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Empirical Investigation of Mediating Role of Six Sigma Approach in Rationalizing the COQ in Service Organizations

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ABSTRACT

The aim of this study is to investigate the role of Six Sigma and Lean Operations in achieving the minimization of Cost of Quality (COQ) in service sector companies in UAE. The impact of the Lean Operations on controlling and rationalizing various costs related to quality through six sigma approach is studied on these companies listed in Dubai Financial Market. To accomplish this, an empirical research methodology has been adopted by conducting a field survey to collect the data, using a structured questionnaire. Totally 120 questionnaires were approved for analysis out of the total number of distributed questionnaires. The results of the study revealed the need for application of six sigma approach in service sector companies to improve the quality of services and for achieving the rationalization of costs related to quality. The study also revealed very interesting aspects related to lean and six sigma in service sector companies. Based on these findings, a number of suggestions and recommendations were made. These include the need to create an awareness about the theoretical concepts and practical implications of six sigma, lean management, and total quality management. The need to adopt a professional methodology to implement these concepts in service companies listed in Dubai Financial Market is also recommended through this study.

Keywords: *cost of quality COQ, financial organizations, lean operations, lean six sigma, six sigma*

1. INTRODUCTION

Influence of six sigma approach in manufacturing sector has been well established and many organizations have benefited out of redesigning their systems and processes in accordance with the requirements of this approach (Snee, 2004). At the same time, in addition to the manufacturing organizations, six sigma has also provided better results and reduced the overall operational costs in service sector organizations too (Hoerl, 2004). Many organizations have achieved significant outcomes by implementing six sigma and lean approaches jointly. In addition to these two approaches, the Total Quality Management (TQM), another popular approach for process improvement and cost reduction has also been implemented by several organizations. Therefore, this paper attempts to study the mediating role of six sigma approach in rationalizing the Cost of Quality in association with lean, lean six sigma and TQM.

Even though the definitions of TQM, Lean and Six Sigma differ from one another, their common objective appears to be improving quality. While lean approach emphasizes on minimizing or removing the waste or non-value-added activities to improve process efficiency, six sigma measures the deviations from the set target (Nicholas, 2010). Enhancing the ability of an organization to achieve the highest quality level is the basic philosophy behind six sigma through the methodology of Define, Measure, Analyze, Improve and Control (DMAIC) and several other statistical techniques (Anbari, 2006; Bertolaccini *et al*., 2011). Both these approaches improve all types of processes and operations in the organization to provide highest possible customer satisfaction by minimizing the defects and mistakes (Antony, 2002). Originally implemented by Toyota in its production system, lean management uses a technique known as Value Stream Mapping (VSM) to eliminate all kinds of waste in its processes (Nicholas, 2010; Huang, 2012).

These process improvement approaches need redesigning of processes and systems in service organizations, as the nature of their business operations is quite different from manufacturing organizations. As service organizations operate in a dynamic business environment and face many challenges related to aspects like ever-increasing competition, changing customer needs and technology (Wang *et al*., 2018) their operations need to be more flexible, customer centric and quality-conscious in order to achieve sustainability and improved performance (Judeh, 2012; Das and Mitra, 2018).

Six Sigma is found to be one such approach for service organizations to achieve their operational excellence, reduction of costs and implementation of quality standards (Barrios & Jiménez, 2016). This approach defines and

measures relevant metrics, known as 'critical-to-quality (CTQ)' characteristics (Bertolaccini *et al*., 2011). In today's modern business environment, managers responsible for ensuring quality often combine six sigma approach with lean and thus the lean six sigma approach has emerged (Drohomeretski *et al*., 2014).

Implementation of projects related to six sigma enable reduction of costs incurred towards maintaining quality in the organizations (Prashar, 2014) and they improve the effectiveness and efficiency (Goldsby & Martichenko, 2005). Six Sigma approach is found to play a significant role in financial service organizations too (Chakraborty & Leyer, 2013). To achieve objectives of total quality management (TQM), service organizations integrate the initiatives of six sigma and lean. Primary objective of most of the service organizations, in general is to identify customer needs and requirements. Therefore, it has become imperative for them to implement six sigma and lean approaches in order to improve the quality of their goods and services and to achieve competitive advantage by reducing the waste and defects (Sujova *et al*., 2016).

However, at the same time, service organizations face with several issues like deciding between implementing six sigma and lean approaches, how to integrate lean and six sigma and they are confused on the role played by these approaches in reducing the cost of quality (COQ). Most of the financial service sector organizations also face many challenges in achieving positive results through the implementation of six sigma. Some of these challenges are related to organization wide implementation (Moormann *et al*., 2009) and implementation within diverse projects of organization (Heckl *et al*., 2010).

Inspite of these challenges, some of the leading financial sector organizations implemented six sigma successfully include, Bank of America, Citibank, GE Capital Corp., GE Medical Systems, Mount Carmel Health System, Carterpillar and Virtua Health (Bott *et al*., 2000; Wyper & Harrison, 2000; Schmidt & Aschkenase, 2004). However, the stories of such successful implementations are limited and there is a need to investigate the influence of six sigma improving the processes and reducing the costs in service sector organizations. At the same time, unlike in manufacturing sector, the influence of six sigma in a tangible manner through measurable outcomes is not emphasized either in academic world or in industry. In addition, there are limited number of studies in this area to establish the mediating role of six sigma in achieving the reduction of costs with special emphasis in service sector organizations, especially in financial sector organizations (Antony, 2006; Sreedharan *et al*., 2018).

