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## OUTCOME of SIX SIGMA IMPLEMENTATION – A CASE STUDY of MANUFACTURING INDUSTRY

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**Abstract:** Manufacturing sector is the back bone of the economy of any country. The economic health of a nation is decided on the basis of financial health of manufacturing sectors. It is mandatory for the manufacturing organizations to control the cost as they do not have the control over the price. To minimize the cost, it is required for them to reduce the defect rate. Six Sigma, a quality management system, is a customer-focused and data-driven quality strategy. It is a rigorous and systematic methodology that utilizes collected information and statistical analysis to reduce defect rate, measure and improve performance. In this paper the role of Six Sigma has been analyzed through case study of manufacturing industry. It is observed through the study that Six Sigma has contributed to the improved financial status, productivity and customer satisfaction. However its contribution towards the welfare of the work force and growth of the company is not significant.

**Key words:** Six Sigma, Implementation, Benefits, manufacturing

### I. INTRODUCTION

Motorola started Six Sigma ( $6\sigma$ ) in the late 1980s [3], the concept has been a key game changer worldwide in firms having trouble with quality improvement in their business processes. Six Sigma, is a quality strategy, based on customer-focus and driven by data rather than assumptions and experience. It is a systematic and rigorous methodology that reduces defect rate, measures and improves performance by utilizing gathered information and statistical analysis tools.

Indian manufacturing industries also have observed these significant changes of the global scenario. Successive Indian governments have responded favorably to changes triggered at the global level, by introducing Liberalization, Privatization and Globalization (LPG) in the 1990's. Due to this the notable changes started in 1991, included supporting Foreign Direct Investments (FDI), termination of 'quota raj' and liberalizing the imports in the form of reduced tariffs. After the implementation of reforms the Gross Domestic Products (GDP) started growing in the 6-8 % range. The contribution of manufacturing sector is very notable as the very economy of any country is greatly dependent on the manufacturing sector. It is evident even for Indian industries on account of improved awareness worldwide, either to improve the quality or perish on account of global competition. Hence, Indian manufacturing industries searched for a quality management system that helps them to overcome the crisis. Six Sigma is one such quality management system, which can pull the company out of quality crisis.

### II. LITERATURE REVIEW

Reference [15] in his article, "The Rise, fall, and revival of Six Sigma. Measuring Business Excellence", has expressed that Six Sigma is a metric, a method, a set of tools and a way of life for a growing number of companies.

Reference [5] in their research at Dow Chemicals, found that by utilizing the Six Sigma methodology combined with discrete event simulation, Dow was able to devise a solution that would allow them to meet the increase in demand with savings of \$2.45 in capital expenditure.

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Reference [12] in their study of success factors for Six Sigma, have observed that Six Sigma provides a comprehensive and flexible system for maximising business success with some key success factors

Reference [10] in their book “Six Sigma: The Breakthrough Management Strategy Revolutionizing the World’s Top Corporations”, have expressed that Six Sigma provides specific methods to re-create the process itself so that defects are never produced in the first place.

Reference [1] in their research, “Method and context perspectives on learning and knowledge creation in quality management”, have shown that how Six Sigma can produce dissimilar types of learning and knowledge, and how a quality advantage can become more sustainable.

Reference [16] in their study of a manufacturing enterprise reveal that there are many benefits of Six Sigma implementation like cost savings, reduced time to market, improved processes, etc.

Reference [8] in their research of The Role of Experience in Six Sigma Project Success, suggest that a well-developed and deployed structured problem-solving process—characteristic of effective Six Sigma deployments—may reduce the importance of team familiarity in the context of improvement teams.

Reference [14] in their study of Asian industries that have implemented Six Sigma find that specific country cultural values impact how effective Quality Management (QM) investments are. They feel that Uncertainty Avoidance (UA) has a positive influence on QM effectiveness. This suggests that employees in cultures desiring predictability and law-like understanding will be motivated to frequently apply QM’s systematic approaches, as in Six Sigma’s improvement heuristics.

