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Status of Quality Improvement Initiatives in Manufacturing Industry of Madhya Pradesh State in India

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Abstract

The objectives of this work are to investigate the status of implementation of quality initiatives by manufacturing firms in Madhya Pradesh, India, and to compare large and small-medium scale industries. Very few researchers have attempted to compare large scale and small-medium scale firms in order to know the extent of implementation of quality initiatives for a state like Madhya Pradesh. In this study, the survey questionnaire method was used for the collection of data. Nine quality initiatives were selected for the study. The obtained data are grouped into two groups: 1) large scale firms, and 2) small-medium scale firms. Descriptive and inferential statistics are used for analysis and the results are presented. Hypothesis testing was used to investigate for any significant difference between the two groups of firms in implementing each quality initiative. Results from inferential statistics reveal that there is a significant difference in the implementation of quality initiatives in large and small-medium scale industries. The findings of the present work will guide firms to identify areas where improvement is required at each quality initiative level. The study will help small-medium scale firms in the Madhya Pradesh state of India to conduct training programs in the areas of relevant quality initiatives for improving their quality of products.

Keywords: Small, Medium and large-scale firms, Quality initiatives, Quality assurance, TQM, Kaizen, Quality function deployment, Manufacturing industry.

1 | Introduction

Indian manufacturing industry occupied 17.4% of GDP in fiscal year 2020. In order to increase the contribution of the manufacturing sector to 25% or more, it is important to focus attention on the improvement of the quality of products, which is one of the important drivers in order to compete locally and globally. Quality is considered very significant in highly competitive markets for any product or service. Often it becomes the market differentiator for products. Quality Initiatives (QI) help a firm or industry to meet or exceed customers' expectations and contribute to its success in the long run. It also contributes to making an organization efficient by minimizing material wastage and in turn raises the levels of productivity. Due to this reason, all manufacturers aim to improve their product quality.

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For maintaining and enhancing the quality of products, many QI, viz. 1) Total Quality Management (TQM), 2) Kaizen, 3) Quality Assurance, 4) Quality Standards, and 5) Testing methods have been introduced. These initiatives have proved in many organizations that the end product meets or exceeds the quality expectations and standards defined for the product.

There are many QI other than listed above which were followed by various firms for achieving and maintaining the required quality level in their organizations. Some organizations believe in the concepts of Quality Function Deployment (QFD) and some others believe in statistical process control and acceptance sampling. Implementation and maintaining QI in a firm may require substantial investment at the beginning. This may be one of the reasons why large-scale firms are ahead of small and medium scale firms in implementing and maintaining QI. It is also true that small and medium scale industries focus more on following ISO as an initiative and they are content with meeting their business needs. However, many researchers focused their attention on factors related to organizational, cultural, and project differences. The effect of these factors is never compared in the implementation of Quality Management (QM) practices. Along with this, cases from developed countries, such as the United States, Britain, and Japan were taken up and examined the dissemination of QM tools and techniques but similar studies are lacking in developing economies such as India. Hence, it is important to study the implementation of QI in manufacturing firms in India and to compare them by taking a case study in one of the states in India.

Madhya Pradesh is chosen as the state where a comparative study of the implementation of various QI /techniques is taken up in this study in order to highlight the areas where there is scope to improve the quality of products in small-medium enterprises. The objectives of the study are to present a descriptive statistical analysis of selected QI and inferential statistics, to identify the QI that need to be implemented in small-medium scale firms for improvement of quality of product and successfully meet the market demands. A brief account of the review of literature is presented in Section 2, the methodology adopted for conducting the survey and analysis is given in Section 3. Section 4 covers the results and statistical analysis. Conclusions are given in Section 5.

2 | Literature Review

Jain and Samrat [1] used the interview method to collect the data and analyze real quality practices of Gujarat based manufacturing industry. Their focus was on quality planning, testing, and recording, supplier assessment, consultants, and certification practices. Chakraborty [2] devised an approach based on a survey for analyzing selected QM practices, implemented in SMEs in Tiruchirappalli, India. They found that 60% of firms implemented QI successfully, but 25% of firms were unsuccessful. The rest needs to be educated about the importance of quality in a competitive market. Limited knowledge and the high cost of training limit the implementation of QM practices in SMEs.

Maguad [3] proposed a system for implementing the Quality Management Initiatives (QMS) and they concluded that every organization should have its own model for QMS based on its strengths and weaknesses. Bhatia and Awasthi [4] conducted a study investigating the efficacy of QMS in Canadian context. They analyzed data collected from 32 organizations from across. The results of the research indicated that implementation of QMS acted as an impetus for change and hence, firms used it in daily practice.

Sandström and Svanberg [5] used force field analysis to find factors for and against change. They recommended considering some factors, such as the quality department, its goals, and their policies independently, as they cannot be categorized as a force for change. Prajogo et al. [6] concluded that a positive correlation exists between operational performance measures and supplier management practices. Further, flexibility, delivery, and cost performance were identified to be key factors for logistic integration and strategic long-term relationships. Martínez-Costa et al. [7] studied the effect of internal motivation on successful implementation of the ISO9000 standard resulting in high performance and found that external motivation did not have much effect.

Majumdar and Manohar [8] studied SMEs in India for implementation of TQM practices using the interview method, analyzed the data, and identified their weakness/difficulties in adopting TQM. They recommended some guidelines for overcoming barriers to implementation after arranging the practices in order of importance. Kumar et al. [9] studied small and medium-scale firms in Australia and the U.K and compared them with reference to QM practices. They reported that six-sigma and lean initiatives contribute significantly to the success of QM practices. They also found that SMEs in the U.K reported significant improvement when compared with firms in Australia, in the implementation of QI. Singh et al. [10] used a questionnaire survey to investigate the impact of QM practices, such as, Just in Time (JIT), 5S's tools, suggestion schemes, etc. on inventory management, cost, etc. They concluded that QMS contributed to the performance output of the firms. Mandal et al. [11] used questionnaire survey and interview methods to collect data from quality professionals of Australian manufacturing firms. They studied the effectiveness of QI that were implemented and found that the awareness towards quality has gone up in these firms and quality became a priority initiative for improving customer satisfaction.