Considering this background and gap, this paper studies the relationship between lean initiatives, role of lean in achieving rationalization of costs of quality with six sigma playing a mediating role. An empirical survey of service organizations listed in Dubai Financial Market was conducted by collecting opinions from middle level managers through a structured questionnaire.

Before proceeding for the empirical survey, a systematic literature review was carried out to explore various theories and frameworks related to six sigma, lean, total quality management, and the elements of cost of quality as proposed by various authors.

2. LITERATURE REVIEW

The concepts of Six Sigma, Lean, TQM and Costs of Quality have been dealt extensively by several authors. The initial part of this review is focused on six sigma and its impact on the improvement of quality in business organizations. The second section of the review focused on Lean Management and its contribution in reduction of wastage and enhancement of quality in the products and services. The remaining part of review focused on TQM, Costs of Quality (CoQ), Costs of Poor Quality (CoPQ) and the contribution of quality approaches in reducing the costs.

The concept of quality has been one of the most studied concepts since a long period. Rapid developments in the business environment due to globalization and disruptive advancements in technology led to consumer awareness of quality organizations (Alkunsol *et al*., 2019). Many tools and methods, beginning from quality inspection (QI) to quality assurance (QA) and total quality management (TQM), six sigma and lean have contributed to quality concept.

2.1 Six Sigma

Six sigma is considered as a customer-oriented approach aimed at improving operations to the highest efficiency by producing high quality products and delivering services to the customer from a customer perspective (Chakraborty & Leyer, 2013). It is a process improvement approach that focuses on factors which produce defects, flaws, and errors, reduces operating cycle and operating costs, improves productivity, helps bring product or service closer to customer expectations, and seeks to achieve the highest ROI (Ulmer, 2008). It is also defined as a concept to improve processes, methodology to solve problems and philosophy to reduce costs and defects and improve the quality of the product or service by minimizing defects in all processes that produce the product in its final form (Camargo, 2006).

A methodological framework of six sigma in service organizations developed by Judeh (2012) for Arab organizations emphasized the importance of applying it to quality of operations for reduction of error rates rather than just applying it for quality of inputs and outputs. Application of six sigma in controlling the quality of internal auditing in private hospitals in Jordan was studied by Al-Rawi (2012). An amount of 1 million US dollars was found to be reduced due to the implementation of six sigma approach in laminate flooring by improving its quality (Thomas and Singh, 2006). The study also found that there is a positive relationship between the six-sigma usage and reduction of costs and increased return on production.

Support and commitment of senior and top management of the organization, design for six sigma (DFSS), training the employees, management of information systems and providing a six-sigma culture are found to be the essential pre-requisites for achieving positive results (Antony & Bhaiji, 2003). These findings were supported by Mohamed (2011) and additionally it is found that while organizational culture has a positive influence (Porter, 2019) the hierarchical structure of the organization has no influence on the implementation of six sigma through the quality practitioners (Zu *et al*., 2010).

Implementation of six sigma impacts the business performance, reduces costs, minimizes defects, and errors,

and increases customer satisfaction (Pie-Shih, 2006). Application of six sigma in libraries to improve the quality in the processes proved to be very useful for increasing the customer satisfaction (Kim, 2006). In another instance, after the application of six sigma in banking industry, highly positive outcomes were achieved in the operations and processes resulting in reduction of total costs of operations and improvement in the customer satisfaction (Salaheldin & Abdelwahab, 2009).

Six Sigma is a systematic procedure and a toolkit for eliminating defects using "Define-Measure-Analyze-Improve-Control" or "Define-Measure-Analyze-Design-Validate" methodologies by a disciplined, data-driven approach (Sunder, 2016; Srinivas & Sreedharan *et al*., 2018). Statistically speaking, it focuses on reducing process variation ideally at a level equivalent to 3.4 defects per million opportunities (Augusto & Monteiro, 2014). Six Sigma has often been noted by scholars as a focused initiative different from TQM, with an aim to reduce process defects (Bengt et al., 2008; Augusto *et al*., 2012).

Implementation of six sigma in services is found to be still comparatively limited than in manufacturing industries (Antony, 2006). Moreover, studies related to its implementation in Dubai and UAE are very minimal. It is found to improve the quality, reduce the cost of quality, and enhance the bottom-line performance of a service company if its key success factors are managed effectively (Harry & Schroeder, 2000; Noble, 2001; Jeffery, 2005; Antony, 2006; Snee, 2010; Sreedharan *et al*., 2018).

Six sigma approach is applicable to manufacturing and service sector organizations equally well. By quoting several examples of firms which implemented six sigma approach, Noble (2001) demonstrated that it reduces costs dramatically and it boosts the bottom-line performance. By integrating six sigma approach to action research techniques organizational effectiveness can be increased and the overall performance of organization can be enhanced (Jeffery, 2005). It is a systematic breakthrough management strategy designed to reduce process errors, improve quality, and improve bottom line (Harry & Schroeder, 2000). It brings significant financial returns to bottom line of service sector organizations (Antony, 2006) as it reduces the defects in service processes and improves the quality. The author demonstrated the benefits of six sigma in organizations belonging to healthcare, banking, financial services, utility services, and other service sectors through empirical evidence. Bottom line improvement of implementation of six sigma with special focus on financial service organizations has been demonstrated by Chakraborty & Leyer (2013) through a systematic literature review and by Heckl *et al*., (2010) through an empirical survey. Identification of costs of quality and projecting their impact on quality and performance can lead to improved business profitability (Antony, 2006).