Reference [2] in her research of success of Six Sigma in Italian companies could conclude that the Italian companies need to be further explored, validated and reorganized that could constitute a Road Map for Six Sigma implementation in Italian companies. This opens up an ample scope of research on Six Sigma implementation.

Reference [11] in their research of Six Sigma success that Six Sigma is perhaps the most successful business improvement strategy developed in last fifty years. Its relevance extends even beyond manufacturing to services, government & the public sectors to service, healthcare & non-profit organizations.

### III. NEED FOR THE STUDY

The literature review revealed that Six Sigma has contributed to the growth of the organization in many ways provided its implementation is done in the right way and direction. Most of the studies have highlighted the implications of Six Sigma on tangible factors like, financial benefits, reduction of cost, improvement of sales, reduced defect rate, and the importance of human factor. However it was found that more research is required to analyse the effect of implementation of Six Sigma and ascertain the above fact. Hence it was found necessary to take up this study titled, “Outcome of Six Sigma implementation – a case study of manufacturing industry”. The industry manufactures heavy earth hauling equipments. Six Sigma is implemented here since 6 years. As a matter of trust and confidentiality the name of the industry is not revealed.

### IV. OBJECTIVES OF THE STUDY

The objectives of this paper are;

- To investigate whether Six Sigma has contributed to the improvement of the organization in terms of growth of the company, financial benefits, peoples’ equity, productivity and customer satisfaction
- To study whether managers and workers differ in their opinions towards implementing Six Sigma.

### V. HYPOTHESES OF THE STUDY

The following hypotheses were drawn to study the impact of Six Sigma implementation on people’s equity.

H1. Existing practices of Six Sigma provides following benefits

- a. Improve growth of the company
- b. Financial benefits
- c. Improve peoples’ equity.
- d. Improve productivity.
- e. Customer satisfaction.

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H2. Managers and employees differ significantly in their opinion on implementing Six Sigma.

## VI. SAMPLE

Sample Population consisted of all 26 employees who were involved in Six Sigma implementation. The respondents included both managers and workers who were trained in Six Sigma implementation. Those who were trained in Six Sigma included master black belt, black belts and green belts. Out of 26 employees 16 belonged to worker level and 10 belonged to managerial level.

## VII. RESEARCH METHODOLOGY

To start the study, the data is collected using questionnaire method. Questionnaire was designed around various parameters that contributed for financial benefits and market growth. After several drafts of the questionnaire, it is pilot-tested twice. The first test involved two professors and practitioners in Six Sigma, and the second one four black-belts working on Six Sigma projects at industries. The objective was to evaluate and validate the survey's questions and provide suggestions for improving the survey in both form and contents. After incorporating the suggestions from experts, finally the questionnaire included eight parameters that measure financial benefits like increased revenue, improved sales, reduced price of non conformance, reduced cost of poor quality, higher profit, faster return on investment, reduced risk of being uprooted from the market and nine parameters that define growth of the company like improved exports, increased share value, higher expansion, better organization structure, new product development, better brand image and competitive edge due to implementation of Six Sigma. Productivity is measured with the help of eighteen factors viz., appropriate selection of the project set up cost, reduced operating cost, Standardized production methods, reduced inventory, follow up action on every project, elimination of unproductive steps, Identification and elimination of defects of process continuously, reduced scrap rate, continuous reduction of variation of the process, reduction of time to complete the project quick response to change in demand of the market, reduced defect rate, reduced rejection rate, decreased production lead time, Improved process capability, targeting both short and long term goals and optimum utilization of the resources that has resulted after implementing Six Sigma.

Peoples' equity is measured by twenty seven such factors, which contribute to employees' welfare, like Top management commitment, Senior management provides resources, Proper leadership style, Awareness of Six Sigma tools and techniques, Decision making based on facts rather than hierarchy, Employee involvement in decision making Employees' learning process, Improved communication skills, Better work culture, Continuous need based training, Incentive program, High human value based management, Better interpersonal relationships, Better employee participation, Employees are recognized and rewarded, Improved morale, Improved pride in work, Work culture change, Employees can get customers feedback, Sharing of knowledge between employees, Improved commitment from suppliers, Overall commitment among employees, Improved employee retention, Employees are more adoptable for change, Increased retention of employees, Get pleasure from the implementation of Six Sigma, and Employees' preference to work with Six Sigma projects.

