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Total Quality Management integration with Six Sigma for Operational Success of a Project

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Abstract

This study examines the connections between total quality management (TQM) and Six Sigma as perceived by a sample of 60 Ethiopian manufacturing firms. The goal is to determine whether TQM and Six Sigma are utilized in tandem in manufacturing firms or if TQM has been driven to the background by Six Sigma. Researchers used quality charts with moving averages. Interesting conclusions on how businesses feel about TQM and Six Sigma have been found, specifically, the connections between TQM, Six Sigma and improvement management. Industrial firms were used that use Six Sigma and TQM together. Researchers used the moving average, quality charts to find the association between TQM and six sigma. In this manner, the study seeks to close a void in the body of knowledge.

Keywords

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

1. Introduction

The strategic framework known as total quality management pushes all employees in an organization to concentrate on

quality improvement. According to the hypothesis, customer happiness will rise as a result of superior operational performance [1]. By identifying and removing flaws, the Six Sigma quality management methodology aids companies in improving their existing procedures, goods, or services [2]. The aim is to minimize or eliminate variation in manufacturing or business operations by streamlining quality control. The Six Sigma approach places a strong emphasis on improving customer requirements knowledge and removing waste and faults [3]. These goals are accomplished by having a thorough understanding of engineering, project management, statistics, and the underlying systems and processes.

The influence of several key factors, including value creation along the supply chain, global operations, the need for sustainability in a constantly changing world, and the close relationship between manufacturing and services, come together to form an operations management plan [5]. The balance between qualitative (managerial issue) and quantitative process aspects is another area where OM interacts strongly. Due to these circumstances, total quality management (TQM) is important in relation to OM and should be assessed using some TQM methodologies [4].

Various kinds of quality instruments and significant Six Sigma metrics can be applied throughout this case study. Different academics and industry experts have defined TQM differently [5]. The contentious Six Sigma concept, which American engineer Bill Smith introduced in 1986 and registered as a trademark in 1991, is also present here. Is Six Sigma a brand-new tool for enhancing quality? Some academics, like Crosby (1979) and Juran (1986), claim that six sigma lacks originality and is simply a rehash of ideas they have already discussed [7].

The quality standards concentrate on many subject areas that are inextricably and dynamically linked. Leadership is the first of these, as it powers the entire quality system. Quality progress is assessed using time-tracked quantitative and qualitative results [8]. The quality program's ultimate purpose is to satisfy customers. Utilising planning and management tools is essential for a quality endeavor to be successful. Successful quality has a relationship with techniques for continuous improvement, such as the Japanese idea of Kaizen, the PDCA Cycle, and benchmarking on both an internal and external industry level [9].

DMAIC, PDCA Cycle, Continuous Improvement, and Kaizen definitions are expanded upon in relation to TQM and six sigma [10]. Additional topics, including SERVQUAL functioning and external Benchmarking for Quality Improvement, were covered. In this case writing, additional topics like external benchmarking for quality improvement and SERVQUAL operation will be covered. The conclusion or a summary was included last.

2. Theoretical Foundation

Despite many people made contributions to the idea of TQM, W. Edwards Deming (1900–1993), Joseph M. Juran, and Philip Crosby are the three "masters" of quality who are most frequently cited [11]. The philosophy of Dr. W. Edwards Deming was straightforward but revolutionary. He said that organizations who put their attention on raising quality would inevitably cut costs, but those that put their attention on lowering prices would inevitably lower quality and end up raising expenses instead [12]. Juran defines quality as a product's ability to satisfy customers by meeting their needs. In the 1980s, his quality-focused philosophy first gained popularity in Japan before spreading to the West [13].

Japanese engineers and executives were taught statistical analysis and quality control techniques by W. Edwards Deming. As a result, according to Juran, each stage had a "Three role model": the provider, the process, and the client. This can be seen as the start of TQM. Crosby thinks things should be done correctly the first time [14]. The Do It Right the First Time (DRIFT) Principle was created by him. This idea is connected to his belief that leaders are in charge of ensuring quality and fostering an environment where there are no flaws at all [15].

