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Total Quality Management Integration With Six Sigma for Operational Success of a Project

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Abstract – In this investigation, a sample of 60 Ethiopian manufacturing companies was used to explore the relationships between total quality management (TQM) and Six Sigma. Either TQM and Six Sigma are used together in manufacturing organisations or if TQM has been pushed to the background by Six Sigma will be determined. Moving average quality charts were employed by the researchers. There have been some interesting findings regarding how firms feel about TQM and Six Sigma, in particular the relationships between TQM, Six Sigma, and improvement management. Industrial businesses that combine TQM and Six Sigma were used. In order to determine the relationship between TQM and six sigma, researchers used moving averages and quality charts. The study aims to fill a gap in the compilation of information in this way.

Keywords: Total Quality Management (TQM), Six Sigma Manufacturing Companies, Quality Charts, Moving Average.

1.INTRODUCTION

All personnel in an organisation are pushed to focus on quality improvement by the strategy framework known as comprehensive quality management. The hypothesis states that better operational performance will increase customer satisfaction [1]. The Six Sigma quality management methodology helps businesses improve their current processes, products, or services by locating and eliminating faults [2]. By streamlining quality control, the goal is to reduce or completely eliminate variation in manufacturing or company activities. Enhancing understanding of client requirements and eliminating waste and errors are two key components of the Six Sigma methodology [3]. A detailed understanding of engineering, project management, statistics, and the underlying systems and processes is required to achieve these aims.

An operations management plan is the result of the interaction of a number of important variables, such as value creation along the supply chain, global operations, the requirement for sustainability in a world that is continually changing, and the intimate connection between manufacturing and services [5]. Another area where OM interacts heavily is the harmony between qualitative (managerial issue) and quantitative process characteristics. Total quality management (TQM) is crucial in relation to OM because of these factors, and it should be evaluated using some TQM approaches [4].

This instance can be used to apply a variety of quality instruments and key Six Sigma measures. TQM has been characterized in a variety of ways by academics and business professionals [5]. This also includes the controversial Six Sigma idea that American engineer Bill Smith presented in 1986 and trademarked in 1991. Is

Six Sigma a new technique for raising quality? According to certain academics, like Crosby (1979) and Juran (1986), six sigma is really a rehash of concepts that have already been covered [7, 30].

The requirements for quality focus on a wide range of topics that are intricately and dynamically connected. The first of these is leadership, which drives the whole quality system. Utilising quantitative and qualitative outcomes that have been time-tracked, quality improvement is evaluated [8]. Customer satisfaction is the ultimate goal of the quality programme. A quality endeavour must use planning and management techniques to be effective. The PDCA Cycle, the Japanese concept of Kaizen, and benchmarking on both an inside and outside industry level are examples of approaches for continuous improvement that are related to successful quality [9].

In regard to TQM and six sigma, the definitions of DMAIC, PDCA Cycle, Continuous Enhancing, and Kaizen are enlarged [10, 29]. Additional subjects were covered, such as how SERVQUAL operates and external benchmarking for quality improvement. Additional subjects like SERVQUAL operation and external evaluation for quality improvement will be included in this case writing. Last was the summary or a summation.

2. THEORETICAL FOUNDATION

Although many persons contributed to the concept of TQM, the three "masters" of quality who are most usually cited are W. Edwards Deming (1900–1993), Joseph M. Juran, and Philip Crosby [11]. Dr. W. Edwards Deming had a simple but innovative worldview. According to him, businesses that focus on improving quality will inevitably reduce costs, but businesses that focus on cutting prices would eventually deteriorate quality and end up increasing costs [12]. According to Juran, a product's quality is its capacity to satisfy clients by attending to their wants. His quality-focused mindset originally became well-known in Japan throughout the 1980s before making its way to the West [13, 31].

Edwards Deming, the American statistician, instructed Japanese engineers and executives in statistical analysis and quality control methods. This led to each step having a "Three role model": the provider, the process, and the client, according to Juran. TQM can be viewed as having begun with this. According to Crosby, everything should be done right the first time [14]. He developed the Do It Right the First Time (DRIFT) Principle. His viewed that leaders are responsible for assuring quality and creating an environment free of any defects was related [15].

