Investigating scope of lean six sigma implementation in automotive manufacturers

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Abstract:

A large number of automotive component SMEs are established in India in last 3 decades. These manufacturing units produce automotive components for domestics and exports markets. Recession in automotive sectors, shift towards electrical vehicles and environmental regulations have brought hard time for these manufactures. According to recent survey 34% of such manufacturing units in Vadodara and Rajkot are planning to shift to other businesses. Lean six sigma are proven change method to improve quality and cost effectiveness in manufacturing plants and service sector. It has brought miracles for same sinking ships. The present research was carried out to examine the suitable tools (practices), barriers and expected outcomes of implementing lean and six sigma in automotive component SMEs. A combined approach of literature review and structured questionnaires survey was adopted. Research and papers related to standard journals. A survey questionnaire was designed in consultation with experts who have experience in implementing lean, six sigma in various tools, barriers, criticalsuccess factor and expected performances out come. Total 90 experts having experience in implementing, training and analyzing lean six sigma implementation participated in the survey. Suitable tools, barriers and expected performance outcome for implementing lean six sigma in automotives SMEs were derived.

Keywords: Automotives SMEs, Quality, Lean six sigma, Change method.

1. Introduction:

India is a major producer of automotive and automobile components. Government's 'Make in India' initiative has created numerous opportunities for small and medium scale auto ancillaries in India. Automotive mission plan 2026 (AMP 2026) will help Indian automotive industry to focus on its strength and improve its competitiveness. India has annual producing target of 1889500 rs by 2026. India could stand first in the world in production/sale of small cars, two wheelers, three wheelers, tractors and buses, 3rd in passenger vehicles and heavy trucks all adding 12% contribution to national GDP.

1.1. Automobile Industry overview : India

- Size of Indian automotive sector $ 77 Billion
- Contributes 7.1% in Indian GDP in volume terms and 45% to the manufacturing GVA
- 29 million automobiles produced in India in FY 18.25 million units sold in domestic market and 4 million units exported.
- Largest three wheeler manufacture in the globe with annual production capacity of 7.8 million units
- Contributes 8% to India's total export
- Employs 19 million people directly and indirectly
- Second largest two wheeler manufacturer in the world with annual production capacity of 20 million units.
- Presently Indian auto component market size is around $43 bn. (Contributes 2.3% to Indian GDP); it is expected to be $115 bn by 2021-22
- India is a major exporting country for OEM's world wide – USA (22%), Germany (7%), Turkey (6.2%), UK (5.1%) and Italy (4.1%) are major market for Indian auto industry.
- 100% FDI is allowed in Automobile sector. FDI worth $18.41 bn. received between April 2000 to December 2018

1.2. Gujarat: An Important manufacturing hub for Auto industry

Major auto giants like Honda, MG motor, Ford, Maruti Suzuki, Hero motor corporation, Tata have their manufacturing plants in Gujarat. Well planned auto clusters in Ahmedabad – Sanand, Mandal – Bechraji, Hansalpur–Vithalpur, Mehsana, Vadodara–Halol and Rajkot have attracted auto giants and auto ancillaries. In Guajarat's overall FDI share of automobile sector is 13% as compared to 5% for India's overall FDI. Gujarat has set target to rise the share of automobile industries in overall engineering output to 10% by 2022 from the present 4% in 2019. There are 30 clusters of casting machine tools, brass parts, oil engines, electric equipment's, bearing and auto ancillaries which provides sound base for auto manufacturers. Dholera special Investment

region will attract the further investment in auto sector supported by modern infrastructure, premium social infrastructure, civic amenities and centers of excellence. Gujarat a major automobile manufacturing hub has advantages as an export hub for auto and auto components because of excellent port infrastructure and connectivity with world's major ports. Ports like Kandla, Mundra and Pipavav plan to developed their infrastructure as well as increase its RORO business on the back of strong car export.

