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# Integrating Lean Six Sigma with Knowledge Management within Service Organisations

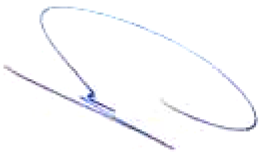
DOCTORAL DISSERTATION


Supervisor: Dr. Schmuck Roland


*Pécs, 2022*

## Declaration of Originality

I, the undersigned, solemnly declare that this diploma work is the result of my own independent research and was written solely by me using the literature and resources listed in the Bibliography.



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Sahoum Aljazzazen, November 2022

# Abstract

Lean Six Sigma (LSS) programs aim to minimise variance in organisational processes, deliver predictable financial outcomes, lower the expenses associated with poor quality, enhance bottom-line results, and provide value for both customers and shareholders. LSS efforts are an effective method of enhancing manufacturing quality. However, for over two decades, LSS has been used in organisations in Western countries. However, it has only begun to be used in Middle Eastern countries. Additionally, there is a dearth of empirical studies examining the current state of LSS in these nations.

Knowledge management is concerned with the collection, distribution, and responsiveness of information from the standpoint of a decision support system. Similarly, the importance of knowledge management has increased significantly in recent years, emerging as a significant source of competitive advantage for businesses. Little study has been conducted on implementing knowledge management and LSS concurrently. This study will examine the state of Lean Six Sigma (LSS) and knowledge management in Jordanian service organisations. Additionally, this dissertation will examine the value of knowledge management in ensuring the effective deployment of LSS in service companies. This research aims to develop a synergistic approach for integrating knowledge management and Lean Six Sigma tools through the DMAIC problem-solving method to strengthen and ensure the quality of services provided by Jordanian organisations, both public and private.

The study relied on the inferential (analytical) approach, which is concerned with procedures that infer the existence of findings in the statistical population through representative samples and, subsequently, the generation of quantitative data. The interpretation task primarily concerns inferential analysis (inferring and concluding). The regression analysis findings indicate that knowledge management contributes to the success of Lean Six Sigma projects. The implications of these findings for existing theory and managers of LSS and knowledge management projects were examined. This study offers value for academics and practitioners working in LSS in Jordan by conducting an in-depth examination of the present state of LSS deployment and knowledge management in the country.


**Keywords**: Lean Manufacturing, Six Sigma, Lean Six Sigma, Knowledge Management. The service sector, Jordan.

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**List of publication**

**A. Journal publications**

1- Aljazzazen, S. and Schmuck, R., 2022. Critical Success Factors for Successful Lean Six Sigma Implementation in the Service Organizations. CALITATEA / QUALITY: ACCES LA SUCCES / ACCESS TO SUCCESS 23 (188): 76 - 85.

2- Aljazzazen, S., & Balawi, A. (2022). Risk and Uncertainty in Consumer Decision-Making: An Overview of Principles and Perspectives. Modern Management Review, 27(1), 7-19.

3- Aljazzazen, S. and Schmuck, R., 2021. The Impact of Knowledge Management Practice on Lean Six Sigma Implementation: The Moderating Role of Human Capital in Health Service Organisations. *International Journal of Operations and Quantitative Management*, 27(3), p.267.

4- Aljazzazen, S. A. (2021). Entrepreneurial ecosystem of Luxembourg: Empirical insights into barriers and stimuli based on GEI data. *International Entrepreneurship Review*, *7*(2), 43-53.

5- Sahoum Ali Aljazzazen, Dojanah "Mohammad Kadri" Bader. (2020). Factors Affecting the Adoption of Electronic Payment Systems – Case Study E-Fawateercom System Users in Jordan. *International Journal of Advanced Science and Technology*, *29*(08), 2800 - 2815.

B. **Conference Publications**

1- Aljazzazen, S. (2021). Factors Affecting the Banks' Profitability in Jordan between 2015 and 2020. In Proceedings of FIKUSZ Symposium for Young Researchers (pp. 21-33). Óbuda University Keleti Károly Faculty of Economics.

2- AlJazzazen, S. A. (2019). New Product Pricing Strategy: Skimming Vs. Penetration. In *Proceedings of FIKUSZ Symposium for Young Researchers* (pp. 1-9). Óbuda University Keleti Károly Faculty of Economics.

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## List of Abbreviations

| | |
|---|---|
| ANOVA | Analysis of Variance |
| BB | Black Belt |
| BOA | Bank Of America |
| BPM | Business Process Management |
| BPR | Business Process Re-engineering |
| CEO | Chief Executive Officer |
| CI | Continuous improvement |
| CoP | Communities of Practice |
| CSFs | Critical success factors |
| CTQ | Critical To Quality |
| DMAIC | Define Measure Analyse Improve Control |
| DMADV | Define Measure Analyse Design Verify |
| DFSS | Design for Six Sigma |
| DOE | Design Of Experiments |
| DPMO | Defect Per Million Opportunity |
| FMEA | Failure Mode and Effect Analysis |
| GE | General Electric |
| GB | Green Belt |
| GM | General Manager |
| HEIs | Higher Education Institutions |
| HR | Human Resources |
| IT | Information Technology |
| JIT | Just In Time |
| KM | Knowledge Management |
| LM | Lean Manufacturing |
| LSS | Lean Six Sigma |
| LT | Lean Thinking |
| MBB | Master Black Belt |
| NGOs | None Government Organizations |
| PDCA | Plan-Do-Check-Act |
| QI | Quality Improvement |
| R&D | Research and development |
| RPN | Risk Priority Number |
| SCM | Supply Chain Management |
| SIPOC | Supplier-Input-Process-Output-Customer |
| SD | Standard deviation |
| SPC | Statistical Process Control |
| SMEs | Small and medium-sized enterprises |
| SPSS | Statistical Package for the Social Science |
| TPS | Toyota Production System |
| TQM | Total Quality Management |
| UK | United Kingdom |
| USA | United State of America |
| VOC | Voice Of Customer |
| VSM | Value Stream Mapping |

| | |
|---|---|
| WB | White Belt |
| WIP | Work In Progress |
| YB | Yellow Belt |
| 5S | Sort – Storage – Shine – Standardize - Sustain |

# CHAPTER ONE: Introduction

## 1.1 Introduction

In the current business environment, various companies and organisations strive to adopt comprehensive management methodologies to enhance their overall performance (Melton, 2005), satisfy their customers, decrease the processes' costs, and have a niche in the market (Tenera & Pinto, 2014). As quality improvement (QI) and continuous improvement (CI) are vital factors for success in manufacturing organisations, several contemporary service organisations (for instance, healthcare and financial organisations) implement QI or CI in their works (Antony et al., 2017). While techniques for business improvement come and go, boosting the bottom line never goes out of style. Business improvement methodologies have evolved last century (Snee, 2004a). Each approach builds on prior ways by incorporating the most valuable features of past approaches and supplementing them with new concepts, techniques, and instruments to overcome identified limits. Snee (2010) argues that development techniques are not fads but rather stages in the growth of business development methodology.

Many companies worldwide apply the Lean Six Sigma (LSS) methodology to reduce product or service defects and eliminate waste in the process (Alhuraish et al., 2017). Lean Six Sigma initially emerged from Lean Manufacturing and Six Sigma methodologies. Integrating both methods compensates for each method's limitations (Arnheiter & Maleyeff, 2005). By implementing LSS, the organisation gains many advantages, including competitive advantages and improving financial and operational performance (Alhuraish et al., 2017). However, many service organisations faced challenges while implementing LSS, and maybe they did not know how to implement LSS successfully (Kalashnikov et al., 2017). Top management commitment, appropriate skills and training (Montgomery, 2016), excellent communication, and evolving employees in the LSS implementation (Antony et al., 2017) are primary factors out of several factors essential to implementing LSS successfully.

Lean manufacturing and Six Sigma are required methods in the present-day business environment to ensure that today's business/organisation has a competitive advantage. A competitive advantage is achieved by maintaining the practice of sustainable development strategies (Pfeffer, 2010). Whether used in conjunction or alone, Lean and Six Sigma are strategies for optimising processes that generate and deliver high-quality services and products (Nave, 2002). Any reference in modern business to the quality of services and goods reflects how companies prioritise production and outcomes. Six Sigma and Lean are two of the most common approaches corporations use to effectively enhance service and product operations (Alhuraish et al., 2016a; Pacheco et al., 2015). Continuous efficiency and quality improvement of products and services are critical for meeting production targets (Indrawati & Ridwansyah, 2015). Numerous contemporary businesses are systematically using Lean and Six Sigma to reduce waste and increase efficiency (Alhuraish et al., 2015; Mousa, 2013; Tjahjono et al., 2010).

Lean thinking (LT) is based on the Toyota Production System (TPS). It is a concept that involves the determination of the value of any process through the distinction between value-added activities or steps from non-value-added activities or steps and the elimination of waste to add value to the whole process (Kovács et al., 2020). The Lean strategy provides established tools and techniques to reduce lead times, inventories, setup times, and downtimes for equipment, scrap, repair and other hidden plant waste (Molnár et al., 2019; Sharma, 2003). Lean focuses on efficiency to produce products and services as cheaply and quickly as possible (Antony, 2011).

An engineer named Bill Smith developed Six Sigma at Motorola in the mid-1980s. Six Sigma is a process improvement methodology that focuses on identifying and eliminating the sources of faults and mistakes by concentrating on essential process outputs from the customer's perspective. Six Sigma concepts may improve a mean process, develop resilient products and processes, and eliminate excessive process variation that results in poor quality (Shah et al., 2008). Six Sigma is a statistically based problem-solving approach that generates data to drive solutions and produces remarkable ultimate outcomes (Snee & Hoerl, 2007).

Over the last two decades, Lean Six Sigma (LSS) has evolved into one of the most frequently utilized and verified techniques for business process improvement ever experienced by enterprises (Antony et al., 2017). Since then, the popularity and implementation of LSS in the industrial sector have risen significantly (Shahin & Alinavaz, 2008), Especially prevalent among big western organizations such as Motorola, Honeywell, and General Electric (Laureani & Antony, 2012). Snee (2010) defines LSS as a business strategy and methodology that improves process performance, leading to increased customer satisfaction and bottom-line results. The LSS technique increases an organisation's capabilities, lowers production costs (M. Chen & Lyu, 2009), and maximises shareholder value (Laureani & Antony, 2012).

Knowledge is a blend of information and practice. Knowledge is one of the organisation’s crucial resources and primary assets (Grant, 1996). Knowledge has value once employed practically; otherwise, it is useless to organise data. Effective Knowledge management (KM) is required to achieve the necessary results (Essawi & Tilchin, 2013). Knowledge management aims to provide the right people with exact knowledge at the right time (O’Dell & Hubert, 2011a). KM is the process of creating, distributing, sharing, and saving staff knowledge (Dalkir, 2005). Consequently, one of the KM objectives is to take advantage of the expertise and old employees' experiences by storing it and educating new employees.

This research aims to investigate knowledge management's role in successfully implementing Lean Six Sigma in the service sector by integrating KM with LSS. This dissertation relied on the qualitative method to illuminate, present, and discuss the theoretical background of this research (Lean Manufacturing, Six Sigma, Lean Six Sigma, and Knowledge management). Moreover, the quantitative method was employed to achieve this research's objectives by examining the level of applied LSS and KM in the service sector.

### 1.2 Problem statement

The current era's main features are high-intensity competition and the service provided at pace. Consequently, excellent customer services require organisations to eliminate defects in the service provided to the customers. At the same time, the company endeavours to maximise profit through these services. Consequently, high resource utilisation, continuous improvement, and reducing the waste of the process as much as possible should be considered to achieve the company’s goals. As a result, companies are forced to adopt quality management methods

In the last two decades, Lean Six Sigma (LSS) methodology has been embraced by various service organisations in the different services sector to enhance the performance of their services by eliminating the defect in the services and reducing waste. Although LSS is a helpful quality and management methodology, not all organisations successfully benefit from applying Lean Six Sigma (Glasgow et al., 2010; Kumar & Antony, 2008). Lack of proper skills and training- which are parts of knowledge- and lack of top management support are the main factors that cause the failure of implementation of LSS (Montgomery, 2016).

### 1.3 Research aims and objectives

This research aims to assess the level of Lean Six Sigma adopted by the service organisations and the level of knowledge management employed by the organisations concurrent with Lean Six Sigma. Investigating the interaction between Lean Six Sigma and the Knowledge management phenomenon is one of this research aims. Therefore, the services organisations can fill the gap in using LSS, enhance the services provided to their customers, and improve the process within the organisation.

The research objectives below emerged Based on the research aims:

1- Evaluate the current level of Lean Six Sigma adopted by the services organisations in Jordan.
2- Evaluate the current level of Knowledge management technique adopted by the services organisation.
3- Investigate the significant association of KM with the implementation of LSS by integrating the LSS approach with KM In order to provide industry-related recommendations finally

### 1.4 Research questions

This research will try to answer the following questions based on the research objective.

1- What is the current level of LSS adoption in the services organization in Jordan?
2- What is the current level of KM concept adoption in the services organization in Jordan?
3- What are the obstacles and failure factors facing the Jordanian services organization during the implementation of LSS?
4- Is there a significant role of the KM in the success of LSS in the services organization in Jordan?

### 1.5 Research model

Figure 1 depicts the research problem, objectives, questions, and the projected relationship between the study variables. The created knowledge should be identified in every step of DMAIC (i.e. Define, Measure, Analyze, Improve, Control) and stored while the breakthrough is performed. The identified knowledge should be adequately managed through the four steps of the KM procedure in every phase of DMAIC, and available required knowledge should be reused immediately to enhance the service performance. In each step of the DMAIC phases, several tools may be used. The hypotheses have been built between KM management as one element and each phase of DMAIC.

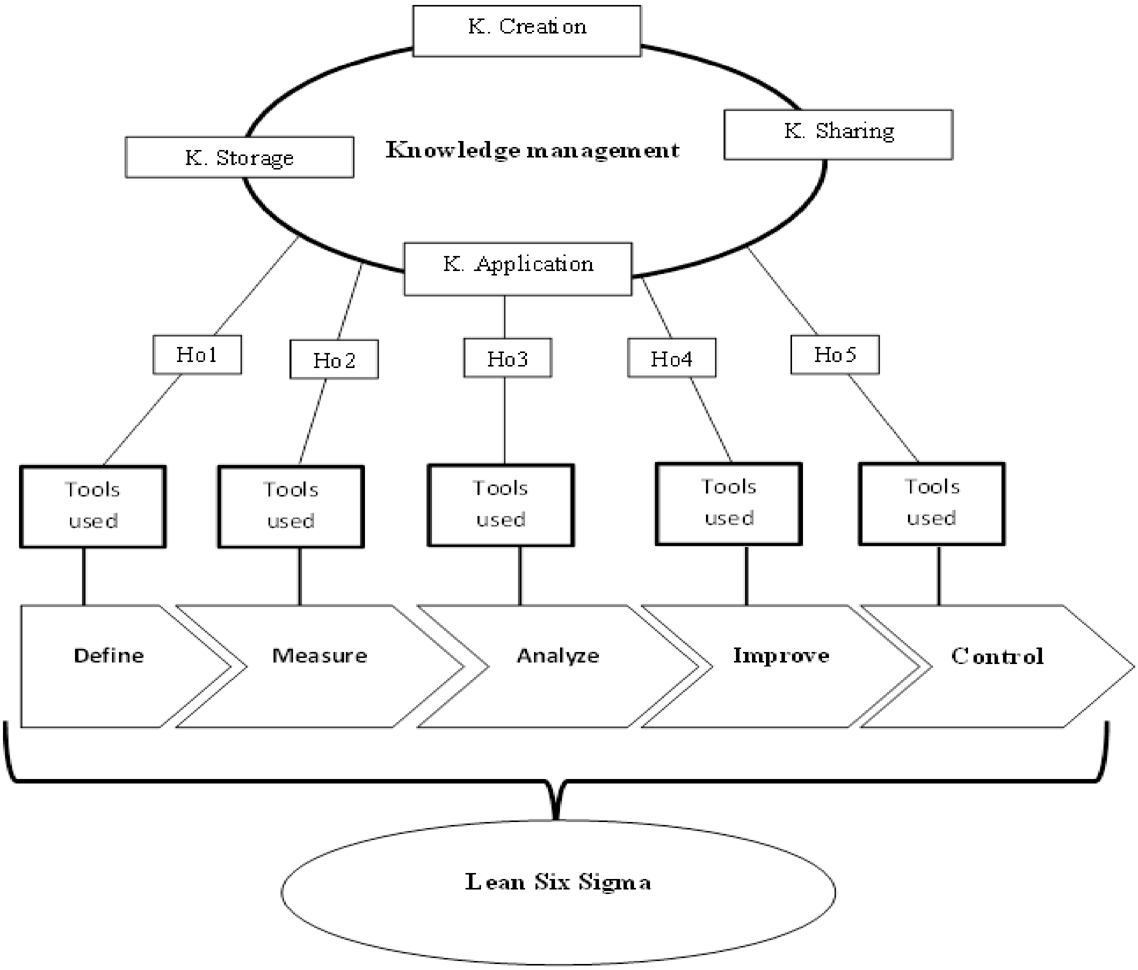


**Figure 1.** The conceptual framework

According to the conceptual framework, the five phases of the LSS are as follows: define, measure, analyze, improve, and control. The following conceptual and procedural definitions were established for each phase (more details are provided in chapter 2):

- Define: Specify the problem, the customer set, the desired outcomes, and the target process.
- Measure: Identify the parameters that need to be quantified, choose the optimal method for measuring them, gather the necessary data, and conduct the measurements experimentally.
- Analyze: Identify gaps between actual and desired performance, analyze their reasons, understand how inputs affect outputs, and rate improvement prospects.
- Improve, determine which options are the simplest to execute, evaluate hypothetical solutions, and implement genuine changes.
- Control: Develop a thorough solution monitoring strategy, watch implemented changes for success, regularly update plan records, and maintain a functional staff training routine.

### 1.6 Research Hypotheses

Based on the research problem, objectives, questions, the theoretical models of Knowledge Management and Lean Six Sigma, the experimental evidence examined in the literature review provided the framework for the following research hypotheses:

**HO 1: There is a significant relationship at the level of ($\alpha = 0.05$) between knowledge management practice, and LSS define phase.**

**HO 2: There is a significant relationship at the level of ($\alpha = 0.05$) between knowledge management practice and the LSS measure phase.**

**HO 3: There is a significant relationship at the level of ($\alpha = 0.05$) between knowledge management practice and the LSS analysis phase.**

**HO 4: There is a significant relationship at the level of ($\alpha = 0.05$) between knowledge management practice and the LSS improvement phase.**

**HO 5: There is a significant relationship at the level of ($\alpha = 0.05$) between knowledge management practice and the LSS control phase.**

### 1.7 Research Contribution and Novelty

The novelty of this research presents focusing on one of the modern critical improvement methodologies Lean Six Sigma (LSS), and its integration with one of the success factors in the organization (Knowledge Management). Integrating the two methodologies mentioned above for the services sectors is considered the primary outcome of this research. Moreover, the importance of this research is in the potential contribution to practitioners and academics.