Similar studies have been conducted in countries such as, Pakistan by Abbasi et al. [12], Namibia by Mutingi and Chakraborty [13], etc. Chakraborty et al. [14] compared the QM practices in India and Namibia for SMEs. In all these cases, the status of implementation of QMS in either SMEs or the entire industry of a specific region was studied. Gutierrez et al. [15] proposed a solution for choosing alternatives among quality control, European Foundation for Quality Management (EFQM), Six Sigma, and ISO 9000 in accordance to the degree of development required for the elements that structure the alternatives. They involved 234 organizations in Europe, used Analysis of Variance and mean comparison t-test, and concluded that quality control is the simplest initiative, followed by ISO 9000, the EFQM model, and Six Sigma. Assarlind and Gremyr [16] emphasized on implementation of successful QM initiatives from large-scale firms gradually in Small and Medium-sized Enterprises (SMEs). They analyzed five categories of critical factors for QM initiatives in SMEs viz. 1) contextualization, 2) gradual implementation using realistic goals, 3) involvement and training of employees, 4) involvement of external support; management involvement, and 5) fact-based follow-up. Thawesaengskulthai [17] provided a holistic framework for selecting a QM initiative in Thailand for improvement which is carried out in three phases. They proposed a holistic model involving four selection views of fashion setting, pay-off, strategic fit, and organization fit to assist managers undertaking selection decisions. Nguyen et al. [18] compared the impact of QI on the operational capabilities of Vietnamese and Japanese manufacturers. The study provides empirical evidence on the implementation of QM practices in different countries by offering insights into performance improvement in both countries.

Gandara et al. implemented QFD approach for the implementation of the right design in improving the service of selling formaldehyde products in a chemical industry according to the customer requirements. They used a customer satisfaction questionnaire survey form for the data collection. Saputra et al. [20] used the statistical process control to determine the capability of the molding machine. They obtained a process capability of the machine to be 0.63 and they improved it to 1.65 by applying Poka-Yoke. Hernadewita et al. [21], studied a large-scale firm that prints magazines that often faces the problem of quality defects in its printouts and thus causes losses due to production defects. They determined the current sigma value of production to be 3.6 and the occurrence of various defects. They proposed necessary steps to achieve Six Sigma using the results of their study.

Very few researchers have made an attempt to compare the implementation of these initiatives in large-scale and small-medium manufacturing firms. In this work, the industries which come under small-medium and large scale are taken into consideration for Madhya Pradesh state. The micro-scale industry is not taken into consideration for the study. Implementation of QI in both these sectors is surveyed and QI that have significant differences in implementation between the two groups are identified. This helps small-medium enterprises in focusing their management's attention on these initiatives and improves their quality standards.

3 | Methodology

A cross-sectional online questionnaire survey was used in this study. The questionnaire was administered during the period from December 2020 to April 2021. Consent to participate was implied by the completion of the survey. The questionnaire tool is a 68-item instrument using a nominal scale for most of the questions. A questionnaire survey is one of the best tools that can be appropriately employed to study the implementation of QI in large and small-medium scale industries. The first part of the questionnaire is general in nature and questions are designed to seek details about the firm, such as name of the firm, investment in the last three years, name and designation of the person participating in the survey, etc.

At the beginning of the questionnaire, definitions of QI are included to ensure that respondents were able to distinguish the intervention from others that may have been occurring in their workspace. Industries that have registered with Micro, Small & Medium Enterprises (MSME), Madhya Pradesh, India, were invited to participate in the online survey. Large scale industries which are located in Madhya Pradesh are also contacted for participating in this survey. The number of small and medium-scale firms in Madhya Pradesh is 531 and the large-scale firms are 287. Some of the questions were repeated so as to verify consistency in answers. The questionnaire consists of three parts. The first part was designed to know whether various QI, such as TQM, JIT, Kaizen, etc. Were implemented in manufacturing firms or not. The second part was at the micro level for the QI in which tools and techniques of each quality initiative were included. The third part of the questionnaire was designed to collect implementation details of the basic quality control and inspection activities in the firms. The online questionnaire was pilot tested with ten professionals using QI in the manufacturing industry. Revisions were made to the questions based on their feedback before sending it by e-mail to sample firms.

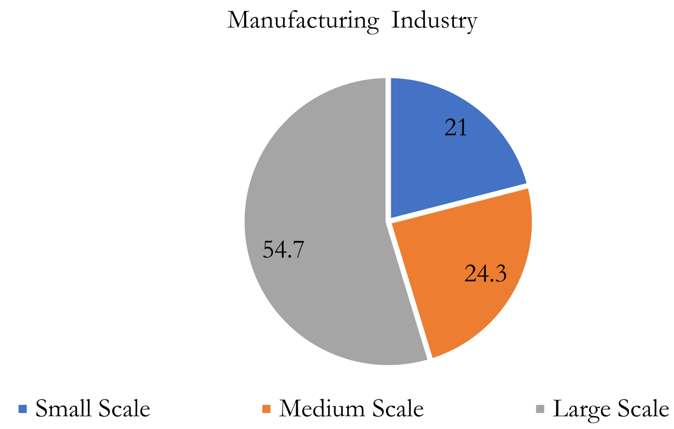
The questionnaire was sent to 400 firms by e-mail, inviting them to participate online through Google forms. Reminders are sent once in 15 days. At the end of 140 days, a response from 106 firms was obtained. Of these, 58 firms are large scale firms and the rest 48 are small-medium scale firms. Some firms have given responses to all the questions, but some others partially answered them. They were contacted on the phone to obtain answers by clarifying some of their queries for the rest of the questions in order to get the questionnaires filled out completely. For analysis, the firms are divided into large scale and small-medium scale firms. For descriptive statistics, Microsoft Excel 10 is used to construct bar graphs for comparison purposes. For inferential statistics, the chi-square test applicable to nominal scale data is adopted. Chi-square tests are used to examine differences between two groups, such as large and small-medium scale industries, in implementing QI and their tools and techniques.