1.3 Importance of LSS

It is important to implement LSS in small and medium scale automotive industries. Scope of implementing LSS in these industries has not been explored much. It is important requirement to investigate and derieve important tools, expected outcome critical success factors and barriers for implementing LSS in these companies. Research in the field of integration of lean and six sigma techniques has gained attention in recent time. Many research projects are carried out for integration and implementing of lean and six sigma(LSS) for large industries and service sectors.

Lean: Concept of lean technique was developed at Toyoto to optimize wastes during the post war recovery. The main of princilpe of lean is to eliminate all kinds of waste from the process. There are 7 types of waste; over production, waiting, unnecessary transportation, over processing, high inventory level motion and defects. Implementation of lean tool leads to reduction in waste, increased production rate, improved product quality and customer satisfaction. Lean also ensures smooth manufacturing flow better utilization of labour and reduced delivery time through continues improvement processes.

Six sigma: Six sigma Methodology was developed by a team of engineers at Mototrela in the mid 80s. The objective was to improve performance of production processes. Six sigma techniques reduces the number of defects which helps organization to reduce cost and increase customer satisfaction.

LSS: The integration between lean and six sigma lead to reduction of wastes and process variation (rejections) both. In modern time lean techniques are integrated with six sigma to achieve better quality and reduced wastes. Lean six sigma refers to combined techniques implemented to achieve operational excellence, customers satisfaction, saving in quality cost and advantage over competitiors. LSS focuses on minimizing wastes and eliminating causes of defects and variation.

The automotive industry must focus on quality efforts, continues improvement and technologies related to adoptability and flexibility.

2. Methodology:

A well balanced questionnaire was designed to get the view of experts for exploring scope of lean six sigma implementation in automotive SME. Primarilly questions were designed by consulting experts of companies who have implemented or are in process of implementing lean/six sigma. A committee of 4 lean/six sigma practitioners, 4 academicians and 4 top management officials was formed to finalize the questionnaire. Final questionnaires had following sections. The detail methodology is shown in Figure1.

Section 1: Suitable six sigma tools (12 questions)

Section 2: Suitable lean tools (12 questions)

Section 3: Critical success factors this section contains 72 questions about 12 important critical success factors.

Section 4: Performance out come this section contains 24 questions about 6 important performance out come.

Section 5: Barriers of lean six sigma imprimentation (12 questions).

The questionnaire was sent to 90 experts. In the second part literature review was carries out research article from standard journals were referenced to identify important tools, critical success factors and impending factors for implementating lean six sigma in automotive SMEs.

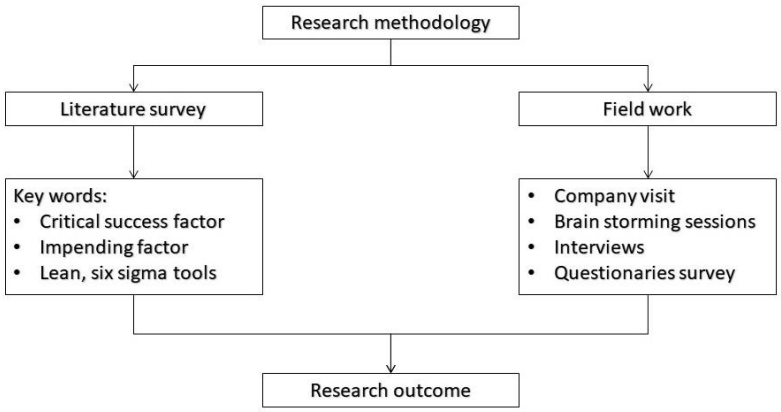


Figure 1 Research Methodology

3. DISCUSSION OF REVIEWED LITERATURE:

Richard E. White et al.[1] carried out an investigative survey to find out differences in implementation of JIT in small scale and large scale U.S. manufactures. A questionnaire was prepared addressing implementation status and change in performance of JIT practices. The questionnaire was validated by panel of JIT experts of association for manufacturing excellence. The questionnaire was sent to 454 respondents, 174 small manufacturers and 280 large manufacturers.

