
5.2	Example for SSIM	145

Table No.	Description	Page no
5.3	Contextual relationship among lean principles impact in an organization	149
5.4	SSIM (Initial Reachability Matrix)	150
5.5	Incorporating Transitivity (Final Reachability Matrix)	151
5.6	First Level Partition	152
5.7	Second Level Partition	153
5.8	Third Level Partition	153
5.9	Fourth Level Partition	154
5.10	Fifth Level Partition	154
5.11	Level Partition	154-155
5.12	Conical Matrix	157
5.13	Identification of Supply Chain Characteristics	160159
5.14	Contextual relationship among Supply Chain Characteristics	160
5.15	SSIM (Initial Reachability Matrix)	160
5.16	Incorporating Transitivity (Final Reachability Matrix)	161
5.17	Level Partition	162
5.18	Conical Matrix	165
5.19	MICMAC Analysis Summarization	166
5.20	Contextual relationship among performance measures	168
5.21	SSIM (Initial Reachability Matrix)	169
5.22	Incorporating Transitivity (Final Reachability Matrix)	169
5.23	Level Partition	170
5.24	Conical Matrix	172
5.25	MICMAC Analysis Summarization	173
6.1	Modified Manufacturing Strategies Model [	181
6.2	Role of Work-Culture enablers in Lean Manufacturing and Supply Chain	186-187
6.3	Principle of working of Ten Commandments	188
6.4	Contextual relationship among the Work–Culture enablers	189
6.5	SSIM (Initial Reachability Matrix)	190
6.6	Incorporating Transitivity (Final Reachability Matrix)	190
6.7	Level Partition	191
6.8	Conical Matrix	193
6.9	MICMAC Analysis Summarization	194

LIST OF FIGURES

Figure No.	Description	Page No.
1.1	Manufacturing process sample layout	2
1.2	Activities in the manufacturing context	5
1.3	Roadmap to convert lean from non-lean	6
1.4	Success factors for lean manufacturing	9
1.5	Supply Chain Process	12
1.6	Conceptual framework for the present work	21
4.1	Mean score contribution of the scale for the construct Lean Manufacturing	71
4.2	Frequency distribution for the construct Lean Manufacturing	73
4.3	SEM diagram of the construct Lean Manufacturing	75
4.4	Regression weights output for the construct Lean manufacturing	76
4.5	Standardized regression weights output for the construct Lean manufacturing	76
4.6	Squared multiple correlations output for the construct Lean Manufacturing	77
4.7	Model fitness Indices CMIN for the construct Lean Manufacturing	79
4.8	Model fitness Indices CFI for the construct Lean Manufacturing	79
4.9	Model fitness Indices GFI and AGFI for the construct Lean Manufacturing	80
4.10	Model fitness Indices RMSEA for the construct Lean Manufacturing	80
4.11	Mean score contribution of the scale for the construct Supply Chain Characteristics	88
4.12	Frequency distribution for the construct Supply Chain Characteristics	89
4.13	SEM diagram of the construct Supply Chain Characteristics	91
4.14	Regression weights output for the construct Supply Chain Characteristics	92
4.15	Standardized Regression Weights output for the construct Supply Chain Characteristics	92
4.16	Squared Multiple Correlations output for the construct Supply Chain Characteristics	93
4.17	Model fitness Indices CMIN for the construct Supply Chain Characteristics	95
4.18	Model fitness Indices CFI for the construct Supply Chain Characteristics	95
4.19	Model fitness Indices GFI and AGFI for the construct Supply Chain Characteristics	96
4.20	Model fitness Indices RMSEA for the construct Supply Chain Characteristics	96

Figure No.	Description	Page No.
4.21	Mean score contribution of the scale for the construct Performance	103
4.22	Frequency distribution for the construct Performance	104
4.23	SEM diagram of the construct Performance	106
4.24	Regression weights output for the construct Performance	107
4.25	Standardized Regression Weights output for the construct Performance	107
4.26	Squared Multiple Correlations output for the construct Performance	108
4.27	Model fitness Indices CMIN for the construct Performance	110
4.28	Model fitness Indices CFI for the construct Performance	110
4.29	Model fitness Indices GFI and AGFI for the construct Performance	111
4.30	Model fitness Indices RMSEA for the construct Performance	111
4.31	Confirmatory factor analysis for the present study	114
4.32	Regression Weights Output in CFA	115
4.33	Standardized Regression Weights Output in CFA	115
4.34	Covariance Output in CFA	116
4.35	Correlation Output in CFA	116
4.36	Variance Output in CFA	117
4.37	Squared Multiple Correlations Output in CFA	117
4.38	Structural model for construct Lean manufacturing impacts on construct Performance	119
4.39	Regression Weights Output for SEM of construct Lean manufacturing impacts on construct Performance	120
4.40	Standardized Regression Weights output for SEM of construct Lean manufacturing impacts on construct Performance	121
4.41	Squared Multiple Correlations output for SEM of construct Lean manufacturing impacts on construct Performance	121
4.42	Model fitness Indices CMIN for construct Lean manufacturing impacts on construct Performance	122
4.43	Model fitness Indices CFI for construct Lean manufacturing impacts on construct Performance	123
4.44	Model fitness Indices GFI and AGFI for construct Lean manufacturing impacts on construct Performance	123
4.45	Model fitness Indices RMSEA for construct Lean manufacturing impacts on construct Performance	124
4.46	Structural model for construct Supply chain impacts on construct Performance	125
4.47	Regression Weights output for SEM of construct Supply Chain impacts on construct Performance	126
4.48	Standardized Regression Weights output for SEM of construct Supply Chain impacts on construct Performance	126
4.49	Squared Multiple Correlations output for SEM of construct Supply Chain impacts on construct Performance	127
4.50	Model Fitness Indices CMIN for construct Supply Chain impacts on construct Performance	128

Figure No.	Description	Page No.
4.51	Model Fitness Indices CFI for construct Supply Chain impact on constructs Performance	128
4.52	Model Fitness Indices GFI and AGFI for construct Supply Chain impacts on construct Performance	129
4.53	Model Fitness Indices RMSEA for construct Supply Chain impacts on construct Performance	129
4.54	SEM Analysis for the present study	132
4.55	Regression Weights output for SEM for the present study	133
4.56	Standardized Regression Weights output for SEM for the present study	134
4.57	Squared Multiple Correlations output for SEM for the present study	134
4.58	Correlation output for SEM for the present study	135
4.59	Model Fitness Indices GFI and AGFI for SEM for the present study	136
4.60	Model Fitness Indices CFI for SEM for the present study	136
4.61	Model Fitness Indices RMSEA for SEM for the present study	137
4.62	Path Analysis for the present study	138
4.63	Regression Weights output for Path Analysis for the present study	138
4.64	Standardized Regression Weights output for Path Analysis for the present study	139
4.65	Squared Multiple Correlations output for Path Analysis for the present study	139
4.66	Correlation output for Path Analysis for the present study	140
4.67	Model Fitness Indices RMSEA for Path Analysis for the present study	141
5.1	Flow diagram for ISM	147
5.2	Diagraph for Lean Manufacturing benefits	155
5.3	ISM diagram for theLean Manufacturing benefits	157
5.4	MICMAC Analysis ofLean Manufacturing benefits	158
5.5	Diagraph for Supply Chain Characteristics	163
5.6	ISM diagram for Supply Chain Characteristics	164
5.7	MICMAC Analysis ofSupply Chain Characteristics	165
5.8	Diagraph for the Performance measures	171
5.9	ISM diagram for the Performance measures	172
5.10	MICMAC Analysis of the Performance measures	173
6.1	Theoretical model for the present study	180
6.2	Diagraph for the Work-Culture enablers	192
6.3	ISM diagram for the Work-Culture enablers	193
6.4	MICMAC Analysis for the Work-Culture enablers	194

LIST OF ABBREVIATIONS

LM	Lean Manufacturing
TPM	Total Productive Maintenance
TQM	Total Quality Management
5’S	Five S
JIT	Just-in-Time
SCM	Supply Chain Management
SEM	Structural Equation Modeling
ISM	Interpretive Structure Modelling
MS	Manufacturing Strategy
Per.	Performance
Mfg.	Manufacturing
CR	Composite Reliability
AVE	Average Variance Extracted
MSV	Maximum Shared Variance
ASV	Average Shared Variance
Var.	Variance
CFA	Confirmatory Factor Analysis
FA	Factor Analysis
PA	Path Analysis
RMSEA	Root Mean Square Error of Approximation
CMin	Chi-Square Test
CFI	Comparative Fit Index
GFI	The Goodness of Fit index
AGFI	Adjusted Goodness of Fit index
MLR	Multiple Linear Regressions
RA	Regression Analysis
CV	Convergent Validity
DV	Discriminant Validity
Df	Degree of freedom

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The manufacturing sector is the vital arm of the nation as well as the vital consumer for the resources like men, machine, material etc. It is an important contributor to the national economy and the level of manufacturing activities in any country indicates the economic health of that country. It is the presumed terms of the economists which state that the standard of living of the employees has the dependency on the level of manufacturing activity happens in that particular organization. In addition, it is the widest contributor to environmental degradation by creating wastes such as harmful gasses, non-degradable constituents.

Every manufacturing industry used the unique manufacturing style to cater and fulfill customer demand. There are numerous variables for defining the unique manufacturing style which varies from industry to industry. [Hopp, 2008] The quantity and quality of resources for the manufacturing industries varies with industry to industry and also has the dependency on both the manufacturer as well as the customer perspectives. The huge amount is invested on manufacturing activities like procurement of the raw resources, on the facilities (used for conversion of raw material in the finished product) and on the transportation of finished material (delivery to customer end) etc. [Skinner, 1974; Arora, 2004]

The decision regarding the resources (selection and consumption) for the manufacturing context is the first and foremost step. It is a very tough task to decide regarding the resources for the manufacturing process. [Skinner, 1985; Chandra and Sastry, 1998] Most of the time, the wrong planning/decisions regarding the resources procurement and their utilization are taken by the manufacturer because of uncompleted information or supporting data for decisions. This further leads to affect the entire working system of the industry. In the past three decades, the manufacturing scenario has undergone the major changes because of the reasons like new technology innovation; changes in the economic environment; the presence of dynamism in customer needs; globalization of the market etc.

1.1.1 What is the manufacturing process?

The Latin word, manufactus, derived the term ‘manufacturing’ which means ‘anything made by hand’. In general, the primary inputs of the manufacturing sector are the men, machines, materials, money, and methods (5M’s). The input resources are converted into useful products passing through a pre-defined sequence of operations. The finished product is then delivered to the end-customer for the use. [Slack, 1987; Gupta et al., 2012; Kumar et al., 2014] The general layout of the manufacturing process is shown in figure 1.1 which depicts the activities in the manufacturing process as well as their respective roles/contribution in a manufacturing context.

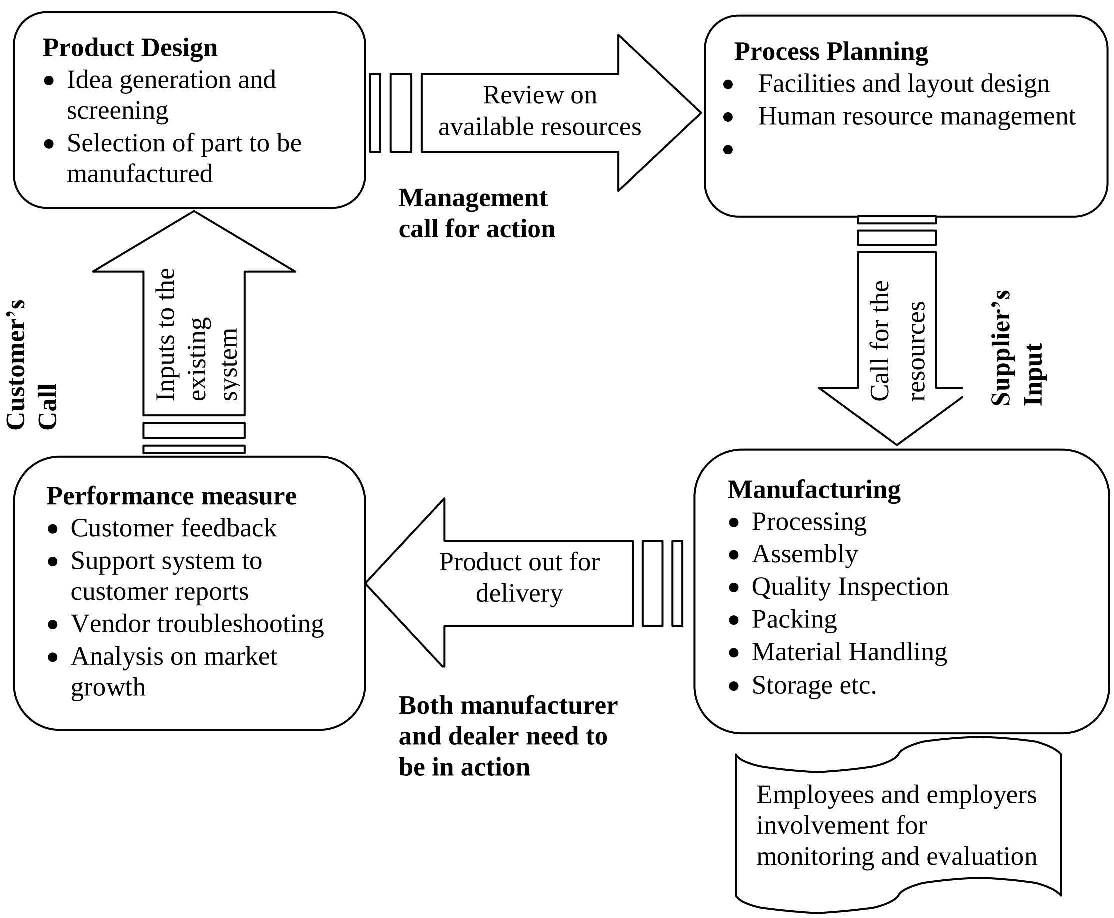


Figure 1.1: Manufacturing process sample layout

The manufacturing of goods (also known as manufacturing process) involves the various activities like procurement, operation, inspection etc. and the well-organized plan for each activity is defined at the beginning of the manufacturing process. The traditional manufacturing is based on the pull production which includes activities such as design, machining and quality inspection of the product etc. [Skinner, 1974]

The manufacturing is categorized into two types based on the operations i.e. discrete manufacturing and continuous manufacturing. The discrete manufacturing includes the production of products with variety and in batches; whereas the continuous production includes the production of the same kind of products in the long run.

1.1.2 Journey of the manufacturing context

At the early age of the twentieth century, Henry Ford (owner of Ford Company) introduced the concept of mass production in the Ford Company. He reported that the performance of an organization is dependent on the efficiency and effectiveness of the man-machine management system used in the organization. At that time, the craft production was very popular and facing the problem to meet the high demand. [Evans and Lindsey, 2004] His work on mass production based on standardized process admires the other manufacturing giants especially in the automobile sector in the world to produce the goods in shorter manufacturing cycle with reduced cost.

After that Frederick Winslow Taylor, an American Mechanical Engineer (known as the father of Industrial Engineering) worked on industrial efficiency improvement. His studies and working on the industrial efficiency improvement were conceived and appreciated by the American industries during the 1890's to 1920s. His book on '*The Principles of Scientific Management*' was pioneered and used as the basis for the factory floor design and development until today. His works help the manufacturers to think of modified ford production lines (design and functioning). [Taylor, 1911; Sharma and Sharma, 2009]

In continuation of the industrial revolution, Deming (1920) devised the statistical quality control tools to help the manufacturing sector on the quality front. He developed the tools to identify the defectives production and the causes by which defect occurs. The literature on manufacturing sector reveals that the mass production in the manufacturing context was the first revolution. Later on, the manufacturing system efficiency and effectiveness of the organizational activities are considered as the important parameters. [Buffa and Sarin, 2011]

1.1.3 Basic consideration of the manufacturing process

The manufacturing process basically works on conversion/transformation principle i.e. procured raw material is converted into the final product/commodities as desired by the customer through processing it on various workstations. [Gupta et al., 2012] The flow of all the resources is oriented in such a manner (sequenced properly) that every workstation aligned to the process can perform/contribute as the productive operation in-time. [Dangyayach and Deshmukh, 2005] Through passing the raw data to each station within the manufacturing system, the value addition is done and passed to the successor work-station for the next operation. With the value addition process, some non-value added activities like, over processing, over-production also happens. These non-values added activities are also termed as wastes and characterized as Muda (non-value adding work), Muri (Overburden), and Mura (unevenness). [Feld, 2001; Monden, 2010] These wastes never add the value in the final product but consume the resources. In addition, the customers are also not willing to pay for these non-value added activities. [Ahlstorm, 1998] These activities can be broadly categorized in three ways that are:

1. **Customer Value-Added:** Value-added activities are those activities, which are acceptable to the customer because the value-addition process adds the value in the product. Also, the customer pays willingly for these activities. These activities are essential to the manufacturing process, therefore, need to maintain. i.e. The machining of the components in the manufacturing process adds value in the final products as good surface finish, shaping etc.
2. **Wastes (Non-Value Added):** The activities, which do not contribute/ add value to the product, are considered as non-value addition activities. These activities are not part of established process practices. Still, these activities can do for the betterment of

the product. For example, the chemical coating/chrome plating on aluminum alloys may not be required as part of the manufacturing process but if carried out shall add to the cost which may not be acceptable to the customer.

3. **Business value Added (Necessary but Non-Value Added):** The movement of material from one work-station to another at the shop floor provides support to the manufacturing process by reducing the lead-time. These movements of material never add value to the product but add some cost to transport of material in the final product cost. Figure 1.2 shows the various activities in the manufacturing context. [Monden, 1993]

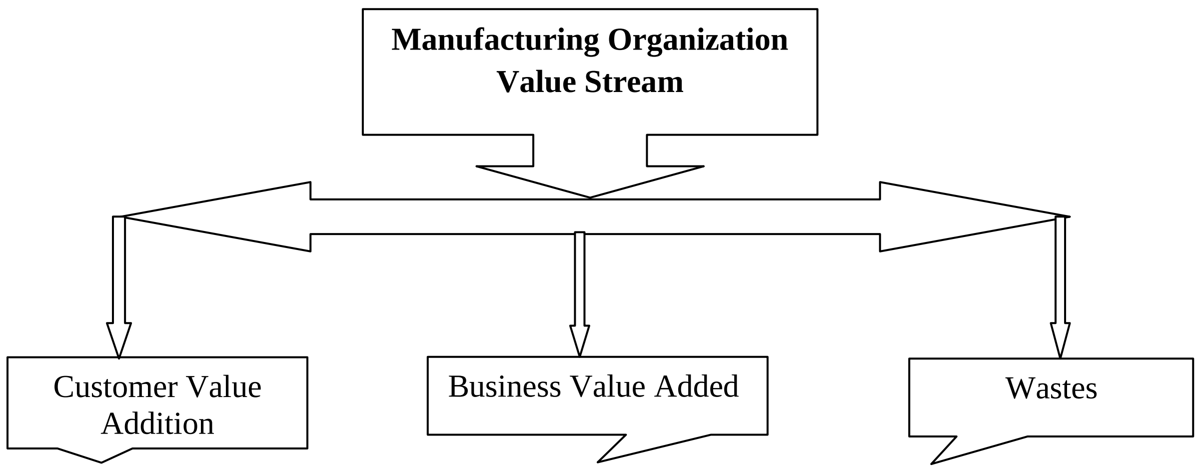


Figure 1.2: Activities in the manufacturing context [Gopalakrishnan, 2016]

The following considerations are used to develop the organizational resource flow stream for the manufacturing systems:

- Optimized resource consumption through the standardized flow
- Induction of flexibility in the plant layout to cater to the need of the customers regarding new/modified products
- Reduction in the equipment setup time
- Workforce welfare (appointment of right people for the given task)
- Effectiveness in the planning and scheduling of the process
- Availability of modular production tools with variants
- In-time delivery of goods/services at reduced cost

- The adequate customer support system

1.1.4 Concept of lean manufacturing in the manufacturing context

Lean manufacturing is also known as 'lean production' or 'lean principles' is a tool especially for shifting the manufacturing paradigm based on the various fundamental goals developed for continuous minimization of wastages from the processes. [Emiliani, 1998] It is all about taking care of the timeline begins from the moment the customer gives an order to the point when the customer returned cash against the receiving of goods. [Shah and Ward, 2003] In the present scenario, almost all the manufacturing industries want to become lean. To do so, the organizations are intended to focus on the *customer perception*, which further leads to building a sustainable competitive advantage. [Bhasin & Burcher, 2006; Abdulmalek & Rajgopal, 2007; Sahoo et al., 2007] The roadmap to be lean is shown in figure 1.3.

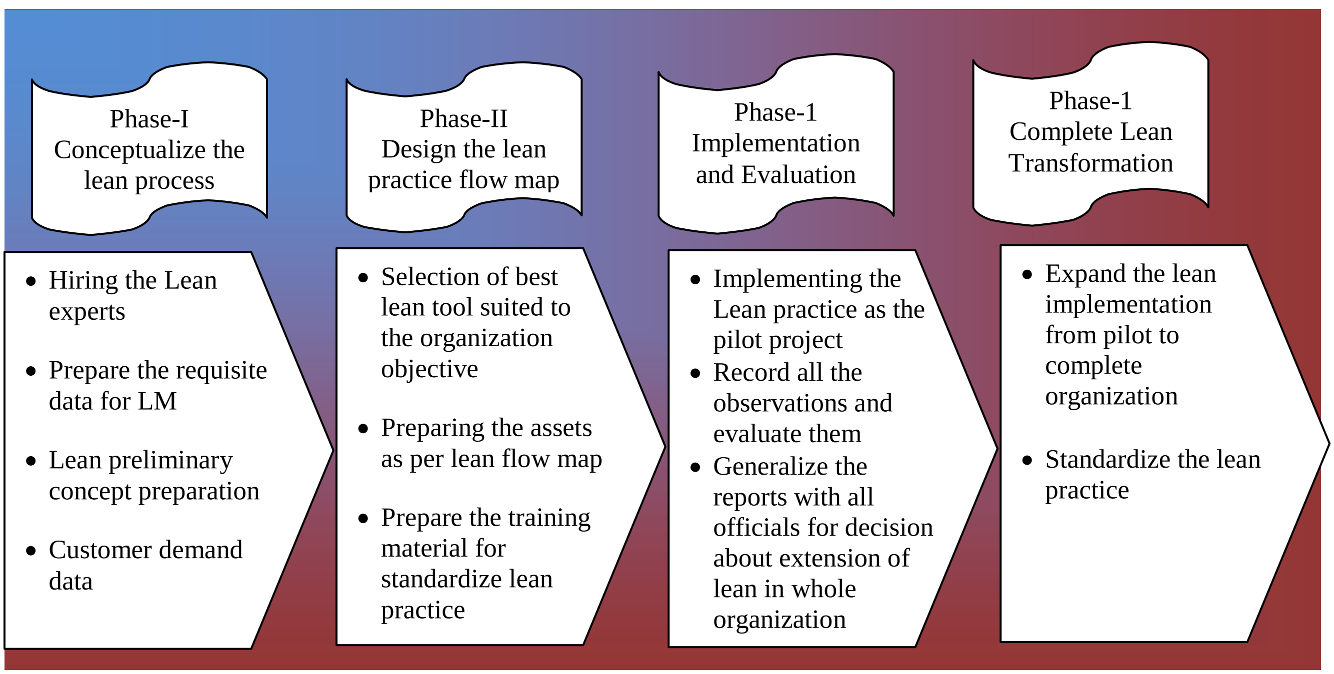


Figure 1.3: Roadmap to convert lean from non-lean

The theoretical fundamentals of lean got more attention through the worldwide manufacturing sector at that time. The researchers on lean manufacturing in the earlier years on lean manufacturing highlights the superiority of Japanese manufacturers in the worldwide market, especially the Toyota Company as a global leader at that time. [Burton and Boeder, 2003; Anand and Kodali, 2009; Singh et al., 2010 (a)] The implementation of lean manufacturing in the manufacturing context reveals the aspects as follows:

- Design effective and better policies,
- Provide the clarity of objective and goals,
- Provide coordination and cooperation among employees,
- Infusion of the fresh talent, and
- The effective grievance redresses system for the employees.

In the manufacturing context, the concept of lean manufacturing commences from identification of the non-value adding activities to the elimination of these activities. [Bhasin and Burcher, 2006; Anand and Kodali, 2008] The wastes in the manufacturing process are referred to as TIMWOOD and explained below:

- **Transport Wastes:** The transport waste means the unnecessary movement of resources within the organization, which never adds any value to the final product. Instead, value addition the unnecessary movement materials from one location to another add the extra cost of the product. The customer has no concern with the internal transportation of the material because he has a direct concern with the final product/service only. The literature reveals that the resources were exhausted during the transportation process results in an increased production cost of the product/services.
- **Inventory wastes:** The inventory refers to the unnecessary holding of raw material, WIP goods or finished goods. These items incur a cost for storage and handling purpose. In addition, the inventory wastes hide many of the other wastes like space consumption, extra manpower for logistics; and, always has the risk of being damaged during transport or becoming obsolete.
- **Motion wastes:** The unnecessary motion of resources (4’M) like the excessive travel b/w the workstations or the excessive manpower movements always has the domination of the production capacity of the plant. The unnecessary motion costs to

the final process, which is being used for manufacturing the product instead of value addition.

- **Waiting wastes:** The waiting in the production process has a major influence on the production quantity and always results in inventory cost. The waiting means how much time the product will wait for the processing to the succeeded workstation. This kind of waste disrupts resource flow results in an additional cost which is almost 20% of the total cost incurred to manufacture the product.
- **Overproduction wastes:** This kind of waste is the most serious amongst all others because of working with oversize batches, long lead times, poor supplier relations and a host of other reasons like high levels of inventory, supply chain flexibility.
- **Over-processing Waste:** This waste is directly associated with the process used for the transformation of raw material into the final product/services. The main reasons for over processing are obsolete tools and techniques; over-sizing of the equipment, and perform processes that are not depicted by the customer and so forth. The over processing of the materials always cause the cost and the increased production lead time.
- **Defect:** Almost all the organizations try to prevent the process where possible to produce the defect-free production instead of identifying the cause and evaluation of their effects. This type of waste contributes to a very small amount of wastages. [Monden, 1988; Womack et al., 1990; Forza, 1996; Ahlstrom, 1998; Amako-Gyampah, 2000; Bozdogan et al., 2000; Carreira, 2007; Anand and Kodali, 2009(a); Upadhyay et al., 2010; Bayo-Moriones et al., 2010]

At present, the seven wastages listed and explained above are increased to 9 in nos. as follows:

- **Talent Waste:** This type of waste is directly associated with the workforce performance of the organizations because the workforce is considered as the greatest asset by far and can help the organization to drive out the other kind of wastes. The organizations still tend to operate within a common command and close control environment. This is because of a waste of talent i.e. using the workforce as the industry need not as per the capability of the workforce. [Threja, 2011; Fehr, 2012; Threja, 2015]

- **Space Waste:** The un-intended inventory and other resources always seek to cover some floor space in an organization. Due to this fact, the organizations lose the opportunity to utilize the floor space to extend their business entities. [Hines et al., 2004; Gupta et al., 2012; Belokar et al., 2012; Kumar et al., 2014; Kumar and Kumar, 2015] The success factor of lean manufacturing is shown in figure 1.4.

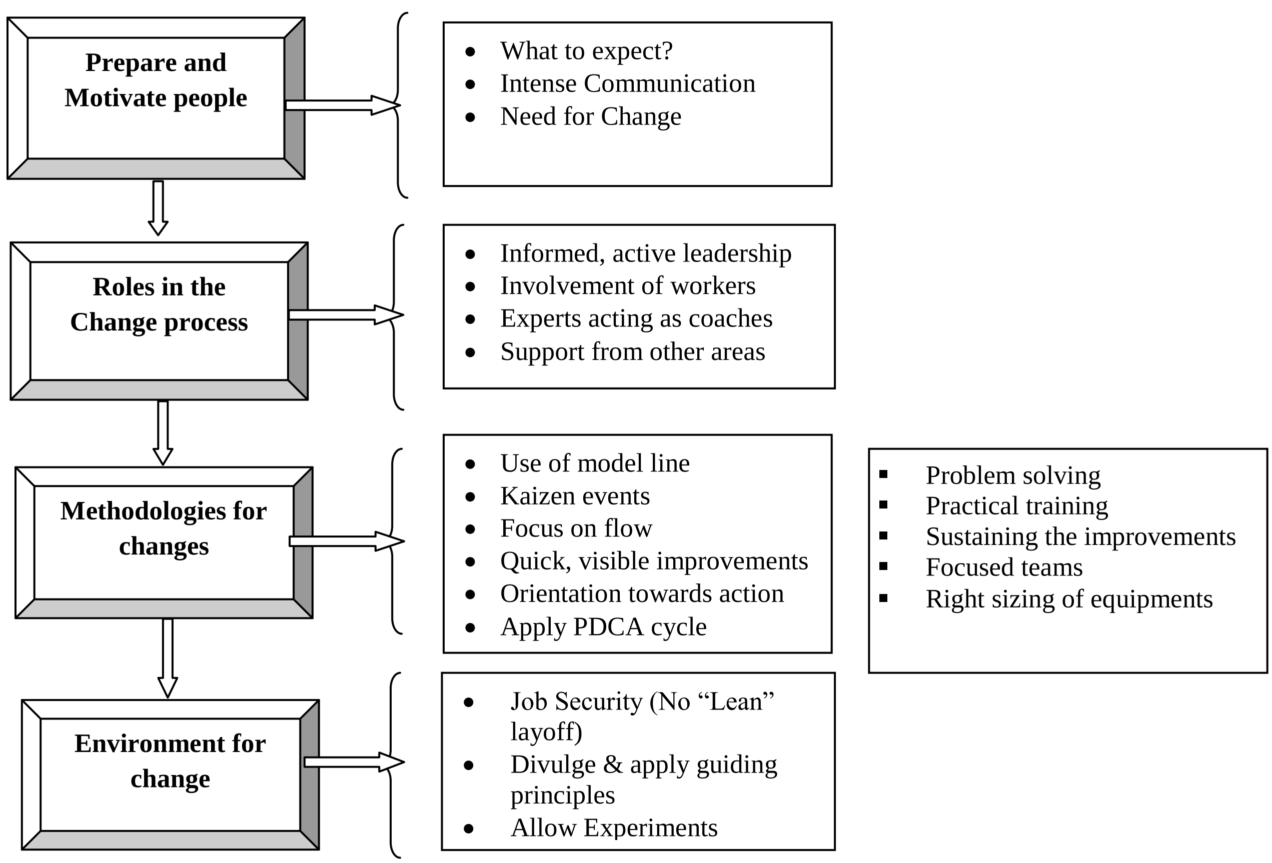


Figure 1.4: Success factors for lean manufacturing [Duque & Cadavid, 2007]

The five distinct principles of lean dictated by Womack et al. (1990) are as detailed below:

- ✓ **Specify Value:** The first and foremost principle of lean manufacturing is to identify the need of the customer. This principle seeks to know what the customer actually wants.

- ✓ **Identify the Value Stream:** After specifying the value to the customer, the whole value stream with which the product/resources flow in the process is mapped to identify the waste activities (nonvalue-added activities). This process is also known as value stream mapping. All the facts and facets of the products/process are mapped for eliminating the nonvalue-added activities (bottlenecks) from the process.
- ✓ **Make the Product Flow:** Developed the new process layout according to the customer perception so-that the goods/services produced has been appreciated by the customers. The developed value stream should be flexible and uninterrupted in nature to cause the value stream.
- ✓ **Customer Pull:** This principle seeks to provide a competitive advantage to the organizations by connecting the customer demand with the organizational efficiency. The organizations produced only those items/services for which the customer deliberated his willingness to pay.
- ✓ **Pursuit the Perfection:** This principle bounds the process to eliminate the waste by doing right for the first time. Pursuit perfection also refers to sustain the organizational efficiency and effectiveness for a long time. [Womack, 1990]

The various objectives of lean manufacturing approach are as follows:

- To help the manufacturing setups through implying the flexibility and make them suitable for uninterrupted material flow, optimized man-machine movements, less no. of setup changes (only desired) and effective occupation of resources (optimum).
- To make the system adequate smart enough to cater to the customer’s demand (pull production) and satisfying them
- To reduce the production and delivery lead-time to serve the customer in a better manner.
- To motivate the employees for group efforts i.e. each one is looking at the organizational goal as their own and trained them to achieve this in a systematic manner.
- To inspire all the personals to reduce the occurrence of non-value-added activities in the manufacturing processes.

- To provide the adequate knowledge and skills to the personals for selection of right tools for gaining the competitive advantages by excelling the firm performance in terms of productivity, quality, cost, delivery, safety, and morale.
- To have the focus on working with lesser resources and delivering the better output with reduced efforts. [Mcdonald et al., 2002; Belokar et al., 2012; Nordin et al., 2012; Kumar et al., 2015(a,b)]

1.1.5 Concept of supply chain management in the manufacturing context

In 1887, **William Cooper Procter** *(grandson of the founder of Procter & Gamble,)* addressed the workforce and motivates them to adopt the quality merchandise as the first job. The quality merchandise helps the customer to keep on buying the products and for every sold product the workforce has their share. Also, he points out the three major concerns with manufacturing context is *productivity, cost, and quality*. [Evans and Lindsay, 2004] While working in an organization either manufacturing or service sector, it becomes necessary to understand the concept of the supply chain for all. Supply chain involves the working professional from top to the bottom levels. [Bhagwat and Sharma, 2007] It is the interlinking chain of various processes happens in an organization i.e. planning, design, and flow of resources from one workstation to the other until the final product is delivered to the customer. [Altekar, 2005] Figure 1.5 shows the general layout for the supply chain in the manufacturing context.

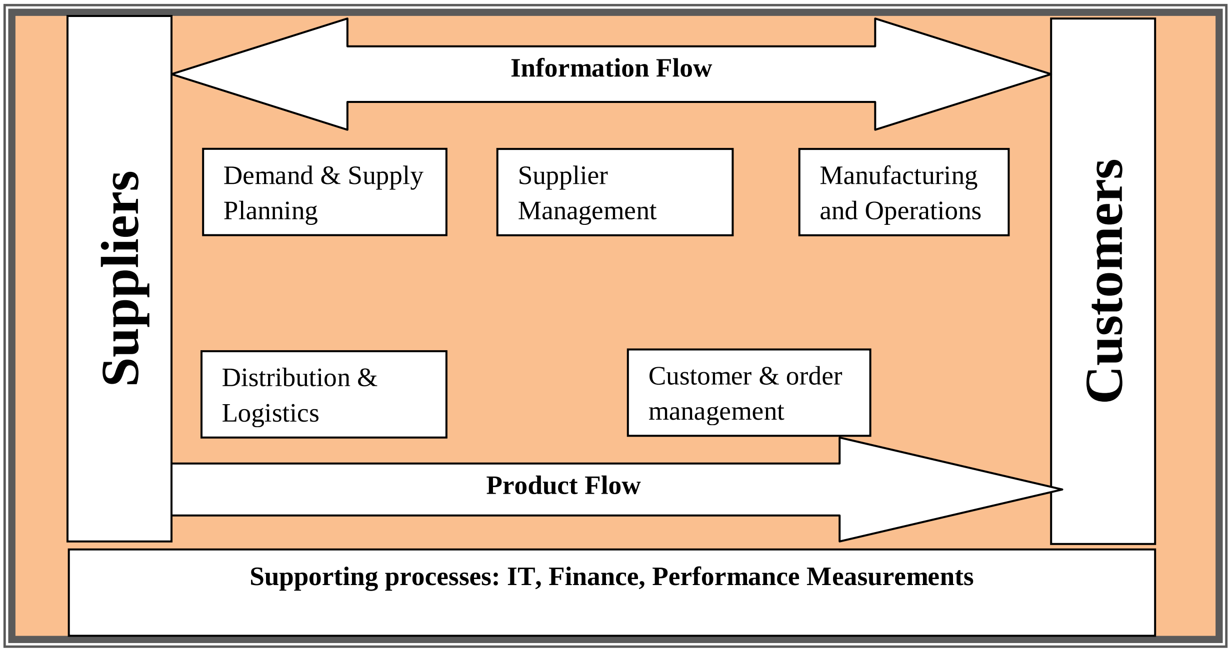


Figure 1.5: Supply Chain Process [Mangal, 2011]

Supply chains of both manufacturing and service sector would remain dynamic in nature because it has to curtail changes over a period. Also, each one the manufacturer, distributors/supplier and the customer has their own perspectives detailed below and all are dominating each other:

- **Manufacturers:** The manufacturer has the perspective to produce the goods/services, which cater the need of the customer for the longer period duration.
- **Distributors/Supplier:** Both distributors and suppliers always seek for optimizing the resource utilization i.e. lower the inventory level, reduced transportation costs, and the quick replenishment capability.
- **Customers:** The customer perspective always conflicting with the manufacturer and distributors because they are looking for in time delivery, which often delayed by them because of their internal process of managing the goods. Also, the customer dictates the manufacturer or distributor of high in-stock inventory with a wide range of variety of products and the lowest prices for goods. [Lambert and Cooper, 2000]

"SCM is a set of approaches used to efficiently integrate suppliers, manufacturers, Warehouses, and stores so that the merchandise is produced and distributed at the right quantities to the right locations and at the right time in order to minimize system-wide cost while satisfying service level requirements". [Simchi-levi et al., 2004] It includes not only the producer of goods/services, suppliers, and the distributors but also the transportation and logistics providers, the warehouses and the customers themselves. [Shah and Singh, 2001; Chopra et al., 2003; Singh, 2014] The four supply chain drivers are as follows:

- **Facility:** The first driver for supply chain is the facilities, which the companies have in actual. The exact assessment of facilities dictates the capability of the organization to deal with customer and respond to the customer query. It also helps in taking the decision within and outside the organization for procuring/hiring of resources and selling of goods/services.

- **Inventory:** Every organization want to manage their inventory because if the inventory is not managed by organization there may be the overproduction/shortage which further leads to monetary loss to the organization,

- **Transportation:** Transportation of the goods generally refers to the transport of goods from one place to another. It is of two types external and internal. Transportation of goods within the organization i.e. raw material transported from one machine to other (known as work in progress inventory) is the internal one and the supply of goods from supplier to producer and from producer to the end customer.
- **Information:** This is the most important driver of SCM. Information is nothing but sharing and collection of data which will further process for finding the state of nature for a given situation to decide further actions. The adequate information always helps the decision maker to take the right type of decisions. [Chopra et al., 2003; Gunasekaran and Ngai, 2004; Kumar et al., 2016]

The role of SCM is very important in performance measures and metrics in the success of an organization. As the complexity of the organizational structure becomes the biggest obstacle to the successful implementation of SCM and affects the strategic, tactical and operational decisions of the organization. [Boyson et al., 1999; Gunasekaran et al., 2001; Mentzer et al., 2001; Mangal, 2013] The most common objectives of supply chain management are as follows:

- To have a competitive advantage in various activities like procurement, production, distribution, and logistics
- To design and develop the procedures/policies for efficient outsourcing of material
- To reduce the costs of inventory by managing the resource utilization
- To meet with customer demand and provide a wide range as per the customer capability
- To meet the challenge of globalization and longer supply chains
- To meet the new challenges from e-commerce
- To manage the complexities of supply chains
- To manage the inventories needed across the supply chain

In the present scenario of globalization, the superior quality goods/services at low cost with the after sale service at the customer end are the few conditions defined by the customer that enforce the entrepreneurs to cut the corner on cost, quality, and delivery fronts. [Mangal, 2013(a)] Ever-increasing customer demands with variations by the customers put the pressure on organizations for dramatic changes in the existing products/services. That's-why supply chain management become an important topic for the research and discussion for both practitioners as well as academicians.

1.2 PROBLEM FORMULATION

No doubt, we all are living in constantly changing the world. The main driven force for these changes is the human's perspective or behavior of the population, which never remains constant. At the beginning of 19th century, the customer perception is the main driving force to run any business reported by *Dr. J.M. Juran* (quality guru), by giving the definition to the quality as the "*fitness for purpose*". [Buffa and Sarin, 2011] The customer, who is perceived as the 'king', in the present scenario, is the main driver of change in the marketplace. As the continuous advancement in the fields of scientific and technological is in progress that causes the customer perspective on the acquisition of products/services.

Merely, all the researchers on manufacturing context always try to find out the solution for optimum utilization of resources. The journey of manufacturing context reveals the growing need for sustainability in the supply chains results in providing the pull-production (what the customers want at the best in class cost) instead of push-production (for which customer never wants to pay). According to the customer perspective on the manufacturing context, he is ready to pay only for those manufacturing activities which are required to manufacture the goods like manufacturing cost along with the small fraction of transportation cost. He never wants to pay for defected items or the storage costs because it never adds value for the customers but increased the final cost. Before finalizing the product selling price, the value for all the activities i.e. manufacturing operations, transportation, procurement, storage etc. is calculated and after that, the final price is finalized. Once a final prize is fixed, it is more difficult for a manufacturer to convince all the stakeholders for change in price if any. So-that the activities in the organization are divided into value-added and nonvalue-added criteria. Perhaps, it is universally known that the nonvalue-added activities are always associated with the manufacturing process. [Threja and Kaushik, 2015]

The present Indian manufacturing context has encountered difficulties in their growth mainly because of mismanagement in the resource utilization i.e. the infrastructural inadequacies and inabilities to manage all the resources (equipment and facilities) etc. [Anderson and Sohal, 1999] Another fact with the Indian manufacturing sector is a production with a small batch size which creates the necessity for continuous resources flow adjustment as per the workstation processing speeds. [Saad et al., 2006, Singh et al., 2007] Thus, these inadequacies and inabilities result in lower production rate, lower the quality, the higher the production cost, and, mainly the ineffective management of resources, etc.

The supply chain of all the organization has the dependency on all the stakeholders i.e. Congruence and Commitment (Harmony) among the customer; supplier and producer are required for the successful implementation of SCM. Despite useful findings, SCM has the limitation i.e. dependency among stakeholders may create a nuisance (interruption) in the flow of resources which further lead to the failure of SCM in the organization. Another reason with SCM is the replenishment quantities and delivery timing for the product/services to the customer end. [Kang et al., 2010]

On the other hand, a lean manufacturing approach resulting improvement in the outcomes in the slow progression that makes it in-preferable for the small-scale industries. The cost incurred on lean manufacturing sometimes goes high then the company actual budget passed for implementation of lean manufacturing. [Pavnaskar et al., 2004] Another limitation of LM is the selection of tools for the organization. Most of the professionals rely on that a single lean tool can handle all the problems. But in actual the wrong tool selection i.e. applying the single tool or same set of tools for all the problems may affect the outcomes of the organization. For example, wrongly selected maintenance strategy in the organization may cause the working of the machine tool i.e. unwanted breakdowns, lesser production etc. [Moayed and Shell, 2009]

1.3 MOTIVATION OF THE WORK

For developed nations like India, it is important to give more attention to the manufacturing sector. The ever-changing customer demand and globalization of the market affects the entire manufacturing system which sometime may cause the failure of that industry. The traditional method used for the manufacturing process is best for less no. of the variety of products. [Mangal, 2011] Nowadays, the products with distinct function are desirable by the customer and enforced manufacturer to produce a variety of products with the existing facilities and resources. [Kumar et al., 2015; Kumar et al., 2016] The present manufacturing industries work on different aspect i.e. they don't want to limit the scope of the products to meet with customer demand for a variety of product alone also have to face the intensive competition from both nature and peers. [Seth and Gupta, 2005; 2008; Singh and Sharma, 2009; Gupta et al., 2012]

In addition, the present government of India has initiated the 'Make-In-India' concept towards the nation growth with the main perspective to support the manufacturing sector. This initiative is considered as the step towards the improvement in the national economy through phrasing the concept of 3'R i.e. Rebuild, Reclaim and Redesign in the policies for the manufacturing sector. These policies help in shifting the manufacturing paradigm from the 'Pull Production' (advanced one considering sustainability as the main constituents) from the 'Push Production' (traditional approach considering profit as the main constituents). Still, in Indian manufacturing context results are not meeting with the planned initiatives.

The extensive research is requisite on the manufacturing context i.e. "*How the manufacturing sector take the decisions as an individual or in a collective manner regarding the main attributes of the manufacturing sector i.e. production (quantity & quality), inventory, allocation of resources, transportation, and information etc.*"

1.4 OBJECTIVES OF THE STUDY

The primary objective of the research study is *to understand and study the relationship among principles of lean manufacturing, supply chain characteristics, manufacturing strategies and performance in the manufacturing sector of the Indian economy.* The present study further divided into sub-objectives as follows:

O_1: To review and classify the literature related to lean manufacturing principles and the supply chain.

O_2: To identify the main attributes of lean manufacturing principles and the supply chain under different manufacturing strategies.

O_3: To understand the level of interest in implementing lean manufacturing principles and supply chain management in the manufacturing industries.

O_4: To identify the impact level of implementing lean manufacturing principles and supply chain management approach in Indian manufacturing organizations.

O_5: To conduct the survey of manufacturing industries to study the applicability of lean manufacturing principles and the supply chain management under different manufacturing strategies.

O_6: To identify the reasons for the slow implementation of lean manufacturing principles in the Indian Context.

O_7: To identify expected benefits from the implementation of lean manufacturing principles and the supply chain under the different manufacturing strategies.

O_8: To study the commonality between lean manufacturing principles and the supply chain management approach and their combined impact on performance.

O_9: To develop the theoretical model for the implementation of lean manufacturing principles throughout the supply chain in the Indian Context.

1.5 SIGNIFICANCE OF THE STUDY

India is a well-known nation for continuous development in the national economy. It is also known for the population as no. 2 in the world. The needs and concerns in the growth of manufacturing sector in India are much-needed aspects. The consideration of the efficiency and effectiveness is vital while designing the entire supply chain because it prepares the replica for the customer feedback. The extensive research on literature published on Indian manufacturing sector (Especially use of LM, SCM in the Indian context) shows the positive correlation among the application of these approaches with the organizational performance in Indian Context on an individual basis. Despite that, literature also provides an insight into the gap between the desired performance level and the actual performance. It means the outcome is far away then the organization capacity to produce the goods/services.

In the present study, the relationship among lean principles, supply chain characteristics, manufacturing strategy, and performance is established to cater to the present market demand and provide the decisional support to the following concerns:

- Help in creating the strong linkages among all the stakeholders which result in
    - The better decision is taken for various business functions like forecasting, planning, procurement, production, and so-on.
    - The resource flow is synchronized (Uninterrupted) throughout the chain.
- Helps in defining the roles and responsibilities of key players for smoothening the workflow throughout the chain.
- Help to focus on actual data by eliminating all the wastes throughout the chain
- Help in increasing the visibility as well as transparency throughout the chain which invoke regarding how to overcome the various dealt conditions.

- Help in minimizing the risks through prioritizing the uncertain conditions and their effect on organizational performance.
- Help in setting down the performance criteria i.e. process rules and regulations, control manuals and the standardized procedures to eliminate the deviation in the organizational goals.
- Empowering all the employees to create a homogeneous work culture environment in order to achieve sustained performance (Pursue perfection in the first time). [Detty and Yingling, 2000; Dangayach and Deshmukh, 2001; Nightingale, 2005; Zhang et al., 2011; Yuen et al., 2016]

1.6 SUMMARY OF THE DISSERTATION REPORT

The uncertainty in the market enforced the manufacturing context to find out the ways to achieve operational excellence through optimum utilization of resources. In addition, the mass customization in producing the goods with lean thinking reported as the cause for the downfall in catering the present customer demand. The established relationship in the present study is seeing one of the best options to explore, and the expected end results should be answered the all the objectives put up earlier in this chapter. The present study also reveals the benefit of application of lean principle through the supply chain i.e. provide the flexibility to withstand the changing patterns and become sensitive to the market. It is, therefore, become necessary to restructure and redefine the organizational structure (work culture). The chapter-wise description of present work is as follows:

Chapter I: The first chapter of the dissertation provides an insight into the concept of manufacturing (the process and resources to be used in manufacturing); the concept of lean manufacturing (history and background) and supply chain management (history and background). In addition, the chapter includes the motivation behind the research; the research objectives and proposed outcomes of the research.

Chapter II: The chapter of the report throws the light on the work done by various researchers on LM, SCM, MF, and Performance. The published literature by the researchers and practitioners were reviewed and summarized in this chapter. The literature reveals the journey of LM and SCM from 1990 to till today.

Chapter III: This Chapter reveals the research methodology used for accomplishing the study. This chapter includes the details regarding the hypothesis consider for research, research frame design, questionnaire setting, validation of questionnaire, sampling frame and data collection, techniques to be used etc.

Chapter IV: The fourth chapter discusses the analyze reports of data collected through the survey and the interpretation of the outcomes. AMOS software is used to apply the SEM approach to data collected through a survey.

Chapter V: The Interpretive Structural Modeling Approach is discussed in this chapter. The ISM approach is used to design the hierarchy of the variables for the said problem/issue (construct in SEM). All three issues in manufacturing sector i.e. lean manufacturing, supply chain and performance is considered individually for developing the hierarchy and find-out the variables who affects the said issue from the identified variables.

Chapter VI: Chapter 6 of the study discusses the theoretical model to represent the relationship among principles of *Lean Manufacturing, Supply Chain Characteristics, Manufacturing Strategy, and Performance.* The chapter gives an insight into the coupling effect of lean and supply chain on the organizational performance by identifying the common attributes in both the approaches. In addition, the importance of work culture in an organization is identified and how to maintain a healthy work culture is suggested through work culture enablers.

Chapter VII: Chapter 7 of the report concludes the work i.e. outcomes of the research work; limitations of the work; and finally, the future work to eliminate the limitations of the study. Figure 1.6 shows the conceptual framework for the present study.

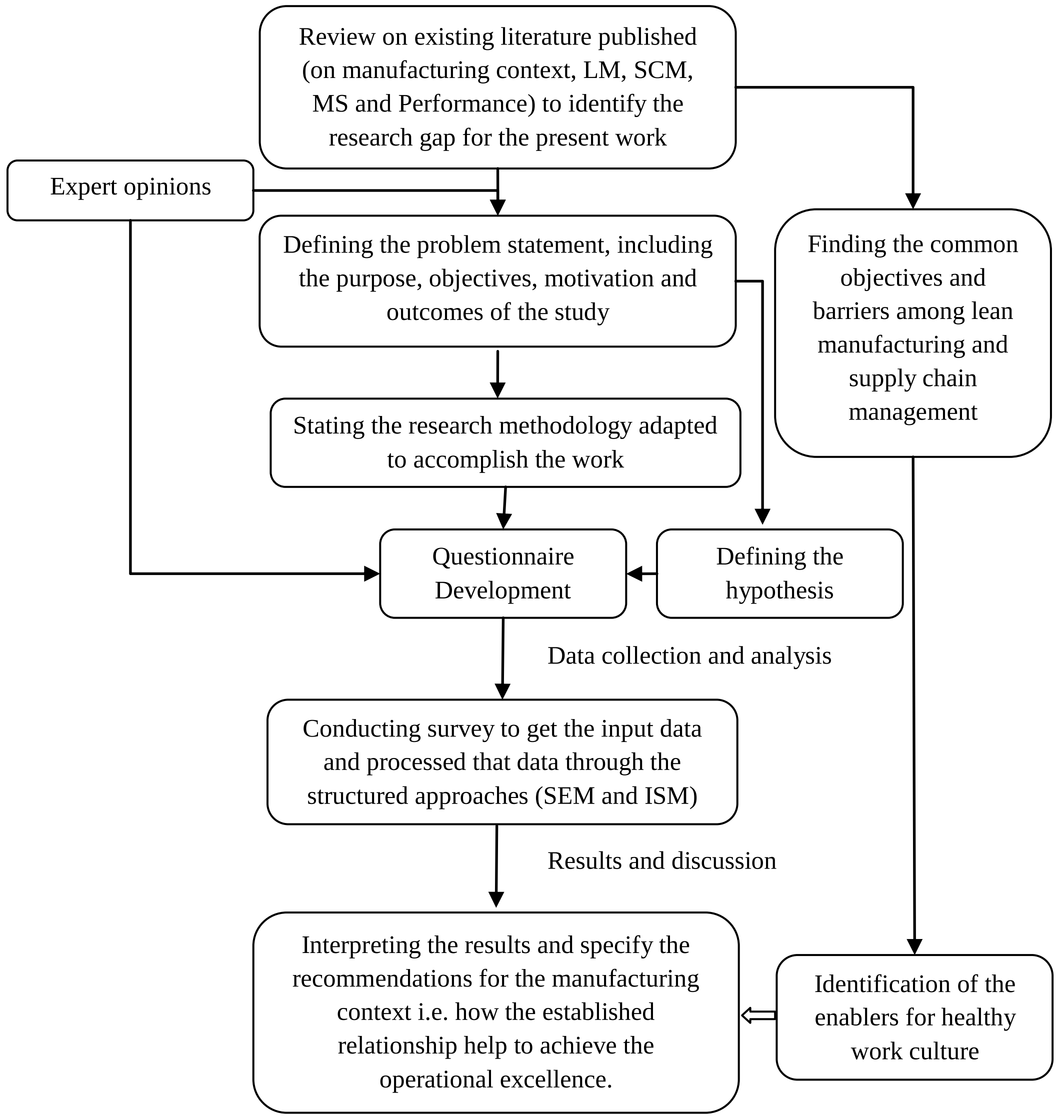


Figure 1.6: Conceptual framework for the present work

1.7 CHAPTER SUMMARY

The most promising feature of any manufacturing industry is to utilize its resources up to full capacity. As literature depicts, there is still a huge gap remaining in the actual performance and the desired one in the Indian context. There are several reasons behind this like the mass customization, demand variation, work culture, technological advancement and uncertainty in market trends etc. Both the academicians and researchers viewed all the aspects of Lean Manufacturing and Supply chain and give an idea to couple both this approach which would be more beneficial than the application of individual ones in the manufacturing industries in the Indian context. The present work is basically the relationship-establishment among the principle of Lean Manufacturing, Supply Chain Characteristics, Manufacturing Strategy, and Performance.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review is the process of critical evaluation of the published information for the purpose of discussion and further study. This evaluation generates a relationship between the works carried out by various researchers to know the present dilemma of the product or the process. The research strategies that are used for the purpose of critical evaluation of research work done by other researchers are of Conceptual; Empirical; Exploratory Cross-Sectional and Longitudinal types. [Dangayach and Deshmukh, 2001]

For the present study, the published work of various researchers in reputed journals/conferences/books are referred for finding the origin of the concept of lean manufacturing, supply chain, manufacturing strategy, performance. In addition, their relevance to each other and gaps is also studied through the published literature. The published work form in research papers and books pertain to the last four decades and provide an insight depth to the recent research work.

The review work includes a detailed discussion about the manufacturing sector and helps to manufacture context to answer the following questions:

- *Why are these techniques useful for the manufacturing sector?*
- *What are the performances based issued and how we can eliminate them?*
- *How can we understand the level of interest for the organization to implement the lean manufacturing and supply chain as an individual approach?*
- *What are the various gaps between the theoretical concept of both the approaches and the practical applications?*
- *What are the main attributes common to both Lean manufacturing and Supply Chain?*

2.2 LEAN MANUFACTURING: AN OVERVIEW

Lean Principles was firstly coined by John Krafcik in an article titled, "Triumph of the Lean Production System," in 1988. The research work was extended at the International Motor Vehicle Program (IMVP) at MIT and the research concludes in the book "The Machine That Changed the World". [Womack et al., 1990] The book reveals LM as the dynamic approach requires the fewer resources i.e. material; labor etc. to bring out the better outputs i.e. enhanced productivity & quality at lower cost. The aforesaid book also explained the requisites of various activities for lean enterprises i.e. design; manufacturing; supply & customer relationship etc. and provides an insight into the various gaps between lean and nonlean enterprises. [Shah and Ward, 2007; Upadhye et al., 2010]

It is the world-wide known fact that the Japan economy was totally diminished during the Second World War. At that time, it seems very difficult for the Japanese to overcome this diminishing cause. [Seng-Chan et al., 1990] Taichi Ohno (Former Engineer Toyota Company, Japan) and Eiji Toyoda (Japanese industrialist) worked on the manufacturing sector to improve the national economy. This was the second revolution in the manufacturing sector. [Womack, 1996; Womack, 2006] Taichi Ohno firstly studied the Ford Production System (FPS) and then brought the additional concepts in the existing one from his experience with the textile industry.

Toyota Production System is generally an integrated socio-technical system. In this system, they put efforts to produce better quality products with having a higher value to the customer. [Ohno, 1988; Liker, 2004; Monden, 1993] TPS comprises the management philosophy and their application to the floor area. [Katayama and Bennett, 1996] TPS helps the manufacturing sector to organize the manufacturing and logistics process for the automobile manufacturer, including interaction with suppliers and customers. TPS has had more focus on 'Autonomation of the system' and considering the technological and human aspects simultaneously while planning the various activities in an organization. [Russell and Taylor, 1999; Feld, 2001] In addition, TPS efforts were based on efficiency enhancement only which sometimes causes the hidden effect on productivity and product quality. [Forza, 1996]

Toyota Production System was popular for tangible benefits, especially in the automobile sector in Japan. It was the disciplined process-oriented system used for process improvement. The various strategies were developed for detailing '*how to improve process parameters and their selection mechanism*' at that time. [Sugimori et al., 1977; Ohno, 1988, Conan, 1990] The creative thinking, just in time, and flexible workforce etc. were the various tools for implementing the TPS.

Later on, in 1988, the concept of lean manufacturing (updated version of TPS) was developed. The restructured TPS (known as "lean manufacturing") was centric to the customer value. [Mason et al., 2000; Rother and Shook, 1999] The lean manufacturing approach (Continuous improvement in the organizational performance) considers both the consideration as in TPS along with the workforce capabilities that ensure the long-term improvement which was overlooked in TPS. [Sugimori et al., 1977; Diego and Cadavid, 2007, Comm et al., 2000]

The Toyota Company of Japan was the first organization where the lean concept was implemented under his guidance. Ohno, (1988) states that lean manufacturing is the best tool having the systematic approach that begins with the identification of the waste activities to their elimination from the process. It has the focus on continuous improvement in the process as well as the product to satisfy the customer expectation. He believes that the reduction in the timeline for the supply of goods by eliminating the nonvalue-added wastes from the process add the specific competitive advantage to the organization.

'Lean Manufacturing is defined as to pursue the business activity with perfection by reducing all forms of "waste" to zero levels. ……………..[Olivella et al., 2008]

As the literature on lean manufacturing reveals that lean manufacturing is the dynamic process of change driven by a systematic set of principles and best practices aimed at continuously improving from the shop floor to the executive suite, and from the supplier to customer value chain. [Carreira, 2007] The presence of dynamicity in lean principles help the manufacturer to set of predefined rules which further leads to drives the changes in the organization. [Mason et al., 2000; Zapfal, 2008; Singh et al., 2009] The main focus of lean manufacturing is on delivering the good quality of product in-time to the customer (by keeping the cost low) and resolves the problems associated to identifying and eliminating of wastes. [Singh et al., 2010]

It helps in improving organizational effectiveness and efficiency. [Karim et al., 2014] In addition, it is the best tool to reduce the wastes such as human effort, inventory, time to market and space etc.; and help the industry to remains more responsive to customer demand while the product quality is not compromised. [Perez and Sanchez, 2001; Abdulmalek and Rajgopal, 2007; Kumar et al., 2015 (b)]

Warnecke and Huser (1995) reported lean as the technique begins with the product development to the after sale services to the end customers through a chain of supply of material and shop floor management etc. The lean principles will develop the capabilities workman to work in flow production or "pull" mechanisms to support the flow of materials at constrained operations. The concept of Lean is to the pursuit of perfection through reducing to zero all forms of "waste". Further, the aspects of organization practices like standardization, discipline, and control, training program, participation, and empowerment, cross-functional team, and compensation including rewards that successfully follow lean production principles. [Olivella, et al., 2008]

Lean manufacturing is the multifaceted concept that may be grouped together as distinct bundles of organizational best practices. [Shah and Ward, 2007 (a)] In general, it is referred to group all the activities of the shop-floor and eliminating the wastages from them by using the several concepts such as one-piece flow, kaizen, cellular manufacturing, synchronous manufacturing, inventory management, poka-yoke, standardized work, workplace organization, and scrap reduction to reduce manufacturing waste. [Russell and Taylor, 1999]

2.2.1 Lean manufacturing history

Birth of Lean Manufacturing methodology was begun from Toyota Industry, Japan three decades ago. But the strong evidence is found in a great quote *"One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is* *moved about, the greater is its ultimate cost",* by Henry Ford (1926) that the Lean has it's begun from that time. The book titled *'The Machine That Changed the World*' states the necessity of lean manufacturing for the manufacturing context. Womack (1990) stated the five-steps for step by step procedure to infuse the lean concept implementation in the manufacturing context. These are:

1. Accurately specific values from the customer's perspective for both products and services.
2. Identify the value stream for products and services and remove non-value-adding waste along the value stream.
3. Make the product and services flow without interruption across the value stream.
4. Authorize production of products and services based on the pull by the customer.
5. Strive the perfection by constantly removing the waste.

The lean manufacturing methodology always tries to smooth the flow of resources throughout the organization. It helps in increasing the speed of the manufacturing process by reducing the wastages (nonvalue-adding activities). [Kumar et al., 2015] It is basically the step by step revision of the manufacturing system and suggests the changes accordingly which further helps the organizations to remain competitive by offering consumers the higher quality of products by giving the solutions to the following aspects within the organization:

a) How to define customer perception in terms quality of the entities?

b) Identification of ways to pursue the perfection to provide quality at the source itself; and

c) Establishing the concept continuous improvement to emphasize on customer perception instead of a market trend. Lean principles help to answer the questions stated above up to some extent. [Shah and Ward, 2007; Rehman et al., 2010 and Warnecke and Husor, 2009]

The Lean Principles requires the devotion of management while an implementation that will help to attain zero defect production facilities. [Ahlstrom, 1998] Becoming lean is a complex business-there is no single thing that will make an organization lean. Lean manufacturing approach begins with the accessing of the prevalent parameters within the organization to know about the current status of the organizational effectiveness and efficiency. The utilization/non-utilization study through work sampling of resources/facilities reveals the effectiveness of the facility as well as the capacity and efficiency of the organization.

2.2.2 Goals and objectives of lean manufacturing

Burton and Boeder (2003) reported that the lean manufacturing approach is to work on group effort (teamwork) to solve the identified problem by the set procedures and standardized the operations in the organizations. LM has three main goals are as follows:

1. The first goal is to design the manufacturing system as simple as possible and based on pull production type. This type of production sets the inventory is only pulled through each workstation when it is needed to meet a customer's order.

2. Secondly, the segregation and elimination of non-value added activities is the core requirement of Lean implementation where it always recognizes the room for improvement.

