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Implementation of Lean Manufacturing Practices and its Impact on Productivity in Coimbatore Foundries

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Abstract

It is very essential to produce the cast components in foundries with high quality, reliable, consistent and at lowest cost. Hence the foundry owners have to introduce the Lean manufacturing to improve the productivity. This study brought out how technically qualified entrepreneurs of selected foundries have carried out technological innovations, mainly due to their self-motivation and self-efforts. Introducing the Lean manufacturing in the process and changing product designs, as desired or directed by the customers resulted in cost reduction, quality and productivity improvement. These have enabled the selected foundries to enhance competitiveness, grow in the domestic market and penetrate the international market and grow in size over time. And have achieved technological innovations successfully based on their technological capability and customer needs, enabling them to sail through the competitive environment.

There are about 35000 foundries in the world with annual production of 90 million metric tons, providing employment to about 20 lakh people. Indian foundry industry is acknowledged as the world's second largest producer of castings (7.4 Million Tons per Annum - MTPA) based on Tonnage during 2009, next to China (35.2 MTPA). There is a large gap between India and other nations, along with the fact that the foundry industry is not able to keep up with the local and international demand and to catch up in terms of absolute production quantities and qualities and hence the market share. Having reached this stage, what we need is to utilise the potential for growth in our favour. Indian Foundry Industry occupies a special place in shaping the country's economy. India has around 5000 foundries, producing about 7.4 MT of castings worth Rs 20,500 crores. It ranks second in terms of casting production, next to China. These units are mostly located in clusters with numbers varying from 100 to 500 per cluster. Some of the notable clusters are Agra, Howrah, Coimbatore, Kolhapur, Rajkot and Belgaum.

Coimbatore foundries have more export opportunities to tap with growth in the end user segment. Coimbatore foundry cluster has about 620 units and most of them are small-scale. They produce 40,000 to 45,000 tonnes of castings a month. The foundry product line of Coimbatore cluster is mainly catering to motor pumps, machineries and is slowly emerging to cater to valves and auto components sector from South India. In the last five years, output of the Coimbatore foundries has grown at 15 to 20 percent and it is estimated that Coimbatore contributes nearly 15 percent of the total casting production in the country. The total monthly casting production has gone up from about 25,000 ton in 2007 and in 2010 it is 60,000 ton. Almost 20% of the total production goes for exports (direct and indirect) to most of the European countries.

Keyword: Foundries, Technology, Lean, Productivity, Profitability, Quality

Introduction

Indian Market

As per Modern Castings USA, India ranks as 2nd largest casting producer producing estimated 7.44 Million MT of various grades of castings as per international standards (2009), including ferrous, non-ferrous, aluminum alloy, graded cast iron, ductile iron, steel etc. Automobiles,

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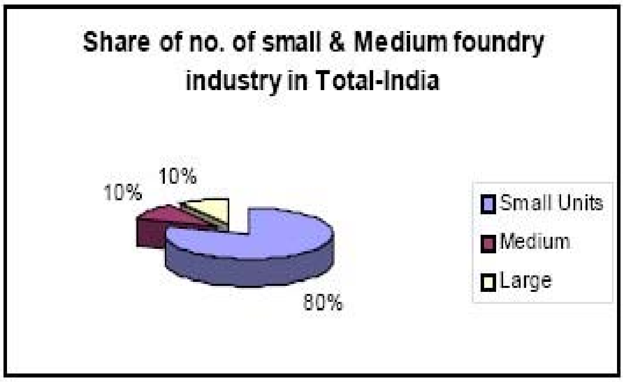
railways, pumps compressors & valves, diesel engines, aero industries, cement, electric motors, tractors and agriculture implants, food processing industry, sugar industry, machine tools, electrical and textile machinery, sanitary pipes & fittings and castings for special applications are some such areas where castings are utilised. There are approximately 4500 units out of which 80% can be classified as small scale units & 10% each as medium & large scale units. Approximately 500 units have International Quality Accreditation.