4 | Findings from the Survey

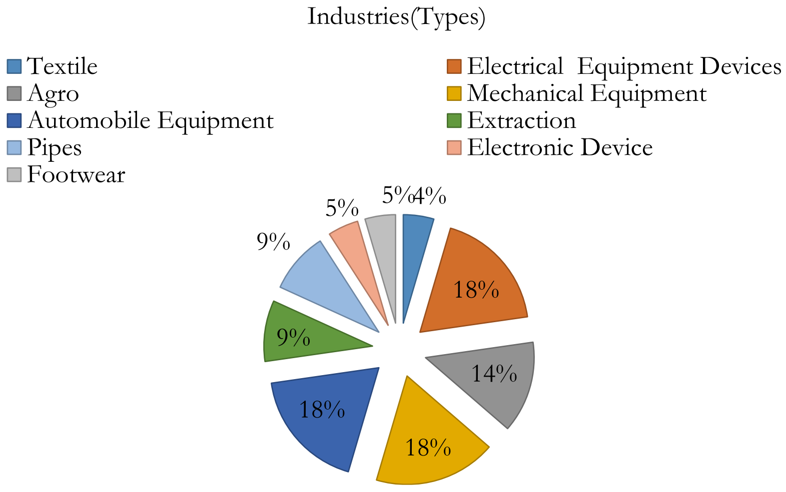
The data obtained from google forms are arranged with a Microsoft Excel sheet based on the investment made by the firms. Those firms which have made an investment up to INR 5crore (USD 670,000) are categorized into small-scale firms and those which have invested from INR 5 crore to INR 10 crore (USD 1,240,000) are categorized into medium-scale firms. Large scale firms are those firms that have invested more than INR 10 crores. The data are grouped into large scale and small-medium scale firms for analysis purposes. Comparison of implementation of QI is presented using descriptive statistics and hypothesis testing is carried out using inferential statistics.

4.1 | Descriptive Statistics

From the 106 responses obtained, 58 responses (54.7%) were from large scale firms and the rest 48 were from small-medium scale firms (45.3%) as shown in *Fig. 1.a.* The categories of firms who responded are shown in *Fig. 1.b.* The data collected represents all types of manufacturing enterprises in Madhya Pradesh state, India. Bar charts are used to compare the large and small-medium scale firms in implementing the QI and the result are shown in *Fig. 2.* Most large-scale firms are using all the initiatives such as, TQM, QA, QI, TM, Quality System (QS) etc. Very few small-medium scale firms are using these initiatives. This is a major difference between large scale and small-medium firms from Madhya Pradesh and the corresponding category of firms elsewhere in the world. Most small-medium scale firms are focused on implementation of TQM, QA, and QI methods only. This may be one of the reasons why they are lagging behind large scale firms which are implementing most of the QI. This will also affect the quality of output products from small-medium scale firms.



a.



b.

Fig. 1. Response diagrams: a. firms categorized based on investment; b. firms categorized based on product/type of product.

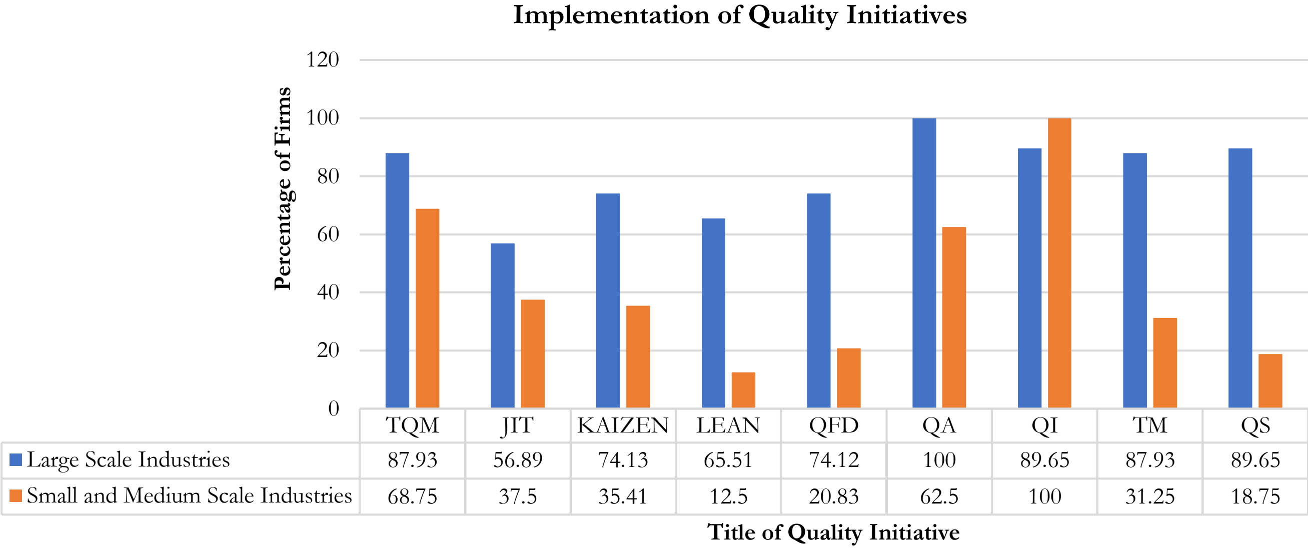


Fig. 2. Comparison of quality initiatives between large and small-medium scale firms.