3. At last, build up the mindset for continuous improvement that means an incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance. [Womack, 1990; Sahoo et al., 2007; Sahwan et al., 2013]

The several case studies were published with different lean tools application to date. The main focus of the studies was on the reduction of cost and time in the manufacturing context by eliminating the nonvalue-added activities only. [Seth and Gupta, 2005; Singh et al., 2007; Singh and Sharma, 2009] Lean principles enable the manufacturing context to work on pull production strategy in which the unique engineering design products are manufactured based on customer specifications. [Sohal, 1996] The objectives of lean manufacturing are as follows:

- To satisfy the customer’s need by providing them what they want (Zero-defect).
- To help the manufacturing setups through implying the flexibility and make them suitable for uninterrupted material flow, optimized man-machine movements, less no. of setup changes (only desired) and effective occupation of resources (Optimum).
- To make the system adequate enough to have pull production demand from the customers.
- To improve the lead-time to serve the customer in a better manner.
- To motivate the employees for group efforts i.e. each one is looking at the organizational goal as their own and trained them to achieve this in a systematic manner. [Emiliani, 1998; Emiliani and Stec, 2004]

Table 2.1: Lean objectives and process requisites

Objectives	**Process Requirement**	**Tools**
Stable Quality Reduced Costs	Standardization of equipment and process	SQC, Six-Sigma, 5’S SPC
Enhanced Productivity	Line layout Reduced setup The uninterrupted flow of material Pull production Produced only what is required	Kaizen, Kanban, TPS
Elimination of nonvalue-added operations	Design improvements Process stabilization Right man on the right job	VSM and Kanban
Less Inventory & Reduced Space Utilization	Reduction in working capital Effective planning and scheduling The free and smooth flow of material Scientific implementation of MPS and MRP The un-interrupted flow of resources Reduce WIP	JIT, TPS, Kaizen, Six-Sigma 3’M, VSM
Increased market share	Modular production with variants Produce as per customer expectations Timely Delivery at a reduced cost The adequate customer support system Logical warehouse location	TPM, Kanban, MIS, DSS

2.2.3 Lean manufacturing tools/techniques

As the literature on lean manufacturing depicts that there is a positive relationship exists between the lean manufacturing and the performance (outcomes) of the organization. [Sohal, 1996; Karim et al., 2013] The lean approach also used as the complex cocktail of ideas for the continuous improvements in the organizational performance as well as the standardization of the process by fixation of organizational structures. [Amako-Gyampah, 2000] The set of synergistic work practices (systematic) is used for eliminating the wastages from the manufacturing organization operations. [Fullerton et al., 2001] The various tools for lean manufacturing are briefed as follows:

- ✓ **5'S**: 5'S is the basic tool used for building the blocks for Lean Manufacturing. The 5'S stands for Sort (identify the activity/event which is nonvalue-added); Set-In-Order (organize all the resources in systematic manner); Shine (clean/eliminate the activity identified earlier as nonvalue-added); Standardize (set the standards for all other activities other than nonvalue-addition) and Sustain (consistent with the same performance level) Nowadays, in addition to these 5'S another S (safety) is considered for the establishing the healthy work-culture. [Feld, 2001; Pavnaskar and Gershenson, 2004; Abdulmalek & Rajgopal, 2007; Bayo-Moriones et al., 2010]
- ✓ **Jidoka**: The Jidoka encompasses the inbuilt quality idea i.e. 'Autonomation'. This aim to give the machines 'human touch' to stop their working while any activity/parameter is happening with incorrect in direction/magnitude. [Ohno, 1988; Rizzardo and Brooks, 2003]

- ✓ **Poka-Yoke**: Also known as, mistake proofing has the focus on preventing the process for defects being produced, accepted or passed for the other process. It helps to identify the defects while production and initiate for stopping the production line. [Russell and Taylor, 2000; Womack, 1996; Feld, 2001]
- ✓ **Cellular Manufacturing**: It is an alternative approach to enable both the flow production and the volume flexibility in the manufacturing process. [White et al., 1999; Singh and Sharma 2009; Pattanaik and Sharma, 2008; Shishir Bhat, 2008]

- ✓ **Value Stream Mapping**: VSM is the most accepted lean manufacturing tool used to identify waste in the value stream of a product. It consists for stages i.e. a) Review of Existing Layout; b) Plan the alternatives and analyze their various courses of actions; c) Select any alternative to possess the improved outcomes and developed the layout accordingly; and d) Finally, the comparison is done before and after VSM implementation to compute the results. VSM is a simple tool begins by drawing the flow chart for the supply chain to identify the wasteful activities in the process. [Rother and Shook, 1999; Shah and Ward, 2003; Seth and Gupta, 2005; Serrano et al., 2008; Seth, et al., 2008; Threja and Sharma, 2013; Threja and Kaushik, 2015]
- ✓ **KAIZEN**: It is a strategy, where all the employees work together proactively to achieve regular incremental improvements in the manufacturing process. Kaizen is all about continuously improving the process efficiency and effectiveness and can be done through the ongoing continual improvement. [Russell and Taylor, 1999; Pavnaskar and Gershenson, 2003; Doolen, 2008; Nordin et al., 2012; Kumar et al., 2017]
- ✓ **KANBAN**: It is a Japanese word refers to the instruction card, which is mainly used for the inventory management purpose. It provides the visual indication that is further used to order the requisite material. It is the manual system, which pulls the entire supply chain and allows the efficient transportation of material/goods part from one workstation to another. [Hines and Rich, 1997; White et al., 1999; Gulyani, 2001; Abdulmalek and Rajgopal, 2007]
- ✓ **Single Minute Exchange of Dies (SMED)**: Setup change in the manufacturing process and again regain the momentum is the very difficult task. To increase the production in the manufacturing unit, SMED is one of the best lean tools focusing on the simplification of the setup change system and make the system more flexible. [Womack et al., 1990; Abdulmalek and Rajgopal, 2007; Sahoo et al., 2008]
- ✓ **Just-In-Time**: JIT is the philosophy especially developed of inventory management concept. Acc. to JIT philosophy, no activity should take place in a system until there is a need for it. This approach has the objective to create a pull production system based on customer demand instead of pushing the parts to the customer without any demand raised by the customer end. This is the most common tool used for managing the inventory intended for providing the right kind of goods/raw material in the right quantity and the

quality within the desired timeframe. [Lee and Ebrahimpour, 1984; Finch and Cox, 1986; Voss and Robinson, 1987; Welgama and Mills, 1995; Sakakibara et al., 1997; White and Prybutok, 2001; Arora, 2004; Mishra et al., 2014; Othman, 2016, Shah, 2016]

- ✓ **Visual Inspection**: Visual Inspection is the very basic tool used while manufacturing process is going on. This kind of inspection helps in easy detection for the faulty processes and provides the leverage to eliminate the error/fault from the process. [Rungtusanatham et al., 1998; Singh and Sharma 2009; Nordin et al., 2012]

- ✓ **Total Quality Management (TQM)**: TQM aims to increase the external and internal customer satisfaction with a reduced amount of resources. It is considered as a continuously evolving management system consisting of values, methodologies, and tools. The eight key elements, which are helpful in the successful implementation of TQM methodology in a manufacturing organization, are ethics; integrity; trust; training; teamwork; leadership; recognition and communication. [Flynn, 1994; Dean and Evans, 1994; Cua et al., 2001, Arora, 2004; Thareja et al., 2011]

- ✓ **Total Preventive Maintenance (TPM):** The low level of maintenance knowledge and skill within the organizational workforce always causes the more idling of the equipment, because the workforce does not have the adequate training to maintain the equipment while breakdowns. TPM is a tool seeks continuous improvement by providing adequate training to operators to attend the smaller breakdown of the equipment. This will help to enhance organizational efficiency and effectiveness. TPM also highlighted those areas where hidden wastes exist and sensitizing the organization to recognize wasteful behaviors and practices. [Nakajima, 1988; Mason et al., 2000; Cua et al., 2001; Abdulmalek and Rajgopal, 2007; Arora, 2004; Ahuja and Khamba, 2008, Sharma et al., 2012]

2.2.4 Lean manufacturing limitations

Except for the numerous benefits of Lean Manufacturing approach, there are some limitations also associated with the implementation of lean manufacturing. The lean manufacturing approach requires an attitude of perfection and devotion of all the employees rather than the management is responsible for any action. This means that at any stage if something happened wrongly or without planning; it can be stopped at the same moment by any employee (Either the shop floor employee or by the official sitting in the office). The organization culture is reported as the main factor affects the planning and directing horizon of management that may further lead to effects of the clarity of vision and leadership capability of the worker. [Bhasin and Burcher, 2006; Achanga et al., 2006]

Shah and Ward (2003) examine the effects of three contextual factors, plant size, plant age, and unionization status, on the likelihood of implementing lean production systems. The cost incurred on lean manufacturing sometimes goes high then the company actual budget passed for implementation of lean manufacturing. [Pavnaskar et al., 2004] Also, the slow progression of the outcomes of implementing lean principles in manufacturing context limited the scope of lean manufacturing large scale industries. The literature on lean manufacturing also insists that there is no right-hand thumb rule to explain each step of the lean process and exactly how to apply the tools within an organization.

2.3 SUPPLY CHAIN MANAGEMENT: AN OVERVIEW

The traditional functioning of all business activities like planning, purchasing, manufacturing, marketing and distribution of, goods in organizations are highly segregated. The function of these activities is independent of each other and meets with their own specific objectives instead of organizational objective.

In general the supply chain is referred to as the network of different facilities in an organization in order to perform the various functions like design and developing new products (planning); raw material procurement (purchasing); transforming the raw material into finished product (manufacturing); distribution of goods to the customer’s end (delivery) and the after sale support (service) to remain competitive in the market (sustain the market growth). The planning, implementing and controlling resource utilization is done through the supply chain which results in a cost-effective flow of raw materials. [The Council of Logistics Management, 2005]

It is the chain of the network involves the upstream and downstream of all the linkages of all functional units to produce product/services through adding value in the raw material and deliver ultimately to the end users. [Christopher et al., 1998; Lee and Billington, 1992] It is the complete system whose constituents like supplier, producer, logistic services, and the customer are linked together in such a manner that the material flows in forward direction i.e. from supplier to producer and so-on; whereas the information flows in both direction especially in the backward direction as the feedback which is helpful in optimizing the resource utilization. [Naylor et al., 1999] "*The integration of key activities of the business in such a manner that will help in the uninterrupted flow of products/services and information in the process; and add the value to customers and other stakeholders*". [Lambert and Cooper, 2000]

Traditionally, the departments in an organization like purchase, planning, production, quality etc. operate independently. Mostly the departments are having the conflict with each other rottenly because of the variation in the objectives of the departments. The basic components for SCM are as follows:

- ✓ **Plan:** It is basically referred to as the strategic part of SCM and help in developing the set of metrics to monitor the supply chain. This will further lead to the tangible outcomes like the efficient flow of resources, less cost of deliverables, product/services perceiving good quality and most importantly give preference (value) to the customer.
- ✓ **Source:** The sources referred here as the identification and selection of best suppliers who will provide all the resources consumed while the transformation of that material in the final product.
- ✓ **Make:** This is basically the manufacturing/assembling/production process. The tasks in nos., their sequence, schedule and all other details prepared in the plan is used for the final transformation of raw material in the product/services.
- ✓ **Deliver:** In general deliver stands for logistics which involves the coordination among the customer (Who is going to place an order?), supplier (Who provides the required resources?) and the network of warehouses (To deliver the goods to the customer end).
- ✓ **Return/Reverse Flow:** This is basically the feedback mechanism or reverses flow where customer dictates his/her requirement to the producer. Some-time the wrong

product delivered at the customer end will send back to the manufacturing industry. [Mohanty and Deshmukh, 1997; Chopra et al., 2003; Shah, 2016]

2.3.1 History of supply chain management

The need for SCM in the manufacturing sector is increased gradually over the last century. The SCM journey started at the early age of 19^{th} century (from 1910 to 1920) when Ford Motor Company managed their process with tightly integrated chain and named as T Ford Model. It has the drawback of inflexibility in the supply chain which causes the Ford Company to work on a variety of products that means they are bound to produce the products with low variety. Also, the higher setup time and inventory in the system are other areas where Ford Company has to prove himself. Other manufacturing industries worldwide also had the same experience and decided to design the more flexible and efficient supply chain at around 1960, this time the manufacturing sector focused on the production of goods and services in a wide variety. [Shah, 2016]

Toyota Company of Japan, manufacturing the automobile products, came up with the idea of an in-house final assembly of products. [Christopher and Towill, 2000; Chopra et al., 2003] According to this, they established the long-term relationship with the suppliers and these suppliers were located to nearby the Toyota Assembly Plants. This will help in reducing the purchase lead-time, inventory, transportation and very important the final cost of assembly. Later on, the Toyota Company philosophy calls for changes and refine because the earlier one has the rigidity to rely on supplier as they have a permanent relationship with them, which could become the liability over a period of time? With the development of Electronic Data Interchange (EDI) around the 20^{th} century, managing the SCM becomes more convenient. Also, the IT sector revolution helped the organization to buy and sell their products/services globally and SCM renamed as Global Supply Chain Networks. [Choi and Hong, 2002; Hugos, 2003] Now, this type of supply chain offers customized products/services as depicted by the customers in a wide variety and ranges. Also keep in consideration the other parameters like cost, delivery rate, after sale service and feedback mechanism to collect the information about what the customer expect?

The time period between 1980 and 1990 was well known for a revolution in the field of science and technology. During, this period the paradigm of the business sector shifted mainly because of Liberalization policies of various economies all over the world.[Mangal, 2011] Later on, the privatization and globalization join the liberalization policies due to the unmarked revolution in the sector of Information Technology and communication structure within and outside the organization. This results in continuous acceleration to the magnitude of competition on the business especially on the manufacturing sector which further leads to affect the organizational performance. To overcome this pressure almost all the organizations focus their attention on the organizational supply chain. [Lummus and Vokurka, 1999;

In the present scenario, almost all the manufacturing organizations willing to design their supply chain in the systematic and strategic manner so-that their throughput is maximized with the lower costs while manufacturing. It is quite an obvious fact that the SCM strategy should align with the business strategy. The main steps for how to align the supply chain strategy with business strategy are as follows:

a. To understand customer requirements (What the customer want?),
b. Defining the core competencies of the organization (How the organization would serve his customers?), and
c. Finally, develop the supply chain capabilities which support the company objectives. [Hugos, 2003]

2.3.2 Objectives of managing the supply chain

SCM can also be viewed as an emergent field encompassing the various domains practiced by both practitioners and academicians. It is referred to as the network of facilities to perform the cross-functional approach (the various functions within and outside the organization in a systematic manner). All the functional units of an organization perform within the supply chain perform their desired task to meet the organizational objective. [Christopher et al., 2000; Chopra et al., 2003; Green et al., 2009] These functions are having dependency on each other. So, it is a much-needed aspect that there is proper communication and coordination among all these functional units so they can perform their task without interfering the work of each-other. In other words, the obstacles between these functional units are required to eliminate. The hot issues with the supply chain if not manage properly are as follows:

1. **To provide the right kind of information to all stakeholders**: Intuitively, anyone can imagine the supply chain resembles the 'chain' in which the 'links' are the participating shareholders connected to add the value so as to meet the customer demand. Information is the one big driver for supply chain management. All the functional units in an organization have the necessity to share the valuable information throughout the chain like the demand signals, forecasts, inventory, transportation, potential collaboration, etc. otherwise the organizational recourses may get blocked/shortened at any intermediate stage. [Ansari and Modarress, 1990; Childerhouse and Towill, 2002; Huang et al., 2003; Hines and Rich, 1997]
2. **To maintain the Cash-flow**: Likewise, blood circulation in the human body is required to live a healthy life; the cash flow is required to perform all the activities in an organization. The interruption in supply chain i.e. affected channel partner performance may affect the exchanging of funds across the entities within the supply chain which further encounter the functional hurdles for all the activities. [Hines, 1998; Simchi-Levi et al., 2000]
3. **To manage the inventory**: In an organization, managing the inventory is the tough task. The un-necessary inventory often blocked the resources like money, space, manpower etc. Also, the shortage of inventory blocks the production line. So, while designing the supply chain efficient tool is considered for managing the inventory throughout the value chain. [Gattorna and Walters, 1996; Sucky, 2005]
4. **To justify the network:** As literature depicts there is positive relation exists among the various activities with each other and they have a dependency on each other. The decision regarding the number of products (purchasing/manufacturing/delivery), transportation of goods (within and outside the organization), the locations of supplier/distributor, selection of production facilities, etc. may cause the network which further affects the organizational performance. So, it is very important to justify the network with the optimum utilization of resources. [Storey et al., 2006]

5. **To meet with the market demand:** For any business unit, it is very important to adopt the business distribution strategy as good as possible so as to meet with the customer demand within specified time and cost. While designing the supply chain, it is very important to consider the logistic strategy i.e. the kind of transportation used (e.g. truck loadings, railway, Flight/cruise in case of international delivery); the replenishment strategy (e.g., pull, push or hybrid); and the control on transportation (e.g. owner-operated, private carrier, common carrier, or contract carrier). [Ballou et al., 2000]

6. **To provide a cushion in Trade-offs situation**: Another well-known issue associated with the supply chain is the trade-off impact i.e. increase/decrease in cost of the product because of trade-offs. In an organization, all the functional units are required to perform in a systematic manner with filly optimized resources utilization otherwise, the partial gap in the rescores utilization among functional units may create the situation for trade-offs. [Ballou et al., 2000; Garfamy, 2011]

The aforesaid reasons specify the intense need for the emergence of a mechanism which helps to integrate all the organizational functions to achieve the organizational objectives as a unified whole instead of individual function objectives.

Table 2.2: SCM objectives and process requisites

Objectives	Process Requirement	Tools
Focus on infrastructure and network Planning	Warehouse locations and capacities Plant locations and production levels Transportation flows between facilities to minimize cost and time Forecast based on customer signals	Electronic data interchange (EDI) Radio-frequency Identification (RFID) Warehouse management system Transportation management system
Improved Distribution Strategy	Selection of distribution strategies (e.g., direct ship vs. cross-docking) No. of the cross-dock station with adequate linkages	Electronic data interchange (EDI) Bar-coding and scanner Enterprise Resource Planning (ERP)
Working Capital Reduction and Fixed Capital Efficiency	Network Optimization Minimizing the Lead Time Accelerating Cash Flow Cycle Ware House Quantity and Location	Inventory management Enterprise Resource Planning (ERP)
Inventory Control	Timescale and cost Clear procurement cost Regulated performance Supplier selection Correct negotiations of Contract	Inventory management Contract management Supplier management
Integration and Strategic Partnering	The adequate feedback management system Defining the processing requirement for vendors Selection of reliable supplier's in terms of delivery, cost, and quality	ERP Inventory management
Outsourcing & Procurement Strategies	Review existing capacity Make and buy a policy Reliability and delivery of supplier Supply at a competitive price	Inventory management Contract management Transportation management

2.3.3 Barriers in the supply chain

The supply chain encompasses the direct control on all the activities happen in an organization i.e. planning (what to do in actual?), organizing (Resource identification), manufacturing (transforming raw material in goods), delivering and returning of feedback. This helps in managing the market demand and supply to the customer. [Supply Chain Council, 2005] As the supply chain represents the dynamic relation i.e. give and take of all the resources among all stakeholders, the workforce always is the dominant factor. The supply chain in the manufacturing sector is affected by various factors like

- Product shelf life (Short life cycle products),
- Customer demand for variety in products (representing uncertainty);
- Product supply and delivery time;
- Unnecessary blockage/shortage of resources due to the interrupted communication channel;
- Wrong inputs in the supply chain like the capability of resources;
- Cost related to implementing supply chain;
- Lack of awareness about SCM among all users;
- Less contribution to Top management in managing the chain;
- Lack of coordination throughout the chain
- Inadequate infrastructure/ facilities and so-on. [Lee and Billington, 1993; Oliver and Lowe, 1997; Storey et al., 2006; Law et al., 2009; Kess et al., 2010]

The study on the Japanese manufacturing and automotive industries reveals supply chain integration, JIT purchasing, and JIT manufacturing had direct and significant benefits to logistics performance. [Othman et al., 2016] Still, the SCM approach has the advantages over the JIT because its design consists the harmony. In the supply chain, the products produce and deliver to the customer with a variety of features strictly as per the expectations laid by customers. [Kawtummachai et al., 2005]

2.3.4 SCM benefits

At the very initial stage, the supply chain was reported as the approach used for activities like procurement, manufacturing, and distribution. Also, the SCM structure was very complex and tough to understand. As time proceeds, the complexion in organizational supply chain structure is transformed into the very simple structure which is easy to understand. [Sharma and Fisher, 1997] In addition, the main areas were identified where the organizations took the decision either on an individual basis or in the group like production; inventory; transportation and information flow throughout the supply chain. The simple structure of the supply chain provides the common platform to all the stakeholders to come ahead and work for common objectives. The various parameters which are considered while designing the supply chain for the manufacturing organization are: location of the industry, allocation of supplier and customer in a different location, the overall capacity of the enterprise, and to specify the way to control all the activities etc. [Spekman et al., 2002; Kumar et al., 2015]

Cooper et al. (1997) reported that the SCM has more focus on customer perception than the producer perception. The customer perception gives an idea of what to produce and how much? The customer perception always dominant the producer perception as considered in the earlier traditional approach. So as to survive in the competitive market in order to meet out the highest level of customer's satisfaction is the much-needed aspect of every entrepreneur's. [Ansari and Modarress, 1990]

One of the best aspects of SCM is to create and improve the trust i.e. Enhanced the collaboration among all stakeholders. This helps in improving the visibility of resources (Whatever the resources company has? And, which is required for satisfying the customer demand?) [Choi and Hong, 2002] The trust between all stakeholder results in a single integrated plan for all the stakeholders rather than numerous in past.

SCM is the prevalent approach for the planning for the long-term success of a buyer-seller relationship. [Hsu et al., 2009] It helps in synchronizing the logistics with the manufacturing process through developing strong communication amongst the supplier; manufacture and the customer. The synchronization of logistic partners will help to provide the delivery to the customer in time as well as help in cater the customer need. [Spekman et al., 2002] The supply chain of an organization offers both the tangible and intangible benefits as given in table 2.3.

Table 2.3: SCM Benefits

Tangible benefits	Intangible benefits
1. Increased labor inputs to optimize resource utilization, 2. Achieve the better control of inventory, 3. Reduced failure rate, 4. Achieve higher revenues, 5. Increased profitability, 6. Lowering the costs of purchasing, manufacturing, transportation, warehousing etc. 7. Higher discount on prices.	1. Better control over suppliers, 2. Increased market visibility, 3. Un-interrupted information flow to achieve better communication, 4. Improved customer care service, 5. Enhanced performance level, 6. Improved brand reputation, 7. Enhanced value for money, 8. Increased capacity, capability, and flexibility in the organization, 9. Faster order processing with accuracy.

[Stewart, 1995; Tan, 2001; Speakman et al., 2002; Towill and Christopher, 2002; Sha, 2016]

2.3.5 Principles of supply chain

Conradi and Westfetchtel, (1999) reported SCM as an integrative approach which helps in dealing with the planning and monitoring of the materials flow from the suppliers to the end-users. The execution of managing and coordinating the resources utilization throughout the chain is designed in an effective manner so that the resources may flow in multi-directions and dependent in nature. [Cho and Gerchak, 2005] To overcome this, the business units opted for the flexibility concept in their supply chain to more focus on core competencies. [Gunasekaran et al., 2004; Mohanty and Deshmukh, 2013]

Improved SCM can enhance customer service while maintaining low costs. Having recognized these benefits of SCM, many successful firms are implementing SCM principles to create and sustain their competitive advantage. [Othman, 2016] The supply chain of manufacturing industry is segmented into seven distinct principles shown as below:

a) Customer segmentation: Purely designed for the targeted audience

b) Customization of logistics network:

c) Optimal resource allocation based on market signals,

d) Differentiate product closer to the customer and speed conversion across the supply chain,

e) Strategic management of the resources of the supply chain,

f) Deploying the multiple level decision-making systems across the entire chain, and,

h) Adoption of the channel for performance measures. [Ross, 2002; Richard and Yigal, 2005;

2.3.6 Limitations of the supply chain

The literature depicts the positive relationship between supply chain management and the performance of an organization. Before the ’90s, the manufacturing industries were strives to attain performance excellence and effectiveness. [McKee and Ross, 2009] As it is a well-known fact regarding SCM i.e. it has the dependency on all the stakeholders that sometime may create a nuisance (interruption) in the flow of resources. [Oliwer and Lowe, 1997]
In the present scenario, the business units reduce the ownership through outsourcing of the entities like semi-finished materials, logistics etc. so- that the organization can perform all the activities in a cost-effective way. By outsourcing of the business entities, the more no. of stakeholders involved to satisfy the customer demands which are uncertain in nature. [Reiner and Trcka, 2004] This will cause the effectiveness of the supply chain which further leads to planning failure of the organization. Another fact limiting the scope of SCM is the replenishment quantities and delivery timing for the product/services to the customer end. [Kang et al., 2010]

2.4 MANUFACTURING STRATEGIES

The concept of manufacturing strategy was firstly coined by Skinner in 1969. He refers to it as an approach to exploit the certain properties of the manufacturing function which helps to achieve the competitive advantages. [Skinner, 1974; Demeter, 2003] “Manufacturing strategy is a tool for effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals” [Swamidass and Newell (1987)]

As the literature on manufacturing context reveals that the scientific management tools are utilizing in the manufacturing context to measure the performance of the organization both in the qualitative and quantitative term. [Dangayach and Deshmukh, 2001] The scientific management tools are beneficial for the management purpose, still, there is consequence regarding how to have the market share in long-term perspective with these existing tools. In order to succeed with the goal of long-term survival, it is important for the organization to deploy their resources in such a manner that the outputs of the organization capture the market. The manufacturing strategy includes the pattern of decisions (both structural and infrastructural) to determine the capability of a manufacturing system. [Suzaki, 1985; Demeter, 2003] Bordogna et al., (1996) reported the manufacturing strategy model on the basis of various parameters selected to differentiate between the strategies as given in table 2.4.

Table 2.4: Manufacturing Strategies Model [Bordogna, 1996]

Attributes to be considered for differentiating the manufacturing strategies	**Manufacturing Strategy**			
	Customized Production	**Mass Production**	**Automation Production**	**Next Generation Production**
Time Frame	Always	1800’s to present	1950’s to present	1990’s beyond
Lot Sizes	Small	Very Large	Moderate	Small
Unit Costs	High	Low	Moderate	Low
Quality	Variable	Good	Good	Excellent
Delivery Times	Long	Long	Moderate	Short
Flexibility	High	Low	Moderate	High
Education and Training	Apprentice	Limited	Moderate	High Continuous
Environmental Consciousness	Low	Low	Moderate	High

Platts et al. (1998) reported that the manufacturing strategy of an organization reveals the modes of operations i.e. ‘how well the organization works to meet specific customer demand?’ The two main aspects of manufacturing strategies are the various organizational decisions that determine the capabilities of the manufacturing system and the existence of specific manufacturing objectives. The decisions regarding deployment of the resources sometimes conscious in nature and dictates the organizational ability in terms of product/services.

The manufacturing organizations have a big concern i.e. how to utilize the potentially scarce resources. The organization seeks to provide structural support to the decisions to capitalize these resources in an effective manner. [Skinner, 1985; Vastag and Montabon, 2001] The manufacturing strategy plays the role as an integral part of the organization which provides consistency in the decision-making process for the aforesaid. The decisions regarding the ability and capability of the manufacturing industry help the manufacturer to take the decision with certainty. [Hayes and Wheelwright, 1984]

Leong et al. (1990) explained the two major constituents of manufacturing strategy i.e. the competitive priorities and decision categories. The competitive priorities in the manufacturing context are merely based on four sub-constituents such as quality (related to the system output), delivery (reaching the product to the right customers in time), cost (competitive enough to have customers) and flexibility (within the manufacturing organization to meet with uncertainties). [Slack, 1987; Smith, 1995; Swamidass, 2000] Most of the researchers treat the four competitive priorities as the key elements of manufacturing strategy. The other constituent of manufacturing strategy i.e. the decision categories is also sub-categorized in two categories i.e. structural (process choice, facilities, capacity, and vertical integration) and the infrastructural (manufacturing planning and control, organization, performance, and quality).

Hill (1994) reported the competitive priorities based on order winners/qualifiers criteria according to which the organizations can approach the customers. The empirical reaches on manufacturing strategy supports the link with competitive strategy and emphasized the manufacturing practices have strong relationships with a firm's competitiveness. [Swamidass, 2000] In a manufacturing context, the competitive priorities and decision categories are considered as important attributes. These attributes further help in facilitating economic production within the organizational boundaries through effective decision making.

Ward et al. (1996) reported the important practical standpoints i.e. understanding the business as well as the manufacturing objectives of the organizations. This will help in identifying the manufacturing capabilities of the organization best suited to the environment. The most common used manufacturing environments are as follows:

- **Assemble-to-order** (**S**ubassemblies of the products assembled upon order)
- **Engineer-to-order** (Specially designed products to meet the customer specification)
- **Make-to-order** (General products with standard design produced only upon order)
- **Make-to-stock** (Produced the goods for inventory purpose and delivered to the customer as on demand)

In the present scenario, every organization put its best efforts to sustain themselves in the global market and want to drive the organizational plan through systematic manner. Further, the organization wants to increase the ability to produce useful deliverables which are helpful for long-time survival. This can be done through having better control of all the activities happen within the organization and optimizing the organization performance. [Doolen et al., 2008] The manufacturing strategy offers an opportunity for developing a structured approach to take the right decision. [Flynn, 1999]

2.5 PERFORMANCE

Performance, in general, is referred to as the output of the activities i.e. the task accomplished by performing some actions. [Arora, 2004; Sharma and Sharma, 2013] In a manufacturing context, the performance of the manufacturing organization is an important attribute. It is used to detail the output of the organization through critical evaluation. [Smith, 1995; Singh et al., 2007] "In an organizational aspect, the performance is the broad concept which has been used synonymously with productivity, efficiency, effectiveness, and more recently the competitiveness". [Chauhan and Vaishwanar, 2010]

For the purpose of comparison between designed goals (pre-defined) and the actual outcomes, the process outcome measures performed with some definite criteria and standard tools. The outcomes from the performed measure based on the procedure for routines notifications that will use to maintain or alter the patterns in organizational activities indicate the performance of that particular system. In management science, the performance is referred to as the sharing and understanding of knowledge, as accrued from the past activities.

The actual performance is compared with the desired one so that it can be decided that what the organization have achieved at present situation? The performance of the organization reveals the efficacy of the man-machine management which helps to meet with the ultimate goal of an organization i.e. market growth and profit. [Digalwar and Sangwan, 2007] It is very complicated to measure the performance of the man-machine system of the organizations. Both the qualitative (quality, brand reputation, customer satisfaction) and the quantitative (production, cost) methods are used for measuring the manufacturing process performance. [Hervani et al., 2007] Literature on manufacturing context reveals that the measures on cost, quality, delivery, and flexibility are the basic attributes of operational performance and these are the most prominent than the other ones. [Thomas et al., 1985] The efficacy and effectiveness of manufacturing process are monitored and evaluated on financial (Inventory turn ratio; profitability; the share of business and revenue-growth) and operational aspects (Productivity; quality; cost; delivery; safety and morale of the workforce). [Swamidass, 2000; Noble, 1997]

Performance of an organization gives feedback support to the top management while taking a decision regarding organizational operations. Also helps in identifying the potentials those contributes to organizational success. [Sharma and Fisher, 1997] The performance management system used in every manufacturing organization is unique in nature that reflects the fundamental purpose and organizational environment. The performance can be measured at the multiple levels which include data relevant to both the products and processes.

Vollmann et al. (1988) reported the empirical support to the importance of strategic choices used to select and utilize the resources in the manufacturing context. In actual, it is very critical to identify the drivers for the effective performance and the sustainable growth in the market through competitive advantage for the manufacturing industry. [Ketokivi and Schroeder, 2004] The performance of an organization can be affected by a large number of reasons such as utility, effectiveness, capability, cost, etc. of the end product. The uncertainties in the environment i.e. the gap between the supply and demand also caused the performance of an organization. [Swamidass, 1986; Swamidass and Newell, 1987]

To improve the performance of an organization, a lot of advanced tools and techniques are deployed in the manufacturing context like LEAN, SCM, and TQM etc. These techniques are well-known and widely applied to improving competitiveness globally. [Tan et al., 2007]

2.6 STRUCTURAL EQUATION MODELING (SEM)

The early stage of the 19th century, the performance of an organization was improved with the work-study technique. The work-study is further categorized as method study (related to the study of the method) and work measurement (related to the study of time spent at work). In the work-study process, the study was simplified by the use of symbols that represents the current position of the resources, whether in operation or in transportation, etc.

Similarly, the SEM approach used symbols but with having different perspectives as in work-study. Structural Equation Modeling (SEM) approach is used to establish and test the complex relationships among the observed variables (measured through an analytical survey) and unobserved variables (the latent constructs). Generally, SEM is referred to as the advancement of the flow process, i.e. hierarchy design used in any organization to the workflow. [Boolen, 1989; Kline, 2010]

In an organization, several departments are connected with each other in such a manner; the work of each department never gets interrupted with this network connection. This is possible in such cases only where the network analysis is done before the execution of hierarchy design in an organization. [Shah and Goldstein, 2006; Chauhan, 2015] In the regression analysis, the priority of most affecting parameter (i.e. Variables for low performance in case of performance analysis) is to be found with some set formulas and decisions can be made only after the mathematical calculations.

SEM used the manifest/observed variables (measured through an analytical survey) and latent/unobserved variables (can't be measured directly). The latent construct can be measured or represented with multiple items/variables and are of three types i.e. Exogenous (independent in nature that can affect the other constructs); Endogenous (those can be affected by other exogenous constructs) and Mediating. [Hair et al., 2010]

SEM generally used for the testing of traditional models, but it also permits the examination of more complex relationships and models, such as confirmatory factor analysis and time series analyses etc. IT is also known as the multivariate statistical analysis because it has the strengths to use the latent variables (constructs) in the dependent modules. [Chauhan, 2015; Jain and Raj, 2016] The various test performed to get the outcomes from the SEM model are as follows:

Analysis of variance: Analysis of variance (ANOVA) is the statistical way to analyze the aggregate variability found within the input data. It is used for determining the impact of independent variables on the dependent variable in the regression study. [Evans and Lindsay, 2004]

Multiple linear regressions: Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data.

Causal modeling with latent variables: Causal modeling in SEM states the correlation among the variables of the latent construct. This relation further depicts how the occurrence of one variable causes the other.

Composite reliability: CR in SEM is referred as the retrospective approach used for evaluating the overall reliability and further, estimates the consistency of the constructs itself including the stability and the equivalence of construct and the value more than 0.70 indicates the good scale reliability of the constructs. [Fornell and Larcker, 1981]

Path analysis: Path Analysis is the special case structural model in SEM in which the constructs consider in the study is used as the variable to study the interrelationship among the constructs.

Confirmatory factor analysis: Confirmatory Factor Analysis (CFA) is a very popular method (statistical) to represent and examine the structure of the construct as a set of observed variables. CFA is used to test the uni-dimensionality and validity (both convergent and discriminant) of the construct with respect to its variables explained below:

> ***Uni-Dimensionality:*** As the name suggests, it simply refers that the variable considers for measuring the one construct is not having the relation in measuring the other constructs in the study.
>
> ***Convergent Validity:*** The convergent validity is used to state whether the variables of one construct are highly correlated with each other or not. It gives the statistical values for the variables i.e. degree to which variables in the constructs are related to each other.
>
> ***Discriminant Validity:*** Discriminant validity states the degree to which variables in different constructs are different from each other. In general, the discriminant validity ensures the correlation among variable of the different construct is low.

The statistical analysis done in SEM is analyzed to determine the statistical fitness of the structural model with the help of software. The software outcomes represent three models outcomes i.e. default model (Consider for the study); saturated model (imaginary model/exactly identified) and independence model (opposite to saturated model). [Hair et al., 2010; Doloi et al., 2011] The fitness indices used for validation of statistical fitness of the model are as follows:

CMIN/df: It is also known as chi-square goodness of fit and represents the observed covariance matrix is similar to the predicted covariance matrix. The value of CMIN/df is <5 represents the model is fit.

Comparative Fit Index: Also known as the Bentler Comparative Fit Index and used to compare the fit of a target model to the fit of an independent model (the variables are assumed to be uncorrelated). In this context, fit refers to the difference between the observed and predicted covariance matrices, as represented by the chi-square index. The value of CFI > 0.9 represents the model is fit.

The goodness of Fit index: GFI is the measure of fit between the hypothesized model and the observed covariance matrix. The value of GFI > 0.9 represents the model is fit.

The adjusted goodness of fit index: AGFI corrects the GFI, which is affected by the number of indicators of each latent variable. The value of AGFI > 0.8 represents the model is fit.

Root Mean Square error of approximation: RMSEA is the most reported measures of misfit/fit in applications of SEM. Its goal is to have an approximate/close fit with the model, rather than an exact fit, which is often not practical for large populations. The value of RMSEA < 0.1 represents the model is fit. [Mullaik et al., 1989]

SEM has a number of attractive virtues:

- Assumptions underlying the statistical analyses are clear and testable, giving the investigator full control and potentially furthering understanding of the analyses.

- Graphical interface software boosts creativity and facilitates rapid model debugging (a feature limited to selected SEM software packages).

- SEM programs provide overall tests of model fit and individual parameter estimate tests simultaneously. Regression coefficients mean, and variances may be compared simultaneously, even across multiple between-subjects groups.

- Measurement and confirmatory factor analysis models can be used to purge errors, making estimated relationships among latent variables less contaminated by measurement error.

- Ability to fit non-standard models, including flexible handling of longitudinal data, databases with autocorrelated error structures (time series analysis), and databases with non-normally distributed variables and incomplete data.

- This last feature of SEM is its most attractive quality. SEM provides a unifying framework under which numerous linear models may be fit using flexible, powerful software.

2.7 INTERPRETIVE STRUCTURE MODELING (ISM)

Interpretive structural modeling (ISM) technique is good enough to dictate the priority index of the measured variable with respect to each other. Important thing is, it is not only used to provide insights into the relationships among the various enablers but also helps to develop the hierarchy based on the importance of each enabler. [Attri et al., 2013; Jayant and Azhar, 2014]

ISM approach initiates with contextual relationship establishment among the measuring variables for latent construct (based on causal approach). A set of different and directly related elements are structured into a comprehensive systematic model reveals it as the interactive learning process. [Warfield, 1974] ISM is the well-known approach for identifying the relationships among variables that will help to define the problem/issue. It is assumed that the variables identified are related to the problem. [Sindhwani and Malhotra, 2016] Still, there may be some variables in complex problems are not having a direct relationship with the problem.

The ISM is considered to evaluate the direct and indirect relationships between the variables which help in representing the current status of the problem more accurately than the individual factor taken into isolation. [Sage, 1977] Therefore, ISM develops insights into the collective understandings of these relationships. [Luthra et al., 2011; Ansari et al., 2013]

The ISM approach is basically to identify and rank the factors affecting/enabling the problem/technique. The group judgment prepares the basis of contextual relationship establishment which states that whether or how the variables are related to each other. [Jain and Raj 2016; Talib et al. 2011; Raj et al., 2008] This relationship further analyzed to address the issue/problem within the system and helps in deciding the nature of variables i.e. either the driving or dependence through the MICMAC analysis. The ISM graph is developed on the basis of analysis work. [Mittal and Sangwan, 2011] The following steps are considered for the application of the ISM approach:

1. Identification of factors affecting the system
2. Development of structural-self interactive matrix (SSIM)
3. Development of the reachability matrix
4. Partitioning the reachability matrix
5. Development of digraph and Conical Matrix
6. Development of the ISM model
7. MICMAC analysis

ISM used the systematic elementary notions of the graph theory and expressed as the contextual relationship among a set of variables. The aid of computers, help the researcher to develop the graphical representations of system composition and structure with ISM.

2.8 CHAPTER SUMMARY

The chapter reveals the explicit review on literature and gives an insight on manufacturing context, the manufacturing environments, lean manufacturing, supply chain, manufacturing strategy, performance, SEM and ISM used for the present study. The chapter also briefs the reasons that are to be perceived as a healthy research problem. The discriminating expectations of customers on various fronts like cost, delivery, and variety, delivery are the need to be addressed well in time. In addition, the ineffective performance of Indian manufacturing context enforced the manufacturers to think for re-examining the resource allocation system, i.e. how they execute the business plans, and meet with the customer-driven challenges are the important task in modern business.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The theoretical background of research methodology is very important to review because it helps in exploring the problem. The problem statement gives a concise description (insights) for the issue which need to be addressed. Moreover, the research methodology includes the research design (questionnaire design and the sampling frame); the survey techniques (data collection techniques); and the techniques used to analyze the primary data/validation of hypothesis etc.

Research which simply means searching again can be defined as a logical process in search of the truth about a concept, theory or a phenomenon. The process of research intended to add new knowledge in the existing theory. The research process includes identifying a new concept, or a business problem, collecting related data, information, and facts in order to enhance the existing knowledge. Research is an organized effort conducted for the purpose of exploring the effective solutions to the well-defined research problems. The research process is logical as well as scientific in nature and starts with the development of a concept or an idea which have potential to explore. This new concept may lead to improving the level of existing knowledge. It is used to ascertain facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories. A research project may also be an expansion of past work in the field.

Research methodology is a systemic method/process dealing with the identifying problem, collecting of facts or data, analyzing these data and reaching a certain conclusion either in the form of solutions towards the problem concerned or certain generalization for some theoretical formulation. It also comprised of a number of approaches and inter-related and frequency overlapping procedures and practices. Since there are many aspects of research methodology, the line of action has to be chosen from a variety of alternative. The choice of suitable method can be arrived at through assessment of objectives and comparison of various alternatives.

This chapter describes the problem statement, objectives of the study, research design, type of data and method of data collection, the sampling procedure, the survey procedure utilized, hypothesis to be tested and the various statistical techniques employed in the study.

3.2 STATEMENT/DESCRIPTION OF THE PROBLEM

A well-defined problem is necessary to start the research work. The process of research must starts with the identifying and explanation of the existing problem. The present research work is based on the efficiency and effectiveness improvement (performance improvement) of the manufacturing organization in an Indian context. Manufacturing industries, in general converts the raw material in final shaped products through processing the raw materials at various workstations. The whole process consumes a huge amount of resources like men, material, and money etc. During the conversion process, some of the resources have been wasted due to various reasons. That's-why, this ever-increasing intensity of competition due to globalization is compelling to the manufacturing sector in order to re-examine their resources. This means it is required to analyze how they are executing their business plans, and meet with the customer-driven challenges.

In the present scenario, the manufacturing organizations are continuously re-thinking and restructuring their supply chains in order to survive and succeed in the long-term perspective. The spearheading competitiveness among the manufacturing context results in arisen of new challenges, i.e. discriminating expectations of customers on various fronts like cost, delivery, and variety. The current challenges for the Indian manufacturing context are to maximize the throughput value along with lowering the cost of manufacturing by modest considerations, i.e. crashing the inventory levels and improving the distribution capabilities. The present study discusses the coupled effect of lean principles and supply chain characteristics on organizational performance. Both lean manufacturing and supply chain management has the different perspective, i.e. lean principles initiated with a focus on waste elimination and continually improved the industry performance, whereas the supply chains are understood primarily in terms of planning the demand forecasts, upstream collaboration with suppliers and optimum utilization of the resources (planning and scheduling).

As literature depicted that the lean manufacturing approach supports the manufacturer's perception that results in significant increases in productivity and quality. While supply chain management supports the customer's and supplier's perceptions through a reduction in process lead-time. So, there is a requisite to couple the lean manufacturing and supply chain approach. The reasons for implementation of coupled approach in the manufacturing sector includes providing valuable products/services as per customer willingness, development of linkage between the suppliers and the customers to avoid interruption in the flow of resources, managing and optimizing the utilization of resources through incorporating flexibility in design of the system, and finally prosper and survival of the organization's in the present competitive environment. Hence, the problem statement of the present study can be stated as

"To understand and study the relationship among principles of lean manufacturing, supply chain characteristics, manufacturing strategies and performance in the manufacturing sector of Indian economy"

The above-mentioned research problem is studied with the help of the following objectives. This research study is *descriptive and causal* in nature.

The main objective of the research study is *to understand and study the relationship among principles of lean manufacturing, supply chain characteristics, manufacturing strategies and performance in the manufacturing sector of the Indian economy.*

In the study the main objective can be achieved with the help of following different sub-objectives:

O_1: To review and classify the literature related to lean manufacturing principles and the supply chain.

O_2: To identify the main attributes of lean manufacturing principles and the supply chain under different manufacturing strategies.

O_3: To understand the level of interest in implementing lean manufacturing principles and supply chain management in the manufacturing industries.

O_4: To identify the impact level of implementing lean manufacturing principles and supply chain management approach in Indian manufacturing organizations.

O_5: To conduct the survey of manufacturing industries to study the applicability of lean manufacturing principles and the supply chain management under different manufacturing strategies.

O_6: To identify the reasons for the slow implementation of lean manufacturing principles in the Indian Context.

O_7: To identify expected benefits from the implementation of lean manufacturing principles and the supply chain under the different manufacturing strategies.

O_8: To study the commonality between lean manufacturing principles and the supply chain management approach and their combined impact on performance.

O_9: To develop the theoretical model for the implementation of lean manufacturing principles throughout the supply chain in the Indian Context.

Hypotheses to be tested

On the basis of defined objectives, the following hypotheses are tested in the research study:

> **Hypotheses 1***: "There exists significant impact of lean manufacturing on the manufacturing organization performance"*
>
> **Hypothesis 2***: "There exists a significant impact of supply chain effectiveness on the manufacturing organization performance".*
>
> **Hypothesis 3:** "*Both the lean manufacturing and supply chain management have the significant relationship with each other".*

3.3 RESEARCH DESIGN

Research design can be explained as a detailed outline of how an investigation will take place. It is actually a master plan which guides the methods and procedures for collecting and analyzing the required information. A research design will typically include how data is to be collected, what instruments will be employed, how the instruments will be used and the intended means for analyzing data collected. This research study is *Descriptive as well as Causal research* based on a large measure on the collection of primary data from the executives working with manufacturing industries in India. This research study tries to analyze the perception of corporate executives with respect to existing lean manufacturing in their manufacturing system, the existing effectiveness of supply chain management and their impact on the performance of the companies as per the designed corporate manufacturing strategies.

3.3.1 Sampling Frame

Sampling frame can be defined as a list of elements from which a sample may be drawn. The sampling frame of a research study can be explained with the help of the following features:

a. **Population:** The population of the study consists of the manufacturing system of all the companies irrespective of the area and boundaries.
b. **Target Population:** The target population of the study includes the manufacturing facilities in Indian Economy.
c. **Sampling Unit:** The data is collected from the executives working in the manufacturing context. The majority of the respondents in the present study were from the industries situated in the Delhi-NCR region.
d. **Sampling Method:** The sampling method used in the study is ***cluster random sampling.*** The data is collected from corporate executives working in the manufacturing sector.
e. **Sample Size:** The primary data is collected from 220 corporate executives who are working in the field of manufacturing context.

3.4 DESIGNING AND DEVELOPING THE QUESTIONNAIRE

The data was collected by means of a standardized questionnaire developed with the help of literature review and expert views working in the various manufacturing industries. The questionnaire is developed as well as tested in the following stages:-

a) Identifying variables and finalize with the help of a literature review.
b) Pilot survey
c) Finalizing the questionnaire
d) Reliability check

The final structured questionnaire is prepared using mainly close-ended questions based on the specified choice option. Actual data collection is preceded by a pilot survey. The pilot survey is carried out with a sample size of 30 corporate executives with a view to clarify questionnaire structure and avoid any interpretation problems. The inputs, as well as the suggestions/comments related to any change in questionnaire (If any), were invited from the experts with the objective of improvement in the quality and texture of the questionnaire to ensure the smooth data collection. Further, the suggestions/comments recommended by the experts are incorporated in the questionnaire for the final draft. Finally, the reliability of the questionnaire is measured of different stages to ensure that data collected is reliable and data can be analyzed further. Cronbach alpha values were computed of three stages, firstly after collecting data from 20 executives and subsequently after the collecting data from 30 and 40 executives.

3.5 DATA COLLECTION, ANALYSIS, AND VALIDATION

Data is basically a collection of facts and facets related to any situation/product. The data collected later to this under go to the filtrations process in order to convert into the relevant information. This relevant information then compiled and interpreted to draw the final conclusion in the form of a problem statement or a solution alternative varies from situation to situation.

The primary data is collected from corporate executives working with manufacturing systems of different companies having their manufacturing plant in India with the help of ***self-designed questionnaire*** designed on the basis of literature review and with the consultation of different area experts in the manufacturing sector.

Various statistical techniques are to be used for testing the hypothesis and drawing the inferences and conclusions about the relationship. In the research study following statistical methods is applied:

1. **Frequency Distribution:** Frequency distribution is a method of displaying the frequency (number of times a particular value of a variable repeat in the data) of different values of a variable in the dataset. It represents the counts of all outcomes of a variable in the sample. The frequency distribution of a variable can be represented in tabular form as well as graphical form. The frequency distribution is very common and important for nominal (categorical) and ordinal (ranking) variables in the dataset. In the research study, the frequency distribution

is used to represent the students belongs to different demographic profiles. [Hair et al., 2010; Chauhan, 2016,]

2. **Descriptive analysis:** In the research study, the primary data is collected from the manufacturing Industry executives selected for the purpose of research. The data is collected with the help of a standardized questionnaire containing the scales. With the help of input data, the descriptive analysis is done through the estimation of central tendency (mean, median) and dispersion (standard deviation).
3. **Correlation Analysis:** Correlation is a measure of the statistical linear relationship between two variables. In the research study, the correlation analysis is done in order to study the relationship between a set of variables. The measure of correlation analysis is known as the Coefficient of correlation and can be mathematically expressed as:

$$Coeeficient\ of\ Correlation\ (r) = \frac{Covariance\ (x,y)}{\sigma_x \sigma_y} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{(N-1)\ \sigma_x \sigma_y}$$

Where, σ_x = Standard deviation of x

σ_y = Standard deviation of y

r = Coefficient of correlation

4. **Regression Analysis:** Bivariate regression analysis is used to analyze the cause and effect relationship between two variables under study. In other words, the purpose of regression analysis is to study the dependence of one variable (*dependent variable)* on another variable (independent variable) and to estimate the expected values of the dependent variable with the help of known values of the independent variables. In regression analysis, the researcher is interested to know the dependence among variables. The dependent variable is considered as a stochastic variable, whereas the independent variables are deterministic in nature. The correlation between two variables indicates the *strength* of *linear association* between them, however, the regression analysis tries to estimate or predict the average value of one variable on the basis of the fixed values of other variables. The regression model can be expressed as:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_i$$

Where Y represents the stress level of the selected students in the study and Independent variables are personality type, wellbeing and achievement motivation level.

5. **Structural Equation Modelling:** SEM is referred to as the advanced version of *Regression Analysis* to represent, estimate and testing of the network of relationships between variables (measured variables and latent constructs). [Hair et al., 2010] Generally, SEM approach is used to establish and test the complex relationships among the observed variables (measured through an analytical survey) and unobserved variables (the latent constructs). It is the analysis technique for the multivariable problems/issues in which statistical analysis is used to analyze the structural relationship. [Fornell and Larcker, 1981] SEM considers the elementary concept; basic statistics (variance, covariance, correlation, and so on) and the factor analysis (chiefly linear, chiefly cross-sectional, confirmatory factor analysis, path analysis, and regression technique). SEM has the strengths to use latent variables (constructs) in the dependent modules. This is a mainly the confirmatory method of modeling and solving the problems, rather than exploratory technique. [Chauhan, 2016]
6. **Interpretive Structure Modelling Approach:** ISM approach is a widely used approach for prioritizing the entities by using the structural set of different and directly related variables in the systematic model. [Warfield, 1974; Sage, 1977] The model has the main aim to develop the direction of complex relationships among elements in a system with each other. The designed model in ISM has a logical structure with some complexity issues. [Ansari et al., 2013; Haleem et al., 2012; Jayant and Azhar, 2014] ISM approach initiates with contextual relationship establishment among the measuring variables for latent construct (based on causal approach). The group judgment prepares the basis of contextual relationship establishment which states that whether or how the variables are related to each other. [Jain and Raj 2016] This relationship further analyzed to address the issue/problem within the system. The ISM graph is developed on the basis of analysis work. [Mittal and Sangwan, 2011] MICMAC analysis provides the

support to the ISM is used to develop the hierarchy based on the importance of each variable on others.

3.6 SUMMARY

The present study is focused on establishing the relationship between lean principles and supply chain characteristics and their impact on the performance of an organization. The manufacturing strategy is also a point of concern for the present study thereby the organizations can have the maximum benefits. This chapter of the study gives an insight into the problem statement and the objective of the present study. In addition, the chapter also discusses the data preparation, collection and validation (testing/analysis) techniques used in the study.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

Globalization of the market in the present scenario bounds the manufacturing context to some specific mission and visions, and all these are measurable with a huge variety of attributes. The manufacturing context has grown up with a complex structure which results in inadequacies/inabilities in managing the resources within and outside the organization. The expected value or an outcome desired at the beginning is attainable if and only if all the happenings are going in the right way.

Due to this fact, the application of any individual approach (i.e. lean manufacturing or supply chain) may result in the improvements, but on the other hand, it will affect the other allied areas. There is an opportunity for the manufacturing sector to couple the two different approaches on a single platform. This will give the advancement to the manufacturing context and the output is realistic by reducing the chance of uncertainties from the system.

In the present study the relationship between lean manufacturing, supply chain characteristics and performance is analyzed with the help of structural equation modeling approach. SEM is the extension of the general linear model (GLM). SEM enables practitioners to test the number of regression equations set simultaneously. In this, the cause and effect analysis is done with the help of AMOS-20 Software. The software generally permits the testing of traditional models. The software also used to examine the more complex relationships/models by confirmatory factor analysis and time series analyses.

The theoretical background of the problem and its measures provide the base for developing the model which is being examined by the SEM Software. The theoretical study answers the following queries such as:

a. What is the problem (Effect)?
b. What are the measures for the said problem (causes such as constituents, parameters etc.)?

c. How to measure constructs such as sample size, data collection, data validation etc?

SEM inputs are usually the covariance matrix of measured variables of the data collected through the survey. Sometimes the correlations or covariance's matrices of means are used as the input to examine the model. The output of SEM reveals the status of the model either good or bad after critical examining overall model fit statistics and parameter estimates of the raw data (input).

4.2 LEAN MANUFACTURING IN MANUFACTURING SYSTEM

The manufacturing systems consume the resources in an independent manner to shape the final product as desired by the consumers. In the consumption of resources, there are problematic arises for the entrepreneurs that what type of resources they may introduce into the process to get higher returns. In the manufacturing sector, approximately 20-25 percent of the resources are un-identified or hidden from the process during manufacturing work in progress. It will further cause the final output as lower than the desired value with higher the cost per unit of output. The current technological revolution and globalization of the markets bridge a gap by introducing the new approaches in concern of industrial optimization. These approaches come into existence because of continuous changes customer demand in terms of quantity, quality, variety, cost, and delivery aspects.

The lean manufacturing approach is the basic need and answers for all types of queries stated in the above para. This approach came into existence in 1990 in the book authored by Womack and named "The machine that changed the world". A Japanese motor company named Toyota was the first industry who introduced the concept of lean production on their shop floor under the guidance of Taiichi Ohno (Former Toyota Engineer and Founder of the Toyota Production System). After that, Taiichi Ohno published many types of research based on his experiences of developing the new strategies to accomplish the improved process parameters under Lean environment. The lean production system is very similar to TPS and having the five very distinct objectives that are Value to the customer, uninterrupted flow of resources within and outside the organization, pull-production instead of push-Production, quick response to the customer's query and demand and finally, the perfection in the work.

These principles help the manufacturers to produce the items as per the customer's expectation and provide the improvements in outcomes of their organizations.

The lean manufacturing system is supposed to eliminate the wastages associated with the manufacturing process. Waste is an activity associated with the process that does not add value to the final product. The wastages lead to a struggle for manufacturer's that the sale of undesired products creates a situation where the marketing department needs to apply all resources at their command to recover the invested money. The unwanted utilization of resources is just a sign that there is a problem in the system and it seems to be identified and addressed as early. The normal symptoms in a manufacturing system are excessive raw material, extra inventory, unregulated material flow, the excessive need for space for storage etc. This kills the efficiency and profitability of the organization.

More liberal and extensive reciprocity in the production and sale of commodities is necessary so that the undesired production of the companies can be satisfactorily disposed of to the market. Therefore, lean manufacturing is the best approach to respond to the above-said symptoms. Further, it provides a competitive advantage to the firm and increases its profitability. It improves the delivery schedule of the manufacturing components and improves the efficiency of the manufacturing system.

The extensive literature on Lean Principles revealed the numerous tangible and intangible benefits of Lean Principles implementation in the manufacturing sector. The twelve most common impacts on organizational performance were considered for the present study as listed below:

1. To provide the value to the customer,
2. To emphasize the quality enhancement as a continuous improvement process,
3. To minimize the resources losses from the unwanted transportation,
4. To minimize the inventory wastages by controlling on all the business activities
5. To optimize the movement of men, material & machine in the manufacturing process.
6. To minimize the lead-time for production as well as purchasing
7. To provide the better understanding on overproduction in an organizations
8. Minimize the losses of resources caused by over-processing

9. Help in producing the defect-free production
10. Helps in utilizing the full potential of its workforce to support the business activities
11. Helps in utilizing the space (Horizontally and Vertically)
12. Helps in providing the safest working conditions which have influence on business activities [Katayama & Bennett, 1996; Emiliani, 1998; Achanga et al., 2006; Puvanasvaran et al., 2008; Olivella et al, 2008; Rajenthirakumar e al, 2011; Anand & Kodali, 2009 (a)]

Based on the benefits mentioned above the twelve statements related to lean manufacturing is prepared for the questionnaire purpose as shown in table 4.1.

Table 4.1: Statements for the construct Lean Manufacturing

Sr. No.	Statements	Designation
1	The organization provides appropriate value to the customer.	C_1
2	The organization has a stronger emphasis on quality improvement in the process.	C_2
3	The organization is able to minimize the loss of resources due to unwanted transportation in production systems.	C_3
4	There is minimum wastage of inventory in the manufacturing process.	C_4
5	The movement of men, material & machine in the manufacturing process is standard and optimized.	C_5
6	The waiting time in the process will keep as a minimum with respect to production lead-time.	C_6
7	The organization believes in excessive production than the market demand.	C_7
8	There is a minimum problem of over-processing associated with the manufacturing process.	C_8
9	The product/services provided by your organization are free from any minor/major defects.	C_9
10	The organization utilized the full potential of its workforce to support the manufacturing process.	C_{10}
11	The proper utilization of space (Horizontally and Vertically) within the organization to support the manufacturing process.	C_{11}
12	The organization provides the safest working conditions that have the strongest influence on productivity.	C_{12}

In the research study, a lean manufacturing approach is considered as a latent variable, which can be studied with the help of the above-mentioned statements. It is assumed that the existence of the lean manufacturing system in a manufacturing setup can be reflected in the mentioned statements. These statements aim to achieve the best production and environment by de-layering the organizational structure in the step-by-step implementation of various lean tools.

In the research study, the data on the perception of the executives working in the manufacturing setup of selected Indian firms are collected with the help of personal interview and questionnaire. One of the objectives of the research is to study the perception of executives towards the existing lean manufacturing system in the manufacturing setup. Lean manufacturing is considered as a reflective construct and is measured with the help of different statements. It is assumed that these statements are the reflections of the existing lean manufacturing system of the company.

Before proceeding further for the statistical analysis of the developed model, it is required to analyze the internal consistency reliability of the construct. The internal consistency reliability of the statements is measured with the help of Cronbach alpha (α). The results of the reliability analysis of responses for different statements of the lean manufacturing system are shown in table 4.2 below. The value of Cronbach alpha for the lean manufacturing construct is 95.5 which indicate the presence of the internal consistency reliability in the responses.

Table 4.2: Reliability analysis for the construct Lean Manufacturing

Statements	Cronbach alpha (α)
C_1: The organization provides appropriate value to the customer.	**95.5**
C_2: The organization has a stronger emphasis on quality improvement in the process.	
C_3: The organization is able to minimize the loss of resources due to unwanted transportation in a Production system.	
C_4: There is minimum wastage of inventory in the manufacturing process.	
C_5: The movement of men, material & machine in the manufacturing process is standard and optimized.	
C_6: The waiting time in the process will keep as a minimum with respect to production lead-time.	
C_7: The organization has believed in excessive production than the market demand.	
C_8: There is a minimum problem of over-processing associated with the manufacturing process.	
C_9: The product/services provided by your organization are free from any minor/major defects.	
C_{10}: The organization utilized the full potential of its workforce to support the manufacturing process.	
C_{11}: The proper utilization of space (Horizontally and Vertically) within the organization to support the manufacturing process.	
C_{12}: The organization provides the safest working conditions that have the strongest influence on productivity.	

This internal consistency reliability is important for the further description of statements of the construct in an individual manner. In the study, the descriptive analysis (mean score and standard deviation) of each statement of lean manufacturing is estimated. The result of the descriptive analysis is shown in table 4.3.

Table 4.3: Descriptive analysis of the construct Lean Manufacturing

Statements	**Mean [Standard Deviation]**
C_1: The organization provides appropriate value to the customer.	4.23 [0.995]
C_2: The organization has the strong emphasis on Quality Improvement in the process.	4.20 [0.976]
C_3: The organization is able to minimize the loss of resources due to unwanted transportation in production systems.	3.94 [0.924]
C_4: There is minimum wastage of inventory in the manufacturing process.	3.94 [0.994]
C_5: The movement of men, material & machine in the manufacturing process is standard and optimized.	3.92 [0.969]
C_6: The waiting time in the process will keep as a minimum with respect to production lead-time.	3.85 [0.888]
C_7: The organization has believed in excessive production than the market demand.	3.47 [0.893]
C_8: There is a minimum problem of over-processing associated with the manufacturing process.	3.79 [0.919]
C_9: The product/services provided by your organization are free from any minor/major defects.	4.00 [0.948]
C_{10}: The organization utilized the full potential of its workforce to support the manufacturing process.	4.06 [0.932]
C_{11}: The proper utilization of space (Horizontally and Vertically) within the organization to support the manufacturing process.	4.07 [1.020]
C_{12}: The organization provides the safest working conditions that have the strongest influence on productivity.	4.05 [0.950]

Table 4.3 shows the results of a descriptive analysis of the construct "lean manufacturing". The results indicate that the statement C_1, i.e. proper attention to the customers has the

highest mean score of 4.23. This indicates that the present customer seeks to get proper attention from the manufacturers. Proper attention to the customer helps to deal with the variation in customer demand that leads to fruitful results.

The statement C_2 with a mean score of 4.20 indicates that the Indian manufacturing context has a stronger emphasis on quality improvement in the process. In the present scenario, the quality of the output is to be set by the customer, so it is required to have the quality improvement process in a continuous manner not only on internal basis but also for the external suppliers.

Next, to the above order, statement C_{11} with a mean score of 4.07 indicates that the most of the organizations have the proper utilization of their space in a horizontal and vertical manner to support the manufacturing process. Some manufacturing industries are looking to grab the opportunity of full utilization of space, but still not achieved because of mismanagement within internal relationships.

The statement C_{10} with a mean score of 4.06 indicates the management perspective, i.e. optimal utilization of workforce to support the manufacturing system for improved performance rate.

The statement C_{12} with a mean score of 4.05 indicates the influencing factor for productivity, i.e. unsafe working conditions, which are provided to the employees. Most of the manufacturing industries have the provision to provide the safest working environments as per government regulations.

The statement C_9 with a mean score of 4.00 indicates that almost all the products/services provided by the industries are free from defects. The mean score is less than the expectation, which further reflects the Quality perspective of the industries within the process.

Further, the statement C_3 with a mean score of 3.94 indicates that some of the organizations fail to minimize the losses from unwanted transportation in the production system. This unwanted transportation may cause the process affected and further increase the cost of output.

The statement C_4 with a mean score of 3.94 indicates that the optimum level of inventory has not been achieved by all the industries. Yet, almost all the industries claimed that they have achieved the optimum level of Inventory through inventory management approaches.

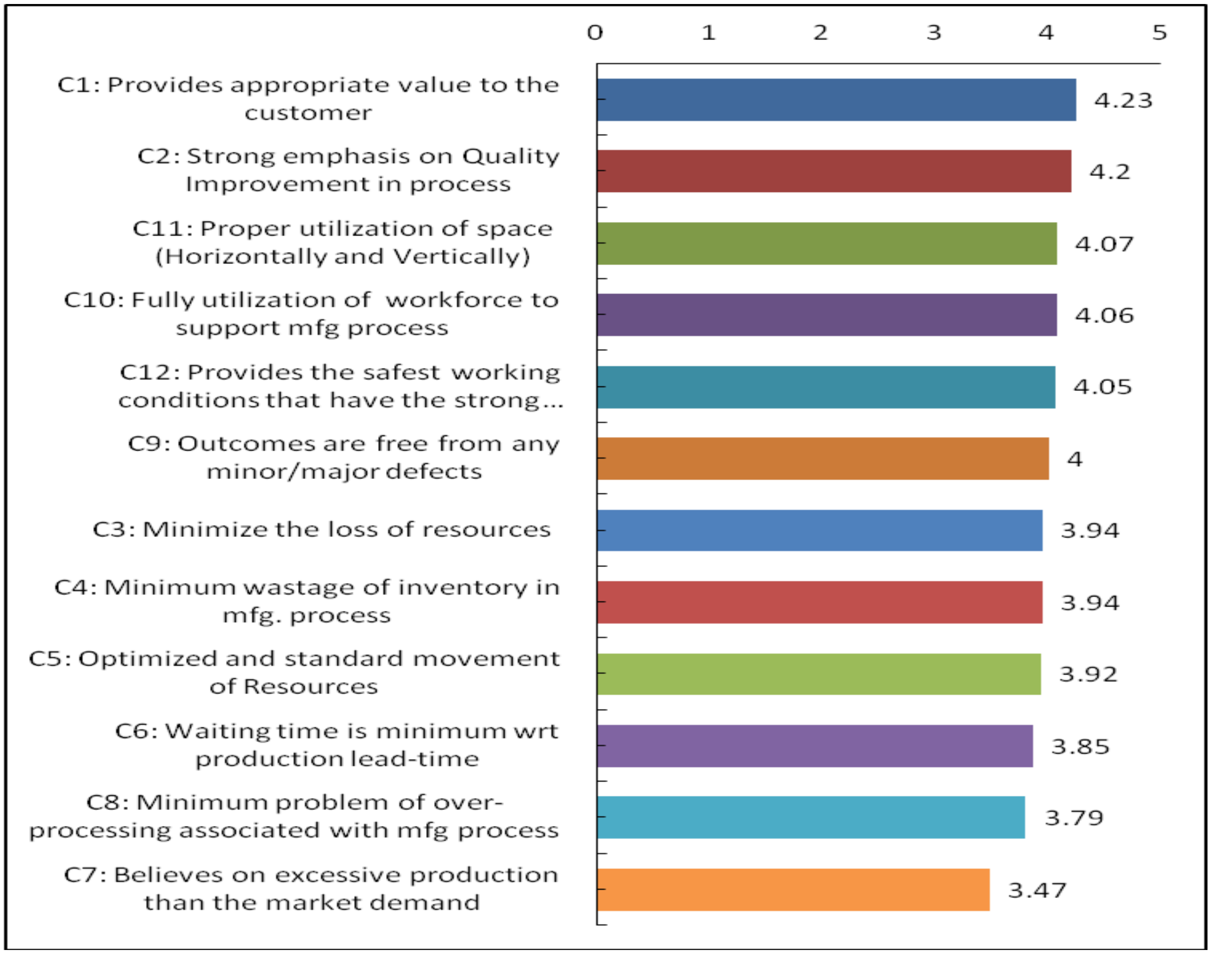


Figure 4.1: Mean score contribution of the scale for the construct Lean Manufacturing

The statement C_5 with a mean score of 3.92 indicates that there is slight improvement required in resource movements within the designed plant layout. The unwanted flow of resources interrupts the working environment of the organizations. The statement C_6 with a mean score of 3.85 indicates that the waiting time within the process is not up to the mark. The waiting time in the process is kept low, but actually, the results differ from the settled one.