Table -1: Theoretical Foundation

S.N	Theory	Profounder	Theory Contribution	Relationship found
1	TQM theory	W. Edwards Deming	statistical analysis and control of quality	Total Quality Management integration with Six Sigma
2	Juran Triology "Three role model"	Joseph M. Juran	Quality meets customer needs leading to customer satisfaction	Total Quality Management assimilation with Six Sigma
3	"DRIFT" Principle	Philip Crosby	Leaders responsible for quality and creating a culture of zero defects.	Total Quality Management incorporation with Six Sigma

4	DMAIC	Bill Smith	Focuses on the development of a new product, service, or proces	Total Quality Management relation with Six Sigma
5	DMADV	Bill Smith and Mikel Harry	Creating new processes in order to achieve their customers' needs	Total Quality Management amalgamation with Six Sigma

Source: Researchers Own Meta analysis (2023)

Crosby asserts that quality is the continuous improvement of the production process, but Deming's methodology highlights that quality is a matter of exceeding and satisfying customer expectations. Both methodologies share the conviction that they can individually help to improve quality, notwithstanding their differences [15, 32].

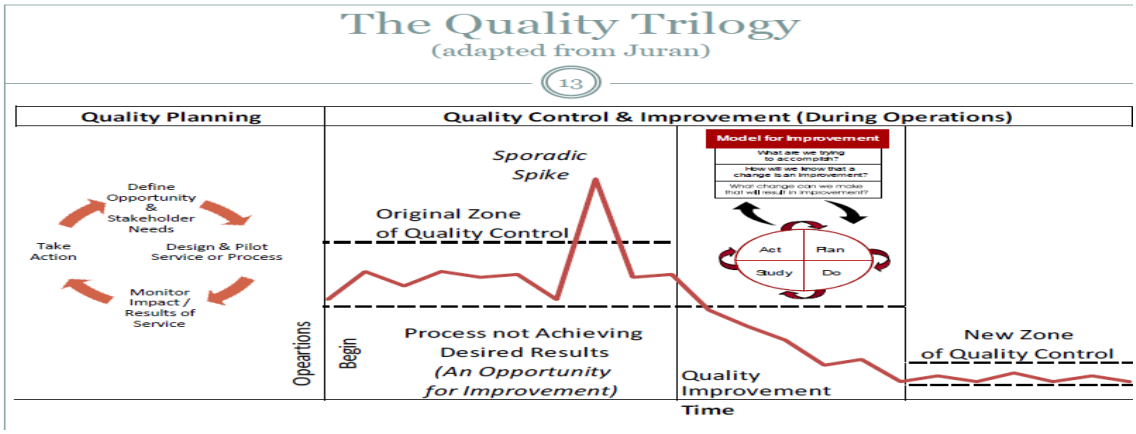

Fig -1: Juran Trilogy
Source: Researchers' own lecture notes (2023)

3. EMPIRICAL LITERATURE REVIEW

Bill Smith, a Motorola technician, initially proposed the concept known as Six Sigma in the 1980s. It does not, however, replace TQM; rather, it is a supplement of it [16]. Quantitative measurements and statistical analysis are the cornerstones of Six Sigma. We can now observe that Six Sigma, a new strategy over the traditional method of TQM, can provide more efficient and superior outcomes than TQM. Six Sigma will likely surpass TQM in the future because it is a method that is more precise and results-driven than TQM [17, 33].

Although Six Sigma and TQM can work together, they can also be used alone. They can be combined in a variety of sectors. Combining them can increase output. While compatible, Six Sigma and TQM can also be used alone. They can be combined in a number of different sectors. They each have a certain concentration, therefore using them in tandem can increase output [18].

Table -2: TQM Manifestation

•Total (T): embracing all aspects of the organization's activities and the whole.
•Quality (Q): ensuring that customer needs and expectations are always met.

•Management (M): allowing everyone in the team to deliver the best results possible.