Market Segments

Current market for castings is about 3 million tonnes per annum. Over 93% of this market is for ferrous castings. Iron castings account for 87.5 % of ferrous castings. Of these, grey iron castings account for nearly 90% while ductile and malleable castings account for the balance. Non-ferrous castings - a small market, is primarily used in the auto sector. Exports as well as imports of castings are not significant; exports in particular have not taken off, primarily because of poor quality of casting supplies from India.

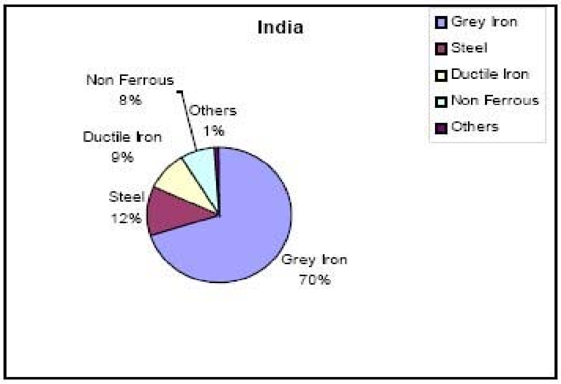
Figure 1: Market Segments as Per Size



Impact of Lean Manufacturing Practices in Foundry

Lean manufacturing is also known as “lean”. It is a philosophy that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. The seven wastes that are targeted by Lean are: overproduction, unnecessary transportation, inventory, motion, defects, over-processing, and waiting. The tools, techniques and practices are derived from the Toyota Production System. Lean is a continuously developing philosophy and its application is different for each and every company. Lean has had a number of names over the years, developed primarily from the Toyota Production System (TPS) it has been called World Class Manufacturing (WCM), Continuous Flow Manufacturing, and Stock-less production, to name a few. Developed mainly within manufacturing, the Lean tools such as 5S or 5C, seven wastes, single minute exchange of die (SMED), value stream mapping etc. are all important parts of Lean manufacturing. The Lean manufacturing paradigm has been used in an extensive manner at some industrial sectors, like automobile industry, where its assembly lines of components present better adaptability to the Lean concepts. Applying Lean manufacturing concepts in productive processes, contributes a lot to turn industries more competitive. Lean manufacturing paradigm in the foundry can increase monthly production and reduce pouring time. Lean helps to reduce the waste of time in the process of pouring metal inside the mould, cooling casting, shake-out, transportation to the finishing area, cleaning and cut burr processes. The Lean concepts improve productivity and make the production effective. Lean manufacturing defines seven types of wastes that make a production system inefficient and costly.

Figure 2: Market Segments as Per Type



Need for the Study

There is large gap between India and other countries in productivity, due to non-application of Lean manufacturing and it has more impact on the quality, low productivity and profitability.

Hence the study will be helpful in identifying the prospects and problems of Indian foundries in applying Lean manufacturing for improving productivity.

Review of Literature

Eduardo Barbosa Pinto (2008) in his study "Lean Manufacturing Paradigm in the Foundry Industry" stated that how the small to medium enterprise of foundry sector have worked to improve their production processes, in way to obtain the competitiveness. The Lean concepts can be applied in the foundry industry, bringing benefits of better productivity and making the production flowing. The research study showed more productivity and shortest times of supply.

Clenio Senra De Oliveira (2009) in his study "Lean Manufacturing Paradigm in the Foundry Industry" stated that the Lean manufacturing paradigm has been used in an extensive manner at some industrial sectors, like automobile industry, where its assembly lines of components present better adaptability to the Lean concepts. The study found that when Lean manufacturing paradigm is applied in a foundry, it improves productivity.

Torielli (2010) in his study "Using Lean Methodologies for Economically and Environmentally Sustainable Foundries" found that Lean manufacturing is often seen as a set of tools that reduce the total cost and improve the quality of manufactured products. This study suggests that Lean manufacturing is more than a set of Lean tools that can optimize manufacturing efficiencies.