2.2 Lean Management

Lean is a philosophy of continuous improvements, and six sigma is an approach to improve the ability of an organization to decrease the defects and increase the quality (Chinvigai *et al*., 2010), while the objective of combined approach of lean and six sigma known as lean six sigma is to maximize shareholders' value (Laureani & Antony, 2012). Though both these approaches have differences in their origin, they share common aspects like focus on customer satisfaction, continuous improvement, identification of root causes and comprehensive employee involvement (Dey, 2014).

The goal of lean management is to improve the performance of manufacturing as well as service organizations by following two guidelines: the elimination of all waste present in all processes and placement of humans in the center of the process (Antunes *et al*., 2013). In summary, lean management can be defined as a continuous improvement tool used to eliminate wastes, achieve better performance results, and create more value for customers by utilizing minimum resources (Alkunsol *et al*., 2019).

Mezouari et al. (2013) stated that lean uses an intuitive approach to achieve three objectives of lean management, which are eliminating waste, improving process speed, and utilizing minimum resources. Dey (2014) defined seven elements of wastes: over-production, inventory, defects, transport, motion, over processing, and waiting. Desale and Deodhar (2014) mentioned six goals of lean management as increasing output flexibility, reducing cycle times, decreasing inventories, benchmarking, rising output value through a systematic consideration of customer requirements and reducing the share of non-value-adding actions.

2.3 Total Quality Management

Almost all the business organizations, consider strategy to improve quality as one of their most important strategies for achieving competitive advantage. Therefore, continuous improvement of quality at every stage of the production and service-related processes enables the organizations to achieve improved customer satisfaction (Herzer & Render, 2001), resulting in the achievement of business and economic excellence (Alzoubi & Ahmed, 2019).

The developments of TQM lead to the development of six sigma, with an objective of reducing the likelihood of errors (George, 2004). Given the importance attached to quality, the concept of Total Quality Management (TQM) has emerged as one of the most important approaches to achieve highest possible quality standards by involving every individual of the organization. TQM is found to provide better solutions for quality related challenges of organizations and improve the customer satisfaction (Judeh, 2012). It is defined as, the large umbrella under which all activities and processes related to coordination between quality assurance, quality control and improvement are included. In another version of TQM provided by Khokha (2004), it is defined as a cooperative approach, which depends on the participation of all individuals in the organization, right from top management to heads of departments to employees and all workers. Noureddine (2007) found that it is an integrated approach aimed at serving the client and it includes all activities and functions of the organization. This view of integrated approach was supported by Chakraborty and Gonzalez (2018) in developing an integrated lean supply chain framework for service sector with special focus on US hospitals. TQM is achieved through coordination and interdependence among the departments, by focusing on all the employees and by not limiting its purview to any specific area of the organization. The objectives of TQM are to reduce all costs of failure by

controlling errors and preventing access to failures. Minimization of costs associated with quality processes will result in valuable savings, in huge benefits to the company (Al-Bakri, 2000).

2.4 Cost of Quality and Costs of Poor Quality

Kaplan et al., (1998) were one of the first few early researchers to discuss about TQM and emphasized the need to measure it in terms of cost. Inability to precisely define the costs related to quality is a challenge faced by accountants and accounting systems in the organizations. In order to provide a solution to this challenge, there is a need to develop proper metrics for measuring the costs related to quality. A systematic approach for identifying the costs related to quality and devising mechanisms and a standard system to minimize these costs at their source will provide huge benefits to organizations (Shenibo, 2009). Existence of such a system helps in provision of complete data about every cost related to quality. Such data consists of origin of the cost, frequency of its occurrence, strategy to minimize it, and audit of the cost from various aspects (Shenibo, 2009).

Cost of Quality (COQ) has gained lot of importance in the recent past due to the increase in different types of costs associated with maintaining quality by the organizations in their products and services. It is defined as a process which enables an organization to estimate the number of resources utilized for averting poor quality due to failures of internal and external origin. This information helps organization in estimating sources of savings due to the implementation of such preventive measures related to non-occurrence of poor quality (ASQ, 2019).

Poor quality can result in decreased customer satisfaction and negative outcomes to the organizations. The cost associated with poor quality is termed as Cost of Poor Quality (COPQ) and it is related to both products and services. Both, COQ and COPQ are analyzed by several authors. In today's globalized world and dynamic business environment, organizations continuously attempt to improve their process capability to decrease COPQ (Prashar, 2014). One of the most successful approaches to reduce COPQ is found to be six sigma DMAIC methodology (Kumar & Sosnoski, 2009). By implementing this methodology, initially the manufacturing sector achieved positive results by minimizing costs of operations, reducing number of defects, improving customer satisfaction, and finally increasing profits (Tong *et al*., 2004). In the subsequent period, its application in service sector is also found to achieve better outcomes, for instance, in healthcare (Dreachslin & Lee, 2007; Taner *et al*., 2007), in finance sector (Heckl *et al*., 2010; Chakraborty & Leyer. 2013) and in retail sector (Kumar *et al*., 2008).

It improves the quality in by reducing the errors due to external and internal factors, improves the processes, and reduces the costs of poor quality (Harry & Schroeder, 2000; Noble, 2001; Jeffery, 2005; Antony, 2006; Snee, 2010; Sreedharan *et al*., 2018).

The five phases, Define, Measure, Analyze, Improve and Control are abbreviated as DMAIC methodology. It helps in the identification, quantification, and elimination of sources of waste. It improves performance in the processes through the implementation of systematic plans and control procedures (Desai & Shrivastava, 2008). Its aim is to completely stop the defects at their origin and sources of occurrence proactively instead of taking corrective measures at the end after the completion of processes. Through a systematic literature review, Tjahjono *et al*., (2010), analyzed the emerging trends, approaches, tools and techniques, benefits, and combinations of six sigma by integrating it with other concepts.