Table 1: Theoretical Foundation

S.N	Theory	Pro-founder	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 process	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)

While Crosby claims that quality is continual production process improvement, Deming's approach emphasises how quality is all about exceeding and meeting customer expectations. Despite their differences, both approaches share the belief that they can each contribute to quality improvement [15].

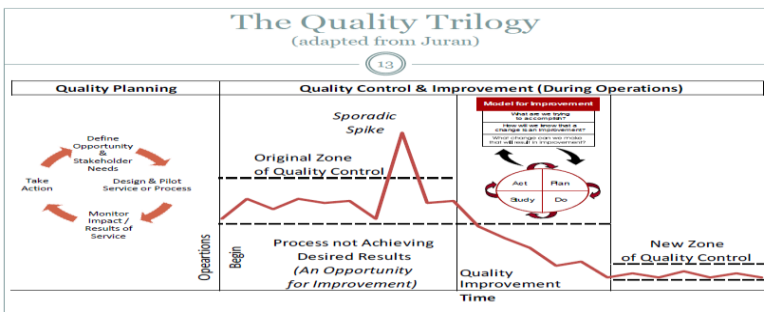

Figure1. Juran Trilogy

Source: Researchers' own lecture notes (2023)

3. Empirical Literature Review

Six Sigma is an innovation that was first introduced in the 1980s by a Motorola engineer named Bill Smith. However, it is an extension of TQM and not a replacement for it [16]. The core principles of Six Sigma are statistical analysis and quantitative measurements. We can now see that Six Sigma, which is a new technique above the previous approach of TQM, can offer more effective 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 [17].

Whereas Six Sigma and TQM are interoperable, they can also be employed separately. The two can be used together in various industries. Utilising them in tandem can improve output because they each have a distinct focus [18].

Table 2: TQM Manifestation

• **Total (T): encompassing the entire organisation and all facets of its operations.**
• **Quality (Q): always meeting the demands and expectations of the consumer.**
• **Management (M): enabling everyone within the organisation to produce results of the highest caliber.**

Source: Researchers' own lecture notes (2023)

Customer orientation, ongoing enhancement, empowerment of workers, quality tools, design of products, management of processes, and supplier quality are the seven fundamental components that best encapsulate the TQM philosophy. A service's tangibility, dependability, adaptability, confidence, and empathy are its five key components [19].

There is a quality of literature regarding TQM in circulation today, but according to Knights and Willmott (2000), authors occasionally contradict one another and it is unclear exactly what TQM entails. The literature demonstrates that management styles and their techniques are where confusion first arises [20]. Senior managers should be heavily involved, though, and management engagement, management by facts, and long-term thinking appear to be the most crucial aspects of TQM implementation in the West (Porter and Parker, 1993). A senior management steering committee often oversees the implementation programme. TQM emphasizes quality outputs, such as costs of poor quality (COPQ), notwithstanding instances of integration between TQM and CSR in the literature [21].

No academic has criticized the importance of using basic and advanced statistical methods, as well as capturing consumer feedback, in improvement efforts. Researchers also looked at TQM's essential components and came to the conclusion that, up until 2000, TQM has been studied in a variety of ways that could be categorized into five main groups. The authors described how national honours like the Malcolm Baldridge and the European foundation for quality management (EFQM) award had also had an impact on TQM. For instance, concepts from this sector like benchmarking and self-assessment are sometimes applied. The identical objectives of Six Sigma and TQM are to lower variability around the targets and eliminate the underlying causes of defects [21].

The define-measure-analyze-improve-control (DMAIC) pattern and tight guidelines for using tools and validating outcomes are however well known to be followed by Six Sigma [22]. Additionally, Six Sigma appears to be more aggressive in its pursuit of cost savings and efficiency, while simultaneously enhancing quality and productivity. Numerous authors have given compelling case examples from various businesses to support this claim [11]. Plan-Do-Check-Act (PDCA), a methodology developed by Deming, can undoubtedly be regarded as the most prevalent pattern within TQM [13].