The importance of the study lies in the following point:

1- The novelty of Lean Six Sigma in the service sector. Where there is a paucity of studies examined in determining the impact of Critical Success Factors for applying Lean Six Sigma methodology.
2- The importance of the quality of services provided by the organisation. Therefore, the high competition between the organisation and companies in the services sector.
3- The outputs of services provided by the organisation constitute inputs for many operations in local and external departments and institutions.
4- Provide results and recommendations for individuals and researchers interested in Lean Six Sigma implementation. Critical impact on the success of its objectives.
5- Linking the results of the current study with the results of the other studies related to the same subject, thus, interpreting the result to arrive at an accurate description of the exact phenomenon or problem and presenting the results.

### 1.8 Methodology and Data Source

This study used quantitative and descriptive approaches to determine the statistical parameters of the model and the Hypothesis. The qualitative method has been employed to analyse the literature review of Lean Six Sigma and Knowledge Management, formulate the proposed model (LSS-KM), and structure the research questionnaire. Moreover, using previously mentioned methodologies gives a clear image of the Lean Six Sigma and KM phenomenon that the researcher desires to collect data about and describe characteristics of the population or phenomenon.

The researcher relied on secondary data to reach and analyse a wide range of literature reviews related to Lean Six Sigma and the Knowledge Management phenomenon. Moreover, Primary data have been applied for this research purpose. An appropriate sample has been reached by developing a questionnaire based on a literature review to collect primary data. In this research, the electronic way through google documents and email has been applied.

The target population of this research was the services organisations in the diverse services sector in Jordan, either in the public or private sector, which applied - full or partial- Lean Six Sigma and Knowledge Management in their works. For instance, health, telecommunication, and financial sectors. Before distributing questionnaires, a comprehensive range survey was conducted to determine the target population precisely.

### 1.9 Research context

Service excellence is not a catchphrase but a long-term commitment to satisfying the customers' ever-increasing demands and desires. It is the duty of the organisation's administration and employees  (Alolayyan et al., 2018). In Jordan, Few pieces of research deal with improving quality in various sectors, including financial and bank sectors (Ali & Omar, 2016; Mualla, 2011), accommodations and hotels sector (Al-Rousan & Mohamed, 2010), and telecommunications (AL-Nawafleh et al., 2019). It is noticeable that the health sector is the most concerned with the quality of services provided (Al-Mhasnah et al., 2018; Mandahawi et al., 2011). However, the research on the LSS methodology in Jordan is very limited (Al-Refaie & Hanayneh, 2014; Alomari et al., 2020).  Therefore, the lacking of research tackled with LSS motivates the researcher to conduct this study. Furthermore, the researcher is looking to increase their knowledge about LSS and its implementation’s success factors.

Improving the quality of services in Jordan, whether for the public or private sector, has received governmental attention and support. The King Abdullah II Award for Excellence for Private Sector (KAAEPS) was created in 1999 to serve as the country's highest quality and excellence recognition criteria. Its mission is to strengthen Jordanian firms' competitiveness by encouraging quality awareness and performance excellence (Samawi et al., 2018). Moreover, an E-government program is considered the interaction of the government with citizens, the public and private sectors using communication technology to offer services effectively and efficiently and communicate with all stakeholders interactively Chen et al., 2018).

### 1.10 Dissertation structure

This dissertation is divided into five chapters, described as follows:

**Chapter 1 Overview and structure of the study**

The first chapter gives the reader an overview of the research context, aims, and objectives. Furthermore, this chapter describes the issues to be solved and the methodologies to be used

**Chapter 2 Lean Six Sigma and Knowledge Management literature study**

This chapter reviews the most authoritative literature on LSS (such as the approaches to LSS and its development and background). It also provides a theoretical background to the research about knowledge management and its role in implementing LSS.

**Chapter 3 Research Methodology**

This chapter reports the methodology used to address the objectives of the research and research questions. Moreover, this chapter describes the data collection process and data analysis methods.

**Chapter 4 Data analysis and interpretation**

We argue that development techniques are not fads but rather stages in the growth of business development methodology. This chapter analyses the empirical research design and methodology discussed.

**Chapter 5 Discussion, conclusions and recommendations.**

Chapter five discusses the key findings of the research hypotheses based on the literature study and data analysis. Moreover, this chapter gives some conclusions by discussing the research outcome and its contribution to the field of knowledge. Furthermore, the research limitations are addressed, and suggestions for future work and a summary for reflection are provided.

## 1.11 Chapter Summary

This dissertation investigates the link between Knowledge management and Lean Six Sigma in the service sector. Moreover, This chapter addressed the theme development, the importance of the research, the problem statement, the objective, the questions, the methodology, and the study's hypotheses. In addition, the study examines the extent of LSS and KM implementation in Jordanian service organizations, both public and private.

# CHAPTER TWO: Literature review

## 2.1 Introduction

The previous chapter gives an overview of the research study. It provides context and history for the identified problem, summarizes the study's aims, includes some basic definitions and delimitations, and emphasizes its significance. This part of the dissertation reviews a wide range of literature associated with Lean Six Sigma, including Lean Manufacturing and Six Sigma, tools used within implementing LSS, and Knowledge Management.

## 2.2 Lean Six Sigma

### 2.2.1 Lean Manufacturing

The Lean Manufacturing (LM) concepts have been extensively documented (Womack & Jones, 1997; Womak et al., 1990) and are frequently cited, as evidenced by the Toyota Production System (TPS) (Liker, 2001). LM is an improvement methodology developed by Toyota's manager, Taiichi Ohno and his associates after the Second World War. Originating Lean manufacturing aimed to help Toyota survive, especially since the War imposed constraints on resources and capital (Kurdve et al., 2014). Through producing high-quality products at a low-cost relative to the rivals. The way to achieve the target is to eliminate non-value-adding processes or activities (Abolhassani et al., 2016).

Many Lean companies are TPS-based (Womack et al., 2007). Unsurprisingly, the TPS is rooted in the development of Henry Ford's assembly line and the work of Frederick Taylor (Womack & Jones, 2003). This approach towards producing motor cars, which emphasized removing all types of waste, including human movement, began to take shape in Toyota in the 1930s and has since evolved. The first use of "Lean manufacturing" was generally recognized (Krafcik, 1988). Lean manufacturing combines the five pillars of Toyota's production philosophy — product development, supplier management, customer management, and policy focusing — into one statement (Holweg, 2007). As the cornerstone of the Lean vision, the aim of eliminating all waste, or Muda, in all aspects of the system persists (Womack & Jones, 1997). There is considerable misunderstanding about the difference between Lean and the Toyota Production System (TPS) (Michael, 2003). Lean is a knowledge-based approach to reducing waste and improving productivity (Snee & Hoerl, 2007).

The Lean method incorporates time-tested tools and procedures for reducing lead times, inventory, setup times, equipment downtime, scrap, rework, and other hidden manufacturing inefficiencies (Albliwi et al., 2015; Antony et al., 2017). Implementing LM depends on the degree of commitment of decision-makers in the organization (Antony et al., 2017) and the commitment of the involved employees in implementing LM (Mancosu et al., 2018). Organizations that apply LM in their works significantly increase analytical performance (Kovács et al., 2020; Shah & Ward, 2003) and maximize customer satisfaction (Erdil et al., 2018). Nevertheless, the researcher noted that LM is insufficient to solve complicated problems requiring sophisticated data analysis (Antony et al., 2017).

Lean is a technique for providing services to clients with fewer resources but increasing their value. The Lean concept is relevant to both manufacturing and service businesses. It is not a tactical or cost-cutting initiative but a style of thinking and behaving. Waste is described as everything that does not add value to the final product or exceeds the minimum amount of equipment, materials, parts, space, and time required to increase the product's value (Modi & Doyle, 2012). Historically, seven categories of waste have been identified: excess production, mistakes, needless inventory, excessive processing, excessive transport, waiting, and extreme motion (Hauck et al., 2021; Womack & Jones, 1997).

LM is concerned with identifying the customer's desired outcome, eliminating all activity within the production process that does not contribute to this outcome, streamlining the remaining steps, and finally matching all activity to deliver at the customer's desired speed. The procedure is viewed as never-ending because once completed, you return and seek to reduce the number and duration of phases (Chaplin & O’Rourke, 2014).

- **The limited success of Lean**

Lean should be used to catalyse continual improvement, not as a tool for cost reduction. A significant flaw of Lean was that when problems were perplexing and had nothing to do with any of the Lean principles, there appeared to be no visible way to address them using Lean thinking. For such challenges, a problem-solving method that makes substantial use of statistical data approaches – including experimental design – is unavoidably required (Antony et al., 2017). Management frequently prioritizes tools and processes above Lean as a concept, seeking to educate workers on new improvement tools instead of immersing them in the practical side of addressing improvement opportunities through a Lean approach (Pepper & Spedding, 2010).

- **Lean in Service Sectors**

Lean manufacturing ideas were initially applied to gigantic industrial processes with high volume and low variation. Japanese-managed plants consistently outperformed their equivalents in the United States (Pepper & Spedding, 2010). Later, US and European companies began to modify the TPS to remain competitive with the Japanese industry under the just-in-time (JIT) (Vörös & Rappai, 2016; Womak et al., 1990).

According to Allway & Corbett (2002), The "Lean" method has acquired universal acceptance to enhance industrial businesses' operations and profitability. It applies to a wide variety of service-sector businesses. They provide a rigorous five-phase technique and explain how this procedure successfully enabled an insurance company to execute a Lean strategy. Arlbjørn et al. (2011) performed a case study on Lean methodologies in the municipal supply chain management of services (SCM). They investigated the Lean principles' acceptance in Danish communities. They developed a model that illustrates the situations in which Lean is most appropriate depending on the type of service supplied. According to the findings, Lean is mainly implemented using "toolbox Lean" approaches such as value stream mapping, kaizen, and information boards. Additionally, the findings suggest that the public sector may use the Lean mentality to be more effective at cost reduction and service improvement when the required assumptions for Lean adoption are in place.

Piercy & Rich (2009) analyse the adaptation of Lean manufacturing principles to the pure service setting and assess their contribution to service marketing development. They discover that service contact centres may reduce operating costs by implementing Lean service technologies while improving the quality of customer service. Qian (2014) offered a market-based model for collaborative decision-making on pricing, delivery time, service level, and supplier selection. He argues that a firm's operation and market features must be complementary to maximize profitability. Additionally, he says that the supplier's operating features should match the market's characteristics. Furthermore, market conditions should dictate how Lean manufacturing and flexible or agile manufacturing ideas should be blended.

### 2.2.2 Wastes

LM concept systematically eliminates all forms of waste after distinguishing value-added steps from non-value-added steps (Antony et al., 2017). As outlined in Figure 2 and further detailed in Table 3, the most popular forms of waste are inventory, over-processing, motion, defects, waiting, rework, and overproduction (Erdil et al., 2018; Hauck et al., 2021; Mancosu et al., 2018). Another form of waste added lately, Skills waste, which means when the organization does not fully utilize the knowledge and capabilities of talented and expert employees. These wastes directly affect performance, quality, and costs, and they are all non-value-adding operations that customers are unwilling to pay for (Cherrafi et al., 2016). LM aims to produce products and services at the lowest cost and reduce the delivery time (Antony, 2011).


**Figure 2. The seven waste forms**

At times, waste, such as financial controls, is an integral part of a process that adds value to the organization and cannot be removed. The Lean concept is based on continuous improvement. At first, waste in all procedures may be easily identified, and early adjustments might result in considerable cost savings. As the company strives to eliminate waste, the waste reduction process will be slow. The critical step is to identify it, i.e., to guarantee that the trustworthy source of waste is eradicated, not simply the symptom (Albliwi et al., 2015).

The primary objective of a Lean system is to provide higher-quality products or services at the lowest possible cost and in the shortest possible time by reducing waste (Cherrafi et al., 2016). Waste is described in the Lean context as "anything other than the bare minimum quantity of equipment, materials, parts, space, and time required to add value to the result" (Cherrafi et al., 2016). The first step toward implementing Lean is to recognize value-added and non-value-added operations. This goal prompted the development of value stream mapping (VSM) (Rother & Shook, 2003), and it remains a dependable qualitative analytical tool to this day (if implemented correctly). Additionally, it establishes the project's scope by specifying its current condition and planned future state. This future state map is then utilized to build Lean improvement initiatives, such as contemporary work and staff flexibility through multi-skilling (requiring minimal expenditure) (Pepper & Spedding, 2010).

According to Womack & Jones (2003), all processes associated with designing, ordering, and manufacturing a product can be classified into three categories: (1) operations that add value to the customer, (2) operations that add no value but are required by the current product development, order fulfilment, or production systems and thus cannot be eliminated immediately, and (3) actions that add no value to the customer and can be eliminated accordingly. These non-value-creating activities are referred to as Muda. Type I Muda is waste required for the existing system to function correctly. Type II Muda has no additional value and should be deleted first. In manufacturing, waste manifests in the form of rectified errors, the production of items no one wants, the performance of unnecessary process steps, the movement of employees and goods between locations for no reason, and the waiting of people in a downstream activity due to an upstream activity failing to deliver on time (Womack & Jones, 2003). Ohno (1988) classified waste into seven categories, which were later confirmed by Womak et al. (1990):

Overproduction: happens when operations extend past the point of no return. Increased inventory occurs as a result of overproduction (Hauck & Vörös, 2015).

Waiting: This is also known as queuing and occurs when an upstream operation fails to provide its output on time (Molnar, 2020).

Transport: is the inefficient movement or movement of items, such as work-in-progress (WIP), from one location to another. Transportation should be minimized because it adds time to the process with no value added. Additionally, damage can occur during transport.

Over-processing: different processes such as rework, handling, or storage caused by defects, overproduction, or surplus inventory.

Inventory: all inventory not required to fulfil customer orders is considered waste. Inventory management necessitates more handling and storage space (Hauck & Vörös, 2015)**.**

Motion: is a term that refers to the additional steps required to accommodate an inefficient layout, defects, reprocessing, overproduction, or surplus inventory.

Defects: goods or services that do not meet the specifications or expectations of the consumer, resulting in dissatisfaction.

Unused human potential is a significant source of waste that was omitted from the original Seven Deadly Wastes. The unrealized potential is frequently the outcome of management rules and styles that discourage employee contribution (Freitag & de Oliveira, 2021; Yeh et al., 2021). Underutilizing people's mental, creative, and physical talents results in missed opportunities, including decreased motivation, decreased creativity and lost ideas.

Molnár et al. (2019) defined lead time as the time required to supply a service or a product following the receipt of an order. Any action that provides value from the customer's perspective is called "value-added" work. Whereas any activity that adds no value or the client would prefer a supplier that does not incur these costs is referred to as "non-value-added" work (or categorized simply as waste). Different types of waste exist in a non-production environment that is comparable to those found in a production environment with a few exceptions Table (1): overproduction (performing work before it is required), waiting time (for information/approval), motion (movement of people/paper), transport (movement of work), inventory (outdated stock, supplies), defects (time spent correcting defects), and underutilization (under-utilized people/skills) (Bicheno & Holweg, 2009).

**Table 1. Wastes Produced by Manufacturing and Service Industries**

| Seven types of waste in manufacturing | Seven types of waste in services |
|---|---|
| Overproduction of goods that are not in high demand | Duplication, such as re-entering data or repeating information on forms. |
| Time waiting for the next process step, machine, or comparable item (Molnar, 2020) | Delay in the delivery of services to customers |
| Transportation of non-essential products | Customers need to travel unnecessary distances to |

| | |
|---|---|
| | get service |
| The processing itself, such as production line inspections | The processing itself, such as internal quality inspections |
| Stock on hand (inventory) that is merely awaiting additional/future requirements | Inventory that is incorrectly stocked and so unable to deliver |
| Unnecessary worker movement occurs when it does not add value to the product. | Movement in transferring orders, queuing consumers multiple times, and similar activities. |
| Producing defective products that are unable to be sold or must be reworked | Service transaction error, including product damage in a product-service package |

Source: Bicheno & Holweg ( 2009)

### 2.2.3 Six Sigma

The first introduction of Six Sigma was by Motorola company in the mid-1980s, aiming to enhance production performance (de Freitas et al., 2017). Later many companies followed Motorola in applying Six Sigma, such as General Electric (Mancosu et al., 2018). Since the dissemination of Six Sigma, many studies have dealt with Six Sigma (Antony et al., 2007; Breyfogle III, 2003). Much literature has explained and used the term 'Six Sigma' differently. While some literature considers Six Sigma as an improvement approach (Antony et al., 2017; Nunes, 2015), others see it as a statistical measurement tool (Klefsjo et al., 2006; Snee & Hoerl, 2007), and others consider it as a Business Strategy (Harry & Schroeder, 2005).

The ultimate goal of applying Six Sigma is to enhance the firm's finances and cost improvements (de Freitas et al., 2017). Six Sigma focus on analyzing data to reduce the variation in the process, which leads to poor quality (Erdil et al., 2018) and eliminating the defect sources (Nunes, 2015). As with other methodologies and improvement approaches, several factors play a crucial role in the success of Six Sigma implementation, such as sufficient training and top-qualified management support.

- **Origin of Six Sigma**

Six Sigma is a project-driven management style that continuously improves an organization’s products, services, and processes through defect reduction. It is a corporate approach to enhance client needs comprehension, company systems, productivity, and financial performance. Six Sigma was inspired by Japanese quality work and Joseph Juran's concepts, such as the project-by-project method and capacity indexes (De Feo, 2017). Since the mid-1980s, Six Sigma approaches have enabled several firms to maintain their competitive advantage by merging process expertise with statistics, engineering, and project management (Anbari, 2002). Numerous publications and articles overview the Six Sigma method's fundamental ideas and advantages (Harry & Schroeder, 2005). The difficulties and realities inherent in adopting the Six Sigma process are considerable. However, the benefits of applying the Six Sigma technique to technology-driven, project-driven enterprises are just as significant (Kwak & Anbari, 2006).