Findings: (i) U.S. based large manufacturers are more likely to implement JIT practices compared to small manufacturers. Rate of implementation is 23.6% in large manufacturer and 13.8% in small manufacturer. (ii) Mean time since adoption of JIT practice is longer in large manufacturer i.e. large manufacturers adopt JIT concept early. (iii) Multifunctional employ concept is suitable for small manufacturers. Large manufacturers are more likely to implement quality circle and total quality maintenance practices.

Rachana Shah and Peter T Ward[2] conducted research to investigate the effect of plant age, plant size and union on Lean manufacturing implementation. A structured questionnaire designed by experts was sent to 1757 respondents of various manufacturing firms of U.S. The questionnaire focused large v/s small plants and old v/s new plants. Plants having employs more than 1000 considered as large plants; 250-999 employs medium plant and less than 250 employs small plants. Plants older than 20 years considered as old plants; 10-20 years adolescent plant and plant and less than 10 years new plant. Empirically validation was carried out for four bundles (a) Total Quality management (b) Total preventive management (c) Human Resource management and (d) Just in time.

Findings : (i) Large companies are more likely to implement change methods like lean compared to smaller companies. It is because larger companies have more financial and other resources (ii) Newer plants are more likely to implement lean practices because older work force ofter more resistance to change. In addition culture and younger age group of newer plant make it easy to adopt new philosophy (iii) Discrete industries are more likely to implement JIT compared to continuous process industries at the same time process plants are more likely to implement TQM.

Jiju Antony et al.[3] carried out research to examine various benefits, critical success factors and hurdles for implementing six sigma in UK based small and medium sized industries. A questionnaire survey was prepared by black belt, green belt and yellow belt experts. The survey was sent to 400 SMEs of chemical, plastic automotive, aerospace, electronics, mechanical food and pharmaceutical sectors.

Findings : (i) Key benefits of six sigma are reduction in process variability, increase in profitability, reduction of operation costs, reduction in cycle time, increase in productivity, reduction in customer complains , improved sales and reduction in inspection. (ii) Important critical success factors are management involvement and participation, infrastructure, culture change, training, liking six sigma to customers, liking six sigma to business strategy, liking six sigma to employees, liking six sigma to suppliers, understanding of six sigma methodology, project management skill and project prioritization and selection. (iii) Reasons for not implementing six sigma by the respondents are not aware of six sigma, insufficient resources, existing quality system is sufficient and no perceived benefits.

M. Kumar et al.[4] carried out a project to implement Lean six sigma in an Indian die casting unit which is engaged in designing and manufacturing different types of precision machine parts. Brain storming sessions were carried out with customers and employees of the company. Various objectives were derived from series of brain storming sessions. The major objectives were to reduce the crack propagations in final product, reduce machine down time to reduce process inventory to improve customer satisfaction and to increase profit margin of company. A frame work integrating various lean tools like 5s, Total productive maintenance, value stream mapping was proposed with six sigma DMAIC methodology. It was identified that the major factor affecting crack propagation is casting density. Total 27 trials were carried out to find out optimum value of metal temperature, piston velocity, filling time and hydraulic pressure for maximum casting density. As a result of optimization 12% rise in casting density was achieved. Scientific total productive maintenance was implemented to reduce down time and increase machine performance. State map was modified to achieve better usage of equipments. Defect rate was reduced from 0.18% to 0.0068% process standard deviation was reduced from 0.069 to 0.0059.

Pius Acharya et al.[5] worked to present important critical success factors and major barriers for lean implementation in SMEs. The important objectives of the research were to explore the operational and functional aspects of SMEs in order to locate cost centers, explore dimensions of lean manufacturing within SMEs and to explore critical factors for lean implementation in SMEs. The research was based on literature survey and case study of 10 large scale company and 30 SMEs of U.K.