Source: Researchers' own lecture notes (2023)

The seven key tenets of the TQM concept are: customer orientation, continuous improvement, worker empowerment, quality tools, product design, process oversight, and supplier quality. The five essential elements of a service are tangibility, reliability, adaptability, confidence, and empathy [19]. There is a wealth of TQM-related literature available today, but as noted by Knights and William Willmott (2000), writers sometimes contradict one another and there is confusion about the precise nature of TQM. According to the research, management styles and their methods are where misunderstanding initially appears [20].

Although senior managers should play a significant role, management engagement, leadership by facts, and strategic planning seem to be the most important TQM implementation factors in the West [34]. The program's implementation is frequently supervised by a top management steering committee. Even if there are examples of TQM and CSR integration in the literature, TQM prioritises quality outputs such costs of poor quality (COPQ).

No scholar has questioned how crucial it is to use both simple and complex statistical techniques as well as customer feedback when making improvements. The key elements of TQM were also examined by researchers, who came to the opinion that, before to 2000, TQM had been investigated in a number of ways that might be divided into five primary groupings. The writers discussed how TQM has been influenced by national awards like the Malcolm Baldridge and the European federation for quality management (EFQM) award. Examples include applying benchmarking and self-assessment concepts from this industry. Lowering variability around targets and removing the root causes of failures are the identical goals of TQM and Six Sigma [21].

Yet, Six Sigma is well known for adhering to the DMAIC structure and strict criteria for applying tools and validating results [22]. Furthermore, Six Sigma seems to be more active in its quest of cost reduction and efficiency, while also boosting quality and productivity. To substantiate this assertion, numerous authors have provided compelling case studies from a variety of industries [11]. Undoubtedly, the PDCA technique proposed by Deming is the TQM paradigm that is most widely used [13].

4. FISHBONE DIAGRAM

A fishbone diagram is a useful tool for illustrating cause and effect relationships. It adopts a more structured approach to problem-solving brainstorming in comparison to some other tools. The fish's mouth or head is where the problem or outcome is seen. A fishbone diagram serves as the foundation of root cause investigation when a process or product malfunctions [23]. It allows team members to make a list of all potential causes and then investigate each one in turn to identify the root cause. A popular Six Sigma tool, it has assisted various organisations in streamlining numerous processes.

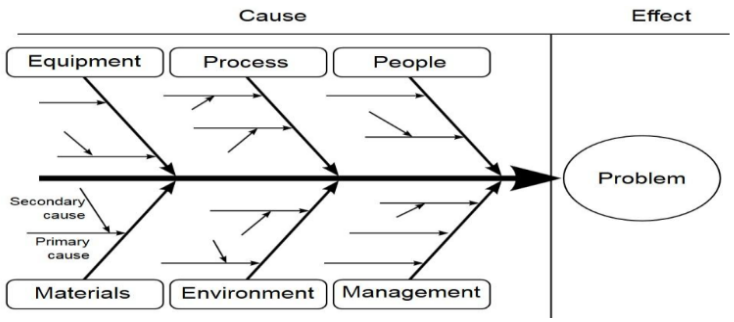

Fig -2: Fishbone Diagram
Source: Researchers' own lecture notes (2023)

The cause-and-effect diagram was used by the researchers to investigate the process dispersion. The diagram's objective was to link causes and effects. The three core categories are analysis of dispersion, classification of processes, and cause enumeration. Effect is the solution of an issue or opening up of a chance that made it possible to attain a goal.

5. METHODOLOGY

The foundations of DMAIC, PDCA Cycle, Continuous Excellence, and Kaizen were further discussed by the researchers in relation to TQM and six sigma. Additional subjects covered in this case study included SERVQUAL functioning and competitors for quality improvement. A summary or epilogue was included at the end [24]. Quality control uses a variety of methods to interact with and keep records of inspection and issues. An illustration of a quality assurance graph is one that shows how far sampled products or processes depart from the planned standards if they do not meet them.