The term "Sigma "originally referred to the Latin letter (σ), which indicates the statistical calculation of the standard deviations (SD). Six Sigma statistically implies that the opportunity or the probability of defective products is less than 3.4 per million or the quality percentage is more than 99.9997% (Youssouf et al., 2014). Therefore, the Six Sigma methodology aims to decrease the SD value and occur within the Six Sigma area (Mancosu et al., 2018).

Six Sigma significantly influenced the bottom line in manufacturing, design, finance, and healthcare, among other fields (Antony et al., 2017). Motorola cut its low-quality expenses and variability in various operations by implementing Six Sigma. Motorola was the first recipient of the USA Malcolm Baldrige National Quality Award in 1988 due to this achievement. Subsequently, several organisations, including General Electric, Allied Signals, Ford, and Bombardier, have effectively implemented Six Sigma. For example, Kwak & Anbari (2006) have shown Six Sigma's benefits and economic effects. However, others dispute the financial advantage of Six Sigma's current implementation (De Mast, 2006).

In the late 1990s and early 2000s, many firms across various sectors implemented Six Sigma programs, including DuPont, Dow Chemical, 3M, Ford, and American Express. The US military also initiated significant efforts in Six Sigma at this time. Overseas, businesses in Europe and Asia, notably Korean firms like Samsung, began using Six Sigma to varied degrees ( Snee & Hoerl, 2004).

- **Core Six Sigma principles**

"Six Sigma" refers to a statistical measurement of a system's defect rate. It provides a planned and methodical approach to process improvement, aiming for a defect rate of 3.4 faults per million chances, or Six Sigma (Brady & Allen, 2006). Pande et al. (2000) present some interesting examples of the difference between 99 per cent quality and the better rate of Six Sigma quality in various settings to clarify the implications of Six Sigma defect rates inside a system. For instance, if the post office maintained a 99 per cent quality rating, there would be 3,000 misdeliveries for every 300,000 letters sent. Still, if operated at the Six Sigma level, there would be only one misdelivery. If television stations functioned at 99 per cent efficiency, they would encounter around 1.68 hours of dead air time every week, compared to 1.8 seconds if they performed at Six Sigma standards (Pande et al., 2000).

Six Sigma is a quality-control method that strives for near-perfection. It employs a systematic approach to defect elimination across all processes. Six Sigma's primary objective is to maximise profit by eliminating unpredictability, faults, and waste that erode customer loyalty. Six -primary Sigma's principle is eliminating variability and making customer-focused, data-driven decisions. It uses statistical analysis to quantify and enhance an organization's operational performance. Six Sigma is inextricably linked to the process improvement approach that establishes the organizational framework necessary to facilitate continuous improvement (Harmon & Trends, 2010). Six Sigma representation enables us to ascertain the process's performance. Therefore, organizations must have a defect rate of no more than 3.4 faults per million chances (DPMO). Numerous businesses are required to follow Six Sigma principles; for instance, the aviation industry cannot have any additional flaws. Although achieving this standard is highly challenging in many sectors, it may nevertheless be utilized as a tool for defect reduction and variability reduction (Modi & Doyle, 2012).

When a process operates at a Six Sigma level, it is six standard deviations from the customer specification limits, implying an average of 3.4 errors per million items Table 2. As a result, this Six Sigma level represents a near-perfect quality level for the particular process.

**Table 2. Sigma Quality Measure.**

| Sigma Performance Level | Defects per Million Opportunities | Process Yield | Estimated Cost of Poor Quality (% Revenue) |
|---|---|---|---|
| 1.0σ | 670 000 | 33% | >40% |
| 2.0σ | 308 537 | 69.2% | 30-40% |
| 3.0σ | 66 807 | 93.32 | 20-30% |
| 4.0σ | 6 210 | 99.38% | 15-20% |
| 5.0σ | 233 | 99.9767% | 10-15% |

| | | | |
|---|---|---|---|
| 6.0σ | 3.4 | 99.99966% | <10% |

Source: (Wary & Hogan, 2002)

Six Sigma provides a structure for process improvement by outlining Deming's plan-do-check-act cycle in greater depth and directing the effort through a five-stage cycle of DMAIC (Andersson et al., 2006). Each stage is associated with a set of tools and techniques, such as statistical process control, design of experiments, and response surface methodology, which provide the user with a comprehensive toolbox of techniques for measuring, analysing, and improving critical processes necessary for bringing the system under control (Keller, 2011).

Most Six Sigma initiatives employ a process improvement technique known as DMAIC (Harmon & Trends, 2010). The phases identify the process's customer needs, quantify existing performance and compare it to the customer demand, assess the existing process, enhance the process's design and implementation, manage the outcome, and sustain the improved performance (Modi & Doyle, 2012).

By the turn of the twenty-first century, the Six Sigma technique had grown, and in addition to various new tools, the fundamental improvement process gained an extra phase called "define," renaming it DMAIC. Additionally, a new technique based on the fundamentals of Six Sigma was developed, Design for Six Sigma (DFSS). The distinction was that DFSS concentrated on new products and process design rather than process improvement. DFSS has a process that includes defining, measuring, analysing, designing, and verifying (DMADV) (Keller, 2011).

When a product or service is subject to significant design changes or is still in its early stages, the five phases become define, measure, analyze, design, and verify (DMADV) or design for Six Sigma (DFSS). DMADV's objective is to reach a Six Sigma level of quality from the start. Six Sigma methodology begins with determining the need for an improvement program (Salah & Rahim, 2019). DMAIC is a process improvement methodology used to enhance an existing business process. In comparison, DMADV is used to develop new products or processes, and consists of five phases define, measure, analyze, design, and verify. DMAIC and DMADV were created due to Deming (Madhani, 2018). The DMAIC process lifecycles are described in detail in another subchapter.

Training key employees is crucial for properly implementing the DMAIC cycle and achieving meaningful outcomes, as is top management buy-in if the program succeeds. Management must actively determine which projects to focus freshly trained Six Sigma teams on and ensure the necessary resources are accessible (Raisinghani et al., 2005). Before commencing the Six Sigma journey, the required roles for implementation must be clearly defined and communicated throughout the organisation so that everyone engaged understands their duties, precisely what needs to be done, and the sequence (Pande et al., 2000). It is critical to understand Six Sigma as a philosophy and a scientific technique that gains recognition (Keller, 2011).

- **Six Sigma implementation and use**

Six Sigma is a structured framework that uses improvement experts, a structured approach, and performance metrics to minimize variance in organizational processes to attain strategic objectives (Schroeder et al., 2009). Numerous world-class firms have effectively implemented Six Sigma in diverse situations and processes (Snee, 2004). According to Linderman et al. (2003), Six Sigma, on the other hand, lacks a theoretical foundation and a basis for research beyond "best practice" studies. Six Sigma's objectives are to optimize process performance and quality by identifying and eliminating underlying causes of faults and reducing process and product variability (Zu et al., 2008). The Six Sigma problem-solving method comprises five steps and is commonly used to accomplish organizational goals (Magnusson et al., 2003). Typically, after defining the problem in the Define phase, specific techniques are used to quantify the present condition of the problem, analyze it, and determine its leading causes. The reasons are eliminated, and the process is improved by adopting precise action plans. Finally, during the control phase, the obtained savings and Sigma level of Critical-To-Quality (CTQ) attributes are assessed and confirmed by the project's senior management sponsor (Cherrafi et al., 2016).

Notably, Six Sigma established an overarching "roadmap" or problem-solving method inside Motorola, dubbed MAIC, which stood for measuring, analysing, improving, and controlling. MAIC connected and integrated the separate instruments successfully. As a result, staff might be taught a single technique that could be applied to various challenges, avoiding the need to reinvent the wheel with each new project. Additionally, Six Sigma gained explicit management support, including infrastructures such as budget line items, resources, and project selection procedures (Antony et al., 2017).

Moreover, the success of Six Sigma depends on the specialists working on implementing the Six Sigma strategy. From a practical point of view, Six Sigma is usually divided based on the experience and their responsibility to "Belts." Master Black Belt (MBB) is responsible for strategic improvement. At the same time, other Black Belts (BB), Green Belts (GB), Yellow Belts (YB) and White Belts (WB) have different responsibilities based on their experience and their positions within the improvement process (Breyfogle, 2003).

Six Sigma implementation in R&D businesses aims to minimise costs, accelerate time to market, and optimise R&D processes. To determine the efficiency of six Sigma, firms should prioritise data-driven assessments, increased project success rates, and the integration of research and development into routine work processes.

Six Sigma may be regarded as a process-improvement approach that focuses on finding and removing the core causes of errors or defects in any process. This process is done by prioritizing the client's essential process outcomes and focussing on the inputs that affect those outputs. This external-in method assures that the benefits are felt in at least one of the following areas: lead time, product and process costs, process yields, and customer satisfaction (Antony, 2006).

- **Six-Sigma in Service Sector**

Motorola was under severe pressure from outside competition, notably Japan, in this environment. While there is no exact date for the birth of Six Sigma, Bill Smith and others launched improvement efforts in 1987 that resembled TQM programs in many aspects (Mikel et al., 2000). Mikel Harry and others eventually assisted Smith in developing this technique into a broader corporate campaign focused on safeguarding Motorola's pager business (Pande et al., 2000). They dubbed the program "Six Sigma" of their goal of reducing variation to the point that specification limits for critical process indicators were within six standard deviations of a target (Mikel et al., 2000). Welch & Byrne (2003) said to Wall Street analysts that Six Sigma would be GE's most extensive program and focus for the next five years. Even before data became available, GE stock increased substantially, and many other businesses started to examine Six Sigma more thoroughly.

Because GE had a sizable financial services sector – GE capital – it was natural for the corporation to apply the real gains in manufacturing to finance and other non-manufacturing areas. As a result, it established a "Commercial Quality" project and pioneered the application of Six Sigma to finance, healthcare, sales, and various other fields (Hoerl, 2001). As directed by CEO Jack Welch, the goal was to engage every GE employee in "the game" of concrete progress (Antony et al., 2017).

Other financial firms initiated Six Sigma projects partly due to GE Capital's success. Bank of America was one of the most successful, posting yearly savings in the billions of dollars. Similarly, Commonwealth Health Corporation pioneered the first large-scale Six Sigma implementation in healthcare in the late 1990s, generating millions of dollars in savings in the radiology department alone (Snee et al., 2004).

Motorola's then-CEO, Bob Galvin, established a target of tenfold improvement in all product and service attributes every two years. As a result of this initiative, aggressive process variation reduction began, and the process of improvement swiftly assumed the form of measure, analyse, improve, and control (MAIC). Motorola was rewarded for their efforts in 1988 with the Malcolm Baldridge National Quality Award (Gowen Iii et al., 2008).

Six Sigma is a very effective business method that may significantly reduce errors in service processes (Antony, 2006). Service industry improvement may be hastened by minimising process variance and non-value-added operations (Kwak & Anbari, 2006). Improved procedures can result in greater customer satisfaction, increased productivity, and business profitability, among other benefits. Six Sigma is particularly popular for various service operations because of its customer-driven methodology (Taghaboni-Dutta & Moreland, 2004). According to Pande et al.  (2000), most service-oriented businesses function at a low Sigma level, between 1.5 to 3.0. (i.e. defects of 45,000- 66,800 per million opportunities). This is due mainly to the service industry's inattention to quality improvement efforts (Does et al., 2002). Six Sigma has been effectively used for a wide variety of services. The Six Sigma approach has been applied by manufacturing organisations to their service operations. The six Sigma strategy's primary purpose should be to address the following four points: What is the nature of the process defect? How frequently do such faults occur? How does a problem affect the customer? How do we quantify these flaws and adopt solutions to avoid their recurrence? (Antony, 2006).

In recent years, finance and credit departments have been under increasing pressure to minimise cash collection cycle time and volatility in collection performance to remain competitive. Typical Six Sigma initiatives in financial organisations include increasing the accuracy of cash allocation. Therefore, minimise bank charges, automate payments, improve reporting accuracy, decreases documentation credit flaws, lower check collection defects, and minimises collector performance variance (Doran, 2003).

Bank of America (BOA) was one of the early adopters and implementers of Six Sigma techniques to streamline operations, attract and keep clients, and establish a competitive edge against credit unions. Hundreds of Six Sigma initiatives have been completed in cross-selling, deposits, and issue resolution. BOA reported an improvement of 10.4 per cent in customer satisfaction and a drop of 24 per cent in customer issues following the implementation of Six Sigma (Roberts, 2004). American Express used Six Sigma methods to optimise external vendor procedures and reduce credit card renewals that were not received. In each example, the findings indicated an increased Sigma level of 0.3. (Bott et al., 2000). Other financial firms, such as GE Capital, JP Morgan Chase, and SunTrust Banks, are utilising Six Sigma to concentrate on and increase consumer wants and happiness (Roberts, 2004).

Six Sigma concepts and the healthcare sector are a perfect combination, owing to the healthcare industry's zero-tolerance for errors and potential for medical error reduction. Several successful Six Sigma initiatives include enhancing timely and accurate claim reimbursement (Laureani et al., 2013), optimising the healthcare delivery process (Ettinger, 2001), and lowering surgical equipment inventory and associated expenses (Revere, 2003). Additionally, the University of Texas MD Anderson Cancer Center's radiology film collection used Six Sigma and significantly enhanced service activities (Benedetto, 2003). Further, at the same institution's outpatient CT test lab, patient preparation times were decreased from 45 minutes to less than 5 minutes in many cases, and exams increased by 45 per cent without adding machines or shifts (Elsberry, 2000).

In 2002, Bechtel Corporation, one of the world's leading engineering and construction firms, announced $200 million in savings from a $30 million investment in its Six Sigma program, which identifies and prevents rework and errors in everything from design to construction to on-time paycheck delivery (Eckhouse, 2003). For instance, Six Sigma was adopted to expedite neutralising chemical agents and optimising cost and schedule management on a nationwide telecommunications project (Moreton, 2003).

According to one poll, just 37% of respondents had formally applied Six Sigma concepts in their R&D company as of 2003 (Johnson & Swisher, 2003). Rajagopalan et al. (2004) claimed that through the DFSS process, the development and manufacture of the new prototype at W.R. Grace (Refining Industry) were reduced to 8–9 months from 11–12 months. Figure 3 illustrates the conceptual advantages and improvements associated with using Six Sigma in research and development initiatives (Kwak & Anbari, 2006).

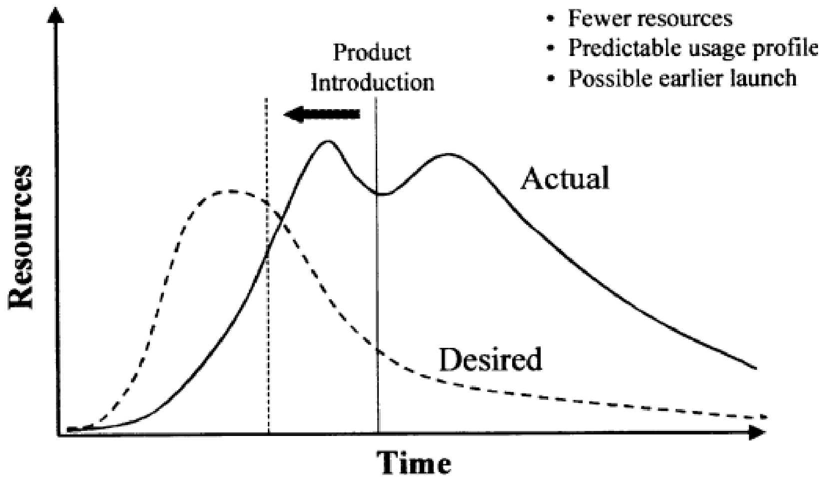


**Figure 3. The advantages of implementing six Sigma in R&D initiatives.**
Source : (Johnson & Swisher, 2003)

### 2.2.4 Lean Six Sigma Overview

The term Lean Six Sigma (LSS) has been defined by Pepper & Spedding (2010) as a systematic method to eliminate all forms of waste and offer products or services out of defects in 99.9997 %. Snee (2010) defined LSS as “a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom-line results.” Cournoyer et al. (2013), the LSS program is a customer-focused, systematic approach to utilising data to manage and improve process performance quality.

LSS emerged as a complementary approach to compensate for the limitation of Lean manufacturing and Six Sigma (Salah et al., 2010). Where Six Sigma focuses on the defect of the product or service only, Lean manufacturing focuses on eliminating the process's waste (Laureani et al., 2010). LSS integrates both systems to eliminate all forms of waste and, at the same time, provide products or services almost free of defects (Alhuraish et al., 2017; Tenera & Pinto, 2014). However, LM and Six Sigma have incredible results in continuous improvement (Salah et al., 2010). Research results show that the operational effectiveness and financial performance of companies that apply only LM or Six Sigma are less than those adopting LSS in their work (Alhuraish et al., 2016). Therefore, to decrease costs and increase satisfied customers, LSS considers a more practical approach because it involves humans in the process (Snee, 2010).

Initially, LSS used widely in the manufacturing and industrial worlds, such as Motorola, GE, and some SMEs (Nunes, 2015). LSS considered quite a modern approach; the first research article about coping with this methodology was published in 2003 (Albliwi et al., 2014). However, the LSS methodology is applicable in different areas within the organisation (Antony et al., 2012). It aims to improve performance in terms of the quality of the service or products, reduce the cost of the service or product, and increase customer satisfaction (Snee, 2010). Top management commitment and lack of appropriate training are part of several factors affecting the success of implementing the LSS (Montgomery, 2016).

In the services sector, organisations aim to implement LSS to increase the quality of the services provided to the customers by reducing the lead time, setup time, rework and other wastes based on the nature of the organisation (Womack & Jones, 2003). LSS rely on variant tools, such as Brainstorming, Cause-and-effect diagram, Control charts, and the structured approach DMAIC cycle (Nunes, 2015). Therefore, reducing variations and eliminating waste (Erdil et al., 2018) improves customer requirements, organisation productivity, and financial performance (Kwak & Anbari, 2006).

### 2.2.5 Integration of Six Sigma and Lean

In the late 1990s and early 2000s, the phrase "Lean Six Sigma" was used to refer to the synthesis of Lean and Six Sigma ideas (Byrne et al., 2007). This integration sought to address both of their weaknesses. By combining the two continuous improvement approaches, businesses could maximise their potential for improvement (Bhuiyan & Baghel, 2005). Lean Six Sigma is a corporate strategy and technique that improves process performance and increases customer satisfaction, leadership, and bottom-line benefits via quality, speed, and cost reduction (Snee, 2010). This is accomplished by applying Lean and Six Sigma technologies and practices. Lean Six Sigma's success as one of the most well-known hybrid continuous improvement techniques has prompted many businesses worldwide to embrace it to handle operational issues and increase competitiveness (Cherrafi et al., 2016).