4. Fishbone Diagram

An effective visual representation of cause and consequence is a fishbone diagram. Compared to some other tools) for problem-solving brainstorming, it takes a more organized approach. The issue or result is seen at the fish's mouth or head. When a procedure or product malfunctions, a fishbone diagram is the central component of root cause analysis [23]. It enables project managers to jot down every potential cause and subsequently explore each one in order to find the core cause. It is a well-liked Six Sigma tool that has helped numerous organizations improve numerous processes.

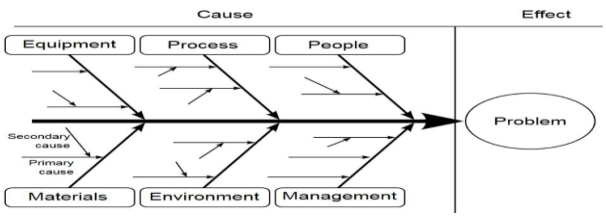

Figure 2. Fishbone Diagram (Source: Researchers' own lecture notes (2023))

The process dispersion was examined by researchers using the cause-and-effect diagram. The goal of the diagram was to connect causes and effects. Dispersion analysis, process classification, and cause enumeration are the three fundamental categories. Effect is the resolution of a problem or opportunity that allowed for the achievement of a goal.

5. Methodology

The researchers elaborated on the base of DMAIC, PDCA Cycle, Continuous Improvement, and Kaizen in connection to TQM and six sigma. In this case study, additional topics including SERVQUAL operation and external benchmarking for quality improvement were discussed. Finally, a summary or conclusion was included [24]. To communicate and keep track of inspections and problems, quality control employs a number of different techniques. A Quality Control Chart, for instance, is a visual representation of whether or not sampled items or processes are fulfilling their intended specifications—and, if not, how much they deviate from those requirements.

Quality circle chart was referred by the researchers as a univariate chart when it analyses a single product attribute. A multivariate chart is one that analyses variations in a number of product attributes. Businesses may identify how many errors they make per manufacturing unit and what kinds of defects are happening by tracking variations. The Quality Chart approach was applied here.

The researchers cited a Six Sigma control chart as an effective tool for assessing a process or operation's consistency across time. A control chart must have a graph that spans a time period, a centre line that displays the outcomes of a process over that period, and upper and lower control limits that demonstrate if process variance falls within an acceptable range. A control chart provides a way to combine all the information needed to develop and improve a process into a single chart that displays the results. That's important knowledge since processes can exist in one of four states: ideal, on the cusp of ideal, on the verge of chaos, or in a chaotic state.

6. Data Analysis

A quality control chart shows graphically whether the required specifications are being met by a company's products or operations. If issues develop, the quality control chart can be used to pinpoint how much they deviate from the specifications and aid in error fixing. A multivariate chart is used to measure variances across multiple product features, whereas a univariate chart analyses just one unique product attribute. Products are tested for the specified attribute(s) the chart is tracking using a random selection process. The x-bar (or "x") chart, which shows the extent to which the variance of the tested attribute is acceptable, is a popular variation of the quality control chart. The tested samples are tracked on the x-axis. A quality control chart's analysis of the variance pattern can be used to assess whether problems occur randomly or deliberately.