When analysing a single product attribute, the researchers referred to the quality circle chart as a univariate chart. An analysis of fluctuations in a variety of product attributes is done using multivariate charts. By tracking variances, businesses may determine how many mistakes they make per manufacturing unit and what kinds of problems are occurring. Here, the Quality Chart method was used. A Six Sigma control chart was mentioned by the researchers as a useful tool for determining a process or operation's consistency across time.

A control chart gives you the opportunity to compile all the data required to create and enhance a process into a single chart that shows the outcomes. This information is crucial because processes can exist in one of four states: the ideal, the idealised state, the chaotic state, or the idealised state on the cusp of chaos.

6. DATA ANALYSIS

A surveillance chart illustrates whether an organization's goods or activities adhere to the necessary criteria. If problems arise, the quality control chart can be used to determine how far they differ from the requirements and help with error correction. A univariate chart examines just one particular product aspect, whereas a multivariate chart measures variances across numerous product features. Products are evaluated using a random selection procedure for the stated attribute(s) which the graph is tracking.

A well-liked variant of the quality control chart is the x-bar (or "x") graph, which displays the degree to which the deviation of the evaluated attribute is acceptable. On the x-axis, the examined samples are monitored.

The examination of the variation pattern in a quality control chart can be used to determine whether issues arise accidentally or on purpose.

Table -3: Six Sigma and TQM as perceived by a sample of 60 Ethiopian manufacturing firms

Unit	Data	Unit	Data	Unit	Data	Unit	Data	Unit	Data	Unit	Data
1	100	11	98	21	113	31	100	41	98	51	113
2	106	12	96	22	111	32	106	42	96	52	111
3	89	13	101	23	111	33	89	43	101	53	111
4	102	14	86	24	97	34	102	44	86	54	97
5	80	15	108	25	112	35	80	45	108	55	112
6	97	16	122	26	98	36	97	46	122	56	98
7	94	17	117	27	102	37	94	47	117	57	102
8	118	18	115	28	115	38	118	48	115	58	115
9	94	19	116	29	118	39	94	49	116	59	118
10	112	20	93	30	110	40	112	50	93	60	110

Source: Researchers field survey (2023)

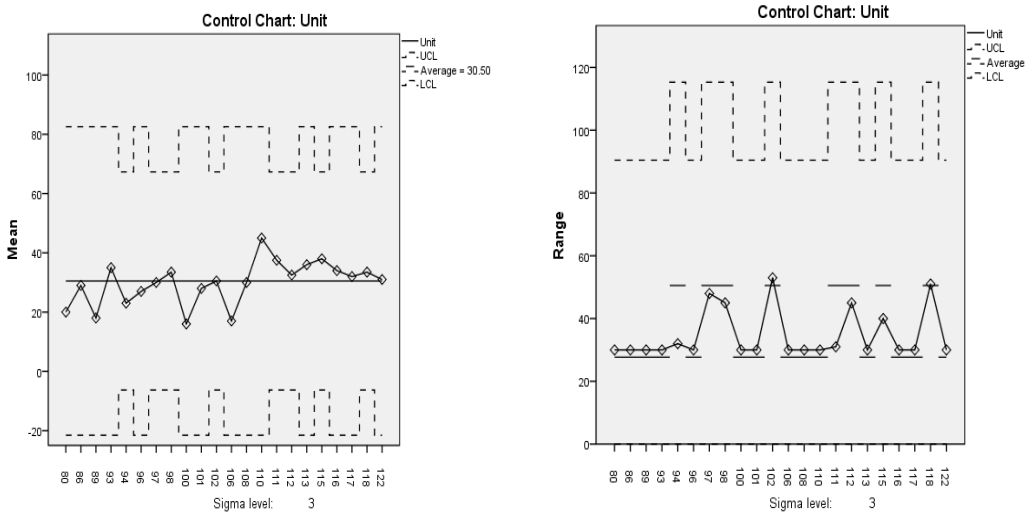

Fig -3: Control Charts
Source: SPSS output. 2023

Researchers developed a quality control chart known as the Individual or Moving Range, R (range) chart to monitor process variation using small samples taken at regular intervals. Indicating if a procedure or product departs from just one or several expected results, a chart for quality assurance may be single- or multi-variate. Different quality control charts, such as X-bar charts, S charts, and Np charts, are used depending on the type of data that needs to be analysed.