In *Fig. 3*, implementations of selected TQM tools are presented. From *Fig. 3*, it may be observed that small-medium scale firms are focusing their attention on improving the system and PDCA cycle. Very few of them are focusing on training of workers, elimination of fear, and removal of barriers between departments. It is important to improve skill level of workers by arranging training program from time to time, creating work environment which facilitates elimination of fear and insecurity among workers.

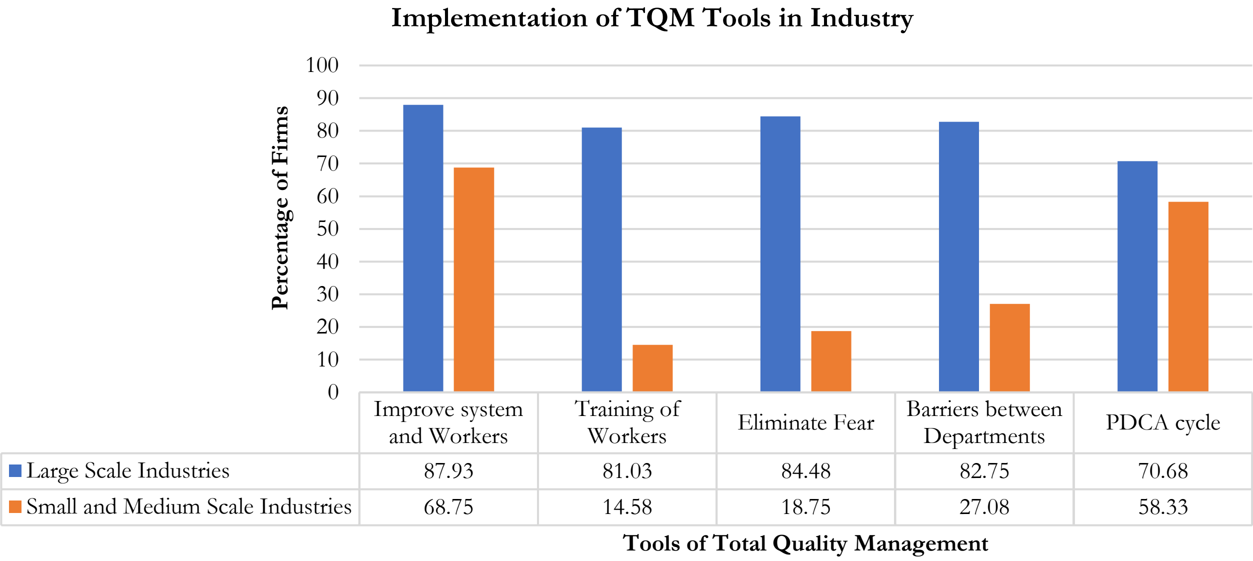


Fig. 3. Comparison of TQM tools between two groups of firms.

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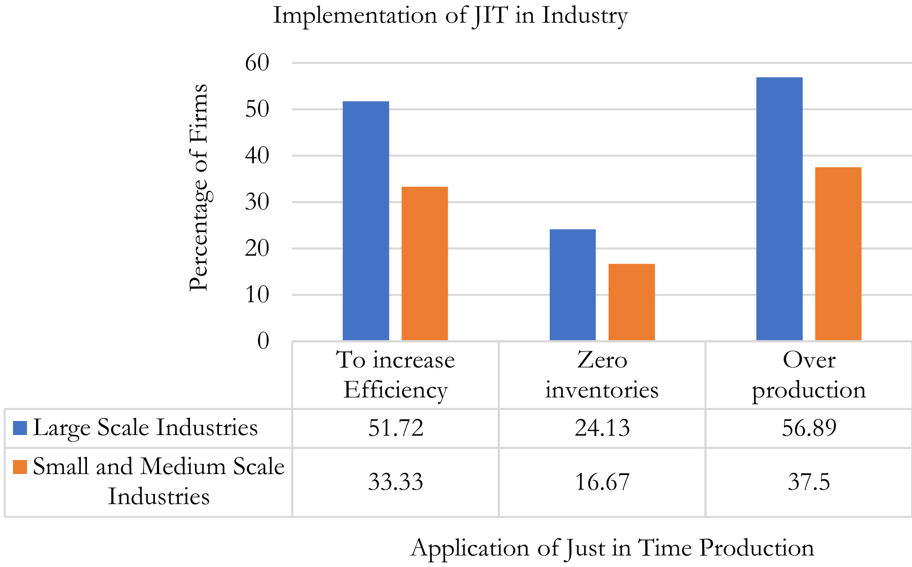

Fig. 4. Comparison of JIT tools between two groups.

From *Fig. 4*, it is clear that JIT implementation is poor at both large scale (max. 57%) as well as small-medium scale firms (max. 37.5%). Out of three factors of JIT taken into consideration, zero inventories concept is least used by the firms and this is a cause of concern and is identified as a barrier for enhancement of quality in the manufacturing industry of Madhya Pradesh state. Two factors are considered in the implementation of Kaizen as shown in *Fig. 5*, and both are found to be implemented in most of the large-scale firms but many of the small-medium scale firms need to implement Kaizen Gemba, which emphasizes on better communication and trust between employees and management. *Fig. 6* shows detailed analysis of Lean manufacturing tools. It is found from the *Fig. 6* that small-medium scale firms hardly use this initiative and there is need to educate them about importance of this tool. There is also scope to increase the number of large-scale firms using this initiative, which is helpful to improve productivity as well.