Bharathi Rajkumar & Gukan Rajaram (2012) in their study **"**Productivity Enhancement in Foundry Industry using Lean Tools" revealed that the industry could not meet the customer requirements due to the increasing cycle time of the individual process and rework due to excess rejection. This paper described some of the quality improvement tasks that reduce the rejection rate which also affect the productivity. The results of process are analysed by conducting time study after implementation and found productivity improvement in foundry industry using Lean tools.

Objectives

- To study the implications of implementing Lean manufacturing and its impact on productivity in Coimbatore foundries
- To study the Lean manufacturing practices followed in industries in particular to foundry industry
- To identifying the prospects and problems of Coimbatore foundries in applying Lean manufacturing for improving productivity

Research Methodology

The study has been carried out in the medium and large-scale foundries in Coimbatore that have successfully implemented the Lean manufacturing. In this study, random sampling is used as sampling technique for getting data from all 94 foundries and every member of the population of interest. As the approach has been directed towards the contributions of initiatives of Lean manufacturing towards realisation of productivity and profitability, a detailed 'questionnaire' has been designed for accessing the implication of Lean manufacturing and its impact on productivity and profitability of foundries. In total, there are 580 foundries in Coimbatore in which the small foundry comprises 83 percent (486 foundries), medium foundries 12 percent (68 foundries) and large foundries comprise five percent (26 foundries) (Indian Institute of Foundry Men, 2011). 42 foundries have been taken for the study. The managers of all the foundries were approached for obtaining details to find out the implementation of various technology and management tools adopted in medium and large foundries.

Exploratory research was adopted for the present investigation. It is the preliminary study of an unfamiliar problem, about which the researcher has little or no knowledge**.** Exploratory research is often conducted because a problem has not been clearly defined as yet or its real scope is unclear. It is aimed to gain familiarity with the problem, to generate new ideas or to make a precise formulation of the problem. Data were collected from the primary and secondary sources. Primary data were collected through questionnaire. Secondary data were collected from the journals, magazines and different websites.

Data analysis and Interpretation

Chi Square Analysis

Chi square analysis is used to test the association and significant difference between rows and columns of

Table 1: Implementation of Lean Manufacturing in Foundry Industry

Year	*2010*	*2009*	*2008*	*2007*	*2006*	*Total*
No of foundries implemented Lean manufacturing	8 (67%)	6 (60%)	7 (64%)	11 (79%)	10 (77%)	42

Table 2: Reported Benefits of Lean Manufacturing Implementation in 60 Foundries (Percent Wise)

Year	*Productivity improvement*	*Quality improvement*	*Capacity Utilisation*	*Lower Rejection*	*Scrap Reduction*	*Maintenance Reduction*	*Employee Turnover*	*Energy savings*	*Cost Reduction*	*Increased Turnover*
2006	10	12	10	8	8	10	12	7	10	10
2007	11	13	11	9	10	11	12	6	11	10
2008	8	11	8	8	8	8	10	5	8	8
2009	8	10	8	7	7	8	9	6	7	9
2010	10	11	10	10	10	10	10	7	9	10
Total	47	57	47	42	43	47	53	31	45	47