Customer satisfaction is explained by sixteen factors viz. Defining customers need, Improved customer satisfaction, Availability of products as per customers needs, Improved customer relationship, Improved commitment towards customers, Complete shift of focus towards customers, Feedback from customers, Product development based on customers' needs, Production plans are shared, Customers are made part of the company, Active customer redressal mechanism, Continued service to satisfy customers, Sharing of risks and rewards with customers, Reduced number of complaints from customers, Improved relationship with customers and Competitive pricing policy to achieve Win - Win situation with customers after implementing Six Sigma.

Questions were framed around these parameters in the simplest language that could be understood by all. The questionnaire is explained to some of them in their vernacular language to get the feed back in the most appropriate manner. Five point Likert Scale (strongly disagree to strongly agree) is used to collect responses in an objective manner. The responses thus obtained were analyzed at two levels such as considering both employees and managers together, then analyzing their responses separately to study whether they differ in their opinion. Statistical tool like SPSS V16 is used to analyze the opinions of the respondents.

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## VIII. RESULTS AND ANALYSIS

The responses from respondents were entered in the SPSS V16 software. The following results are obtained.

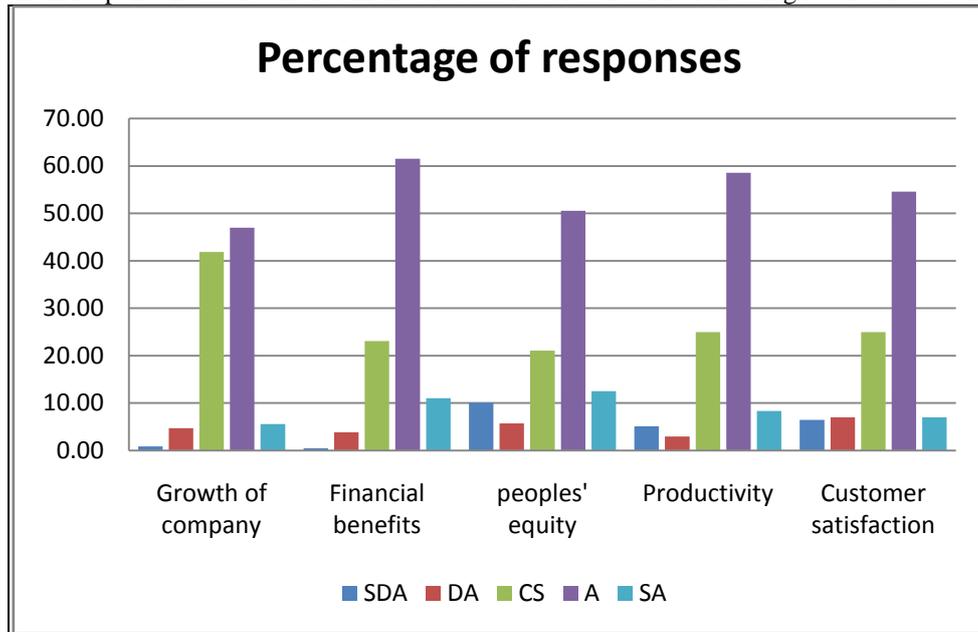


Fig1: Percentage of response by respondents regarding various benefits of Six Sigma

From the graph we can understand that the percentage of agree and strongly agree are more compared to disagree and strongly disagree. We can also observe that the percentage of respondents who are not clear is also quite significant. These responses are tested for their significance in order to understand the contribution of Six Sigma towards the benefits defined earlier.