The statement C_8 with a mean score of 3.79 indicates that some of the manufacturing industries have the over-processing problems associated with the production system. This further causes the scheduling and delivery of products within and outside the organizations.

The statement C_7 is found to have the lowest mean score of 3.47, which indicates that most of the respondents refused to produce the products more than the demands. Figure 4.1 shows the mean score contribution of all the statements for the construct lean manufacturing.

In the study, the responses of the executives working with the manufacturing system of the company are collected on five-point Likert scales used in the questionnaire. The frequency distribution of the responses related to constructing lean manufacturing is estimated and shown in table 4.4 and figure 4.2.

Table 4.4: Frequency distribution table for the construct Lean Manufacturing

Statements	**Strongly Disagree (1)**	**Disagree (2)**	**No-opinion (3)**	**Agree (4)**	**Strongly Agree (5)**
C_1	8 [3.6 %]	9 [4.1 %]	14 [6.4 %]	83 [37.7%]	106 [48.2 %]
C_2	6 [2.7 %]	12 [5.5 %]	15 [6.8 %]	87 [39.5%]	100 [45.5 %]
C_3	3 [1.4 %]	15 [6.8 %]	38 [17.3 %]	101 [45.9%]	63 [28.6 %]
C_4	5 [2.3 %]	20 [9.1 %]	25 [11.4 %]	103 [46.8%]	67 [30.5 %]
C_5	6 [2.7 %]	16 [7.3 %]	28 [12.7 %]	109 [49.5%]	61 [27.7 %]
C_6	2 [0.9 %]	16 [7.3 %]	46 [20.9 %]	106 [48.2%]	50 [22.7 %]
C_7	5 [2.3 %]	18 [8.2 %]	92 [41.8 %]	78 [35.5 %]	27 [12.3 %]
C_8	7 [3.2 %]	17 [7.7 %]	28 [12.7 %]	132 [60 %]	36 [16.4 %]
C_9	2 [0.9 %]	22 [10 %]	21 [9.5 %]	105 [47.7%]	70 [31.8 %]
C_{10}	4 [1.8%]	12 [5.5 %]	29 [13.2 %]	97 [44.1 %]	78 [35.5 %]
C_{11}	5 [2.3 %]	15 [6.8 %]	32 [14.5 %]	76 [34.5 %]	92 [41.8 %]
C_{12}	5 [2.3 %]	13 [5.9 %]	25 [11.4 %]	101 [45.9%]	76 [34.5 %]

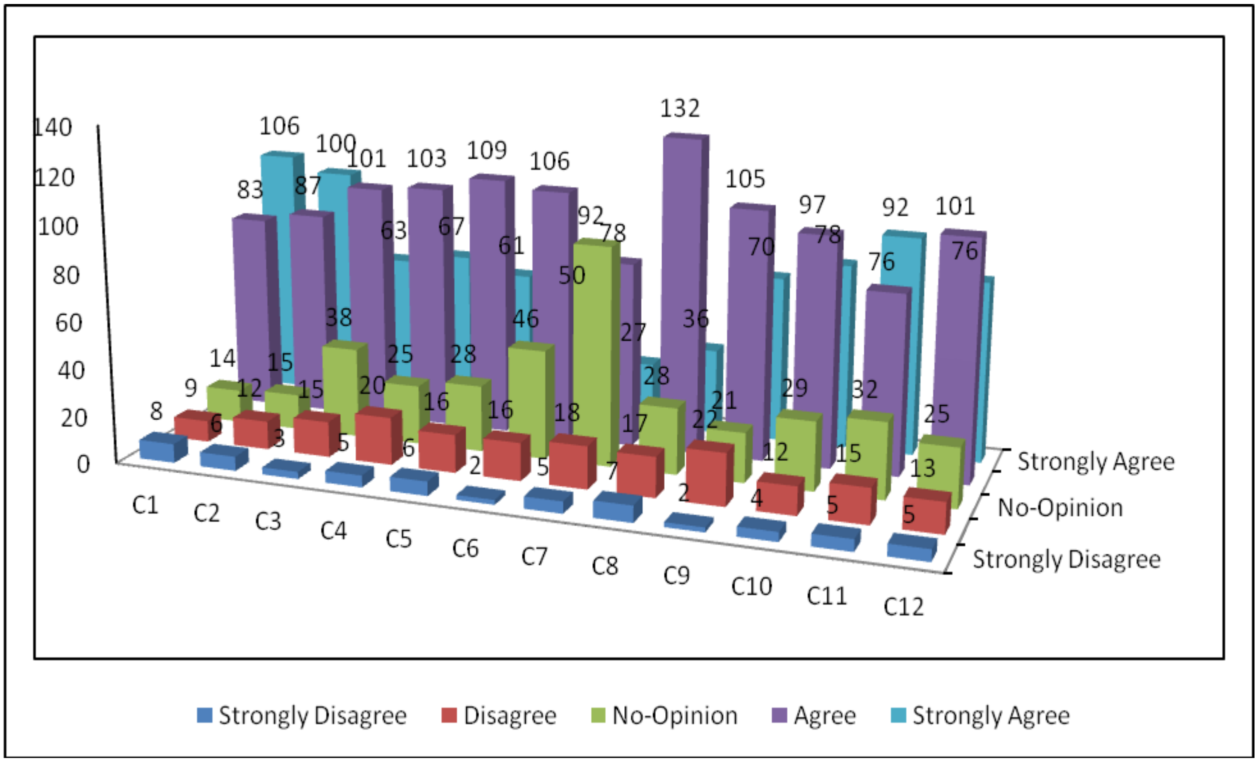


Figure 4.2: Frequency distribution for the construct Lean Manufacturing

The success and sustainability of business in the market are difficult to achieve without providing the appropriate value to the customer. The result in table 4.4 indicates that customer perception is necessary which can help organizations to have the improved product/service quality as an outcome.

Almost 60 percent of respondents agreed with the statement i.e. minimum loss of resources due to over-processing. As literature depicted that lean principle creates the boundaries in the manufacturing process, which restricts the process to go beyond certain limits. On the other hand, the minimum number of respondents agreed with the statement i.e. proper utilization of space. This means that the space utilization in lean principles can be considered as the barrier in lean principle application.

The most numbers of respondents refuse to answer the statement i.e. production is more than demand. This means that still there is a gap remaining in between actual production and the planned production. In Indian manufacturing concern, most of the organizations believe in producing the goods more than the demand. This will lead to blockage/shortage of resources for future concern. The revolution in the quality management sector inbounds the manufacturer to produce the products within the desired specifications.

Still, there is little bit concern about the defect-free production is pending in Indian manufacturing concern. The reason behind this argument is a huge population and with a wide variety of financial status. Some of the respondents have chosen the strongly disagree choice for the statement i.e. providing the appropriate value to the customer. This indicates about the industries that are in the market for making profits only with short-term planning concern. This type of industries has the priority to provide value to the product instead of customers. This is a very critical issue for those who try to sustain their market for long-range concern.

In the study, construct lean manufacturing is consists of 12 distinct statements. It is assumed that these statements reflect the existing lean manufacturing system in the manufacturing process. In other words, these statements reflect the feasibility and validity of the lean manufacturing approach implemented in industry. The construct (lean manufacturing) along with its measured items (statements C_1- C_{12}) can be mathematically modeled as:

$$C_1 = \beta_1 * Lean\ Manufacturing + \varepsilon_1$$

$$C_2 = \beta_2 * Lean\ Manufacturing + \varepsilon_2$$

………………………………………….

$$C_{12} = \beta_{12} * Lean\ Manufacturing + \varepsilon_{12}$$

Where C_1 to C_{12} represent measured variables related to lean manufacturing.

The regression coefficients β_1 to β_{12} represents the construct loading (standardized regression coefficient) of different statements with respect to the construct.

The error (ε_1-ε_{12}) represents the error of the regression model.

The above-mentioned equations are estimated with the help of a measurement model approach in structural equation modeling method. The construct LM along with its measured variables are shown below in figure 4.3 and output of the AMOS Software are shown in figure 4.4, 4.5, 4.6 and summarized in table 4.5 below:

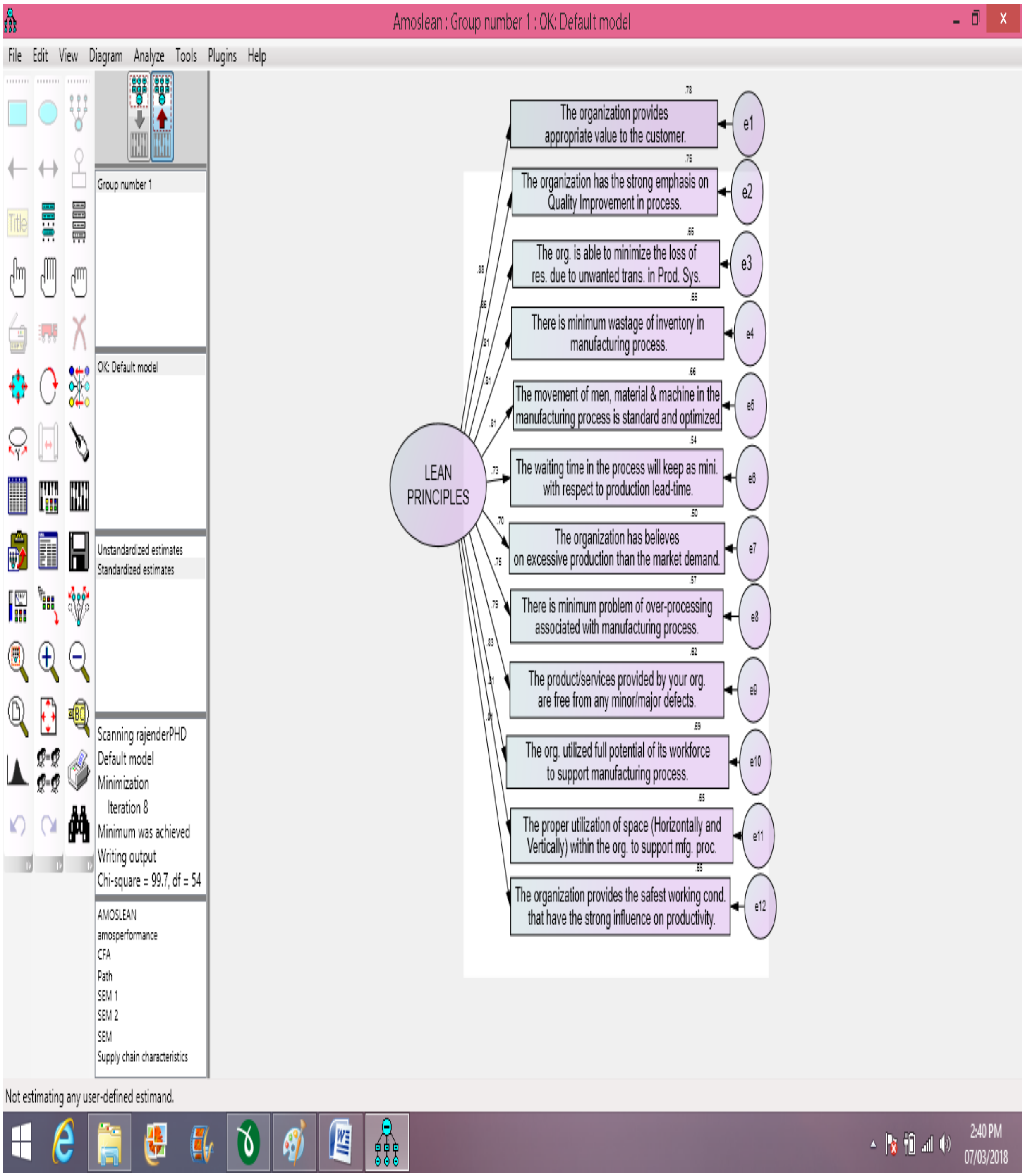
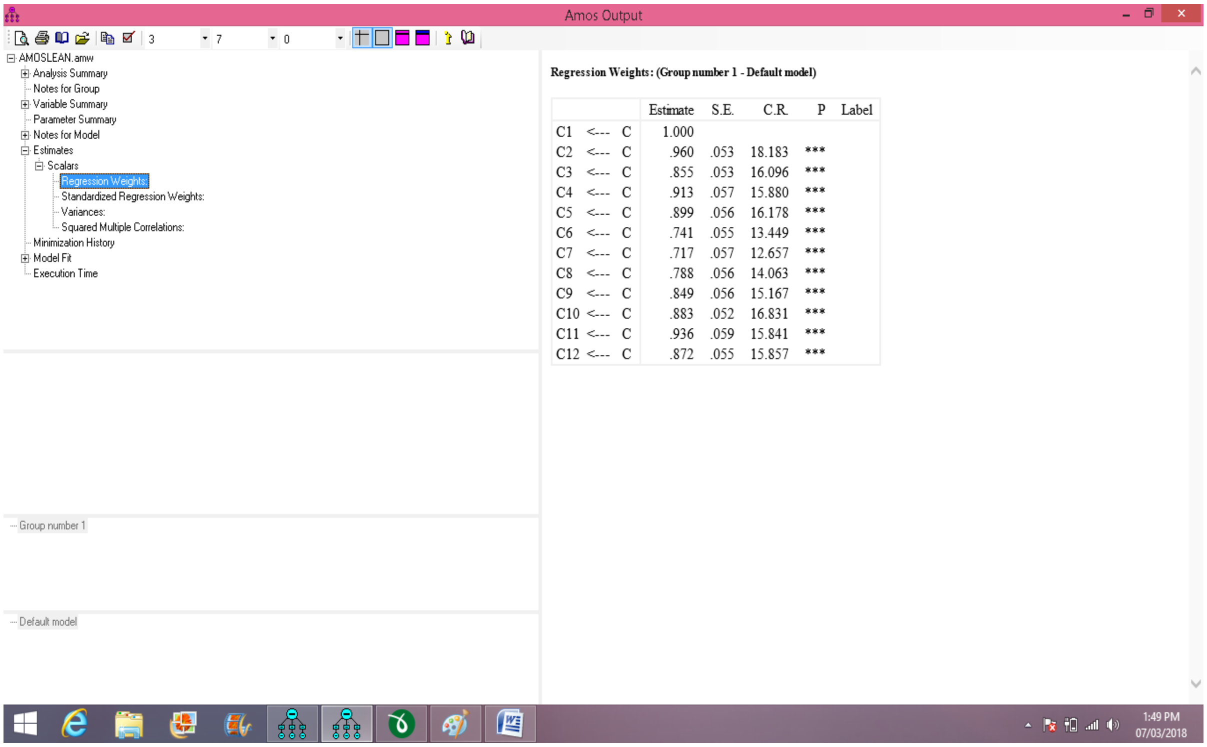


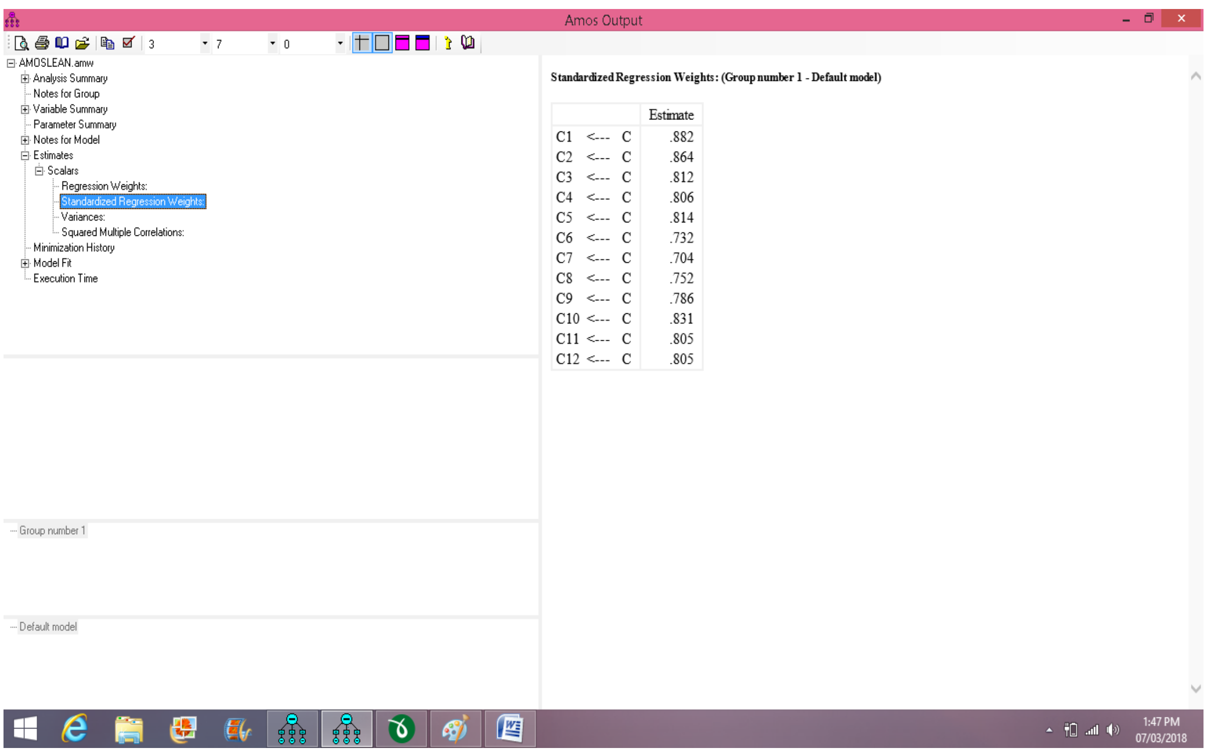
Figure 4.3: SEM diagram of the construct Lean Manufacturing



Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
C1	<---	C	1.000				
C2	<---	C	.960	.053	18.183	***	
C3	<---	C	.855	.053	16.096	***	
C4	<---	C	.913	.057	15.880	***	
C5	<---	C	.899	.056	16.178	***	
C6	<---	C	.741	.055	13.449	***	
C7	<---	C	.717	.057	12.657	***	
C8	<---	C	.788	.056	14.063	***	
C9	<---	C	.849	.056	15.167	***	
C10	<---	C	.883	.052	16.831	***	
C11	<---	C	.936	.059	15.841	***	
C12	<---	C	.872	.055	15.857	***	

Figure 4.4: Regression weights output for the construct Lean manufacturing



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
C1	<---	C	.882
C2	<---	C	.864
C3	<---	C	.812
C4	<---	C	.806
C5	<---	C	.814
C6	<---	C	.732
C7	<---	C	.704
C8	<---	C	.752
C9	<---	C	.786
C10	<---	C	.831
C11	<---	C	.805
C12	<---	C	.805

Figure 4.5: Standardized regression weights output for the construct Lean manufacturing

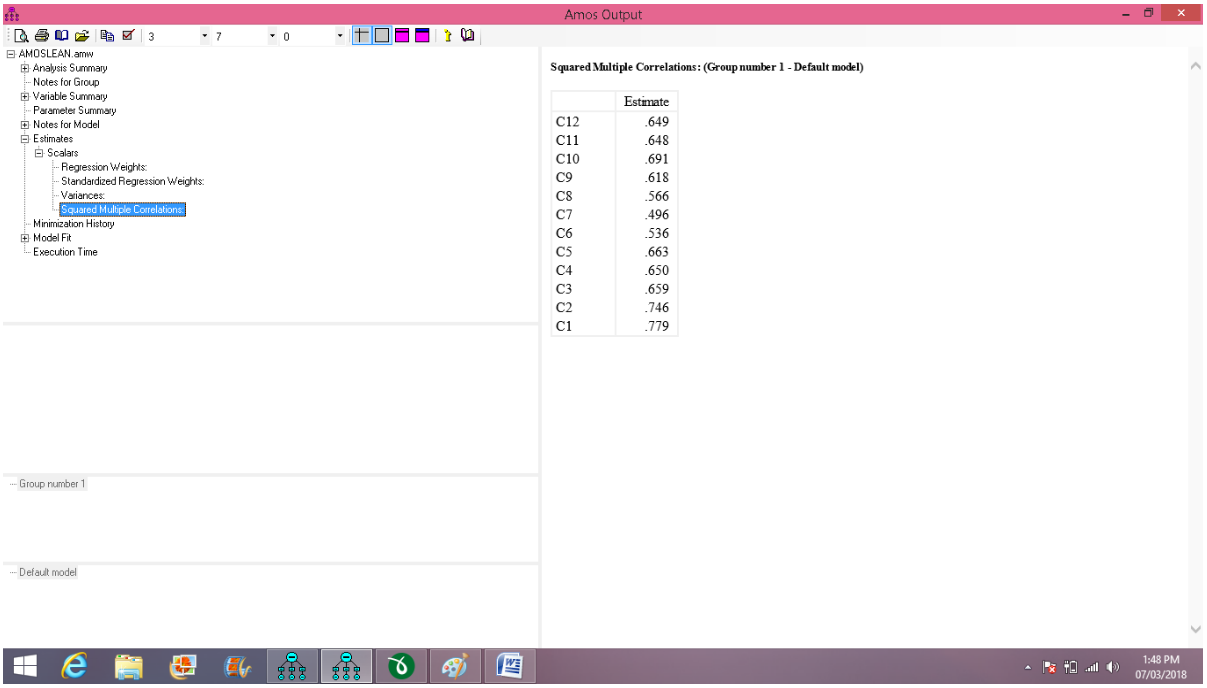


Figure 4.6: Squared multiple correlations output for the construct Lean Manufacturing

Table 4.5: Analysis summary for the construct Lean Manufacturing

Statements	Standardized Construct Loading	Critical Ratio	P-Value	Squared Multiple Correlation
C_1	0.882	--------	0.000	77.9
C_2	0.864	18.183	0.000	74.6
C_3	0.812	16.096	0.000	65.9
C_4	0.806	15.880	0.000	65
C_5	0.814	16.178	0.000	66.3
C_6	0.732	13.449	0.000	53.6
C_7	0.704	12.657	0.000	49.6
C_8	0.752	14.063	0.000	56.6
C_9	0.786	15.167	0.000	61.8
C_{10}	0.831	16.831	0.000	69.1
C_{11}	0.805	15.841	0.000	64.8
C_{12}	0.805	15.857	0.000	64.9

The result of the regression model indicates that the probability value of the critical ratio is found to be less than 5 percent level of significance. Hence, with 95 percent confidence level, it is concluded that all the statements considered in the study are significantly reflected the existence of lean manufacturing in the manufacturing sector.

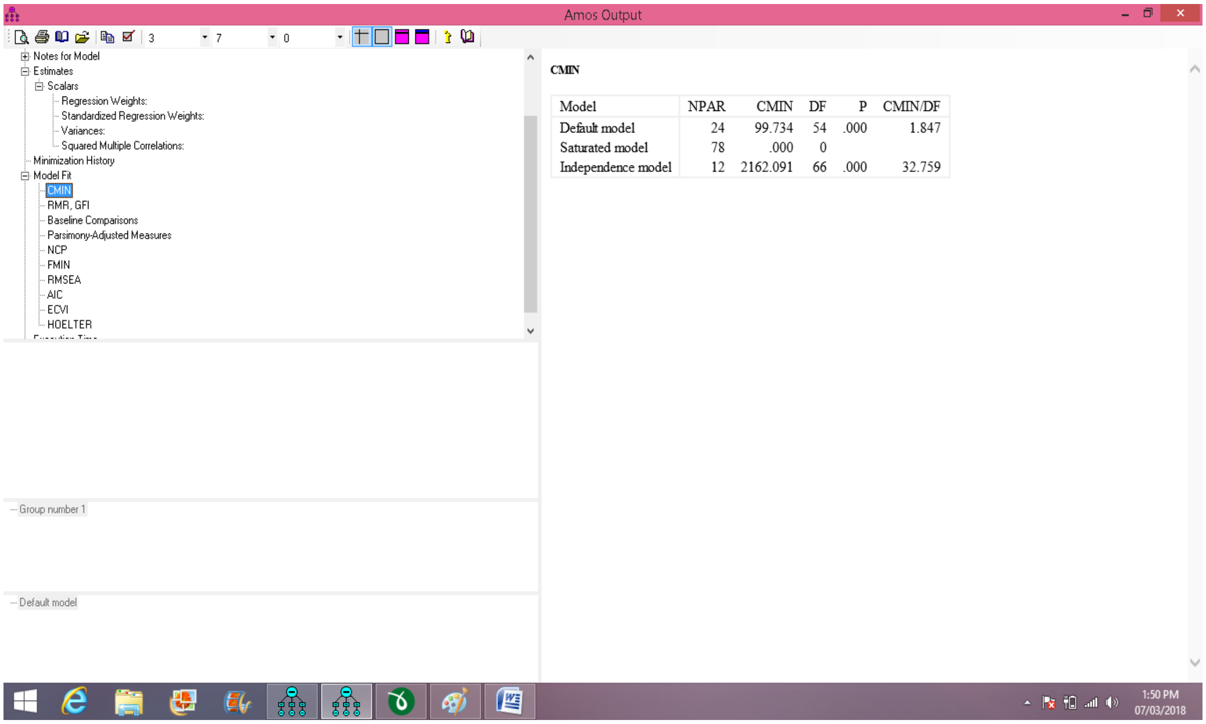
In addition to this, all the constructs loadings of statements are found to be greater than 0.7, which ensures the presence of convergent validity of the construct. It is also depicted from the results that the statements C_1 have the highest factor loading followed by C_2, $C_{10,}$ and so-on. This represents the presence of an efficient lean manufacturing system in the manufacturing industries is reflected in the form of better value addition to the customer perception.

Further, the second highest factor loading on statement C_2 i.e. strong emphasis on quality improvement in the organization reflects the presence of lean manufacturing system in the manufacturing context. Statement C_7 has the lowest factor loading because lean manufacturing has the aim to reduce/eliminate the over-production in the organization. So, this statement also reflects the presence of the lean manufacturing system.

The R square value indicates that 77.9 percent of the variance of the statement C_1 can be explained with the help of variations in the construct lean manufacturing. This is followed by the statement C_2 with 74.6 percent of the variance can be explained with the help of variation in the construct.

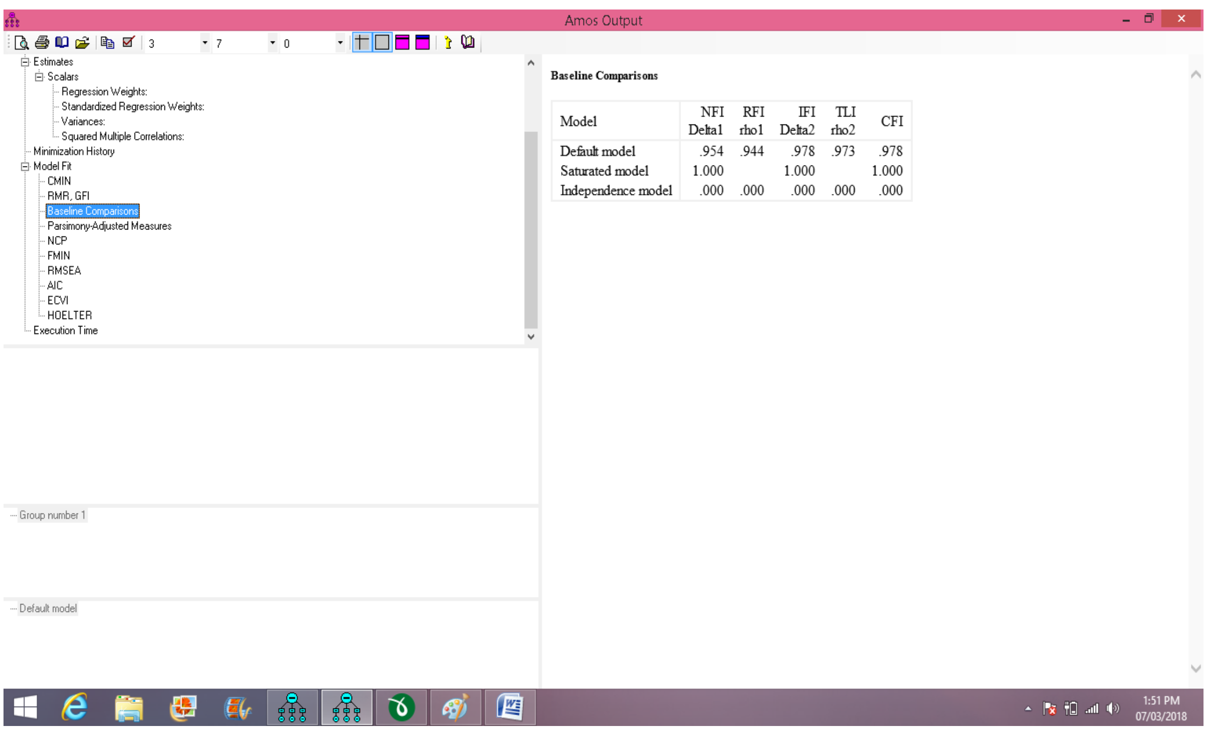
Similarly, 74.6 percent of the variance of statement C_2, 65.9 percent of the variance of the statement C_3 and so-on can be explained with the help of the construct i.e. lean manufacturing. In this study, it is found that lower factor loading of the statement $C_{7,}$ which means that it reflects the lean manufacturing less than other statements.

The model fitness indices are examined to depict whether the said model is good or not. To find out the goodness of fit or model fitness analysis the statistical tests is run on the Amos Software. Figures following 4.7, 4.8, 4.9, and 4.10 show the various model fitness indices and summarized in table 4.6.



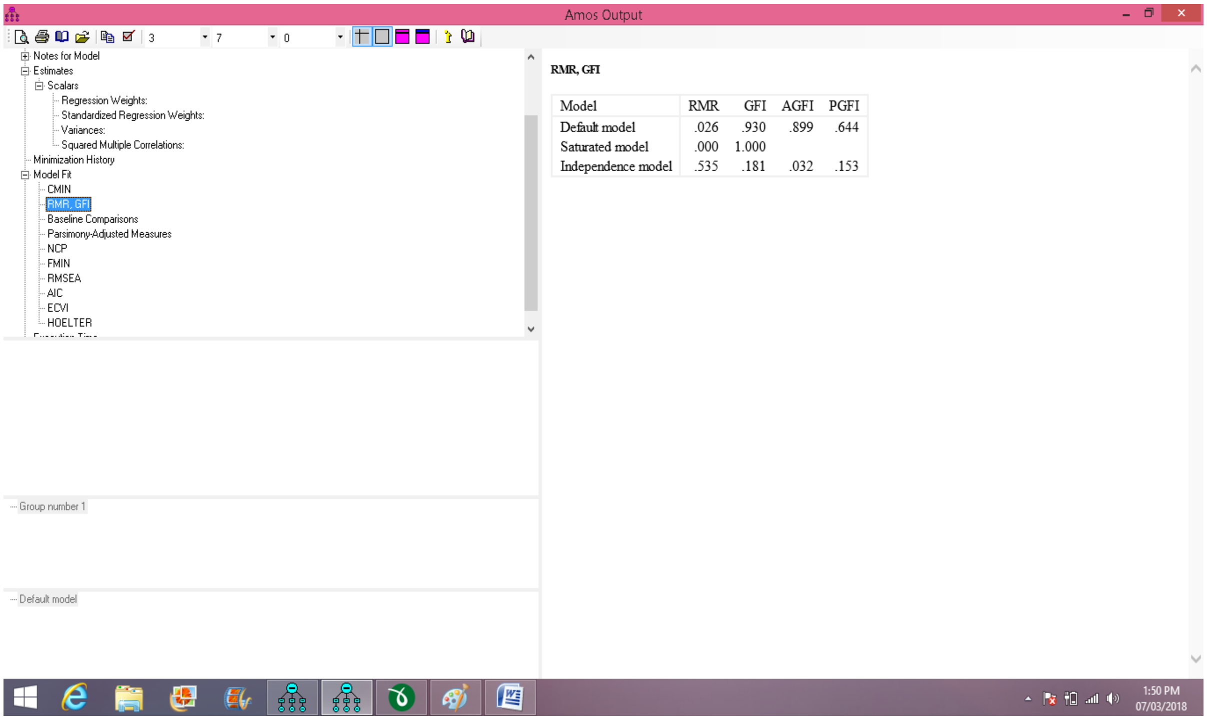
Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	24	99.734	54	.000	1.847
Saturated model	78	.000	0		
Independence model	12	2162.091	66	.000	32.759

Figure 4.7: Model fitness Indices CMIN for the construct Lean Manufacturing



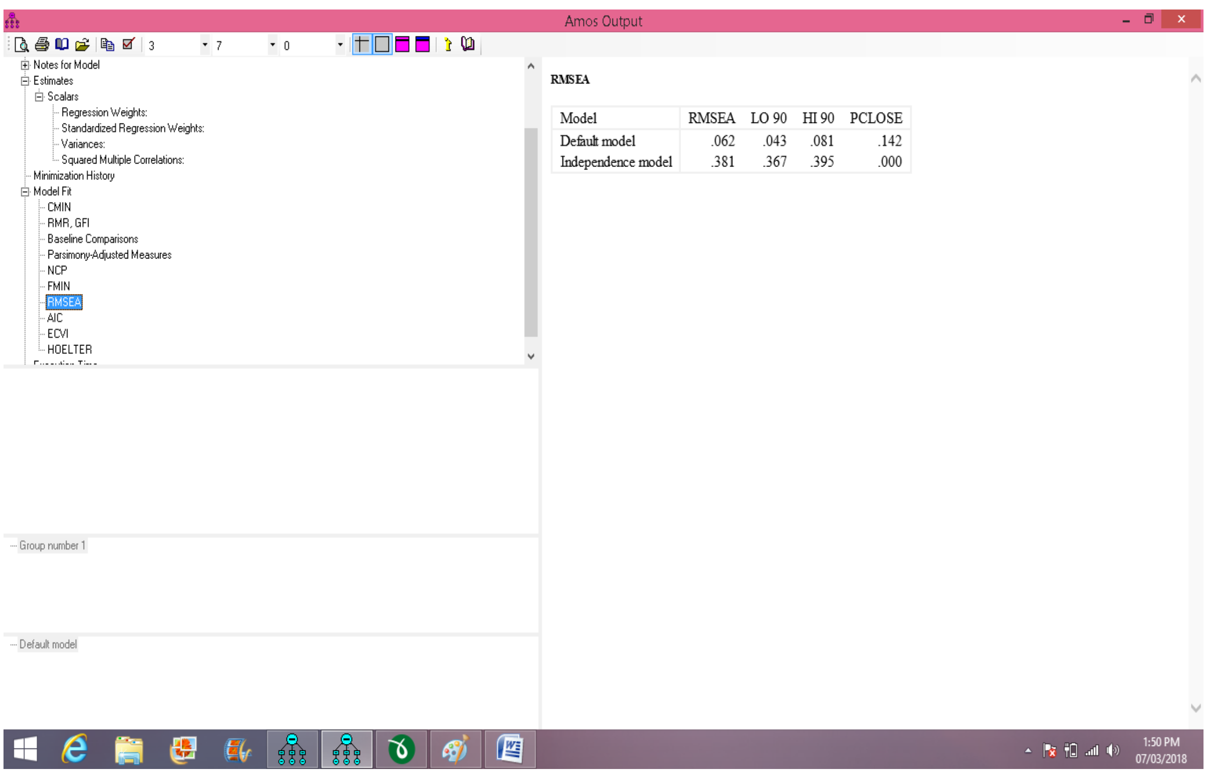
Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.954	.944	.978	.973	.978
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Figure 4.8: Model fitness Indices CFI for the construct Lean Manufacturing



Model	RMR	GFI	AGFI	PGFI
Default model	.026	.930	.899	.644
Saturated model	.000	1.000		
Independence model	.535	.181	.032	.153

Figure 4.9: Model fitness Indices GFI and AGFI for the construct Lean Manufacturing



Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.062	.043	.081	.142
Independence model	.381	.367	.395	.000

Figure 4.10: Model fitness Indices RMSEA for the construct Lean Manufacturing

Table 4.6: Statistical analysis for the construct Lean Manufacturing

Construct	Designation	CMIN/df ≤ 5	CFI ≥.9	GFI ≥.8	AGFI ≥.8	RMSEA ≥.08
Lean manufacturing	C_1-C_{12}	1.847	0.978	.0.930	0.899	0.062

The statistical outcomes of the software summarized in table 4.6 indicate that the constructed model of lean manufacturing is statistically fit model.

4.3 SUPPLY CHAIN IN MANUFACTURING SYSTEM

The supply chain in the manufacturing industry is referred as the cross-linking network of internal departments of the organization with"its suppliers and customers. In general, this integrative approach is required to deal with the planning and control of the material flow from suppliers to end-users. In the supply chain, multiple firms interacted with each other for the smooth flow of raw material supply to the industry and after the manufacturing process, the final product flow to the market for final delivery to the customers.

SCM worked on the systematic and strategic coordination of all the functionaries within and across the boundaries of an organization. The purposes of supply chain design and development are to improve the performance. For the long-term business aspects, getting a competitive advantage in markets is dependent on the optimum utilization of supplier's resources. The four drivers, which incorporate the SCM in an organization, are a facility, inventory, transportation, and information. These drivers drive the supply chain of an organization through the right decisions at the right time for the selection and production of the right kind of material. These drivers also help to find out the right kind of customer for the products along with the marketplace. The supply chain of manufacturing industry is segmented into seven distinct principles shown as below:

a) Customer segmentation,
b) Customization of logistics network,
c) Optimal resource allocation based on market signals,
d) Differentiate product closer to the customer and speed conversion across the supply chain,

e) Strategic management of the resources of the supply chain,

f) Deploying the multiple level decision-making systems across the entire chain, and,

h) Adoption of the channel for performance measures.

In the present scenario, the SCM concept has received much more attention from academicians, consultants, and business managers because it is the key for building a sustainable competitive edge for the products/services of an organization in an increasingly crowded and competitive marketplace. Moreover, the supply chain of manufacturing sector always expects crises because of uncertain situations to happen. The uncertainty in supply chain influences the demand horizon and market trend for the particular product on various aspects. Most of the time the uncertain situations affects because of improper supplier's collaboration and results in an interrupted resource flow to the system. Therefore, it is important for industry to design and develop the supply chain as simple and more flexible that facilitates the ongoing processes of the organization. The present study has the main view of identification of various Supply Chain Characteristics who advocates the effectiveness of SCM implemented in an organization. These characteristics are somewhat close to the organizational performance managing criteria's. The present study considers the ten characteristics identified through with the help of literature and reported in table 4.7 below.

Table 4.7: Identification of Supply Chain Characteristics

Supply Chain Characteristics	**Aspects of considerations**
Optimized Lead Time	Operational Aspect
Strong Decision Making	Financial as well as operational aspect
Cross Enterprise Collaboration	Financial as well as operational aspect
Uninterrupted Information Flow	Operational Aspect
Inventory Management	Financial as well as operational aspect
Internal Integration	Operational Aspect
Flexible to deal with Uncertainty	Operational Aspect
Vendor Troubleshooting	Operational Aspect
Simple in Design	Financial as well as operational aspect
Market Demand growth	Financial Aspect

The Supply Chain Characteristics identified through literature then explored in the questionnaire as given in table 4.8 shows along with their designation as D_1 to D_{10}.

Table 4.8: Statements for the construct Supply Chain Characteristics

Sr. No.	Statements	Designation
1	The lead-time in terms of the order and delivery to the suppliers/customers is well managed and optimized.	D_1
2	The organization has the strong decision making leadership along with the suitable decision support environment to support the strategy of growth.	D_2
3	The organization has the cross-enterprise collaboration among all suppliers/customers to provide flawless production/distribution activity.	D_3
4	The flow of information within and outside (suppliers and vendors) the supply chain is well managed.	D_4
5	The supply chain has focused on building strong horizontal processes such as sales and operations planning to achieve the highest performance in terms of inventory.	D_5
6	The organization's supply chain has integration with other allied departments like HRD, Finance etc. to have the right kind of resources.	D_6
7	The supply chain process of the organization is flexible enough to deal with changing market trends.	D_7
8	There is a proper mechanism for problem-solving for the outside suppliers and vendors.	D_8
9	The design of the supply chain is simple to understand so, the organization is thinking about the plans for the future.	D_9
10	The organization has grown their market demand and new markets for products through its effective supply chain.	D_{10}

The supply chain mechanism of an organization is represented with above-mentioned statements. The aim of supply chain management is to achieve the optimum utilization of resources through networking of all the functionaries/facilities of the manufacturing system. In the study, the data on the perception of the executives working in the manufacturing setup of selected Indian firms are collected with the help of personal interview and questionnaire.

One of the objectives of the research is to study the perception of executives towards the existing supply chain and its characteristics in the manufacturing setup.

In the study, the supply chain is considered as a reflective construct and is measured with the help of different statements. It is assumed that these statements are the reflections of the existing supply chain system in the manufacturing industry. Before starting the statistical analysis, it is required to analyze the internal consistency reliability of the construct.

The internal consistency reliability of the statements is measured with the help of Cronbach alpha (α). The results of the reliability analysis of responses for different statements of a lean manufacturing system are shown in table 4.9.

Table 4.9: Reliability analysis for the construct Supply Chain Characteristics

Statements	**Cronbach alpha**
D_1: The lead-time in terms of the order and delivery to the suppliers/customers is well managed and optimized.	**91.7**
D_2: The organization has the strong decision making leadership along with the suitable decision support environment to support the strategy of growth.	
D_3: The organization has the cross-enterprise collaboration among all suppliers/customers to provide flawless production/distribution activity.	
D_4: The flow of information within and outside (suppliers and vendors) the supply chain is well managed.	
D_5: The supply chain has focused on building strong horizontal processes such as sales and operations planning to achieve the highest performance in terms of inventory.	
D_6: The organization's supply chain has integration with other allied departments like HRD, Finance etc. to have the right kind of resources.	
D_7: The supply chain process of the organization is flexible enough to deal with changing market trends.	
D_8: There is a proper mechanism for problem-solving for the outside suppliers and vendors.	
D_9: The design of the supply chain is simple to understand so, the organization is thinking about the plans for the future.	
D_{10}: The organization has grown their market demand and new markets for products through its effective supply chain.	

The results of the reliability analysis as shown in table 4.8 indicate that the value of Cronbach alpha is 91.7, which indicates the presence of the internal consistency reliability in the responses. This internal consistency reliability is important for the further description of statements of the construct in an individual manner. In the study, the descriptive analysis (mean score and standard deviation) of each statement of Supply Chain Characteristics is estimated. The result of the descriptive analysis is shown in table 4.10.

Table 4.10: Descriptive analysis of the construct Supply Chain Characteristics

Statements	**Mean [Standard Deviation]**
D_1: The lead-time in terms of the order and delivery to the suppliers/customers is well managed and optimized.	4.20 [0.813]
D_2: The organization has the strong decision making leadership along with the suitable decision support environment to support the strategy of growth.	4.12 [0.988]
D_3: The organization has the cross-enterprise collaboration among all suppliers/customers to provide flawless production/distribution activity.	3.88 [0.868]
D_4: The flow of information within and outside (suppliers and vendors) the supply chain is well managed.	3.80 [0.818]
D_5: The supply chain has focused on building strong horizontal processes such as sales and operations planning to achieve the highest performance in terms of inventory.	3.88 [0.924]
D_6: The organization's supply chain has integration with other allied departments like HRD, Finance etc. to have the right kind of resources.	3.88 [0.953]
D_7: The supply chain process of the organization is flexible enough to deal with changing market trends.	3.85 [0.933]
D_8: There is a proper mechanism for problem-solving for the outside suppliers and vendors.	3.77 [0.929]
D_9: The design of the supply chain is simple to understand so, the organization is thinking about the plans for the future.	3.83 [0.841]
D_{10}: The organization has grown their market demand and new markets for products through its effective supply chain.	3.82 [0.932]

The results of the descriptive analysis indicate that statement D_1 has the highest mean score of 4.20. The statement D_1 indicates that every industry has the focus on the lead-time because the optimized lead-time (in the purchase or production case) can result in the increased economics as an output in terms of customer satisfaction, sale and competitive advantage.

The statement D_2 with a mean score of 4.12 indicates that the growth of the business is dependent on the decision-making approach of that industry. Almost all the respondents emphasize the strong decision-making process. The present technological revolution in the information technology sector provides the best information to support the decisions of the leaders.

The statement D_3 has a mean score of 3.88 indicates that the organizations have the cross-enterprise collaborations with all of its suppliers and customers. This can further lead to the uninterrupted flow of resources within and outside the industry.

The statement D_5 with a mean score of 3.88 indicates the main aspect of implementing SCM approach i.e. inventory management. This statement depicts the focus of leaders in the organization on building strong horizontal processes through a simple supply chain network.

The statement D_6 with a mean score of 3.88 indicates the requisite of a good supply chain, i.e. integration between the various departments to optimize the resource utilization.

The statement D_7 with a mean score of 3.85 indicates that the manufacturing industries have the main requisites i.e. flexible supply chain, which helps the organization to withstand with changing market trend.

The statement D_9 with a mean score of 3.83 shows the importance of supply chain design for future perspective. Simplicity in supply chain design is easy to understand and can be modified as per future demand.

The statement D_{10} with a mean score of 3.82 indicates that the supply chain plays a very important role in the growth of any organization in terms of market demand or new product development. The effective supply chain will result in the optimum utilization of resources to have the growth in market demand. The supply chain has information as one of its drivers. The proper management of the supply chain is dependent on the information flow between the suppliers, manufacturers, and customers.

The mean score of statement D_4 (3.80) is very low as compared to other statements, which indicates that the organization fails to share their plans and perspectives with their vendors and suppliers. Every individual organization has the problem-solving mechanism and some of them (big industries) have the provision in their policies to support their vendors and suppliers in problem troubleshooting.

The statement D_8 has the mean score of 3.77, which means that either they do not have the problem-solving mechanism or they have but mechanism not working properly. Figure 4.11 shows the estimated mean score contribution of all the statements of supply chain characteristics statements.

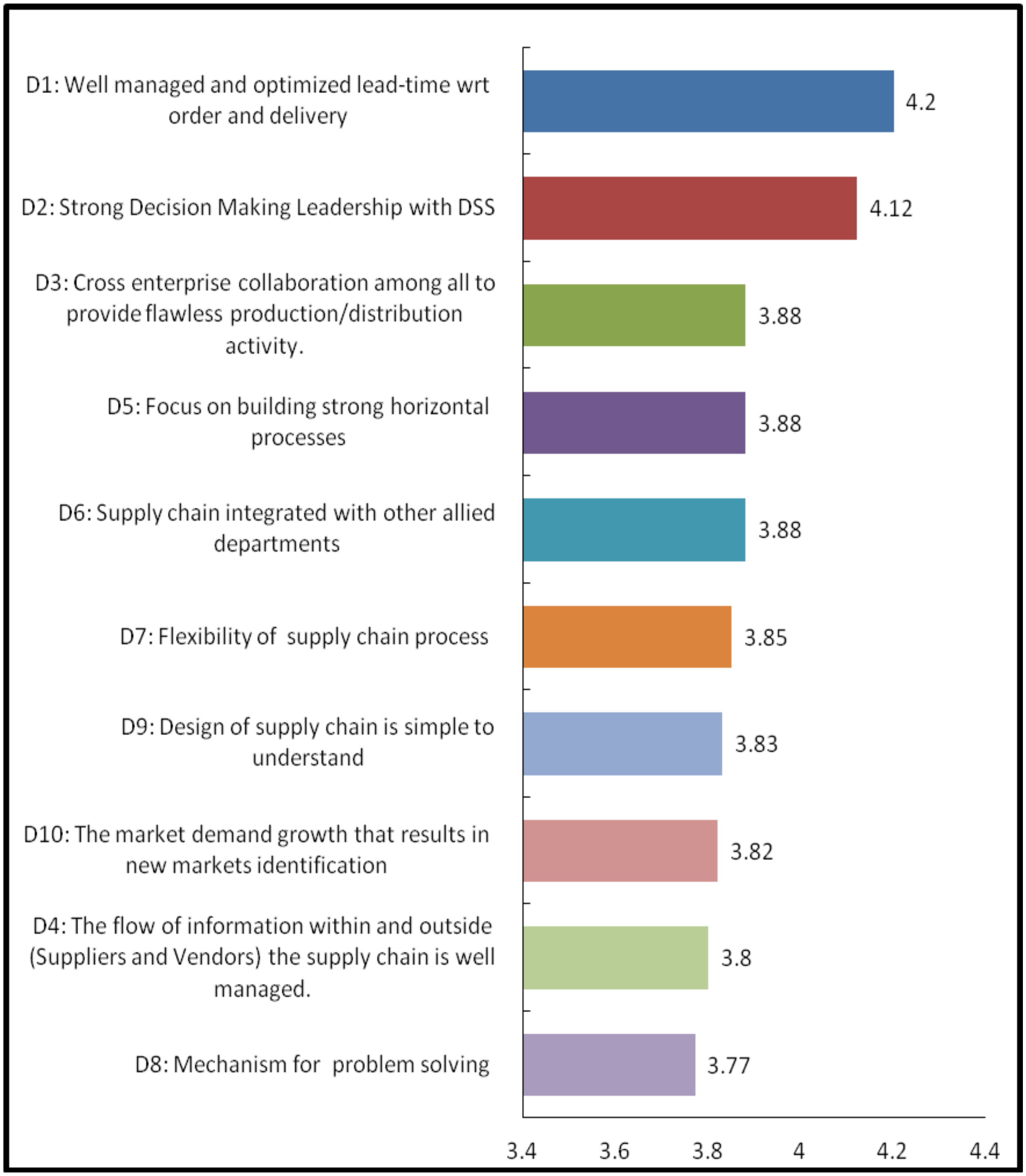


Figure 4.11: Mean score contribution of the scale for the construct Supply Chain Characteristics

The frequency distribution of the responses for the statements related to constructing "supply chain characteristics" is estimated and shown in Table 4.11. Each statement has the five distinct options varies from strongly disagree to strongly agree.

Table 4.11: Frequency Distribution table for the Construct Supply Chain Characteristics

Statements	Strongly Disagree (1)	Disagree (2)	No-opinion (3)	Agree (4)	Strongly Agree (5)
D_1	--------	10 [4.5%]	25 [11.4%]	97 [44.1%]	88 [40%]
D_2	6 [2.7%)	10 4.5%]	29 [13.2%)	81 [36.8%]	94 [42.7%]
D_3	--------	19 [8.6%]	40 [18.2%)	109 [49.5%]	52 [23.6%]
D_4	--------	12 [5.5%]	63 [28.6%)	101 [45.9%]	44 [20%]
D_5	4 [1.8%]	16 [7.3%]	36 [16.4%]	110 [50%]	54 [24.5%]
D_6	1 [0.5%]	22 [10%]	42 [19.1%]	92 [41.8%]	63 [28.6%]
D_7	--------	23 [10.5%]	46 [20.9%]	93 [42.3%]	58 [26.4%]
D_8	5 [2.3%]	15 [6.8%]	51 [23.2%]	104 [47.3%]	45 [20.5%]
D_9	2 [0.9%]	16 [7.3%]	39 [17.7%]	123 [55.9%]	40 [18.2%]
D_{10}	1 [0.5%]	20 [9.1%]	52 [23.6%]	91 [41.4%]	56 [25.5%]

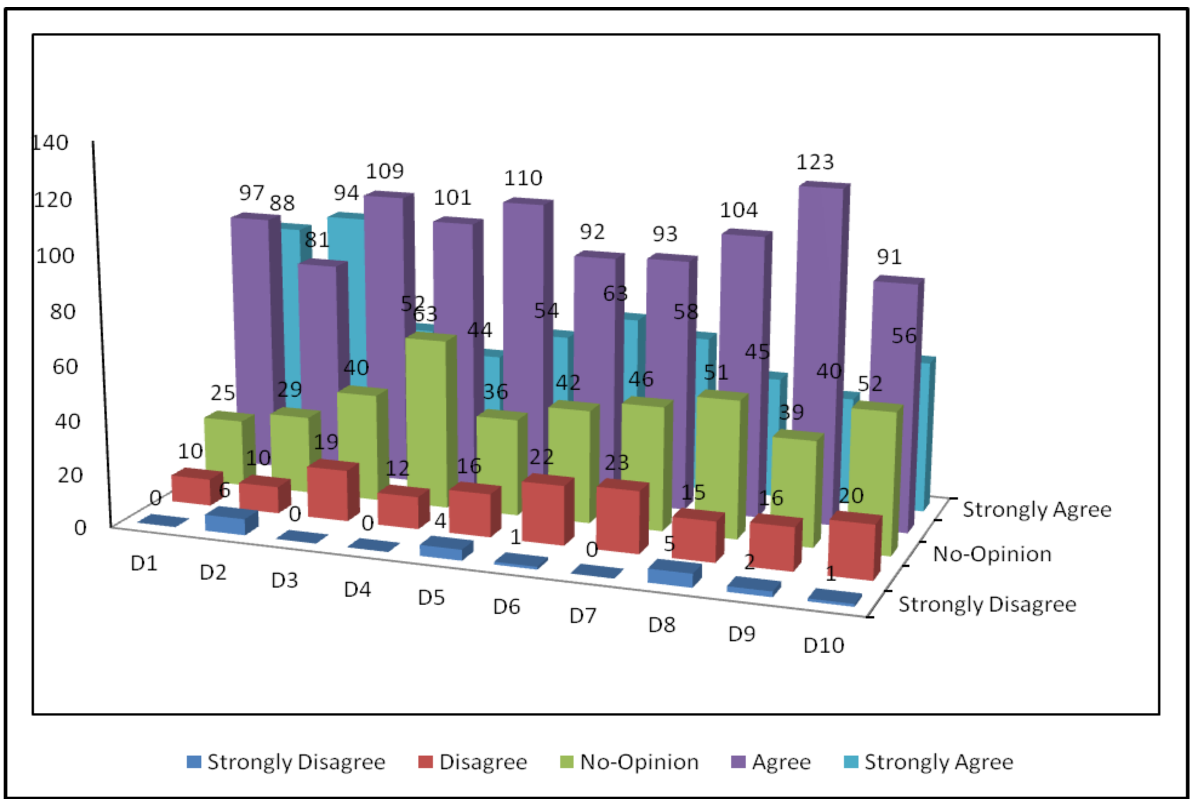


Figure 4.12: Frequency distribution for the construct Supply Chain Characteristics

The success and sustainability of business in the market are difficult to achieve without a strong decision-making mechanism. In addition, the strong decision-making environment has the requisites of a well-designed decision support system. The result in table 4.10 indicates that the statement D_2 is strongly agreed by most of the executives. They believe that strong decision making will help them to overcome any kind of uncertain situations. The highest number respondents (about 56 percent of the total respondents) agreed with the statement D_9, i.e. simplicity in the design of the supply chain help in understand and also, help for thinking about the plans for the future. Further analysis on table 4.10 indicates that about 29 percent (higher in percentage) of the respondents refused to answer the statement D_4, i.e. the flow of information within and outside the supply chain is well managed. This means that still, some industries feel that the sharing of information with suppliers and vendors can cause their businesses. About 11 percent of the respondents disagree with the statement D_7, i.e. the supply chain of industries is not flexible enough to deal with the market changing trend. Some of the respondents (about 3 percent) disagree with the statement $D_{2,}$ who describes the role of strong decision-making environment within the supply chain supports the industrial growth.

In the study, the construct supply chain characteristics are consists of 10 distinct statements. It is assumed that these statements reflect the existing characteristics in the supply chain of the manufacturing industry. In other words, these statements reflect the feasibility and validity of supply chain characteristics implemented in industry. The construct (supply chain characteristics) along with its measured items (statements D_1 to D_{10}) can be mathematically modeled as:

$$D_1 = \beta_1 * Supply\ Chain\ Characteristics + \varepsilon_1$$

$$D_2 = \beta_2 * Supply\ Chain\ Characteristics + \varepsilon_2$$

…………………………………………….

$$D_{10} = \beta_{10} * Supply\ Chain\ Characteristics + \varepsilon_{10}$$

Where D_1 to D_{10} represent measured variables related to supply chain characteristics;

Regression coefficients β_1 to β_{10} represents the construct loading (standardized regression coefficient) of different statements with respect to the construct.

The ε_1 to ε_{12} represents the error of the regression model.