Findings: (i) Strong leadership and excellent project management skills are essential factors for proper implementation of Lean six sigma (ii) SMEs have limited financial resources but to implement lean practices additional financial resources are to be developed. Financial resources are required to hire the experts and training the people. (iii) High level of employee skill and expertise is prime requirement for lean implementation. This is important because most SMEs employ people with low skill and expertise (iv) Organizational culture plays vital role in lean implementation. The company culture should be adaptive to change.

Salaheldin Ismail[6] carried out research to investigate critical success factors for TQM implementation in small and medium scale enterprises of Qatar.

Methodology: Structured interview and questionaries' feedback from 297 small and medium scale enterprises were carried out for research. It included enterprises from machinery, equipment, petrochemical, chemical, wood and furniture, mining and textile sectors. 63% enterprises had implemented TQM since less than 3 years while 37% had implemented TQM since greater than 3

years. Questionaries' were answered by general managers, production managers and marketing managers. Exploratory factor analysis was used for questioner survey in which co-efficient level 0.5 was used as cut off score.

Outcome: Derived critical success factors were divided in 3 categories (a) Strategic factors (b) Tactical factors and (c) Operational factors. Important strategic factors are organizational culture, leadership, top management support and quality goals and policy. Important tactical factors are employee training, supplier relationship, team building , problem solving and employee empowerment. Major operational factors are product and service design, inspection and checking, process control and value addition process. It may be noted that major critical success factors for TQM are same as for Lean Six Sigma.

K. Jeyaraman and Leam Kee Teo[7] investigated critical success factors for Lean Six Sigma implementation and its significance in multinational electronic manufacturing services industries.

Methodology: After extensive literature review twenty five important critical success factors were identified. The list of this critical success factors was forwarded to 25 Lean Six Sigma practitioners serving in EMS industries. A structured questioner was prepared. The questioner was sent to 65 sites of 4 multinations located in Asia, America and Europe.

Outcome: The important critical success factors are (a) Management commitment and engagement (b) Reward and recognisation system (c) Organizational belief and culture (d) Communication and assessment of Lean Six Sigma results. (e) Project prioritization, selection, review and tracking (f) effective Lean Six Sigma training programme (g) Project success stories and best practices sharing (h) Company financial capabilities (i) Establishment of Lean Six Sigma dash board (j) Competency of master black belt and black belt. These factors are independent to each other in order to make successful implementation of the project. Organizational set up and culture moderates the impact of CSFs on particular organization.

Alessandro Brun[8] carried out research to investigate weather Italian companies have same CSFs for Six Sigma implementation as defined by international literature. Author conducted extensive literature survey of more than 100 research paper and 96 books. A structural questionnaire was prepared reflecting company history, quality department, staff training, methods of project selection and successful six sigma projects. Case studies and structural interviews were carried out for 18 Italian companies including SONY, SKF, WHIRLPOOL and DOW CHEMICALS.

Findings : (i) Important CSFs for Italian companies are management involvement , linking six sigma to business strategy, infrastructure and culture, linking six sigma to customers, project prioritization and selection. Thus the important critical success factors are same for traditional application and for small scale Italian manufacturing firms (ii) More weightage is given to cost saving and operational efficiency than customer satisfaction (iii) Out sourcing of training plays important role in six sigma implementation for Italian SMEs (iv) Manufacturers have not much interest in transferring six sigma approach to supplier. (v) Higher number of Italian small and medium scale industries are family owned it is difficult to implement six sigma in family owned unit compared to professionally managed companies.

Alessandro Laureani and Jiju Antony[9] carried out important investigation on CSF and other aspects on lean six sigma. CSF (Critical Success Factors) refers to those important factors which are important for successful examinations for any improvement methods. In the first part of research investigation research articles related to critical success factors of important change method were studied in second part a questionnaires was designed to investigate important aspects of change method. This questionnaires was sent to more than 500 companies involved in manufacturing and service sector. Management commitment was designed as the most important critical success factor. Other important critical success factors are training, project prioritization, change in culture, infrastructure and linking LSS TO BUSINESS. Important objectives for implementing LSS are (A) cost saving (B) quality importance (c) customer satisfaction.