7. INDIVIDUAL OR MOVING RANGE (QUALITY CONTROL CHARTS RELATION WITH SIX SIGMA)

Control graphs were utilised by the researchers to better understand the variations that are inherent in every activity. The effectiveness of the strategy is demonstrated by variations that are within your control limits. There are problems to be fixed when a variation surges beyond of your grasp parameters.

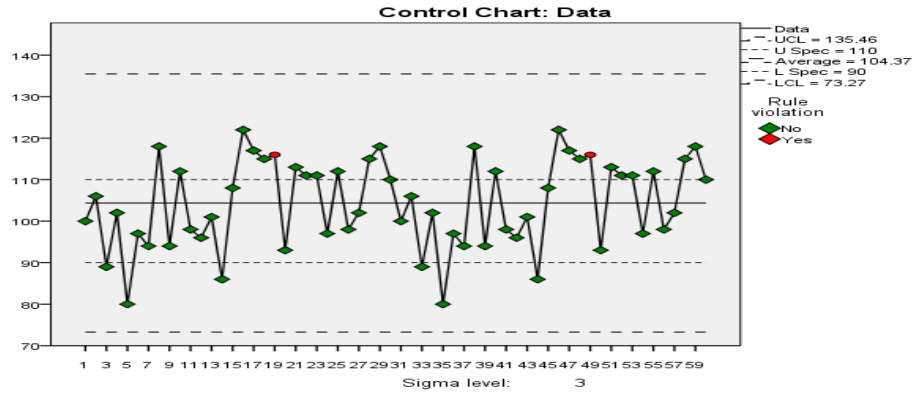

Fig -4: Control Charts
Source: SPSS output. 2023

Similar to how a value process map outlines each stage of a procedure and shows where defects and consistency are hidden, a control chart offers a tool to evaluate whether the whole process is leading to the best result possible. It accomplishes this by tracking variation. A Moving Range chart is used to track the percentage difference among each value and its predecessor. The range chart tracks the subgroup's range shift over time. Control graphs can also be used as an analytical tool. Six Sigma tools, including a Pareto chart or histogram, can be used to better interpret data produced by a control chart.

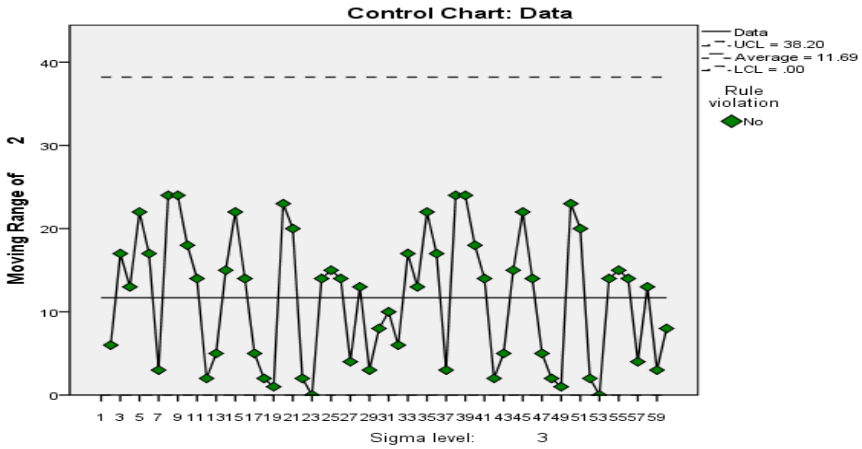

Fig -5: Control Charts
Source: SPSS output. 2023

If ongoing process enhancement and analysis are not used, any process or activity, whether it be on the factory floor, at a hospital receptionist desk, or at your own office, will eventually descend into chaos. Really, it's only a matter of time. Similar to how a value process map outlines each stage of a procedure and shows where defects and consistency are hidden; a control chart offers a tool to evaluate whether the whole process is leading to the best result possible. It accomplishes this by tracking variation. From all variations, two broad categories can be derived [25, 27].