The above-mentioned equations are estimated with the help of a measurement model approach in structural equation modeling method. The construct SCC along with its measured variables are shown below in figure 4.13. The output of the software is shown in figure 4.14, 4.15, 4.16 and summarized in table 4.12

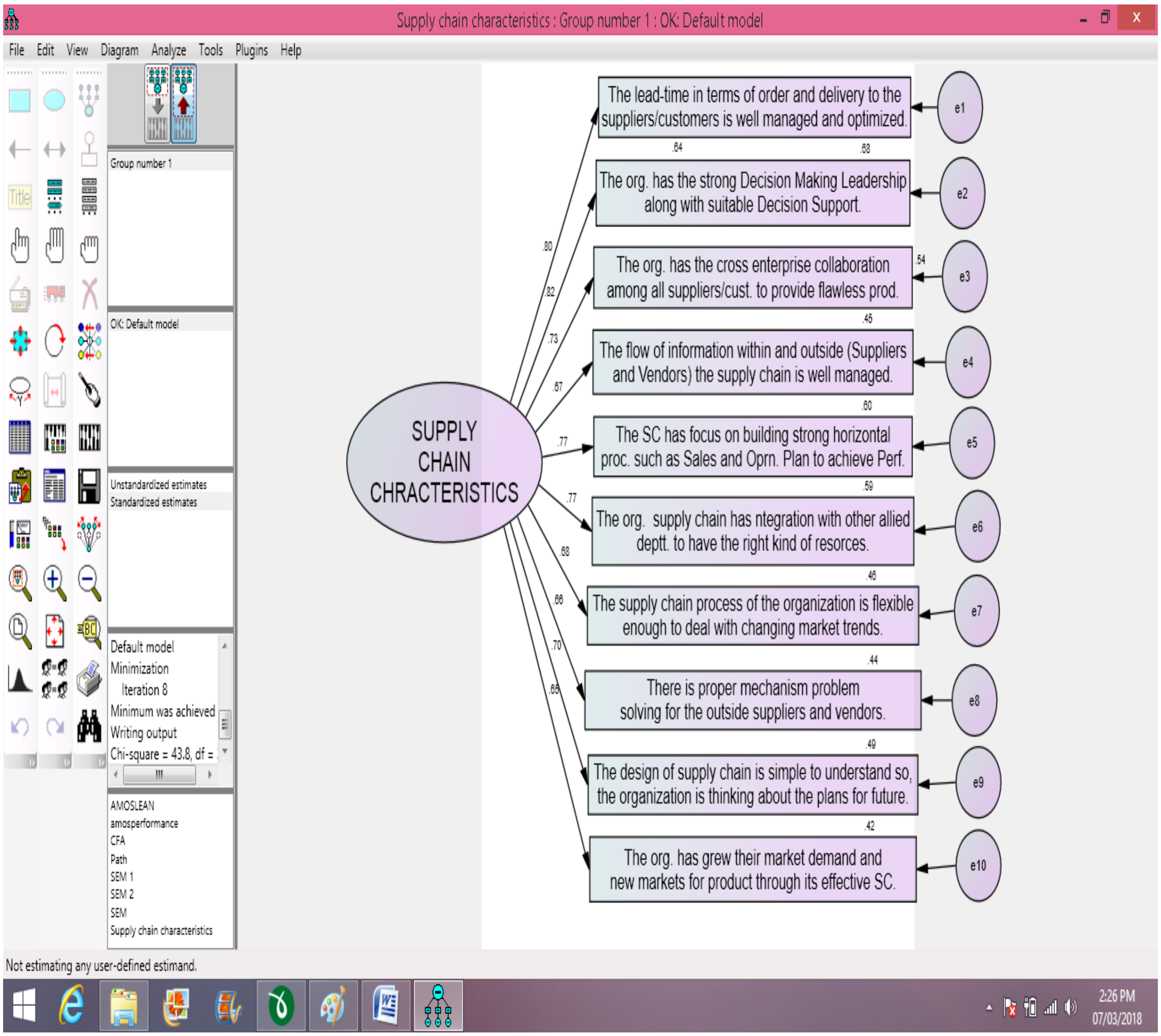
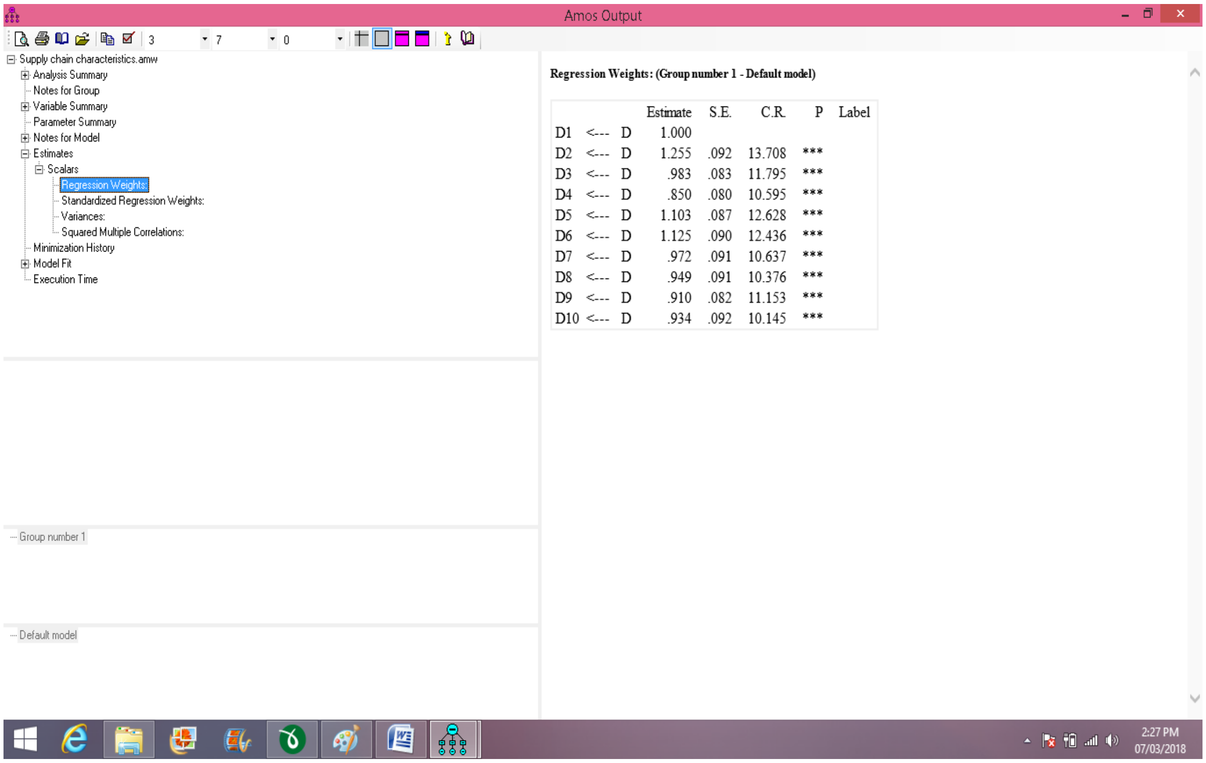


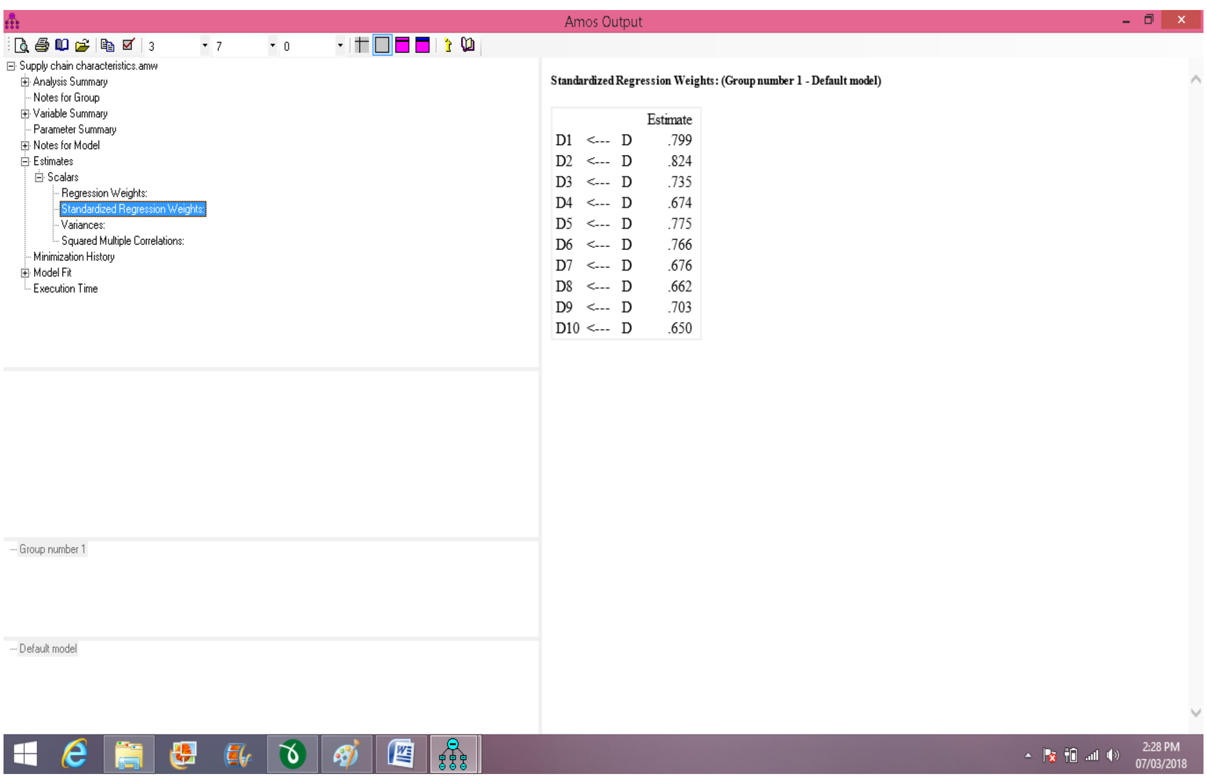
Figure 4.13: SEM diagram of the construct Supply Chain Characteristics



Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
D1	<---	D	1.000				
D2	<---	D	1.255	.092	13.708	***	
D3	<---	D	.983	.083	11.795	***	
D4	<---	D	.850	.080	10.595	***	
D5	<---	D	1.103	.087	12.628	***	
D6	<---	D	1.125	.090	12.436	***	
D7	<---	D	.972	.091	10.637	***	
D8	<---	D	.949	.091	10.376	***	
D9	<---	D	.910	.082	11.153	***	
D10	<---	D	.934	.092	10.145	***	

Figure 4.14: Regression weights output for the construct Supply Chain Characteristics



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
D1	<---	D	.799
D2	<---	D	.824
D3	<---	D	.735
D4	<---	D	.674
D5	<---	D	.775
D6	<---	D	.766
D7	<---	D	.676
D8	<---	D	.662
D9	<---	D	.703
D10	<---	D	.650

Figure 4.15: Standardized Regression Weights output for the construct Supply Chain Characteristics

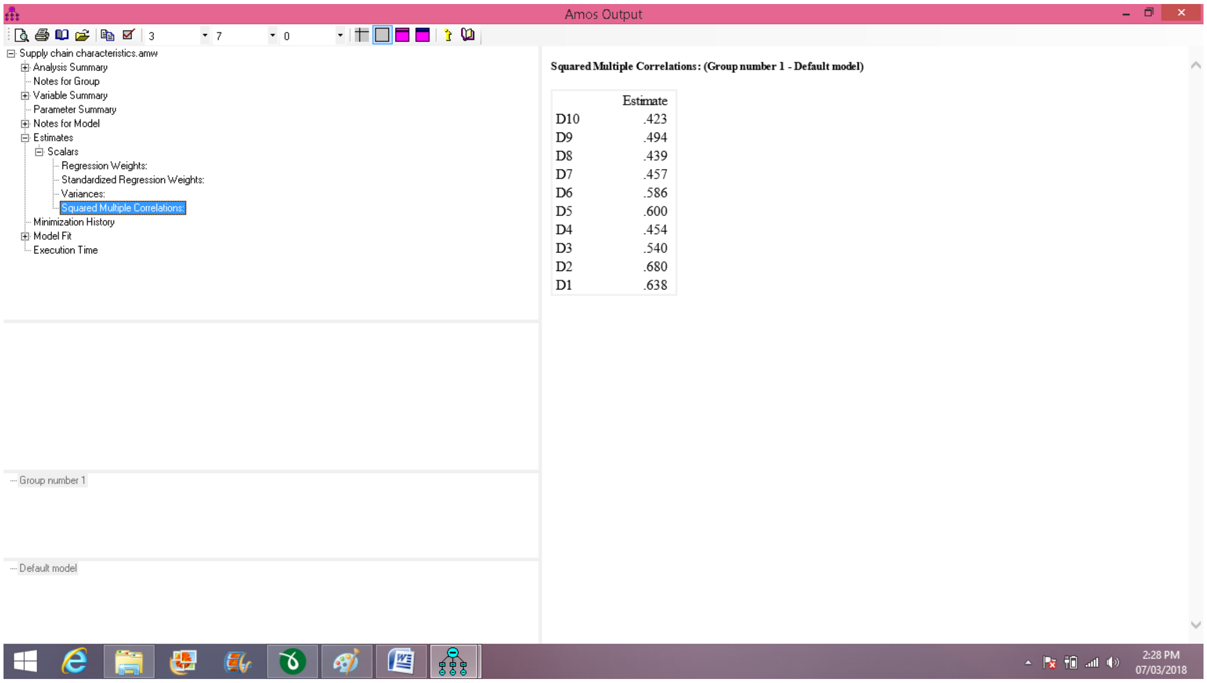


Figure 4.16: Squared Multiple Correlations output for the construct Supply Chain Characteristics

Table 4.12: Analysis summary for the construct Supply Chain Characteristics

Statements	Standardized Construct Loading	Critical Ratio	P-Value	Squared Multiple Correlation
D_1	0.799	-------	0.000	63.8
D_2	0.824	13.708	0.000	68.0
D_3	0.735	11.795	0.000	54.0
D_4	0.674	10.595	0.000	45.4
D_5	0.775	12.628	0.000	60.0
D_6	0.766	12.436	0.000	58.6
D_7	0.676	10.637	0.000	45.7
D_8	0.662	10.376	0.000	43.9
D_9	0.703	11.153	0.000	49.4
D_{10}	0.65	10.145	0.000	42.3

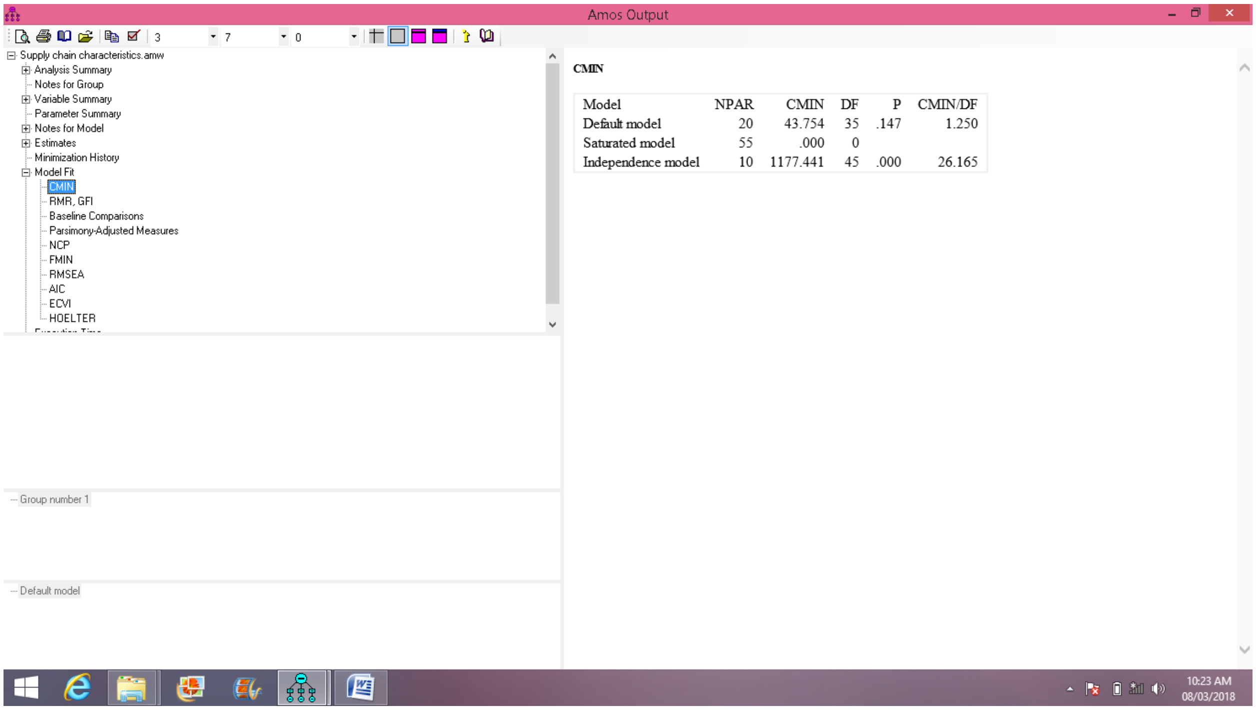
The result of the regression model indicates that the probability value of the critical ratio, which is found to be less than 5 percent level of significance. Hence, with 95 percent confidence level, it is concluded that all the statements considered in the study are all significant and they represent the existence of lean manufacturing in the manufacturing sector.

In addition to this, all the construct loadings of statements are found to be greater than 0.7, which ensures the convergent validity of the construct. It is also found that the statements D_2 have the highest factor loading followed by D_1, D_5, and so-on. This represents the presence of an efficient supply chain characteristics in the Indian manufacturing context is reflected in the form of the decision-making process with suitable decision support environments.

Further, the second highest factor loading on statement D_1 i.e. well managed and optimized lead-time reflect the presence of supply chain characteristics in the Indian manufacturing context. The statement D_{10} is found to have the lowest construct loading. This means that some of the industries are failing to grow grew their products demand in the market. Still, this reflects the presence of supply chain characteristics in the Indian manufacturing context.

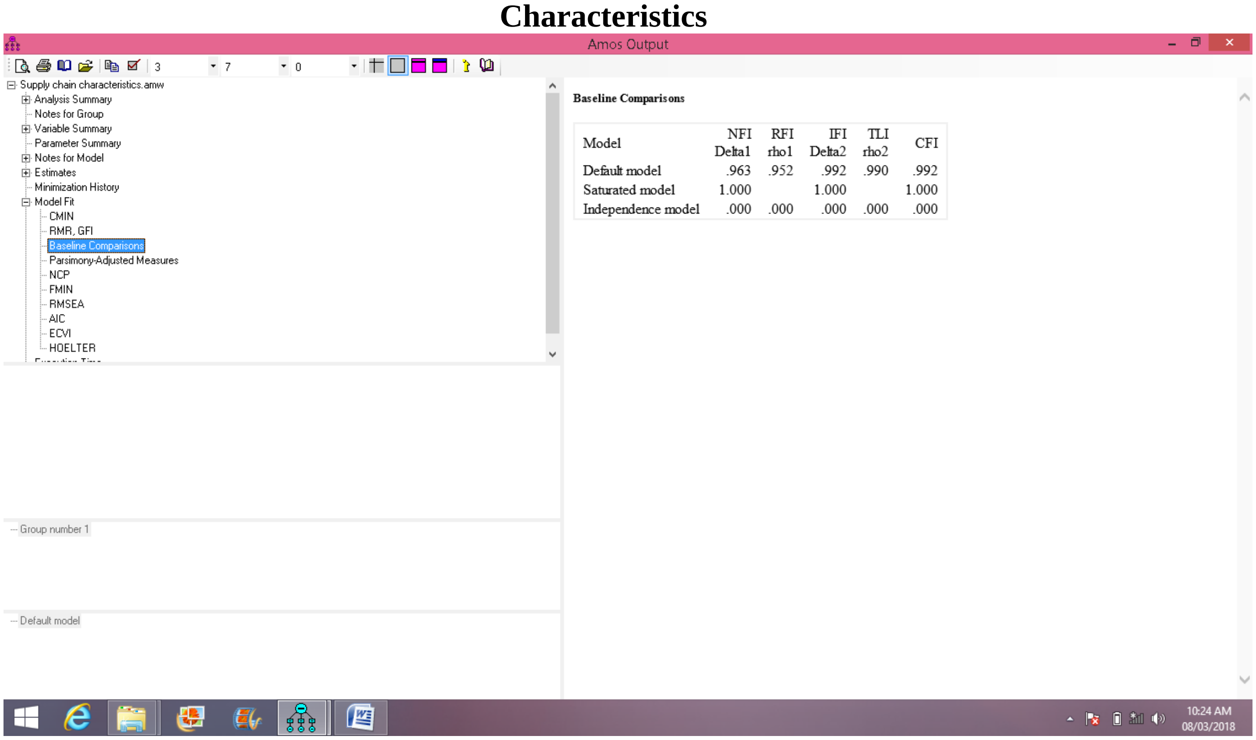
The R2 value indicates that 68 percent of the variance of the statement D_2 can be explained with the help of variations in the construct supply chain characteristics. This is followed by a statement D_1 with 63.8 percent of the variance can be explained with the help of the construct. Similarly, 60 percent of the variance of statement D_5, 58.6 percent of the variance on statement D_6 and so-on can be explained with the help of the construct supply chain characteristics.

In this study, it is found that lower factor loading is on the statement D_{10}, which indicates the less effect of the supply chain in industries comes through the statement. The model fitness index is shown in 4.17, 4.18, 4.19, 4.20, and summarized in table 4.13 which indicates that the constructed model of supply chain characteristics is statistically fit model.


CMIN

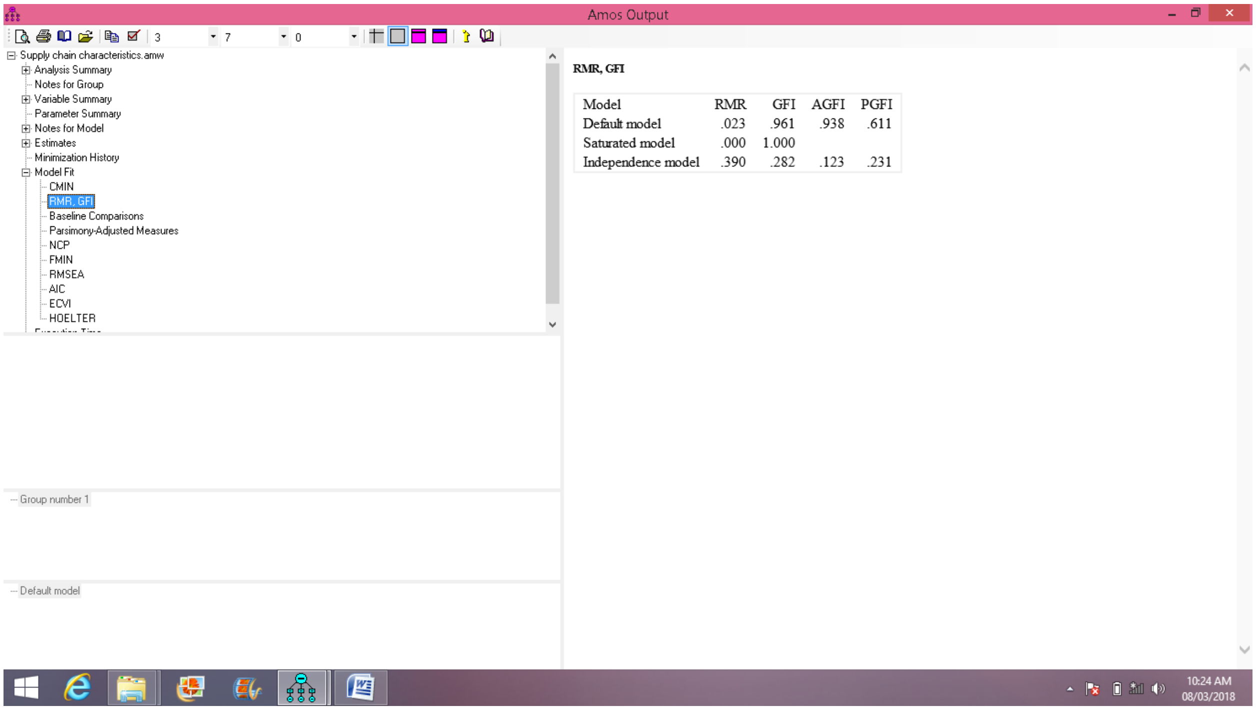
Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	20	43.754	35	.147	1.250
Saturated model	55	.000	0		
Independence model	10	1177.441	45	.000	26.165

Figure 4.17: Model fitness Indices CMIN for the construct Supply Chain Characteristics


Baseline Comparisons

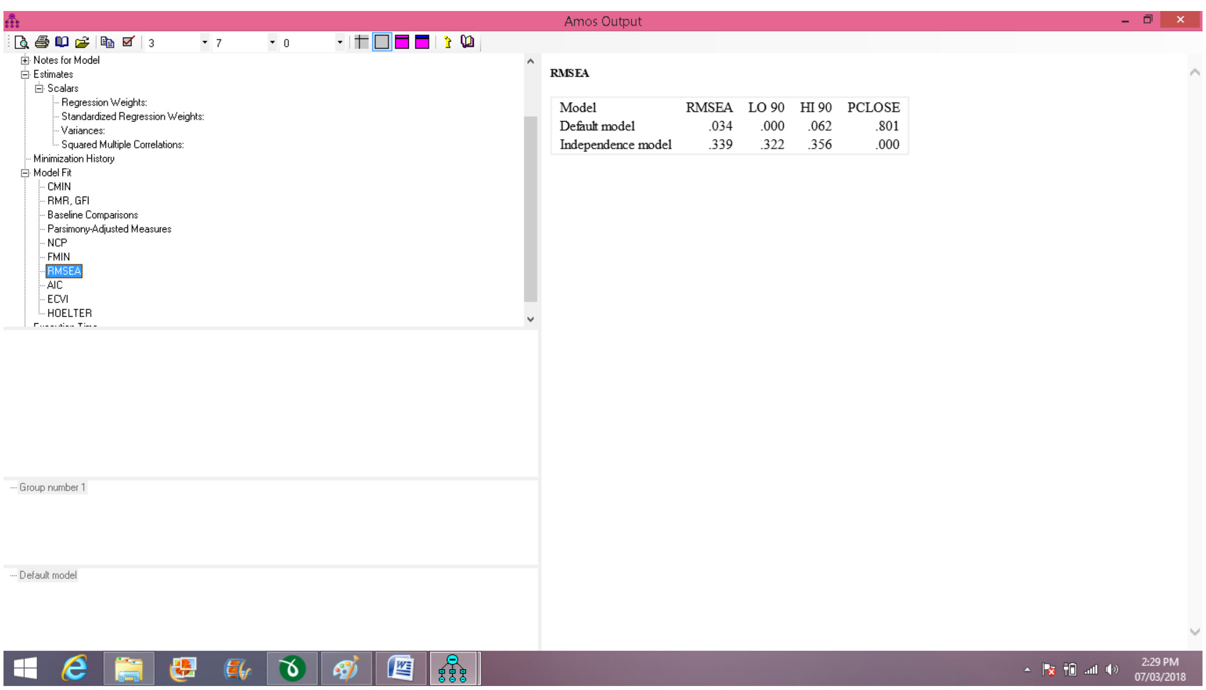
Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.963	.952	.992	.990	.992
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Figure 4.18: Model fitness Indices CFI for the construct Supply Chain Characteristics



Model	RMR	GFI	AGFI	PGFI
Default model	.023	.961	.938	.611
Saturated model	.000	1.000		
Independence model	.390	.282	.123	.231

Figure 4.19: Model fitness Indices GFI and AGFI for the construct Supply Chain Characteristics



Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.034	.000	.062	.801
Independence model	.339	.322	.356	.000

Figure 4.20: Model fitness Indices RMSEA for the construct Supply Chain Characteristics

Table 4.13: Statistical analysis of the construct Supply Chain Characteristics

Construct	Designation	CMIN/df ≤ 5	CFI ≥.9	GFI ≥.8	AGFI ≥.8	RMSEA ≥.08
Supply chain characteristics	D1-D10	1.250	0.992	0.961	0938	0.034

4.4 PERFORMANCE OF THE MANUFACTURING SYSTEM

The activities carried out in an organization by a group of peoples with due some predefined goals, defined as the process. According to the outcome, the process may have a variety of production, inspection, finance, and human resources, etc. For the purpose of comparison between designed goals (pre-defined) and the actual outcomes, the process outcome measures performed with some definite criteria and standard tools. The outcome of the performed measure indicates the performance of that particular system. In management science, the performance is referred to as the sharing and understanding of knowledge, as accrued from the past activities. The actual performance is compared with the desired one so that it can be decided that what the organization have achieved at present situation? Performance management is complicated because it is associated with the man-machine system of the organizations. The performance of an organization can be affected by a large number of reasons such as utility, effectiveness, capability, cost, etc. of the end product. This can be merely solved through answering: “what is to be achieved in the future?”

In an Indian manufacturing context, most of the individuals have the desires to work as an individual not as a team member. The effectiveness of the team is dependent on its members working and their willingness to achieve the desired goal. On the other hand, the performance of a team can be affected by selecting the wrong member in the group, whose willings create conflicts among the team goal. Similarly, machine performance will also affect the performance of the organization. Therefore, it becomes pertinent to utilize given resources effectively and intelligently to achieve the desired outcomes.

In the present scenario, the manufacturing industries focus on implementing strategies which have inbuilt features like cost, quality, reliability, flexibility, and speed, etc. These inbuilt features help to sustain the organizational performance in a long-term business perspective.

The research study has the performance as a construct and ten statements for the depiction of performance in an organization.

In the research study, ten statements related to organizational performance are identified in the questionnaire based on the review of performance from various researchers. Table 4.1 shows the ten distinct statements along with their designation as EE_1 to EE_{10} in the questionnaire. The performance of an organization has a dependency on these statements.

Table 4.14: Statements for the construct Performance

Sr. No.	Statements	Designation
1	The sales revenue of the organization is increasing with time.	EE_1
2	The organization earns good profits as compared to earlier years.	EE_2
3	The organization increases the employment rate every year.	EE_3
4	The production capacity of the organization is better than earlier.	EE_4
5	The organization is satisfying the demands of markets and try to move ahead to capture new markets.	EE_5
6	All the employees of the organization have the focus on the vision and mission of the organization to achieve proper utilization of resources.	EE_6
7	The brand name of the organization and products is improving the market.	EE_7
8	The company is trying to explore new areas of inventions in the manufacturing process.	EE_8
9	The quality of the product is good enough and the product has the competitive advantage to sustain its demand in the market.	EE_9
10	The organization structure is flexible enough to get revenge in the uncertain working environment.	EE_{10}

In present scenario, the manufacturing sector is pressurized not only to meet the demand for a variety of products with the best quality at reasonable costs but also to face the intense competition from the environment. Countless researchers raised solutions and benchmarks to settle on best practices through continuous improvement processes such as TPS, LMS, SCM, TPM, TQM, and JIT etc. The improvement claimed with these techniques fails to claim sustainability of the results for the long-term success.

The performance of the manufacturing industries generally comprises of all the events in which a group of performers presents to work and produced goods/services for the end customers. However, the performance management system encompasses diverse activities. So, the design and execution of performance appraisal are a very difficult aspect of performance management.

The actual performance of the manufacturing industry depicts the SWOT for that particular industry with which industry has the opportunity to grab the new markets or expansion of the business. In the study, performance is considered as a reflective construct and is measured with the help of ten different statements. It is assumed that these statements are the reflections of the existing performance in the manufacturing industry. The internal consistency reliability of the statements i.e. Cronbach alpha (α) for the different statements of performance is shown in table 4.15.

In the research study, organizational performance is considered as a latent variable, which can be studied with the help of the statements given in table 4.13. It is assumed that the existence of the performance in a manufacturing setup can be reflected in the mentioned statements.

Table 4.15: Reliability analysis for the construct Performance

Statements	**Cronbach alpha**
EE_{1}: The sales revenue of the organization is increasing with time.	**92.6**
EE_{2}: The organization earns good profits as compared to earlier years.	
EE_{3}: The organization increases the employment rate every year.	
EE_{4}: The production capacity of the organization is better than earlier.	
EE_{5}: The organization is satisfying the demands of markets and try to move ahead to capture new markets.	
EE_{6}: All the employees of the organization have the focus on the vision and mission of the organization to achieve proper utilization of resources.	
EE_{7}: The brand name of the organization and products is improving into the market.	
EE_{8}: The company is trying to explore new areas of inventions in the manufacturing process.	
EE_{9}: The quality of the product is good enough and the product has the competitive advantage to sustain its demand in the market.	
EE_{10}: The organization structure is flexible enough to get revenge in the uncertain working environment.	

The results of the reliability analysis as shown in table 4.14 indicate that the value of Cronbach’s alpha is 92.6, which indicates the presence of the internal consistency reliability in the responses. This internal consistency reliability is important for the further description of statements of the construct in an individual manner. In the study, the descriptive analysis (mean score and standard deviation) of each statement of the construct performance is estimated. The result of the descriptive analysis is shown in table 4.16.

Table 4.16: Descriptive analysis of the construct Performance

Statements	**Mean [Standard Deviation]**
$EE_{1:}$ The sales revenue of the organization is increasing with time.	4.12 [0.880]
$EE_{2:}$ The organization earns good profits as compared to earlier years.	3.95 [0.900]
$EE_{3:}$ The organization increases the employment rate every year.	3.85 [0.871]
$EE_{4:}$ The production capacity of the organization is better than earlier.	4.02 [0.984]
$EE_{5:}$ The organization is satisfying the demands of markets and try to move ahead to capture new markets.	3.87 0.863]
$EE_{6:}$ All the employees of the organization have the focus on the vision and mission of the organization to achieve proper utilization of resources.	3.90 [0.868]
$EE_{7:}$ The brand name of the organization and products is improving into the market.	3.92 [0.980]
$EE_{8:}$ The company is trying to explore new areas of inventions in the manufacturing process.	3.91 [0.869]
$EE_{9:}$ The quality of the product is good enough and the product has the competitive advantage to sustain its demand in the market.	3.78 [0.863]
$EE_{10:}$ The organization structure is flexible enough to get revenge in the uncertain working environment.	3.96 [0.938]

The descriptive analysis result of the construct "performance" is shown in table 4.15. The results indicate that the statement EE_1, i.e. increment in revenue with time has the highest mean score of 4.12. This indicates that the manufacturing industries are implementing advanced technologies to increase their sales revenue.

The statement EE_4 with a mean score of 4.02 indicates that the present production capacity is far better than the earlier ones. This production capacity is further used to capture the new markets every year.

The statement EE_{10} with a mean score of 3.96 indicates that almost all the organization has flexible structures for getting revenge in the uncertain working environment. The flexibility in organization structure (in plant layout) can help in satisfying a large number of customers.

The statement EE_2 with a mean score of 3.95 indicates that the organization earns good profits as compared to earlier years. The statement EE_7 with a mean score of 3.92 indicates the brand name of the organization and products is improving into the market.

Next, to the above order, the statement EE_8 a mean score of 3.91 indicates that the present competition or boom in the manufacturing sector forces industries to explore the new areas of in the manufacturing process. These areas can result in improved manufacturing process performance and the optimum utilization of the resources.

The statement EE_6 with a mean score of 3.9 indicates that the employees of the organization have clarity about the vision and mission of the organization. By focusing on the vision and mission of the organization, the employees can achieve better results through the proper utilization of resources.

The statement EE_5 with a mean score of 3.87 indicates that the organization is satisfying the demands of markets up to a certain level and some of them trying to move ahead to capture new markets. The statement EE_3 with the mean score of 3.85 indicates that almost all the manufacturing industries increase the rate of employment every year.

The statement EE_9 with a lower mean score of 3.78 indicates that the quality of the product is not up to the mark. This statement also depicts the difference between the manufacturing qualities of various industries. Figure 4.19 shows the mean score contribution of all the statements for the construct performance.

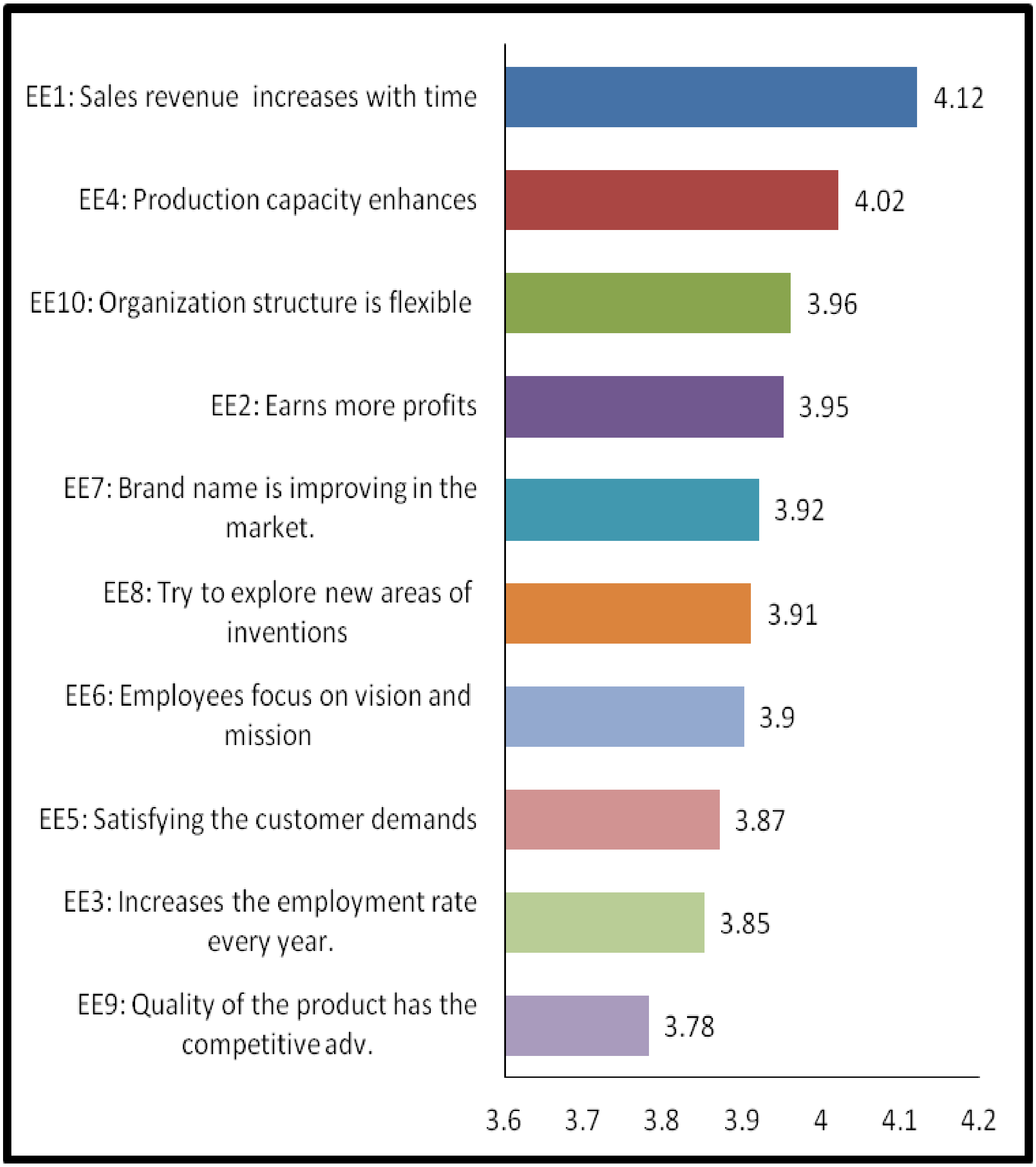


Figure 4.21: Mean score contribution of the scale for the construct Performance

In the study, the responses of the executives working with the manufacturing system of the company are collected on five-point Likert scales used in the questionnaire. On scale 1 indicates strongly disagree and 5 indicates strongly agree. The frequency distribution of the responses related to constructing performance is estimated and shown in table 4.17.

Table 4.17: Frequency distribution table for the construct Performance

Statements	Strongly Disagree (1)	Disagree (2)	No-opinion (3)	Agree (4)	Strongly Agree (5)
EE_1	5 [2.3%]	10 [4.5%]	13 [5.9%]	117 [53.2%]	75 [34.1%]
EE_2	4 [2.8%]	11 [5%]	37 [16.8%]	107 [48.6%]	61 [27.7%]
EE_3	1 [0.5%]	17 [7.7%]	45 [20.5%)	108 [49.1%]	49 [22.3%]
EE_4	5 [2.3%]	12 [5.5%]	38 [17.3%]	84 [38.2%]	81 [36.8%]
EE_5	3 [1.4%]	12 [5.5%]	44 [20%]	113 [51.4%]	48 [21.8%]
EE_6	3 [1.4%]	14 [6.4%]	34 [15.5%]	119 [54.1%)	50 [22.7%]
EE_7	8 [3.6%]	11 [5%]	34 [15.5%]	105 [47.7%]	62 [28.2%]
EE_8	1 [0.5%]	17 [7.7%]	36 [16.4%]	112 [50.9%]	54 [24.5%]
EE_9	--------	24 [10.9%]	44 [20%]	115 [52.3%]	37 [16.8%]
EE_{10}	8 [3.6]	6 [2.7%]	35 [15.9%]	109 [49.5%]	62 [28.2%]

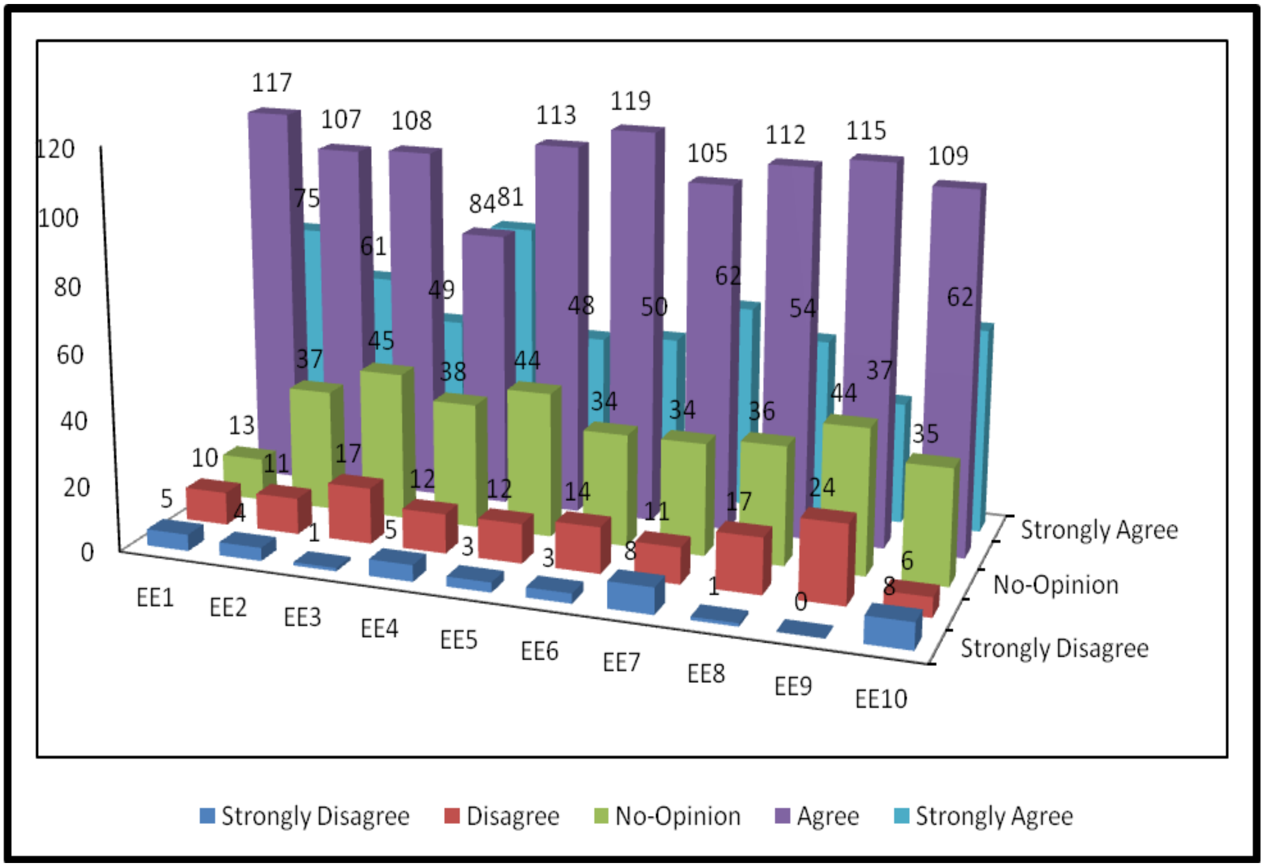


Figure 4.22: Frequency distribution for the construct Performance

The result in table 4.17 indicates that the 37 percent of respondents strongly agreed with the statement i.e. performance improved with the production capacity. The increased production capacity drags the manufacturing process boundaries which further results in improved performance. The 54 percent of respondents agreed that the focus on the vision and mission of the organization helps in achieving the optimum utilization of resources. The most numbers of respondents refuse to answer the statement i.e. the rate of employment is increasing every year. This means that still some manufacturing industries are surviving in the market but they never create employment for the newcomers.

The results in table 4.17 indicate that the 11 percent of respondents mark the choice disagree for the statement EE_9. This means that some of the manufacturing industries in India still have a focus on quantity not on quality. That's-why the products from these industries still fighting to grab the competitive advantage and sustainability. Approximate 4 percent of the respondents strongly disagree with the statement EE_7 i.e. performance of the organization has an impact on the brand name of the industries. This means that it is not mandatory for all the industries that their performance can enhance their market reputation. Still, there is little bit concern about the improved performance impact on brand name.

In the study, the construct performance consists of 10 distinct statements. It is assumed that these statements reflect the existing performance of the manufacturing process. In other words, these statements reflect the feasibility and validity of the performance of the manufacturing industry. The construct (performance) along with its measured items (statements EE_1-EE_{10}) can be mathematically modeled as:

$$EE_1 = \beta_1 * Performance + \varepsilon_1$$

$$EE_2 = \beta_2 * Performance + \varepsilon_2$$

…………………………………………

$$EE_{10} = \beta_{10} * Performance + \varepsilon_{10}$$

Where EE_1 to EE_{10} represent the measured variables related to performance. The regression coefficients β_1 to β_{10} represents the construct loading (standardized regression coefficient) of different statements with respect to the construct. The above-mentioned equations are estimated with the help of a measurement model approach in structural equation modeling method. The construct performance along with its measured variables is shown below in figure 4.23. The output of the software is represented in figure 4.24, 4.25, 4.26 and summarized in table 4.18.

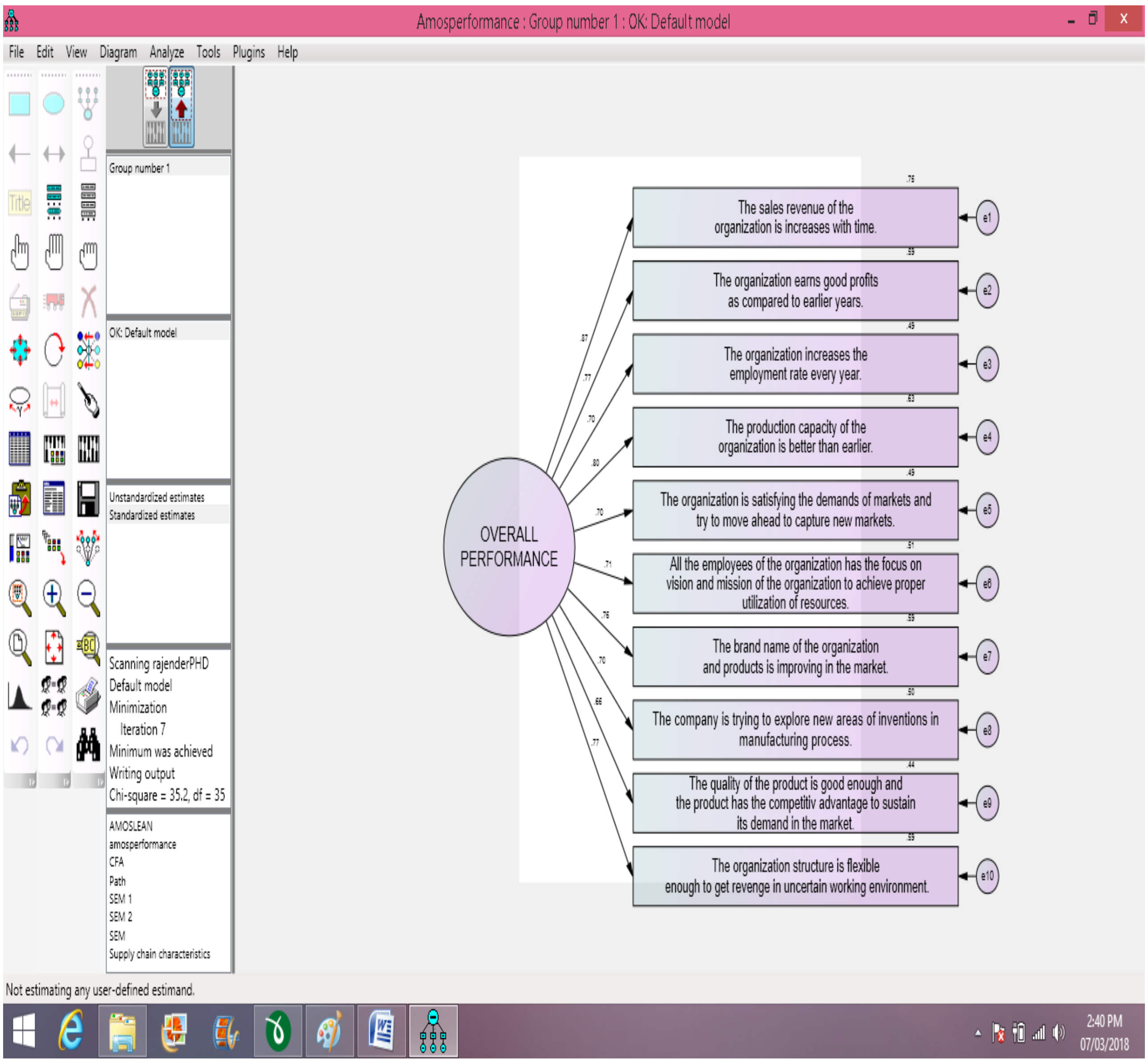


Figure 4.23: SEM diagram of the construct Performance

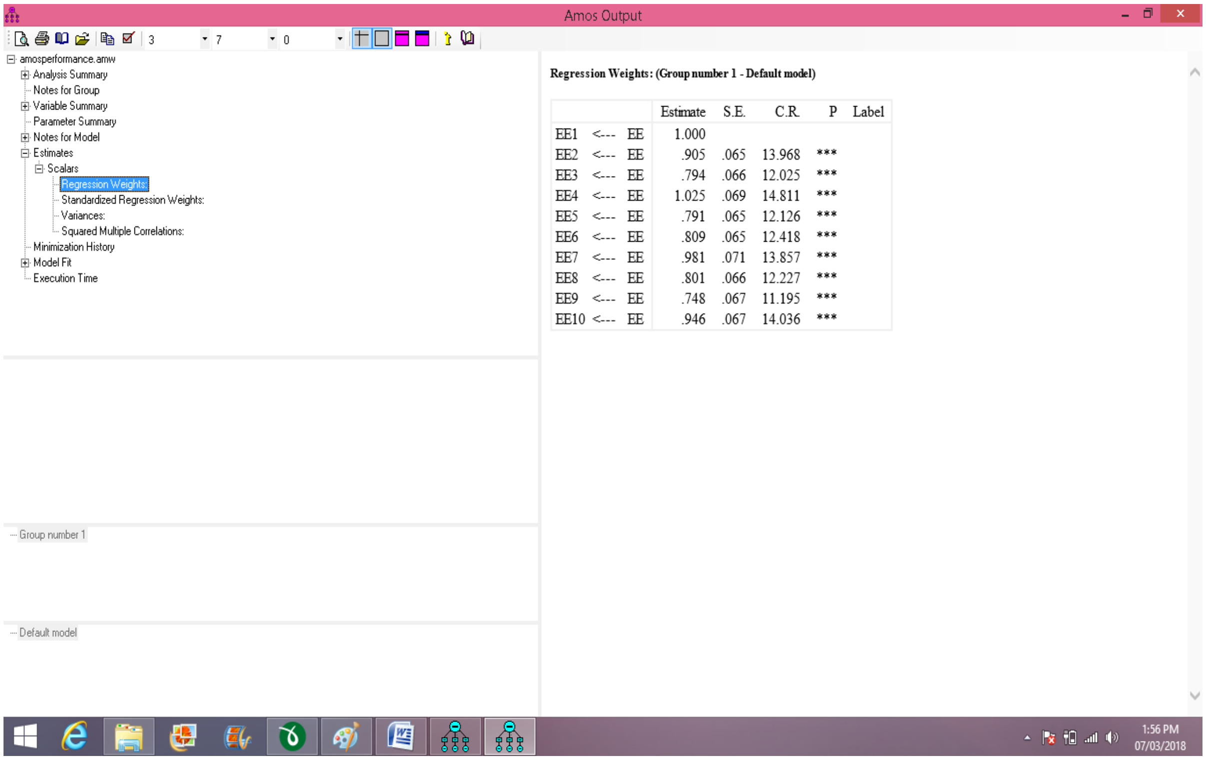


Figure 4.24: Regression weights output for the construct Performance

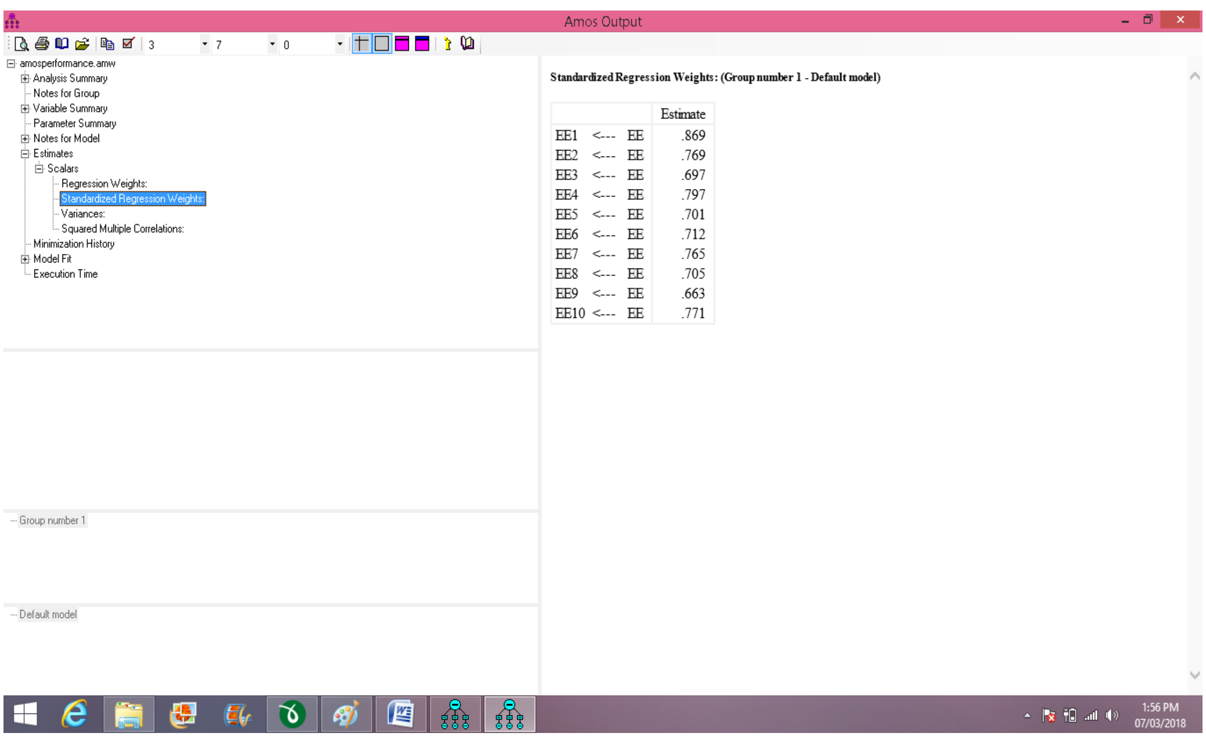


Figure 4.25: Standardized Regression Weights output for the construct Performance

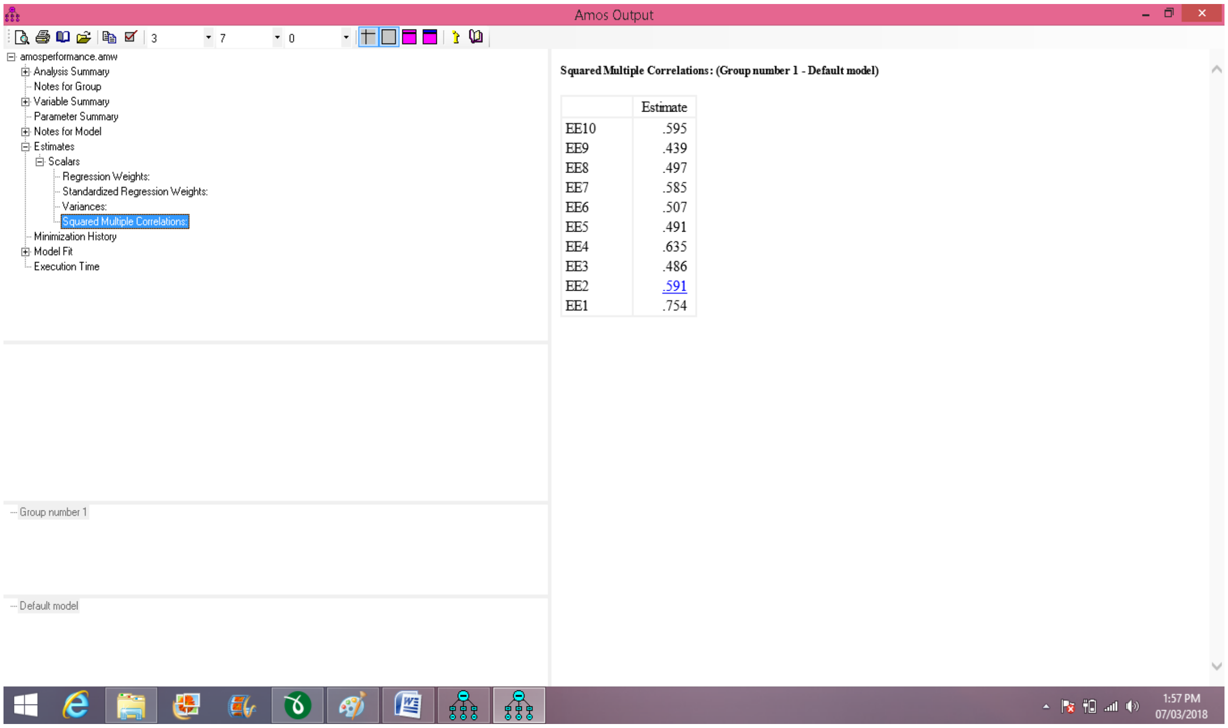


Figure 4.26: Squared Multiple Correlations output for the construct Performance

Table 4.18: Analysis summary for the construct performance

Statements	Standardized Construct Loading	Critical Ratio	P-Value	Squared Multiple Correlation
EE_1	0.869	------------	0.000	75.4
EE_2	0.769	13.968	0.000	59.1
EE_3	0.697	12.025	0.000	48.6
EE_4	0.797	14.811	0.000	63.5
EE_5	0.701	12.126	0.000	49.1
EE_6	0.712	12.418	0.000	50.7
EE_7	0.765	13.857	0.000	58.5
EE_8	0.705	12.227	0.000	49.7
EE_9	0.663	11.195	0.000	43.9
EE_{10}	0.771	14.036	0.000	59.5

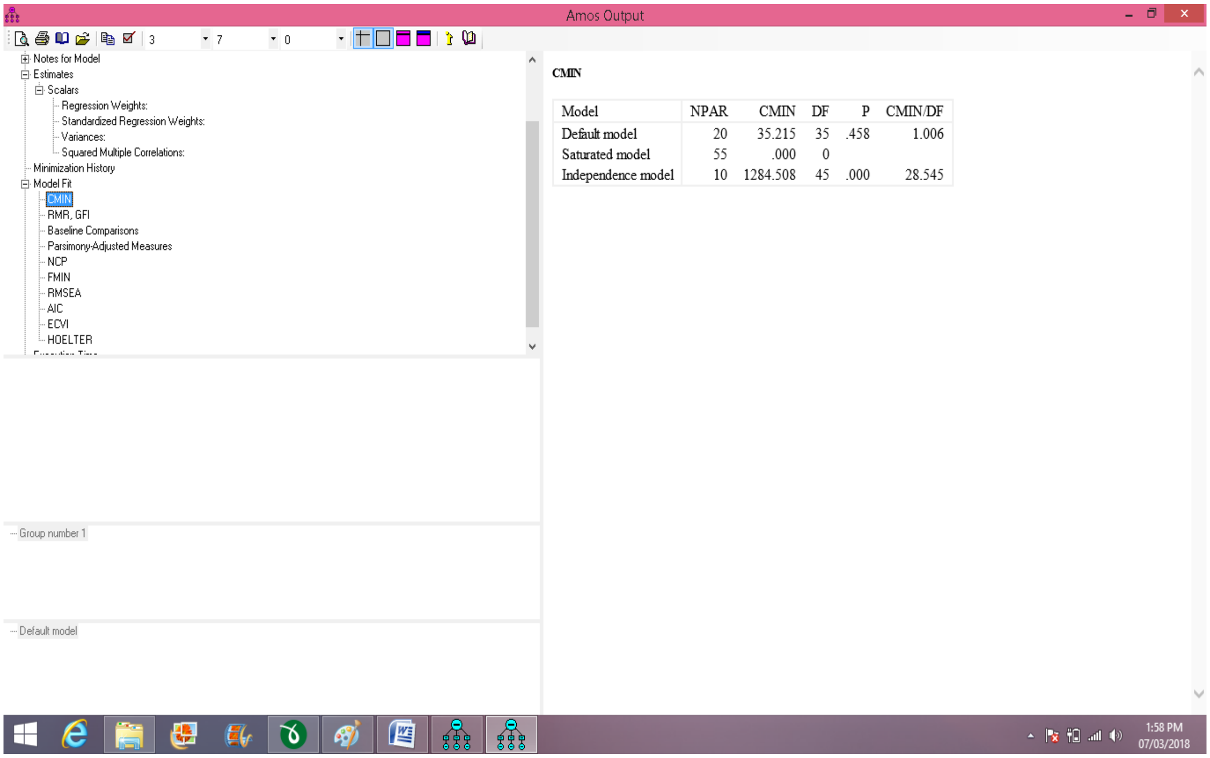
The result of the regression model indicates that the probability value of the critical ratio is found to be less than 5 percent level of significance. Hence, with 95 percent confidence level, it is concluded that all the statements considered in the study are significantly reflected the existence of performance of the manufacturing sector.

In addition to this, all the constructs loadings of statements are found to be greater than 0.7, which ensures the presence of convergent validity of the construct. It is also found that the statements EE_1 have the highest factor loading followed by EE_4, $EE_{10,}$ and so-on. This represents the presence of an efficient and effective performance in the manufacturing industry is reflected in the form of higher sales revenue.

Further, the second highest factor loading on statement EE_4 i.e. improved production capacity has an impact on the performance of the manufacturing industry reflects the presence of the construct performance. Since the statement EE_9 has the lowest factor loading. This means that the output quality has less reflection of the construct the performance.

The R square value indicates that 75.4 percent of the variance of the statement EE_1 can be explained with the help of variations in the construct performance. This is followed by the statement EE_4 with 63.5 percent of the variance can be explained with the help of variation in the construct. Similarly, 59.5 percent of the variance of statement EE_{10}, 59.1 percent of the variance of the statement EE_2 and so-on can be explained with the help of the construct i.e. performance.

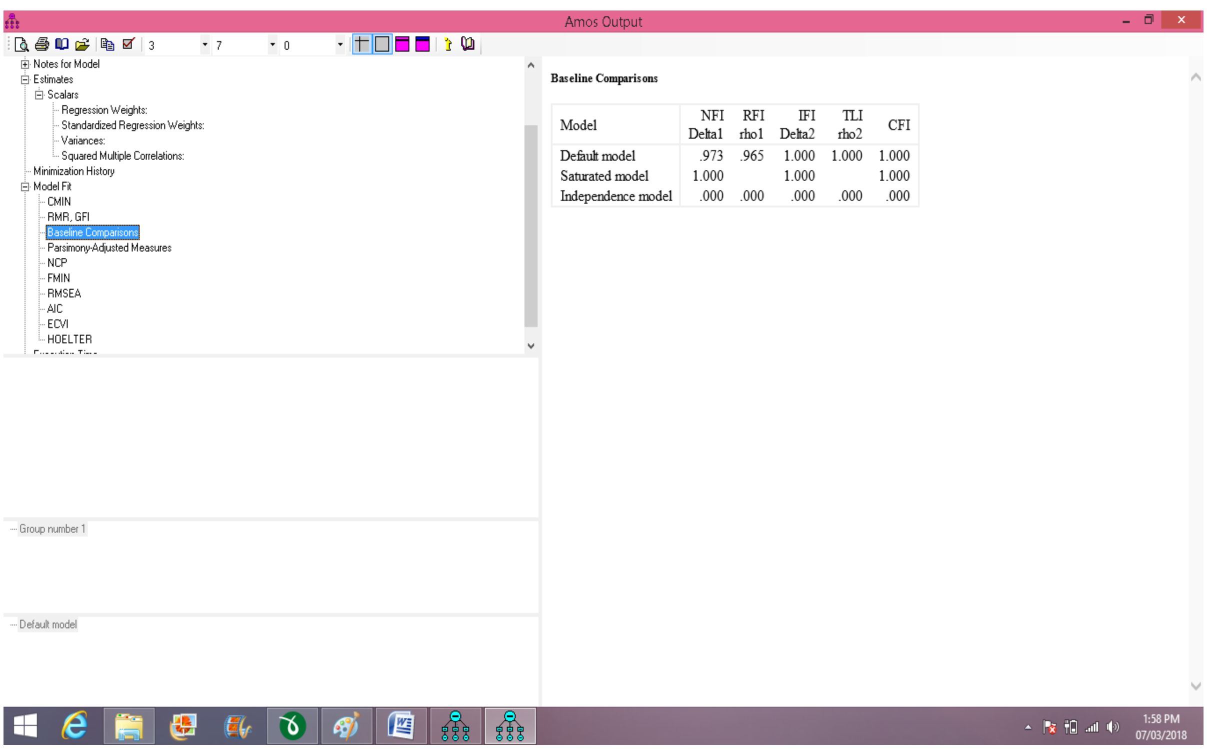
Figure 4.27, 4.28, 4.29 and 4.30 shows the output of the software and summarized in table 4.19 reveals the construct performance is the statistical fit model.



CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	20	35.215	35	.458	1.006
Saturated model	55	.000	0		
Independence model	10	1284.508	45	.000	28.545

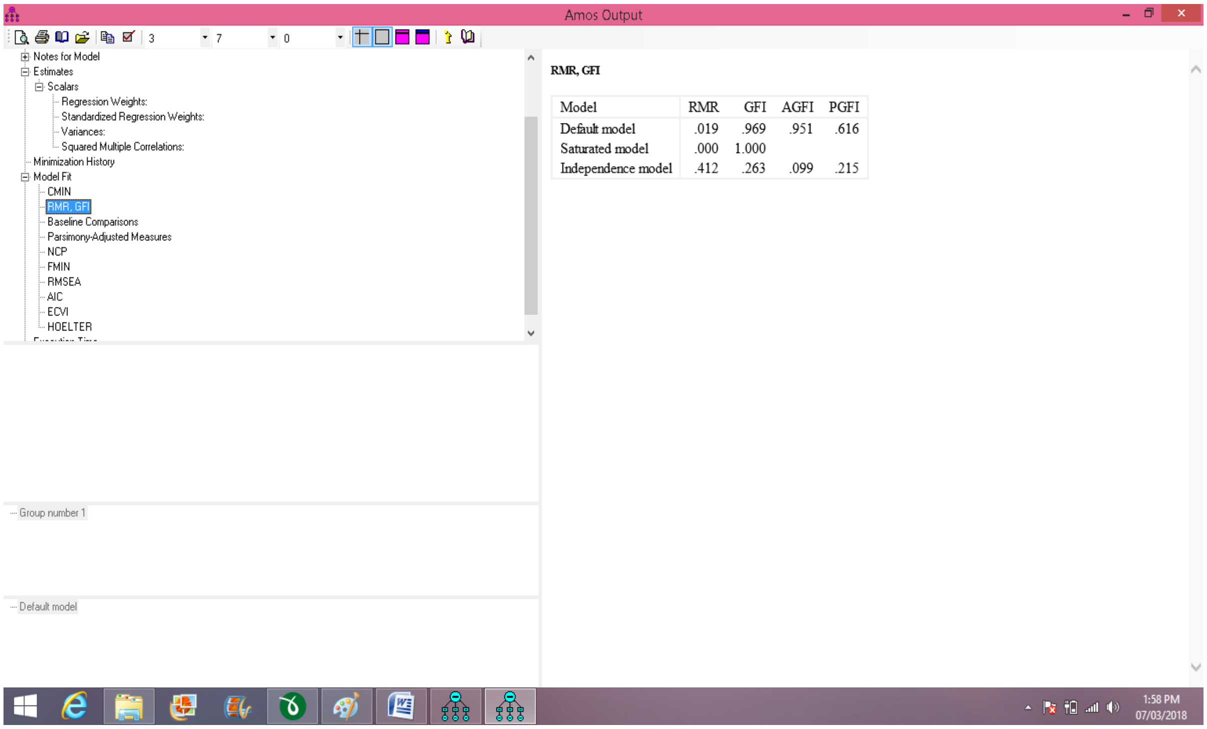
Figure 4.27: Model fitness Indices CMIN for the construct Performance



Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.973	.965	1.000	1.000	1.000
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

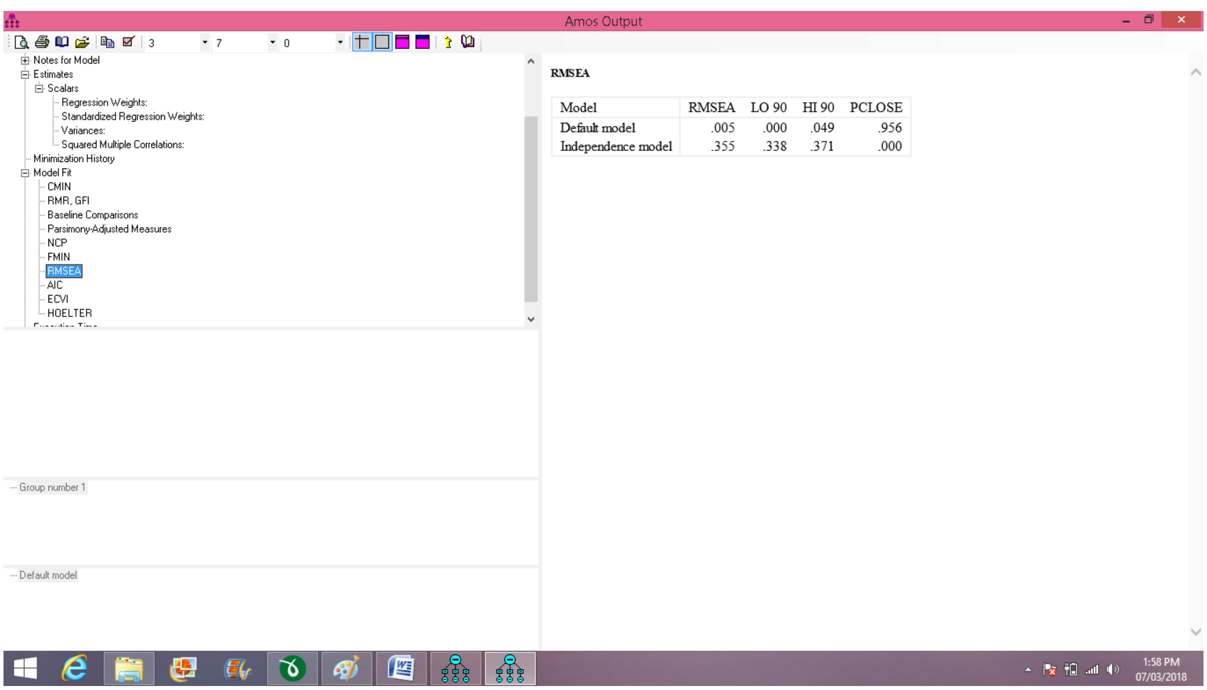
Figure 4.28: Model fitness Indices CFI for the construct Performance



RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.019	.969	.951	.616
Saturated model	.000	1.000		
Independence model	.412	.263	.099	.215

Figure 4.29: Model fitness Indices GFI and AGFI for the construct Performance



RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.005	.000	.049	.956
Independence model	.355	.338	.371	.000

Figure 4.30: Model fitness Indices RMSEA for the construct Performance

Table 4.19: Statistical analysis of the construct Performance

Construct	Designation	CMIN/df ≤ 5	CFI ≥.9	GFI ≥.8	AGFI ≥.8	RMSEA ≥.08
Performance	EE1-EE10	1.006	1.00	0.969	0.951	0.005

4.5 VALIDITY OF RESULTS ANALYSIS USING CONFIRMATORY FACTOR ANALYSIS

Validation of the construct in the SEM model is termed as construct validity referred to represent the degree of accuracy by which the construct correctly measured with the help of variable assign to the constructs. In SEM modeling approach, Confirmatory Factor Analysis (CFA) is the very popular method (statistical) to represent and examine the stricter of the construct as a set of observed variables. CFA is used to test the uni-dimensionality and validity (both convergent and discriminant) of the construct with respect to its variables explained below:

Uni-Dimensionality: As the name suggests, it simply refers that the variable considers for measuring the one construct is not having the relation in measuring the other constructs in the study. The value of the Comparative Fit Index (CFI) ≥ 0.8 gives strong evidence of uni-dimensionality in the studied model.