Through the 1990s, manufacturing organisations began combining Lean and Six Sigma methodologies (Snee, 2010); there appeared to be a natural match between the two process-oriented approaches. Variability is a cause of waste inside a process; hence, Six Sigma can be considered a kind of Lean. The service industry gradually embraced the LSS approach, which was initially used in manufacturing. Today, LSS is regarded as the most widely used improvement methodology in the western business world (Pepper & Spedding, 2010), with applications ranging from the National Health Service in the United Kingdom (Westwood & Silvester, 2007) to insurance companies in the Netherlands (Pepper & Spedding, 2010). Despite the numerous enhancements to the idea and the abundance of training and consulting available to support the approach, it remains fundamentally a process-oriented, internally focused technique (Chaplin & O'Rourke, 2014). However, it is easy to see the benefits that organisations gained from this technique's usage through academia, including the extensive research on the implementation of the LSS methodology (Michael, 2003; Zhang & Chen, 2016) and proposing potential implementation models for successful projects (Snee, 2010; Sunder, 2016).

Six Sigma and Lean manufacturing have begun to be used internationally due to the spectacular results achieved by US or Japanese firms such as Motorola and Toyota (Andersson et al., 2006). As a result, Six Sigma and Lean manufacturing have emerged as the most widely utilised approaches for establishing and continuously improving business processes (Alhuraish et al., 2016). While their aims may differ, they can work together or individually to enhance corporate functions, service, and product quality. (Snee, 2010) demonstrates that the primary goals of Six Sigma and Lean are congruent, namely, to seek and improve processes. The confluence of Six Sigma and Lean objectives is illustrated in Figure 4. Thus, a business typically determines which processes require change and which approach suits this objective.

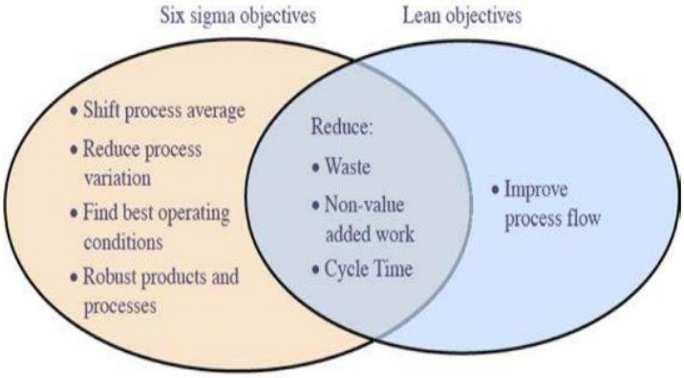


**Figure 4. comparison between Lean and Six Sigma.**
Source: Snee (2010)

LSS is a technique that focuses on reducing waste and variation, using the DMAIC framework to improve customer satisfaction in terms of quality, delivery, and cost. It focuses on the firm's process improvement, customer satisfaction, and financial results (Salah et al., 2010).

Businesses interested in integrating Lean and Six Sigma have ambiguity about which technique to use initially. According to Antony (2011), it is advisable to begin with, Lean. A 5S exercise is an excellent beginning point in this respect, as it may assist in setting up the workspace for the process to take form. Because Lean tools are less sophisticated than Six Sigma, it is more practical to begin with, the Lean approach to engage staff members early on while also delivering fast outcomes for the business. According to Nash et al. (2006), many enterprises have merged Lean and Six Sigma by initially deploying one technique. According to research, Six Sigma is often deployed efficiently only after a Lean manufacturing process has been established. In one instance, a corporation chose to use Six Sigma after implementing Lean manufacturing, which may help speed up the adoption of Six Sigma (Bożek & Hamrol, 2012).

Implementing Lean manufacturing or Six Sigma might be challenging. Researchers have advised implementing Lean manufacturing and Six Sigma concurrently since they complement one another; yet, this approach may overlook a business's existing resources. Numerous companies have encountered difficulties applying one of these techniques (Alhuraish et al., 2017). While both Six Sigma and Lean involve data and information, they differ in their concentration on implementing various principles based on experience and knowledge (Antony et al., 2017). Some organisations that employed Six Sigma before implementing Lean continue to refer to it as Six Sigma, while others refer to it as Six

Sigma Lean (Byrne et al., 2007). Additionally, some firms refer to it as LSS or Six Sigma Lean, depending on the methodology used to drive the program. Additionally, Honeywell refers to it as Six Sigma plus (Kovach et al., 2005).

Six Sigma is projected to grow and become more integrated with other approaches for continuous improvement. Antony (2004) believes that additional tools will be introduced to the Six Sigma package since the Six Sigma methodology must be improved to adapt to market changes. In terms of Lean, Hines et al. (2004) demonstrated that it is feasible to integrate Lean with other methodologies without jeopardising its goal of giving value to consumers. Numerous tools are interchangeable between Six Sigma and Lean (McAdam & Donegan, 2003), as seen in Figure 5. Although the tools used in Lean and Six Sigma were not designed specifically for these approaches, they were combined in an organised manner to create each. Thus, both may be viewed as toolboxes, with some tools being more appropriate than others depending on the problem's nature or opportunity. The LSS method enables individuals to select the proper tools for tackling specific issues immediately through Kaizen events or in-depth examination of more complicated initiatives (Salah & Rahim, 2019).

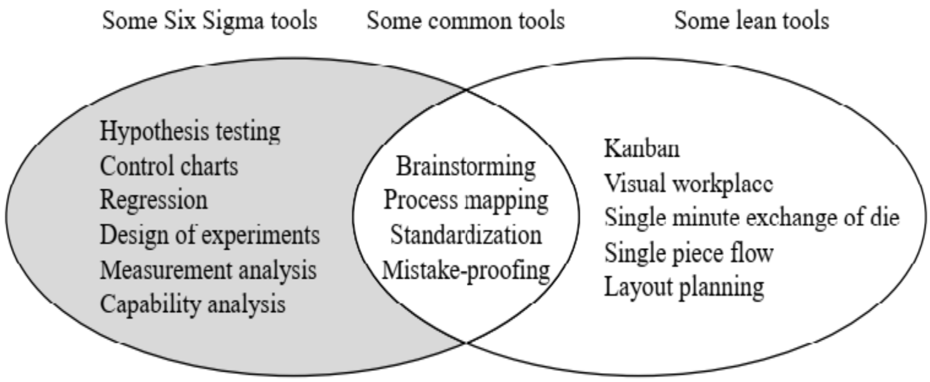


**Figure 5. An example of Lean and Six Sigma common tools**

Since both Six Sigma and Lean fundamentally integrate established techniques in unique ways to reach breakthrough outcomes. Neither Six Sigma nor Lean developed tools in and of themselves, so neither owns the copyright to any particular tool (Antony et al., 2017).

### 2.2.6 LSS Implementation

Although the hurdles to LSS implementation are diverse, one common denominator is that most of the difficulties highlighted are not connected to tool or technique application but to organisational concerns such as change resistance (Assarlind et al., 2013). Numerous articles have been published on the effectiveness of LSS deployment in various sectors (Psychogios et al., 2012).

The combination of Lean and Six Sigma attempts to enhance every aspect of an organisation. Whereas Six Sigma is applied by a small number of highly skilled employees inside an organisation, Lean empowers and educates everyone to identify and remove non-value-adding tasks (Higgins, 2005). The combination of the two approaches aims to empower employees throughout the higher-level process analysis phases, resulting in actual process ownership. If the two are executed in isolation, the conclusion may be that neither is carried out properly; they will be hampered by one another's organisational demands (Harrison, 2006). Again, this may result in the emergence of two distinct subcultures within the organisation, each fighting for the same resources (Smith, 2003).

Additionally, the organisation must decide how and when to use Six Sigma and/or Lean production. Without this, the organisation may not reap the benefits of Lean manufacturing and/or Six Sigma. Scientific research has demonstrated that businesses should employ integrated Lean manufacturing and the Six Sigma technique for best performance outcomes. There is a knowledge gap about this subject in the published literature. Simultaneously, because the two techniques are based on opposing beliefs, there is considerable controversy over whether they should be deployed concurrently or separately. The disagreement is primarily about whether methodology should be deployed first: Lean manufacturing or Six Sigma (Alhuraish et al., 2017).

When used as a stand-alone paradigm, the scope and magnitude of benefits produced via implementing Lean principles are constrained. According to Antony et al. (2003), this limit of improvement is achieved because the improvement technique depends on the problem being handled and must thus be aligned to generate successful outcomes. Antony et al. (2003) propose that Lean concepts lack a focused cultural infrastructure, as the Six Sigma method demonstrates. As a result, these activities must be guided by a solid methodology capable of sustaining the business's direction and concentration. Sharma (2003) argues that Six Sigma methodologies should be used to assist in implementing Lean efforts in an improvement initiative, as it can be challenging to establish momentum when attempting to extend the philosophy throughout the organisation or supply chain.

Regarding Lean and Six Sigma implementation, firms often choose one of six techniques. The first technique views Lean as an all-inclusive technique incorporating Six

Sigma as a tool. The second technique considers Six Sigma an all-inclusive approach that includes some Lean tools within the DMAIC structure. This is similar to the integration model given later but requires further explanation and makes holistic and comparable use of the two. The third technique, Six Sigma or Lean, is employed in isolation (to tackle different problems). The fourth technique operates both approaches in parallel (when applied to the same issue individually) and in series, whereas the fifth operates sequentially (when applied to the same problem). Finally, the sixth applies both concurrently, as outlined in this work's suggested and integrated strategy (Salah & Rahim, 2019).

Another strategy is implementing Lean first to remove waste and then Six Sigma to focus on specific process steps. The goal is to reduce waste and simplify procedures before moving on to more complex challenges via optimization and process control focused on specific process steps. According to Snee (2005), Lean techniques may be quite successful in the initial stages of process improvement. However, it is more beneficial to combine the two, as the core causes of issues happening inside or between processes may be located in areas other than where they manifested (Salah et al., 2010).

Figure 6 illustrates that each method benefits from being viewed as a unified framework and has the potential for balance if brought together successfully. This is a critical notion for integrating the two approaches to continuous improvement. Maintaining a balance between them is necessary to avoid becoming excessively Lean and stiff in reaction to the market, impairing value generation (Arnheiter & Maleyeff, 2005). On the other hand, focusing excessively on minimizing variation beyond the customer's expectations results in the waste of needless resources to achieve zero variation. The balance is between providing good value to the client to preserve market share and minimizing variance to acceptable levels to reduce expenses (Pepper & Spedding, 2010).

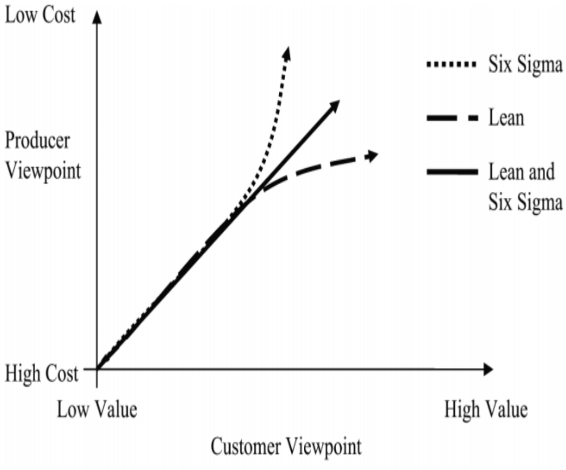


**Figure 6. The competitive advantage of Lean, Six Sigma and LSS.**
(Source: Arnheiter & Maleyeff, 2005).

Since both Six Sigma and Lean had remarkable achievements yet had constraints, some form of integration was tempting and made natural sense. As previously stated, Lean is unsuitable for tackling complicated problems requiring extensive data analysis and advanced statistical techniques. When deciding between a Six Sigma and a Lean method, the critical questions to examine are: Is the answer known or unknown? Is the fundamental cause of the problem regarded to be in a process step that adds value or in the connections between process steps that add value?

The first issue examines whether established concepts can be used immediately with considerable data collecting or whether a longer-term project comprising data collection and analysis cycles would be necessary. For instance, if the issue is that our inventory levels are excessive, the remedy is obvious - decrease inventory! While the specifics of doing this may be challenging, what must be done is well understood (Snee & Hoerl, 2007). In many Lean applications, we have discovered that the task is well-defined; a technique and tools are required to achieve the well-defined solution. Lean primarily collects well-established ideas rather than data analytic tools if the solution is entirely unknown. We are unsure how to get the required distribution. As a result, considerable data gathering, analysis, and design of experiments will almost certainly be required to tackle the issue. The requirement for a thorough diagnosis of the problem reaffirms the critical nature of the define step in problem solutions (Antony et al., 2017).

The second question demonstrates how Lean concepts are oriented around information and material flow through a process. Thus, if the underlying cause of the problem is a flow issue – in the connections between value-adding actions — Lean is likely to function well. On the other hand, understanding the cause-and-effect links is crucial for improvement if the problem originates in a value-adding stage. Typically, developing such insight takes substantial data collecting and analysis and experiment design. Six Sigma is more likely to be successful in resolving such issues. This idea is shown in Figure 7 (Snee & Hoerl, 2007).

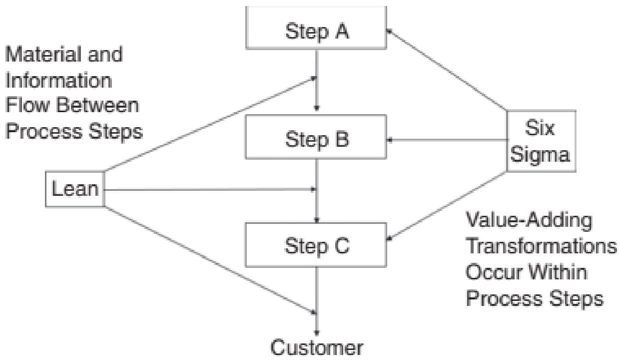


**Figure 7. Process view of Lean Six Sigma.**
Source: Snee & Hoerl (2007).

It is unclear which improvement approach should be started for several organisations, either Lean or Six Sigma, or both (Albliwi & Antony, 2013; Kumar et al., 2006). The primary objective is to produce concurrent, rapid, and visible operational improvements by implementing Lean and Six Sigma (Aboelmaged, 2010; Huang & Klassen, 2016).

### 2.2.7 Critical Success Factors

Lean Six Sigma's CSFs must be identified to understand how LSS can be implemented successfully. Brotherton & Shaw (1996) describe CSF as the key to identifying which sectors will generate the most significant and best competitive leverages for a company. They underline that the CSFs are not primary aims but are actions and processes that the management can control to achieve the organization's objectives. CSFs also be defined as "those few things that must go well to ensure success"(Boynton & Zmud, 1984). According to Griffin (1995), CSFs are a small set of criteria that must be met for an organization to compete successfully. CSFs are interdependent; each has short-term and long-term implications and requirements (Alnadi & McLaughlin, 2021). Accordingly, the organization's success and continuity depend on achieving the results related to these factors, and failure will lead to disastrous consequences for the entire organization

(Rockart, 1979). Besides, suppose one of the CSFs is missing during the LSS program development and implementation phases. The difference could be between a successful implementation and a lack of resources, effort, time, and money.

The key CSFs for continuous improvement initiatives are identified by Fryer et al. (2007) as being: management commitment, customer management, supplier management, quality information, measures and reporting, teamwork, communication, process management, ongoing assessment, monitoring and review, training and learning, employee empowerment, goal management culture, product design, and organization. Additional factors included recognition and compensation systems, effective use of technology, cultural change, confidence in and selection of projects, and priority. Generally, the above factors can apply equally to services as to production (Achanga et al., 2006; Chakrabarty & Tan, 2007). Regarding implementing the Lean management project, Panayiotou & Stergiou (2021) stress the importance of management commitment to support any desired initiatives to improve productivity, followed by financial capacity, competence, expertise, and a sustainable and proactive organizational culture.

Since this is one of the improvement methodologies, several researchers have studied the CSF of the Six Sigma implementation. Some of the most critical factors are Top-down top management commitment since it contributes in a short period to influence, restructure, and cultural change in employee attitudes towards quality; Six Sigma and project management extensive education and training: Change in organizational culture, structure, and change in channels and communications plans, motivate people to overcome resistance and train senior managers, staff, and customers on how Six Sigma benefits (Alnadi & McLaughlin, 2021; Brun, 2011; Näslund, 2008).

Service companies have many things in common with production organizations from an improvement point of view. Although service sector organizations constantly had a lower level (of practice) than manufacturing organizations, Badri et al. (1995) found that both organizations agreed on the importance of training, product design, supplier quality management, and employee relations. However, each firm, function, a business will withstand LSS's application. All processes do not perform correctly and can be improved with data collection, scientific thought, and LSS's concepts, methods, and tools. Nevertheless, Data collection is the problematic aspect of LSS's deployment. This is especially true when working on service processes where data collection is not cultural.

The project management review can overcome this by checking the data's correct use and providing resources for data collection, retrieval, and analysis (Oliver et al., 2019; Snee, 2010).

### 2.2.8 Lean and Six Sigma in the service organization

Although LSS was primarily created for the manufacturing sector, it is now frequently employed in the services sector. The LSS technique is applicable in various industries and contexts (Kalashnikov et al., 2017). To improve the quality of services supplied to customers, numerous European public organisations employ LSS in their work, even at an early stage (Antony et al., 2017). In service organizations, LSS focuses on eliminating wasted time during service processing and decreasing variance in how services are processed and given to clients, whether external or internal (Delgado et al., 2010). The findings indicate that the services sector emerged in second place regarding financial and operational performance when LSS was used (Alhuraish et al., 2016).

Studies demonstrate that only 50 % of the process in the services sector adds value from customers' perspectives (Michael, 2003). Customers could be external customers, for instance, patients in the hospital or clients of the bank, or internal customers if one service depends on another service from another department. By adopting the LSS process, performance and customer satisfaction will be increased, as LSS helps develop personality and leadership ability (Snee, 2010).

By their very nature, services are frequently time-bound regarding the activities carried out and deliver value to the consumer. In service businesses, Lean serves as a methodology for reducing waste (in terms of time) and increasing the efficiency of processes. It entails examining the process from the client's perspective to identify and reduce inefficiencies and waste. On the other hand, Six Sigma is concerned with improving the process and eliminating variability to get the same outcome at least 99.9997 per cent of the time (Six Sigma) (Delgado et al., 2010).