Six sigma has been studied by authors in service sector too and it is found to play a significant role in both the sectors (Obaidullah, 2005; Sunder, 2016). In a study of banking sector, Kateeb (2009) found that there is a significant influence of six sigma implementation on mistake reduction and time circle reduction. Hensley & Dobie (2005) studied the readiness of six sigma in service organizations based on two components i.e., organizational experience and organizational understanding processes, and found that there exists a difference in the awareness between customers and organizations in these processes.

The Six Sigma approach is a system that, when implemented, requires a methodology (phases & steps). There are two approaches to Six Sigma: DMAIC and DMADV. DMAIC approach includes five stages: (definition phase, measurement phase, analysis phase, improvement phase, and control phase). This approach is applied if the company's operations or outputs do not meet the needs of customers or satisfy their desires (Medina, 2006).

DMADV approach also includes five phases: definition, measurement, analysis, design, and assurance. This approach is applied if the company's operations are in the design phase, and the company must choose and differentiate between the two approaches based on processes that produce a product or service or new processes that need to be designed (Froehling, 2009).

2.5 Nature and Types of Quality Costs

American Society for Quality (ASQ, 2019) identified three types of costs of quality. They are i) Appraisal costs, ii) Internal failure costs and iii) External failure costs.

Costs which are incurred to adhere to the quality standards are known as appraisal costs. They are the costs associated with measuring and monitoring activities related to quality to conform to various specifications. They could include costs related to verification, quality audits, and supplier rating. Failure costs ensure all costs required to evaluate, correct, and replace the defective product because of unsuccessful production of products in accordance with predetermined quality standards (Atkinson, 2004).

Organizations spend money to rework on the defects identified before the delivery of the products or services to the customer. This cost is termed as internal failure cost resulted due to process failure, scrap and waste generated due to these defects, cost of rework and repairs (ASQ, 2019). Examples of internal failure costs include recheck repairs and rebooting, downgrade costs due to defects, and cost of downtime due to quality problems.

Similarly, external failure costs are costs associated with defects found after the customer receives the product or service. These are the costs incurred to rectify defects discovered by customers. They generally include costs related to replacement of product, reverse logistics costs, settlement of claims by the customer, and costs related to administrative activities and documentation (ASQ, 2019).

Examples of costs of external failure include, market share, inspection and operating claim costs, customer response costs, lost return on operating costs, collateral costs, opportunity cost lost because of poor quality, allowable costs arising from poor quality, cost of consumers' complaint examination during the warranty period, the costs of product warranty issues.

Quality costs are defined as the total costs incurred by the company to ensure that the product is provided with specifications and requirements tailored to the client's desire (Kaplan, 1998). These costs are also defined as costs that occur because of trying to avoid manufacturing low quality products or modifying quality defects if they do occur. The process of studying quality costs consists of motivating the employees, collecting quantitative data, allotting budgets for quality programs, and creating awareness about continuous improvement at all levels in the organization.

3. RESEARCH METHODOLOGY AND PROBLEM

The importance of the study is to emphasize the importance of expanding the Six Sigma approach and utilizing the UAE environment to rationalize the cost of quality, which will reflect on the company's survival, continuity and competitiveness faced by all organizations recently.

This study aims to achieve the following objectives:

- Expand the understanding regarding the availability of Six Sigma requirements in a sample of service organizations listed on the DFM.
- Expand the understanding regarding the feasibility of applying lean operations in a sample of service organizations listed on the DFM in rationalizing quality costs and improving service.
- Investigate the relationships and the impact among lean operations, six sigma approach and cost of quality at service organizations in the Dubai Financial Market.

4.1 Research Gaps

In service industry, majority of these studies are of practical approach than conceptual approach (Sreedharan *et al*., 2018). Many authors opined that implementation of six sigma has been well-documented and studied in manufacturing sector. However, its implementation in service sector is relatively very less due to many obstacles and reasons (Antony, 2006). Research has shown that most of the service processes like payroll processing, billing, invoicing, shipping, order entry, response to service requests, baggage handling, etc. are performing at less than 3.5 sigma quality level only with a defect rate of over 23,000 ppm or yield 97.7 percent (Yilmaz & Chatterjee, 2000). Many service-oriented organizations still believe that six sigma is confined to only manufacturing organizations. However, it is found that implementation of six sigma can provide better results in finance and banking sectors. Reduction of transaction processing time, minimization of transaction errors, reduction in number of complaints received from customers, increase in the speed of solving a complaint, and reduction of errors related to the preparation of various financial reports are some of them (Antony, 2006; Chakraborty & Leyer, 2013).

In spite of several benefits, empirical studies on the mediating role of Six Sigma approach in rationalizing the Cost of Quality through Lean Operations in service organizations has not been done in the past. Therefore, considering these gaps in the existing research, the paper focuses on studying the relationship between lean initiatives, role of lean in achieving and rationalization of costs of quality with six sigma playing a mediating role. An empirical survey of service organizations listed in Dubai Financial Market was done by collecting opinions from middle level managers through a structured questionnaire.