Figure 2(a): Benefits of Lean Manufacturing Implementation in Foundries

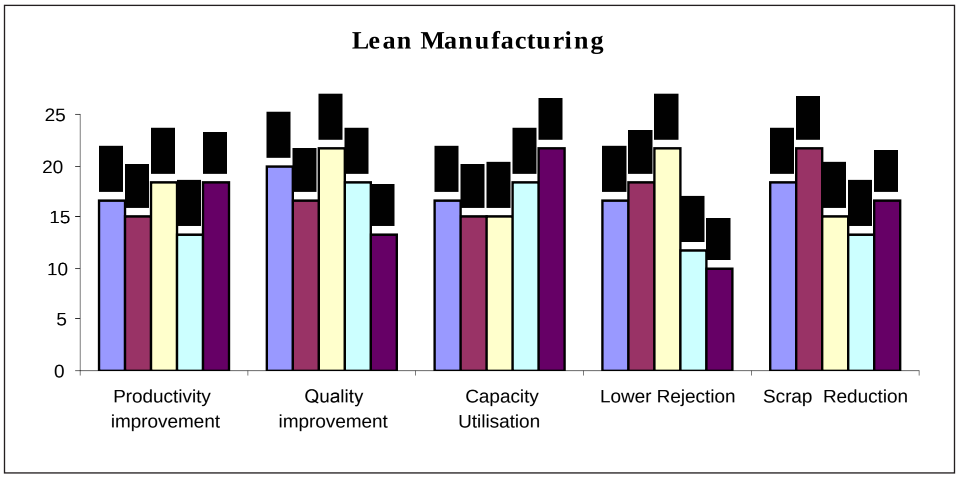
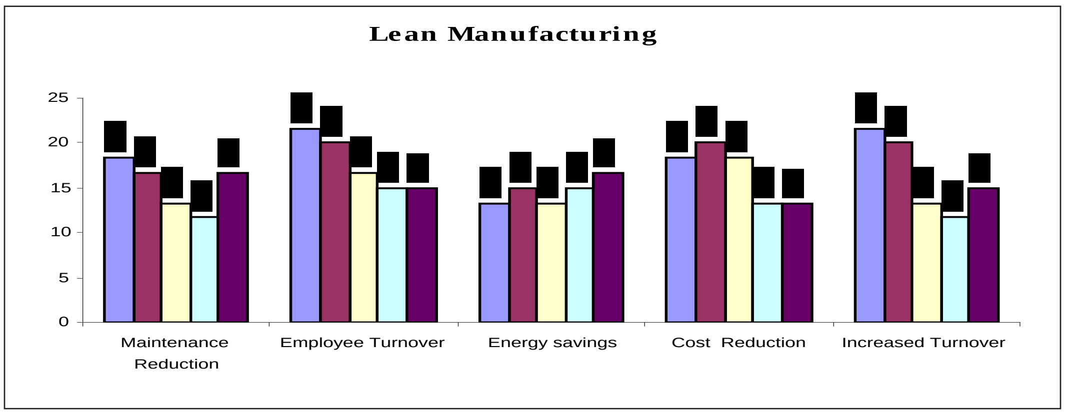


Figure 2(b): Benefits of Lean Manufacturing Implementation in Foundries



a particular study. Here in this paper rows takes Lean manufacturing technology and columns includes the number of foundries implemented those Lean technologies in the past five years. This analysis after implementation yields a significant value which states that whether there is any association between the variables considered and which one is best in which year.

Hypothesis Testing

Null Hypothesis: There is no association between the modern technologies implemented with respect to year considered. But profitability and productivity increases due to modern technologies.

Degrees of freedom-39

Level of significance - 5%

Chi-Square Test: 2010, 2009, 2008, 2007, 2006

Expected counts are printed below observed counts

Chi-Square contributions are printed below expected counts

Table 3: Lean Manufacturing Implementation

2010	*2009*	*2008*	*2007*	*2006*	*Total*
8	6	7	11	10	42
8.29	6.66	7.20	10.33	9.51	
0.010	0.065	0.006	0.043	0.025	

Chi-Sq = 4.858, DF = 28, P-Value = 1.000

Statistical Inference:

In the above analysis Lean manufacturing, P-value is the significant value which is greater than the level of significance 0.05. Hence we conclude the null hypothesis is accepted stating that that there is no significant association between rows and columns.

And also from the Wilcoxin signed rank test it is proved that Lean manufacturing shows higher efficiency in the year 2007.

Due to implementation of modern technology the foundries are benefited and those benefits were ranked as shown in Table 4.