Convergent Validity: The convergent validity is used to state whether the variables of one construct are highly correlated with each other or not. It gives the statistical values for the variables i.e. degree to which variables in the constructs are related to each other. In the CFA model, the size of factor loading (standardized beta) of the variables to the construct indicates the convergent validity, which in general is measured by Composite Reliability and Average Variance extracted.

$$CR = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum Var\left(\varepsilon_i\right)}$$

Whereby, λ (lambda) is the standardized factor loading for item *i* and ε is the respective error variance for item *i*. The error variance (ε) is estimated based on the value of the standardized loading (λ) as:

$$\epsilon_i = 1 - \lambda_i^2$$

The item r-square value is the percent of the variance of item *i*, explained by the latent variable. It is estimated based on the value of the standardized loading (λ) as:

$$r^2 = \lambda_i^2 = 1 - \epsilon_i$$

Discriminant Validity: Discriminant validity states the degree to which variables in different constructs are different from each other. In general, the discriminant validity ensures the correlation among variable of the different construct is low. It can be analyzed with the Average Variance Extracted, average shared Variance (ASV) and Maximum Shared variance (MSV) measure of the construct in multiple variables constructs. The CFA must ensure the value of AVE should be ≥ 0.5; ASV and MSV.

The confirmatory factor analysis (CFA) results reveal the constructs has a positive correlation or not with the other constructs. The Discriminant Validity in SEM has identified the extent up to which a construct is truly distinct from other constructs. [Hair et al., 2010] Most of the researchers on SEM have focused on two common methods for estimating Discriminant Validity. The first one is the correlation between the measures of theoretically different constructs. The limitation of this method is the use of different instruments for measuring the variables. So, the constructs should not correlate too strongly with instruments of a comparable, but with distinct characteristics. [Trochim, 2006] The other method is to estimate the Average Variances Extracted (AVE) of the individual constructs which are higher than the shared variance between the constructs. And, the level of the square root of AVE should be greater than the correlations involving the constructs.

In addition, the Convergent validity that shows the extent to which any attributes/indicators of a specific construct converges or has a high proportion of variance in common. The significance of standardized factor loading is to indicate the variables that are under study are significant and representative of the latent variable. The range of standardized factor loading is 0.7-0.9, which means the modeled variables are adequate corresponded to their constructs. [Hair et al., 2010] The validity is estimated by calculating the standardized factor loadings.

In the research study, the primary data is collected with the help of a questionnaire. There are mainly three latent factors considered for the study. These are lean principles, supply chain characteristics, and performance. These latent variables or factors are measured with the help of different statements. The reliability measurement of all the constructs is explained earlier in section 4.1, 4.2 and 4.3. After ensuring the presence of consistent reliability, it is required to test the construct validity of the different constructs used in this study. The confirmatory factor analysis (CFA) is used to test the construct validity of all the three factors used in the study. The Confirmatory factor analysis model for the present study is shown in figure 4.31. The composite reliability and the validity statistics is shown in figures 4.32, 4.33, 4.34, 4.35, 4.36 and 4.37.

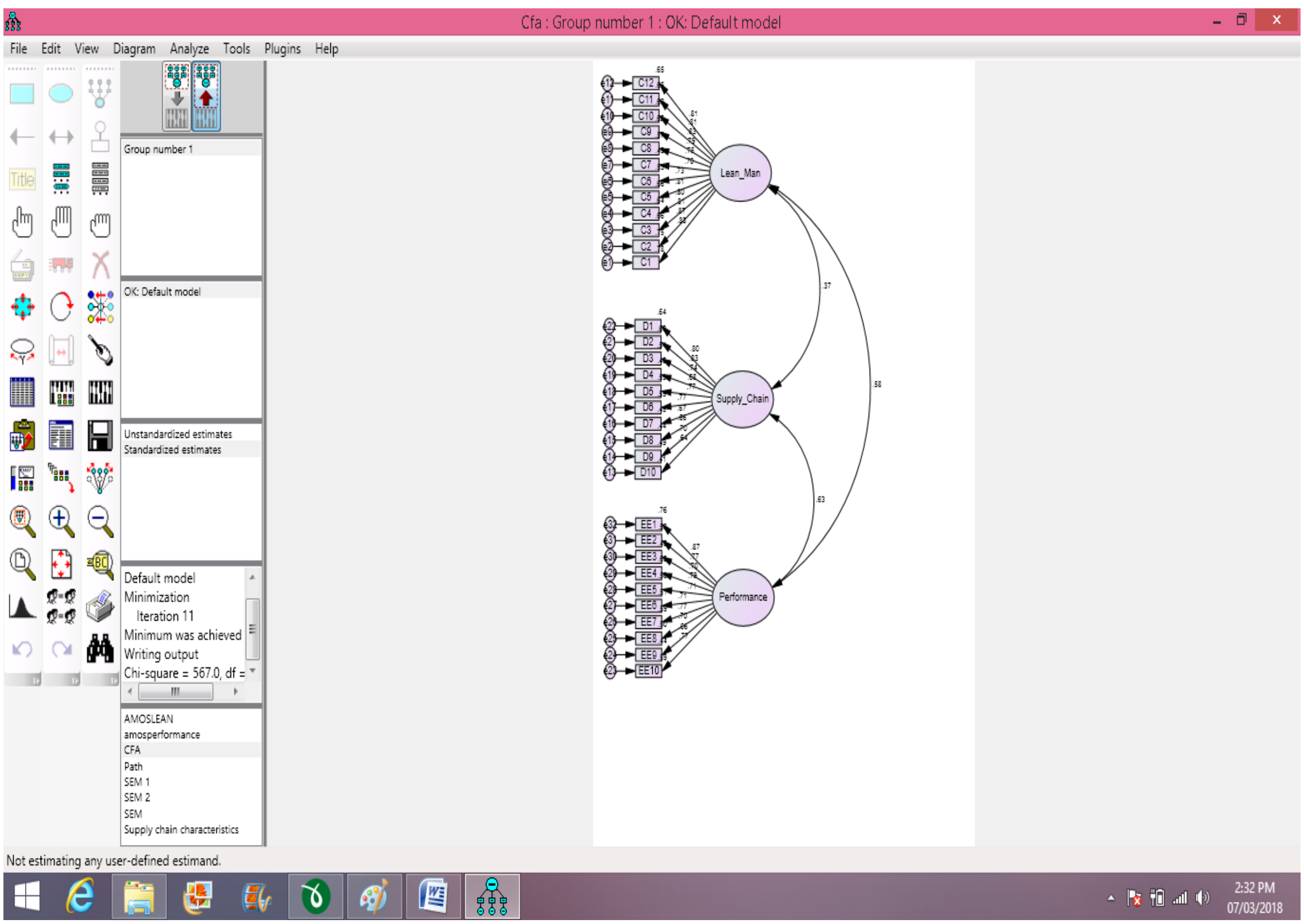
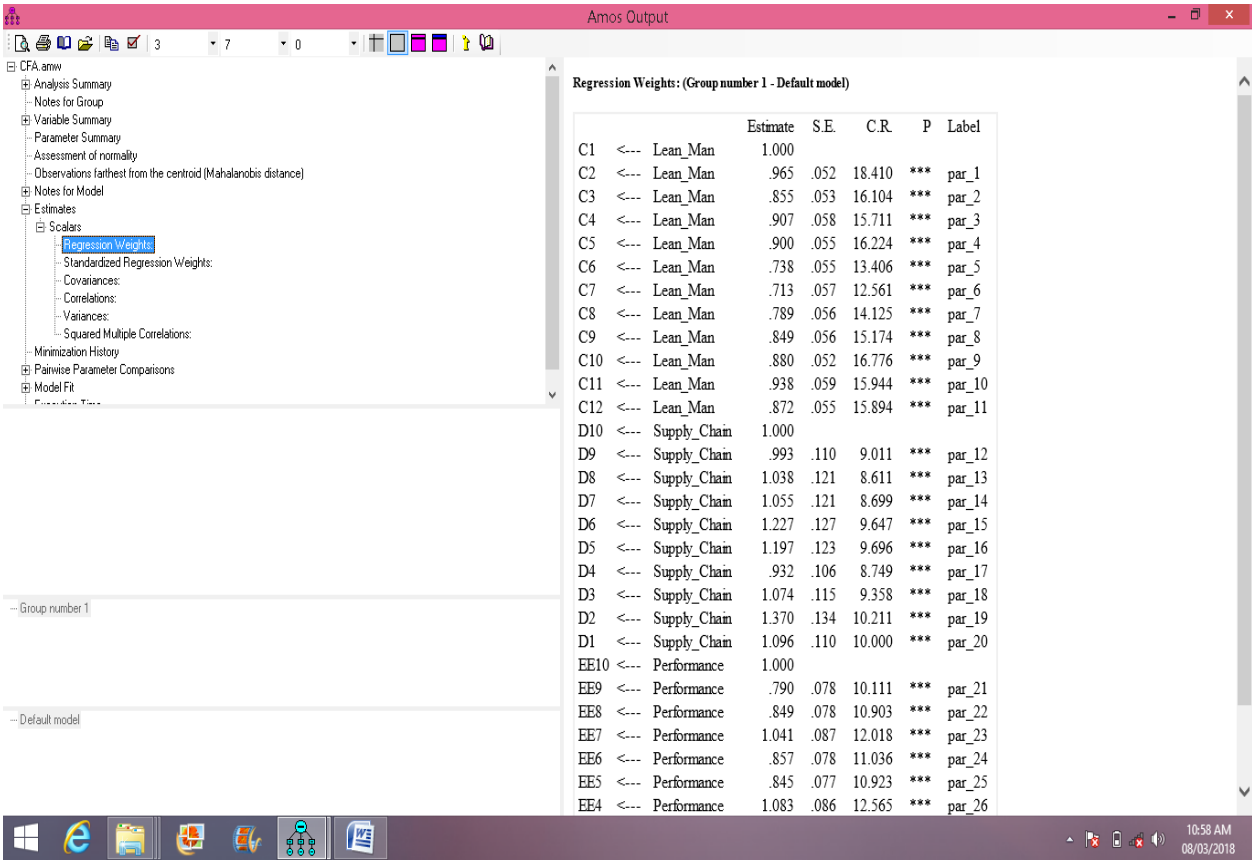


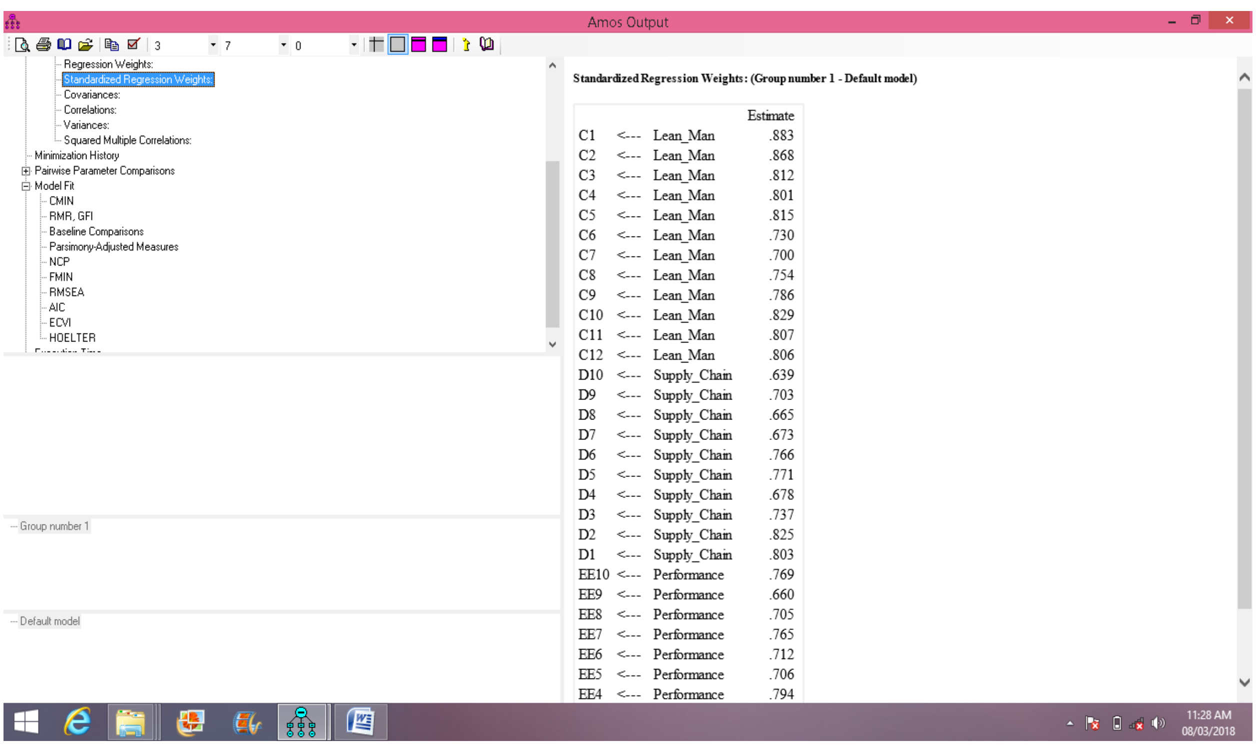
Figure 4.31: Confirmatory factor analysis for the present study



Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
C1	<---	Lean_Man	1.000				
C2	<---	Lean_Man	.965	.052	18.410	***	par_1
C3	<---	Lean_Man	.855	.053	16.104	***	par_2
C4	<---	Lean_Man	.907	.058	15.711	***	par_3
C5	<---	Lean_Man	.900	.055	16.224	***	par_4
C6	<---	Lean_Man	.738	.055	13.406	***	par_5
C7	<---	Lean_Man	.713	.057	12.561	***	par_6
C8	<---	Lean_Man	.789	.056	14.125	***	par_7
C9	<---	Lean_Man	.849	.056	15.174	***	par_8
C10	<---	Lean_Man	.880	.052	16.776	***	par_9
C11	<---	Lean_Man	.938	.059	15.944	***	par_10
C12	<---	Lean_Man	.872	.055	15.894	***	par_11
D10	<---	Supply_Chain	1.000				
D9	<---	Supply_Chain	.993	.110	9.011	***	par_12
D8	<---	Supply_Chain	1.038	.121	8.611	***	par_13
D7	<---	Supply_Chain	1.055	.121	8.699	***	par_14
D6	<---	Supply_Chain	1.227	.127	9.647	***	par_15
D5	<---	Supply_Chain	1.197	.123	9.696	***	par_16
D4	<---	Supply_Chain	.932	.106	8.749	***	par_17
D3	<---	Supply_Chain	1.074	.115	9.358	***	par_18
D2	<---	Supply_Chain	1.370	.134	10.211	***	par_19
D1	<---	Supply_Chain	1.096	.110	10.000	***	par_20
EE10	<---	Performance	1.000				
EE9	<---	Performance	.790	.078	10.111	***	par_21
EE8	<---	Performance	.849	.078	10.903	***	par_22
EE7	<---	Performance	1.041	.087	12.018	***	par_23
EE6	<---	Performance	.857	.078	11.036	***	par_24
EE5	<---	Performance	.845	.077	10.923	***	par_25
EE4	<---	Performance	1.083	.086	12.565	***	par_26

Figure 4.32: Regression Weights Output in CFA



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
C1	<---	Lean_Man	.883
C2	<---	Lean_Man	.868
C3	<---	Lean_Man	.812
C4	<---	Lean_Man	.801
C5	<---	Lean_Man	.815
C6	<---	Lean_Man	.730
C7	<---	Lean_Man	.700
C8	<---	Lean_Man	.754
C9	<---	Lean_Man	.786
C10	<---	Lean_Man	.829
C11	<---	Lean_Man	.807
C12	<---	Lean_Man	.806
D10	<---	Supply_Chain	.639
D9	<---	Supply_Chain	.703
D8	<---	Supply_Chain	.665
D7	<---	Supply_Chain	.673
D6	<---	Supply_Chain	.766
D5	<---	Supply_Chain	.771
D4	<---	Supply_Chain	.678
D3	<---	Supply_Chain	.737
D2	<---	Supply_Chain	.825
D1	<---	Supply_Chain	.803
EE10	<---	Performance	.769
EE9	<---	Performance	.660
EE8	<---	Performance	.705
EE7	<---	Performance	.765
EE6	<---	Performance	.712
EE5	<---	Performance	.706
EE4	<---	Performance	.794

Figure 4.33: Standardized Regression Weights Output in CFA

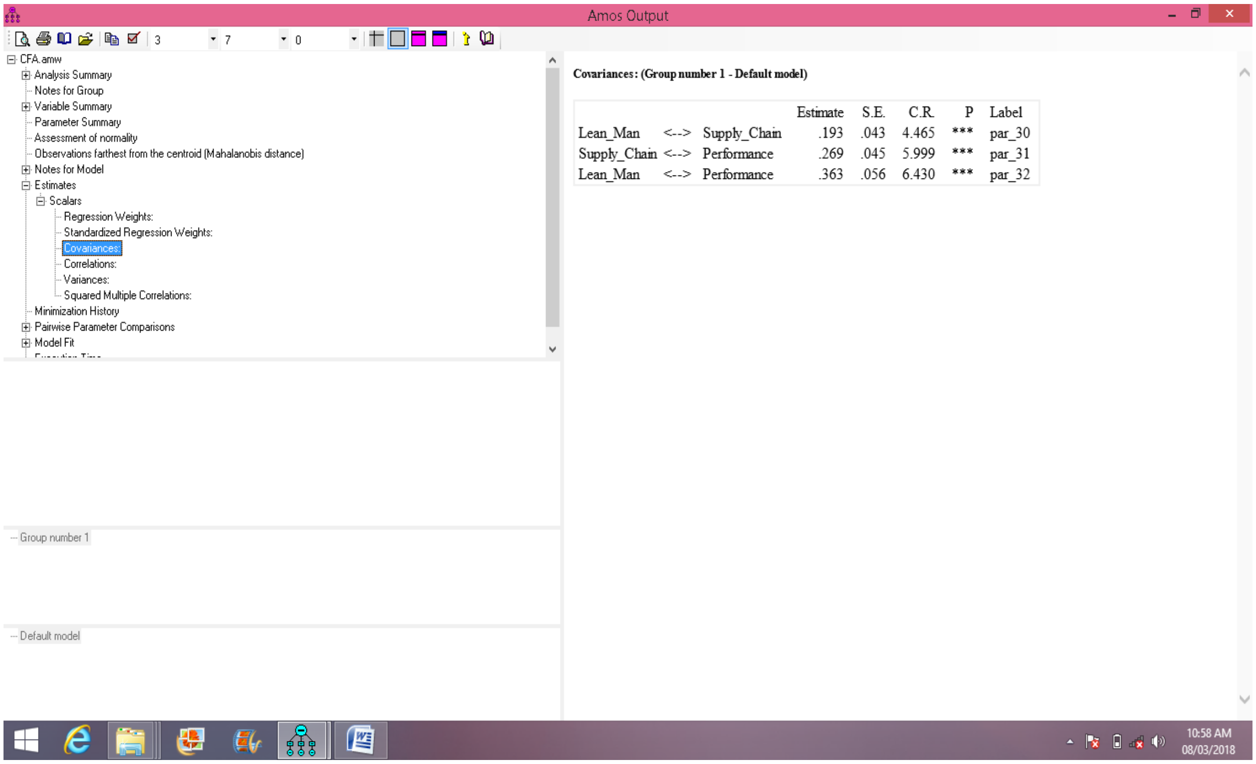


Figure 4.34: Covariance Output in CFA

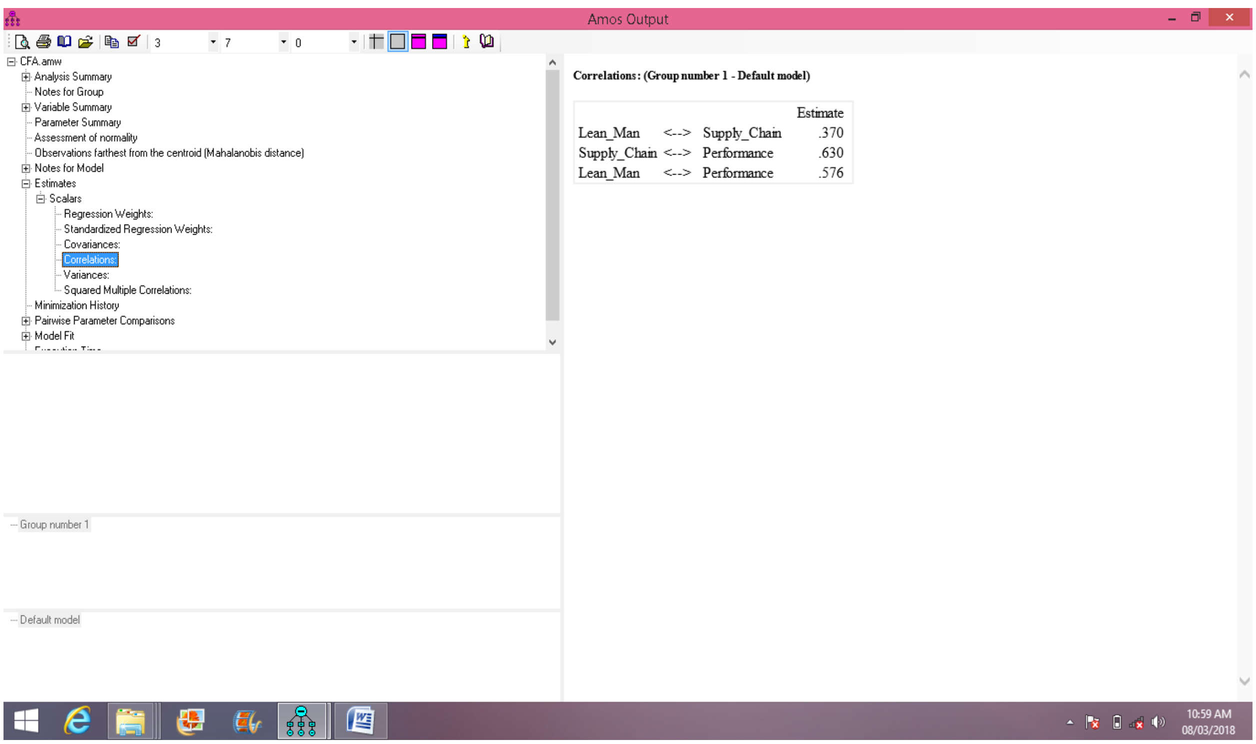
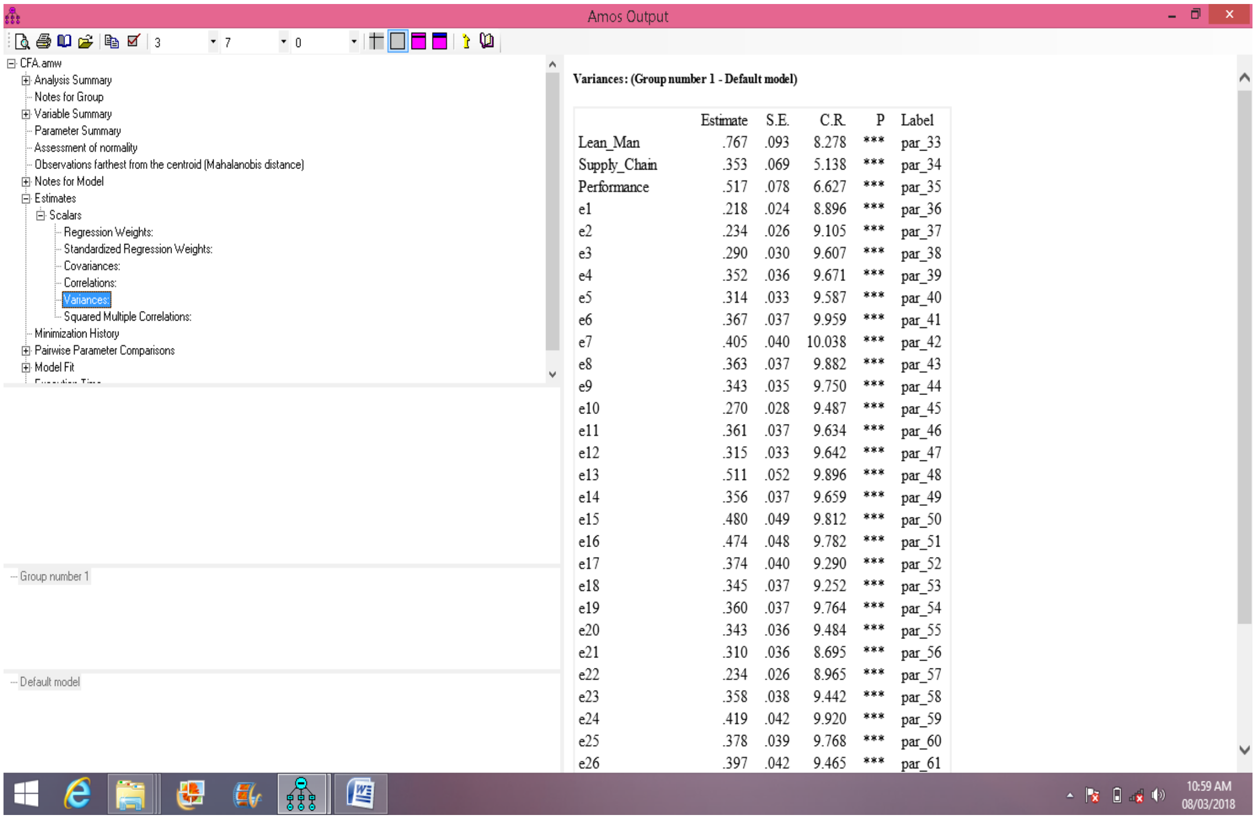


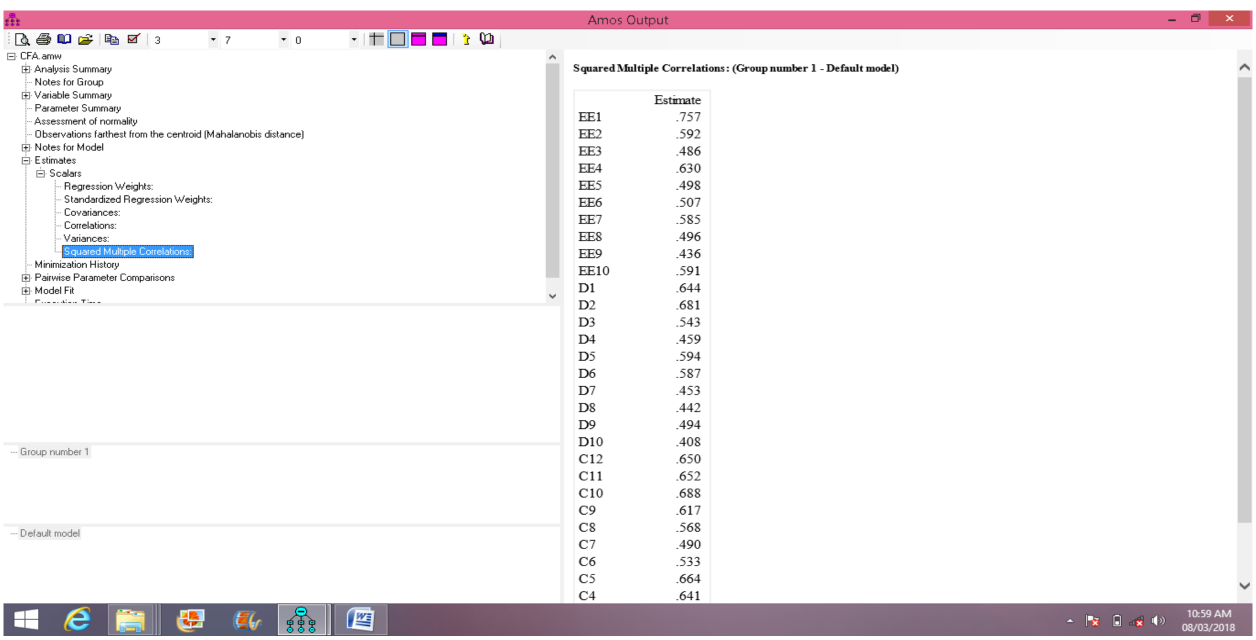
Figure 4.35: Correlation Output in CFA



Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Lean_Man	.767	.093	8.278	***	par_33
Supply_Chain	.353	.069	5.138	***	par_34
Performance	.517	.078	6.627	***	par_35
e1	.218	.024	8.896	***	par_36
e2	.234	.026	9.105	***	par_37
e3	.290	.030	9.607	***	par_38
e4	.352	.036	9.671	***	par_39
e5	.314	.033	9.587	***	par_40
e6	.367	.037	9.959	***	par_41
e7	.405	.040	10.038	***	par_42
e8	.363	.037	9.882	***	par_43
e9	.343	.035	9.750	***	par_44
e10	.270	.028	9.487	***	par_45
e11	.361	.037	9.634	***	par_46
e12	.315	.033	9.642	***	par_47
e13	.511	.052	9.896	***	par_48
e14	.356	.037	9.659	***	par_49
e15	.480	.049	9.812	***	par_50
e16	.474	.048	9.782	***	par_51
e17	.374	.040	9.290	***	par_52
e18	.345	.037	9.252	***	par_53
e19	.360	.037	9.764	***	par_54
e20	.343	.036	9.484	***	par_55
e21	.310	.036	8.695	***	par_56
e22	.234	.026	8.965	***	par_57
e23	.358	.038	9.442	***	par_58
e24	.419	.042	9.920	***	par_59
e25	.378	.039	9.768	***	par_60
e26	.397	.042	9.465	***	par_61

Figure 4.36: Variance Output in CFA



Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
EE1	.757
EE2	.592
EE3	.486
EE4	.630
EE5	.498
EE6	.507
EE7	.585
EE8	.496
EE9	.436
EE10	.591
D1	.644
D2	.681
D3	.543
D4	.459
D5	.594
D6	.587
D7	.453
D8	.442
D9	.494
D10	.408
C12	.650
C11	.652
C10	.688
C9	.617
C8	.568
C7	.490
C6	.533
C5	.664
C4	.641

Figure 4.37: Squared Multiple Correlations Output in CFA

Figures showed above represent the level of internal consistency reliability and the construct validity of the present study. The variables-statistical measures of construct validity (convergent as well as discriminant validity) are estimated and given in table 4.20.

Table 4.20: Confirmatory factor analysis results for CFA

Statistical Measures	**Constructs**		
	Lean Manufacturing	**Supply Chain Characteristics**	**Performance**
Composite Reliability (≥ .7)	0.955	0.918	0.926
Average Variance Extracted (≥ .5)	0.641	0.531	0.558
Maximum Shared Variance	0.332	0.397	0.397
Average Shared Variance	0.234	0.267	0.364

The result of construct validity measures indicates the composite reliability of all the selected constructs are found to be greater than 0.7and average is found to be greater than 0.5. The average variance extracted in table 4.20 represents the variance of the variables of the constructs, which can be explained by the variations in the construct is found to be greater than the average shared variance and maximum-shared variance of the construct with other constructs. This ensures that the convergent, as well as the discriminant validity of the scale, consisted of three different constructs in the study.

4.6 LEAN MANUFACTURING IMPACTS ON THE ORGANIZATIONAL PERFORMANCE

As literature depicts, it is much difficult to comment on the beginning of Lean philosophy. It is essentially the combination of several threads of ideas. Perhaps, the Toyota Company Japan was credited for the first time execution of lean principles around 1980s. At that time, Taiichi Ohno noticed the problem related to huge inventory which restricts the production diversity. The revolution in industrial sector especially in the manufacturing of automotive parts segment explore the requisites of ‘Continuous Improvement’, organizations used lean as a pursuit to perfection. Later on, lean manufacturing became very popular as a technique for waste reduction and saving industrial resources and supports the flow of products through identifying the value inherent within the specific products/processes. Practitioners in industries using LM believes that it is the pull production, which means let the customer will pull the value from the producer, and they pursue with perfection.

Lean manufacturing also offers the best alternative solution on the cost front by optimizes the flow of products and services to its customers. It delivers customer value by reducing lead times; improving quality; eliminating waste; reducing the total costs; engaging and energizing people. The present study depicts the impact of lean manufacturing principles on organizational performance. The structural model for the impact of lean manufacturing principles on organizational performance is shown in figure 4.38.

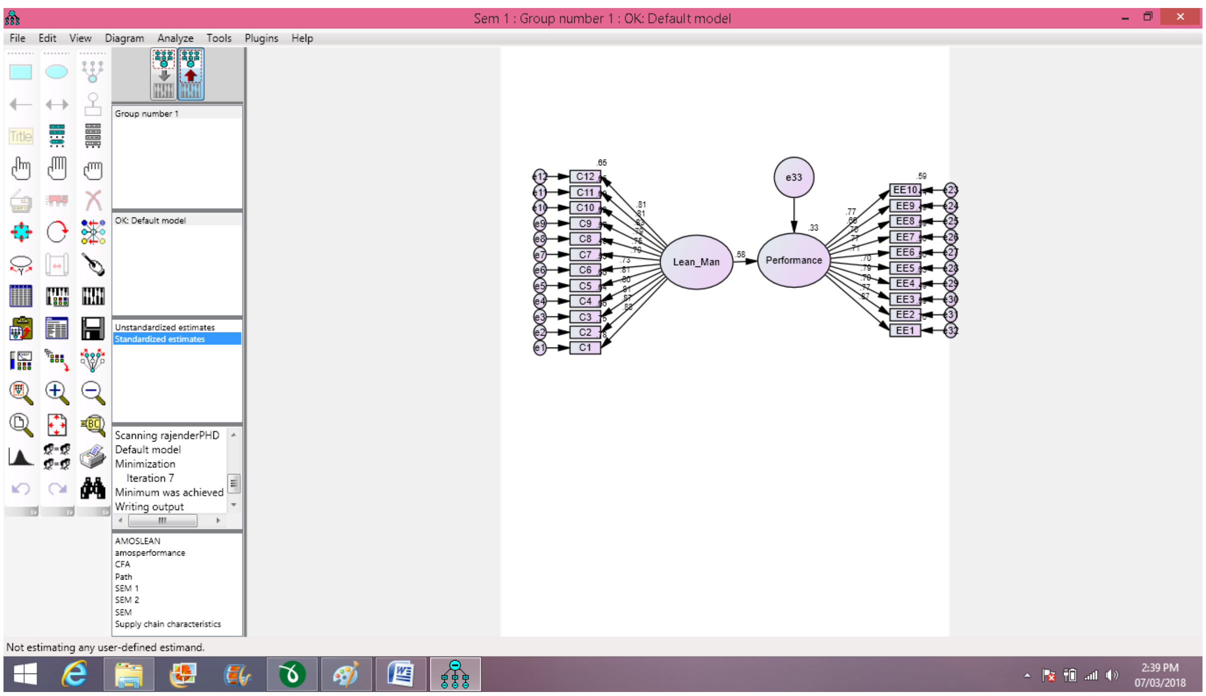
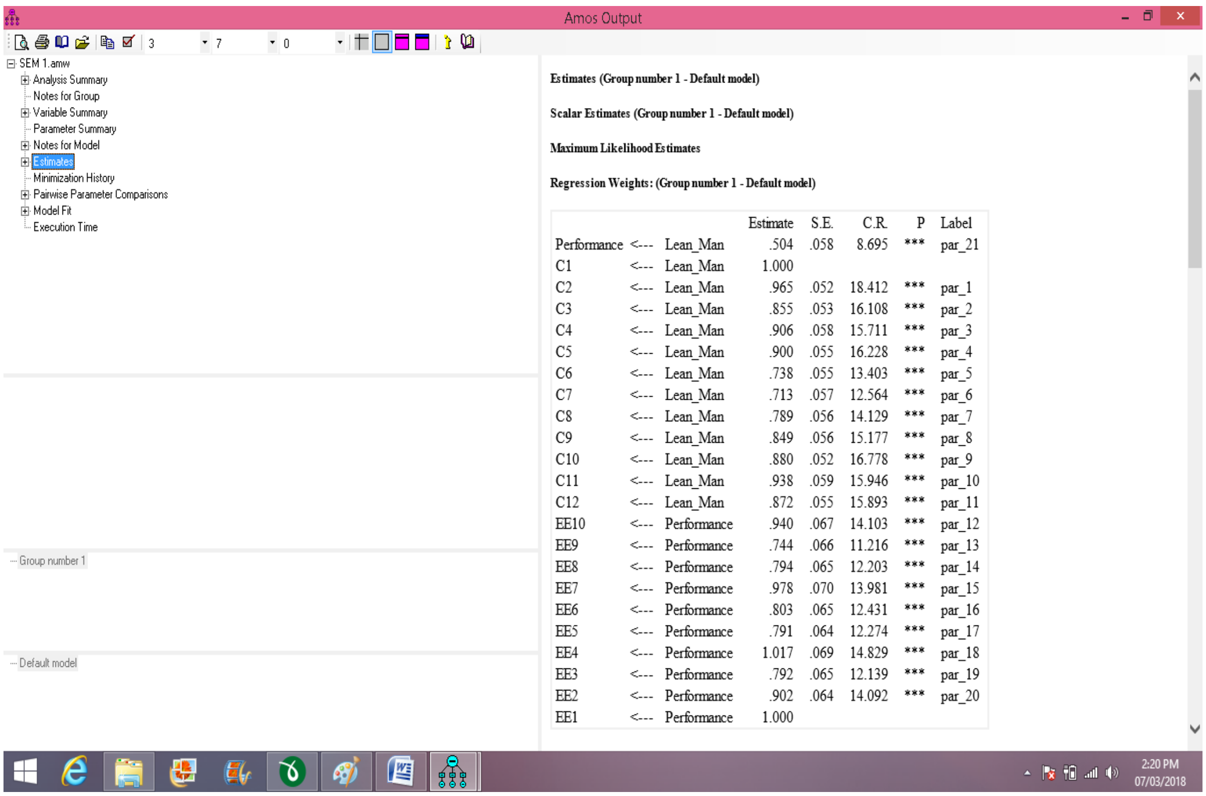


Figure 4.38: SEM model for the construct Lean manufacturing impacts on construct Performance

The results for the impact of lean manufacturing principles on the organizational performance are shown in figure 4.39, 4.40, 4.41 and summarized in table 4.21depicts that the construct lean manufacturing has the significant impact on construct performance. The results indicate that the probability value of the critical ratio is found to be less than 5 percent level of significance. Hence, with 95 percent confidence level, the null hypothesis of no impact of Lean manufacturing on Performance cannot be accepted. From the study, it can be concluded from the study that Lean manufacturing system in manufacturing setup in selected firms has a significant impact on their business performance. The r squared value of 0.332 indicates that 33.2 percent of the variance of the business performance can be explained with the help of variations in Lean Manufacturing variances.



Estimates (Group number 1 - Default model)

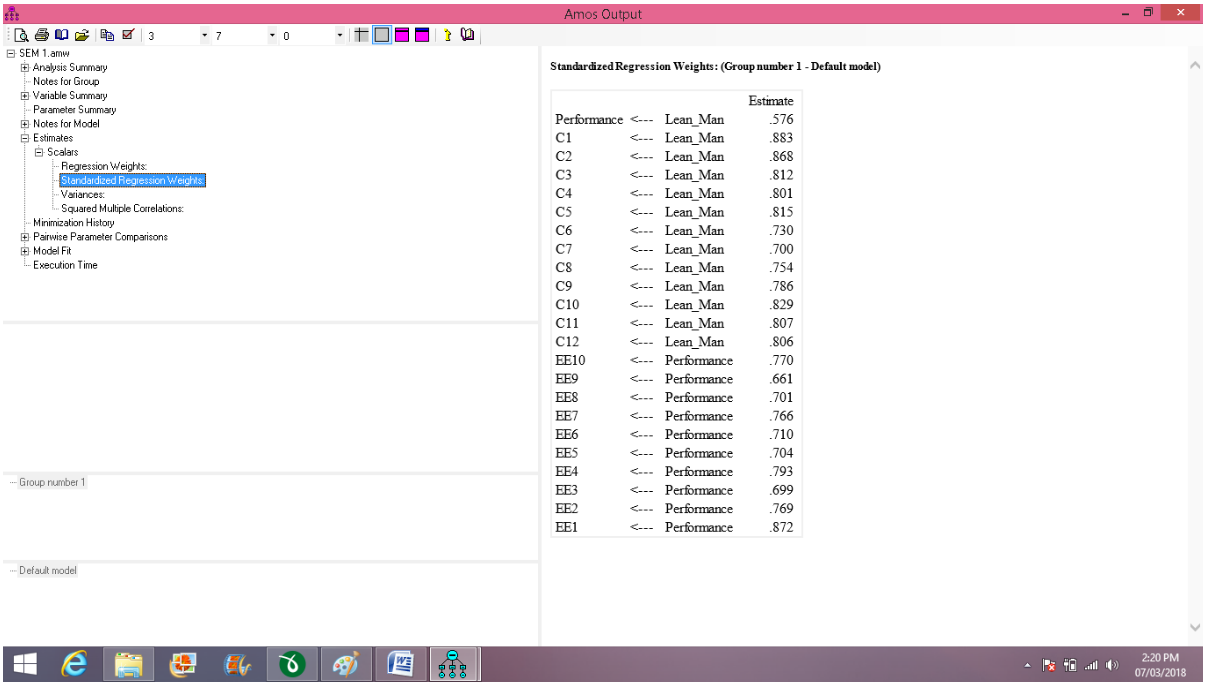
Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Performance	<---	Lean_Man	.504	.058	8.695	***	par_21
C1	<---	Lean_Man	1.000				
C2	<---	Lean_Man	.965	.052	18.412	***	par_1
C3	<---	Lean_Man	.855	.053	16.108	***	par_2
C4	<---	Lean_Man	.906	.058	15.711	***	par_3
C5	<---	Lean_Man	.900	.055	16.228	***	par_4
C6	<---	Lean_Man	.738	.055	13.403	***	par_5
C7	<---	Lean_Man	.713	.057	12.564	***	par_6
C8	<---	Lean_Man	.789	.056	14.129	***	par_7
C9	<---	Lean_Man	.849	.056	15.177	***	par_8
C10	<---	Lean_Man	.880	.052	16.778	***	par_9
C11	<---	Lean_Man	.938	.059	15.946	***	par_10
C12	<---	Lean_Man	.872	.055	15.893	***	par_11
EE10	<---	Performance	.940	.067	14.103	***	par_12
EE9	<---	Performance	.744	.066	11.216	***	par_13
EE8	<---	Performance	.794	.065	12.203	***	par_14
EE7	<---	Performance	.978	.070	13.981	***	par_15
EE6	<---	Performance	.803	.065	12.431	***	par_16
EE5	<---	Performance	.791	.064	12.274	***	par_17
EE4	<---	Performance	1.017	.069	14.829	***	par_18
EE3	<---	Performance	.792	.065	12.139	***	par_19
EE2	<---	Performance	.902	.064	14.092	***	par_20
EE1	<---	Performance	1.000				

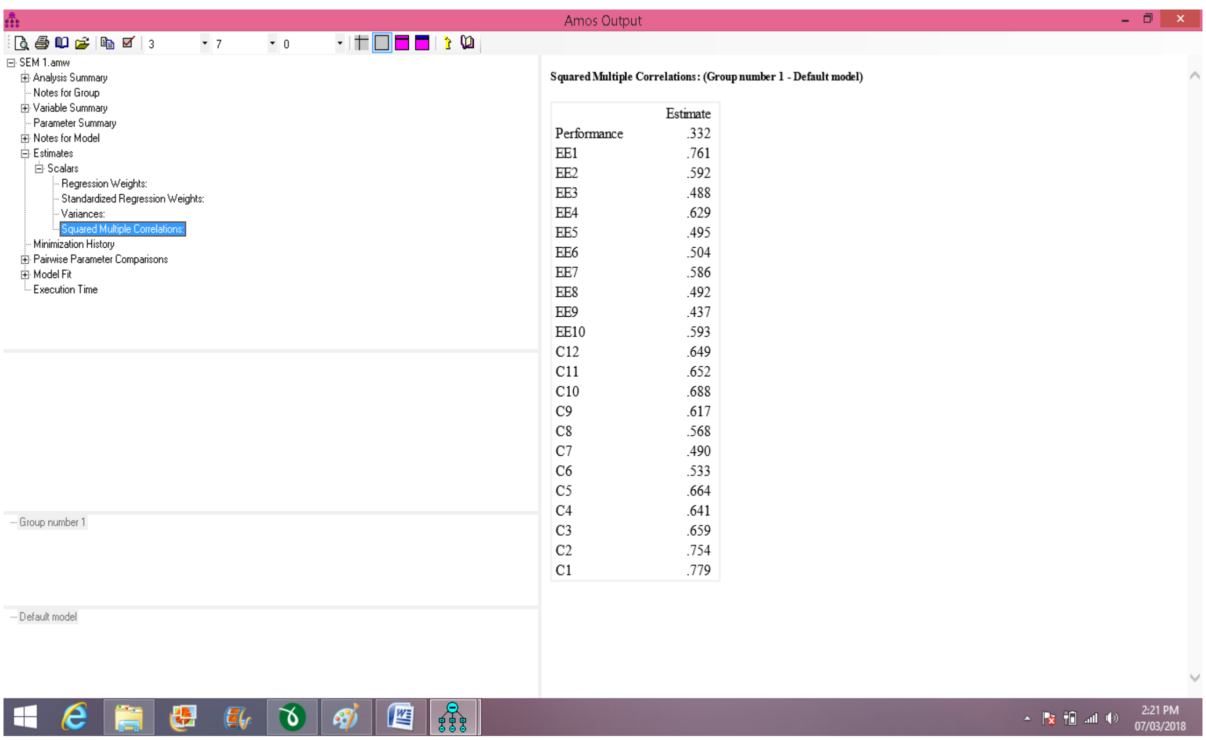
Figure 4.39: Regression Weights output for SEM of construct Lean manufacturing impacts on construct Performance



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Performance	<---	Lean_Man	.576
C1	<---	Lean_Man	.883
C2	<---	Lean_Man	.868
C3	<---	Lean_Man	.812
C4	<---	Lean_Man	.801
C5	<---	Lean_Man	.815
C6	<---	Lean_Man	.730
C7	<---	Lean_Man	.700
C8	<---	Lean_Man	.754
C9	<---	Lean_Man	.786
C10	<---	Lean_Man	.829
C11	<---	Lean_Man	.807
C12	<---	Lean_Man	.806
EE10	<---	Performance	.770
EE9	<---	Performance	.661
EE8	<---	Performance	.701
EE7	<---	Performance	.766
EE6	<---	Performance	.710
EE5	<---	Performance	.704
EE4	<---	Performance	.793
EE3	<---	Performance	.699
EE2	<---	Performance	.769
EE1	<---	Performance	.872

Figure 4.40: Standardized Regression Weights output for SEM of construct Lean manufacturing impacts on construct Performance



Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Performance	.332
EE1	.761
EE2	.592
EE3	.488
EE4	.629
EE5	.495
EE6	.504
EE7	.586
EE8	.492
EE9	.437
EE10	.593
C12	.649
C11	.652
C10	.688
C9	.617
C8	.568
C7	.490
C6	.533
C5	.664
C4	.641
C3	.659
C2	.754
C1	.779

Figure 4.41: Squared Multiple Correlations output for SEM of construct Lean manufacturing impacts on construct Performance

Table 4.21: Regression results of SEM for Lean manufacturing impact on Performance

Endogenous Construct	Exogenous Construct	Standardized Beta	C.R.	P-Value	R^2
Performance	Lean Manufacturing	0.576	8.695	0.000	33.2%

For any business entity, the strength is dependent on the availability of resources. The materials in all forms such as raw, work-in-progress and finished one of the biggest resources which engage the other resources like money, space, manpower etc. Therefore, it became necessary in manufacturing to adopt lean principles. In addition, the extensive literature review work reveals the journey of lean principles application in the manufacturing sector and its contribution to continuous improvement of organization performance. Figure 4.42, 4.43, 4.44, 4.45 represents the output of the software and summarized in table 4.22 which reveals that the model is statistically fit.

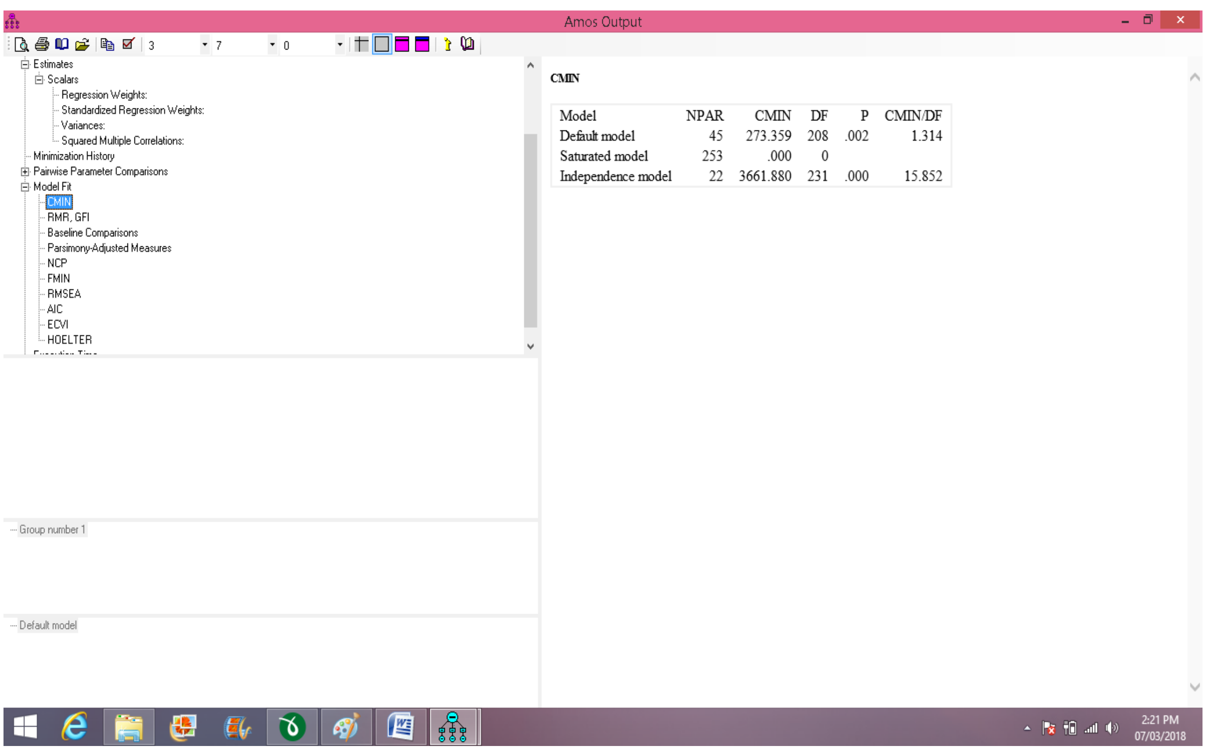
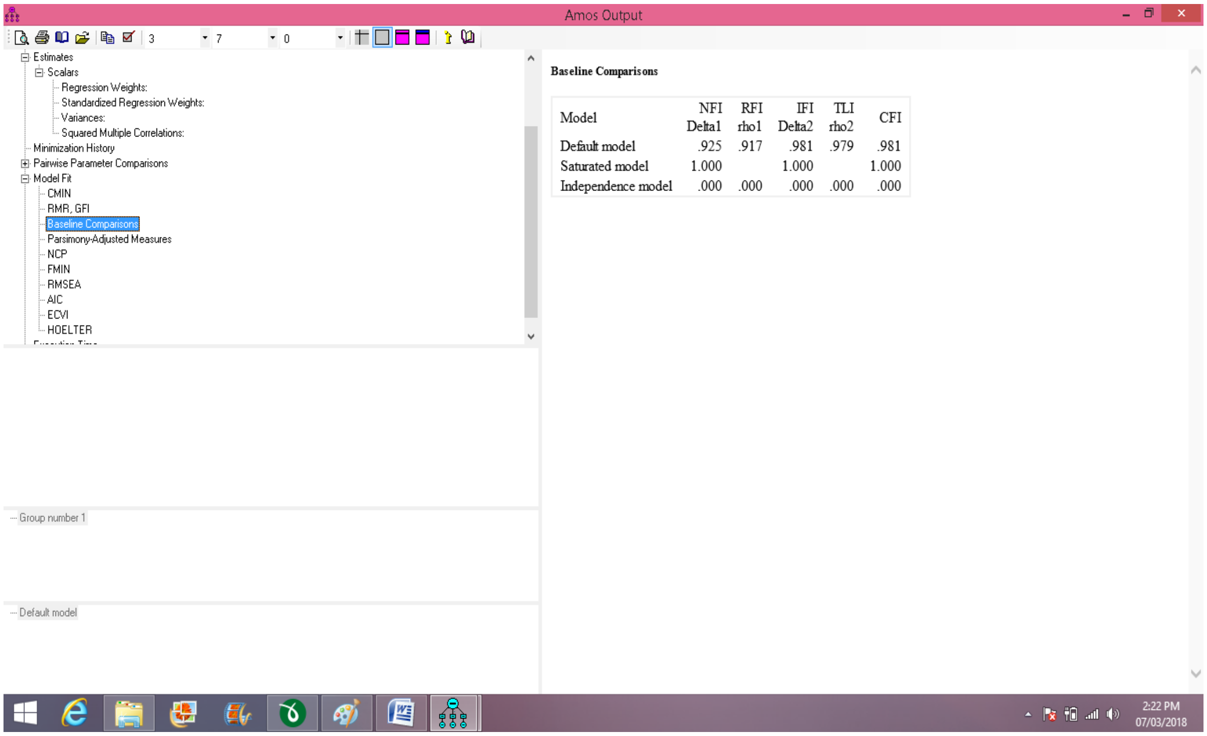


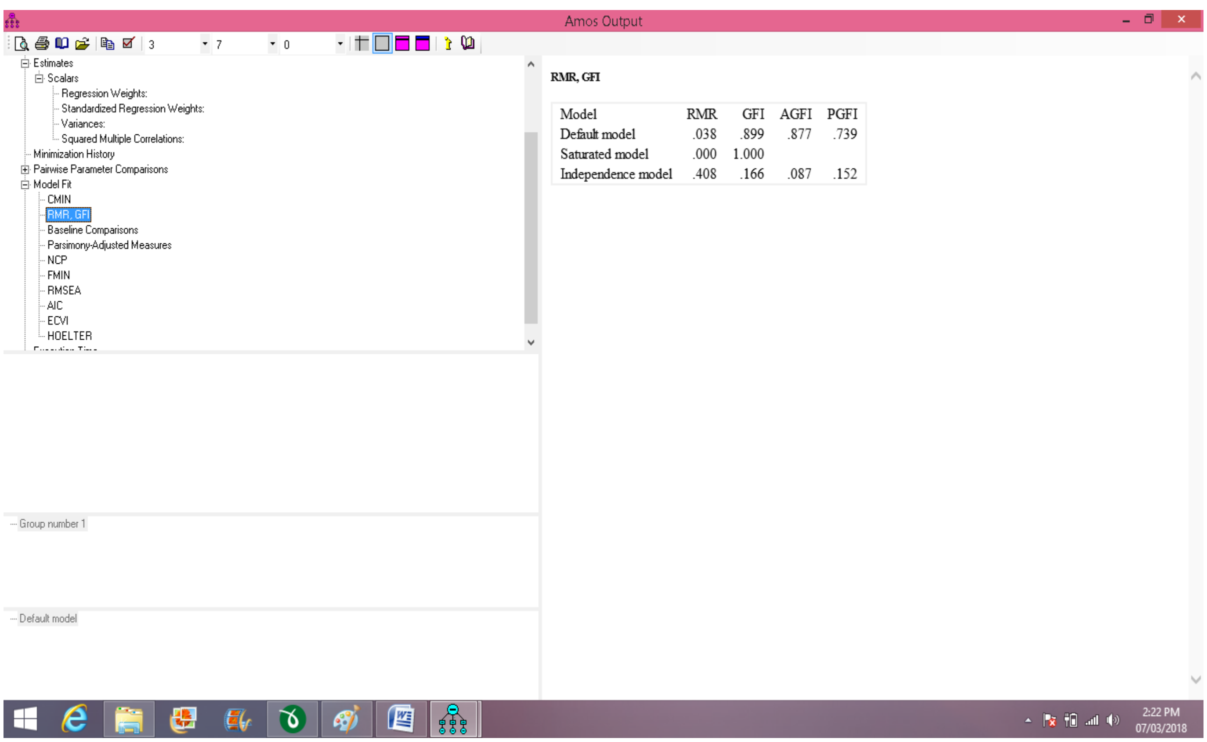
Figure 4.42: Model fitness Indices CMIN for construct Lean manufacturing impacts on construct Performance



Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.925	.917	.981	.979	.981
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Figure 4.43: Model fitness Indices CFI for construct Lean manufacturing impacts on construct Performance



RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.038	.899	.877	.739
Saturated model	.000	1.000		
Independence model	.408	.166	.087	.152

Figure 4.44: Model fitness Indices GFI and AGFI for construct Lean manufacturing impacts on construct Performance

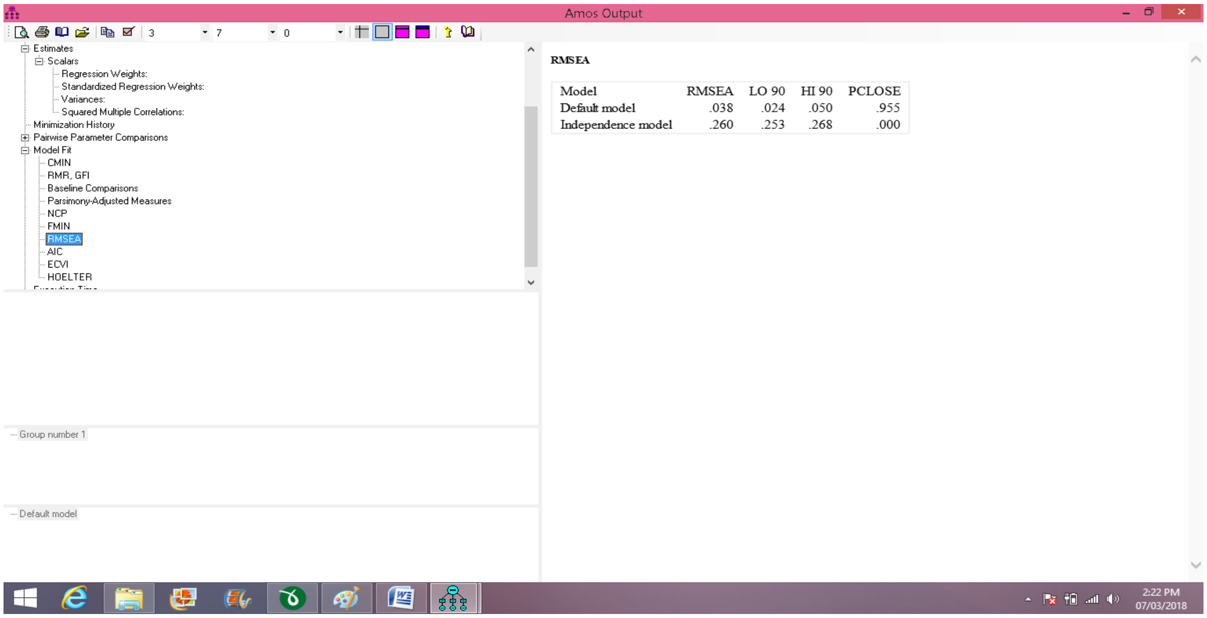


Figure 4.45: Model fitness Indices RMSEA for construct Lean manufacturing impacts on construct Performance

Table 4.22: Statistical fitness analysis for Lean manufacturing impact on performance

CMIN/df	CFI	GFI	AGFI	RMSEA	Lo90	Hi90
1.314	0.981	0.899	0.877	0.038	0.024	0.050

4.7 SUPPLY CHAIN MANAGEMENT IMPACTS ON THE ORGANIZATION PERFORMANCE

Supply Chain Management approach has its growing acceptance in the manufacturing sector and led to significant changes in the way business is done. [Stevens, 1989] With the scarce resources in a highly competitive environment, the first priority of any manufacturing industry is to improve supply chain performance. It is also important to know about the supply chain characteristics and their impact on performance. [Chareonsuk et al., 2010]

As far as the performance attributes concern, the trust among the supply chain partners plays an important role in building the inter-organization relationships through coordination and cooperation. The scope of integration SCM with the performance of an organization change the mindset of the entrepreneur's and forced them to go beyond the organizational boundaries (to include suppliers and customers) to create long-lasting partnerships. This will further lead to a reduction in lead times and costs; alignment of interdependent decision-making processes; and the improvement in the overall performance of each member through the supply chain. [Pochampally et.al., 2009; Jones et al., 2010]

In the present study, the impact of supply chain management on the business performance of the organization is studied with the help of SEM approach. In the structural model, business performance is considered as endogenous construct and supply chain characteristics are considered as an exogenous construct. The SEM approach used to study the cause and effect relationship among the constructs. Since, supply chain and performance of the organization are considered as the latent construct and measured with the help of different statements, their cause and effect relationship can be analyzed by using SEM. The SEM diagram and its results are shown in figure 4.46 and the outputs of the software in figure 4.47, 4.48, 4.49. The summarized results are given in table 4.23 below.