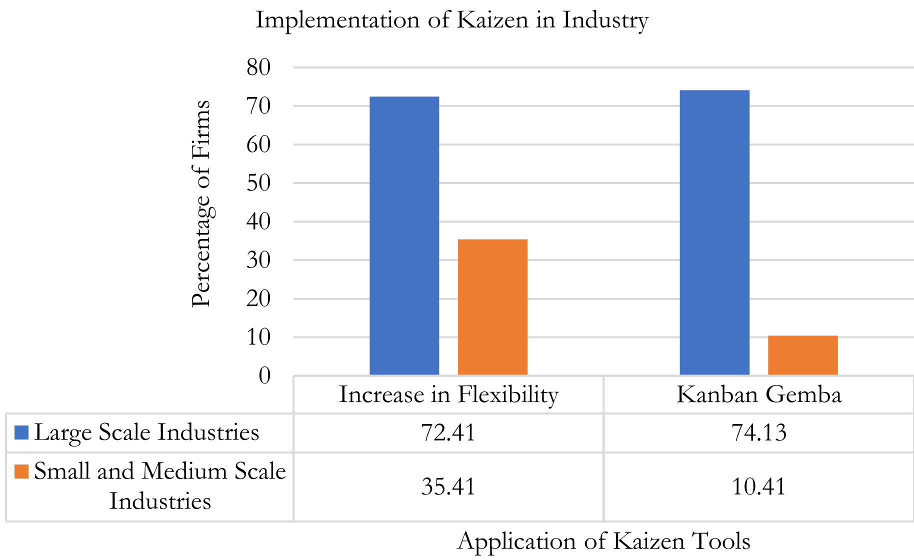

Fig. 5. Comparison of kaizen tools between two groups.

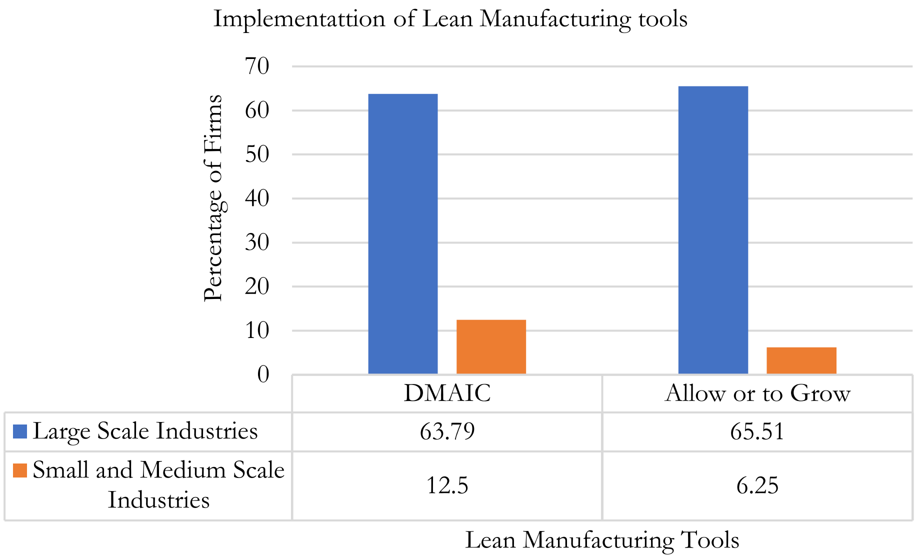

Fig. 6. Comparison of LEAN Manufacturing tools between two groups.

Fig. 7 shows the implementation of the QFD initiative in both categories of firms. Even though large-scale firms perform better in the three factors that are considered, small-medium scale firms have a lot of scope for improvement, especially in implementation of house of quality tools in design. This helps them in converting the customer requirements into design specifications in the most effective manner. *Fig. 8* shows details related to the implementation of quality assurance tools by both groups of firms. Written procedures are maintained by more than 50% of both the firms and quality assurance tools are used by large scale firms. Small-medium scale firms need to improve complaints, handling and documentation procedures which will improve goodwill of firms and quality of product.

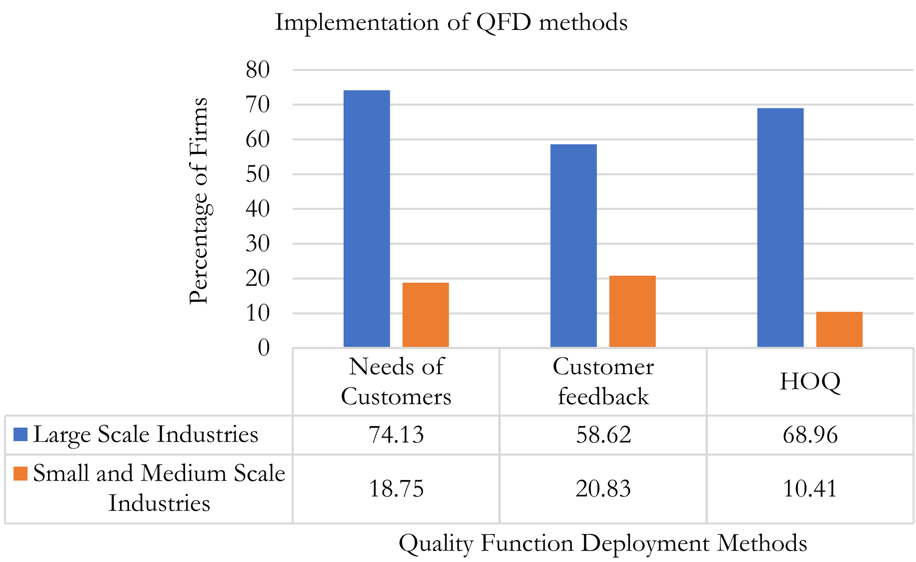

Fig. 7. Comparison of QFD methods between two groups.