Lean Six Sigma tools are more difficult to apply in the service industry because of its unique characteristics, which can be summarized in the following main areas (Kotler & Turner, 1997; Zeithaml et al., 1985):

Intangibility: Service consumption and perception are possible but not easily and objectively quantifiable, as with manufacturing products. In service organizations, proxy metrics are used to compensate for the lack of objective metrics (e.g. customer survey). Six Sigma relies on objective measurement to eliminate defects and reduce variation.

Perishability: Services, on the other hand, cannot be stocked but are delivered in response to demand. There are many "work in progress" service processes, meaning work can spend more than 90% of its time waiting to be executed (Michael, 2003).

Inseparability: The service is delivered and consumed simultaneously. In contrast, manufacturing processes are not affected by this. A manufacturing process does not require the emotional management of customers waiting in line or on the phone.

Variability: Each service is a one-of-a-kind event dependent on various variables that cannot be replicated precisely. Therefore, services are more variable than manufacturing processes, resulting in a wide range of customer experiences.

These differences have made it more difficult for service organizations, such as financial companies, healthcare providers, retail, and hospitality organizations, to adopt Lean Six Sigma to their reality. Service organizations, on the other hand, offer great opportunities.

According to (Michael, 2003), Empirical evidence indicates that the cost of services is exaggerated by 30%–80% due to waste. Service functions have a limited history of making decisions based on data. Data retrieval is frequently challenging, and many vital decision-makers are not as 'numerically literate' as their industrial counterparts. Around 30%–50% of the cost of a service organization is due to expenditures associated with sluggish pace or repeating operations to fulfil client expectations. Although LSS has been used highly successfully in manufacturing, its application in the service sector has been less tried and tested due to concerns that service industry processes do not lend to the rigorous application of the Six Sigma set of statistical tools (Patton, 2005). There are three primary reasons services should use Lean Six Sigma: Service processes can be inefficient and costly, i.e. prone to mistakes, resulting in decreased customer satisfaction. Numerous service procedures are complicated and involve excessive "work-in-progress," resulting in increased wait times — a cost that adds no value. The Pareto principle holds for slow processes: 80% of delay is produced by 20% of activity. Thus, increasing the speed of that essential 20% results in an 80% reduction in cycle time (Michael, 2003).

The following subsections will review the literature on LSS implementation in some services sectors. The researcher settles for these sectors because implementing the LSS methodology is similar to other industries.

- **LSS in Higher Education**

Universities are complex organizations that use many resources and have various business procedures (Svensson et al., 2015). Instead of a single 'client,' higher education institutions (HEIs) have multiple stakeholders, including administrators, faculty, staff, students, alumni, benefactors, and taxpaying citizens. A public HEI's core aim often entails exploration, learning, and involvement through the generation, distribution, and application of new information (Li et al., 2019). To support these fundamental responsibilities, a range of supporting mechanisms are in place to ensure that the HEI's primary mission of research, education, and engagement is fulfilled (Svensson et al., 2015). Antony et al. (2012) noted that while LSS may be a very effective tool for identifying process inefficiencies, many universes and schools have not extensively embraced it due to the long-held notion that it is only appropriate for manufacturing organizations. Additionally, the decentralized character of conventional institutions and their lack of direct connections to the core business of research and instruction contribute to the HE industry's delayed adoption of LSS (Svensson et al., 2015).

The combination of declining public financing (Gordon & Fischer, 2011) and the influence of global competitiveness (Hess & Siciliano, 2007) has resulted in an increased emphasis on efficiency and effectiveness within the HEI sector. Historically, regarding quality initiatives on the HEIs, the USA focused on TQM as CI methodologies (Bandyopadhyay & Lichtman, 2007). However, LSS has emerged in recent years to provide organizations with the methods, tools, and techniques for superior improvement (Antony, 2017).

Higher education institutions are increasingly using Lean Six Sigma (LSS). Whereas previous research examined applying Lean wastes to HEIs, this study focused on sorting, straightening, shining, standardizing, and sustaining, as well as point-of-use storage, process mapping, value-stream mapping, and level scheduling (Douglas et al., 2015). Adina-Petruţa & Roxana (2014) incorporated Six Sigma and quality management principles. Bandyopadhyay (2014) facilitated the advancement of online education. Whereas (Tetteh, 2015) used LSS to examine the pedagogy and professional growth. Other research examined case studies at higher education institutions, such as the adoption of LSS at the King Abdullah University of Science and Technology (Svensson et al., 2015).

Practically speaking, a few colleges have included LSS in their operations: Miami University in the United States of America often offers Lean and Six Sigma training. In 2012, Kings College saved approximately £1 million by implementing LSS solutions to streamline college operations related to infrastructure (Sunder, 2016). Through LSS, the University of Central Florida accelerated the admissions process for suitable applicants (Coowar et al., 2006). Apart from these instances of the LSS methodology's general application or administrative HEI procedures, actual data on the implementation of LSS in academic core processes is scarce. Both Simons (2013) and Antony (2014) were adamant that education could be improved in the same way as any other sector, encompassing academic and non-academic procedures. While reviewing the research and reported cases, it appears that LSS has several impediments and problems in educational settings; there are also numerous success stories (Pryor et al., 2012).

Antony (2014) highlights the preparedness characteristics that an HEI must possess to successfully embark on the LSS path. The preparedness factors include visionary leadership for establishing the desired culture for LSS; visible management involvement and commitment in allocating budget and resources for training, followed by time for completing LSS projects; selection of the suitable projects using appropriate project selection criteria; and selection of the institute's most talented individuals to execute the projects (Antony et al., 2018). Nawanir et al. (2019) identified several barriers to implementing LSS in HEIs, including excessive top-down management, departmental politics and inter-departmental acrimony, a lack of LSS knowledge and experience within the majority of universities, an insufficient focus on metrics, and a lack of key quality indicators for several business processes.

Sunder offered an overview and success stories of the LSS system implemented by several HEIs worldwide. Sunder also includes a case study demonstrating how LSS improved a university library's process. The case study lowered the average time spent searching for books from 15 minutes to less than 5 minutes. The university's executive team lauded the initiative for its benefits to the library system. Bargerstock & Richards ( 2015) demonstrated how to simplify and increase the efficiency of an educational evaluation process by applying the LSS methodology. The upgraded process decreased cycle time by two-thirds, eliminated inconvenient non-value-added activity stages, identified extra customer value, and considerably increased compliance rates. This case study highlights how Six Sigma may drastically enhance business processes in higher education environments. Additionally, the authors stated that every organizational process with inputs, outputs, and feedback loops is amenable to continuous process improvement activities (Antony et al., 2018).

- **LSS for Financial Services.**

Companies employ a variety of strategies to avoid competitive disadvantages, including eliminating operational inefficiencies - which are significant in the financial sector, accounting for 20% or more of total banking industry costs – and increasing revenue growth through increased customer numbers and satisfaction (De Koning, De Mast, et al., 2008). Lean Six Sigma (LSS) is a process that may assist financial organizations in increasing their operational efficiency and effectiveness (Michael, 2003; Snee & Hoerl, 2004). The combination tool LSS enables the financial services industry to increase efficiency and quality (De Koning et al., 2008a).

In the early 2000s, the application of Six Sigma to financial services was in its infancy. However, Chakrabarty & Tan (2007) analysis revealed that Six Sigma is increasingly used in nearly all service industries, including financial services. Stoner & Werner (1994) provided a case study on using Six Sigma in an internal auditing process at Motorola Finance. The study's findings include an improvement in cycle time, a reduction in internal and external mistakes, and a reduction in external audit expenditures of $1.8 million per year. The cycle time for closing the books on a monthly basis has been cut from more than nine days to only two days, resulting in savings of more than $30 million for the firm (Antony et al., 2017). Implementing LSS has several benefits, such as cost savings, process and product quality improvements, enhanced efficiency, increased production, and the organization's agility and adaptability, surpassing expenses. At the worldwide level, cultural distinctions exist primarily in internal resistance and receptiveness to change (Delgado et al., 2010).

Additionally, Heckl et al. (2010) research showed that Six Sigma in financial services is growing tremendously. Additionally, the survey discovered that British and German banks and insurers use Six Sigma more extensively than Swiss and Austrian banks and insurers. Additionally, the authors discovered that nearly a quarter of respondents believed that Six

Sigma could not be utilized to change the financial services industry's culture. However, over 85 per cent of respondents said Six Sigma might benefit from process optimization. The primary motivation for implementing Six Sigma is to decrease operating expenses. Additionally, business possibilities and unhappy consumers are the primary reasons for its utilization(Antony et al., 2017).

Brewer & Eighme (2005) identified the following components required for the effective development of LSS initiatives in any financial services industry: Committed leadership: this involves providing clear direction on the overall strategic deployment of LSS, committing time, resources (people), and other resources to the deployment, communicating the initiative's importance to everyone, insisting on visible bottom-line effect, and so on. Select the best personnel: allocating the best staff to LSS efforts demonstrates leadership commitment to the initiative. Supporting infrastructure: this should include the usage of belt systems (Black Belts, Green Belts, and Yellow Belts), active participation of LSS deployment champions and project sponsors, and a management system to ensure the initiative's sustainability.

Several fundamental problems in using the LSS technique in financial services include a lack of appropriate data and insufficient human resources in terms of quality and quantity for LSS project implementation. Organizational culture and employee attitude, Expertise in tools and procedures, and communication. A significant barrier to LSS adoption in service companies, in general, is communication. To establish a sustainable LSS project, each employee should be informed (Antony et al., 2017).

- **LSS for public sector organizations**

The public sector is a vital component of every country's economy and, regardless of function or service or country of operation, has several obstacles and operational constraints. Public sector services are shaped and guided by fluctuating governmental policies and agendas. They compete for a piece of the overall budget and must offer services within the budget's affordability, a critical factor in the strategic management of public sector services (Poister & Streib, 2018). Frequently, services are offered to the most vulnerable members of society and are neither sought nor desired by the receivers. The services are also offered to a greater or lesser extent regardless of the customer's capacity to pay (Rodgers & Antony, 2019).

Several advantages of using LSS in the public sector include the following: The costs of firefighting and misdirected problem-solving attempts without a systematic or disciplined technique might be significantly minimized. Improved awareness of the VOCs and related CTQs that have the most significant influence on customer satisfaction. Reduced non-value-added operations by systematic removal, resulting in faster service delivery, shorter lead times, and shorter cycle times for processing essential performance characteristics for customers and stakeholders, among other benefits. Organizational culture transformation from reactive to proactive thinking/mindset. Numerous managers are statistically ignorant and cannot use statistics to issue solutions. LSS establishes a foundation for managers to employ proven and practical statistical tools and methodologies for issue resolution in public sector companies and increased responsiveness and adaptability to consumer requirements (Antony et al., 2017).

Today, many public sector organizations face the challenge of reducing spending while maintaining or enhancing service delivery efficiency and effectiveness. We need to decrease waste and maximize value-added activities for consumers by using LT, and we need to offer consistent services by minimizing process variation by implementing Six Sigma. Several critical problems in implementing LSS in public sector companies include the following (Antony, 2015): The LSS program requires unwavering management commitment. Without their support and dedication, the attempt will be completely pointless. Antony et al. (2016) discuss the primary problems associated with adopting LSS across the UK public sector. Additionally, the authors give several specific instances drawn from three to four distinct public sector firms that demonstrate the effectiveness of the Lean Six Sigma methodology and accompanying technologies in the public sector.

- **Lean Six Sigma in Healthcare**

LSS is used in a wide variety of healthcare operations; however, a particular emphasis is placed on patient flow and appointment management in various departments, such as a doctor's clinic (Lummus et al., 2006) and mental health screening (Aleem et al., 2015). As with education, health-related publications examine a variety of broader organizational concerns as well as case studies of deployments, including leadership obstacles (Waring & Bishop, 2010), implementation barriers (de Souza & Pidd, 2011), and policy challenges (Rodgers et al., 2021).

A literature survey discovered a variety of applications for Six Sigma in healthcare, including admission, discharge, and critical and cardiac care (de Souza & Pidd, 2011). Curatolo et al. (2014) studied the literature on Lean implementation in hospitals. While there are several examples of Lean in action, the evaluation notes the absence of a consistent approach in all implementations and a lack of maturity in the papers evaluated. Leggat et al. (2015) discussed the potential for quality improvement to increase efficiency and effectiveness in healthcare and discussed the difficulties associated with human resource management in an environment where practitioners strongly influence their duties. More broadly, they encapsulate the critical nature of incorporating personnel in any process reform or quality endeavour. D'Andreamatteo et al. (2015) identified several broader issues that needed to be addressed, including the absence of a common definition of lean, the need to explore a more blended approach of Lean Six Sigma, and the need to critically review both failures and successes.

LSS implements the DMAIC process, incorporating tools from both ideologies (Albliwi et al., 2015). Additionally, LSS tackles the fundamental cause of process flow and waste problems and lowers variance within a process (Bhat et al., 2014). As such, LSS has the potential to contribute just as much to healthcare businesses as it has to industrial industries (Laureani et al., 2013). Following this initial success with LSS in the healthcare industry, other LSS initiatives have been implemented to enhance procedures in various areas of healthcare. This has not been without difficulties; for example, Laureani et al. (2013) asserted that the healthcare sector's deployment of LSS has experienced the same constraints as other industries. Several studies have extensively cited successful projects in healthcare. Good examples are the reduction in waiting time during the registration process (Bhat et al., 2014), a tertiary care otolaryngology clinic (Lin et al., 2013), an audiology clinic, and the reduction of turnaround time in a medical records department (Huddle et al., 2016). Trakulsunti & Antony (2018) add that LSS is a practical improvement approach that may minimize medication mistakes, enhance patient safety, and save operational costs.

Antony & Kumar (2012) argue that hospitals must use an integrated Lean and Six Sigma strategy and emphasize the need to pay attention to the predefined core flow. If Lean is applied alone, it is possible to enhance process flow speed, but this may result in a dissatisfied patient owing to the physician's lack of attention. On the other side, if Six Sigma is used exclusively, the patient experience will be enhanced. Still, the medical facility will not sustain the requisite patient volume to be financially sustainable (Antony

& Kumar, 2012). The LSS method aids the healthcare organization in developing a culture of continuous improvement, ensuring superior results in terms of quality, speed, and cost promptly (Ahmed et al., 2013). Thus, LSS provides an efficient framework for systematic and ongoing improvement in healthcare. The approach aims to reduce healthcare expenditures while improving the quality of care, patient safety, and patient experience (de Koning et al., 2006).

Numerous healthcare business researchers have implemented LSS in various areas to enhance quality, decrease wait times, and speed up processes, among other things. Black (2009) examined LSS and concluded that while it is a structured approach for altering processes, it does not adequately account for the complex social interactions that result in the formation of processes in organizations such as hospitals. Mozammel & Mapa (2011) discussed nurse shift directors, who are accountable for the effective use of nursing employees and patient placement and work as liaisons to enable communication and issue-solving inside the healthcare institution. Bhat et al. (2014) examined the effective implementation of the LSS method in the Indian healthcare business by using it throughout the hospital registration procedure. Similarly, Bhat & Jnanesh (2014) investigated the effect of implementing the LSS approach on the cycle time of an outpatient department service at a rural hospital.

Kulkarni et al. (2011) used LSS to establish and modify critical processes to reduce waste and improve quality. Similarly, Shirey et al. (2017) examined the LSS in the quality improvement approach concerning facilities management services in a healthcare company. It discusses the healthcare business's current issues and how to overcome them through LSS. There has been considerable interest in using LSS to help prevent drug mistakes. According to (Trakulsunti et al., 2020), the United States of America is the leading country using Lean, SS, and LSS to decrease hospital prescription mistakes.

### 2.2.9 DMAIC phases

LSS is a synthesis of the Lean and Six Sigma concepts, and its origins are mainly based on the synergies these two separate methodologies give one another. LSS follows the same DMAIC improvement method as Six Sigma but incorporates Lean and Six Sigma tools into the various phases. Whereas Six Sigma focuses mainly on defect and variation reduction, Lean emphasises process standardization, simplicity, and waste reduction (Pepper & Spedding, 2010).

DMAIC is a proven framework used for statistical data analysis to improve performance (Mancosu et al., 2018). The DMAIC abbreviation stands for (Define, Measure, Analyze, Improve, and Control). DMAIC was initially built for Six Sigma for its implementation on projects through the different stages (Erdil et al., 2018). Moreover, variant tools and techniques used by LSS can be integrated with each phase of DMAIC (Youssouf et al., 2014). Belts system (MBB, BB, GB, YB, WB) used with the entire DMAIC; aims to determine the source of process variation and sustaining achievement over time (Breyfogle III, 2003; Kumar & Antony, 2008).

The DMAIC methodology optimises corporate processes, identifies, and resolves issues. The DMAIC model enables the identification of a problem, the establishment of key metrics, the implementation of solutions, the establishment of processes, and lastly, the management and improvement of the implementation process. The DMAIC cycle focuses on continual process improvement to meet client demands. DMAIC phases are briefly explained as the following (Breyfogle III, 2003; Kwak & Anbari, 2006):

1. **Define Phase**

Define is the initial stage in the DMAIC process. This process begins with a determination of the nature of the problem. The issue might be a financial worry, a customer issue, process inefficiency, a product failure, or a flow bottleneck, to name a few. It is critical to properly comprehend and describe the project's consumer to create goals. Furthermore, the 'define' step identifies a process needing improvement. The 'define' phase's objective is to specify the project's scope and objectives (Jugulum & Samuel, 2010). The project's resources comprise personnel and other expenditures visible at this point. Costs and benefits estimates enable the team to conduct a rigorous analysis of the project's viability. This stage establishes a project charter to ensure that pertinent information is kept current and accessible to all participants. This charter contains general project information, scope and description, team organization, key performance indicators, and milestones. The charter is produced at the define phase, but it will be maintained during the project and will serve as part of the project's documentation once it is complete. Figure 8 shows some of the most often used tools during the Define phase.