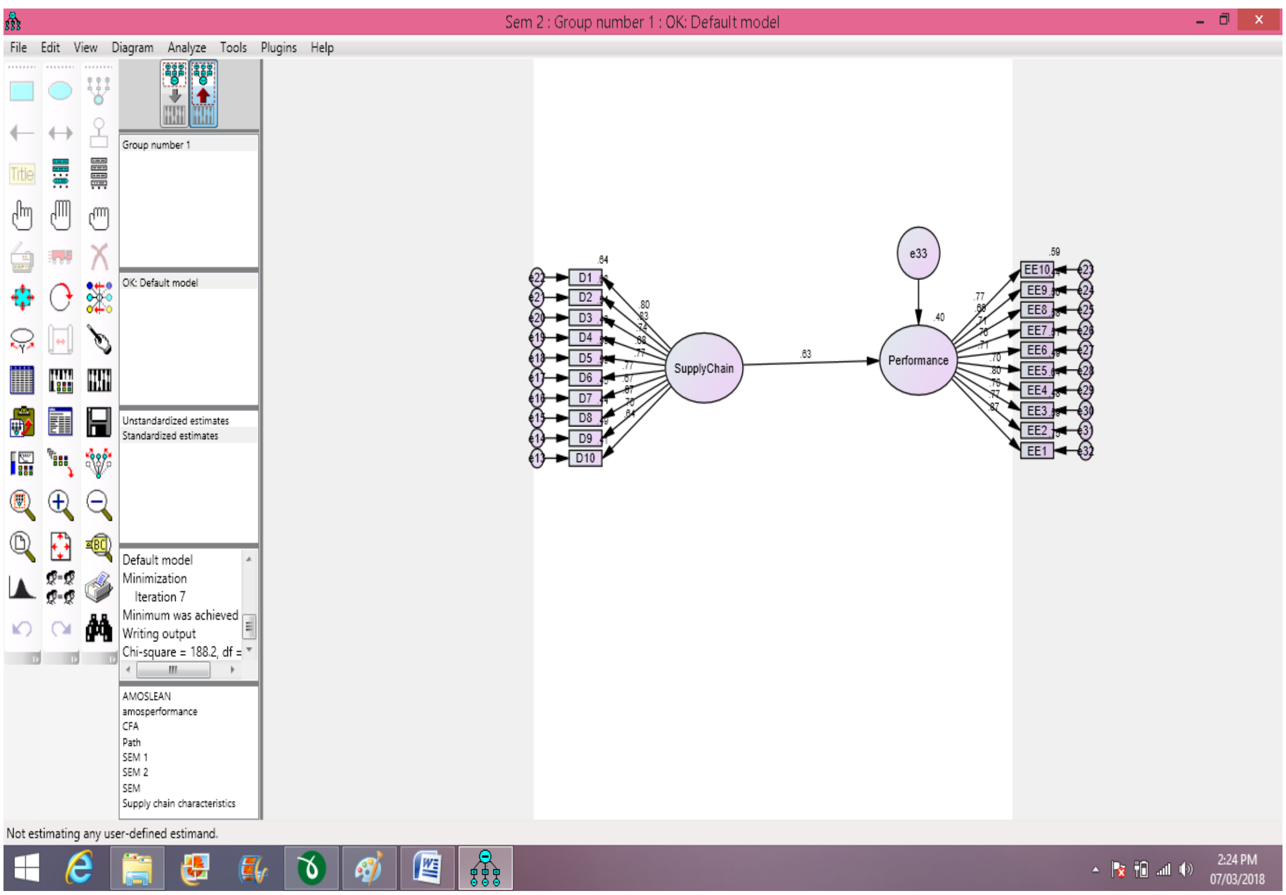
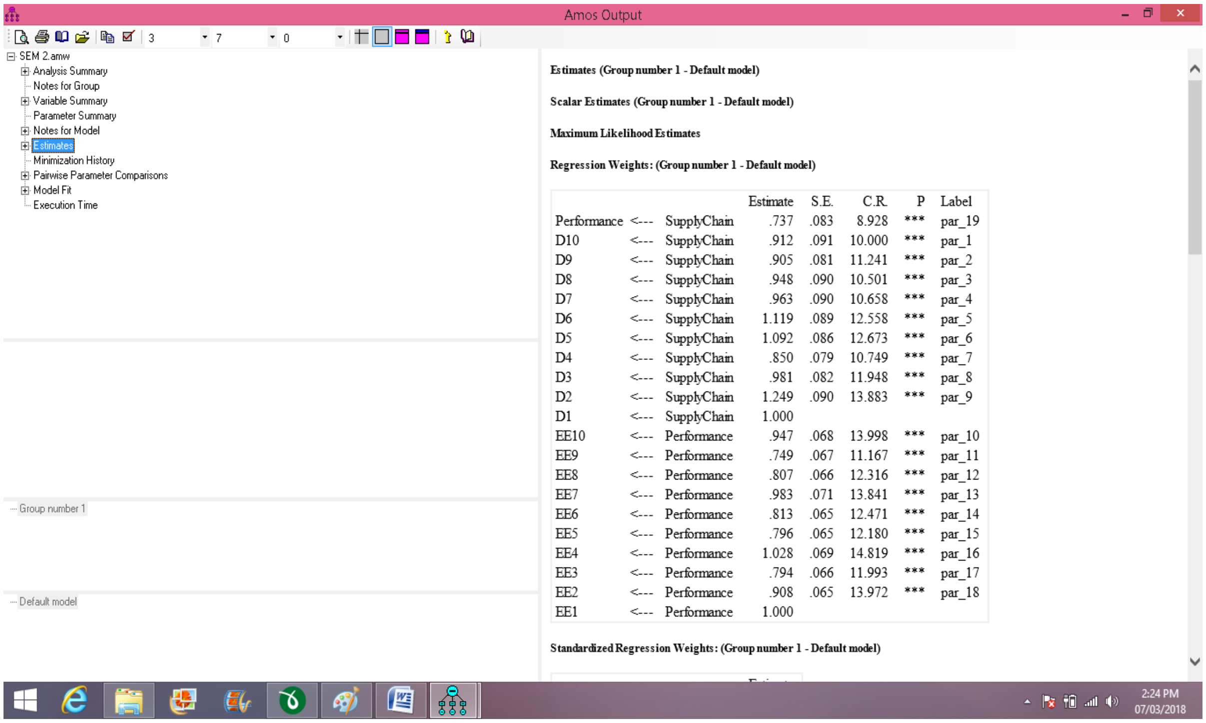


Figure 4.46: Structural model for construct Supply chain impacts on construct Performance



Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

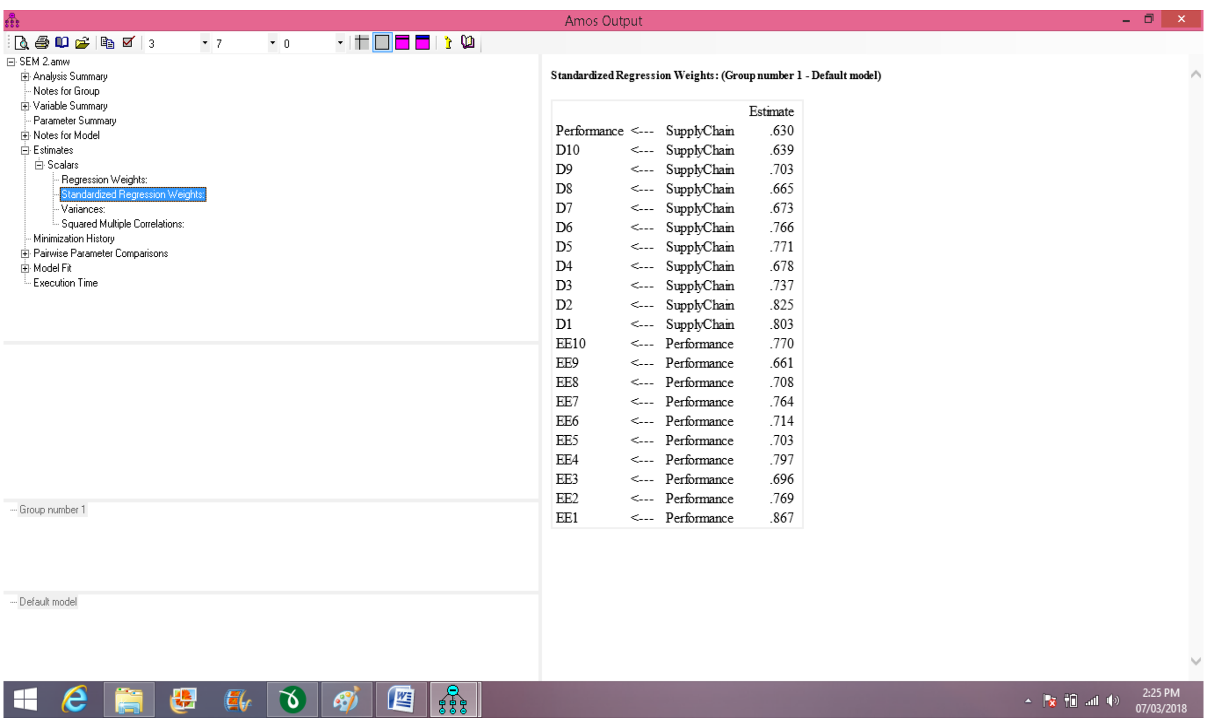
Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Performance	<---	SupplyChain	.737	.083	8.928	***	par_19
D10	<---	SupplyChain	.912	.091	10.000	***	par_1
D9	<---	SupplyChain	.905	.081	11.241	***	par_2
D8	<---	SupplyChain	.948	.090	10.501	***	par_3
D7	<---	SupplyChain	.963	.090	10.658	***	par_4
D6	<---	SupplyChain	1.119	.089	12.558	***	par_5
D5	<---	SupplyChain	1.092	.086	12.673	***	par_6
D4	<---	SupplyChain	.850	.079	10.749	***	par_7
D3	<---	SupplyChain	.981	.082	11.948	***	par_8
D2	<---	SupplyChain	1.249	.090	13.883	***	par_9
D1	<---	SupplyChain	1.000				
EE10	<---	Performance	.947	.068	13.998	***	par_10
EE9	<---	Performance	.749	.067	11.167	***	par_11
EE8	<---	Performance	.807	.066	12.316	***	par_12
EE7	<---	Performance	.983	.071	13.841	***	par_13
EE6	<---	Performance	.813	.065	12.471	***	par_14
EE5	<---	Performance	.796	.065	12.180	***	par_15
EE4	<---	Performance	1.028	.069	14.819	***	par_16
EE3	<---	Performance	.794	.066	11.993	***	par_17
EE2	<---	Performance	.908	.065	13.972	***	par_18
EE1	<---	Performance	1.000				

Standardized Regression Weights: (Group number 1 - Default model)

Figure 4.47: Regression Weights output for SEM of construct Supply Chain impacts on construct Performance



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Performance	<---	SupplyChain	.630
D10	<---	SupplyChain	.639
D9	<---	SupplyChain	.703
D8	<---	SupplyChain	.665
D7	<---	SupplyChain	.673
D6	<---	SupplyChain	.766
D5	<---	SupplyChain	.771
D4	<---	SupplyChain	.678
D3	<---	SupplyChain	.737
D2	<---	SupplyChain	.825
D1	<---	SupplyChain	.803
EE10	<---	Performance	.770
EE9	<---	Performance	.661
EE8	<---	Performance	.708
EE7	<---	Performance	.764
EE6	<---	Performance	.714
EE5	<---	Performance	.703
EE4	<---	Performance	.797
EE3	<---	Performance	.696
EE2	<---	Performance	.769
EE1	<---	Performance	.867

Figure 4.48: Standardized Regression Weights output for SEM of construct Supply Chain impacts on construct Performance

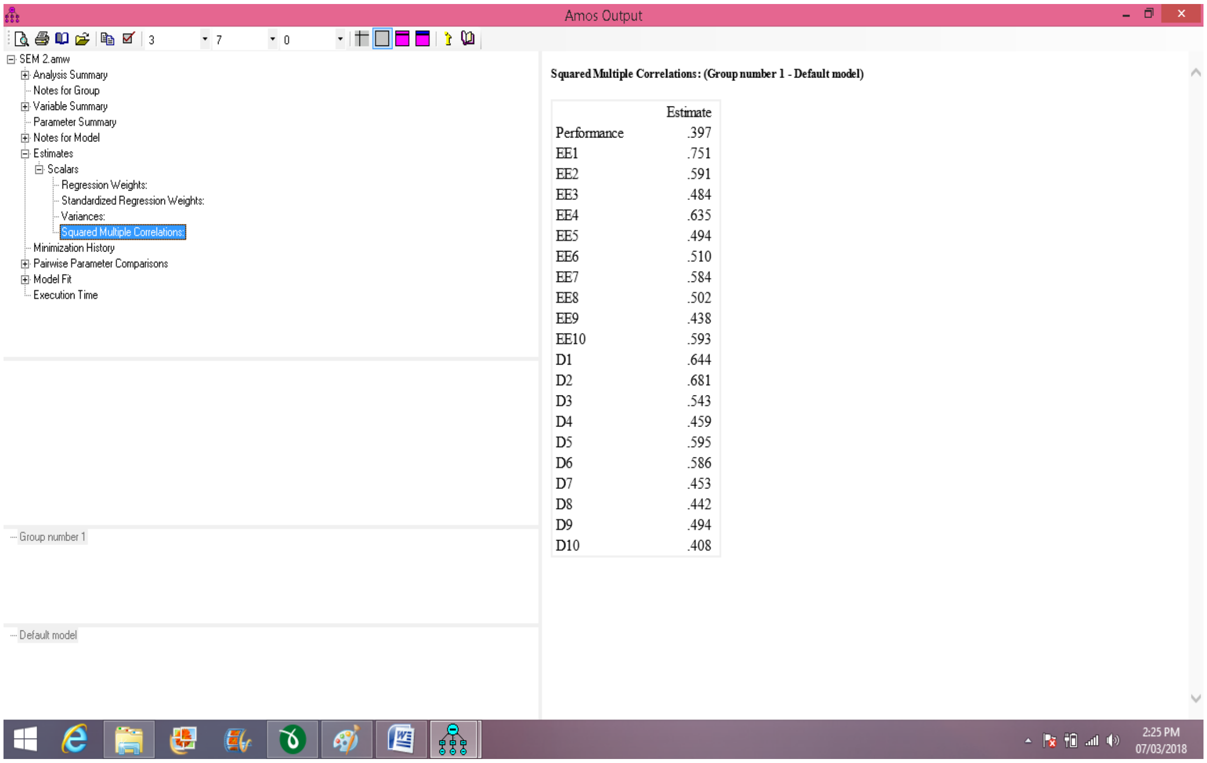


Figure 4.49: Squared Multiple Correlations output for SEM of construct Supply Chain impacts on construct Performance

Table 4.23: Regression results of SEM for supply chain impact on performance

Endogenous Construct	**Exogenous Construct**	**Standardized Beta**	**Critical Ratio**	**P-Value**	**R^2**
Performance	Supply Chain Characteristics	0.630	8.928	0.000	39.7%

The results indicate that the probability value of the critical ratio is found to be less than 5 percent level of significance. Hence, with 95 percent confidence level, the null hypothesis of no impact of Supply Chain Management on Performance cannot be accepted. Hence, it can be concluded from the study that SCM in manufacturing setup has the significant impact on their business performance. The R^2 value of 0.397 indicates that 39.7 percent of the variance of the business performance can be explained with the help of variations in SCM variances. The statistical fitness of the SEM Model is shown in figure 4.50, 4.51, 4.52, 4.53 and summarized in table 4.24.

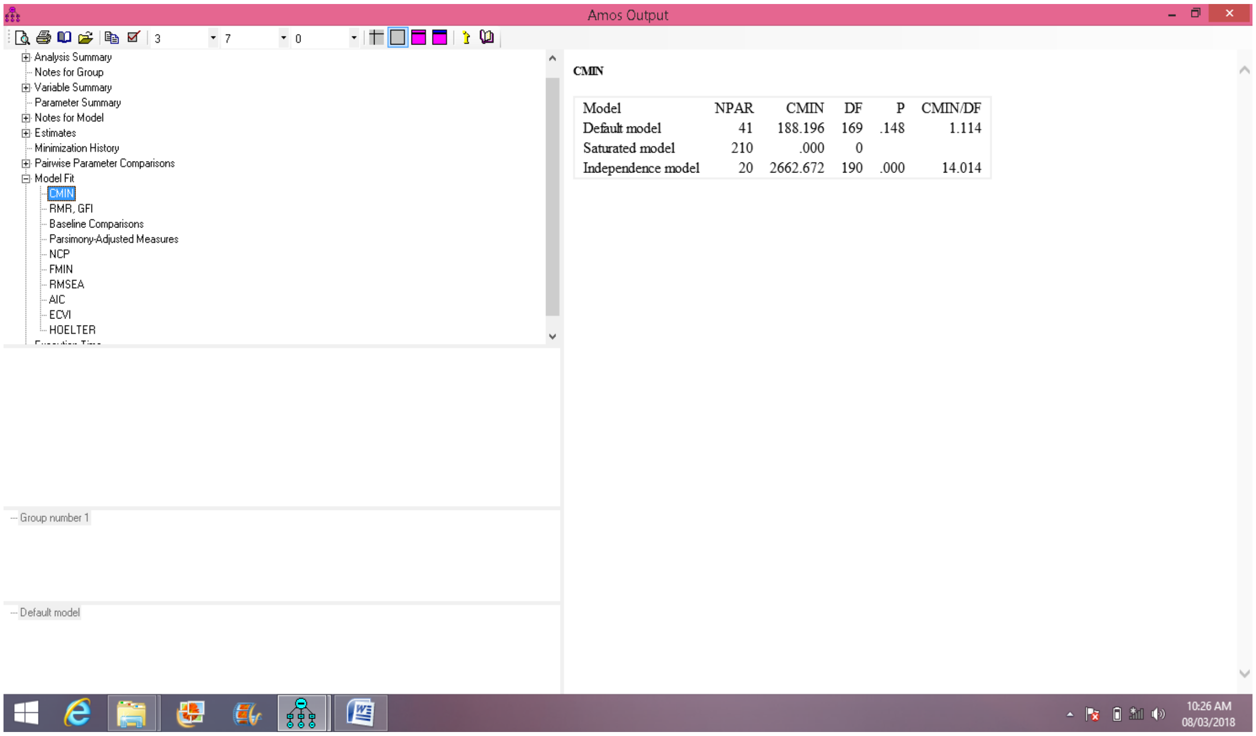


Figure 4.50: Model Fitness Indices CMIN for construct Supply Chain impacts on construct Performance

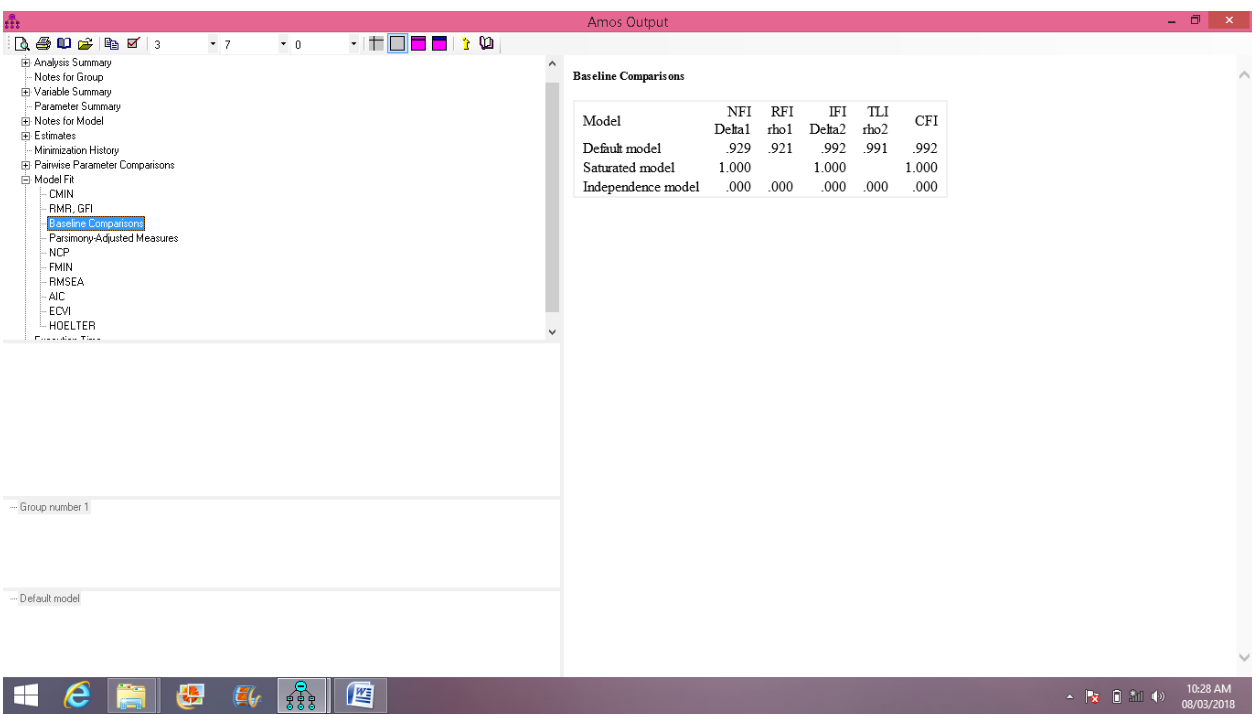
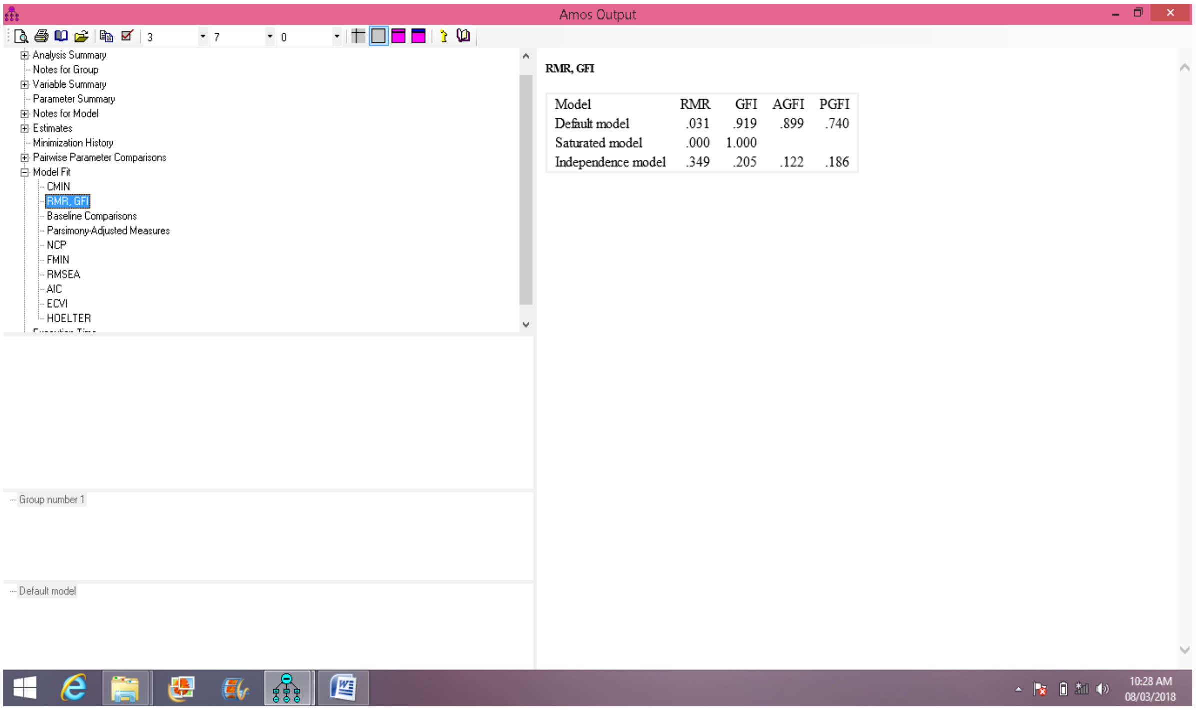
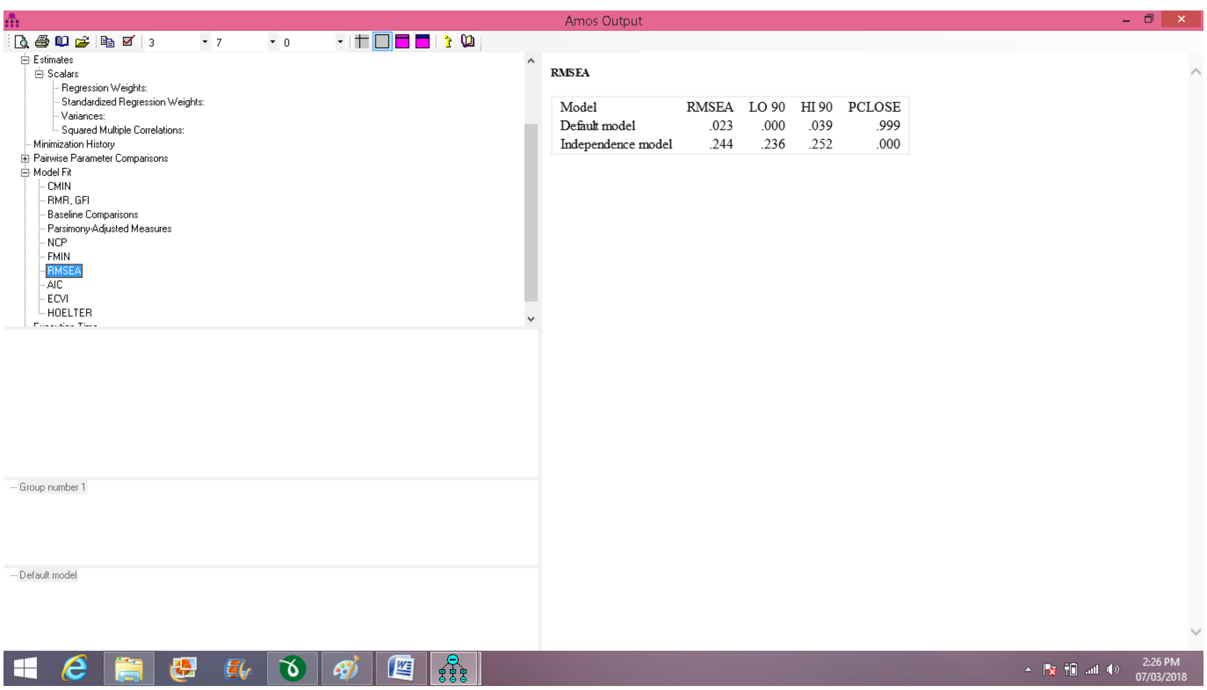


Figure 4.51: Model Fitness Indices CFI for construct Supply Chain impact on constructs Performance



Model	RMR	GFI	AGFI	PGFI
Default model	.031	.919	.899	.740
Saturated model	.000	1.000		
Independence model	.349	.205	.122	.186

Figure 4.52: Model Fitness Indices GFI and AGFI for construct Supply Chain impacts on construct Performance



Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.023	.000	.039	.999
Independence model	.244	.236	.252	.000

Figure 4.53: Model Fitness Indices RMSEA for construct Supply Chain impacts on construct Performance

Table 4.24: Statistical fitness analysis for Supply Chain impact on performance

CMIN/df	CFI	GFI	AGFI	RMSEA	Lo90	Hi90
1.114	0.992	0.919	0.899	0.23	0.000	0.039

The results indicate that SEM model is a statistical fit model. The present study reveals the revolution in the manufacturing sector and the role/importance of SCM in that revolution. During the past three decades, supply chain management is one of the prominent approaches to improvements in the manufacturing sector. As the fundamental background, SCM philosophy is used to synchronize the decisions regarding the flow of resources like material, money, and importantly the information among multiple autonomous business entities (various supply-chain members). The same has been dictated in the present study.

4.8 STRUCTURE EQUATION MODEL AND RESULT VALIDATION FOR THE PRESENT STUDY

Structure equation modeling as the name suggests it is the modeling of any problem in a structured manner so that the cause and effect analysis is done in an easier manner. SEM is also the advanced version of Regression Analysis. The regression analysis is done to find the priority of most affecting parameter (variable) through the set formula's and decisions can be made only after the mathematical calculations. Whereas in SEM the correction factor analysis and path analysis is done. Generally, ***Structural Equation Modeling*** (SEM) approach is used to establish and test the complex relationships among the observed variables (measured through an analytical survey) and unobserved variables (the latent constructs). This is the advancement of flow process charts or hierarchy design used in any organization. In an organization, several departments are connected with each other in such a manner that the work of each department never gets uninterrupted through this network connection. This is possible in that case only where the network analysis is done before the execution of hierarchy design in an organization.

The use of SEM approach is done mainly for multivariate statistical analysis. SEM has the strengths to use latent variables (constructs) in the dependent modules. SEM is a very general approach for solving the problems through chiefly linear, chiefly cross-sectional statistical modeling technique, confirmatory factor analysis, path analysis, and regression technique. This is a mainly the confirmatory method of modeling and solving the problems, rather than exploratory technique. The assumptions in SEM are multivariate normality, independent observation from the respondents, sufficient sample size for the study, correctly specified structured models etc.

In the present study, the constructs lean manufacturing principles and supply chain characteristics are studied with the help of 12 and 10 distinct statements respectively. Both the constructs have an impact on the performance of the manufacturing organization as dictated earlier in sections 4.5 and 4.6. The construct lean manufacturing, in an organization, improves the efficiency and effectiveness of manufacturing system by eliminating the wastages associated with the manufacturing process.

On the other hand, healthy relations of the supplier, customer, and manufacturer of the supply chain help in balancing the supply and demand issues of any product/services. The analysis of data in earlier section 4.1, 4.2, 4.4 and 4.5 reveals that both constructs (lean manufacturing principles and supply chain characteristics) have the inter-relationship with the common objective is to improve the performance of an organization through the optimized arrangement of all the resources. The SEM and path analysis of the data collected earlier is estimated to test the following hypothesis:

H1: Lean principles have the significant impact on the performance of an organization.

H2: Supply Chain has the significant effect on the performance of an organization.

H3: Both the lean manufacturing and supply chain management have the significant relationship with each other

The SEM analysis of the data is shown in figure 4.54 which shows that the construct lean manufacturing has an impact on both Supply chain and the performance constructs. Similarly, the supply chain characteristics construct has an impact on lean manufacturing and performance.

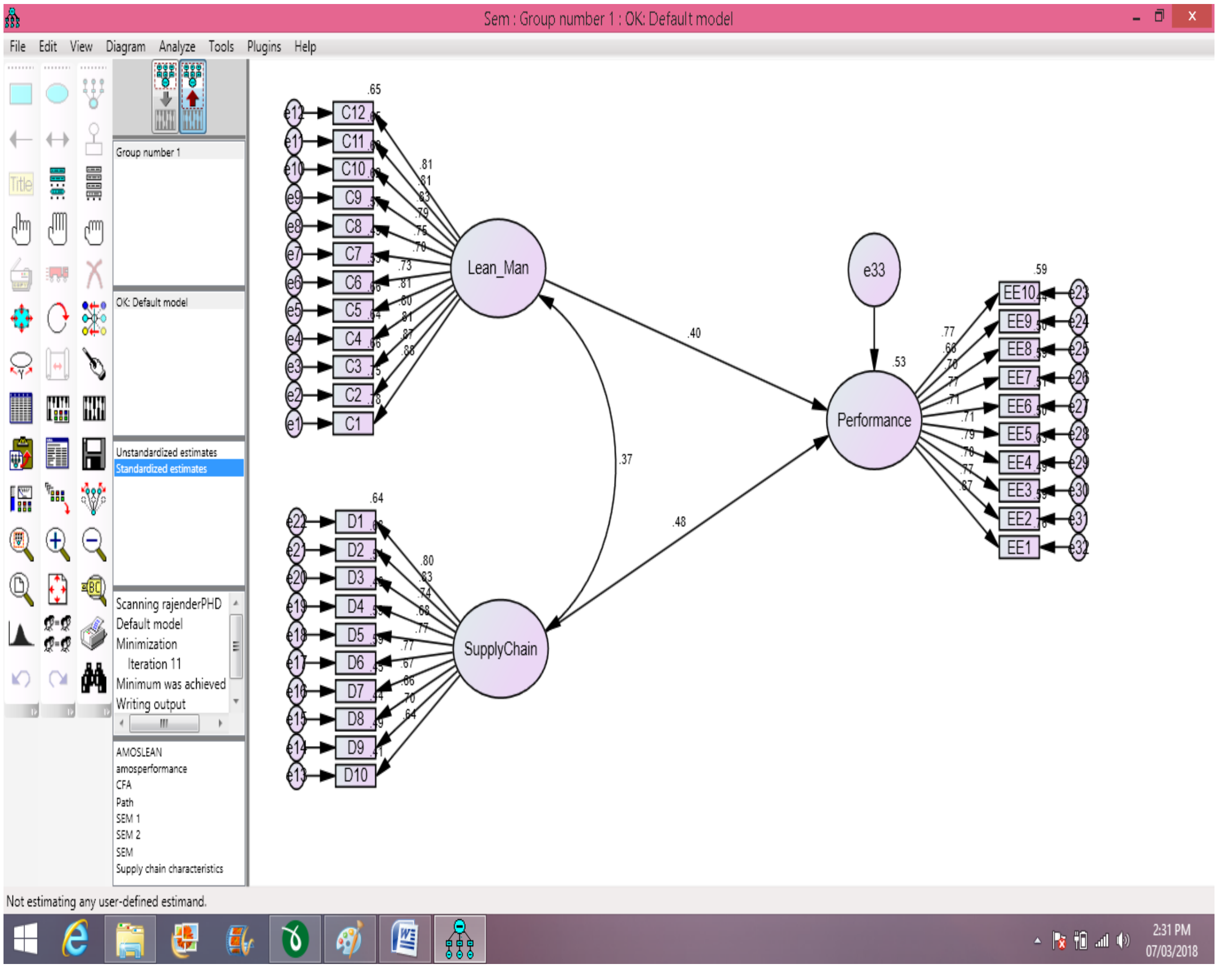
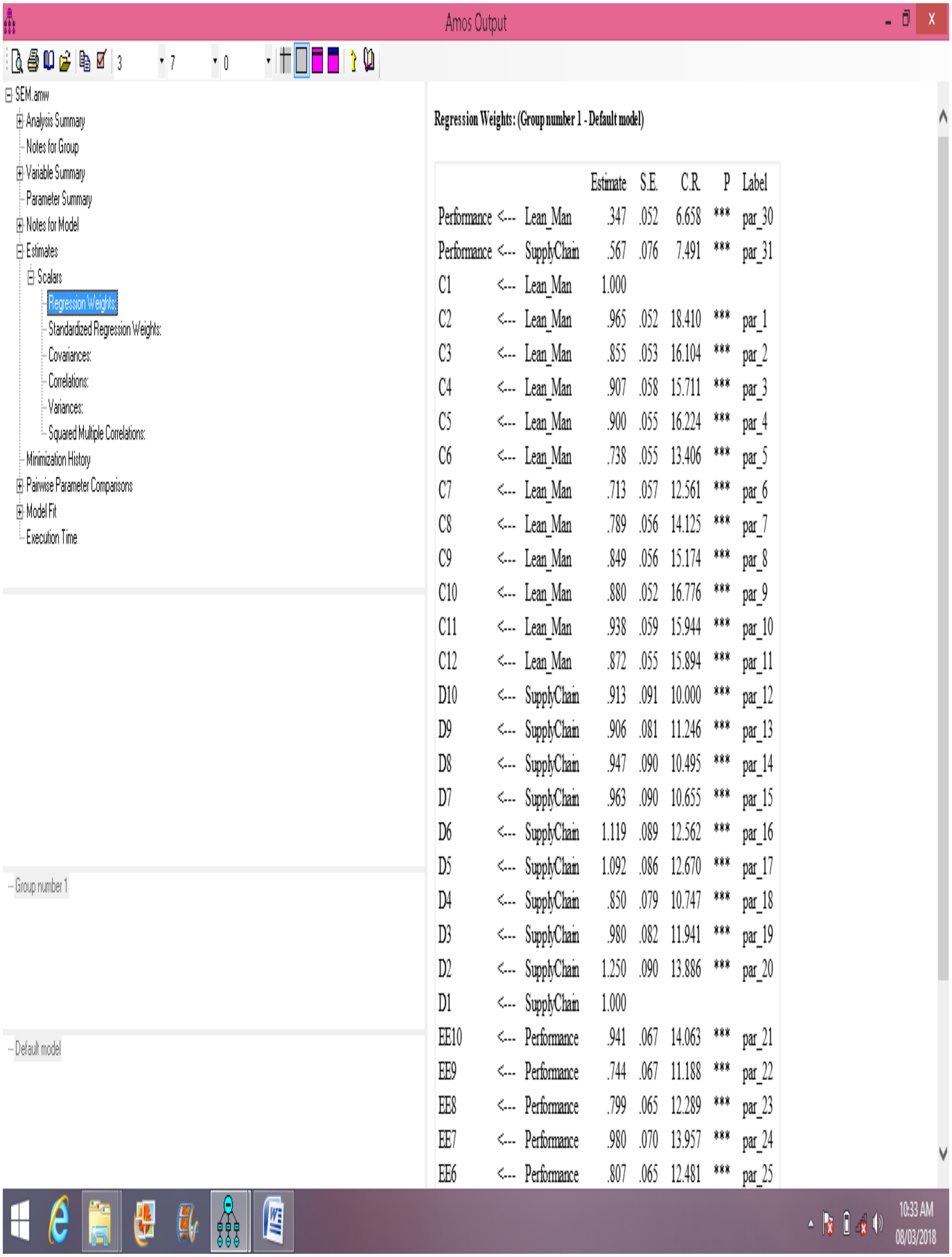


Figure 4.54: SEM Analysis for the present study

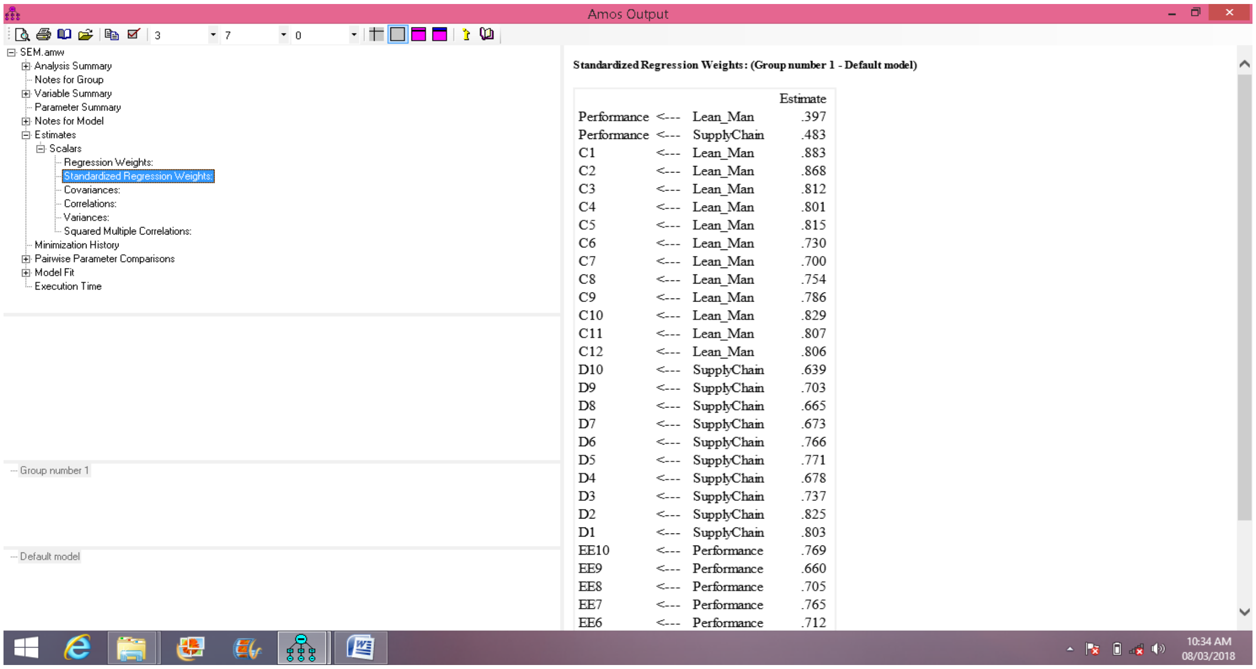
As shown in the figure, the performance of an organization is considered as the endogenous variable whereas the lean manufacturing and supply chain as the exogenous constructs. In addition, it is assumed that both constructs are managed and maintained by the organization for improving the effectiveness and efficiency i.e. performance of the organization. The result of the SEM is shown in figure 4.55, 4.56, 4.57, 4.58 and summarized in table 4.25.



Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Performance	<---	Lean_Man	.347	.052	6.658	***	par_30
Performance	<---	SupplyChain	.567	.076	7.491	***	par_31
C1	<---	Lean_Man	1.000				
C2	<---	Lean_Man	.965	.052	18.410	***	par_1
C3	<---	Lean_Man	.855	.053	16.104	***	par_2
C4	<---	Lean_Man	.907	.058	15.711	***	par_3
C5	<---	Lean_Man	.900	.055	16.224	***	par_4
C6	<---	Lean_Man	.738	.055	13.406	***	par_5
C7	<---	Lean_Man	.713	.057	12.561	***	par_6
C8	<---	Lean_Man	.789	.056	14.125	***	par_7
C9	<---	Lean_Man	.849	.056	15.174	***	par_8
C10	<---	Lean_Man	.880	.052	16.776	***	par_9
C11	<---	Lean_Man	.938	.059	15.944	***	par_10
C12	<---	Lean_Man	.872	.055	15.894	***	par_11
D10	<---	SupplyChain	.913	.091	10.000	***	par_12
D9	<---	SupplyChain	.906	.081	11.246	***	par_13
D8	<---	SupplyChain	.947	.090	10.495	***	par_14
D7	<---	SupplyChain	.963	.090	10.655	***	par_15
D6	<---	SupplyChain	1.119	.089	12.562	***	par_16
D5	<---	SupplyChain	1.092	.086	12.670	***	par_17
D4	<---	SupplyChain	.850	.079	10.747	***	par_18
D3	<---	SupplyChain	.980	.082	11.941	***	par_19
D2	<---	SupplyChain	1.250	.090	13.886	***	par_20
D1	<---	SupplyChain	1.000				
EE10	<---	Performance	.941	.067	14.063	***	par_21
EE9	<---	Performance	.744	.067	11.188	***	par_22
EE8	<---	Performance	.799	.065	12.289	***	par_23
EE7	<---	Performance	.980	.070	13.957	***	par_24
EE6	<---	Performance	.807	.065	12.481	***	par_25

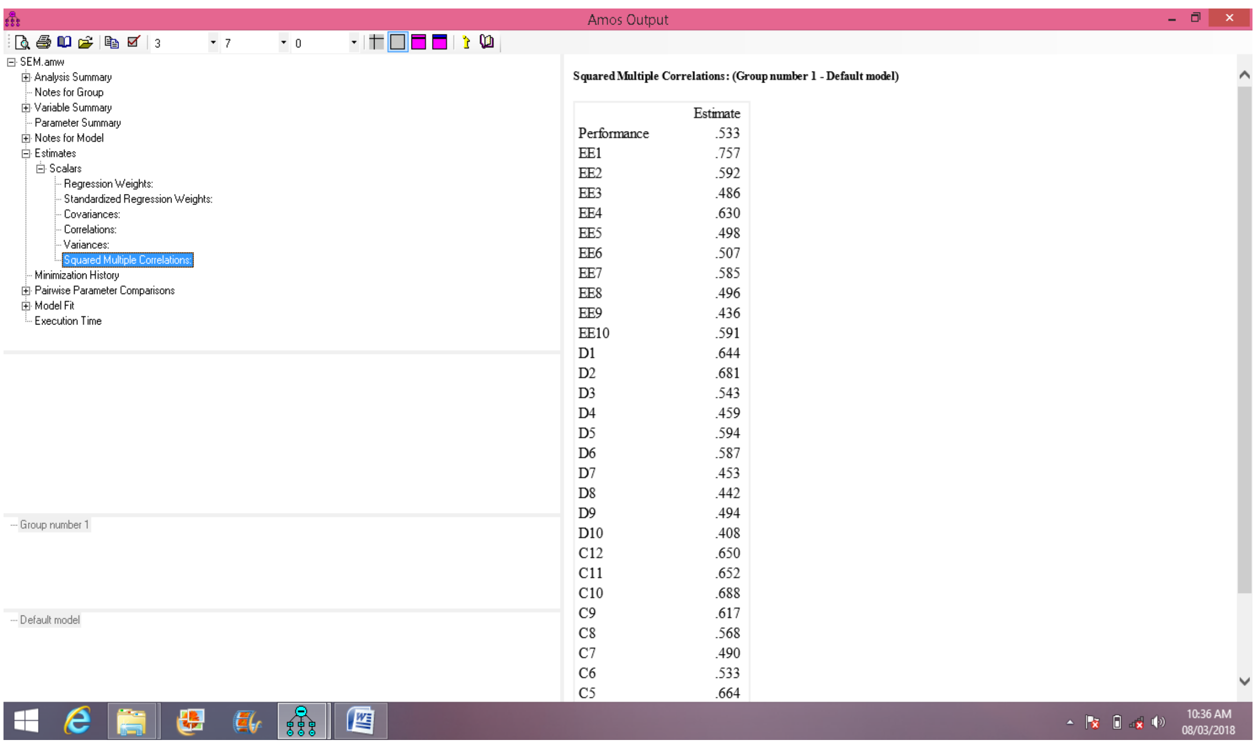
Figure 4.55: Regression Weights output for SEM for the present study



Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Performance	<---	Lean_Man	.397
Performance	<---	SupplyChain	.483
C1	<---	Lean_Man	.883
C2	<---	Lean_Man	.868
C3	<---	Lean_Man	.812
C4	<---	Lean_Man	.801
C5	<---	Lean_Man	.815
C6	<---	Lean_Man	.730
C7	<---	Lean_Man	.700
C8	<---	Lean_Man	.754
C9	<---	Lean_Man	.786
C10	<---	Lean_Man	.829
C11	<---	Lean_Man	.807
C12	<---	Lean_Man	.806
D10	<---	SupplyChain	.639
D9	<---	SupplyChain	.703
D8	<---	SupplyChain	.665
D7	<---	SupplyChain	.673
D6	<---	SupplyChain	.766
D5	<---	SupplyChain	.771
D4	<---	SupplyChain	.678
D3	<---	SupplyChain	.737
D2	<---	SupplyChain	.825
D1	<---	SupplyChain	.803
EE10	<---	Performance	.769
EE9	<---	Performance	.660
EE8	<---	Performance	.705
EE7	<---	Performance	.765
EE6	<---	Performance	.712

Figure 4.56: Standardized Regression Weights output for SEM for the present study



Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Performance	.533
EE1	.757
EE2	.592
EE3	.486
EE4	.630
EE5	.498
EE6	.507
EE7	.585
EE8	.496
EE9	.436
EE10	.591
D1	.644
D2	.681
D3	.543
D4	.459
D5	.594
D6	.587
D7	.453
D8	.442
D9	.494
D10	.408
C12	.650
C11	.652
C10	.688
C9	.617
C8	.568
C7	.490
C6	.533
C5	.664

Figure 4.57: Squared Multiple Correlations output for SEM for the present study

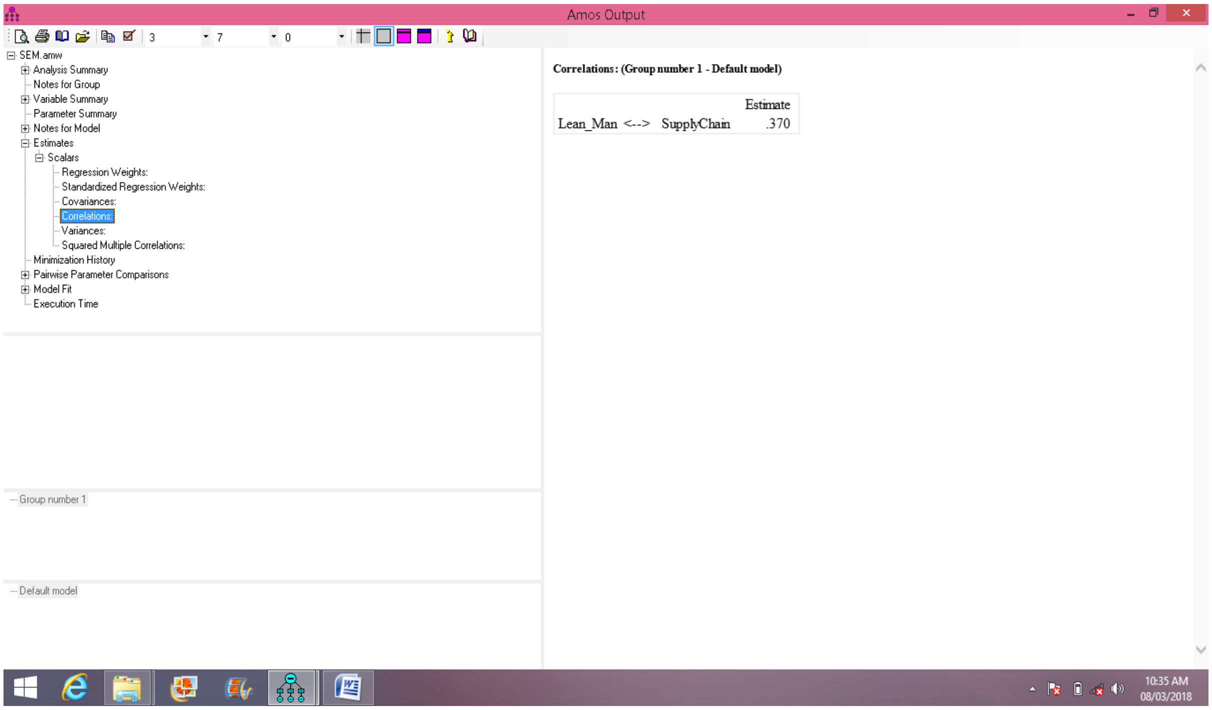


Figure 4.58: Correlation output for SEM for the present study

Table 4.25: SEM results for the present study

Endogenous Construct	Exogenous Construct	Standardized Beta	Critical Ratio	P-Value	R^2
Performance	Lean Principles	0.397	6.658	.000	53.3%
	Supply Chain Characteristics	0.483	7.491	.000	

The goodness of the present model is now analyzed and shown in figures 4.59, 4.60 and 4.61. The results are summarized in table 4.26 which represents the present model for the study is statistically fit model.

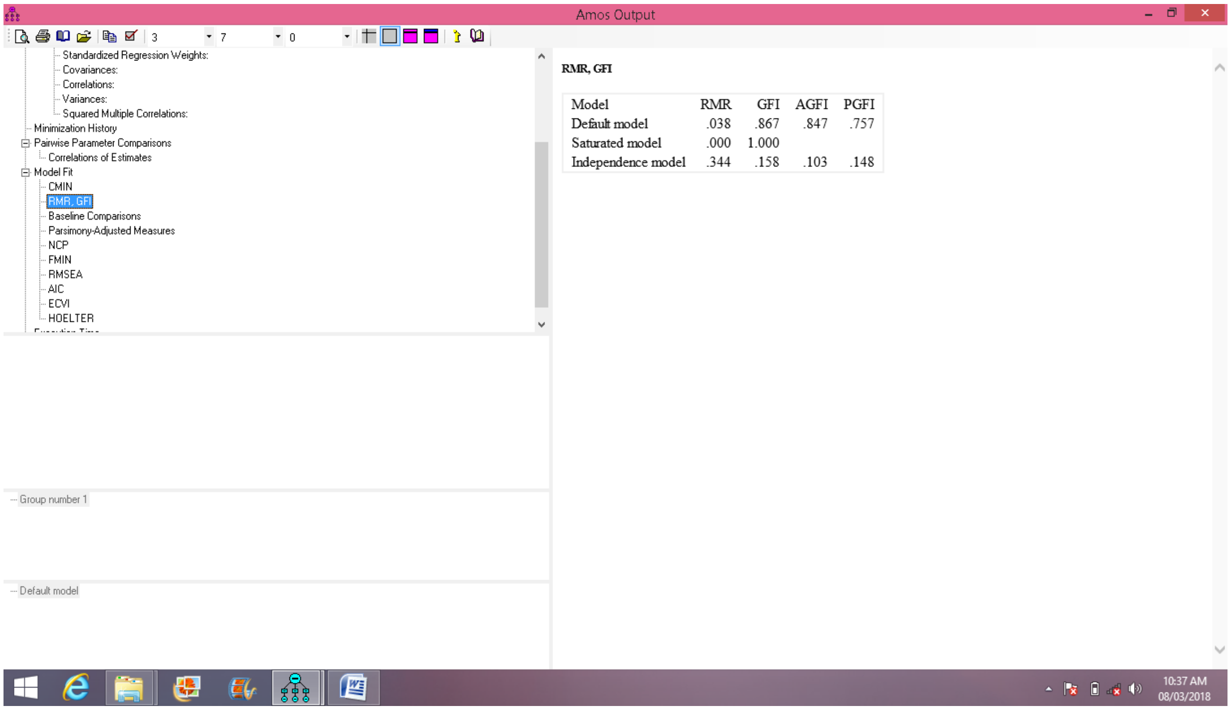


Figure 4.59: Model Fitness Indices GFI and AGFI for SEM for the present study

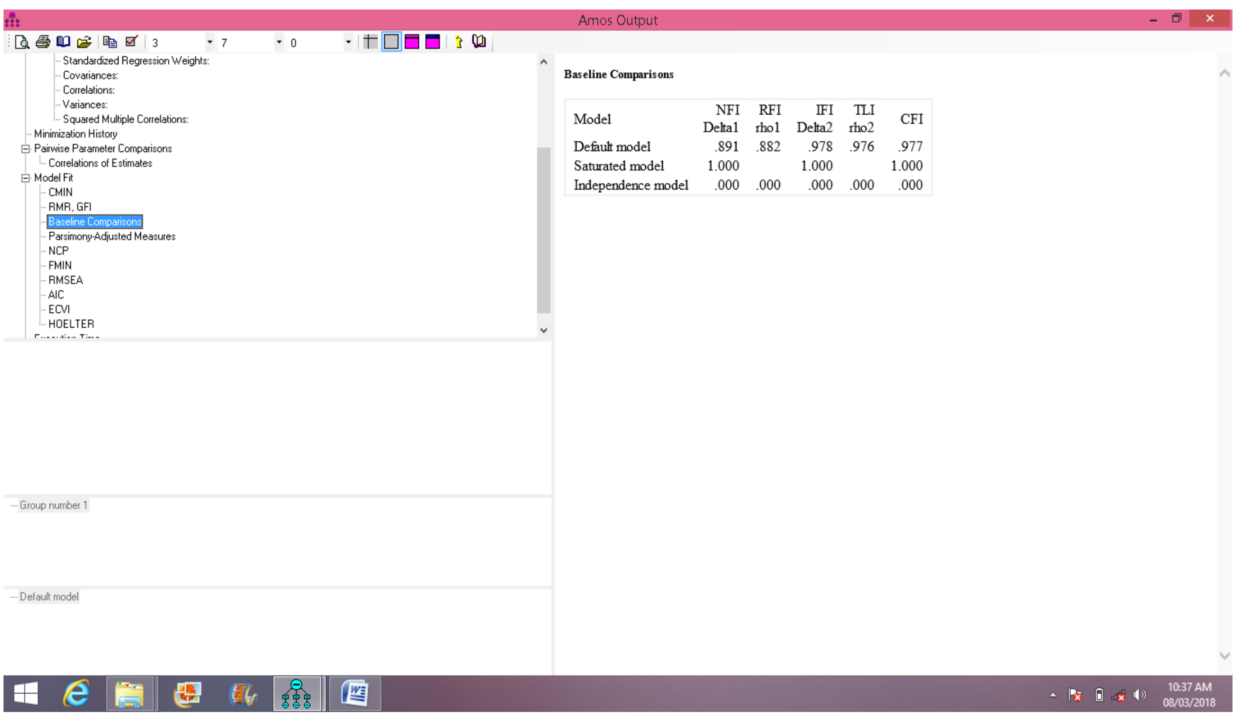


Figure 4.60: Model Fitness Indices CFI for SEM for the present study

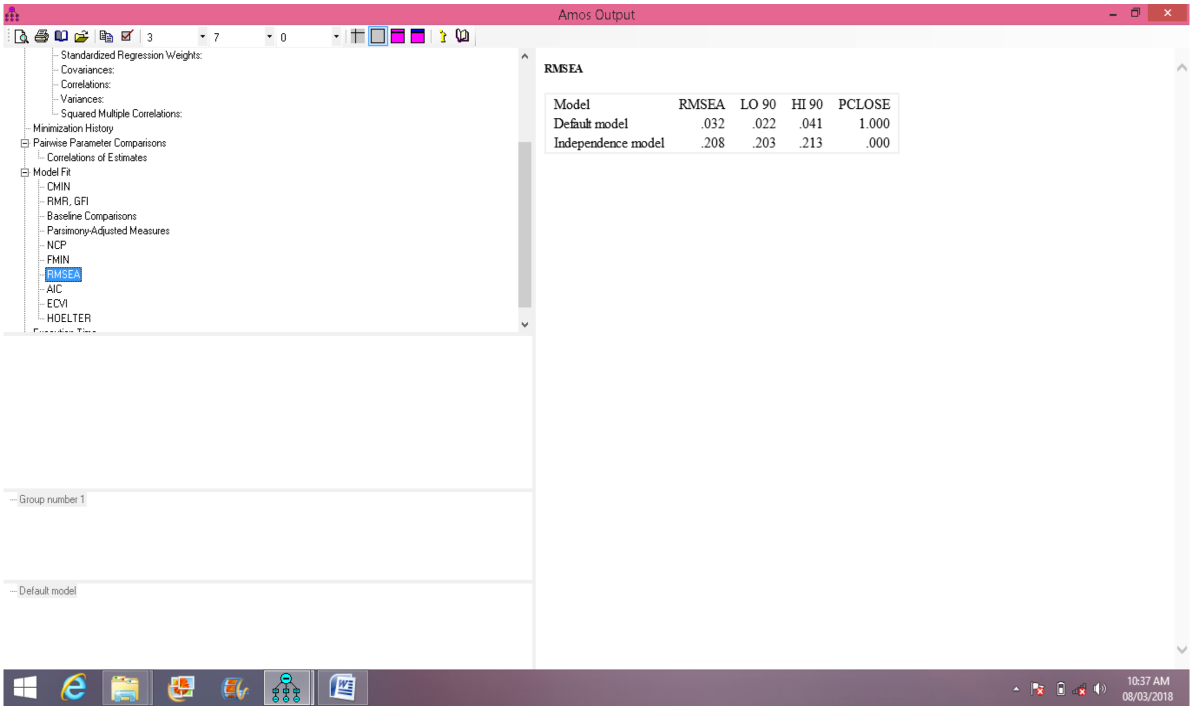


Figure 4.61: Model Fitness Indices RMSEA for SEM for the present study

Table 4.26: SEM goodness fit indices for the present study

Model	**AGFI**	**CFI**	**GFI**	**RMSEA**	**Lo90**	**Hi90**
SEM	0.847	0.977	0.867	0.32	0.22	0.41

4.9 PATH ANALYSIS AND RESULT VALIDATION FOR THE PRESENT STUDY

It is the special case structural model in SEM in which the constructs consider in the study is used as the variable to study the interrelationship among the constructs. In this, the constructs score are imputing using the confirmatory factor analysis. Figure 4.62 represents the path analysis for the present study. Also, the figures 4.63, 4.64, 4.65 and 4.66 represent the outcomes of the path analysis and the results summarized in table 4.27.

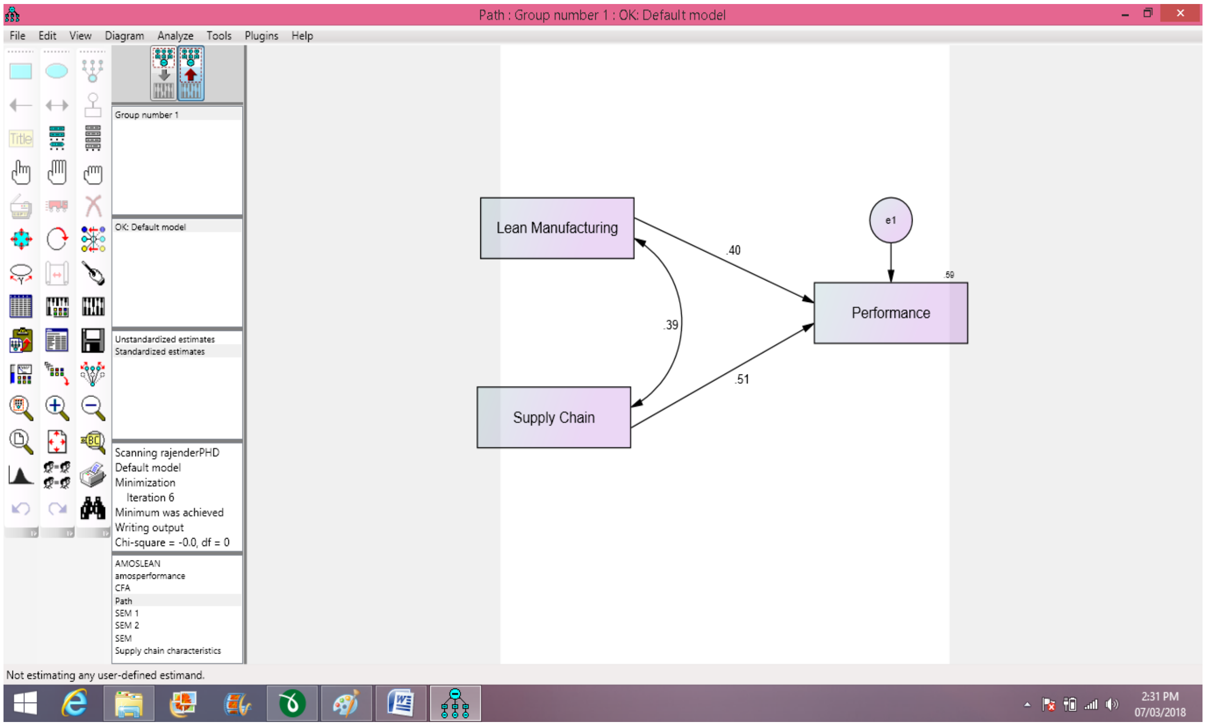


Figure 4.62: Path Analysis for the present study

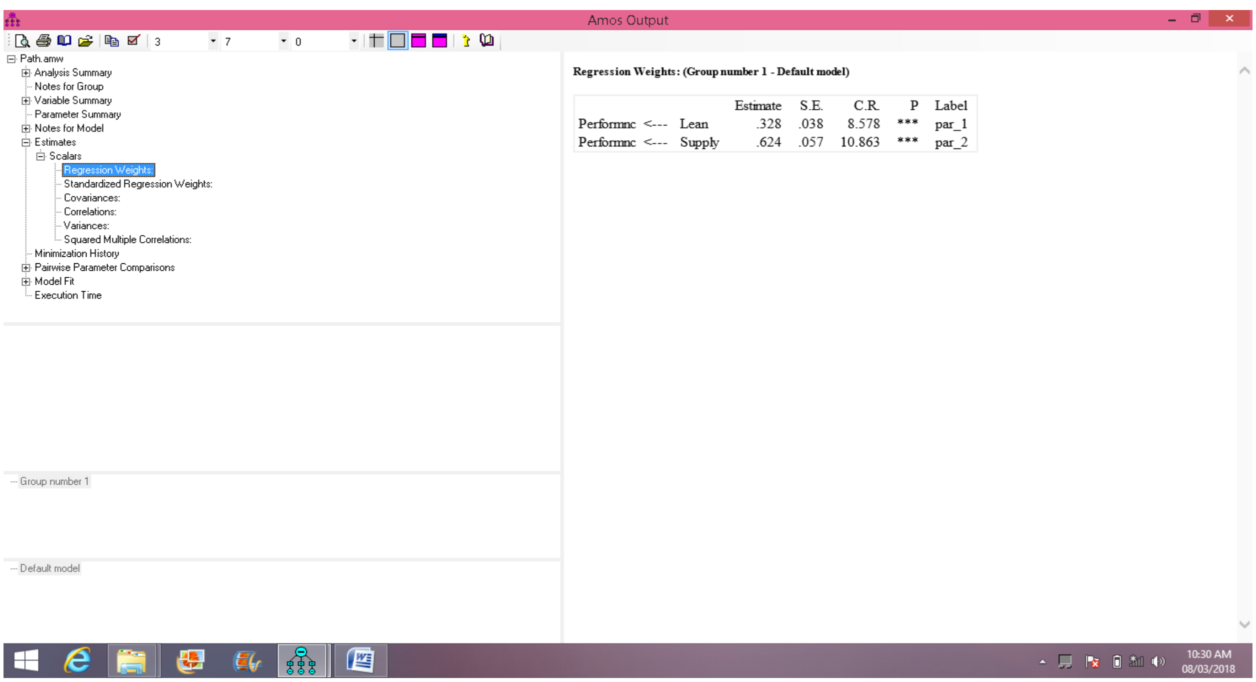


Figure 4.63: Regression Weights output for Path Analysis for the present study

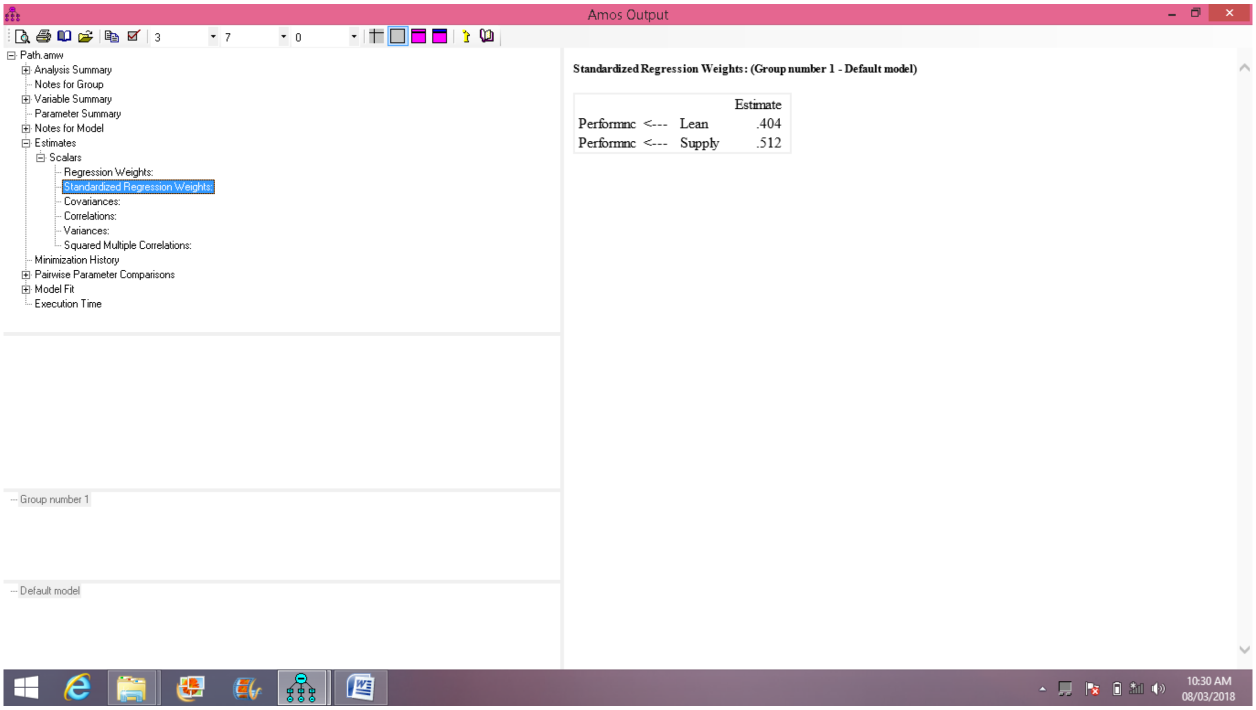


Figure 4.64: Standardized Regression Weights output for Path Analysis for the present study

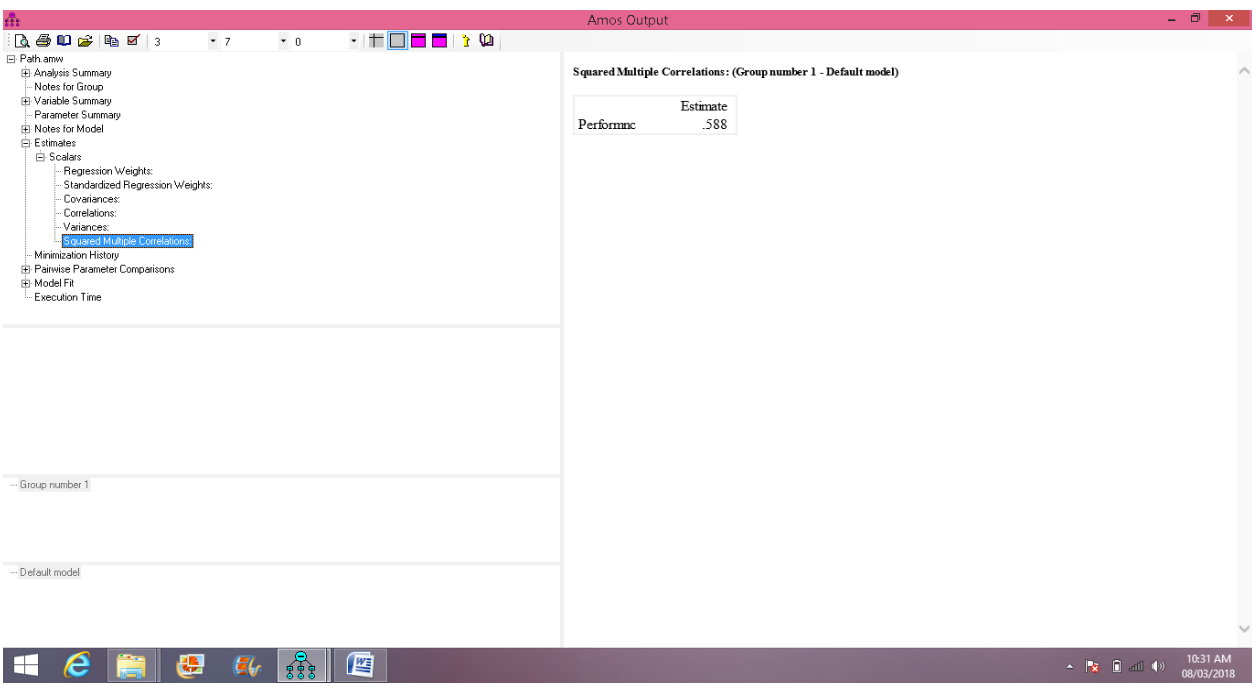


Figure 4.65: Squared Multiple Correlations output for Path Analysis for the present study

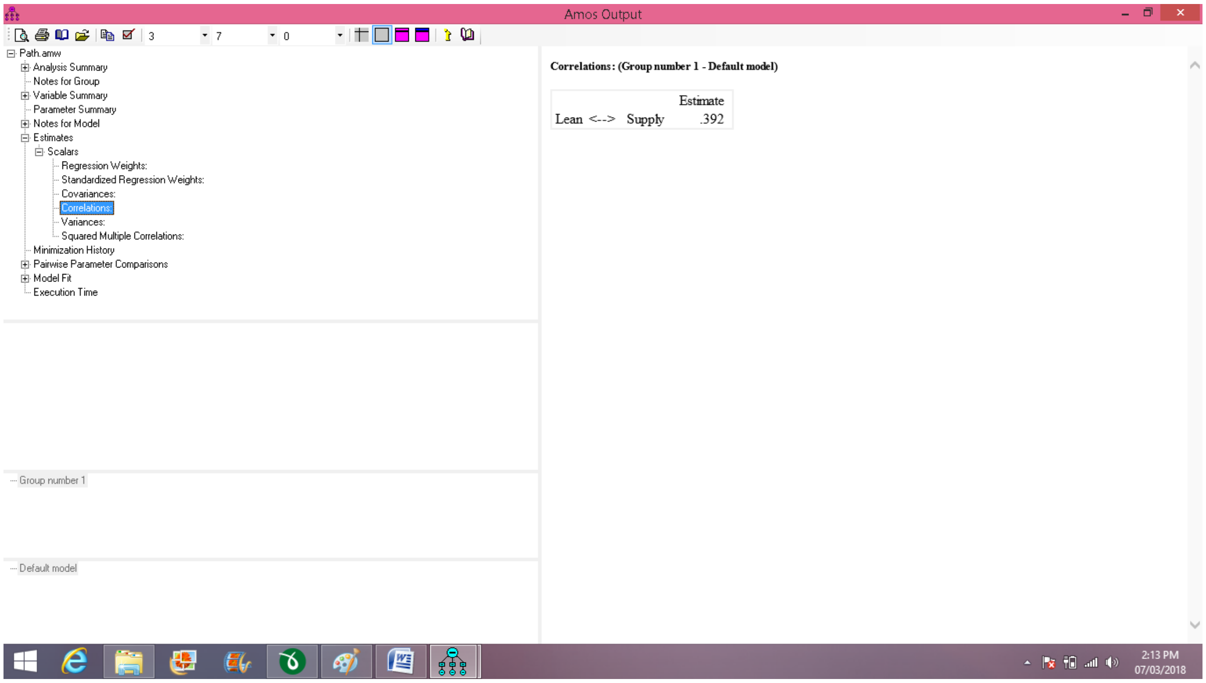


Figure 4.66: Correlation output for Path Analysis for the present study

Table 4.27: Path analysis results for the present study

Model	Endogenous Construct	Exogenous Construct	Standardized Beta	C.R.	P-Value	R^2
Path Analysis	Performance	Lean Principles	0.404	8.578	.000	58.8%
		Supply Chain Characteristics	0.512	10.863	.000	

The results indicate that the p-value of both the constructs is less than 5 percent level of significance. Thus, it can be concluded that both the lean manufacturing principles and supply chain have an impact on the performance of an organization. With this conclusion, the hypothesis H1 and H2 are accepted.