4.2 Problem Statement

Costs play an important role in the implementation of total quality management programs and six sigma approach. Therefore, attention to costs related to quality is essential for financial organizations, especially considering intense competition in international markets to reduce costs and increase return. Some quality related costs are hidden and are not easy to detect or reduce. Research shows that many financial organizations implement the lean and six sigma approaches hoping to improve quality and reduce the cost of quality. These financial organizations consider it as an opportunity to achieve quality, reduction of costs, especially the ones listed in Dubai Financial Market in UAE. Based on the above discussion of problem of study, we introduce the following research question:

> *To what extent can the Lean operations and Six Sigma portal be used to rationalize quality costs in DFM services sector organizations?*

Based on the literature review, the constructs of the study are identified. **Table 1** presents the constructs for lean operations, six sigma and cost of quality. The process of measurement for each construct is mentioned against each construct.

4.3 Problem Statement

In order to achieve the objectives of the study and to answer its questions, the following hypotheses have been formulated. These hypotheses were validated, and conclusions were drawn to provide relevant recommendations based on them:

From the discussions based on the literature review, it is found that practices related to lean operations have a significant role to play in the achievement of six sigma in service organizations and improvement in performance (Antony, 2006; Sunder, 2016; Sreedharan *et al*., 2018; Alkunsol *et al*., 2019). Therefore, it is relevant to identify the impact of lean operations on six sigma, which is hypothesized as H01.

H01: *Lean Operations has no statistical impact on Six Sigma in service organizations*

Similarly, practices of lean and six sigma are found to influence the cost of quality in service organizations. Successful implementation of lean, six sigma and lean six sigma strategies is found to be reduce the costs related to quality and lean enhanced the ability to identify and manage these costs (Chakraborty & Leyer, 2013; Desale *et al*., 2014; Heckl *et al*., 2010). Therefore, this paper investigates the

impact of lean and six sigma on costs of quality through Hypothesis H02 and H03.

H02: *Lean Operations have no statistical impact on Cost of Quality in service organizations*

H03: *Six Sigma has no statistical impact on Cost of Quality in service organizations*

Some authors also highlighted the integration of lean and six sigma to name the concept as lean six sigma. Some authors emphasized that six sigma plays a mediating role in influencing the costs related to quality through the implementation of lean operations (Huang Yu, 2012; Desale & Deodhar, 2014; Dey, 2014, Conceição *et al*., 2019, Alkunsol *et al*., 2019). Hypothesis H04 is developed to validate this aspect in select sample of financial service organizations listed in Dubai Financial Market.

H04: *Lean Operations has no statistical impact on Cost of Quality with the mediating effect of Six Sigma in service organizations.*

The conceptual model of the study is presented in **Figure 1**.

Table 1. Constructs of the Study

Lean Operations	
Max. Value	Equipment and machines are utilized in best way to achieve low-cost activities
	Suggestions are taken seriously, and efforts are initiated to achieve low cost
	Management links all activates and transactions to achieve cost-benefit
Min. Waste	Management tracks and records defects in all processes and activities
	Operators are evaluated based on number of defects due to them
	A clear and systematic procedures are followed to reduce defects
Constant Process Improvement	Employees can add inputs for operations' improvement
	Management conducts regular reviews and makes changes in the processes
	Management encourages employees to make suggestions for process improvement
Six Sigma	
Six Sigma Planning	Six Sigma approach is part of the organization's vision, mission & values
	Management consults external experts or auditors to review the processes
	Management adopts& sets quality goals & plans for long run
Six Sigma Delivery	Management measures the defects in the related processes
	Management keeps a record of defects through systematic statistics
	Management takes correction actions to solve each defect
Six Sigma Monitor & Review	Management discusses outputs of processes by involving employees
	All corrective actions are documented & updated in the system
	All employees responsible for defects are liable for penalty
Cost of Quality	
Prevention Cost	Management spends considerable money on training employees
	Management uses internal & external initiatives for process planning
	Management upgrades systems & maintains equipment regularly
Appraisal Costs	Management uses reviews and audits to evaluate the processes
	Management spends on inspection & tests tools & systems
	We have department or inspection section for testing products' quality
Internal Failure Cost	Some employees' performance is less than the standard performance
	Management spends extra amount on re-work or delay
	We noticed increased amount of waste
External Failure Cost	We noticed increased number of complaints from customers
	We spend extra amount to compensate customers on delivery related problems
	Sometimes we pay for settlement of legal cases and penalties

4.4 Methodology and Study Design

To achieve the objectives of the study, empirical research has been done in the present study. Also, explorative, descriptive, and analytical methodologies were used to describe, interpret, and analyse the results of data collected, and how to use them in addressing the problem of the study and achieve its objectives. A survey was designed and used to collect the data.

The primary data is collected using a structured questionnaire using a five-point Likert scale. The initial questionnaire was sent for review to experts and based on their comments the final version of questionnaire was developed. The questionnaire consisted of three major sections to measure the main three variables and its dimensions. The data collected by the questionnaire were analysed using appropriate statistical methods.

The study population consisted of 79 service organizations listed on Dubai Financial Market. The questionnaires were sent by email to key managers of all service organizations listed on Dubai Financial Market. Totally 190 questionnaires were distributed, out of which 120 questionnaires (63%), were found to be appropriate for analysis. Others were rejected due to their incomplete nature.