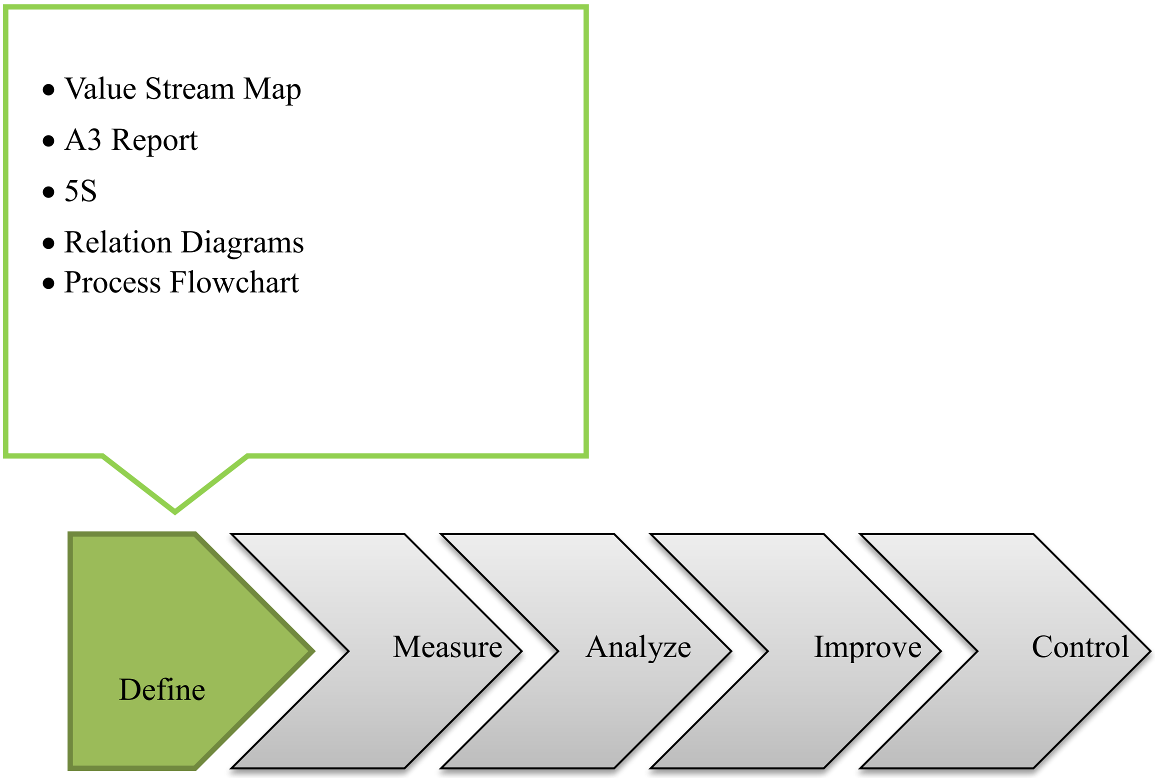


**Figure 8. Define Phase tools.**

### 2. Measure Phase

After defining the business challenge, the project moves to the measurement phase. The project team will identify the work processes associated with the challenge at this phase. After identifying connected processes, the processes' flow, feedback loops, measurement-control points, and hand-offs between organizational groups are mapped. Once this information is gathered, the processes may be split into logical models that give quantitative insight. Process assessment can then be carried out using actual process data to confirm the validity of the results (Kumar & Gupta, 1993).

The process evaluation also necessitates collecting data on the process's performance. A significant portion of the measure phase ensures that the necessary data is available and accurate. It is not commonplace for data to be required to be measured or gathered before the project. As a result, the project may involve establishing a new measuring system or enhancing an existing one. This ensures that improvement efforts are concentrated on the areas with the highest potential for change concerning the specified business challenge.

Once the present level of performance is determined, it will be compared to the maximum level of performance feasible without significant expenditure. The optimal performance baseline may be established in various ways, including historical performance comparisons, process benchmarking, and engineering maximum capacity estimations.

When the present and ideal performance levels are established, the project's future benefits may be assessed more precisely. Figure 9 illustrates many of the instruments utilized during the measurement process.

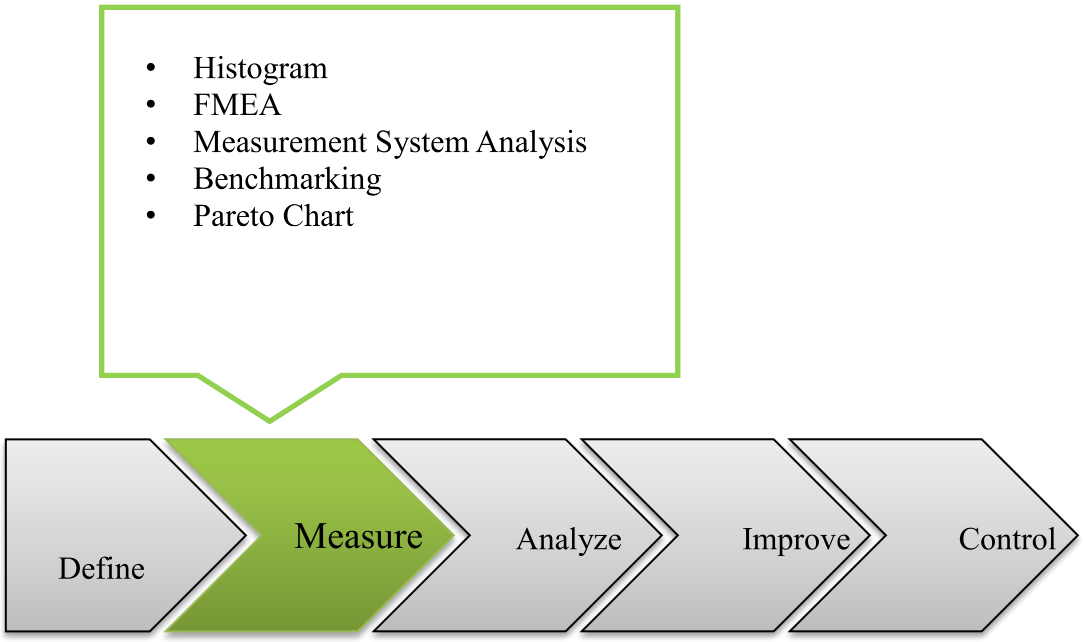


**Figure 9. Measure Phase tools.**

### 3. Analyze Phase

The first two phases of DMAIC have defined the business problem, identified relevant processes, and assessed current performance. The analysis step aims to identify the most significant sources of controlled variation within the identified processes, from which the problem's improvement possibilities and fundamental causes may be found. In other words, now that the processes' output performance is known, the attention will turn to analysing the inputs contributing to the output performance.

The 'analysis' step analyzes the data to ascertain the most likely sources of the defect or problem. After identifying essential elements, the emphasis is turned to determining the core reasons for these factors' inadequacy in performance during the 'analysis' phase. Statistical techniques are used to verify that the analysis is objective and fair. These techniques determine the amount of variation given to the total process variance by each element. As a result, this assists in determining which inputs are most critical to overall performance. Additionally, any interaction effects between the variables will be measured. Occasionally, the number of components is enormous, and in this case, a Pareto chart can be used to prioritize hypothesis testing.

Figure 10 shows some of the most commonly used tools in analyzing phase.

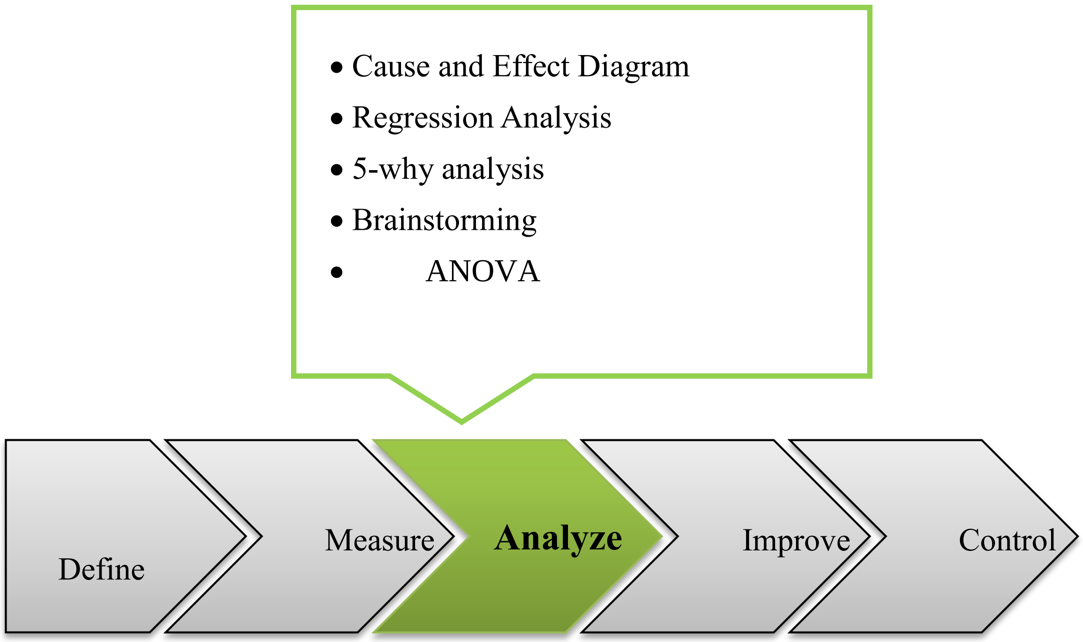


**Figure 10. Analyze Phase tools.**

## 4. Improve Phase

The improvement focus has been decided upon due to the preceding processes. The Improve phase identifies and validates the elements that push the process toward the statistical solution: variance reduction, mean shift, or both. Before the intended change is noticed due to modifying the components, the solution is not verified. Validation is frequently accomplished by testing, frequently referred to as the design of experiments (DOE). After validating the solution, essential elements will be handled to ensure robust performance. Additionally, it should be recognized that not all changes are beneficial. Thus, assessing the solution's impact on the whole system's performance is critical.

After collecting and analyzing data, the improvement phase will begin by identifying strategies to remove the identified sources of variance. The 'improve' step is fine-tuning the essential components to ensure that the end outputs meet pre-defined quality requirements. Certain restrictions, such as workforce reductions and new technology, must be addressed when the project team designs alternate procedures (Michael, 2003). Figure 11 illustrates many of the most often used tools during the Improvement phase.

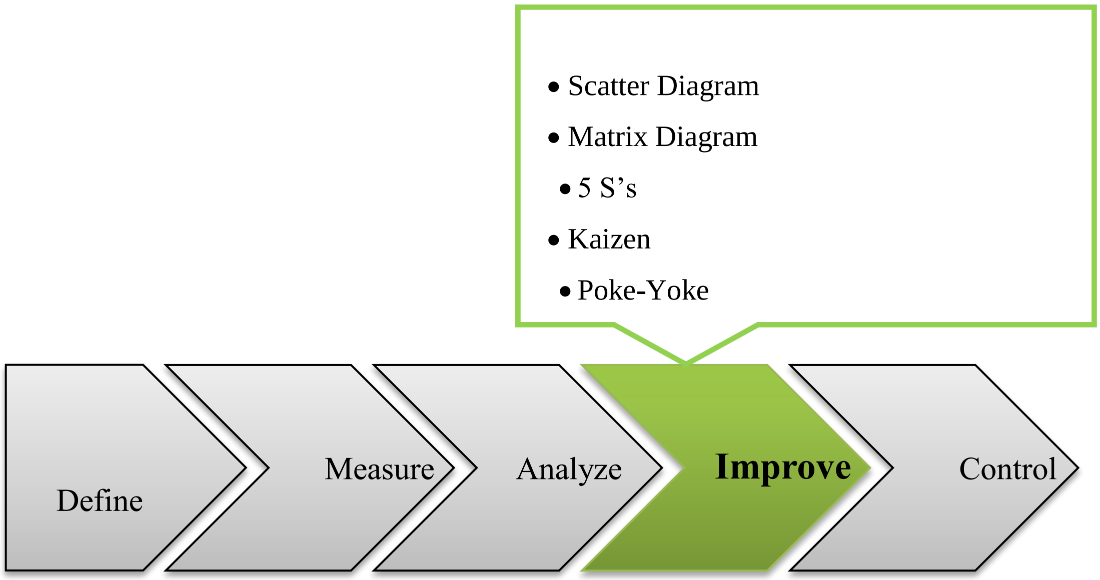


**Figure 11. Improve Phase tools.**

### 5. Control Phase

Finally, a strategy for systematic improvement maintenance will be developed during the control phase. The process owner has to manage the process and its outcomes throughout the 'control' phase, i.e., the phases following the optimization. Wherever feasible, foresee problems that will arise while implementing the enhanced procedure. The DMADV cycle is employed for freshly formed processes, replacing the improvement and control phases with the design and verify phases (Madhani, 2018). The control phase's objective is to guarantee that the changes stick and become ingrained in how things are done. If an even better way of doing things is discovered and validated, should the enhancements be rescinded (Michael, 2003). Figure 12 illustrates the most often used tools during the control phase.

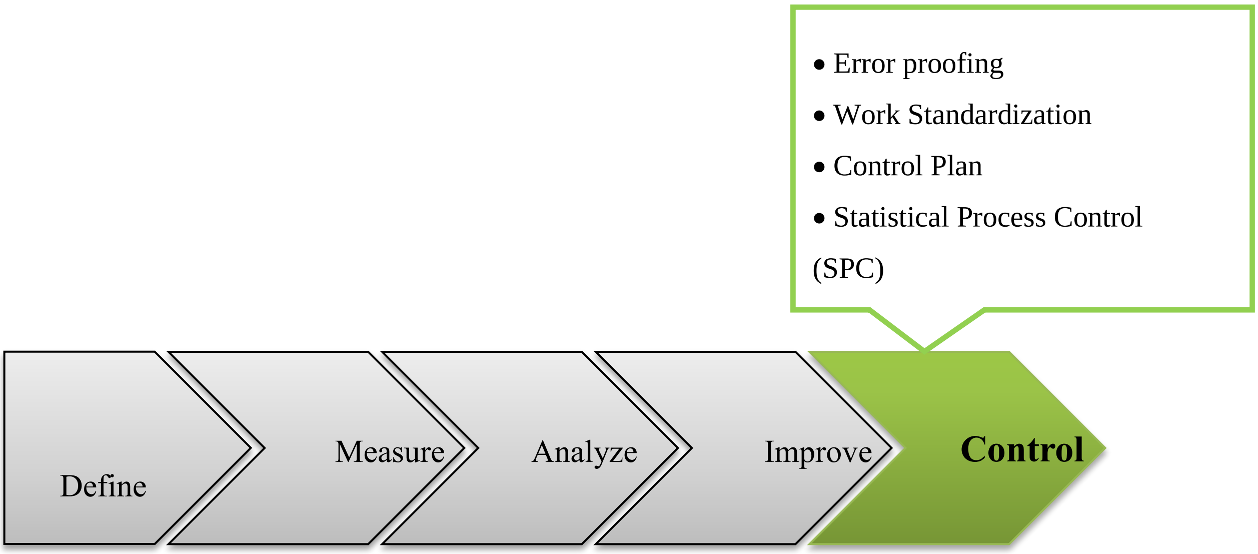


**Figure 12. Control Phase tools.**

### 2.2.10 Tools used in implementing LSS

DMAIC is the primary framework used by LSS, which mainly consists of five stages. Each stage could use different tools (Maleszka & Linke, 2016). The implementation of LSS in a sequential way starts from the define phase, where the problem statement is defined, and the value-added and non-added-value processes are defined through applying different tools, for instance, stream mapping (VSM) (Pepper & Spedding, 2010).

The Maleszka and Linke (2016) study showed that the appropriate LSS tools positively affect the working process (Maleszka & Linke, 2016). Some LSS tools can be used in more than one phase of the DMAIC as an essential tool; for instance, CTQ (Critical to Quality) is obligatory for the DMAIC approach. Other tools can be recommended or suggested for another phase; for example, SIPOC (Supplier, input, process, output, control) is recommended for the Define phase and suggested for the measure phase. Some tools can be used for only one DMAIC phase; for instance, FMEA (Failure Mode and Effects Analysis) is obligatory for the define phase only (Maleszka & Linke, 2016).

Although choosing the tools during the implementation of LSS depends on different factors such as size and structure, using no limiting tools increases the desired improvements in performance (Alhuraish et al., 2016). However, the main challenge in implementing LSS in services sectors, especially in financial services, is choosing the appropriate tools at the appropriate time (Antony et al., 2017). Lean Six Sigma employs tools from both toolboxes to gain the most from the two techniques, increasing speed while enhancing accuracy. The following subsections detail some of the LSS tools cited in the literature.

- **Histogram**

A histogram is a fundamental quality management tool to summarize, visualize, and analyze process data. Additionally, it may be viewed as a graphical depiction of a table indicating the percentage of cases falling into each defined category. Karl Pearson (1857-1936) invented it to illustrate the probability distribution of continuous data Histograms are constructed from tabular frequencies represented by contiguous rectangles that span discrete intervals and have an area equal to the frequency of the observations inside the interval. It is a data analysis tool that may examine data fluctuations within variable intervals.

- **Scatter Diagram**

A Scatter diagram is a tool used to enhance the overall quality and uniformity of products and organizations. Additionally, it is known as a scatter plot, scatter diagram or X-Y graph. It illustrates the potential link between two distinct variables through data points on a graph. Correlation is the term used to describe the relationship between two distinct variables. Correlation can be positive, negative, or null. When variables are plotted, their proximity to forming a line determines their degree of connection. Correlation is denoted by the direction of the graphical data points. If both variables rise in the same direction, the connection is positive. It is negative if one variable rises in the y-direction while the other decreases in the x-direction. Additionally, if there is no direction, the correlation is nil.

- **Pareto Diagram**

The Pareto Chart, named after Italian economist Vilfredo Pareto (1848-1932), is a quality control tool for determining the percentage of issues linked to each occurrence. The bar chart and line graph combine to form this graphic. Chart with frequency causes plotted on the X-axis, and cumulative percentages plotted on the Y-axis. Each defect category and the proportion of each defect kind are listed in column format.

The Pareto chart is frequently used in both the measure and analyze stages of the DMAIC approach and is widely utilized in non-manufacturing applications of quality improvement methods. It assists the analyst in determining which flaws occur the most frequently in management. When combined with the check Sheet, the examined flaws form the most often occurring deformities. Then, divide each incidence by one hundred per cent and construct a cumulative line at nearly one hundred per cent as possible. Pareto analysis is a practical statistical approach for determining which activities contribute to an overall outcome. It is predicated on the 80:20 rule, which argues that most issues (say, 80%) are caused by a small number of factors (say, 20 per cent). Concentrating on 20% of critical issues can significantly decrease the number of difficulties (Modi & Doyle, 2012).

- **Process Flowchart/ Mapping**

A process chart is a graphical depiction of the stages or activities (workflow) that comprise a process, beginning with raw materials and ending with the final result. It is used to examine the process to discover opportunities for improvement thoroughly. It is a versatile instrument used in engineering, business, and other spheres of life. Process charts may describe and evaluate processes, convey steps to other stakeholders, standardize processes, enhance processes, identify bottlenecks, and troubleshoot problems (Boutros & Cardella, 2017).