Further, through comparing the value of standardized beta the higher impact is found of the supply chain on the performance. The reason behind this is lean manufacturing optimized the effectiveness of the resources within the organization itself; on the other hand, supply chain optimized the resources throughout the value chain from the supplier to the customer. That's why the supply chain has the more impact on the performance as compared to lean manufacturing.

In further continuation, the value of R^2 in path analysis is found to be 58.8 percent which means that approximately 59 percent of the performance can be explained with the help of variation in lean manufacturing principle and supply chain characteristics. The goodness of fit indices is shown in figure 4.67 and summarized in table 4.26.

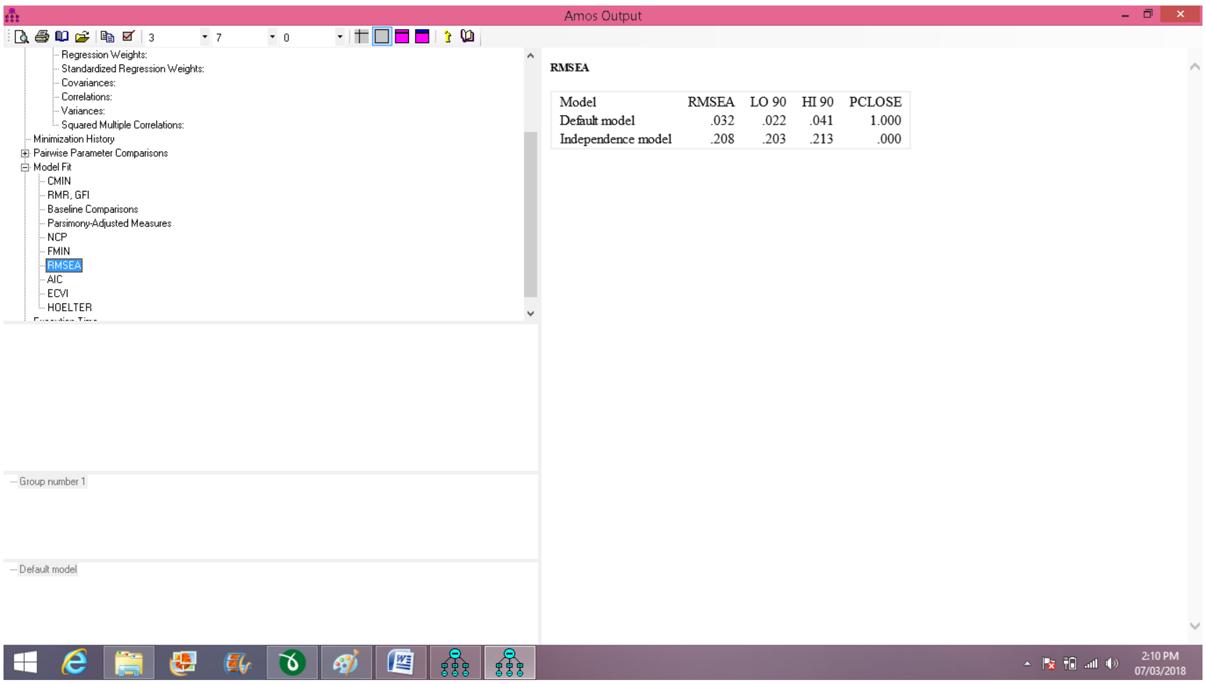


Figure 4.67: Model Fitness Indices RMSEA for Path Analysis for the present study

Table 4.28: Path analysis goodness fit indices for the present study

Model	**AGFI**	**CFI**	**GFI**	**RMSEA**	**Lo90**	**Hi90**
PA		0.99	0.99	0.589	0.526	0.655

The table shows that the path analysis model is statistically fit. It is concluded from the study that both the construct have the interrelationship with each other and also have the dependency. Thus, hypothesis H3 is also accepted that lean manufacturing principles and supply chain have the interrelationship.

4.10 CHAPTER SUMMARY

The chapter discussed the analysis concept of lean principles, supply chain, and performance. The structural Equation Modelling approach is used to analyze the relationship between lean manufacturing, supply chain characteristics, and the manufacturing organization performance. The primary objective of the analysis work is to know about the significance of both the approaches in the Indian industries i.e. impact of lean manufacturing and supply chain management on organizational performance on an individual basis. The primary data for analysis purpose is collected through a survey and analyzed with the software. The output (analysis result) is discussed in the earlier sections of the chapter reveals the specific contribution of the application of lean manufacturing and supply chain management in the manufacturing context.

CHAPTER 5

RESEARCH STUDY VALIDATION USING INTERPRETIVE STRUCTURE MODELING

5.1 INTRODUCTION

The organization refers to bring together to all the employees to achieve the predefined goal. The organization has the resources as the input material (raw); facilities as to utilize these resources (transmission process); and output as the product/service comes out from the organization. Perhaps, it is critical to evaluate and measure the status of attributes for a given situation in an organization. Despite the fact, almost all the organizations seek to improve the performance inadequacies in man-machine management. It is necessary to evaluate every situation in the organizations to become the opportunistic one. Also, the priority setting is an important task in an organization.

5.2 INTERPRETIVE STRUCTURE MODELING (ISM)

Interpretive structural modeling (ISM) technique is good enough to dictate the priority index of the measured variable with respect to each other. Important thing is, it is not only used to provide insights into the relationships among the various enablers but also helps to develop the hierarchy based on the importance of each enabler. A set of different and directly related elements are structured into a comprehensive systematic model reveals it as the interactive learning process.

ISM is the well-known approach for identifying the relationships among variables that will help to define the problem/issue. It is assumed that the variables identified are related to the problem. Still, there may be some variables in complex problems are not having a direct relationship with the problem. The ISM is considered to evaluate the direct and indirect relationships between the variables which help in representing the current status of the problem more accurately than the individual factor taken into isolation. Therefore, ISM develops insights into› collective understandings of these relationships. The following steps are considered for the application of the ISM approach:

1. **Identification of the variables:** The first and foremost step in ISM is to identify the variables which help in determining the problem. The variables either the barriers or the enablers identified are generally relevant to the problem/issue. Later on, the identified variables are then extended to the group problem-solving approach.
2. **Contextual relationship establishment:** The second step in the ISM technique is the set-out the contextual relationship of the variables with each-other which are identified earlier. The contextual relationship establishment is done on the basis of judgmental inputs by the experts or by the data survey. The Delphi and brainstorming approach is used basically to come to the final relationship establishment. In the ISM approach, the accuracy of the ISM outcomes is mainly dependent on the inputs are given by the experts in the contextual relationship. The basic rule for establishing the contextual relationship is shown in table 5.1 and represented with notations.

Table 5.1: Example of Contextual relation establishment

Variable	I_1	I_2	I_3	I_4
I_1	1	A		X
I_2		1	V	
I_3			1	O
I_4				1

The notation V represents the variable i leads to variable j and variable j does not lead the variable i; notation A represents the variable j leads to variable i and variable i does not lead the variable j; notation X represents the variable i leads to variable j and vice-versa; and finally, the notation O represents there is no relation appears in between variables i and variable j.

3. **Self-Structured Interaction Matrix (SSIM):** SSIM is developed through the pair-wise comparison of all identified variables. Self Structured Interaction Matrix for the present study is developed and shown in table 5.2 by replacing the notations with 0's and 1's with the predetermined rule as follows:

- If the (i, j) entry in the SSIM is V, then (i, j) entry in the SSIM becomes 1 and the (j, i) entry becomes 0.
- If the (i, j) entry in the SSIM is A, then (i, j) entry in the SSIM becomes 0 and the (j, i) entry becomes 1.
- If the (i, j) entry in the SSIM is X, then both (i,j) (j,i) entries in SSIM are become 1.
- If the (i, j) entry in the SSIM is O, then both (i,j) (j,i) entries in SSIM are become 0.

Table 5.2: Example for SSIM

Variable	I_1	I_2	I_3	I_4
I_1	1	0		1
I_2	1	1	1	
I_3		0	1	0
I_4	1		0	1

4. **Reachability Matrix (RM):** To do the ISM work, the binary matrix must be balanced. To check the balancing matrix, the relationship among each variable is evaluated in such a manner i.e. if variable A holds the relationship with variable B; and the variable B holds a relationship with C, then there is relation exist in between variable A and variable C. If it happens, the new relation is represented as the transitive one and marked as 1* in the original SSIM.

5. **Development of the Diagraph:** The balanced binary matrix helps in developing the ISM diagraph basically the hierarchical diagram. To develop the diagraph level partitioning is done for each variable i.e. developing the hierarchy of the variables

according to their percentage of contribution to success/failure of the construct. The portioning of the variables is done by critical evaluation of reachability matrix. The reachability and antecedent set for every variable are identified and the intersection of these sets is derived. The variable, for which the reachability and the intersection sets are the same, is assigned the first level in the ISM hierarchy. The variables once assigned in the hierarchy are not helped to assign the levels to the other variables. So, the variables identified once, separated out from the other elements and the process will continue till all the variables are not assigned for the hierarchy. The diagraph is then developed with the help of hierarchy level assigned to the variables and then the ISM model is developed.

6. **MICMAC Analysis:** MICMAC analysis is basically used to analyze the characteristics of the individual variable. For this purpose, the conical matrix is developed which represents the driving and dependence power of the variable. The reachability matrix is used to develop the conical matrix i.e. clubbing together the variables at the same level, across rows and columns. The driving power of the variable is the sum of a number of 1's in variable rows and the dependence power is calculated by the sum of 1's in variables columns in the reachability matrix. The driving power and dependence power of the variables are kept as the basis for the MICMAC analysis and the graph is developed with the driving and dependence power values. The graph is divided into the four core subsections referred to as the clusters namely Autonomous (weak drive power as well as weak dependence on other variables); Dependence (weak drive power but strong dependence); Linkage (strong drive power as well as strong dependence) and Driving (strong drive power but weak dependence). The flow diagram to utilize ISM technique in general problem identification and solution is shown in figure 5.1.

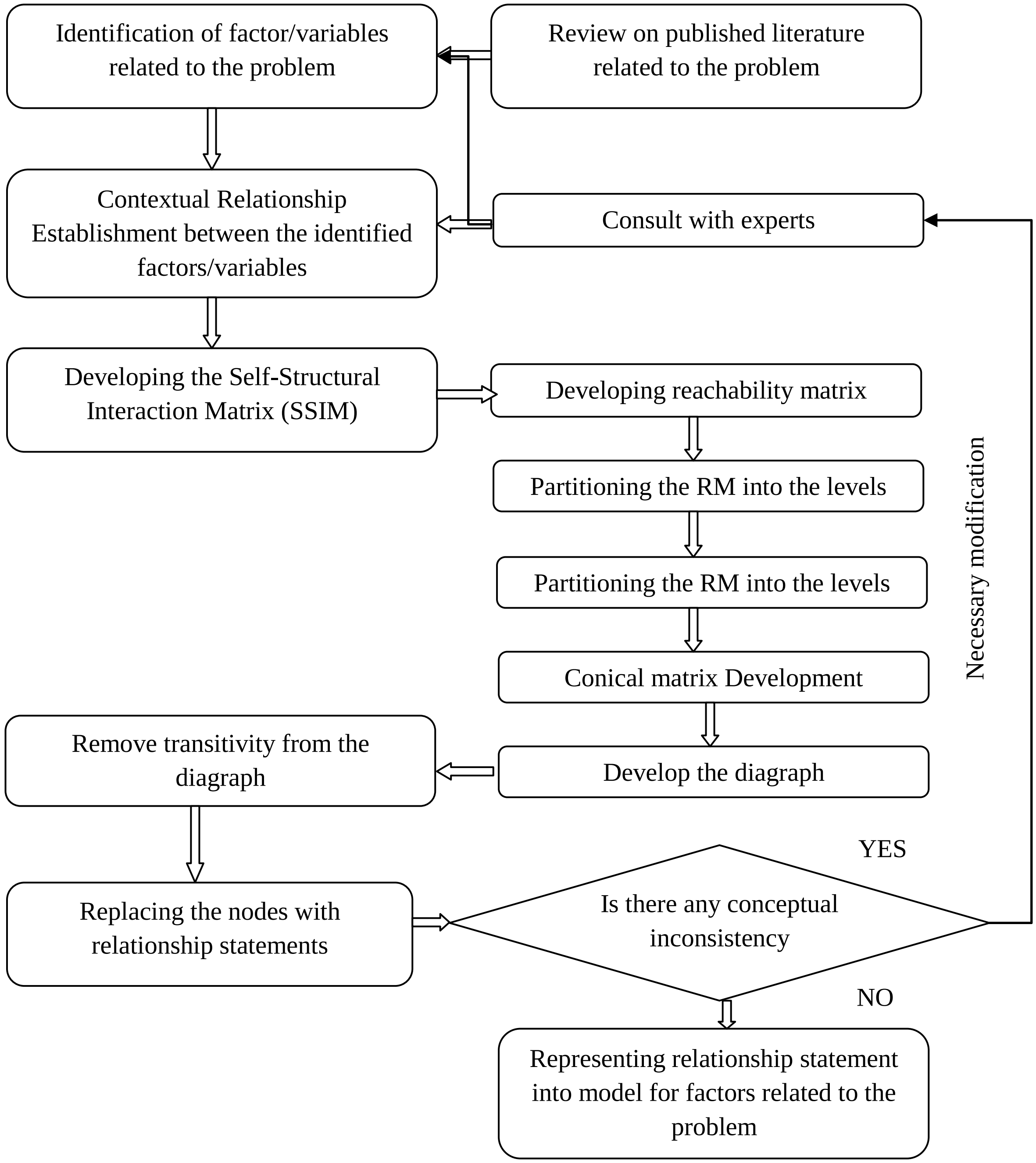


Figure 5.1: Flow diagram for ISM [Attri et al. 2013]

5.3 IMPLEMENTING ISM APPROACH ON LEAN MANUFACTURING

To identify and eliminate the wastes listed in the introduction section; Lean Principles is the finest tool, which helps the organization convert the non-value added activities into the value-added activities. Lean principles result in a customer-centric perspective of the organization that pulls the customer to buy more and more. [Kumar et al., 2017]

Step 1: Identification of Lean principles impact on organizational performance

The extensive literature on lean principles revealed the numerous tangible and intangible benefits in the manufacturing sector especially. The twelve most common benefits of organizational performance were considered for the present study as listed below:

C_1: To provide the value to the customer

C_2: To emphasize the quality enhancement as a continuous improvement process.

C_3: To minimize the resources losses from unwanted transportation

C_4: To minimize the inventory wastages by controlling on all the business activities

C_5: To optimize the movement of men, material & machine in the manufacturing process.

C_6: To minimize the lead-time for production as well as purchasing

C_7: To provide the better understanding of overproduction in organizations

C_8: Minimize the losses of resources caused by over-processing

C_9: Help in producing the defect-free production

C_{10}: Helps in utilizing the full potential of its workforce to support the business activities

C_{11}: Helps in utilizing the space (Horizontally and Vertically)

C_{12}: Helps in providing the safest working conditions which have an influence on business activities

Step 2: Development of contextual relationship among variables

In the present case, the contextual relationship among the impacts for implementing lean principles is done using Causal Approach based on the judgmental *opinions* of the experts working in the same areas shown in table 5.3.

Table 5.3: Contextual relationship among lean principles impact in an organization

LM Impact on Performance	**C_{12}**	**C_{11}**	**C_{10}**	**C_9**	**C_8**	**C_7**	**C_6**	**C_5**	**C_4**	**C_3**	**C_2**
C_1	O	O	O	V	V	V	V	A	V	O	V
C_2	A	A	A	V	V	V	V	V	V	V	
C_3	A	V	V	A	V	V	A	X	V		
C_4	A	A	A	X	V	V	A	V			
C_5	X	V	V	V	V	V	V				
C_6	A	V	O	O	V	O					
C_7	A	A	A	O	O						
C_8	A	A	A	A							
C_9	A	O	O								
C_{10}	A	X									
C_{11}	A										

Step 3: Development of SSIM

After the development of contextual relationship among the variables, the binary matrix is developed by keeping the table 5.3 as a reference. Table 5.4 shows the Self Structured Interaction Matrix for the present study.

Table 5.4: SSIM (Initial Reachability Matrix)

LM Impact on Performance	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	1	1	0	1	0	1	1	1	1	0	0	0
C_2	0	1	1	1	1	1	1	1	1	0	0	0
C_3	0	0	1	1	1	0	1	1	0	1	1	0
C_4	0	0	0	1	1	0	1	1	1	0	0	0
C_5	1	0	1	0	1	1	1	1	1	1	1	1
C_6	0	0	1	1	0	1	0	1	0	0	1	0
C_7	0	0	0	0	0	0	1	0	0	0	0	0
C_8	0	0	0	0	0	0	0	1	0	0	0	0
C_9	0	0	1	1	0	0	0	1	1	0	0	0
C_{10}	0	1	0	1	0	0	1	1	0	1	1	0
C_{11}	0	1	0	1	0	0	1	1	0	1	1	0
C_{12}	0	1	1	1	1	1	1	1	1	1	1	1

Note: Self Structured Interaction Matrix for the present study is developed and shown in table 5.4 by replacing the notations with 0's and 1's with the predetermined rule i.e.

For Example:

- In table 5.2, the entry in (1,4) is V, so, in table 3, the entries in (1,4) and (4,1) becomes 1 and 0 respectively.

- In table 5.2, the entry in (1,5) is A, so, in table 3, the entries in (1,5) and (5,1) becomes 0 and 1 respectively.
- In table 5.2, the entry in (4,9) is X, so, in table 3, both the entries (4,9) and (9,4) becomes 1.
- In table 5.2, the entry in (6,10) is O, so, in table 3, both the entries in (6,10) and (10,6) becomes 0.

Now, the transitivity is incorporated in SSIM to develop the reachability matrix as given in table 5.5.

Table 5.5: Incorporating Transitivity (Final Reachability Matrix)

LM Impact on Performance	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**	**C_{12}**
C_1	1	1	1*	1	1*	1	1	1	1	0	1*	0
C_2	1*	1	1	1	1	1	1	1	1	1*	1*	1*
C_3	1*	1*	1	1	1	1*	1	1	1*	1	1	1*
C_4	1*	0	1*	1	1	1*	1	1	1	1*	1*	1*
C_5	1	1*	1	1*	1	1	1	1	1	1	1	1
C_6	0	1*	1	1	1*	1	1*	1	1*	1*	1	0
C_7	0	0	0	0	0	0	1	0	0	0	0	0
C_8	0	0	0	0	0	0	0	1	0	0	0	0
C_9	0	0	1	1	1*	0	1*	1	1	1*	1*	0
C_{10}	0	1	1*	1	1*	1*	1	1	1*	1	1	0
C_{11}	0	1	1*	1	1*	1*	1	1	1*	1	1	0
C_{12}	1*	1	1	1	1	1	1	1	1	1	1	1

Step 4: Development of the diagraph

The diagraph for the present study is developed with the help of level partitioning. The reachability and antecedent set for each variable are identified. The intersection of both reachability and antecedent set provides the variables level of contribution in the problem statement/issue. Tables 5.6 to 5.10 in the present study represent the levels for all the variables (Impacts of Lean Manufacturing). The variables at different levels are then used for developing the ISM diagraph.

Table 5.6: First Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_1	1,2,3,4,5,6,7,8,9,11	1,2,3,4,5,12		
C_2	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6, 10,11,12		
C_3	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,6,9,10,11,12		
C_4	1, 3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,6,9,10,11,12		
C_5	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,6,9,10,11,12		
C_6	2,3,4,5,6,7,8,9,10,11	1,2,3,4,5,6,10,11,12		
C_7	7	1,2,3,4,5,6,7,9,10,11,12	7	1st
C_8	8	1,2,3,4,5,6,8,9,10,11,12	8	1st
C_9	3,4,5,7,8,9,10,11	1,2,3,4,5,6,9,10,11,12		
C_{10}	2,3,4,5,6,7,8,9,10,11	2,3,4,5,6,9,10,11,12		
C_{11}	2,3,4,5,6,7,8,9,10,11	1,2,3,4,5,6,9,10,11,12		
C_{12}	1,2,3,4,5,6,7,8,9,10,11,12	2,3,4,5,12		

Table 5.7: Second Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_1	1,2,3,4,5,6,9,11	1,2,3,4,5,12		
C_2	1,2,3,4,5,6,9,10,11,12	1,2,3,5,6, 10,11,12		
C_3	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11,12	2nd
C_4	1, 3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11,12	1, 3,4,5,6,9,10,11,12	2nd
C_5	1,2,3,4,5,6, 9,10,11,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11,12	2nd
C_6	2,3,4,5,6,9,10,11	1,2,3,4,5,6,10,11,12	2,3,4,5,6,9,10,11	
C_9	3,4,5, 9,10,11	1,2,3,4,5,6,9,10,11,12	3,4,5, 9,10,11	2nd
C_{10}	2,3,4,5,6, 9,10,11	2,3,4,5,6,9,10,11,12	2,3,4,5,6, 9,10,11	2nd
C_{11}	2,3,4,5,6, 9,10,11	1,2,3,4,5,6,9,10,11,12	2,3,4,5,6, 9,10,11	2nd
C_{12}	1,2,3,4,5,6, 9,10,11,12	2,3,4,5,12		

Table 5.8: Third Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_1	1,2	1,2,12		
C_2	1,2,6,12	1,2,6,12	1,2,6,12	3rd
C_6	2,6	1,2,6,12	2,3,4,5,6,9,10,11	3rd
C_{12}	1,2, 6,12	2,12		

Table 5.9: Fourth Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_1	1	1,12	1	4th
C_{12}	1,12	12		

Table 5.10: Fifth Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_{12}	12	12	12	4th

The level partition done earlier is summarized in table 5.11, which clearly depicts that the lean principles impacts on organizational performance are found on five levels in present study i.e. variables C_7 & C_8 are at 1st level; variables C_3, C_4, C_5, C_9, C_{10} & C_{11} at 2nd level; variables C_2 & C_6 at 3rd level; variable C_1 at 4th level and finally, the variable C_{12} at the fifth level.

Table 5.11: Level Partition

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_{12}	1,2,3,4,5,6,7,8,9,10, 11,12	2,3,4,5,12	12	5th
C_1	1,2,3,4,5,6,7,8,9,11	1,2,3,4,5,12	1	4th
C_2	1,2,3,4,5,6,7,8,9,10, 11,12	1,2,3,5,6, 10,11,12	1,2,,12	3rd
C_6	2,3,4,5,6,7,8,9,10,1 1	1,2,3,4,5,6,10,11,12	2,6,9,10,11	3rd
C_3	1,2,3,4,5,6,7,8,9,10, 11,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11, 12	2nd
C_4	1, 3,4,5,6,7,8,9,10,11, 12	1,2,3,4,5,6,9,10,11,12	1, 3,4,5,6,9,10,11,12	2nd

LM Impact on Performance	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
C_5	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,6,9,10,11,12	1,2,3,4,5,6,9,10,11,12	2nd
C_9	3,4,5,7,8,9,10,11	1,2,3,4,5,6,9,10,11,12	3,4,5, 9,10,11	2nd
C_{10}	2,3,4,5,6,7,8,9,10,11	2,3,4,5,6,9,10,11,12	2,3,4,5,6, 9,10,11	2nd
C_{11}	2,3,4,5,6,7,8,9,10,11	1,2,3,4,5,6,9,10,11,12	2,3,4,5,6, 9,10,11	2nd
C_7	7	1,2,3,4,5,6,7,9,10,11,12	7	1st
C_8	8	1,2,3,4,5,6,8,9,10,11,12	8	1st

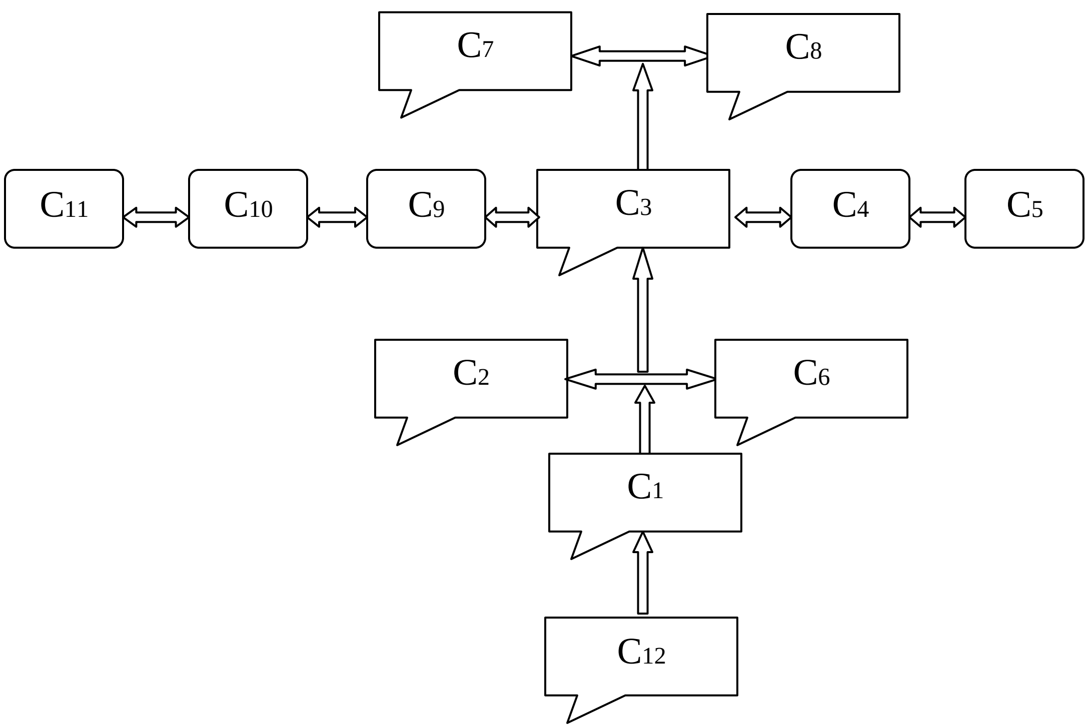


Figure 5.2: Diagraph for the Lean manufacturing benefits

Step 5: Development of the ISM model

The digraph as in figure 5.2 is now converted into an ISM model by replacing nodes of the elements with Lean Impacts as shown in figure 5.3. The ISM model for lean impacts on organizational performance reveals that the provision for the safest working conditions in the manufacturing industry is the high driving power variable for implementation of LM. Further, the directional arrows in the model indicate that a particular variable is dictated by other one or helps in dictating to others. The positioning of the variables is done based on their ranking in context with respect to their driving and dependence power. The variable having high driving power may have an impact on the variable with less driving power. In the present case, the variable (safest working conditions in an organization) is found the high driving power that leads to the culture change i.e. helps in aligning the objectives of the individuals with the industry objectives. The model also reveals that the variables having higher driving power i.e. creation of value to the customer also play an important role in the implementation of LM and it needs to be specified before the process and more devotion is required because of high driving and low dependency of the variable. The variables (Lean principle impacts) like Continuous improvement and lead-time minimization improves the process capability as well as the quality and cost of the product. Further, the model dictates the control on production related matters such as overproduction/over-processing/blockage etc. makes the lean manufacturing approach is much more prominent for continuous improvement than the traditional one. In the traditional approach, the more emphasis is given to control on over-production and over-processing exhaust the other resources whereas lean principles systematically control on both the variables beginning from the safest working environment and customer value creation.

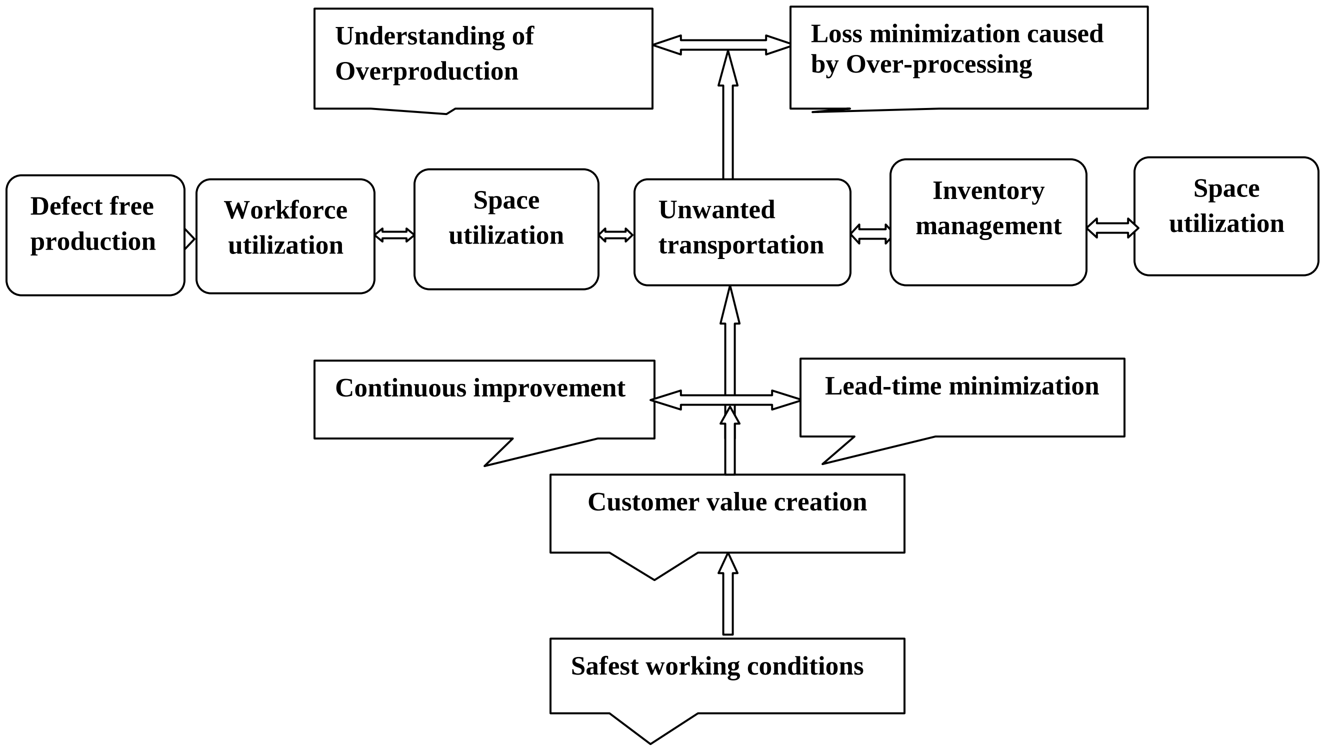


Figure 5.3: ISM for the Lean manufacturing benefits

Step 6 MICMAC analysis

Later on, the MICMAC analysis is done to analyze the driving or dependence power for the variables (Lean manufacturing impacts in the present study) as given in conical matrix table 5.10. Further, the variables are divided into four clusters based on their driving and dependence power as shown in figure 5.12.

Table 5.12: Conical Matrix

Driving Power	10	12	12	11	12	10	1	1	8	10	10	12
Dependence Power	6	8	10	10	10	9	11	11	10	9	10	5

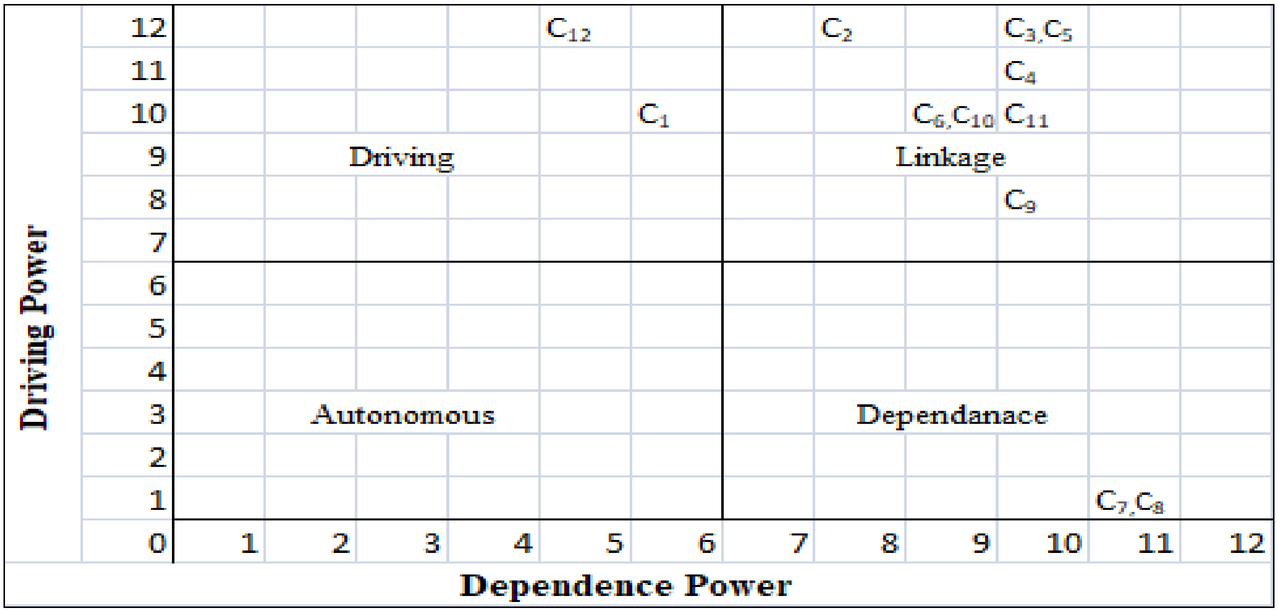


Figure 5.4: MICMAC Analysis of the Lean manufacturing benefits

In the present study, none of the variables of identity mix are independent (have little interaction with the system). Further, the variable C_7 & C_8 are the dependent variables (have little guidance power but extremely dependent on the system). These variables can seldom affect other variables but they are affected by others more. The variables such as $C_{3,}$ C_4, C_5, C_9, C_{10} & C_{11} are the linking variables have a great guidance power and a high degree of dependency. They not only affect the other variables but also depend on other variables. The variable C_1 & C_{12} are the driving variables having high driving power and less dependency on others.

Summary of the work: In the present study, the twelve lean impacts on organizational performance (generally, the benefits of LM) are identified through the extensive literature review. The ISM approach is used to reveal the inter-relationships between the lean principles (construct) and its impacts on organizational performance (measured variables). The present study concludes the requisites of the safest working environment for any organization. It is the first and foremost activity followed by the value to the customer for the successful implementation of lean manufacturing approach. Hence, it becomes necessary to identify the various facts and facets about the safest working environment and the customer value i.e. customer desires on quality, quantity, and cost aspects so-that the organization can drive with maximum benefits.

5.4 IMPLEMENTING ISM APPROACH ON SUPPLY CHAIN CHARACTERISTICS

The present study has the main view of identification of various Supply Chain Characteristics who advocates the effective SCM strategies implemented in the organization. These characteristics are somewhat close to the organizational performance managing criteria's.

Step 1: Identification of Lean principles impact on Organizational Performance

The extensive literature on SCM helps to identify the ten characteristics as given in table 5.13 below.

Table 5.13: Identification of Supply Chain Characteristics

Des.	**SC Characteristics**	**Principle of Working**
SC_1	Optimized Lead Time	Operational Aspect
SC_2	Strong Decision Making	Financial as well as operational aspect
SC_3	Cross-Enterprise Collaboration	Financial as well as operational aspect
SC_4	Uninterrupted Information Flow	Operational Aspect
SC_5	Inventory Management	Financial as well as operational aspect
SC_6	Internal Integration	Operational Aspect
SC_7	Flexible to deal with Uncertainty	Operational Aspect
SC_8	Vendor Troubleshooting	Operational Aspect
SC_9	Simple in Design	Financial as well as operational aspect
SC_{10}	Market Demand growth	Financial Aspect

Step 2: Development of contextual relationship among variables

The contextual relationship in ISM reflects the importance of variables considers in a study on each-other. In the present work, the relative importance of the characteristics of the supply chain is established with the judgmental opinion of the experts in the same area.

Table 5.14: Contextual Relationship among Supply Chain Characteristics

SCC	SC_{10}	SC_9	SC_8	SC_7	SC_6	SC_5	SC_4	SC_3	SC_2
SC_1	A	X	A	O	A	A	A	A	A
SC_2	X	X	V	V	A	V	A	V	
SC_3	A	A	V	V	X	V	V		
SC_4	A	V	V	V	V	V			
SC_5	A	X	A	V	A				
SC_6	A	X	V	V					
SC_7	A	V	O						
SC_8	O	A							
SC_9	A								

Step 3: Development of SSIM

After the development of contextual relationship among the variables, the binary matrix is developed by keeping the table 5.14 as a reference. Table 5.15 shows the Self Structured Interaction Matrix for the present study.

Table 5.15: SSIM (Initial Reachability Matrix)

SCC	SC_1	SC_2	SC_3	SC_4	SC_5	SC_6	SC_7	SC_8	SC_9	SC_{10}
SC_1	1	0	0	0	0	0	0	0	1	0
SC_2	1	1	1	0	1	0	1	1	1	1
SC_3	1	0	1	1	1	1	1	1	0	0
SC_4	1	1	0	1	1	1	1	1	1	0
SC_5	1	0	0	0	1	0	1	0	1	0
SC_6	1	1	1	0	1	1	1	1	1	0
SC_7	0	0	0	0	0	0	1	0	1	0
SC_8	1	0	0	0	1	0	0	1	0	0
SC_9	1	1	1	0	1	1	0	1	1	0
SC_{10}	1	1	1	1	1	1	1	0	1	1

Table 5.16: Final Reachability Matrix (FRM) – Incorporating Transitivity

SCC	SC_1	SC_2	SC_3	SC_4	SC_5	SC_6	SC_7	SC_8	SC_9	SC_{10}	Driving Power
SC_1	1	1*	1*	0	1*	1*	0	1*	1	0	**07**
SC_2	1	1	1	1*	1	1*	1	1	1	1	**10**
SC_3	1	1*	1	1	1	1	1	1	1*	0	**09**
SC_4	1	1	1*	1	1	1	1	1	1	1*	**10**
SC_5	1	1*	1*	0	1	1*	1	1*	1	0	**08**
SC_6	1	1	1	1*	1	1	1	1	1	1*	**10**
SC_7	1*	1*	1*	0	1*	1*	1	1*	1	0	**08**
SC_8	1	0	0	0	1	0	1*	1	1*	0	**05**
SC_9	1	1	1	1*	1	1	1*	1	1	1*	**10**
SC_{10}	1	1	1	1	1	1	1	1*	1	1	**10**
Dependence Power	**10**	**09**	**09**	**06**	**10**	**09**	**09**	**10**	**10**	**05**	**87**

Step 4: Development of the diagraph

The diagraph for the present study is developed with the help of level partitioning. The reachability and antecedent set for each variable are identified. The intersection of both reachability and antecedent set provides the variables level of contribution in the problem statement/issue. Table 5.17 reveals the SCC at various levels according to their contribution.

Table 5.17: Level Partitioning

SCC	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
SC_{10}	1,2,3,4,5,6,7,8,9,10	2,4,6,9,10	10	4^{th}
SC_3	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,9,10	3,4	3^{rd}
SC_4	1,2,3,4,5,6,7,8,9,10	2,3,4,6,9,10	3,4,10	3^{rd}
SC_2	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,9,10	2,3,4,6,7,10	2^{nd}
SC_6	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,9,10	2,3,4,6,7,10	2^{nd}
SC_7	1,2,3,5,6,7,8,9	2,3,4,5,6,7,8,9,10	2,3,6,7	2^{nd}
SC_1	1,2,3,5,6,8,9	1,2,3,4,5,6,7,8,9,10	1,2,3,5,6,8,9	1^{st}
SC_5	1,2,3,5,6,7,8,9	1,2,3,4,5,6,7,8,9,10	1,2,3,5,6,7,8,9	1^{st}
SC_8	1,7,8,9	1,2,3,4,5,6,7,8,9,10	1,7,8,9	1^{st}
SC_9	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	1^{st}

The diagraph for SC characteristics is shown in figure 5.5.

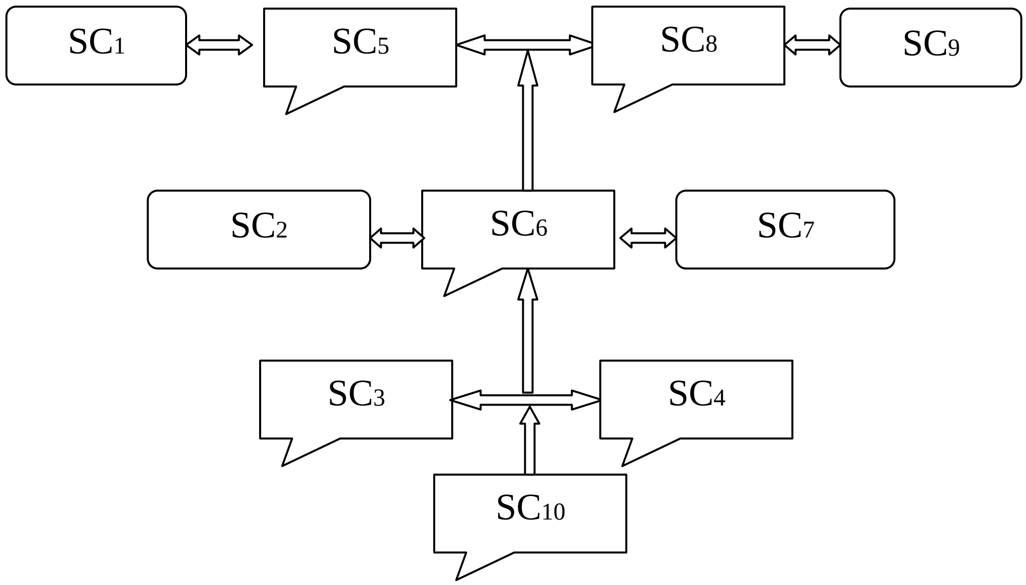


Figure 5.5: Diagraph for Supply Chain Characteristics

Step 5: Development of the ISM model

The digraph as in figure 5.5 is now converted into an ISM model by replacing nodes of the elements with Lean Impacts as shown in figure 5.6. As per the study, the market demand growth is found the important characteristic of SCM. In layman term an organization is said to be the successful one; when and only when it's market demand grew. The market demand has both the positive and the negative impacts on Supply Chain. Mangal et al. (2013) point out the presence of uncertainty in the market just because of the dynamic behavior of the customer which offers an opportunity to the organization may be grabbed or not. As the demand increase or decrease it may affect the whole supply chain and reflected through a gap in the gap between demand and supply. That's-why, the market growth in any organization should be taken seriously. Characteristic i.e. un-interrupted information is also affecting factor for the effectiveness of SCM in an organization. Chopra et al., (2003) reported Information as a driver for effective SCM. The information flow is the main contributor to an organization which defines the organizational plan including, scope objective resources and so-on... The literature review reveals that the information stuck off at any stage in the organization always has an adverse effect on organizational performance. The information flow creates a platform where all the stakeholders in SCM will contribute their plans and make the strategies accordingly in the most efficient manner. [Gunasekaran & Ngai, 2004]

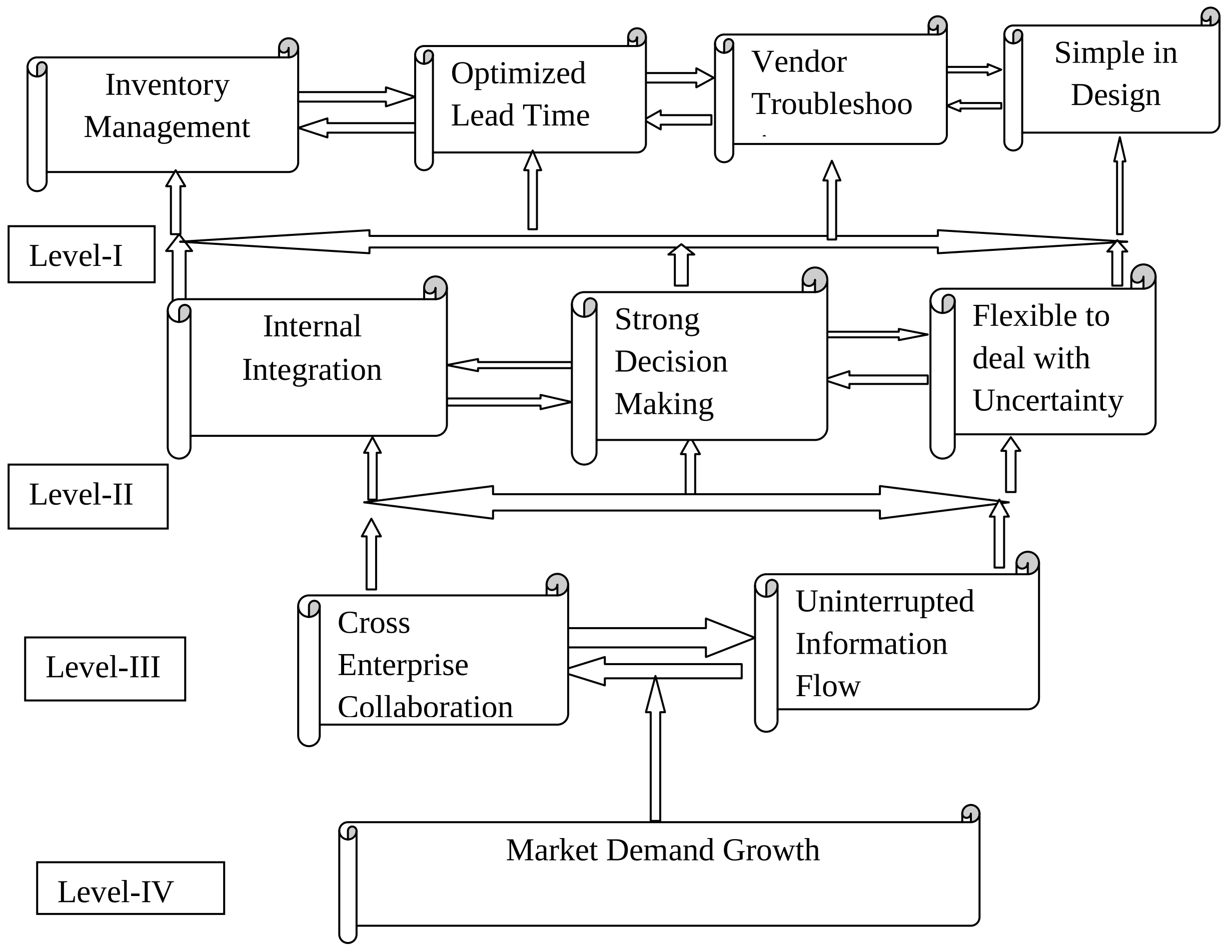


Figure 5.6: ISM diagram for Supply Chain Characteristics

Step 6 MICMAC analysis

Later on, the MICMAC analysis is done to analyze the driving or dependence power for the variables as given in conical matrix table 5.18.

Table 5.18: Conical Matrix

Driving Power	07	10	09	10	08	10	08	05	10	10
Dependence Power	10	09	09	06	10	09	09	10	10	05

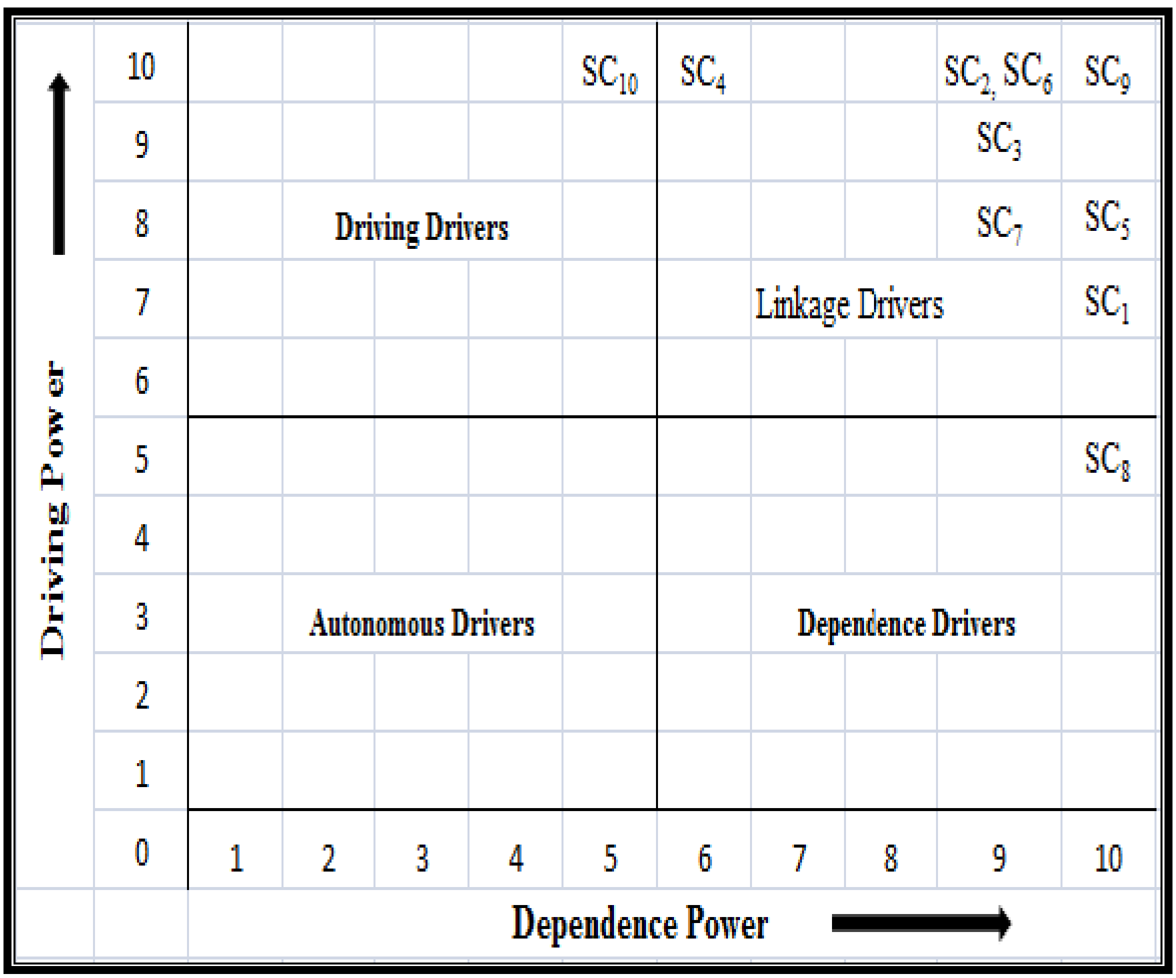


Figure 5.7: MICMAC Analysis of Supply Chain Characteristics

Table 5.19: MICMAC Analysis Summarization

Region 1: Autonomous Drivers	The variables lying in this region having the weak drive as well as dependence on the other variables. So-that these variables can be handled separately. In the present case, there is no variable lying in the autonomous region.
Region 2: Dependence Drivers	The variables SC_8 is lying in this region. The variables in this region have weak driving power but strongly dependent on other variables. This states that vendor troubleshooting never helps to attain the effectiveness and dependent factor on all other variables.
Region 3: Linkage Drivers	Variable SC_1, SC_2, SC_3, SC_4, SC_5, SC_6, SC_7, and SC_9 are lying in the linkage region. These variables are having the drive power for SCM and also, dependence on other variables strongly.
Region 4: Driving Drivers	The variable SC_{10} is lying in the driving region. This states that the variable market growth has strong drive power and helps to drive all other variables. Also, this variable has a weak dependence on others is variable.

The MICMAC analysis in the study reveals that the supply chain characteristics like optimized lead time, strong decision making, cross-enterprise collaboration, uninterrupted information flow, inventory management, internal integration, and simple design of value chain is having the driving as well as the dependence power. The vendor troubleshooting (supply chain characteristic) contributes to a little bit in the effectiveness of SCM i.e. it has the least impact on the supply chain. So, this characteristic should be handled at last.

Summary of the work:

The effectiveness of supply chain management in the organization is dictated the overall performance of the organization. In general, it is necessary to evaluate the SCM effectiveness otherwise it can affect the organization in many ways. The ISM model developed with the help of experts reflects the inter-relationship among all the supply chain characteristics is analyzed through MICMAC analysis.

The present work reveals the various supply chain characteristics which are further utilized as the evidence for the presence of effective/ineffective supply chain in the organization.

5.5 IMPLEMENTING ISM APPROACH ON PERFORMANCE MEASURES

The perspective behind measuring and evaluating the performance in an organization is to ensure the market value of the product and the organization as well. In an organization, the variety of tasks is performed under the distinct circumstances and most of the time the tasks are interrelated with each other. So, any interruption in a task can create the interruptions for all interrelated tasks. In addition, the presence of uncertainty in the global market (means market changes dynamically and drastically) that enforced the manufacturing sector to perform constantly confronted with the challenges i.e time, cost, delivery, and quality.

Step 1: Identification of Performance measures in an organization

The dynamic nature of the market will further result in dissatisfaction with the customer as well as the producers. To overcome the above-said situations, every organization reviewed its performance level based on criteria's mentioned below:

- Increased Sales Revenue (P_1)
- Profit Maximization (P_2)
- Increased Employment Rate (P_3)
- Improved Production Capacity (P_4)
- Meet with Customer Demand (P_5)
- Optimum Resource Utilization (P_6)
- Brand Value Enhancement (P_7)
- New Product Development (P_8)
- Competitive Advantage (P_9)
- Flexibility (P_{10})

Step 2: Development of contextual relationship among variables

In the present case, the contextual relationship among the identified performance measures is done using Causal Approach based on the judgmental opinions of the experts working in the same areas and shown in table 5.20.

Table 5.20: Contextual relationship among performance measures

Performance	**P_{10}**	**P_9**	**P_8**	**P_7**	**P_6**	**P_5**	**P_3**	**P_3**	**P_2**
P_1	A	A	V	X	A	A	A	V	V
P_2	A	A	A	X	A	A	A	V	
P_3	A	V	V	V	V	V	A		
P_4	A	V	V	V	V	V			
P_5	A	A	A	A	A				
P_6	V	V	A	V					
P_7	A	A	V						
P_8	A	V							
P_9	A								

Step 3: Development of SSIM

After the development of contextual relationship among the variables, the binary matrix is developed by keeping the table 5.20 as a reference. Table 5.21 shows the Self Structured Interaction Matrix for the present study.

Table 5.21: SSIM (Initial Reachability Matrix)

Performance Enablers	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
P_1	1	1	1	0	0	0	1	1	0	0
P_2	0	1	1	0	0	0	1	0	0	0
P_3	0	0	1	0	1	1	1	1	1	0
P_4	1	1	1	1	1	1	1	1	1	0
P_5	1	1	0	0	1	0	0	0	0	0
P_6	1	1	0	0	1	1	1	0	1	1
P_7	1	1	0	0	1	0	1	1	0	0
P_8	0	1	0	0	1	1	0	1	1	0
P_9	1	1	0	0	1	0	1	0	1	0
P_{10}	1	1	1	1	1	0	1	1	1	1

Table 5.22: Incorporating Transitivity (Final Reachability Matrix)

Performance Enablers	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	Driving Power
P_1	1	1	1	0	1*	1*	1	1	1*	0	**08**
P_2	1*	1	1	0	1*	1*	1	1*	1*	0	**08**
P_3	1*	1*	1	0	1	1	1	1	1	1*	**09**
P_4	1	1	1	1	1	1	1	1	1	1*	**10**
P_5	1	1	1*	0	1	0	1*	1*	0	0	**06**
P_6	1	1	1*	1*	1	1	1	1*	1	1	**10**
P_7	1	1	1*	0	1	1*	1	1	1*	0	**08**
P_8	1*	1	1*	0	1	1	1*	1	1	1*	**09**
P_9	1	1	1*	0	1	0	1	1*	1	0	**07**
P_{10}	1	1	1	1	1	1*	1	1	1	1	**10**
Dependence Power	**10**	**10**	**10**	**03**	**10**	**08**	**10**	**10**	**09**	**05**	**85**

Step 4: Development of the diagraph

The diagraph for the present study is developed with the help of level partitioning. The reachability and antecedent set for each variable are identified. The intersection of both reachability and antecedent set provides the variables level of contribution in the problem statement/issue. Table 5.23 represents the levels for all the variables and these levels are further used to develop the ISM diagraph.

Table 5.23: Level Partitioning

Performance Enablers	Reachability Set (RS)	Antecedent Set (AS)	Intersection	Level
P_2	1,2,3,4,5,6,7,8,9,10	2,3,4,5,10	2,3,4,10	4th
P_3	1,2,3,4,5,6,7,8,9,10	2,3,4,5,7,9,10	2,3,4,10	4th
P_4	1,2,3,4,5,6,7,8,9,10	2,3,4,5,9,10	2,3,4,10	4th
P_{10}	1,2,3,4,5,6,7,8,9,10	2,3,4,5,6,9,10	2,3,4,10	4th
P_5	1,2,3,4,5,6,7,8,9,10	2,3,4,5,6,7,9,10	2,3,4,5,6,7,9,10	3rd
P_6	1,5,6,7,8,9,10	2,3,4,5,6,7,9,10	5,6,7,9,10	3rd
P_7	1,3,5,6,7,8,9	2,3,4,5,6,7,9,10	3,5,6,7,9	3rd
P_9	1, 3,4,5,6,7,8,9	2,3,4,5,6,7,9,10	3,4,5,6,7,9	3rd
P_8	1,8	2,3,4,5,6,7,8,9,10	8	2nd
P_1	1	1,2,3,4,5,6,7,8,9,10	1	1st

Table 5.23 concludes that the variable P_1 is at the first level, variable P_8 is at the 2nd level, variables P_5, P_6, P_7 & P_9 are at the 3rd level, and finally, the variables P_2, P_3, P_4 & P_{10} are at the 4th Level. The diagraph for performance measures is shown in figure 5.8.