The reliability of the research instrument is tested using reliability analysis. The cronbach alpha helps us to understand the reliability of the research instrument. If the cronbach alpha is more than 0.7, we can establish the reliability. In this case study, the Cronbach's alpha is obtained as 0.811, hence, the reliability of the research instrument is established.

### A. Testing of Hypothesis H1

H1. Existing practices of Six Sigma provides following benefits

- a. Improve growth of the company
- b. Financial benefits
- c. Improve peoples' equity.
- d. Improve productivity.
- e. Customer satisfaction.

After calculating the percentage of responses for each category of the Likert scale, and establishing the reliability of the questionnaire, the observed mean is calculated as shown in table below.

The company has a policy of accepting the survey results if the mean value is 3.6 and above for each parameter under study. In this regard the test value was set at an overall value for the category of growth of company as 32.4 (This is calculated by multiplying the test value with the number of factors i.e. for growth of company:  $9 * 3.6 = 32.4$ , for Financial benefits:  $8 * 3.6 = 28.8$ , for peoples' equity:  $27 * 3.6 = 97.2$ , for productivity:  $18 * 3.6 = 64.8$  and for customer satisfaction:  $16 * 3.6 = 57.6$ ) and one sample t-test for a 95% confidence level (Significance level of 0.05) at 25 degrees of freedom ( $df=N-1$ ) is administered to test the hypothesis H1.

The following table gives the result of t-test for various benefits stated earlier.

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Variable	N	Mean observed	Std. Deviation	Mean expected	t value	P value
Growth of the company	26	31.70	3.03	32.4	-1.192	.244 (non significant)
Financial benefits	26	30.29	2.59	28.8	2.991	.006 (significant)
Peoples' equity	26	94.70	18.26	97.2	-.710	.484 (non significant)
Productivity	26	65.14	8.05	64.8	.225	.824 (non significant)
Customer satisfaction	26	55.96	10.57	57.6	-.804	.429 (non significant)

Table 1: Observed and expected mean values on different benefits of Six Sigma and results of one sample t-test

The result of the one sample t-test for growth of company shows that the calculated mean value is 31.7 as against the test value of 32.4. The difference in mean values between observed and expected on growth of the company is not significant,  $t(26) = -1.192$ ,  $p(0.244) > 0.05$ . Since the test statistics revealed equality between observed and expected values, one can infer that existing practices of Six Sigma contribute to the growth of the company hence H1a is accepted.

The result of the one sample t-test for financial benefits shows that the calculated mean value is 30.29 as against the test value of 28.8. The difference in mean values between observed and expected on financial benefits is highly significant,  $t(26) = 2.991$ ,  $p(0.006) < 0.05$ . Since the test statistics revealed a highly significant difference between observed and expected mean values, supported by positive value of t, one can infer that the company has reaped financial benefits after implementing Six Sigma. Hence, H1b is accepted.

The result of the one sample t-test for peoples' equity shows that the observed mean value is 94.7 as against the test value of 97.2. We can observe that the observed mean value is lesser than expected mean value, but the difference in mean values between observed and expected on peoples' equity is not significant,  $t(26) = -0.710$ ,  $p(0.484) > 0.05$ . Since the test statistics revealed equality between observed and expected values, one can infer that existing practices of Six Sigma contribute to the improvement of peoples' equity in the company. Hence H1c is accepted.

The result of the one sample t-test for productivity shows that the calculated mean value is 65.14 as against the test value of 64.8. The observed mean value is more than the expected value. However, the difference in mean values between observed and expected on growth of the company is not significant,  $t(26) = .225$ ,  $p(0.824) > 0.05$ . Since the test statistics revealed equality between observed and expected values, one can infer that existing practices of Six Sigma contribute to the improvement of productivity of the company hence H1d is accepted.

The result of the one sample t-test for customer satisfaction shows that the calculated mean value is 55.96 as against the test value of 57.6. Here also the obtained mean value is less than expected mean value, but the difference in mean values between observed and expected on growth of the company is not significant,  $t(26) = -0.804$ ,  $p(0.429) > 0.05$ . Since the test statistics revealed equality between observed and expected values, one can infer that existing practices of Six Sigma contribute to the growth of the company hence H1e is accepted.