Darshak A. Desai et al[10] carried out investigate critical success factord for six sigma implementation in various Indian companies. There were two main objectives first objective was to identify important critical success factors and then second objective was to analyze if CSF varies with company type and size or not. Different sizes companies of variety of sectors were included in the research. A well designed questionnaires was sent to more than 500 companies of different sectors across the country. The companies were asked to rank different CFSs for six sigma implementation. It was derieved that important critical success factors for big companies were

(1) Management commitement
(2) Organizational infrastructure
(3) Linking LSS to customers
(4) Linking LSS to business strategy
(5) Traning
(6) Linking LSS to emploies

For small scale industries important critical success factors are culture change and project selection criteria. At a large there was not any significant change in critical success factors for large scale and small scale industries.

Alireza Shokri[11] investigated important research articles published in 20 years lean, six sigma and lean six sigma. Researcher carries out quantative analysis to identify critical research objectives and to develop research methodology. Standard databases of Elsevier, Business premier, willey online were used for reference.

1. Increasing number of researches are working on lean six sigma projects compares to pursue six sigma concept. Similarly those are more number of case study projects.
2. Important themes are 'Impending factors', 'Tools and techniques' and 'Critical success factors'

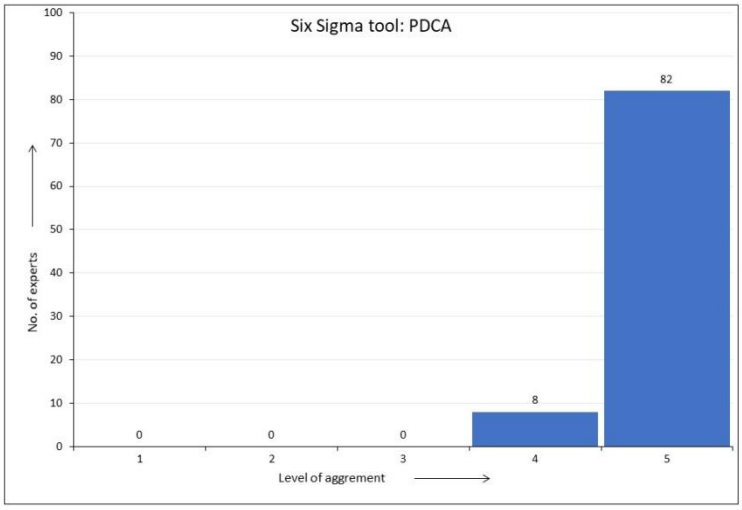
3. Majority research articles are about manufacturing, IT and healthcare industries.
4. Western countries of Europe and U.S.A. have major share in research articles about lean, six sigma and lean six sigma. There are less research articles from developing countries of Asia and Africa.
5. Food industries, air ports and call centres have less interest about lean, lean six sigma implementation.

Gunjan Yadav et al.[12] developed hybrid frame work for LSS implementation and to identify important barriers/solutions. Scopus based database of 2000 to 2018 was used as reference. Total 35 impending factors and 28 success factors were identified as a result of extensive research. An expert panel was formed consisting of senior officers(industry representatives), lean six sigma practitioners and academicians. It was derieved that important success factors are management commitment, availability of LSS belt persons, sufficient financial resources and project tracking and review. Important Impending factors are longer implementation phase; family owned business, recession and technology based barriers.