Table 4: Benefits for Foundries

Sl. No	*Benefits*	*Rank*
1	Quality Improvement	I
2	Productivity Improvement	II
3	Capacity Utilisation	III
4	Scrap Reduction	IV
5	Lower Rejection Rate	V

Figure 3: Research Model Specification – Lean Manufacturing

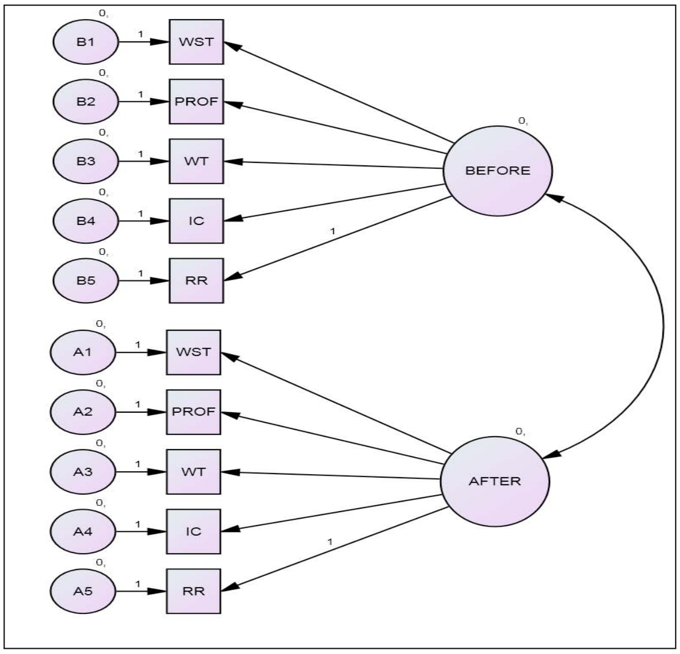


Table 5: Variables specification for implementation of Lean Manufacturing

Manifest Variables	*Latent Variables*
WST =Waste (Percentage)	Before Implementation
PROF =Profitability (Rs)	
WT =Waiting time (T)	
IC =Inventory cost (Rs)	
RR =Rejection rate(Percentage)	
WST =Waste (Percentage)	After Implementation
PROF =Profitability (Rs)	
WT =Waiting time (T)	
IC =Inventory cost (Rs)	
RR =Rejection rate(Percentage)	

Table 6: Co-Variance Matrix – Lean Manufacturing

	BWST	BPROF	BWT	BIC	BRR	AWST	APROF	AWT	AIC	ARR
BWST	8.988823									
BPROF	16.40161	231.9736								
BWT	2.025693	10.587	1.836261							
BIC	0.830019	1784.822	82.72652	29040.62						
BRR	6.458993	12.18427	1.395703	128.9983	11.67223					
AWST	5.689215	9.771376	1.127014	143.4963	10.44506	9.840325				
APROF	9.39754	179.9031	5.382417	1976.764	18.756	16.03116	316.2181			
AWT	1.744811	6.568878	0.761068	48.6358	1.912759	1.638409	14.03007	2.023516		
AIC	107.1613	1812.027	30.0045	16747.03	93.8817	91.00915	2765.063	131.9281	35380.73	
ARR	6.206271	14.99476	0.645232	23.17855	5.632458	4.706924	13.99988	2.33372	254.2286	11.55262

VARIABLES		*VARIABLES*	
BWST =Waste (Percentage)	Before Implementation	AWST =Waste (Percentage)	After Implementation
BPROF =Profitability (Rs)		APROF =Profitability (Rs)	
BWT =Waiting time (T)		AWT =Waiting time (T)	
BIC =Inventory cost (Rs)		AIC =Inventory cost (Rs)	
BRR =Rejection rate(Percentage)		ARR =Rejection rate(Percentage)	