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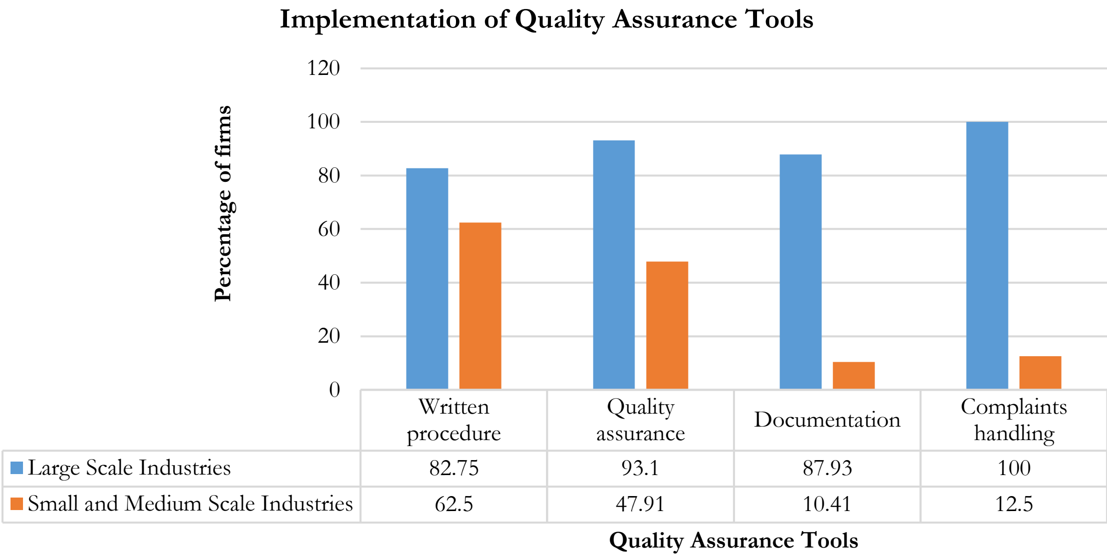

Fig. 8. Quality assurance tools: a comparison between both groups of firms.

However, in Quality Inspection (QI) activity (shown in *Fig. 9*), both groups are firms that use all the tools and techniques. This shows that basic quality control and inspection activities are carried out by most of the firms. As shown in *Fig. 10*, quality standards, such as, ISO9000, ISO9001 is implemented by most of the firms, whereas, OHS-AS, MS-ISO-14001, and HAC-CP, are used by very few firms. Out of these, implementation of Operational Safety and Health Standards needs to be considered as a primary requirement by small-medium scale firms. Small-medium scale firms also need to adopt environmental management systems which are need of hour in regulating pollution of the environment. Implementation of advanced testing procedures in small-medium scale firms received low response when compared to large scale firms. Reasons for this may be attributed to the non-availability of funds with small-medium scale firms.

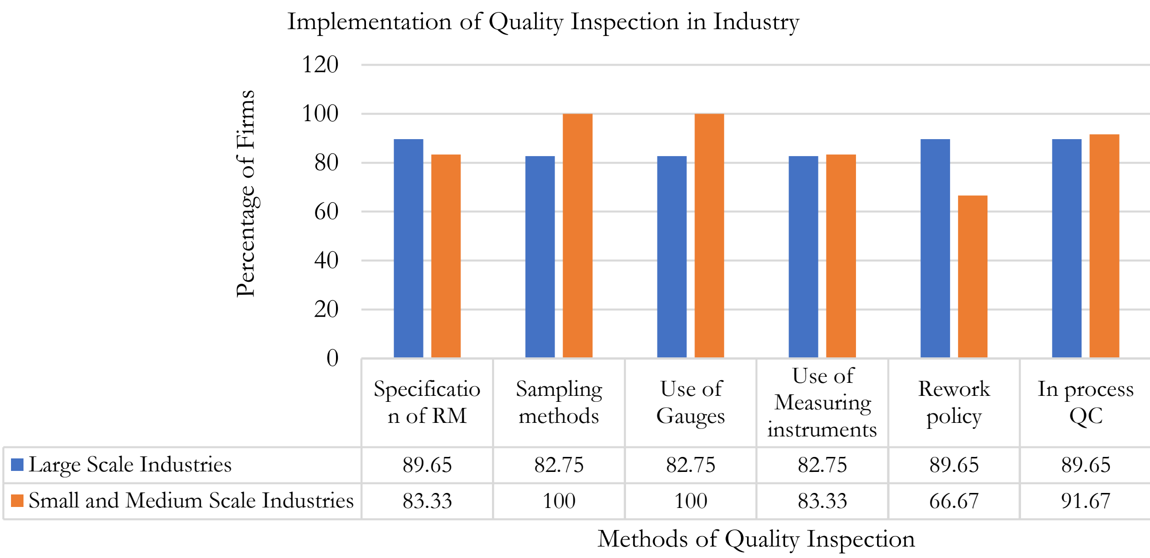

Fig. 9. Methods of quality inspection: comparison between both groups of firms.