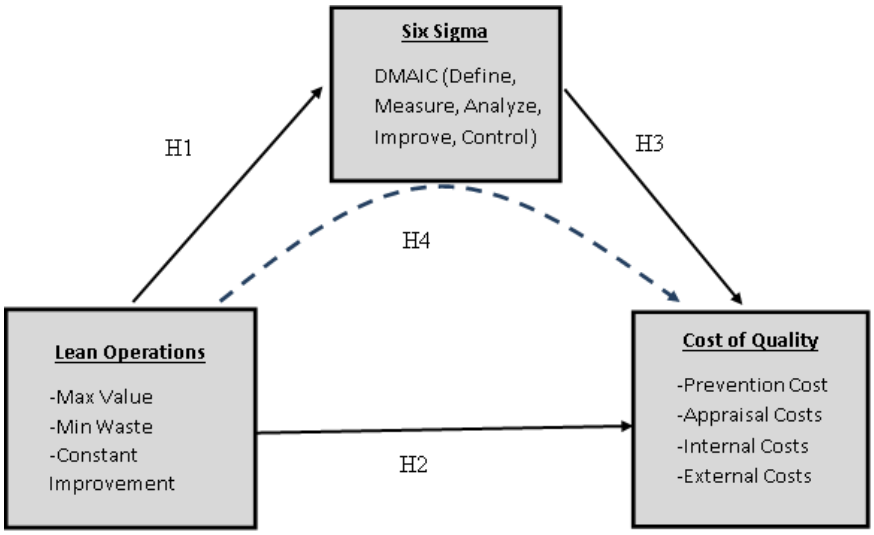

Figure 1. Conceptual model of the study

4. DATA ANALYSIS

In order to test the direct and indirect influence of lean operations on cost of quality with six sigma as a mediating factor in service organizations listed on Dubai Financial Market in UAE, the collected data was analysed using Partial Least Square Structure Equation Modelling through Smart PLS statistical software package.

The six sigma as a variable with five dimensions of Define, Measure, Analyse, Improve, and Control and was assessed using 15 items. Lean Operations variable, consisting of three dimensions (Max Value, Min Waste and Constant Improvement) was assessed using 9 items. Cost of Quality variable consisted of four dimensions (Prevention Cost, Appraisal Costs, Internal Costs and External Costs) and was assessed using 12 items. Cronbach's alpha was used in order to measure the consistency of each part of the measure. Also, Exploratory Factor Analysis (EFA) was used in order to describe and examine the measures. Varimax rotation of exploratory factor analysis helped in determining questions considered to be the best to measure the study variables and dimensions. The cross-loaded items were deleted from the scale.

4.1 Validity and Reliability

In this section, internal consistency has been examined for study model's variables and dimensions using Cronbach's alpha coefficient. **Table 2** shows acceptable levels of reliability to all model items, where the reliability coefficient was ranging between (0.701-0.908), and all constructs were above (0.7) (Hair et al. 2010). This indicator enabled us to conclude that the design and scale of the questionnaire were able to measure the study variables and dimensions, and the items in the questionnaire were able to represent each variable of the study.

Average Variance Extracted (AVE) was also used to assess the validity of the measurement model. Results showed in **Table 3** below indicate that all these values are above the standard value of .50.

Table 2. Cronbach's alpha coefficient for study variables

Construct	Cronbach's Alpha	Construct	Cronbach's Alpha
Define	0.898	Prevention Cost	0.732
Measure	0.788	Appraisal Costs	0.871
Analyze	0.709	Internal Costs	0.788
Improve	0.701	External Costs	0.732
Control	0.738	Six Sigma	0.802
Max Value	0.879	Lean Operations	0.808
Min Waste	0.756	Cost of Quality	0.795
Constant Improvement	0.801		

4.2 Descriptive Analysis

Table 4 displays the descriptive analysis of variables and dimensions of the study. The means and standard deviations are used to verify the significance of items based on the responses of respondents of service organizations listed on Dubai Financial Market in UAE. It can be observed that all the items have high significance level as the means ranged from (2.892) to (4.184). The dimension 'Six Sigma Define' has the highest significance level with mean and standard deviation of (4.184: 0.846). It is followed by six sigma measure with a mean and standard deviation of (4.084: 0.913). The third position was occupied by 'Max Value' and 'Appraisal Costs', with a mean (3.957; 3.832) and standard deviation (0.880; 0.939) values respectively.

Table 3. Average Variance Extracted (AVE)

Construct	AVE	Construct	AVE
Define	0.691	Prevention Cost	0.736
Measure	0.704	Appraisal Costs	0.608
Analyze	0.689	Internal Costs	0.601
Improve	0.715	External Costs	0.760
Control	0.666	Six Sigma	0.621
Max Value	0.674	Lean Operations	0.609
Min Waste	0.665	Cost of Quality	0.642
Constant Improvement	0.733		

Therefore, the authors can conclude that the measurement models confirmed to an acceptable fit to the data, and this asserts that the structural equation model of the study fits the data of the study, based on the data of the goodness-of-fit showed in **Table 5** for the path model.

Annexure-1 illustrates the correlation matrix for all the constructs' dimensions included in this study. Aligned with the recommendation of Pallant (2013), the dimensions of independent variables show meaningful relation to the dependent variable (all correlation more than 0.230) and indicates that the correlation between the independent variables is not very high (all correlation below 0.670). The correlation matrix reflects normal levels and indicated that variables of the study are correlating to each other in a good way (Hair *et al*., 2005).