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)											

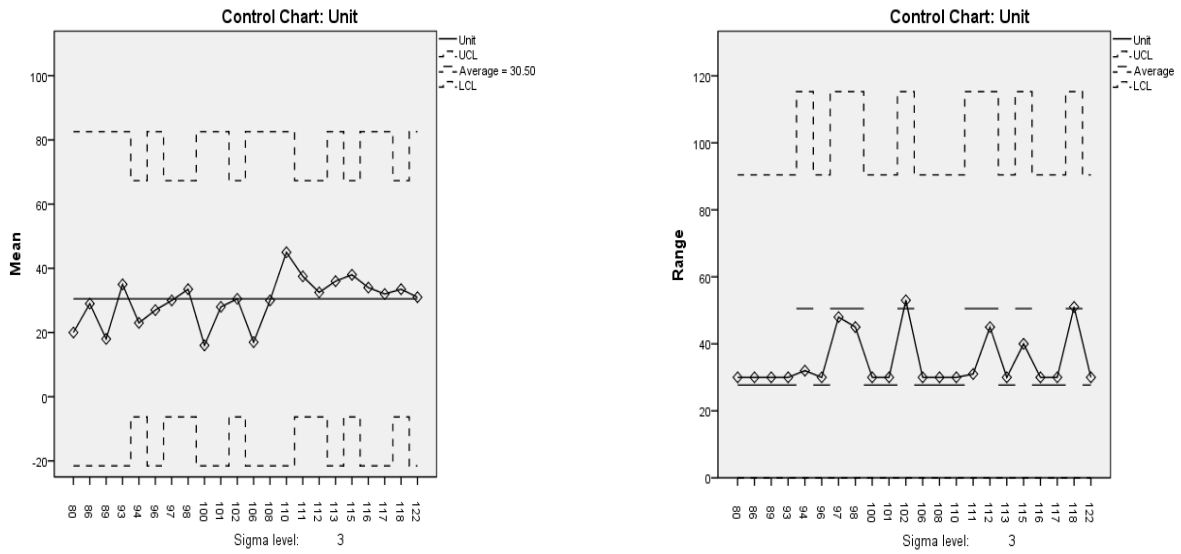

Figure 3. Control Charts

Source: SPSS output. 2023

A quality control chart called the Individual or Moving Range, R (range) chart was used by the researchers to track process variation using small samples taken at predetermined intervals. A quality control chart can also be single- or multi-variate, indicating if a process or product deviates from just one or several anticipated outcomes. Depending on the sort of data that needs to be analyzed, various quality control charts, including X-bar charts, S charts, and Np charts, are employed.

7. Individual or Moving Range (Quality Control Charts Relation with Six Sigma)

The researchers used control charts to better comprehend the fluctuations that are present in all operations. Variations that fall within your control parameters show that the technique is effective. When a variation spikes outside of your control parameters, there are issues that need to be fixed.

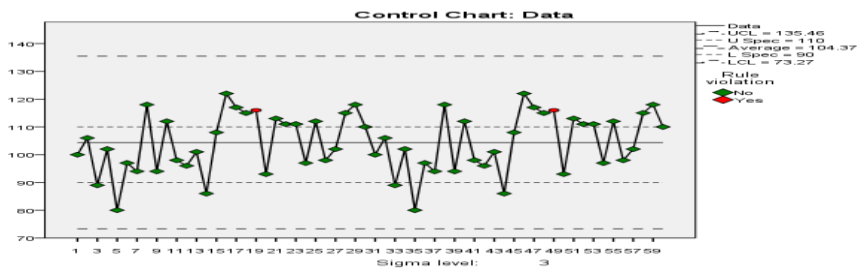

Figure 4. Control Charts

Source: SPSS output. 2023

A control chart provides a tool to assess if the overall process is producing the best conclusion feasible, just like a value process map sketches out every stage of a process and identifies where flaws and consistencies hide. By measuring variation, it achieves this. The absolute difference between each measurement and its prior measurement is tracked using a Moving Range chart. The subgroup's range shift over time is tracked by the range chart. Control charts can also be employed as a tool for analysis. To better analyze data generated by a control chart, Six Sigma tools can be used, such as a Pareto chart or histogram.