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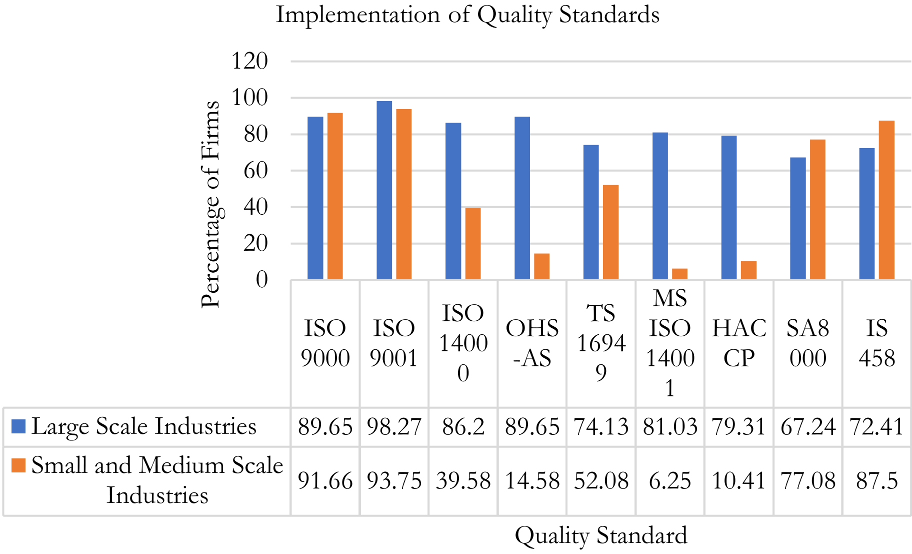
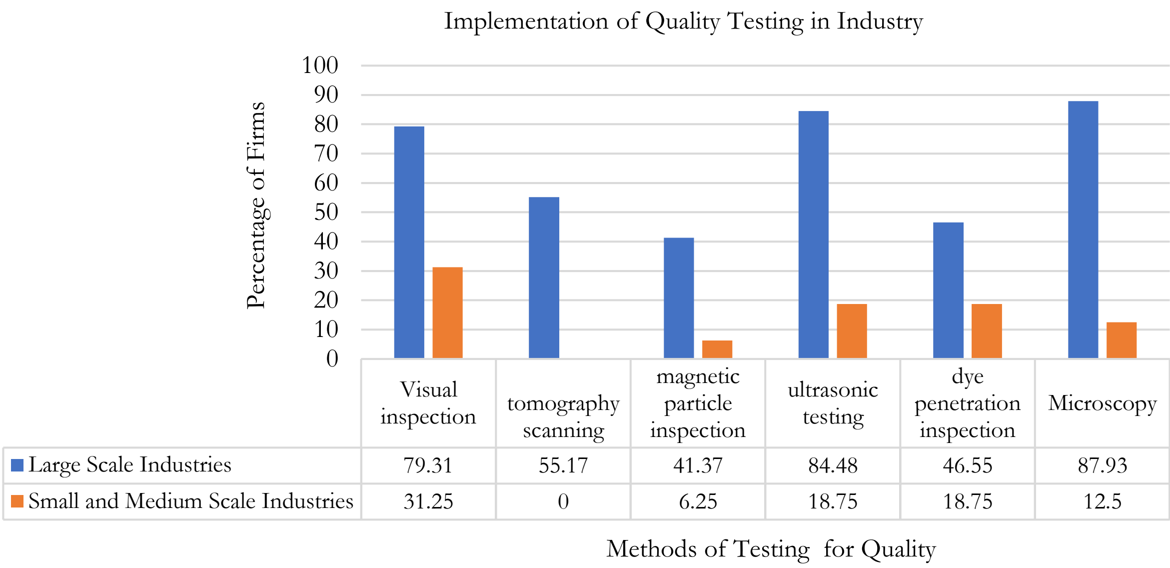


	ISO 9000	ISO 9001	ISO 14000	OHS-AS	TS 16949	MS ISO 14001	HACCP	SA8000	IS 458
Large Scale Industries	89.65	98.27	86.2	89.65	74.13	81.03	79.31	67.24	72.41
Small and Medium Scale Industries	91.66	93.75	39.58	14.58	52.08	6.25	10.41	77.08	87.5

Fig. 10. Methods of quality standards: comparison between both groups of firms.

4.2 | Inferential Statistics

Hypothesis testing and test of significance methods are used in this paper to find out whether implementation of QI in large scale and small-medium scale industries is significantly different. For a test of significance, Chi-square test is used as most of the data is nominal data comprising 'yes,' or 'no' type responses. From *Fig. 11*, it is observed that there is a difference in the implementation of QI between the two groups. In order to test the significance of it using the Chi-square test, the following null and alternative hypothesis are framed.



	Visual inspection	tomography scanning	magnetic particle inspection	ultrasonic testing	dye penetration inspection	Microscopy
Large Scale Industries	79.31	55.17	41.37	84.48	46.55	87.93
Small and Medium Scale Industries	31.25	0	6.25	18.75	18.75	12.5

Fig. 11. Comparison of methods of testing for quality between the two groups.

Hypothesis H0: there is no difference between large and small-medium scale enterprises in the implementation of quality improvement initiatives.

Hypothesis H1: large and small-medium scale enterprises differ significantly in the implementation of quality improvement initiatives.

Data from *Fig. 2* is reproduced in *Table 1* to illustrate the computation of expected values. The total expected value (36.93) is calculated using *Eq. (1)*, which is shown in *Table 2*. Chi-square tables are referred to find out p-value. If a p-value is less than 0.05 (confidence level), it may be concluded that the difference between the two groups is significant; otherwise, the difference between the two groups is insignificant.

Table 1. Responses from firms in implementation of quality initiative.

Quality Initiative	TQM	JIT	Kaizen	Lean	QFD	QA	QI	TM	QS	Total
Large Scale Industries	51	33	43	38	43	58	52	51	52	421
Small and Medium Scale Industries	33	18	17	6	10	30	48	15	9	186
Total	84	51	60	44	53	88	100	66	61	607

Table 2. Expected values of responses for quality initiatives.

Quality Initiative	TQM	JIT	Kaizen	Lean	QFD	QA	RM	TM	QS
Large Scale Industries	58.26	35.37	41.61	30.52	36.76	61.03	69.36	45.78	42.31
Small and Medium Scale Industries	25.74	15.63	18.39	13.48	16.24	26.97	30.64	20.22	18.69

4.2.1 | Chi-square test for nominal data

Step 1. Compute expected value using the following equation.

$$\text{Expected Value}\left(E_{ij}\right) = \frac{\sum_{j=1}^{n} O_{ij} * \sum_{i=1}^{m} O_{ij}}{N}, \qquad (1)$$

where Eij is expected value of ith row and jth column (calculated and shown in *Table 2*); Oij is observed value of ith row and jth column (given in *Table 1*); $\sum_{j=1}^{n} O_{ij}$ is sum of ith row and $\sum_{i=1}^{m} O_{ij}$ is sum of jth column; N is the total value of above two sums.