Table 4. Descriptive analysis to six sigma, lean operations, and cost of quality

Variables and dimensions of study		M	Std.	Sig rank	Sig level
Six Sigma	Define	4.184	0.846	1	High
	Measure	4.084	0.913	2	High
	Analyze	3.809	0.929	5	High
	Improve	3.511	0.935	8	Medium
	Control	2.892	0.761	11	Medium
Lean Operations	Max Value	3.957	0.880	3	High
	Min Waste	3.809	0.929	5	High
	Constant Improvement	3.233	0.902	9	Medium
Cost of Quality	Prevention Cost	3.812	0.8183	7	High
	Appraisal Costs	3.832	0.939	4	High
	Internal Costs	3.233	0.961	9	Medium
	External Costs	2.991	0.998	10	Medium

Table 5. Goodness of fit statistics for the structural model

Chi Square	D.F	Chi Square / D. F	Sig	NFI	CFI	GFI	RAMSA
81.823	11	7.438	.000	.786	.874	.842	.108

GFI: Goodness of fit index
NFI: The Bentler-Bonett normed fit index
CFI: The comparative fit index
RMSEA: Root Mean Square Error of Approximation

4.3 Hypothesis Testing

A multi-collinearity test was conducted before testing the hypotheses to confirm absence of high correlation between dimensions of each variable and to proceed for path analysis later. Results of multi-collinearity showed that there is no abnormal correlation between dimensions of variables. We ran a structural equation modelling in order to test the hypotheses and to examine the effect and the significance level of each path in the model, as shown in Figure 2. The path model indices indicated the model's goodness-of-fit, and ensured an acceptable fit of data to the model presented in Table 5 as the following: Chi square/D.F (81.823/11) was (7.438), while (GFI) Goodness of fit index was (0.842) (range between 0 to 5, the fewer the better), (NFI) Normed fit index was (0.786), (CFI) Comparative fit index (the revised form of the NFI) was (0.874) (both NFI, CFI range between 0 to 1, values closer to 1 indicating good model fit), and the Root mean square error of approximation (RMSEA) was (0.108) (values range between 0 to 1, values closer to 0 indicating good model fit) (Hair et al. 2010). Therefore, we conclude from all models fit indices that the overall fit of the model is approved for continuing with hypothesis testing to examine the causal relationships between the study variables.

To test the hypotheses, we established two structural models; the main effect model to test the direct relationship between lean operations and cost of quality and the mediation model to test the indirect role of six sigma between lean operations and cost of quality. The data shown in **Table 6**, presents standardized path coefficients of the study model (beta coefficients in which the estimates results were taken from a regression analysis). Moreover, **Figure 2** illustrates that the path coefficients from lean operations to six sigma

are positive and significant (Standardized coefficient = 0.429; $p < 0.05$), and the path coefficients from lean operations to cost of quality were positive and significant (Standardized coefficient = 0.304; $p < 0.05$). Therefore, there is enough evidence to support H1 and H2.

The path coefficients from six sigma to cost of quality are also positive and significant (Standardized coefficient = 0.412; $p < 0.05$), Therefore, hypothesis H3 is supported. The indirect effects of lean operations on cost of quality through six sigma as mediator were also positive and significant (indirect standardized coefficient = 0.222; $p < 0.05$). This indicates that hypothesis H4 is also supported. Therefore, the results reveal that all the four hypotheses are supported and accepted.

Figure 2 shows the coefficient of determination (r2) (the part of the variance in the dependent variable that is predictable from the independent variable, range between 0 and 1, the highest the better). The results illustrated in Figure 2 show that Lean Operations account for 30% of variance in Six Sigma: Lean Operations and Six Sigma, account for 22% of variance in Cost of Quality.

Table 6. Direct, indirect, & total effect for path analysis

	Direct Effect		Indirect Effect		Total Effect	
From / To	Lean Operations	Six Sigma	Lean Operations	Six Sigma	Lean Operations	Six Sigma
Six Sigma	.429	.000	.000	.000	.429	.000
Cost of Quality	.304	.412	.222	.000	.321	.412

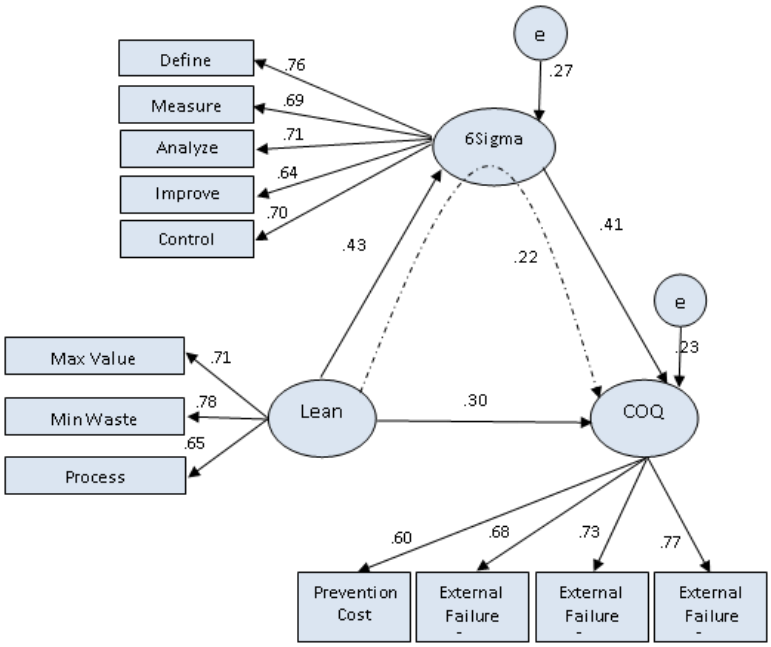

Figure 2. Result of path analysis

Table 7. Summary of results of hypothesis testing

Hypothesis	Causal path	Standardized Coefficients	Test result
H1	Lean Operations on Six Sigma	0.429*	supported
H2	Lean Operations on Cost of Quality	0.304*	supported
H3	Six Sigma on Cost of Quality	0.412*	supported
H4	Indirect effect to Lean Operations on Cost of Quality through Six Sigma as mediator	0.222*	supported

* Significant at a level of ($\alpha \leq 0.05$).