4. Results and Discussion

Research outcome regarding six sigma/lean tools, expected performance outcome and important barriers is described below. Figure 2 represents important six sigma tools and Figure 3 represents important of lean tools.

i) Important six sigma tools



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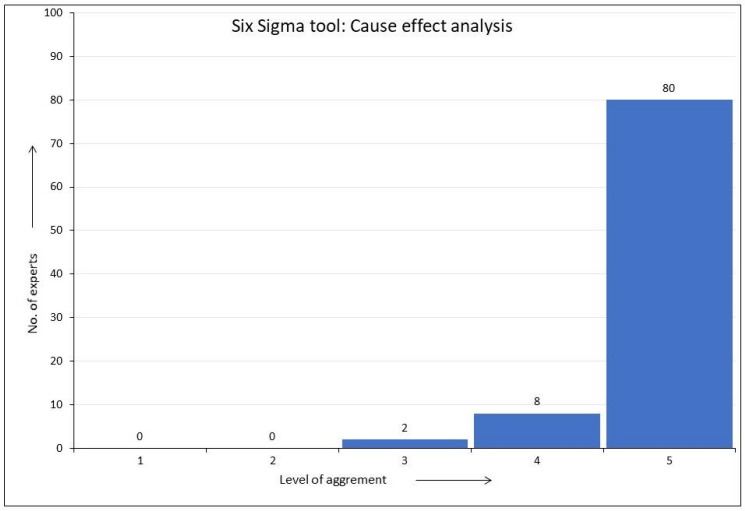

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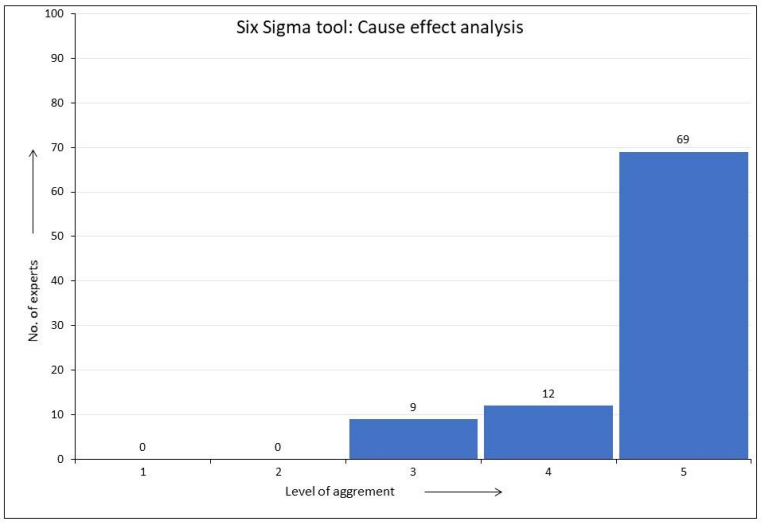
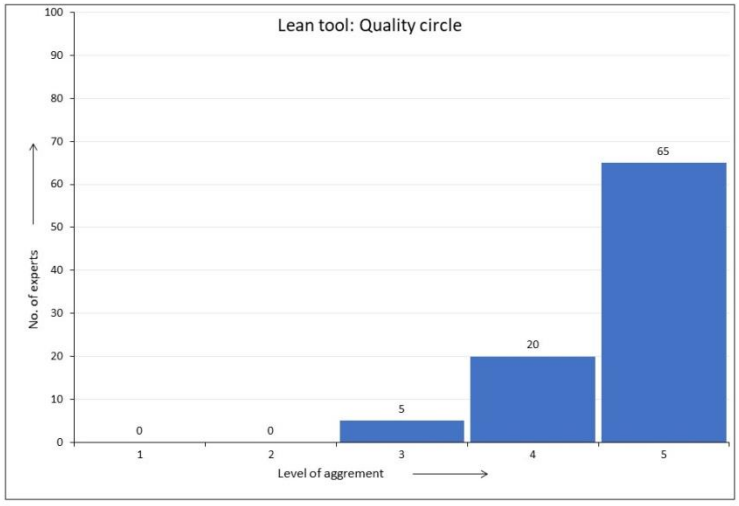