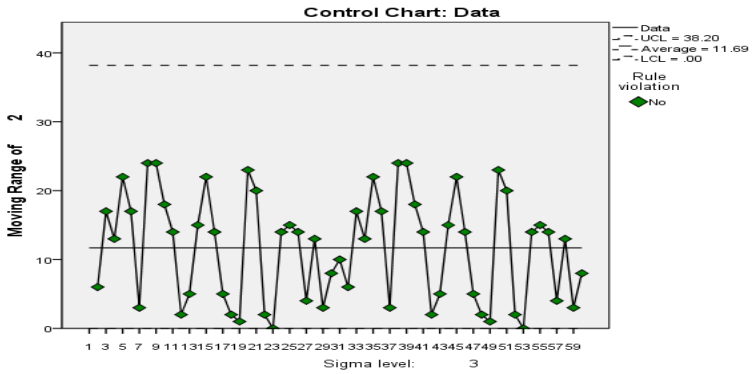

Figure 5. Control Charts

Source: SPSS output. 2023

Any process or activity, whether it be on the manufacturing floor, at a hospital reception desk, or at your home office, will eventually devolve into chaos if continuous process improvement and analysis are not applied. Just a matter of time, really. A control chart provides a tool to assess if the overall process is producing the best conclusion feasible, just like a value process map sketches out every stage of a process and identifies where flaws and consistencies hide. By measuring variation, it achieves this. Two general groupings can be drawn from all variations [25].

Common-cause variation – This kind of variation was typical of processes. Although expected, common-cause variance usually stays within acceptable control ranges. This kind of variation is random; no single action or set of factors contributed to it, making it impossible to totally eradicate.

Special-cause variation – This kind of variation is not random; it results from a person's activities or from a group of variables coming together during an operation. These mistakes or poorly thought out process designs are correctable or eradicable.

It is important to understand the sort of variation present in a process. A control chart identifies the kind of variance that is present. It enables you to determine when to take action and when to take no action, as well as whether a process is under control or heading towards the verge of anarchy.

8. Pareto Chart

The Pareto principle, which states that 80% of an outcome derives from 20% of its inputs, is the foundation of the Pareto chart, a tool for quality improvement. One of the essential tools in overall quality management and six sigma approaches is the Pareto chart. In essence, it is a bar graph that illustrates how much each cause influences a result or an impact. The Pareto Principle aids Six Sigma practitioners in understanding that the majority of issues with a process will have a condensed number of root causes. The Pareto Chart provides more information by displaying the sources of problems and how often or expensive they are [25].

Determine the subtotal for every cause over the selected period of time. You can determine the percentage that each cause contributes if you'd like. This would be equal to the subtotal of each cause divided by the sum of all the causes. The scale for measured values can then be drawn next to a scale for percentages. On Pareto charts, cumulative percentage curves are plotted. A dot at the percentage of the first bar on the cumulative percentage curve indicated the cause's contributions of TQM and Six Sigma. Place the second dot at the sum after adding the first and second percentages at the second bar. Place the third dot by multiplying the previous total by the third percentage, and so on. The final dot established on the numerical

scale, at 100%. Finally, joining the dots to produce an average percentage curve revealed the causes of TQM and Six Sigma's efforts.