Common-cause variability: Processes frequently experienced this type of variance. Common cause variance, while predicted, typically remains within appropriate control ranges. It is hard to completely eradicate this kind of variance because it is random and was not caused by a single action or a particular collection of elements.

Special-cause discrepancy – Variation with a special cause is not random; instead, it is brought on by a person's actions or the confluence of several factors during an operation. These errors or ill-conceived process designs can be fixed or eliminated. Understanding the type of variation a process contains is crucial. The type of variance that is present is determined by a control chart. It lets you to decide whether a process is under control or on the verge of anarchy, as well as whether to act and when to take no action.

8. PARETO CHART

The Pareto graph, a tool for quality improvement, is built on the Pareto principle, which posits that 80% of an outcome arises from 20% of its inputs. The Pareto graph is a key tool in six sigma and overall quality management methodologies. Essentially, it shows how much each cause affects an outcome or an impact using a bar graph. Six Sigma practitioners can better comprehend that most process problems have a small number of core causes thanks to the Pareto Principle. By showing the causes of issues and their frequency or cost, the Pareto Chart gives more details [25]. Calculate the subtotal for each cause over the chosen time frame. If you'd like, you can calculate the amount of money that each cause contributes. This would be the result of dividing the total number of causes by the summation for every cause.

Adjacent, a scale for percentages can be drawn adjacent to the scale for measured values. Cumulative percentage curves are displayed on Pareto diagrams. TQM and Six Sigma's contributions to the cause were shown by a dot at the % of the first bar on the aggregate percentage curve. After combining the initial and last fractions at the second bar, add the second dot to the sum. By dividing the previous sum by the third percentage, add the third dot, and so forth. the 100% dot at the end of the numerical scale. The causes of the efforts made by TQM and Six Sigma were finally discovered by connecting the dots to create an average percentage curve.

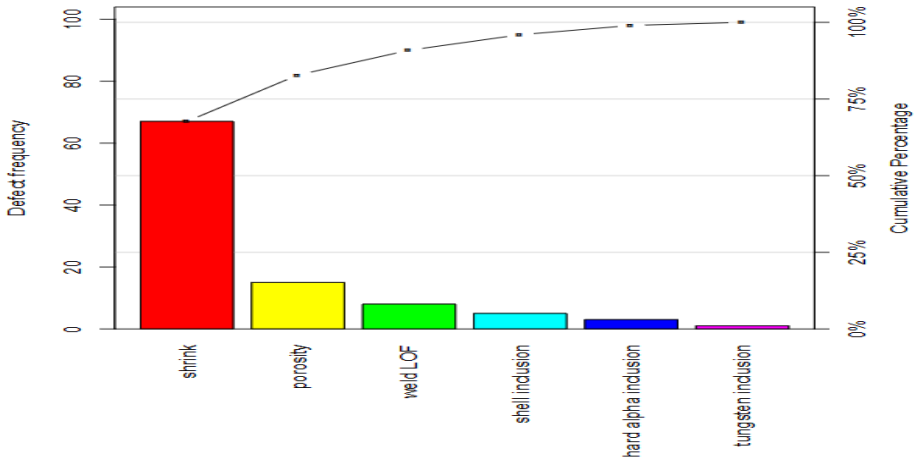

Fig -6: Pareto Charts

Considering the researchers were interested in using the 80/20 rule at this point, the line was drawn beginning at 80% on the proportional scale, continuing perpendicular to the x-axis, and stopping where it met the cumulative percentage curve. 80% of the problems are caused by elements on the left side of this axis,

whereas factors on the right are less important [28]. This made it simpler to concentrate on improving the elements that have the biggest an impact on the problems.