(c)

Figure 2 six sigma tool a) PDCA b) Cause effect analysis c) Histogram

Important six sigma tools are derived based on literature review and experts' consultation. First three six sigma tools are PDCA(82/8/0/0/0), cost effect analysis (80/8/2/0/0/0) and histogram (69/12/9/0/0). [For PDCA out of 90 experts ; 82 experts expressed level of agreement 5, 8 experts expresses level of agreement 4, 0 experts expressed level of agreement 3, 2 and 1 as mentioned in figure 2(a)]

ii) **Important Lean tools**



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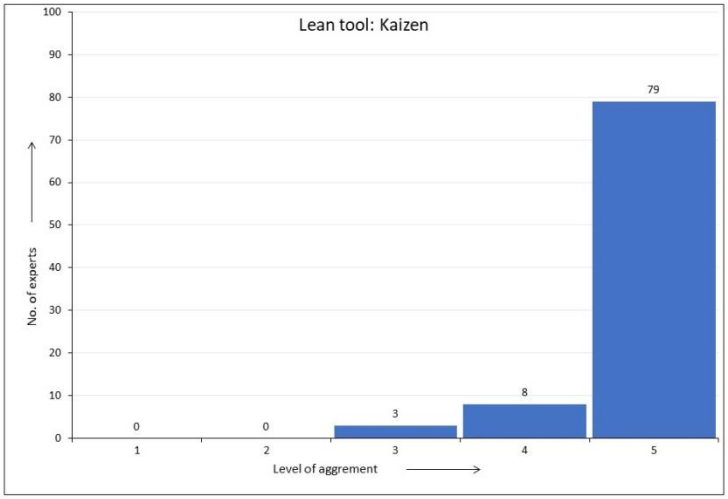

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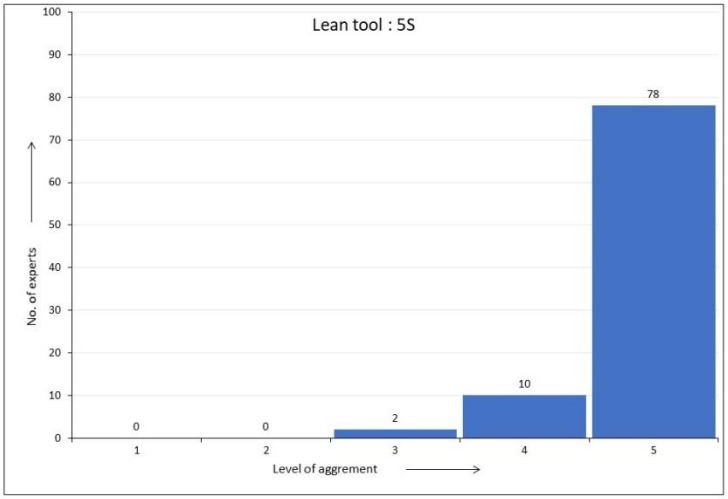

(c)

Figure 3 Lean tool a) quality circle b) Kaizen c) 5S

Important lean tools are derived based on literature review and experts' consultation. First three lean tools are 5 S (78/10/2/0/0), kaizen (79/8/3/0/0) and quality circle (65/20/5/0/0).

iii) Important expected performance outcome are quality, financial performance and customer satisfaction.

iv) Important barriers for lean six sigma implementation are resistance to change, poor understanding for LSS tools, fewer successful implementation in surrounding clusters and shortage of LSS experts.

Conclusion & Future work:

Lean six sigma methodologies have fair implementation potential in small and medium scale automobile manufacturers. Systematic implementation of the LSS in target group of industries can improve quality, financial performance and customer satisfaction.

Important Lean and six sigma tools are derieved for small and medium scale automobile industries in this research. Suitable industries from target group are to be identified for lean/six sigma tools implementation. Standard derieved framework is to be implemented with the help of lean six sigma consultants in these industries.

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