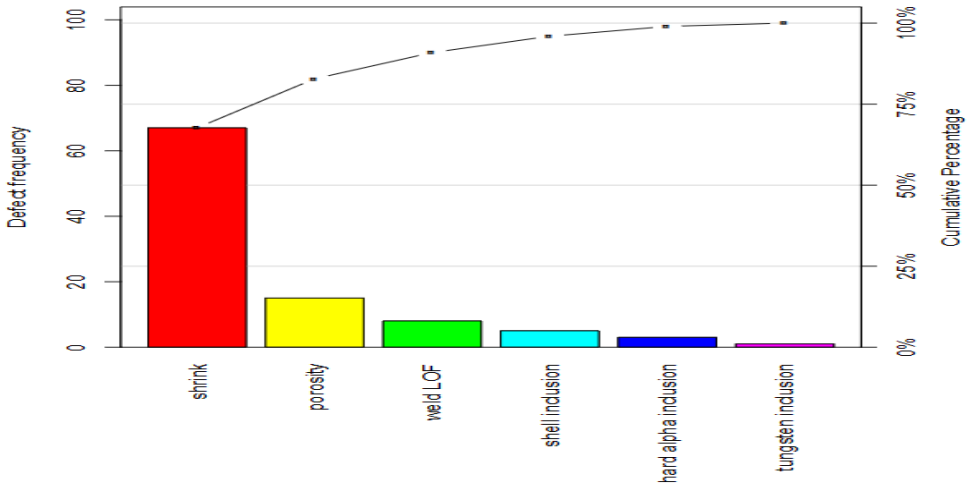

Figure 6. Pareto Charts

The line was drawn starting at 80% on the proportional scale, continuing parallel to the x-axis, and halting where it met the cumulative percentage curve since the researchers were interested in using the 80/20 rule at this point. The factors that lie to the left of this axis account for 80% of the issues, whilst those to the right are less significant. This made it easier to concentrate on making improvements on the factors that have the most effects on the issues.

9. Confirmatory Factor Analysis

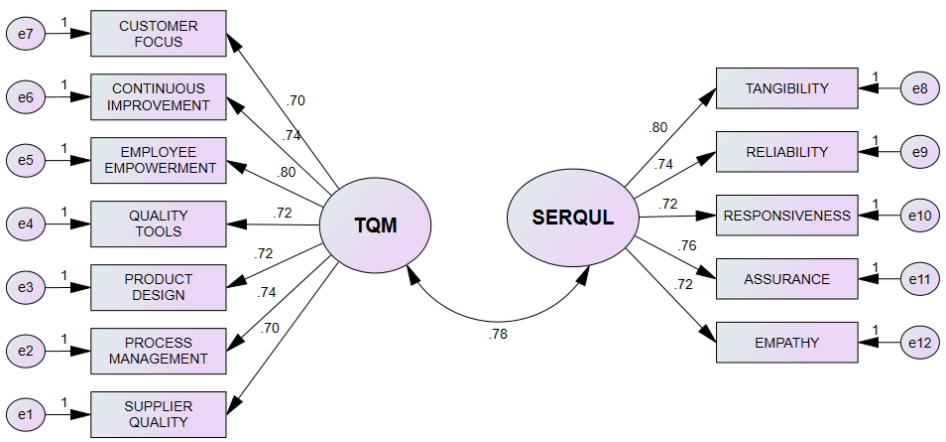

Figure 7: Confirmatory Factor Analysis

Source: AMOS output, 2023

A statistical method called confirmatory factor analysis (CFA) was used by the researchers to confirm the factor structure of a collection of observed data. Researchers investigated the idea that there is a connection between TQM dimensions (observed variables) and the TQM (latent constructs) that underlie them using CFA. It was used to see if measurements of a construct are in line with what the researcher believes those constructs (or factors) to be. Confirmatory factor analysis's goal is to determine whether the results conform to the proposed measurement model [26].

According to AMOS output, RMSEA levels under 0.05 found considered good, those between 0.05 and 0.08 are considered acceptable, those between 0.08 and 0.1 are considered marginal, and those over 0.1 are considered poor. RMSEA level under CFA model founded as 0.006, thus model considered as considerable good in correlation between TQM and six sigma.

9. Mediation of Serqul in Between TQM And Six Sigma

Researchers employed structural equation modelling as a multivariate statistical analysis tool to examine structural correlations. This method examines the structural link between measured variables and latent constructs by combining component analysis and multiple regression analysis [27].