9. CONFIRMATORY FACTOR ANALYSIS

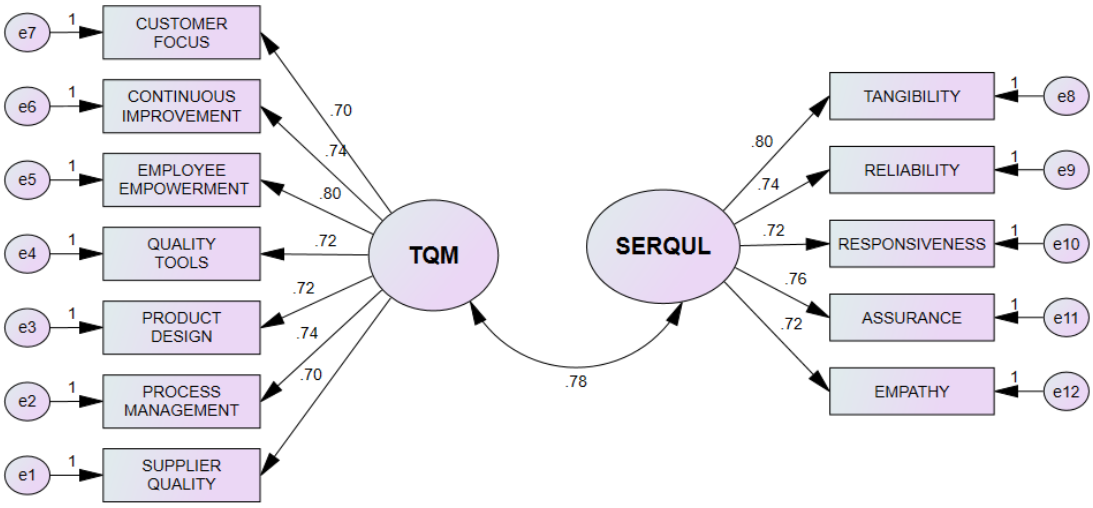

Fig -7: CONFIRMATORY FACTOR ANALYSIS
Source: AMOS output, 2023

The researchers utilised confirmatory factor analysis (CFA), a statistical technique, to verify the factor structure of a set of observed data. Researchers used CFA to examine the possibility of a relationship between the latent constructs that underlie the TQM (observed variables) and the TQM dimensions (observed variables). It was used to check whether readings of a construct matched the researcher's conception of those constructions (or factors). The purpose of confirmatory factor analysis is to assess if the data are consistent with the proposed assessment framework [26].

AMOS result indicates that RMSEA levels under 0.05 are good, those between 0.05 and 0.08 are acceptable, those between 0.08 and 0.1 are marginal, and those beyond 0.1 are poor. Since the RMSEA level for the CFA model was founded at 0.006, it was deemed to have a very excellent association with regard to TQM and six sigma.

10. MEDIATION OF SERQUL IN BETWEEN TQM AND SIX SIGMA

As a form of multivariate quantitative analytic method, researchers used structural equation modelling to look at structural correlations. Using a combination of component analysis and multiple regression modelling, this approach investigates the structural relationship among variables that are measured and latent constructs [27].

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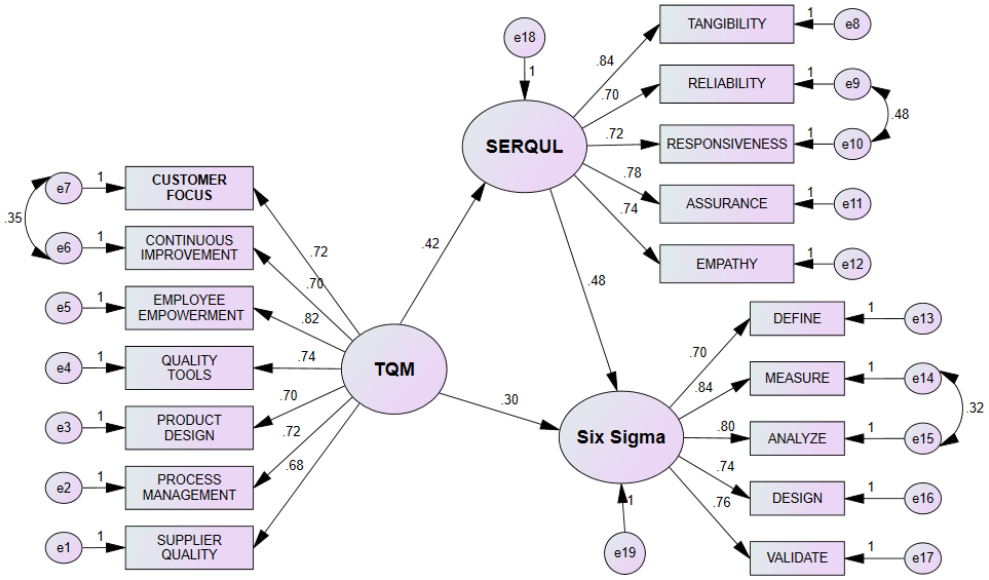