- **Five S's**

5S is a management approach developed by Takshi Osada in the 1980s to help organizations create and preserve a high-quality, productive, and safe work environment. It eliminates waste from an ill-organized workspace (e.g., wasting time looking for a tool). The 5S is self-sustaining, with the advantages resulting from a disciplined workforce (Zailani et al., 2015). The five phases of 5S are sorting (to eliminate superfluous objects), shining (to keep the workspace clean), setting in order (to maintain everything in its proper place), standardizing, and sustaining (to ensure continuation) (Khlat et al., 2014).

Perhaps the most often utilized Lean tool is 5S. By implementing 5S first, organizations face the danger of their improvement emphasis becoming absorbed by 5S, detracting from the other effective strategies that will result in systemic change. It is not to argue that 5S is not a robust method; instead, it is self-limiting unless applied as part of a more extensive, well-managed program (Pepper & Spedding, 2010). 5S is a methodology for establishing and maintaining an organized, clean, efficient, and high-quality workstation. 5S is not confined to manufacturing; it is effective in other sectors, such as administration. 5S is derived from five Japanese words:

1S Seiri – Sort: Sorting needed and non-required stuff; removing unnecessary ones. Seiri symbolizes 'organization,' which means putting everything in order (Kobayashi et al., 2008). It entails a concerted effort of organization and self-control. Seiri's objective is to retain only necessary elements in the workplace (Khanna & Gupta, 2014). The advantage of the 1S strategy is that it eliminates dangers and clutter obstructing practical work. Employees want clear guidance on detecting and categorising superfluous objects (Michalska & Szewieczek, 2007).

2S Seiton – Storage: The term "set in order" refers to organizing essential materials and things appropriately to minimize wasteful employee mobility and material movement (Patil et al., 2016). It focuses on developing systematic and adequate storage systems to manage the products and parts in an easy-to-use manner. 2S activities include characterizing each object, utilizing colour to facilitate reorganization, conserving comparable goods, storing different items, and utilizing racks, shelves, and shadow boards to organize tools (Moradi et al., 2011). Essentially, the seiton addresses how quickly you can obtain the items you require and how quickly you can remove them from a distance.

3S Seiso – Shine: After removing superfluous materials from the workplace and correctly organizing the remaining equipment and parts, the following step is to thoroughly clean and maintain the work environment (Patil et al., 2016). Seiso is an efficient activity that maintains a clean and orderly work environment. From the top to the bottom management, everyone in the organisation plays a critical part in keeping the workplace tidy and sanitary (Randhawa & Ahuja, 2017).

4S Seketsu – Standardize It refers to standardizing work areas via the development of methods to sustain the first three pillars' success. It places a premium on establishing self-contained, neat operating processes to keep the complete work environment. Standards should be clear, concise, and simple to comprehend (Michalska & Szewieczek, 2007). 4S should be used in routine operations, such as manufacturing and storage, and management processes, such as bookkeeping, customer service, accounting, and human resources. Employees contribute significantly to the development of standards in any organization. Employees should be aware of their obligations, and housekeeping activities must be fulfilled consistently (Gupta & Jain, 2014). Visual management solutions should enable employees to act rapidly at all times and boost overall employee morale in the workplace (Ahuja & Singh, 2018).

5S Shitsuke – Sustain to adhere to 5S principles through audits, job inspections, and visualizations of 5S team performance (Maleszka & Linke, 2016). Sustain may be described as adequately maintaining equipment using the necessary processes. This needs proactive adjustments in people's behaviour patterns at all organizational levels to accomplish goals efficiently and effectively (Kobayashi et al., 2008). Shitsuke translates as ingraining the capacity to accomplish things the right way. Sustain is a critical component of industrial safety. Everyone should develop the habit of following simple safety principles (Ahuja & Singh, 2018).

- **Failure Mode and Effect Analysis**

According to a survey of the historical literature, FMEA was created in the early 1950s in a defence laboratory in the United States of America (Sutrisno & Lee, 2011). FMEA is unusual because it quantifies failures on three dimensions: incidence, severity, and detection (Sharma et al., 2007). The sum of these quantifiable percentage values is the Risk Priority Number (RPN). Actions must be advised to keep the RPN value to a minimum. Thus, FMEA enables the recording of failures and the implementation of corrective steps to mitigate or eliminate their severity and occurrence (Sivakumar et al., 2008).

The FMEA approach is used to analyze potential failures to improve safety and, as a result, customer satisfaction. Its objective is to reduce costs while enhancing dependability, customer happiness, and market share. It is dependent on the principle of failure prevention. One of the primary distinctions between FMEA and other quality assurance approaches is that FMEA is an active process, whereas other methods are inert (based on reaction). Thus, when failures occur, additional methods describe some possible responses. However, reactions incur high costs and resources. FMEA aims to quantify potential problems and associated risks and then decide on activities that would mitigate or eliminate these risks (Khalili et al., 2017).

- **Kaizen**

In 1950, Japan created the notion of kaizen. Kaizen is a compound term that combines the principles of Kai (change) and Zen (good) to mean "for the better" (Gupta & Gupta, 2017). Kaizen requires a premium on details and common sense to make every individual in the organization more intelligent (Asada, 2000). Kaizen is a concept based on continual learning and improvement of the standard operating procedure in the workplace (Topuz &

Arasan, 2013). Kaizen is more than a continual improvement process; it embodies the daily conflicts in the workplace and how these problems may be conquered (Malik et al., 2007).

Kaizen event application includes defining the area to be improved, analyzing and selecting critical problems, identifying the root cause of the problem, enhancing project execution, measuring, analyzing, comparing outcomes, and standardizing processes (Kraszewski, 2005). Kaizen's concepts and ideas are analogous to quality control management, six-Sigma, and Lean manufacturing. The discipline focuses on resolving issues and seeking the best solutions (Folinas & Ngosa, 2013). Kaizen assists in identifying hidden wastes in manufacturing processes, determining their fundamental cause, and recommending the best feasible remedies. Therefore, Kaizen is one of the structural repair techniques that an organization may utilize to efficiently manage its work environment while enhancing staff procedures and efficiency (Chittipaka & Sagi, 2012).

Numerous sectors might benefit from kaizen events since they boost a company's efficiency and aid in producing high-quality products. Benefits from kaizen initiatives may be obtained with the slightest effort (Reid, 2006). Kaizen is no longer confined to the industrial sector; it has expanded to encompass all facets of business, including the software and service industries (Cheser, 1998). The success of kaizen efforts is strongly dependent on collaboration. Chiarini (2012) identified and contrasted six critical systems: management style, end outcomes, system development, customer demands, personnel management, information technology, technology, and frequent examination of situations and system stabilisation. Kaizen event efficacy is critical to quantify, and several case studies are crucial for determining its success. Kaizen's advantages include superb quality, financial savings, increased safety, shorter delivery times, and increased productivity (A. Gupta & Gupta, 2017).

- **Cause and Effect / Ishikawa Diagram**

A fishbone diagram is a problem-solving diagram used to determine the root causes of an issue. Causes are often classified into broad groups to determine the root cause of an issue. Individuals, techniques, machines, materials, measurement, and environment are frequently included in the categories (Modi & Doyle, 2012).

Through brainstorming approaches, it enables methodical examination of all probable reasons. Kauru Ishikawa created it to assist a group in focusing on particular areas for development throughout a linear process. The cause-and-effect diagram was used to narrow the focus of attention on the core causes of the threats previously identified as "the important few." Through systematic brainstorming of possible contributing elements to each danger, a thorough grasp of the current condition of operations was gained. When a single contributing component, such as a lack of expertise, regularly appears as a secondary contributing factor to the main contributing factors, a comprehensive cause-and-effect diagram assists in finding fundamental causes. Finally, the cause-and-effect diagram guides a Lean Six Sigma team in determining which data to gather and which actions to take in response to the discovered problem's likely causes.

- **Benchmarking**

Continuous quality improvement, which is at the heart of TQM, has been demonstrated through benchmarking during the previous two decades. While benchmarking is primarily concerned with comparing a higher product or performer, it also implies that any gaps discovered during the comparison process be efficiently closed to increase the product's quality. Camp & Camp Robert (1989) detailed the success story of Xerox Corporation of the USA and inspired numerous firms worldwide to use benchmarking to enhance their products and services. Simultaneously, several experts and practitioners have developed benchmarking frameworks with varying phases. It's worth noting that while benchmarking also requires a set number of stages to be followed sequentially, there is no consistency in the number of steps used by various firms.

In practice, benchmarking typically entails the following: regularly comparing aspects of performance (functions or processes) to best practices, identifying performance gaps, seeking new approaches to improve performance, implementing improvements, monitoring progress and evaluating the benefits (Gershon & Rajashekharaiah, 2013).

- **Poka-yoke (Mistake Proofing)**

Poka-yoke is a quality assurance procedure invented by Japanese engineer Shigeo Shingo. Poka-yoke is one of these error-proofing methods (also referred to as mistake-proofing). In the Japanese language, this phrase is referred to as 'poka', which means a mistake, and 'yoke', which means prevent, i.e., a strategy for preventing or proofreading errors. Poka-yoke establishes procedures for minimizing faults by preventing or fixing errors during the early design and development phases. Although this approach is primarily employed in manufacturing, it is increasingly being modified in software development processes (Khalili et al., 2017).

The poka-yoke method applies to all operations that include human error. Assuming that everyone commits errors, emphasis must be paid to minimizing and eliminating them (Maleszka & Linke, 2016). The poka-yoke system comprises three fundamental components: contact, counting, and motion sequence. Each strategy employs a distinct approach to process prevention when dealing with abnormalities (Khalili et al., 2017).

- **Value Stream Mapping**

A value stream map (VSM) is a subset of a flow chart that employs unique symbols (Bicheno & Holweg, 2009). It is used in industrial firms to visualize and enhance the flow of inventories and information. It indicates where delays occur, allowing you to optimize the flow and reduce waste (Molnár et al., 2018). VSM adds the most value to the consumer by utilizing a comprehensive value-creation process with the least waste possible. VSM assists in displaying the process's present condition (Modi & Doyle, 2012).

Value stream mapping is a technique for visualizing the movement of materials and information. It enables tracking all actions from when a consumer places an order to when it is delivered (Molnár et al., 2018). Additionally, it highlights both value-adding and non-value-adding actions. Value stream mapping consists of two critical steps. The initial stage is to create a map of existing processes for a selected group of items, which will be updated to incorporate all pertinent information about the present state. The second stage is building a map of a desired future state, a vision of the desired state (Maleszka & Linke, 2016).

Abdulmalek & Rajgopal (2007) and Lian & Van Landeghem (2002) have all researched the combination of VSM with simulation. Compared to paper and pencil, the software allows more incredible data to be represented. A plethora of VSM software (for example, eVSM) is accessible on the internet. Such software provides a dynamic (rather than static) representation of the value stream, enabling the user to observe proposed modifications' "real-time" impact. Essentially, it enhances the flexibility and knowledge improvement teams have at their disposal. The Lean concept must be viewed holistically. To establish a Lean business, VSM must be used carefully before other approaches, such as 5S (Pepper & Spedding, 2010).

## 2.3 Knowledge management

Today, the world is witnessing many changes and developments that directly affect the work of business organizations. In this rapidly changing global environment, especially after the Second World War, the economic concept came that knowledge is a strategic element. Therefore, it gives the organization a competitive advantage of paramount importance and supports it in keeping pace with all the developments and changes in its work environment and facing competitors' fierceness. Management scholars see that renewable and innovative thought and knowledge are among the essential means of success for organizations, whether private or public, regardless of their objectives and the nature of their work and activity. This vision and this modern management thought forced the organizations to re-form themselves, and it forced them to re-engineer their work to keep pace with the knowledge-based organization model that we produce and disseminate (Kordab & Raudeliūnienė, 2018).

Without the proper knowledge, the organization cannot sustain a tremendous competitive advantage in a highly dynamic environment. Therefore, affording documented experiences to most of the employees is an important decision that should be taken by top management in the organization (Chawla & Joshi, 2010). In response to the need to organize knowledge in the current environment, knowledge management became a crucial discipline practised by most successful organizations for over 30 years (Girard & Girard, 2015). Nowadays, organizations are increasingly interested in leveraging KM tools as an adequate basis for the processes of creativity and innovation in the organization and as a foundation for administrative guidance in achieving efficiency, effectiveness, and outstanding performance (Raudeliūnienė et al., 2018).

One of the main concepts of KM is Knowledge Generation and Knowledge Sharing. Knowledge Generation is the interaction between implicit and phenomenal knowledge through which new knowledge is created, derived and structured within the organization to secure different types of knowledge in future decisions (Chen et al., 2009). Knowledge Sharing is the purpose of exchanging and sharing different kinds of knowledge among individuals and interacting in dialogues with others inside and outside the organization. It provides cooperation between them to form new mental ideas, reach and work simultaneously on the same document and from different locations, and coordinate activities (Majchrzak et al., 2004).

### 2.3.1 Data, Information, and Knowledge

A range of unorganized and unprocessed facts is known as data. After data is assessed, it is transformed into information. Every sort of organization needs data in some form, but they must recognize how much data is sufficient. Too much data may leave employees bewildered about how to evaluate or process the data to transform it into information. Therefore, the business must establish early on which types of data are helpful, timely, and accurate. Unlike data, information has a defined purpose and significance, facilitating decision-making processes. Information is the source of knowledge, but only if it is comprehended. Knowledge ultimately affords a business a competitive advantage. Therefore, a business needs efficient processes that turn data into information and knowledge (Ghaziri & Awad, 2005).

Knowledge has been defined as actionable related information gathered from previous experiences of the people (Davenport & Prusak, 1998). Moreover, Knowledge is classified according to (Lundvall, 2006) into four sections. Know-what expresses knowledge about facts that can be encoded. Know-why is about knowing about principles and laws. Know-how means the skills and ability to perform a particular task successfully. Know-who is about knowing who knows what and how. There are many divisions of knowledge, perhaps the most famous of which is the Nonaka division, which divides knowledge into tacit and explicit knowledge.

### 2.3.2 Explicit and tacit knowledge

Most literature defines two types of knowledge: explicit and tacit (Nonaka, 1994). Explicit knowledge is information encoded in an external medium, such as paper documents, computer databases and files, and business procedures (Sternberg & Horvath, 1999). Tacit knowledge is accumulated experiences in the person’s brain, including cognitive learning and technical skills. Tacit knowledge is considered valuable, although it is hard to manage (Dalkir, 2005).

The primary distinction is in how knowledge is shared. Because explicit information is obvious, expressed, and can be summed up, it is easier to convey and share. In contrast, implicit information is intuitive, making its distinction difficult. Dombrowski et al. suggest that a significant portion of human knowledge is implicit (Lam, 2000). Moreover, according to (Dombrowski et al., 2012), implicit knowledge is action-oriented and personal, making it difficult to transmit. There must be intimate contact and a shared understanding for tacit knowledge to exist. On the other hand, explicit knowledge may be explained and simplified, and it can be conveyed independently of subject or time and location.

Figure 13 iceberg example demonstrates that explicit information is easily observable and tangible in nature, unlike tacit knowledge. Individuals recognise it as their knowledge (Anttila et al., 2001). A more considerable fraction of knowledge (tacit knowledge) cannot be observed, quantified, or easily communicated since it is innate to individuals and beyond what can be documented (Haldin Herrgard, 2000).


**Figure 13. The Iceberg analogy Explicit and Tacit knowledge**
Source: (Anttila et al., 2001)

Organizations should keep documentation of past experiences and make it accessible to others so that as many individuals as possible will be aware of past events and be able to profit from them, enhancing their ability to make judgments on various organizational challenges (Chawla & Joshi, 2010).

It is vital to document and organize data. Old employees' expertise, knowledge, and wisdom may be saved and used to educate new ones. Therefore, the organization converts the tacit knowledge into explicit knowledge by applying different techniques, such as experience groups (McIver et al., 2013).

In organizations, there are four tacit and explicit knowledge transmission mechanisms Figure 14: socialization, externalization, internalization, and combination (Nonaka, 1994;

Nonaka & Konno, 1998). Socialization is conveying tacit information to another individual, who encodes this new tacit knowledge. Socialization can be conducted casually, such as over coffee, over lunch, or officially, as in a mentorship program. Due to the personal character of tacit-to-tacit information transmission, hierarchical management structures do not encourage this knowledge exchange.

Externalization encodes tacit information in an explicit format, such as email or business correspondence. Internalization is the process of gaining access to explicit knowledge, which is subsequently "learned" by the individual and incorporated into their tacit knowledge resources. When explicit sources, such as a vast organizational database, are accessed and understood by an individual, context is always added to knowledge. The combination is the translation of explicit information into a new explicit format, which may include the inclusion of additional contexts or simply modifying the explicit knowledge's encoding format. Externalization, internalization, and combination are all assisted by research in information technology.

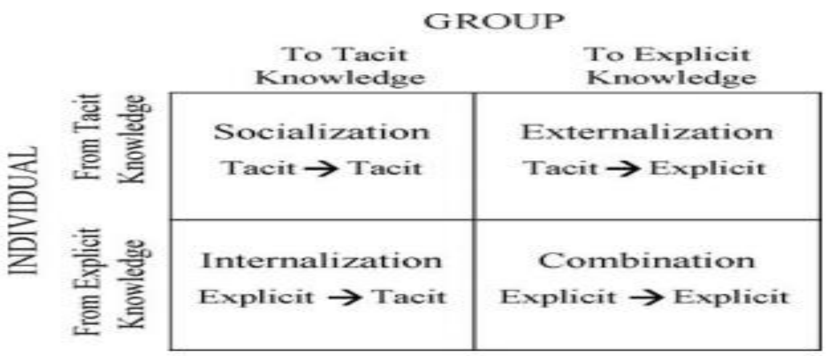


**Figure 14. The organizational knowledge creation model**
Source: (Nonaka & Takeuchi, 1995)

### 2.3.3 Knowledge Management definition

According to the researchers, many definitions are provided to explain the concept of Knowledge management. KM is defined as the creation, interpretation, dissemination, and use of knowledge (O'Dell & Hubert, 2011b). Where others defined KM as an approach to improving and simplifying the process related to the knowledge within the organization, including creating, capturing, sharing, distributing, and understanding knowledge (Girard & Girard, 2015). KM can also be defined as an interaction between technologies, tools, and human resources that help organizations acquire, transfer, share, apply and use organizational knowledge to use organizational goals, problem-solving, decision-making, learning, and strategic planning (Dalkir, 2005).