### B. Testing of Hypothesis H2

It could be true that managers' and workers' view point would be different as they belong to two different class of working. We also test whether their view point is same or different in case of Six Sigma implementation with respect to five variables stated earlier. Hence one more hypothesis is stated.

H2. Managers and employees differ significantly in their opinion on implementing Six Sigma.

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In the first instance we test their opinion in case of growth of the company. Independent sample t-test is used to check whether workers and supervisors differ in their opinion that implementation of Six Sigma has contributed to the growth of the company.

The group statistics table shows means of both the groups differ. Next we will conduct the independent samples t test to test the statistical significance of this difference.

Variable	Designation of respondent	N	Mean	Std. Deviation	t-value	P-value
Growth of the company	Worker	16	31.25	3.45	-.934	.359 (non significant)
	Manager	10	32.36	2.29		
Financial benefits	Worker	16	30.50	2.96	.484	.633 (non significant)
	Manager	10	30.00	2.04		
Peoples' equity	Worker	16	90.00	19.69	-1.669	.108 (non significant)
	Manager	10	101.5	14.09		
Productivity	Worker	16	62.50	8.80	-2.208	.037 (significant)
	Manager	10	69.00	4.97		
Customer satisfaction	Worker	16	51.93	11.64	-2.646	.014 (significant)
	Manager	10	61.81	4.89		

Table 2: Group statistic table for benefits of Six Sigma and result of independent sample t test

Independent samples 't' test revealed a non-significant difference between workers and supervisors in their scores on 'growth of the company' ( $t=-.934$ ;  $P=.359$ ), for financial benefits ( $t=.484$ ,  $p=0.633$ ), and for peoples' equity ( $t=-1.669$ ,  $p=0.108$ ). The two tailed significance value is greater than  $p (0.05)$ . Thus we can infer that managers and workers do not differ in their opinion towards implementation of Six Sigma with regard to growth of the company, financial benefits and peoples' equity.

On the other hand, we can observe that independent samples t-test revealed a significant difference between managers' and workers' mean scores for productivity ( $t=-2.208$ ,  $p=0.037$ ) and for customer satisfaction ( $t=-2.646$ ,  $p=0.014$ ). The two tailed significance value is less than  $p (0.05)$ . thus we can infer that managers and workers have difference of opinion towards Six Sigma implementation with regard to productivity and customer satisfaction. Workers still are of the opinion that Six Sigma implementation has not contributed towards improvement of productivity and customer satisfaction, whereas managers believe that Six Sigma implementation has improved productivity and customer satisfaction (the mean value of managers is higher than workers).

## IX. CONCLUSION

Six Sigma is seen as a savior by many companies. They feel that their position in the market can be significantly improved with the help of Six Sigma. This case study was also taken to prove a point about implementation of Six Sigma. The survey results revealed the following facts about the implementation of Six Sigma in the manufacturing company

1. The implementation of Six Sigma has helped the company to gain benefits like growth, finance, peoples' equity, productivity and customer satisfaction. Out of these benefits we observe that as per respondents' opinion, only financial benefits are quite significant ( $P<0.05$ ), while other benefits are not as significant. This is proved by the significance value ( $p>0.05$ ). Thus we could just establish the equality of observed mean with that of expected mean. Though we can claim that Six Sigma has contributed to growth of the company, peoples' equity, productivity and customer satisfaction, it is not highly significant. This results in a great responsibility for the management to look into this matter on a serious note.

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- Further, the survey revealed a mixed response between the opinions of managers and workers. Their opinion about the Six Sigma implementation is not significantly different for financial benefits, growth of the company and peoples' equity. However for productivity and customer satisfaction, while managers believe that Six Sigma implementation has improved them, workers feel that the contribution of Six Sigma towards improved productivity and customer satisfaction is questionable

**This opens up a huge scope for deeper study of the Six Sigma practices and improve them further to gain more benefits.**

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