Fig -8: Structural Equation Modeling
Source: AMOS output, 2023

Although Six Sigma & TQM can work together, they may also be used alone. They can be combined in a variety of sectors. Due to the fact that they each have a unique emphasis, using them together might increase production. TQM and SIX SIGMA founded the SERRQL mediation. This study found that service quality can act as a link between six sigma and TQM procedures.

In the current SEM model shown in figure 8, mediation took many distinct guises. Full mediation, often referred to as indirect only mediation is when the immediate connection between two ideas is minimal but their secondary connection through a mediator is significant. The SERQUL was viewed as a mediator variable since it significantly affects changes in the level of TQM, which in turn affects the degree of TQM. Since it significantly affects variations in the level of TQM, which in turn affects variance in the six sigma, the SERQUL was considered a mediator variable.

11. CONCLUSION

Based on the results of the analysis, it was determined that TQM and Six Sigma were employed internally to uphold excellence throughout all business operations. TQM concentrated on enhancing internal procedures to enhance customer service and uphold currently implemented quality methods. The goal of Six Sigma was to enhance one specific business process. The researchers employed Six Sigma as a quality assurance technique to enhance the procedure. Since a single standard deviation in a data collection is referred to by the term "sigma," Six Sigma is named after this. Six of these variations are supposed to occur before a defect is produced by the method. Six Sigma helps you further leverage efficient processes in addition to assisting with waste reduction. You are going to discover how to use resources to achieve optimum performance while utilising your present company procedures with the help of formal training. The DMAIC and DMADV Six Sigma techniques are the two basic ones. Each has a unique set of suggested practises that should be put in place for business transformation.

A data-driven technique called DMAIC is used to enhance current goods or services so that customers are more satisfied. Internal procedures are used by TQM and Six Sigma to ensure quality throughout all business

operations. TQM concentrates on enhancing internal procedures to increase client service and uphold current quality systems. The goal of Six Sigma was to enhance one specific business process. Additionally, despite their potential value, new tools and methodologies cannot theoretically be introduced into the Six Sigma process. It can be challenging to adopt or experiment with different process techniques for other parts of the organisation because Six Sigma often requires complete devotion across all teams. We are able to observe that Six Sigma can produce results that are more effective and superior to TQM. We are able to observe that Six Sigma, which is a new technique above the previous approach of TQM, can offer greater efficiency and better results than TQM. Six Sigma is a method that is more accurate and results-driven than TQM, hence it will undoubtedly outperform TQM in the future. The findings of the current study were found to be comparable to those of earlier ones [1] [2] [3] [5] [7].

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AUTHOR CONTRIBUTIONS

The manuscript's draught was produced with equal input from all authors. Lamesa Bulto carried out the conceptualization. Dr. Shashi Kant collected and analysed the data. Lamesa Bulto is the author of Draught Preparation. The finished manuscript has been read and approved by all authors.

CONFLICT OF INTEREST

The authors declare they have no competing interests. There are no competing interests of the authors that are material to the subject matter of this article. This is the initial piece of study that Lamesa Bulto, a research scholar, completed under the supervision of adviser Dr. Shashi Kant, based on his seminar on the impact of TQM integration with six sigma evaluations and quality charts.

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