Figure 4: Unstandardised Estimates – Lean Manufacturing

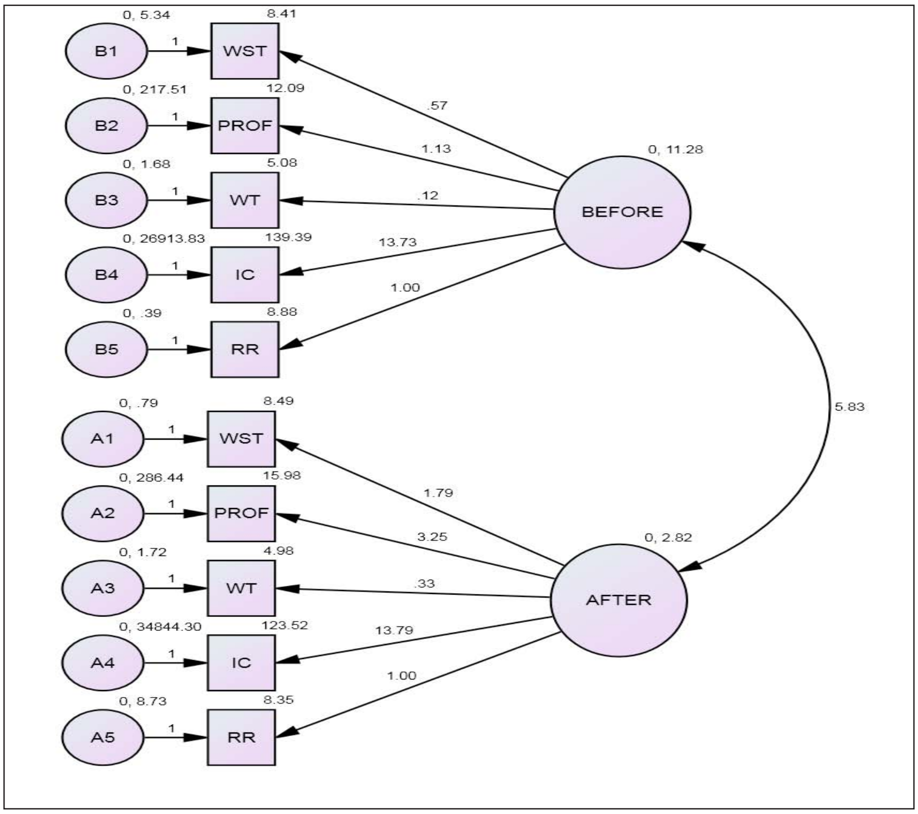


Figure 5: Standardised Estimates – Lean Manufacturing

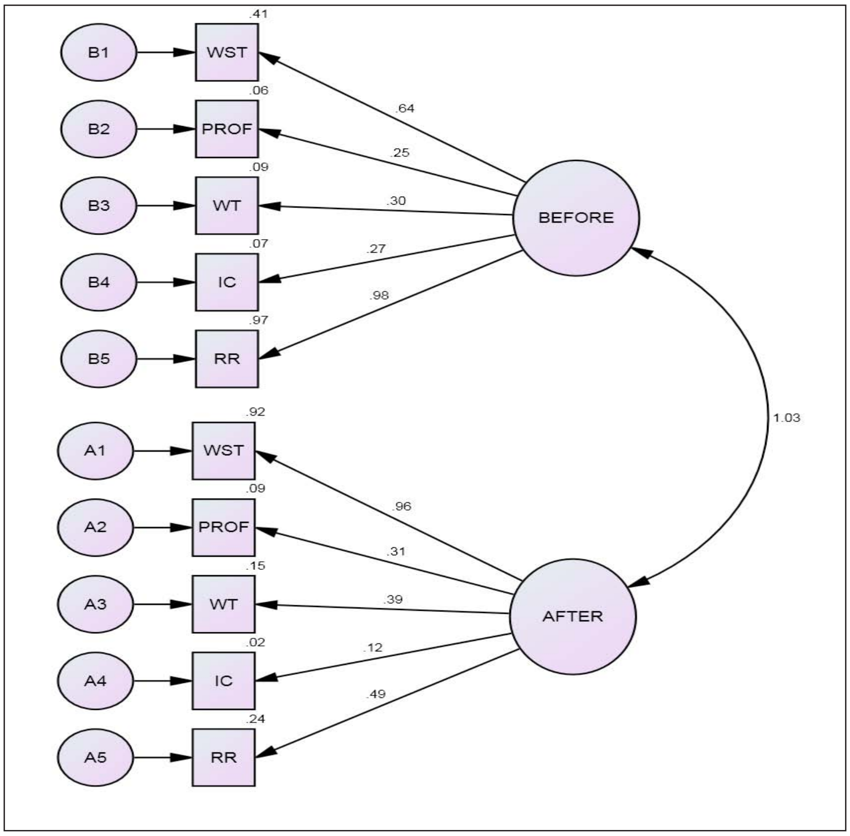


Table 7: Testing of Hypotheses

Hypotheses	*Hypothetical Relationship*	*Result*
H1: There is a positive impact of WST and after implementation of Lean manufacturing.	Positive	Confirmed
H2: There is a positive impact of PROF and after implementation of Lean manufacturing.	Positive	Confirmed
H3: There is a positive impact of WT and after implementation of Lean manufacturing.	Positive	Confirmed
H4: There is a positive impact of IC and after implementation of Lean manufacturing.	Positive	Confirmed
H5: There is a positive impact of RR and after implementation of Lean manufacturing.	Positive	Confirmed

Testing of Hypotheses– Standardised Estimates - Lean Manufacturing

Table 7 represents the results of the testing of the hypotheses.

Chi-square = 5520.2 Degrees of freedom = 55, Probability level = .000

Discussion of the result

From the path diagram, all the measured variables with latent variable of successful operation Lean manufacturing have positive relationship and are also significant at 1 percent and 5 percent level after implementation of Lean technology.

Regression Weights for Implementation of Lean Manufacturing

Table 8 shows the regression coefficient of the exogenous variables. It is noted that the critical ratio of all the variables are above the table value 2.962 and it is significant at 1 percent level except BPROF and BWT.

Hence, the selected variables are the most influenced factors for after implementation of Lean manufacturing.

Table 8: Lisrel Maximim Likelihood Estimates

Latent Variable		*Measured Variables*	*Estimates*	*SE*	R^2	*CR*	*P*
BEFORE	<---	BWST	11.282	1.844	.64	6.118	***