5. DISCUSSION

The results of present study indicated that the lean practices have a direct and significant influence on cost of quality as well as the six-sigma approach has direct and significant influence on cost of quality. Additionally, there is an indirect impact of lean practices on cost of quality through the six-sigma approach in financial service sector organizations.

It is clear from the results that implementation of lean practices and six sigma approach have a significant impact on cost of quality in financial service sector organizations. The results related to the first hypothesis reveal that lean operations in financial organizations have a significant influence on six sigma. This indicates that max value, min waste, and constant improvement depend on the ability of organizations to implement the six-sigma approach of define, measure, analyse, improve, and control. These results are consistent with the findings of previous studies such as Raja (2017), Desale & Deodhar (2014), Dey (2014) and Chinvigai *et al*. (2010).

It can be seen from the results of second hypothesis test that the lean operations of financial sector organizations have a significant influence on cost of quality. This indicates that max value, min waste, and constant improvement are related to the ability of these organizations to improve the efficiency of its costs related to quality (prevention cost, appraisal cost, internal failure cost, and external failure cost). These results are consistent with the findings of Alkunsol *et al*., (2019) and Mezouari *et al*. (2013). The results related to the testing of third hypothesis indicate that six sigma practices of management of these organizations have a significant effect on cost of quality. Therefore, it can be concluded that define, measure, analyse, improve, and control approach of six sigma is related to ability of organizations to improve cost efficiency of its quality (prevention cost, appraisal cost, internal failure cost, and external failure cost). These results are consistent with the findings of Prashar (2014) and Pie-Shih (2006).

The results of fourth hypothesis reveal that lean operations of organizations contribute to six sigma practices of management, which in turn have a significant impact on cost of quality, directly and indirectly. These results are consistent with the findings of Conceição (2019), Vijaya (2016) and Huang *et al*. (2012). Even though the implementation of lean practices and six sigma approach is not uniform among the surveyed organizations, most of them listed on the Dubai Financial market possess the main requirements for their implementation. Thus, lean practices and six sigma approach contributed to the rationalization of costs of quality. Implementation of these approaches is based on the philosophy of continuous improvement in quality which leads to operations enhancement and prevention of errors in all the processes and activities related to quality. While analysing the responses it is also found that implementation of lean and six sigma can lead to more customer satisfaction. It is also found that management of some of these organizations have started motivating their employees and provided training to them for better implementation of lean and six sigma approaches.

6. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The paper studied the mediating role of six sigma in rationalizing the cost of quality (COQ) in financial sector organizations listed in Dubai Financial Market. The outcome of the study has provided very interesting conclusions. The first interesting conclusion is about the influence of lean operations on six sigma in financial sector organizations in the selected segment of study. This can be explained from the fact that many financial sector organizations consider these two practices from different perspectives and there is no systematic approach measure the impact of these approaches. The second conclusion is related to the influence of lean operations on cost of quality. While the third conclusion is related to the influence of six sigma on cost of quality. The fourth and conclusion is about the mediating effect of six sigma and lean operations on the cost of quality.

The general and broad conclusions of this study, based on the interactions with the managers of the finance service organizations are presented here. It is found that these organizations have been facing various problems due to the increasing costs of quality. Some of these problems are related to the inefficiency in the processes related to financial transactions leading to defects and increase in the costs. Though the managers are aware of lean and six sigma practices and their influence in reduction of costs, they are not fully clear about their implementation strategies. This highlights the need of committed efforts and systematic plan from the top management. These efforts would lead the financial sector organizations to reduce their process-related errors and could provide huge benefits financially.

Effective implementation of these approaches requires a change in the mindset of top management and development of a new organizational culture. A thorough monitoring system to identify the defects and take a correct action is an essential prerequisite to achieve cost reduction. This present study also concludes that quality management concepts are not just limited to manufacturing sector but also to services sector, especially the financial sector. The scope of this research can be expanded by conducting a similar empirical survey in organizations belonging to other sectors and other geographical areas. The future research can also be conducted by considering a greater number of constructs than the ones mentioned in the present research study.

7. RECOMMENDATIONS

Six sigma and lean approaches should be considered more seriously by the financial sector organizations as the results of this study reveal that their implementation has a strong positive influence on optimizing costs of quality. In order to optimize these costs, these organizations should identify the costs of quality, create awareness among the employees, and develop a professional approach towards implementation of these approaches. At the same time, the top management of these organizations should monitor the outcomes of their implementation. These organizations need to restructure their organizations and redesign the processes to enable smooth implementation of lean and six sigma.

Activities like allocation of adequate resources, a systematic approach to identify the defects in the processes, collection, and analysis of data at all levels, corrective measures to rectify the processes should be taken up on a priority basis by the top management. Employees should be trained to improve their efficiency to reduce the defects and they should be provided feedback on a regular basis.

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APPENDING 1: CORRELATION MATRIX

Table 1 Correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1	1									
2	.567	1								
3	.299	.275	1							
4	.383	.281	.324	1						
5	.408	.579	.263	.512	1					
6	.434	.453	.256	.439	.570	1				
7	.374	.374	.268	.392	.309	.270	1			
8	.439	.503	.472	.577	.664	.364	.447	1		
9	.406	.495	.238	.495	.494	.497	.287	.443	1	
10	.338	.558	.356	.559	.616	.452	.352	.665	.575	1
	1 Max. Value	2 Min. Waste	3 Constant Process Improvement	4 Six Sigma Planning	5 Six Sigma Delivery	6 Six Sigma Monitor	7 Prevention Cost	8 Appraisal Costs	9 Internal Failure Cost	10 External Failure Cost

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