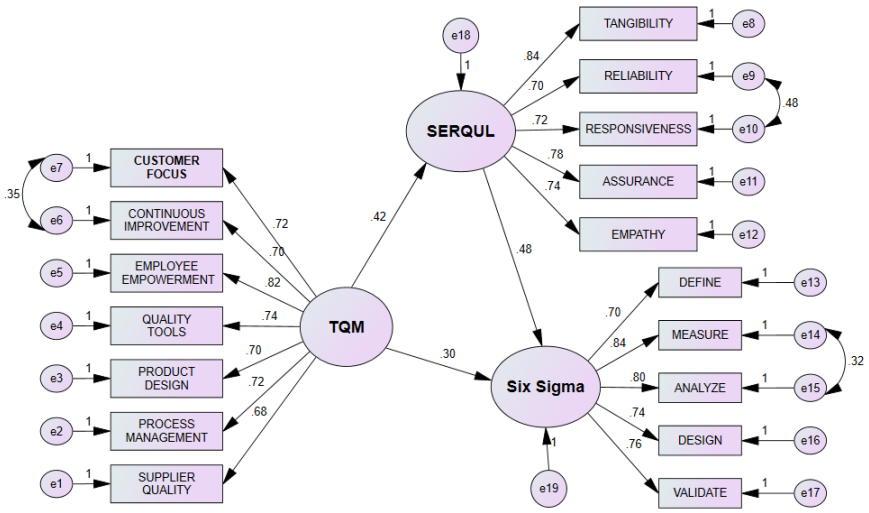

Figure 8. Structural Equation Modeling

Source: AMOS output, 2023

While Six Sigma and TQM are interoperable, they can also be employed separately. The two can be used together in various industries. Utilising them in tandem can improve output because they each have a distinct focus. SERRQL mediation founded between TQM and SIX SIGMA. According to this study, service quality can operate as a bridge between six sigma and TQM practices [1] [2] [3] [5] [7].

In the present SEM model under figure 8, mediation was taken in many different forms. When the direct relationship between two conceptions is insignificant but the indirect relationship through a mediator is significant, this is known as full mediation (also known as indirect only mediation).The SERQUL was regarded as a mediator variable since it strongly contributes to changes in the degree of TQM, which in turn affects variance in the six sigma.

10. Conclusion

It was concluded on the base of data analysis both TQM and Six Sigma were used internal processes to maintain quality in all business practices. TQM focused on improving internal processes to advance customer service and maintain quality systems already in place. Six Sigma worked to improve operations within a single business process. Six Sigma was used by the researchers as a quality control methodology to improve the process. It's called Six Sigma because the term sigma refers to one standard deviation in a data set. The idea is that six such deviations should occur before the process results in a defect. Six Sigma not only helps you reduce waste, but it also helps you further leverage effective processes. With formal training, you

will learn how to utilize resources to achieve maximum effectiveness using your current business processes. The two main Six Sigma methodologies are DMAIC and DMADV. Each has its own set of recommended procedures to be implemented for business transformation. DMAIC is a data-driven method used to improve existing products or services for better customer satisfaction. Both TQM and Six Sigma use internal processes to maintain quality in all business practices. TQM focuses on improving internal processes to advance customer service and maintain quality systems already in place. Six Sigma worked to improve operations within a single business process. Six Sigma also does not technically allow for the introduction of new tools or methods, even when they could be beneficial. Since Six Sigma generally requires total dedication across all teams, it's difficult to use or experiment with other process methodologies for other areas of the organization. So, we can now see that Six Sigma can deliver more effective and better results as compared to TQM, as it is a new approach over the traditional approach of TQM. The process of Six Sigma is more result-oriented and accurate, which will definitely make it go much further than TQM in the future. The present study results found similarity with previous studies.

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Author Contributions

All authors equally contributed to the drafting of the manuscript. Conceptualization was carried out by Lamesa Bulto. Data collection and analysis was done Dr. Shashi Kant. Draft Preparation was written by Lamesa Bulto. All authors have read and approved the final draft of the manuscript.

Conflict of Interest

The authors declare no conflict of interest. The authors have no competing interests to declare relevant to this article's content. This is the original research work done by research scholar Lamesa Bulto under the guidance of advisor Dr. Shashi kant from his seminar on effect of TQM integration with six sigma evaluations with quality charts.

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