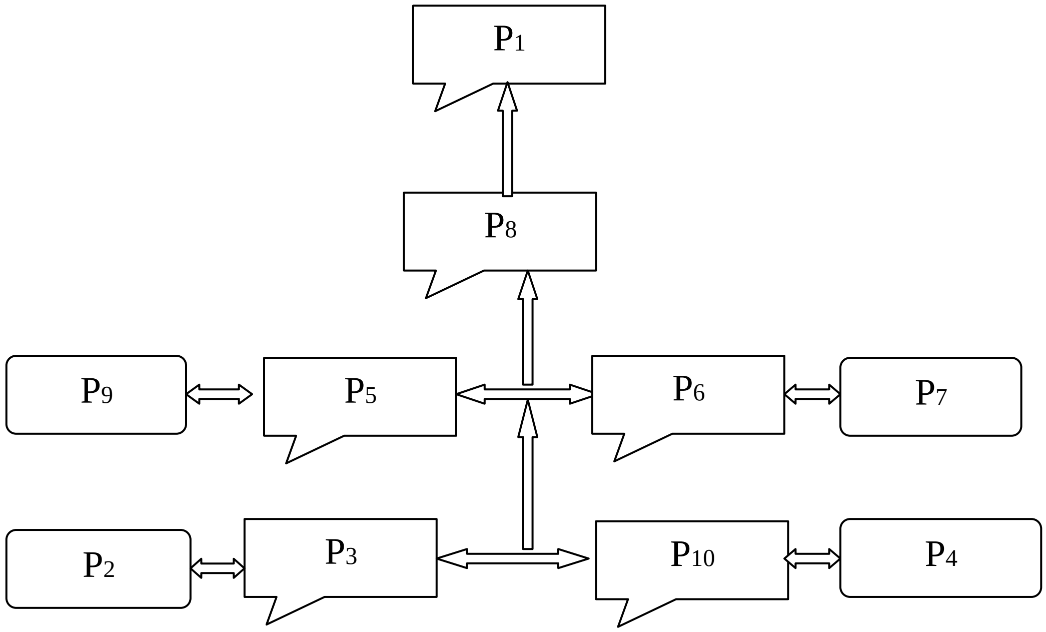


Figure 5.8: Diagraph for the Performance Measures

Step 5: Development of the ISM model

The ISM diagraph is now converted in the ISM hierarchy diagram as shown in figure 5.9.

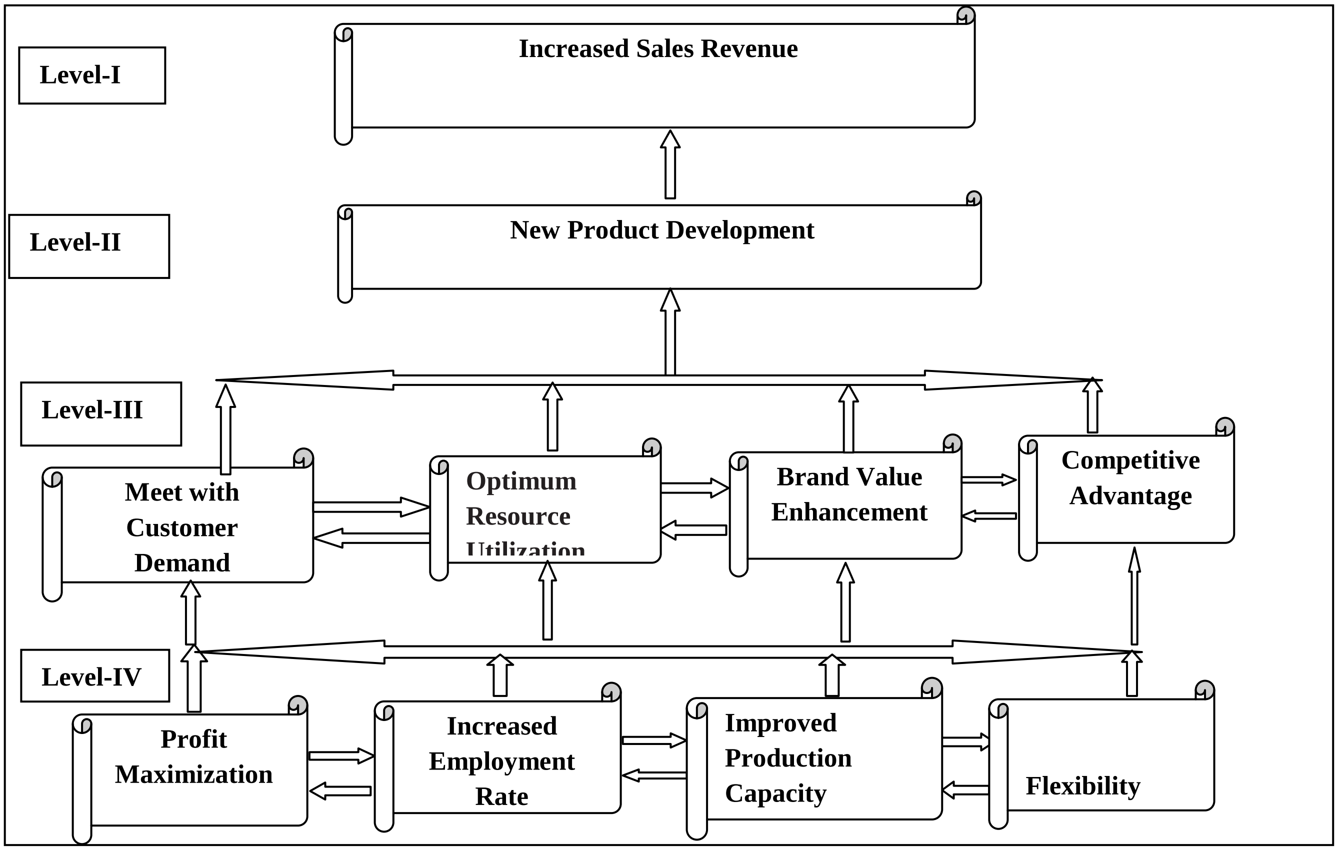


Figure 5.9: ISM diagram for the Performance Measures

Table 5.24: Conical Matrix

Driving Power	08	08	09	10	06	10	08	09	07	10
Dependence Power	10	10	10	03	10	08	10	10	09	05

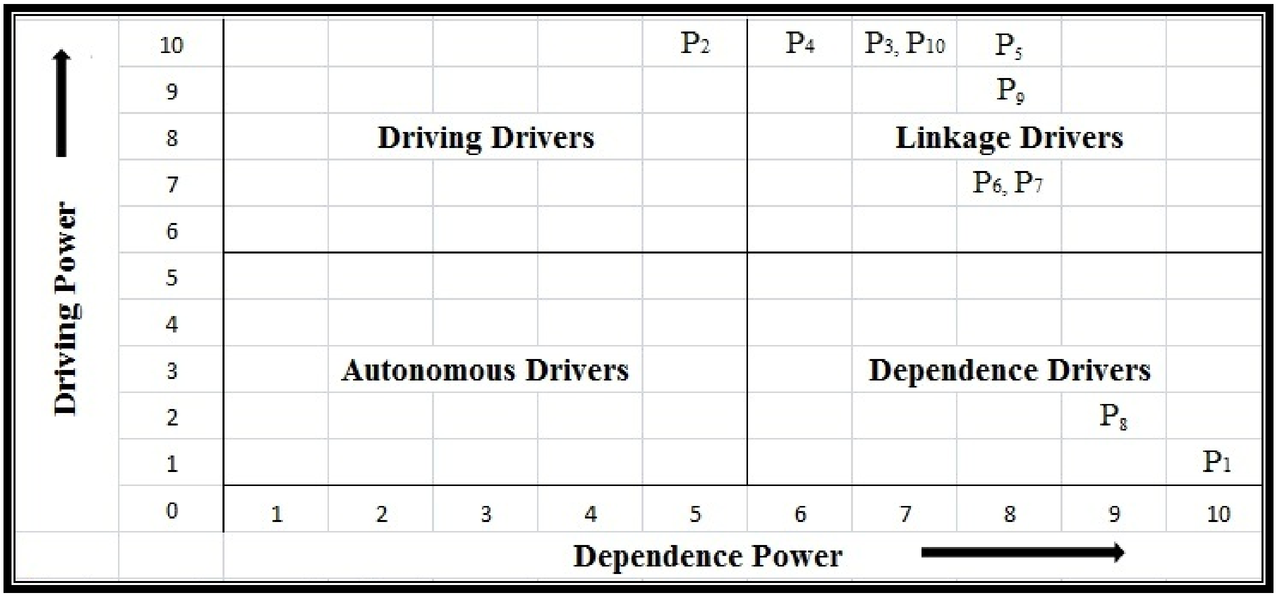


Figure 5.10: MICMAC Analysis of the Performance Measures

Table 5.24: MICMAC Analysis Summarization

Autonomous Drivers	In the present case, there is no variable lying in the autonomous region. So, this region is disconnected from the present system.
Dependence Drivers	In this region, variable P_1 and P_8 are lying and named as a dependent enabler. It means the increased sales revenue and new product development are the dependent variables on all other variables.
Linkage Drivers	In the present work, the variables P_3, P_4, P_5, P_6, P_7, P_9, and P_{10} are lying and named as the Linkage Drivers.
Driving Drivers	In this region, variable P_2 is laying which means this is the driving measure for organizational performance.

The MICMAC analysis as shown in table 5.24 reveals that the performance in an organization is mainly explained through the profit maximization. The other criteria such as increased employment rate, improved production capacity, meet with customer demand, optimum resource utilization, brand value enhancement, and flexibility are the linkage drivers which has the capacity to drive as well as dependent on each other. The increased sales revenue and new product development contribute to a little bit as the performance measures of an organization.

Summary of the study: To reveal the success story of an organization, the performance measurement is the only way to accomplish the task. In an organization, the performance can be measured through its attributes as discussed earlier in this section. In general, it is necessary to evaluate the effectiveness of an organization based on the attributes. As per the study, profit maximization is the main objective of all the organizations. It can help to drive the other measures like imparting flexibility in the organization to meet with customer demand, increasing the employment rate, increasing the production capacity etc.

5.5 CHAPTER SUMMARY

In the present scenario, the manufacturing sector has grown up with very complex structures that result in inadequacies and inabilities in managing the resources within and outside the organization. Due to this fact, the individual variable of each problem statement is addressed well in time. ISM helps in prioritizing the variables according to their contribution i.e. affect the final cause/problem. The outcomes of ISM will provide the strongest support for developing the model for the present study.

CHAPTER 6

RELATIONSHIP BETWEEN LEAN, SUPPLY CHAIN AND PERFORMANCE: A MODEL

6.1 INTRODUCTION

The manufacturing of any item is not an easy task in the present environment because of varying customer demand on attributes like cost, quality, and design. That's-why, the manufacturing sector has received a great deal of attention to producing the products by efficient utilization of all concerned resources. The market has become the customer oriented, so there is still no consensus on how best to measure and manage the resources within and outside the industry. Further, global competition is forcing an entrepreneur's to cut the corners on customer deliveries and input production cost. Under these circumstances, the production scheduling and management (like minimum inventory, occupancy of the workforce) are the important factors affecting the performance of an industry.

The role of lean thinking and supply chain characteristics is to create an effective marked on the organizational performance, including bonding of all the participants where-so-ever possible. The purpose of this work is to examine the challenges, which integrate the Lean Principles to Supply Chain Characteristics for the real world situation to achieve better utilization of resources, timely delivery to the customer, and deletion of non-value added items including the control of all types of wastages as linked with supply chain systems.

"A set of organizations directly linked by upstream and downstream flows of products, services, finances and information that collaboratively work to reduce cost and waste by efficiently and effectively pulling what is needed to meet the needs of the individual customer."

6.2 NEED TO CALL THE CHANGES IN MANUFACTURING CONTEXT

The competitive environment forced the manufacturing context to maximize its output on the other hand reduction in the resources consumption as well. The faster communication to customers regarding the product design, quality, comparative index (various aspect in comparing the same kind of products offered by competitors), availability etc. and the demand communication to the manufacturer influenced the market scenario. In addition, the stringent regulations on the manufacturing context to meet the specific demand as depicted by the national/international market also impact the sustainability of the manufacturing industries in the long-term running business entities. [Dunphy, 1996]

In an Indian manufacturing context, the globalization has resulted in a competitive environment with the uncertainty in customer demands, due to plethoric imports of all types. This has created large volatility calling for a fighting spirit and a huge pressure for improvement in design, quality, and services of products. There is thus a need for meeting customer satisfaction achieved through lower costs, which may be materialized by effective monitoring of product flow, efficient utilization of all the resources with high-performance rates. [Kumar et al., 2015 (a)] The literature on manufacturing context reveals the domination of manufacturing process like the design; development and delivery are caused by the customer needs as the demand reaches from the customer right back to the raw material suppliers. [Reichhart and Holweg, 2006]

The improvement in the manufacturing industry performance has been the never-ending effort, which is being driven by the culture of the organization. Therefore, an attitude of perfection, innovation, and devotion is an essential part of the performance improvement of an organization. Recently, innovations in the field of engineering have helped the manufacturing context to produce and sold the products in the very short span of time and making more profits. Perhaps, the design criteria; cost and timely delivery of goods, works as the yardstick, which contributes to the performance index. The performance of the manufacturing industry is mainly dependent on how best the industry utilizes the resources pertaining to the industry.

The implementation of lean principles in the manufacturing context reveals the changes in the value stream (flow stream through which the material flow from one workstation to other) and finally impact on the organizational performance. Still, there is a consequence remains in the manufacturer mind on various attributes like supply chain operations; management decisions; and workforce contribution etc. in the newly developed value stream (modified one).

To overcome the consequences discussed earlier in the last para, the supply chain of the manufacturing context should be lean so that maximum benefits within the organization are to be sustainably realized. [Melton et al. 2005] The lean manufacturing approach can be applied to all the aspects of the manufacturing organization supply chain. It helps in developing the pull production paradigm that extended beyond the boundary of the manufacturing organization to include the upstream and downstream of all the supply chain partners. [Hines et al., 2004]

6.3 IDENTIFICATION OF COMMANILITIES AMONG LEAN MANUFACTURING AND THE SUPPLY CHAIN

The published literature (surveys/case studies outcomes) reports the evidence for the failure of both the methodologies of Lean manufacturing and SCM in Indian manufacturing context when these approaches applied individually. The huge gap between the desired results and the actual output of their respective process resulted from partial applications. In addition, the product features and parameters are increasingly dependent upon the organization's competencies regarding infrastructural adequacies and abilities of the organization to manage its equipment and facilities in an optimal manner. That's-why single tool/technique is not subsequent to achieving the desired goal.

A report published by Ventana gives in-depth insights on integrating the lean principles among the supply chain. The report also reveals the common attributes among both the approaches which enable the uninterrupted flow of resources and information. The least common attributes were siphoned out as below:

a) **Demand Management**: An unyielding focus on demand for the product is perhaps the guiding attribute for any approach. For example, if a product for which there is no demand enters the supply chain, it creates the wastages of resources. Both LM and SCM manages the demand and supply for the manufacturing organization.

b) **Standardization:** For the manufacturing organization, it is compulsory that the organization should adopt the concept of standardization. The standardization process is referred as a management approach of an organization centered on Lean thinking or effectiveness of the entire supply chains, which is based on the participation of all its members and aiming at long-term success through customer satisfaction and benefits to all members of the organization and society. In other words, the standardization process is creating the uniformity in all business activities throughout all divisions of the concerned organization. There are three kinds of standardization:

(i) **Process Standardization**: Process standardization stands for providing continuous flow throughout the value chain. Both the approach will help to standardize the processes used for the transformation of raw material into the final goods.

(ii) **Product Standardization**: It is a very critical aspect for continuous supply chain flow because it keeps the company locked to one vendor for the component, and the company can use the same component in many products it manufactures. Component standardization reduces required inventory levels because of the common use of components in many products and standardization can enhance the ability of the company to develop postponement initiatives.

(iii) **Industry Standardization***:* Standardization will help to reduce waste in the company's supply chain management by reducing the complexity and development costs of products and product variation through interchangeability, and it reduces the complexity of required supporting information.

c) **Collaboration**: This is the main attribute because it keeps the organization in collaborative activities within the company and with suppliers and customers, which is very crucial in actual. Without collaboration, the smooth flow of information and product required for a lean supply chain can't be enabled.

d) **Cultural Change**: Culture changes are requisites for changing the manufacturing scenario from the traditional one to Lean or SCM. Every participant in the process must concentrate on company objectives like reduction of waste, cost and many others. All the organizations have the requisites of creating the culture which is not just a goal at the beginning stage it should continue to the long-term aspect.

6.4 ESTABLISHING THE RELATIONSHIP AMONG LEAN PRINCIPLES, SUPPLY CHAIN CHARACTERISTICS, MANUFACTURING STRATEGY AND PERFORMANCE

The Japanese automotive products manufacturing industries are well-known for their contribution to the industrial revolution i.e. in the production sector and quality as well. They developed several techniques to increase the production rate, subsequently work on a quality aspect of the products. Contribution by Taiichi Ohno (an Industrial Engineer) at Toyota Motor Corporation after the Second World War was remarkable. He developed the Toyota Production System (TPS) with the help of which the production rate and quality of the product increased. In the Western countries, TPS was known as Just-in-Time (JIT) in the initial stage later on modified as the Lean Manufacturing. [Womack and Jones, 2003; Reichhart and Holweg, 2007; Ozelkan *et al.*, 2007]

The literature reveals that lean thinking in general help to understand the industrial processes and their contribution on an individual basis in the final product. [Bhasin and Burcher, 2006] At the earlier age, lean is simply focused on shop-floor which only works on reduction in wastages. But nowadays, it is referred to the cost and waste reducing approach i.e. reduce the cost of operations that consistently sought to increase value for customers by adding product or service features and removing wasteful activities. [Hines et al., 2004; Taylor and Pettit, 2009]

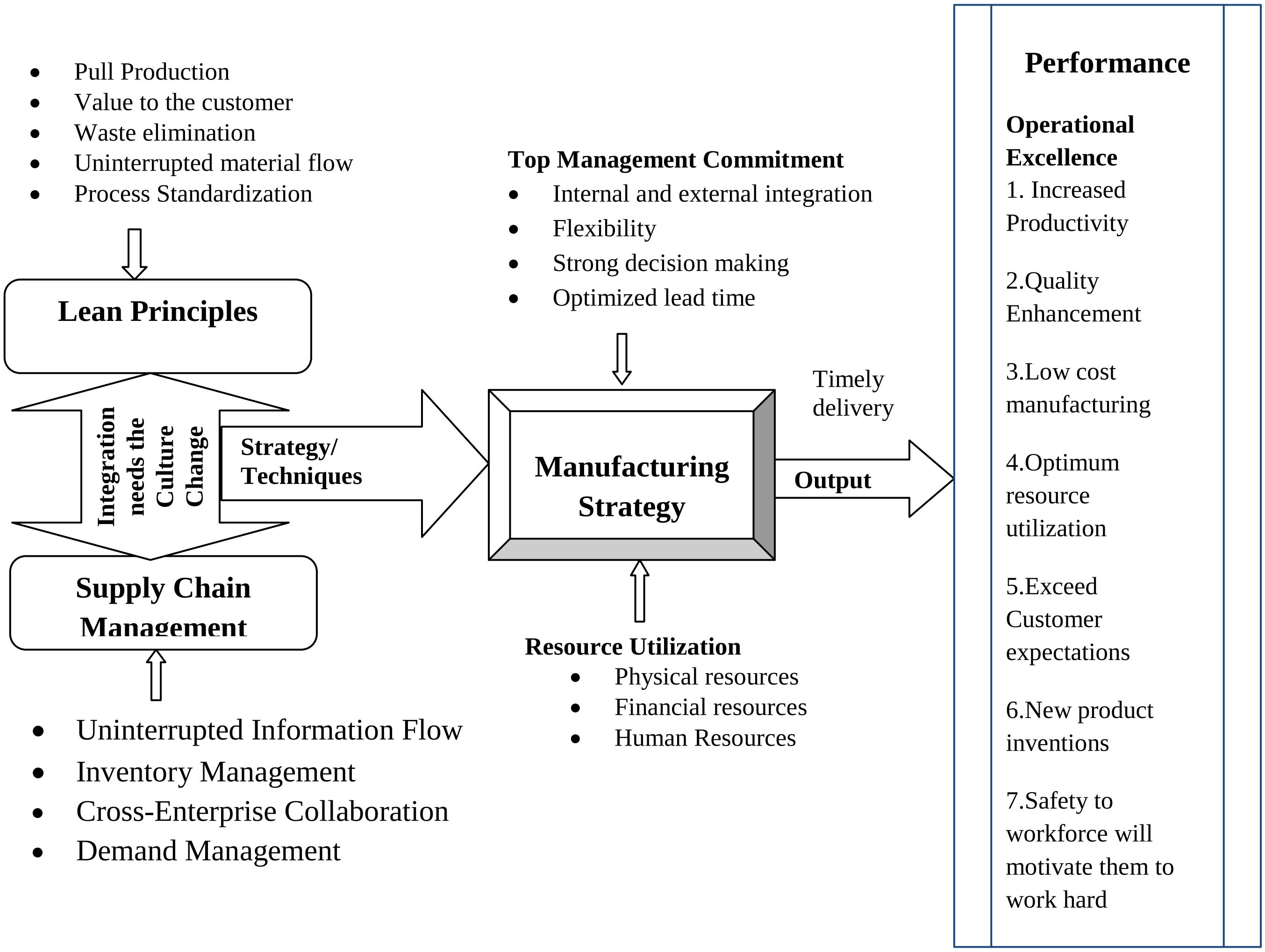


Figure 6.1: Theoretical model for the present study

6.4.1 Benefits of establishing a relationship

Lean manufacturing, in general, is a tool that integrates the value stream of the material flow from one workstation to another. It helps in segregating the value addition and nonvalue addition processes and also provides the basis for how the nonvalue-added activities can be removed. As far as the present scenario consideration, it is difficult to get the optimum results with the utilization of single tool in practice. The integration attempt of lean manufacturing in the supply chain supports the manufacturing process and improves the output that creates substantial opportunities in the market. [McKee and Ross, 2009; Jasti et al., 2012] The coupling of these approaches will brief the requisites of current technological revolution and help in setting the Indian manufacturing context aims to 2025 as shown in table 6.1 (Modified Bordogna Model).

Table 6.1: Modified Manufacturing Strategies Model [Bordogna, 1996]

Attributes to be considered for differentiating the manufacturing strategies	**Manufacturing Strategy**				
	Customized Production	**Mass Production**	**Automation Production**	**Next Generation Production**	**Current Technological revolution**
Time Frame	Always	1800's to present	1950's to present	1990's beyond	2025 Vision
Lot Sizes	Small	Very Large	Moderate	Small	Single
Unit Costs	High	Low	Moderate	Low	Least
Quality	Variable	Good	Good	Excellent	World Class
Delivery Times	Long	Long	Moderate	Short	JIT based
Flexibility	High	Low	Moderate	High	Very High
Education and Training	Apprentice	Limited	Moderate	High Continuous	JIT
Environmental Consciousness	Low	Low	Moderate	High	Very High

The integration also helps in meeting with the customer satisfaction achieved through lowering the product cost which may be the result of effective monitoring of product flow or the efficient utilization of all the resources. The benefits of the integration of lean manufacturing with the manufacturing industry supply chain are as follows:

- The recognition of non-value added activities in an organization's supply chain such as incorrect lot size, nonavailability of material, frequent setup changes and a high degree of rejections/rework is a massive task to the entrepreneur. This non-value added activities further leads to insufficient utilization of resources.

- Customer value identification is crucial and deviated from the production floor focus towards a logical approach that helps in controlling the wasteful activities. This situation is achieved by using modern management principles like JIT, LSCM, Six-Sigma, TQM, TPM to make the system customer order driven. The lack of exposure to the latest management principles and strategies in the manufacturing arena leads to shortages and blockage of the product while manufacturing and also the low-quality production with the high cost of production. [Sharma et al., 2012;
- In an Indian Environment, the building of a congenial atmosphere is the topmost priority of the manufacturer to generate the success and adaptability of the improvement plans. Further, the implementation of new strategies is curtailed due to lack of response from workers. This is the fact that the behavioral aspect of the organization workers plays a very important role in designing the organizing style and very dependent on the situational constraints of the environment in which the workers operate.
- Another fact in Indian environment is that most of the industries comprise of small scale and medium scale units which employed a large no. of the workforce with certain constraints, especially the education level of the working supervisors/managers. The workforce does require the continued and tailor-made programs to implement scientific management in varying scientific ways.
- The present environment relies on customer demand and it is one of the best tools to guide the entrepreneur regarding the profitable and effective running of the business. So, it is very difficult to prioritize customer demand and optimize customer demand through satisfaction.

6.5 WORK CULTURE IN MANUFACTURING CONTEXT

The perspective behind defining the importance of work culture referring to the values imparted in the workforce (belief and motivation) and the introduction of the assumptions (policies) developed with the common agreement of the employees. It is also subject to a variety of circumstances, such as national context, professional culture, and organizational characteristics. [Deal and Kennedy, 1983; Madu, 2011] The organization must offer a positive ambiance to the employees (motivation) for them to concentrate on their work as defined by the employer. When all the employees of the organization strictly follow the organization's rules and regulations, the organization is said to have a strong work culture. [Amako-Gyampah, 2000; Khatib, 1996; Karlsson and Ahlstrom, 1996]

In addition, the presence of uncertainty in the global market (means market changes dynamically and drastically) that enforced the manufacturing sector to perform constantly confronted with the challenges i.e time, cost, delivery, and quality. The dynamic nature of the market will further result in dissatisfaction with the customer as well as the producers. [Macduffie, 1995]

6.5.1 Importance of Work Culture

The literature reveals that it is critical to evaluate and measure the status of work culture importance in an organization. Despite the fact, the organizations always seek to improve the performance inadequacies in man-machine management. The importance of work culture in an organization is as follows:

- To satisfy the employees and employers through the common agreement on decisions,
- To create interconnectivity through the advanced communication channels,
- To design the best policies for the appreciation and motivation of employees
- To encourage the cordial discussion among the employees for the real-life problems,
- To promote the concept of team building. [Jelinek et al., 1983; Willcoxson and Millett, 2000; Mozaffarri, 2008; Fehr, 2012]

6.5.2 Identification of Work Culture Enablers

The Harward business school research reports the 4'C concept model to evaluate the performance of Human Resource Development i.e. Congruence, Commitment, Competence, and Cost-effectiveness. To continue with the 4'C concept the present work identifies the 10 commandants for the healthy work-culture discussed below:

1. **Congruence:** Congruence means a common agreement/harmony, which is compatible with the working environment for all the employees. For a successful organization, congruence plays a very important role by uniting all the employees to do work in a harmonious manner.
2. **Concentration and Cooperation:** In general, cooperation and concentration are the two different concepts but act as concentric. Both the concept has the common goal of focusing the attention on all individuals (Employer and Employees) on organizational goals and objectives. These concepts unite the workforce and generate a spirit to fight wasteful activities. [Boardman, 1995]
3. **Commitment:** Commitment is a state of being dedicated to a common goal-activity-objective. It is resulted in engaging all the activities within the restricted freedom of action. [Emiliani and Stec, 2004; Nongo et al., 2012]
4. **Concerted:** In industry, Concerted stands for arranging the activities of production, sales, and marketing, packaging, etc. (Which are the interdependent activities) with an agreement between employees and employers. It's a very tough task to arrange all the activities throughout the organization; therefore, the activities will be done or performed together with equal importance.
5. **Conceivable:** Conceivable means the adoption of a single possible scheme throughout all activities of an organization from various possibilities. It involves due planning and predictability to paint the implementation scheme and the belief of effective achievement.
6. **Contribution: C**ontribution generally referred to as a course of action performed by an individual in an organization to bring out the results or helping something to reach its accelerated stage under the desired environment.
7. **Consistency:** Maintaining the compatibility of system constituents with the system under undefined environmental conditions is termed as Consistency i.e. Uniformity among the substitutes of a complex system. In a manufacturing organization, the waviness in the process output is resulted because of complexity in the production system involved. The flow of information is so consistent that any undesirable information does not seep into the system, making it monotonous and does the workflow smoothly. [Sharma and Threja, 2011]

8. **Contingency/Cost-effectiveness:** It is well-known fact that in any production system the great deal of relevance in the productivity with the cost of the production process, curtailment of overproduction, the effectiveness of Pull production System etc. Every process in the manufacturing industry engages huge costs with it and the outcome of the process is measured through productivity in compliance with the cost incurred on it. [Threja, 2016]
9. **Convergence:** The contingency is referred to as the possible provision to ensure the future event or circumstances, which is possible, but can't be predicted with certainty at the earlier stage of occurrence.
10. **Compettitude (Competence + Attitude):** It is an art of manifestation of human intellectual achievements regarding the common goals and objectives with competence. In all the industries, every individual member contributed his required work performance in a collective manner to attain the desired objectives of the industry in terms of cost and time front, in both quantitative and qualitative manner, and the effective utilization of all the resources. [Schein, 2000; Thareja, 2011(a)]

The Ten Commandments (Enablers), if applied in any manufacturing sector in a systematic and arranged manner, leads to the existence of a smooth and congenial atmosphere. The commandments help in revising the process of the manufacturing process by arranging the activities in a purposeful manner. Further, these commandments shall increase the production capacity, reduction in lead-time, and most importantly, the reduction in decision uncertainty that shall have an effect to stay in the market and be a part of the competitive spirit.

6.6 WORKS-CULTURE ENABLERS CONTRIBUTING IN LEAN AND SUPPLY CHAIN

In today's era, the enablers listed above play a major role in arranging all the facilities in a congenial manner and also respond to due sentiments of producer and customer. Moreover, the cost-cutting in the production system along with distribution and delivery to the customer end promises the necessary competitiveness to stay in the market. Table 6.2 represents the role of work culture enablers in lean manufacturing and supply chain management.

Table 6.2: Role of Work-Culture enablers in Lean Manufacturing and Supply Chain

Sr. No.	Commandments	Principle of Working	
		Lean Principles	**Supply Chain Characteristics**
1	Congruence	Lean principles provide congeniality in the individual working that will result in a harmonious group effort.	SCM links all the suppliers and customers with the organization and each one of them is congruent i.e. meeting the single harmonious effort exactly by superimposing one above the other.
2	Cooperation & Concentration	Lean Principles have a basic focus on identification of wasteful activities, which are indulged with the process i.e. non-value added activities because-of, customer perception as not to pay for these activities.	Supply Chain has the concentration on communication between the customer and the supplier.
3	Commitment	Application of Lean principle is the commitment towards eliminating wastes, which may be in any of forms such as transportation, inventory, work in progress, space, over-production and repetitive processes etc.	SCM is committed to the following path of least resistance so-far-as information travel is concerned.
4	Concerted	Lean Principles assist each individual to grab an opportunity so-that system can be made faster and acceptable for the whole society.	SCM is having a strong link of cooperation between supplier and customer, as the forecast is no more relevant under this SCM scenario.
5	Conceivable	Lean Principles contributes towards compiling huge savings in terms of materials, men, time and money making the organization competent enough to fight on the global front.	Contribution plays a big role in the whole supply chain so as to accept the product by the customer as it involves low expenditure, best design, and best quality.
6	Contribution	The application of Lean Principles, smoothened-out the process-waviness and create a smooth workflow environment with consistency in eliminating the common cause of waviness i.e. blockages or shortages.	The flow of information is so consistent that any undesirable information does not seep into the system making it monotonous and does the workflow smoothly.

7	Consistency	Lean makes the entire supply chain system cost-effective making enterprise cost-efficient and giving an edge for survival in the global market.	The system becomes so cost-effective that the product is directly acceptable by the customer in the first go itself because of best feature designs, cost-effective process, zero defect and highly competitive on the price.
8	Contingency/ Cost-effectiveness	The adoption of Lean principles will have an incidental provision to the non-value added activities because these activities never add to the value of the product being delivered to the customer.	Supply Chain coordination takes care of all the supplementary issues apart from the main contributors of upward and downward movement. It provides not only a contingency plan rather the full-fledged workout detail to stay and protect your head in the global competitive environment
9	Convergence	A lean program is a powerful tool for the management, which makes the entire system complementary to each other since, all the resources like a man, machines, materials, and methods get concentrated around Lean principles.	Supply coordination in the competitive market provides scoring on any other issues, which make the system competent enough to withstand varying market pressures.
10	Compettitude (Competence+Attitude)	The principles of Lean Manufacturing creates a working culture in which all the participants perform their task in an effective and efficient manner that will lead to the success of the industry.	On applying the philosophy/principles of supply chain system there is a great impact on the performance of each individual as well as the group which forms the part of the organization. The culture goes a major change making it more congenial, happily going, understanding the sentiments and respect for each other.

6.7 IMPLEMENTING ISM APPROACH ON WORK CULTURE ENABLERS

The study advances the current knowledge base of the employees and employers of all the manufacturing organizations by developing the ISM model that will further help in attaining the healthy work culture.

Step 1: Identification of work culture enablers

The present work initiates with the identification of work-culture enablers as compiled in Table 6.3 below with their brief working principles.

Table 6.3: Principle of working of Ten Commandments

Sr. No.	Commandments (Work-Culture Enablers)	Principle of Working
1	Congruence	Commitment, harmony, and compatibility within the organization
2	Cooperation & Concentration	Command/Power to focus on common goals by all employees and employer, Working Together
3	Commitment	Engaging all the activities within the restricted freedom of action
4	Concerted	Done together for a shared purpose
5	Conceivable	Planning and predictability
6	Contribution	The various course of actions performed by an individual for the results
7	Consistency	Uniformity among the sub-constituents of a complex system
8	Contingency/ Cost-effectiveness	Sustain the cost and provisions at a significant low level through higher productivity measures. It enables the maneuver future events and system sustainability for a long time
9	Convergence	Involves the processes and energies to meet goals
10	Compettitude (Competence+Attitude)	The capability to carry out the various course of action on cost front as well as on time front in both the manner (Qualitative and Quantitative). With attitude, human intellectual achievements get utilize to meet common goals and objective.

Step 2: Development of contextual relationship among variables

The relative importance of the variables (Work Culture Enablers) also referred to as contextual relationship establishment is done through Causal Approach based on the judgmental opinions of the expert in the same area. The inputs provided by the expert is used to establish the contextual relationship among the variables with respect to their influence on each other and shown in table 6.4.

Table 6.4: Contextual relationship among the Work–Culture enablers

Work-Culture Enablers	WC_{10}	WC_9	WC_8	WC_7	WC_6	WC_5	WC_4	WC_3	WC_2
WC_1	A	V	V	V	V	A	V	O	V
WC_2	A	V	V	V	X	A	V	V	
WC_3	A	V	V	V	V	V	A		
WC_4	A	A	V	V	A	V			
WC_5	A	A	A	O	A				
WC_6	A	V	V	O					
WC_7	A	A	V						
WC_8	A	V							
WC_9	A								

Step 3: Development of SSIM

After the development of contextual relationship among the variables, the binary matrix is developed by keeping the table 6.4 as a reference. Table 6.5 shows the Self Structured Interaction Matrix for the present study.

Table 6.5: SSIM (Initial Reachability Matrix)

Work-Culture Enablers	WC_1	WC_2	WC_3	WC_4	WC_5	WC_6	WC_7	WC_8	WC_9	WC_{10}
WC_1	1	1	0	1	0	1	1	1	1	0
WC_2	0	1	1	1	0	1	1	1	1	0
WC_3	0	0	1	0	1	1	1	1	1	0
WC_4	0	0	1	1	1	0	1	1	0	0
WC_5	1	1	0	0	1	0	0	0	0	0
WC_6	0	1	0	1	1	1	0	1	1	0
WC_7	0	0	0	0	0	0	1	1	0	0
WC_8	0	0	0	0	1	0	0	1	1	0
WC_9	0	0	0	1	1	0	1	0	1	0
WC_{10}	1	1	1	1	1	1	1	1	1	1

Table 6.6: Incorporating Transitivity (Final Reachability Matrix)

Work-Culture	WC	WC	WC	WC	WC	WC	WC	WC	WC	WC_1	Drivin
WC_1	1	1	1*	1	1*	1	1	1	1	0	**09**
WC_2	0	1	1	1	1*	1	1	1	1	0	**08**
WC_3	1*	1*	1	1*	1	1	1	1	1	0	**09**
WC_4	1*	1*	1	1	1	1*	1	1	1*	0	**09**
WC_5	1	1	1*	1*	1	1*	1*	1*	1*	0	**09**
WC_6	1*	1	1*	1	1	1	1*	1	1	0	**09**
WC_7	0	0	0	0	1*	0	1	1	1*	0	**04**
WC_8	1*	1*	0	1*	1	0	1*	1	1	0	**07**
WC_9	1*	1*	1*	1	1	0	1	1*	1	0	**08**
WC_{10}	1	1	1	1	1	1	1	1	1	1	**10**
Dependence Power	**08**	**09**	**08**	**09**	**10**	**07**	**10**	**10**	**10**	**1**	**82**

Step 4: Development of the diagraph

The diagraph for the present study is developed with the help of level partitioning as shown in table 6.7. The variables at different levels are then used for developing the ISM diagraph as shown in figure 6.2.

Table 6.7: Level Partitioning

Work-Culture Enablers	**Reachability Set (RS)**	**Antecedent Set (AS)**	**Intersection**	**Leve l**
WC_{10}	1,2,3,4,5,6,7,8,9,10	10	10	4^{th}
WC_1	1,2,3,4,5,6,7,8,9	1,3,4,5,6,8,9,10	1	3^{rd}
WC_2	2,3,4,5,6,7,8,9	1,2,3,4,5,6,8,9,10	2,3,4,6	2^{nd}
WC_3	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,9,10	1,2,3,4,6	2^{nd}
WC_4	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,8,9,10	1,2,3,4,6	2^{nd}
WC_6	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,6	2^{nd}
WC_5	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9	1^{st}
WC_7	5,7,8,9	1,2,3,4,5,6,7,8,9,10	5,7,8,9	1^{st}
WC_8	1,2,4,5,7,8,9	1,2,3,4,5,6,7,8,9,10	1,2,4,5,7,8,9	1^{st}
WC_9	1,2,3,4,5,7,8,9	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,7,8,9	1^{st}

The table concludes the levels of each variable as WC_5, WC_7, $_WC_8$, and WC_9 are at the 1^{st} level, WC_2, WC_3, WC_4, and WC_6 are at the 2^{nd} level, WC_1 is at the 3^{rd} level and WC_{10} is at the 4^{th}

Level.

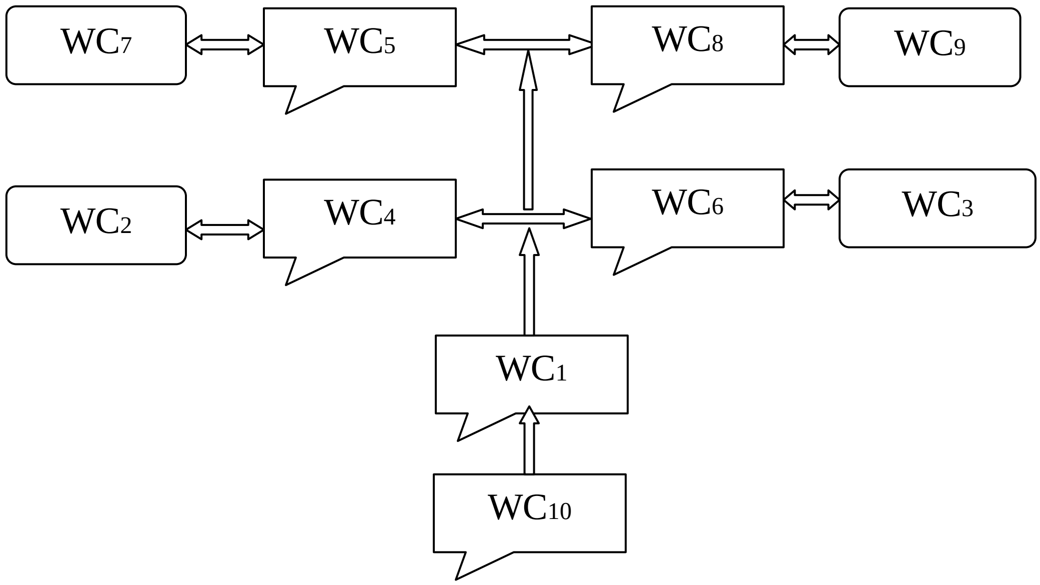


Figure 6.2: Diagraph for the Work-Culture enablers

Step 5: Development of the ISM model

The digraph as in figure 6.2 is now converted into an ISM model by replacing nodes of the elements with work-culture enablers as shown in figure 6.3.

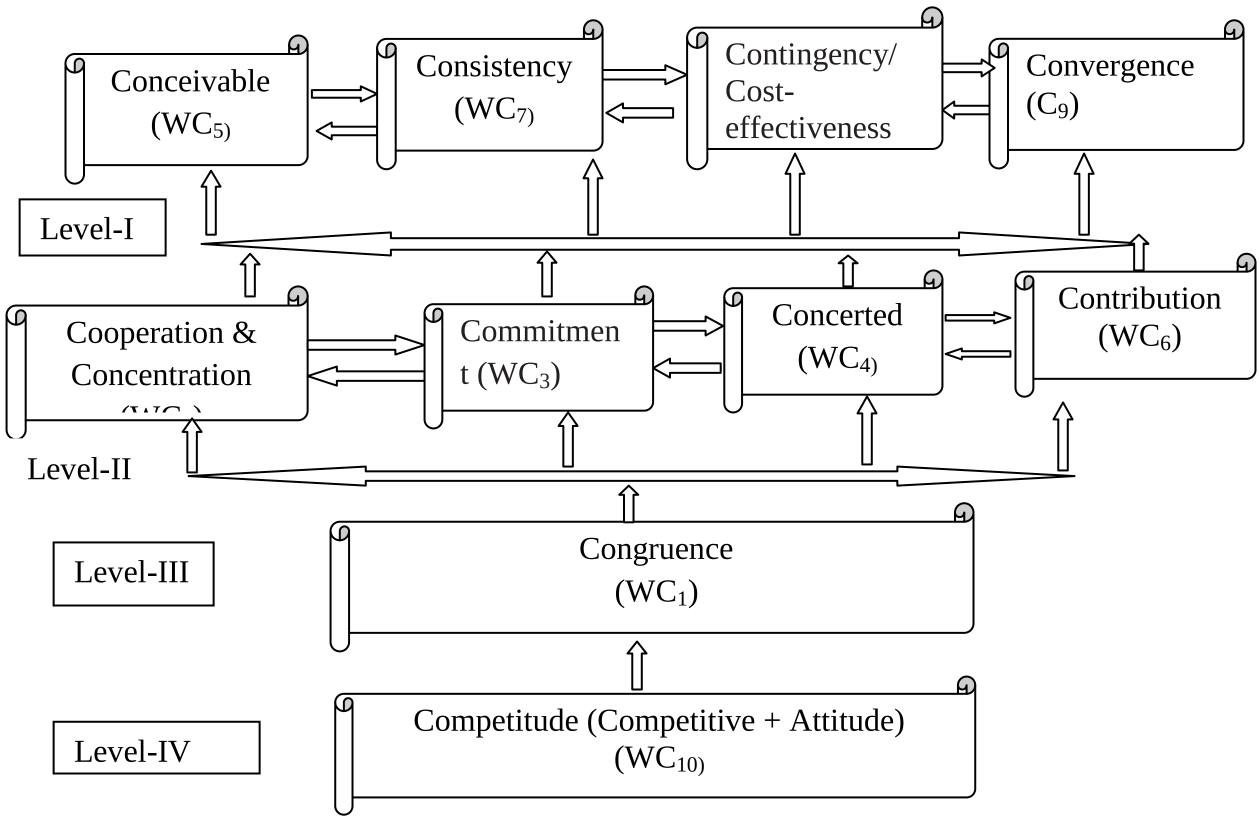


Figure 6.3: ISM Diagraph for the Work-Culture enablers

Step 6 MICMAC analysis

Later on, the MICMAC analysis is done to analyze the driving or dependence power for the variables as given in conical matrix table 6.7.

Table 6.8: Conical Matrix

Driving Power	09	08	09	09	09	09	04	07	08	10
Dependence Power	08	09	08	09	10	07	10	10	10	1

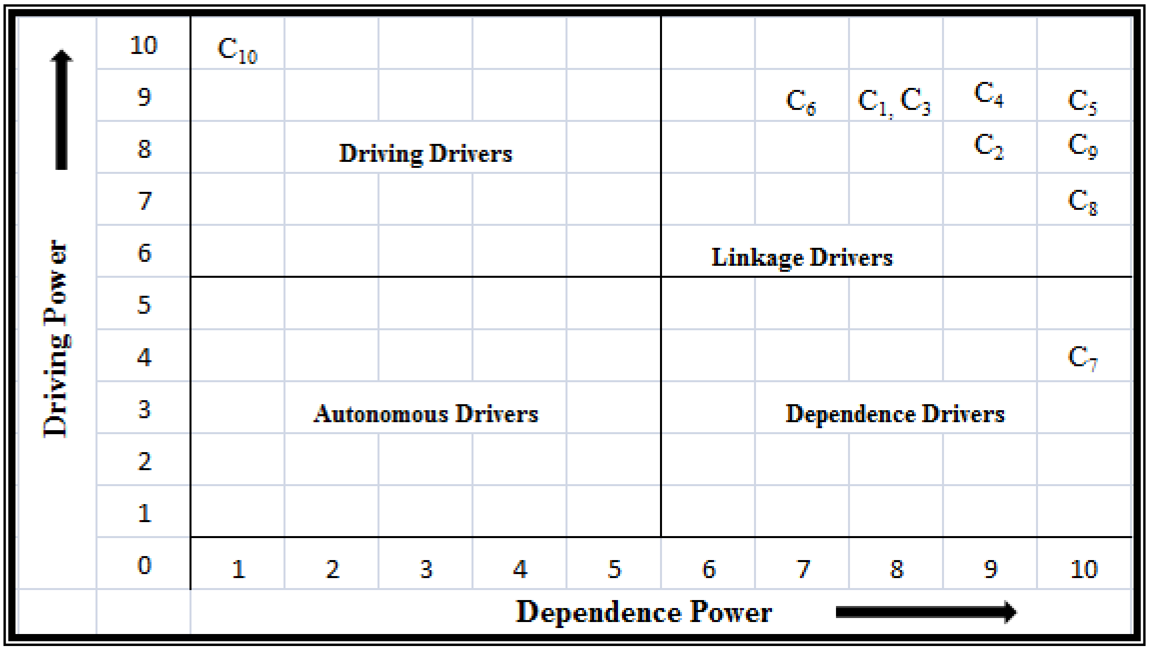


Figure 6.4: MICMAC Analysis for the Work-Culture enablers

Table 6.8: MICMAC analysis results

Region 1	Autonomous Drivers	The variables that have the weak drive power as well as weak dependence on other variables. In the present case, there is no variable lying in the autonomous region. So, this region is disconnected from the present system.
Region 2	Dependence Drivers	The variables that have the weak drive power but strongly dependent on others are lying in this region. In this region, variable WC_7 is lying and named as a dependent enabler. It means the Consistency in an organization has the dependency on the other variables such as contribution, cooperation etc.
Region 3	Linkage Drivers	The variable that has both the drive power as well as the dependence on other variables strongly are lying in this region. In the present work, the variables WC_1, WC_2, WC_3, WC_4, WC_5, WC_6, WC_8, and WC_9 are lying and named as the Linkage Drivers.
Region 4	Driving Drivers	The variable that has the strong drive power but having a weak dependence on others is termed as the Driving Driver. In this region, variable WC_{10} is laying which means this is the driving enabler for the healthy work culture.

Summary of the work:

In the present research, the Competitude (Competitive + Attitude) is found the main driving enabler for the healthy work culture. In the present scenario, the work culture has the only objective to eliminate the wastes and it is possible only when the resources are fully utilized. Compettitude in the hierarchical progression from the work floor workmen's to the top level management helps in morale building to improve all in one's performance level. The enablers such as Congruence; Cooperation & Concentration; Commitment; Concerted; Conceivable; Contribution; Contingency/Cost-effectiveness and Convergence are lying in Linkage Region having the high driving and dependence power. From the literature, it is depicted that group effort in an organization will result in improving the cost, quality, time and productivity. These enablers are unstable in the system i.e. any action on one of these enablers may have the effect the corresponding enablers i.e. affect the organizational culture. The Consistency (WC_7) is lying in the dependent region, which means that this enabler has weak driving force; simultaneously have a high dependence on the other enablers. The consistency aspect in the organizational framework maintains the compatibility of system constituents with the system under undefined work environment. As depicted in the literature, Consistency has the dependency on the group efforts like cooperation, contribution etc.

6.8 CHAPTER SUMMARY

The chapter discusses the need to call the change in the manufacturing context i.e. "Why the supply chain should be lean?" The present work reveals the application of any individual approach (i.e. lean manufacturing or supply chain) may result in improvements, but on the other hand, it will affect the other allied areas. So there is an opportunity for the manufacturing sector i.e. to combine/coupled both the approaches on a single platform. This will reduce the chance of uncertain conditions within the system.

Another fact is the globalization of the market, due to which the manufacturing context bounds to some specific mission and visions; and all these are measurable with a huge variety of attributes. The expected value or an outcome desired at the beginning is attainable if and only if all the happenings are going in the right way. So that, the concept of the lean supply chain (coupling of lean and supply chain) gives an advancement of the manufacturing system of the organization under which all activities can happen timely and the output is realistic. In addition, the chapter reveals the relationship and the impact of established relationship on the organizational performance. The common attributes of the lean principles and supply chain management are identified through literature and discussed.

CHAPTER 7

RESULTS, CONCLUSION AND FUTURE SCOPE OF THE WORK

7.1 INTRODUCTION

The journey of lean manufacturing and the supply chain management is following the well-known proverb i.e. "slow and steady wins the race". Likewise, both the approaches came into existence around 1970 and getting their momentum slowly-slowly. The earlier researchers on both the approaches (Individually) reveal the contribution in the manufacturing context. Almost five-decade has been passed, still, some gaps are perceived in the manufacturing context i.e. interrupted flow chain, unsatisfied customers etc. The reason behind these gaps is the discriminating expectations of customers which creates the uncertainties in the business environment. The consistency in sustaining the output is reported as lips & bounds particularly in the manufacturing sector while adopting these approaches. The application of LM and SCM in Indian manufacturing context reveals that the lean has supported manufacturer views, which results in significant increases in productivity and quality, while SCM reducing lead times. Both the Lean and supply chain has the most significant objectives as common such as profit increment, customer satisfaction, and quality of the product including timely delivery to customer hand etc.

7.2 SUMMARY OF RESEARCH WORK

The present work is based on relationship establishment among LM, SCC, MS, and Performance. The research summary is as follows:

1. In the first phase of the present study, the work carried out by the practitioners and academicians i.e. research articles, books, and websites are studied for understanding the concept of lean principles and the supply chain, manufacturing strategy, and performance.

2. The extensive literature reveals the gap between the actual and proposed results for the application of LM and SCM because of barriers such as unjustified networking distribution, the various distribution strategies, trade-offs impacts, interruption in the flow of information & resources, management of inventory, and especially the cash-flow etc. The literature also supports that the barriers for both the approaches are common and gives an indication to *'Why the supply chain of manufacturing industry is to be lean?'*

3. The gap perceived from literature is further used for developing the research directions. The aim of the present study is as follows:

   - To provide the valuable products/services for which customers are willing to pay
   - To develop the advanced performance measurement systems to deal with the flexibility required of the system,
   - To set-out the linkage between the suppliers and the customers to avoid interruption in the flow of resources,
   - To manage and optimize resource utilization, and
   - To prosper and indeed survive on the organizations in the present competitive environment.

4. To accomplish the task, the various dimensions/parameters related to both approaches identified based on literature and used for survey purpose of manufacturing industries in India. These parameters prepare the base for establishing the relationship among the lean manufacturing, supply chain characteristics and the performance of manufacturing industry.

5. The Structural Equation Modeling approach is used to explain the relationship between these approaches and their impact on organizational performance is reviewed. Total 32 statements are identified through the literature on lean principles

(12 Nos.), Supply Chain (10Nos.) and Performance (10 Nos.) and questionnaire are developed for the survey process.

The outcomes of the study strongly support that the designed model along with hypotheses proposed at the beginning of this study is well developed. The findings of AMOS software reveals that both lean manufacturing and supply chain characteristics construct have an impact on organizational performance that can be explained with the help of the model suggested in the research study. In addition, the confirmatory factor analysis (CFA) shown in chapter 4 reveals that the construct 'Lean Manufacturing' has low positive correlation then the 'Supply Chain Characteristics' with the 'Organizational Performance' which means Supply chain management in the manufacturing organization is more beneficial than the lean manufacturing approach.

6. The Interpretative Structure Modeling Approach is also used to analyze the contextual relationship among the parameters identified earlier for SEM. The hierarchical diagram (ISM Diagraph) on the basis of ISM results is developed to represent the importance of variables as per their level of contribution to affect the construct. This set-out the priority of the activities that need to be addressed accordingly.
7. The theoretical model for the relationship between LM, SCC, MS, and Performance is developed. The various contribution developed model in the manufacturing organization are as follows:

- Improves the organizational forecasting accuracy and delivers the goods in the most optimal manner to meet with demand,
- Enhance the internal and external collaboration to ensure visibility and transparency,
- Synchronize the material and information flow by eliminating the wastages to manage the uncertainty and risk,
- Defining the roles and responsibilities of various key players to foster innovation and knowledge-sharing**,**
- Pursue perfection through work standardization,

- Enable visual management for review and reporting,
- Empowers the employer and employees to create a continuous improvement culture, and
- To align the core competencies to enable the quick response mechanism to the customer demand within and outside the organizations

8. The present work also answered the importance of work culture in the manufacturing industry i.e. *How work culture play a role in organizational success and failures?* The individual behavior of the workforce affects organizational working. The present study identified the Ten Commandments for increasing the efficacy of the organizational outcomes. These commandments are also designed and developed in hierarchical progression by using the ISM approach. These commandments are helpful to all employees i.e. the work floor workmen's to the top level management in morale building and to improve the all in one's performance level.

7.3 SPECIFIC CONTRIBUTION OF THE RESEARCH WORK

The specific contribution of the present research work is as follows:

1. The literature related to lean manufacturing, supply chain management, performance, and manufacturing strategy is reviewed and classified into four different categories i.e. conceptual articles, survey models, case studies and empirical study. The reviewed literature reveals the reasons for the huge gap in supply and demand aspects in the manufacturing context and also, the different ways of handling these uncertainties in the value chain.

2. The relationship between the Lean Manufacturing, Supply Chain and the performance of the manufacturing organization is examined with the help of SEM approach. The outcomes of the SEM work reveal the positive correlation among the variables used to represent the constructs and the interrelation among the constructs. The study also supports that both the supply chain and lean manufacturing has an impact on organizational performance individually.

3. The ISM models explained in chapter 5 reveals the contextual relationship among all the variables and hierarchical progression model is developed to set the priority of handling this variable.

4. This study strongly supports the designed model and hypotheses proposed at the beginning of this study by giving attention to 'why the supply chain of manufacturing industry should be lean'.

5. Empowers the employer and employees to create a continuous improvement culture to align the core competencies to enable the quick response mechanism to the customer demand within and outside the Ten Commandments for the healthy work culture is identified. Competitude (Competitive + Attitude) of the workforce is found the main driving enabler for the healthy work culture out of tens by using ISM approach. The work culture of an organization is help in:

   - Optimizing the resource consumptions
   - Imparting flexibility in the workforce to deal with uncertainties.
   - Developing the line layout much efficient to cater to the need of the new customers
   - Planning and routing the activities within and outside the organization in an effective manner
   - Increasing the adaptability of advanced modular production tools with variants
   - Reducing the cost through efficient handling of the inventory and transportation
   - Increasing the adequacy of customer support system
   - Creates strong linkages among all the stakeholders
   - Increasing transparency to overcome the various dealt conditions
   - Minimizing the risk factors through prioritizing the uncertain conditions

- Empowering the employees through social and moral welfare

7.4 LIMITATIONS OF THE RESEARCH WORK

The present work has the following limitations:

1. The empirical evidence using SEM, it is found that around 65% of the variation in lean manufacturing and supply chain characteristics construct, and their impact on organizational performance can be explained with the help of the model suggested in the research study. However the model is good enough, still, the model is not able to cover rest 35% (an approximation) of the variation. In the SEM model, all the measured variables considered are widely accepted drawn from literature; there might be a possibility that some variables are not included in the research.

2. The data collected in the survey is perceptual and dependent on the capacity of the respondents. The research work does not carry the details about the experiences, designation, knowledge, and skill of the respondents so that it may not provide clear measures of performance.

3. The study doesn't cover the environmental aspects i.e. greening of the manufacturing context. In the present scenario, environmental sustainability is the advanced aspect and topic of the discussion in the manufacturing context. The outcomes of the present study are not supporting the environmental aspects of the manufacturing i.e. how the manufacturing context can eliminate the various hazardous wastages of the manufacturing organization outcomes related to the environment.

4. The present study developed the theoretical model which is not validated by the cost incurred to combine and apply to lean manufacturing and supply chain in the manufacturing context. As well as the time frame of the outcomes is also not discussed either as slow progression as in the case of lean manufacturing (applied individually) or the faster one as in the case of SCM (applied individually).

7.5 SCOPE FOR FUTURE WORK

The following areas are identified for future research work:

- As given in limitations of the research work, the generalization of the findings having the restrictions just because of the survey. The present study is based on a survey within India and to enhance the generalization of research findings the cross-country studies can be conducted in the future.

- The study also has the scope for the data collection method i.e. the other parameters like expertise, skill etc of the respondents may be used to get the exact data input i.e. the multiple data collection methods.

- This study can be increased in future by introducing the concept Green Manufacturing instead of Lean manufacturing that will be more beneficial in terms of operational excellence; enhance customer services; optimum resource utilization and ultimately, the strategic excellence etc.

7.6 CHAPTER SUMMARY

After passing 70 years of independence, Indian manufacturing context is still striving to produce a high-quality product at low cost in the global market to compete with manufacturing giants globally. Some of the key players in this are the inefficient utilization of resources; disrupted communication channel; and the organizational culture of an organization etc. In industrial engineering, the smooth flow of resources is happening only in the case when there is smooth information flow and it's utilization at an optimum level.

  - The present study aims to establish the relationship between lean principles, supply chain characteristics, performance, and manufacturing strategy. The literature reviewed reveals the gap between individual application of lean principles and supply chain management and their impact on performance. In addition, the role of manufacturing strategy in the successful implementation of these approaches in the manufacturing context is also discussed.

- The study reveals the impact of lean manufacturing and supply chain characteristics on the performance of the organization with the help of SEM approach in which the performance of an organization is considered as endogenous construct and both the LM and SCC are considered as an exogenous construct. The hypotheses stated in chapter 3 are tested and reveals that there is a positive relation between LM and SCC is existing. In addition, both the approaches have a significant impact on the organizational performance. The study also reveals the impact of SCM is more on organizational performance than lean manufacturing. The result of the regression model indicates that the probability value of the critical ratio is found to be less than 5% level of significance. Hence, with 95% confidence level, it is concluded that all the statements considered in the study are significant and reflect the existence of both lean manufacturing and supply chain in the manufacturing sector. The said model is tested and found a fit on the basis of outcomes as shown in Table 4.26.

- The interrelationships between constructs and their measured variables (as considered in the SEM Model) are also analyzed with the help of the ISM approach (Binary-Matrix approach). ISM results are used to design the hierarchical progression among the variables according to their level of contribution in the constructs. This gives an idea to the managers that what is to be handled on a priority basis.

The present study also reveals the importance of work culture in extracting the best out of employees and making them stick to the organization to serve for a longer duration. On the basis of literature, the three levels of organizational culture i.e. visible organizational structures, espoused values manifested, and the basic assumptions (unconscious beliefs; perceptions; thoughts; feelings etc.) is considered for the research study and identified the Ten0020Commandments as an enabler for the healthy work culture.

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List of Published Papers in International Journals (08)

1. Kumar, R., Kumar, V. and Singh, S. (2014). Effect of Lean Principles on organizational efficiency. *International Journal of Applied Mechanics and Materials*, 592-594, 2613-2618.

2. Kumar, R., Kumar, V. and Singh, S. (2014). Role of lean manufacturing and supply chain characteristics in accessing the manufacturing performance. *International Journal of Uncertain Supply Chain Management*, 2, 219–228.

3. Kumar, R., Kumar, V. and Singh, S. (2015). Establishing the relationship among principles of Lean Manufacturing, Supply Chain Characteristics, Manufacturing Strategies and Performance theoretically in an Indian environment. *Journal of Industrial Engineering,* Feb Issue, 25-31.

4. Kumar, R., Kumar, V. and Singh, S. (2015). Managing the utility of manufacturing process facilities through Lean Supply Chain. *Journal of Advance Research in Production and Industrial Engineering*, 2(1), 13-23.

5. Kumar, R., Kumar, V. and Singh, S. (2016). Relationship establishment between lean manufacturing and supply chain characteristics to study the impact on organizational performance using SEM approach. *International Journal of Value Chain Management*, 7(4), 352-367.

6. Kumar, R., Kumar, V. and Singh, S. (2017). Modeling and analyzing the impact of lean principles on organizational performance using ISM approach. *Journal of Project Management*, 2, 37-50.

7. Kumar, R., Kumar, V. and Singh, S. (2017). Work Culture Enablers: Hierarchical Design for Effectiveness & Efficiency. *International Journal of Lean Enterprise Research (IJLER)* (In Publication).

8. Kumar, R., Kumar, V. and Singh, S. (2017). Modeling and analysis on supply chain characteristics using ISM technique. *Apeejay Journal of Management and Technology* (UGC Approved) in printing.

Annexure-1
QUESTIONNAIRE

Dear Respondents,

This questionnaire is a part of the Ph.D. Program. You are requested to kindly spare time out of your busy schedule to provide valuable information. It is ensured that the data provided by you will be kept confidential and will be used only for academic purpose.

Objective of the work: The objective of the research is to assess the application and accessibility of lean principles with supply chain characteristics for different manufacturing strategies in manufacturing organizations to achieve the highest performance.

Section A:
Name of the Organization: …………………………………………………………………….
Designation: ………………………………………………………………………………
Department: ………………………………………………………………………………
Working with current organization: ……………………………………………...(in Years)
Total Experience: ………………………………………………………………(in years)

Section B: Manufacturing Strategies
Please tick the manufacturing strategy used by your organization

a) Customized Production ☐

b) Mass Production ☐

c) Automation Production ☐

d) Next Generation Production ☐

e) Any Others, Please Specify____

Section C: Lean Manufacturing

Please rate the following statement related to manufacturing system in your organization in the scale of 1 to 5, where 1 means the strongly disagree, 2 means agree, 3 means no opinion, 4 means agree and 5 means strongly agree.

Sr. No.	Statement	SD 1	D 2	NO 3	A 4	SA 5
1	The organization provides appropriate value to the customer.					
2	The organization has the strong emphasis on Quality Improvement in process.					
3	The organization is able to minimize the loss of resources due to unwanted transportation in a production system.					
4	There is minimum wastage of inventory in the manufacturing process.					
5	The movement of men, material & machine in the manufacturing process is standard and optimized.					
6	The waiting time in the process will keep as a minimum with respect to production lead-time.					
7	The organization has believed in excessive production than the market demand.					
8	There is a minimum problem of over-processing associated with the manufacturing process.					
9	The product/services provided by your organization are free from any minor/major defects.					
10	The organization utilized the full potential of its workforce to support the manufacturing process.					
11	The proper utilization of space (Horizontally and Vertically) within the organization to support the manufacturing process.					
12	The organization provides the safest working conditions that have the strongest influence on productivity.					

Section D: Supply Chain Management Characteristics

Please rate the following statement related to order and delivery distribution in your organization in the scale of 1 to 5, where 1 means the strongly disagree, 2 means agree, 3 means no opinion, 4 means agree and 5 means strongly agree.

Sr. No.	Statement	SD 1	D 2	NO 3	A 4	SA 5
1	The lead-time in terms of order and delivery to the suppliers/customers is well managed and optimized.					
2	The organization has the strong Decision Making Leadership along with suitable Decision Support environment to support the strategy of growth.					
3	The organization has the cross-enterprise collaboration among all suppliers/customers to provide flawless production/distribution activity.					
4	The flow of information within and outside (Suppliers and Vendors) the supply chain is well managed.					
5	The supply chain has focused on building strong horizontal processes such as Sales and Operations Planning to achieve the highest performance in terms of inventory.					
6	The organization's supply chain has integration with other allied departments like HRD, Finance etc. to have the right kind of resources.					
7	The supply chain process of the organization is flexible enough to deal with changing market trends.					
8	There is a proper mechanism for problem-solving at outside suppliers and vendors end.					
9	The design of the supply chain is simple to understand so, the organization is thinking about the plans for the future.					
10	The organization has grown their market demand and new markets for products through its effective supply chain.					

Section E: Overall Performance

Please rate the following statement related to outcomes of the manufacturing process allied with supply and distribution strategies in your organization in the scale of 1 to 5, where 1 means the strongly disagree, 2 means agree, 3 means no opinion, 4 means agree and 5 means strongly agree.

Sr. No.	Statement	SD 1	D 2	NO 3	A 4	SA 5
1	The sales revenue of the organization is increasing with time.					
2	The organization earns good profits as compared to earlier years.					
3	The organization increases the employment rate every year.					
4	The production capacity of the organization is better than earlier.					
5	The organization is satisfying the demands of markets and try to move ahead to capture new markets.					
6	All the employees of the organization have the focus on the vision and mission of the organization to achieve proper utilization of					
7	The brand name of the organization and products are improving in the market.					
8	The company is trying to explore new areas of inventions in the manufacturing process.					
9	The quality of the product is good enough and the product has the competitive advantage to sustain its demand in the market.					
10	The organization structure is flexible enough to get revenge in the uncertain working environment.					

Thanks With Regards

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