Expected values are computed from *Eq. (1)* from observed values of QI are shown in *Table 2*.

Step 2. Compute χ2values in order to test of independence between two groups of variables.

$$\chi^2 = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}. \qquad (2)$$

The values of $\frac{(O_{ij}-E_{ij})^2}{E_{ij}}$ are calculated and shown in *Table 3*. The grand sum of all these values is obtained as 36.93.

Table 3. Chi-square values computed for quality initiatives.

Quality Initiative	TQM	JIT	Kaizen	Lean	QFD	QA	QI	TM	QS	Total
Large Scale Industries	0.90	0.16	0.05	1.83	1.06	0.15	4.34	0.60	2.22	11.32
Small-Medium Scale Industries	2.05	0.36	0.10	4.15	2.40	0.34	9.83	1.35	5.03	25.61
Total	2.95	0.52	0.15	5.99	3.46	0.49	14.18	1.95	7.25	36.93

Number of degrees of freedom = (number of rows-1)*(number of columns-1) = 1*8=8.

For $\chi 2$= 36.93, from statistical tables, the p-value obtained is 0.000012 and the result is significant at $p<0.05$.

The null hypothesis is rejected, indicating the significant difference between large and small-medium scale firms in the implementation of QI. Analyzing further, each quality initiative is taken into consideration and from the data, $\chi 2$ values, degrees of freedom and p-values are computed. The results obtained are shown in *Table 4*. Take for example, at the next level, the factors of TQM are taken into consideration and the following hypotheses are framed.

Table 4. Hypothesis testing for quality initiatives.

Quality Initiative	TQM	JIT	Kaizen	Lean	QFD	QA	QI	TM	QS
χ^2	22.79	4.30	5.49	0.86	2.13	25.32	3.57	13.67	71.31
DOF	8	2	1	1	2	3	5	5	8
p-value	0.000139	0.116	0.019	0.32	0.34	0.00003	0.61	0.017	0.00001
p<0.05 (yes/No)	Yes	No	Yes	No	No	Yes	No	Yes	Yes
Null Hypothesis	Rejected	Not Rejected	Rejected	Not Rejected	Not Rejected	Rejected	Not Rejected	Rejected	Rejected

Hypothesis H0: there is no difference between large and small-medium scale enterprises in the implementation of TQM tools.

Hypothesis H1: large and small-medium scale enterprises differ in the implementation of TQM tools.

Number of degrees of freedom = (number of rows-1)*(number of columns-1) = 1*8=8.

$\chi 2$ = 22.79. The p-value is 0.000139 and the result is significant at $p<0.05$. The null hypothesis is rejected in this case and hence the difference in the implementation of TQM tools is significant.

From the above results (refer to *Table 4*), it may be concluded that QI, viz., 1) TQM, 2) Kaizen, 3) QA, 4) TM, and 5) QS have significant different implementation between large scale and small-medium scale firms in Madhya Pradesh. This indicates that small and medium scale firms should focus on the implementation of these techniques for improving the quality of their products and in turn competitiveness in the market. Take for example, small and medium scale firms should focus on improvement of the system, training of workers, eliminating fear, barriers between departments, and implementation of plan–do–check–act (PDCA) cycle, etc. in order to improve their efforts towards implementation of TQM initiative. Similarly, the null hypothesis is not rejected in the case of QI, such as, JIT, LEAN, QFD, QI etc. which indicates that large and small-medium scale firms do not differ much with regard to implementation of these techniques. This proves that either both groups have implemented these initiatives to some extent or are actively practicing them.

5 | Conclusions

In this paper, a questionnaire survey was conducted for two groups of firms (large and small-medium) in Madhya Pradesh state in India in order to know the status of implementation of QI in those firms. The results are presented using descriptive statistics and inferential statistics. For descriptive statistics, a comparative study of both groups of firms is made using bar graphs. By analyzing the bar graph in terms of percentage of firms, small-medium scale firms are found to implement initiatives such as, TQM, JIT, Kaizen, and QA at par with the large-scale firms in initiatives. However, they are far behind in implementation of initiatives such as, LEAN, QFD, TM and QS in comparison with that of large-scale firms. But in the area of QI, small-medium firms are performing better than large firms as shown in *Fig. 2*. In quality standards, in some of the quality standards such as, ISO 9000, ISO 9001, SA8000, and IS458, small-medium scale firms are matching with large scale firms. However, in most of the other criteria, small-medium scale firms are lagging behind large-scale firms. Especially in TQM, small-medium scale firms are lagging behind in the areas of providing training to workers and eliminating fear among them, as compared to large scale firms as revealed from *Fig. 3*. For providing adequate training to workers, they need skilled trainers and adequate training facilities, which needs greater investment.

In inferential statistical analysis, χ-square tests and hypothesis testing are used. Test of significance for the overall implementation of QI indicates that there is a significant difference between the two groups of firms. As there is a significant difference, each quality initiative is taken up and χ-square test is used to study the level of significance for each of them. The results indicate that some of the areas of TQM, Kaizen, QA, TM and QS need improvement for small-medium scale firms in order to improve their quality and compete with market leaders. Although the percentage of small-medium scale firms using TQM and QA is high, their implementation is not good enough to match the level of large-scale firms. For implementation, they need more funds in order to improve their infrastructure, and also local as well as central government support. Government needs to promote the use of modern techniques and provide opportunities for small-medium scale firms to grow. In addition to this, they need to train their employees in order to upgrade their skills. They need to focus on improving the quality of product, efficiency of the firm, and fulfilling the customer needs. Government support is also required in terms of establishing proper markets for the products from small-medium scale industries till they grow to a certain level.

The drawback of this study is that the authors are very selective in their studies regarding the factors in each of the QI. Future researchers may consider an exhaustive list of factors for each of the QI and conduct similar studies in other countries. This helps a firm to know and highlight the areas in which they need to focus in order to improve their quality in both design and production areas.

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