BEFORE	<---	BPROF	2.823	1.167	.25	2.419	.016
BEFORE	<---	BWT	.391	.292	.30	1.338	.181
BEFORE	<---	BIC	26913.825	4237.359	.27	6.352	***
BEFORE	<---	BRR	1.676	.263	.98	6.380	***
AFTER	<---	AWST	217.511	34.009	.96	6.396	***
AFTER	<---	APROF	5.345	.846	.31	6.320	***
AFTER	<---	AWT	8.730	1.351	.39	6.463	***
AFTER	<---	AIC	34844.298	5449.671	.12	6.394	***
AFTER	<---	ARR	1.718	.269	.49	6.394	***

***- Significant at 1% level

Conclusion

Indian industries need overall operational excellence in today's era of global competitiveness. Especially, the basic manufacturing sectors such as foundries and other metal working/ forming industries need breakthrough improvements in quality as well as in productivity. Indian foundry industry faces great challenges and requires advancement in productivity, quality and cost competitiveness to increase its domestic and world market share. A key notion of success in a highly competitive business is not just getting the orders but processing the orders effectively with high quality and profitability by implementing modern technologies and management methods. This key concept of important technology was put to test through an empirical approach in this study and this view is exactly endorsed by the results of this study. Growth efforts of the Coimbatore foundries have been on the lines of introducing advanced technology, expansion of local market, entry into foreign markets through up gradation of quality castings and productivity. Foundries do not see the need for technical assistance due to fear of divulging company information. Therefore, efforts such as this study will give a view on the technology support required by the foundries for increasing the productivity and profitability.

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