It is a systematic and organizationally defined process for sharing, transferring, creating, utilizing, and archiving company data to improve organizational performance (Davenport & Prusak, 1998; Shahzad et al., 2016). KM is also defined as accumulating and generating knowledge efficiently, facilitating sharing of knowledge, and managing its base to improve the organisation effectively (Akbari & Ghaffari, 2017). Organisations can improve the knowledge collection, use, and dissemination process to enhance their memory and improve its utility by finding systematic mechanisms to link workers to knowledge sources (Kordab & Raudeliūnienė, 2018).

In light of the previous definitions, the researcher believes that knowledge management is a dynamic process that includes activities and practices aimed at identifying, developing, distributing, using, preserving and facilitating knowledge retrieval. As knowledge management is a sequential and integrative process, as one stage depends on the other, integrates with it and supports it.

### 2.3.4 Knowledge Management Processes

Laudon & Laudon (2004) believe that knowledge management seeks to obtain knowledge, document it, organize it and enable access to it. These operations have become a strategic asset that depends on the success and survival of the organization. Kucza (2001) indicates that the general task of knowledge management is to manage the process of creating, storing and sharing knowledge, in addition to other related tasks. Rashid et al. (2021) stress that most of the concepts of knowledge management, its approaches and models focused on that knowledge management are a set of processes directed towards creating, capturing, storing, sharing, applying and reusing knowledge.

The primary purpose of knowledge management is to provide the proper knowledge to the right person at the right time, thus increasing the efficiency and effectiveness of the decisions taken (O'Dell & Hubert, 2011b). King (2009) indicates that knowledge tool processes improve business, including creativity, individual learning, group learning and decision-making. Consequently, it improves intermediate processes, including organizational behaviour, decisions, processes, products, services and customer relations, leading to improved strategic performance. KM processes are a sequential and complementary series despite the differences between researchers and writers in determining their number and name (Kordab & Raudeliūnienė, 2018). The four core KM processes identified by Mertins et al. (2001), including knowledge creation, storage, distribution, and application, will be adopted in this work. Brief explanations of each are addressed in the following paragraphs:

### 1- Knowledge Creation

As per Wee & Chua (2013), knowledge creation refers to developing new ideas through explicit knowledge interactions between people. The process of acquiring knowledge comprises the organization's ability to extract information and ideas from the external and internal environment (Mills & Smith, 2011). Therefore, knowledge enters organisations by enabling employees to learn from external sources, such as developing greater awareness of customer directions (Sangari et al., 2015).

Concerning knowledge creation and knowledge access, Lueg (2001) claimed that knowledge is dependent not only on information processing but also on standard clarification of the information and the weighting of the knowledge. Moreover, employees at all levels arrange meetings to exchange information and develop constructive conversations to accomplish the organization's goals. Some academics define knowledge generation as the interaction between tacit and explicit knowledge, manifested through four modalities of knowledge conversion: socialization, externalization, combination, and internalization. Socialization is the process of transferring tacit knowledge from person to person. In contrast, externalization converts tacit to explicit knowledge. The combination combines different forms and sources of explicit knowledge, such as documents and computerized data. Finally, internalization is the process that converts explicit to tacit knowledge (de Sousa & Van Dierendonck, 2010).

Knowledge generation entails exchanging and disseminating human experience; it occurs at two organizational levels: between individuals and organizations. Sharing between people brings together individual distinctions and may be utilized to generate new information. Still, sharing between organizations is a potential source of knowledge and is crucial for knowledge acquisition (Gold et al., 2001).

### 2- Knowledge Sharing

Knowledge sharing refers to knowledge distribution, transfer, and diffusion (Newman & Conrad, 2000). Knowledge transfer is the first step in implementing knowledge sharing and is concerned with appropriate knowledge to the right person at a reasonable cost (Känsäkoski, 2017). Knowledge transfer refers to joint activities with the flow of knowledge from one group to another, including communications, translation, transition, technical aspects, and performance. Most knowledge processes are carried out through communication as it is considered more flexible and easier to move across the organisational units.

### 3- Knowledge Application

Knowledge Application grants individual and group learning processes that lead to new knowledge creation. This process refers to knowledge use, reuse, and exploitation. Hence, it is often called a closed-loop KM process (Mills & Smith, 2011). All KM processes are not helpful unless knowledge is put to practical use. Workers must realize that knowledge is available and have sufficient freedom to use and apply it, which requires a culture to support learning and change (Chang & Lin, 2015). Through tools such as experience groups and quality circles, businesses transform implicit information into explicit knowledge for application. Experience-based knowledge is applied by organizations in the form of problem-solving and the creation of new products and services (Jensen et al., 2007).

### 4- Knowledge Storage

Knowledge storage processes are those processes that include retention, maintenance, search, access, and retrieval. The storage of knowledge is essential, especially for organizations with high employee turnover rates, as those employees often take their undocumented tacit knowledge with them (Kianto et al., 2016). The process of storing knowledge goes into organizational memory in various forms, including written documents, stored information in electronic databases, human knowledge stored in expert systems, and knowledge stored in documented organizational procedures and processes (Sangari et al., 2015).

Information and communication technology is essential in improving and expanding organizational memory and retrieving stored information and knowledge. Knowledge storage bridges knowledge capture and retrieval (Vahedi & Irani, 2011). Tools such as the

Knowledge Directory and the Document Management Model are used to access knowledge.

### 2.3.5 Benefits of knowledge management

It has been demonstrated that a company's intellectual capital is precious if it is to endure economic downturns. This occurs because the globe has transitioned from an industrial economy, in which the fundamental consumptions were material-based (e.g. assembly lines and hierarchical control), to a global, decentralized, information-driven economy saturated with data (Paliszkiewicz, 2021). Powell & Snellman (2004) argued that organizations are progressively moving toward a knowledge economy by depending more on intellectual talents than physical inputs and knowledge-intensive activities in production and service delivery. The knowledge economy is defined as production and services based on knowledge-intensive activities that contribute to faster technical and scientific progress and quick obsolescence (Sukharev, 2021).

Quast (2012) provides three reasons why managing knowledge is essential to company success, highlighting the significance of KM. It aids decision-making by giving managers the facts and knowledge required to make better, more educated, high-quality judgments that are advantageous to their organization. Knowledge management creates a learning organization by integrating CI into daily activities and assignments and highlighting successes and failures. This allows a company to increase its expertise and enhance its business procedures. It promotes cultural transformation by encouraging managers to share their ideas and insights, frequently resulting in innovation (Sin et al., 2015).

With KM's adoption, employees' training requirements may be identified and increased appropriately. By analyzing the workforce's knowledge gaps, managers may build training programs tailored to each employee's job requirements and aligned with the organization's strategic objectives. It also harvests tacit knowledge by inventing tools and ways for people to use in the workplace, enhancing businesses' value-creating ability. This may be accomplished by building communities of practice (CoP) where team sharing and communication can be promoted and implementing systems that assist it (Peñarroja et al., 2019).

Dalkir (2013) sees the importance of knowledge on three levels:

- **At the level of individuals:** It helps individuals during a business performance by saving time by improving the decision-making process, solving problems, enhancing community ties within the institution, and increasing the opportunity to achieve goals.
- **At the level of groups**: it works on developing functional skills, enhancing the effectiveness of networks, collaborative work, and sharing knowledge in developing the language of participation within the organization.
- **On an organizational level:** Knowledge management contributes to driving the strategy, achieving its goals, and disseminating best practices within the organization, thus improving the integration of knowledge. Moreover, it increases opportunities for innovation and building organizational memory.

### 2.3.6 Knowledge management impediments

Knowledge management faces several problems during implementation (Arqawi et al., 2018), including the following:

- **Isolation:** the implementers of the knowledge management system may work away from other employees, which causes them to be isolated. This may lead to building capabilities and capabilities that are compatible with the personal system's beliefs, which is reflected in their conviction of the operational and functional activities and works that the higher management may not prefer.
- **The lack of a sufficiently qualified HR** to carry out the knowledge management tasks indicates an evident lack of training programs and targeted quality.
- **The lack of the necessary infrastructure** means failure that leads to negative repercussions for the organization.
- **The gap between potential and ambition:** knowledge management, after its application, is expected to achieve the competitive advantage that the organization seeks.

Pfeffer & Sutton (2000) indicate that there are errors in knowledge management during its application in the organization, including a lack of procedural and practical definitions of terms and a monopoly of information by senior management. Therefore, it prevents access to stakeholders and circulation at the middle and lower levels. It is not employing knowledge to spread a shared understanding about issues and phenomena related to its topics. The knowledge difference level among the workers leads to different attitudes about the interpretation and justification of knowledge. Moreover, one of the leading knowledge barriers is a lack of interest in tacit knowledge from which explicit knowledge can be derived.

The application of knowledge management also faces a set of challenges, which are as follows:

- **Organizational culture:** Knowledge management requires the prevailing cultural values to be appropriate and compatible with continuous learning and knowledge management principles. Effective leadership takes care of knowledge and the factors that help and motivate the adoption of the concept of knowledge management. The organizational culture should also encourage team spirit at work, exchange ideas and help others (Singh et al., 2011). Organizational culture includes three essential components. Values refer to what members of the organization believe to be best and will achieve desirable results and express the organization's ambition. Values are judgments the individual acquires and determine the areas of his thinking and behaviour. Values may be positive, such as respecting time, or negative, if they are the opposite. The second element is norms, which are the common standards for how people behave within the organization while they are in the process of completing their work. The third criterion is the practices, which mean the formal or informal procedures followed when carrying out the required activities and tasks, such as the steps of the project implementation process (Khan & Rashid, 2012).

- **Organizational Challenges:** Organizational challenges include:

Organizational Structure: The organizational structure plays a crucial role in knowledge management. It may aid knowledge management within the organization, lead to unintended results, and represent an obstacle to cooperation and knowledge sharing within the organization (Danish et al., 2012). One of the challenges facing the organizational structure is that it encourages individual behaviour within one of the organizational units and withholds knowledge from the rest of the units. In addition, the hierarchical organizational structure, characterized by stagnation, is an obstacle to knowledge management programs (Balodi, 2014).

Leadership: Leadership plays a critical role in the management of knowledge. The leader is the model and role model for others. Just as there is a method of learning by doing, it is also necessary to adopt it through example. The leader is responsible for building, continuity and success of an organization with individuals, groups and work teams seeking to develop their capabilities continuously. The leader also bears the burden of designing knowledge management strategies in the organization and determining the role assigned to each individual or workgroup (Xue et al., 2011).

- **Technological challenges:** Some see technology as the most critical determinant of knowledge management. Organizations that employ technology in the best way to manage knowledge will be better able to survive and continue in light of the current competition in the market for goods and services. Information technology is used to collect, classify, prepare, store and communicate data between devices, people, and organizations through multiple media. Using information technology in knowledge management programs would improve workers' abilities. Therefore, they communicate with each other because there are no barriers that exist due to place, time and job title, in addition to providing more flexibility in dealing with information and data due to the presence of databases (Yildirmaz et al., 2018).

In light of this, the technical infrastructure, physical components and devices must be available for entering, processing and retrieving data and information. Thus, it is integrated with software to support knowledge management and organizational learning through the freedom to access and share knowledge using technological media such as e-mail and a decision support system.

### 2.4 Lean Six Sigma and Knowledge Management

This section will identify possible synergies between Lean Six Sigma and knowledge management. Although a considerable connection between them is hypothesized, there is a paucity of scholarly study on their potential relationship. Cooperating with employees at every process level is a crucial element of LSS. Group work involves cooperation, exchanging ideas, collaborative problem-solving, and deliberation (Pinjari & Teli, 2018). According to Lean Six Sigma, every decision is based on actual data and facts. We are collecting, measuring, and analyzing data. Following Lean Six Sigma, data on client satisfaction, corporate financial position, process speed, and defects should be collected and analyzed (Maleszka & Linke, 2016). Figure 15 depicts how the classification of KM components in LSS projects has been constructed.

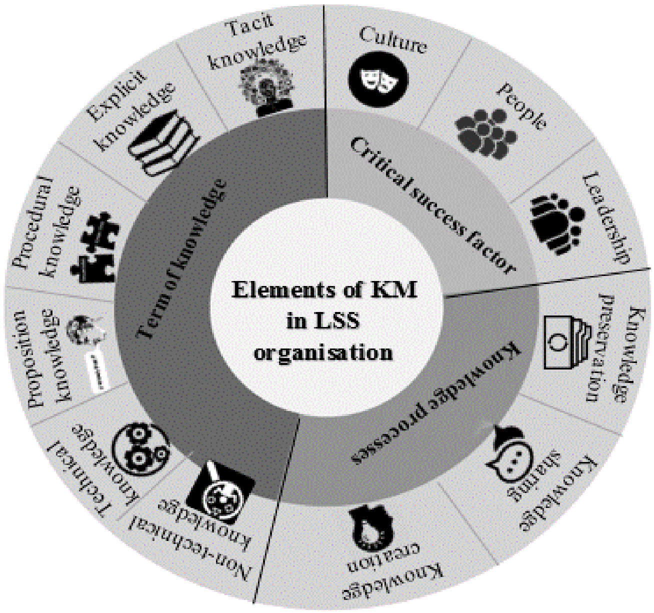


**Figure 15: elements of KM in LSS.**
Source : (Muhammad & Chin, 2020)

### 2.4.1 Six Sigma and Knowledge Management synergy

KM and Six Sigma are effective techniques for optimizing company operations. KM is concerned with how an organization acquires, stores, and shares information that contributes to achieving business objectives, whereas Six Sigma implementation seeks to eliminate deviations using statistical techniques (Pinjari & Teli, 2018). An inadequate understanding of Six Sigma deployment reduces the organization's best results and competitiveness. Coaching, expertise with human resources (Zu & Fredendall, 2009), and development are crucial to the Six Sigma project execution. Hahn & Doganaksoy (2011) and Snee (1999) recognize the importance of Six Sigma training and development for an organization's personnel. Six Sigma methodology adoption requires individuals to possess statistical and non-statistical abilities.

Knowledge Management contributes to the maintenance of Six Sigma's benefits by creating networks and communities of practice (CoP) that boost the sharing, transfer, and reapplication of best practices by developing KM platforms that ease team engagement. Six Sigma results may stabilise, allowing for the durability of improvement benefits. KM has a synergistic relationship with Six Sigma by fostering a learning culture through training, knowledge generation, and distribution, hence building mechanisms that aid in accelerating Six Sigma's learning cycle (Strubelt & Mollenhauer, 2019). By making prior Six Sigma project documentation standards readily available for reapplication, KM also aids in preventing the duplication of Six Sigma initiatives through benchmarking. Because Six Sigma is an analytical technique, the findings of the different metrics may be effectively communicated to the teams and leadership through KM. With strategic objectives in mind, KM systems facilitate the connection between results and the bottom line, enhancing decision-making and planning (Leavitt, 2002).

### 2.4.2 Lean Manufacturing and Knowledge Management synergy

LM is mainly designed for the removal of all non-value-added operations and wastes while focusing on customer satisfaction. KM systems provide continuous learning, achieving the perfection level advocated by Lean (Caiado et al., 2018). CoPs are a KM approach that promotes team knowledge sharing. CoPs promote the sharing of Lean knowledge through benchmarking best practices, eliminating human and material waste in Lean programs. Both KM and Lean are customer-centric. While KM discovers customer requirements, Lean meets those demands through its continuous improvement cycle (Saini, 2015).

### 2.4.3 Knowledge Management in different LSS phases

#### 3.1. Define Phase

One of the many purposes of the define phase is to explain the issue comprehensively. Fundamentally, a pool filled with difficulties is required to take in all of them and identify the essential and crucial ones. Still, the issue is not apparent enough due to a lack of these resources (Sandner et al., 2020). In addition, KM inference, including descriptions of Knowledge maps, is an additional concern. The purpose of this technique is the organization's acknowledgement of its knowledge deficiencies (Sveiby, 2001). Understanding Pareto Chart, SIPOC Process Map, and Functional and Deployment Map is essential for a more accurate picture of the process during the Define phase (Gutierrez-

Gutierrez et al., 2016). The expression and selection of applicable principles in many sectors to separate the issue/problem is an additional positive aspect of KM at this phase.

Voice of Customer (VOC) is one of the fundamental motivations driving this Define phase. LSS has a comprehensive view of the consumer area. Customer KM is the technique which supports Voice of the Customer (VOCs) in KM. A confirmation has occurred because customer basics are unavailable in a trustworthy state or do not include every level. Moreover, Client Knowledge is a self-motivated method of practice, value, and practical origination. It denotes that the customer has the required knowledge for essential leadership in shopping and that the company has secured the client's understanding of knowledge and current requirements, which may be utilized in developing new items. Thus, a company's KM framework improves by assessing VOC in better form and clarifying the client's actual demand to make Critical To Quality decisions (CTQ) (Strubelt & Mollenhauer, 2019).

### 3.2. Measure Phase

Among the basic judgments at this level are the identification of critical concerns, the development of foresight through the application of knowledge, and the clarification of the dimensions and available LSS development. Knowledge frameworks and KM systems' significant achievements are developing a suitable infrastructure for encoding, storing, and retaining data and completing optimal extraction and deployment (Mohajan, 2017). The codification, arrangement, and acquisition of this stage's implications for future use include the consulting relationship of Six Sigma. One of the most crucial aspects that professionals must standardize is to verify future highlighted procedures and to help with possible evaluation (Aldairi et al., 2017).

### 3.3 Analyze Phase

The KM framework explicitly addresses this subject. The knowledge and comprehension of 5 Whys, Statistical Data Plots, Hypothesis Testing, and CTQ flow-down is especially crucial to the degree that the Analysis stage is intimidating (Nonthaleerak & Hendry, 2008). Choosing the best extract to bring to meetings to generate new ideas is one of the essential KM services to LSS (Bennet & Bennet, 2004).

### 3.4. Improve Phase

Integrating knowledge of critical rational combination, coordination, clarity, recognizing dangers, and executing an arrangement of configuration, modernization, conceptualization, and consulting are the improve phase's most important objectives (Womack & Jones, 1997). Fundamental leadership necessitates osmosis between an endless pool of information dispersed throughout an organization. It implies that a member of a primary organization must review vital information across organizations and attempt to exchange it within a specific timeframe. Seeking inadequacies, disseminating new information, and pushing toward creativity is among KM's most important motivations (Chen & Holsapple, 2009). Thoughts of specialists are ordinarily essential for detecting improvement responses. Henceforth, the speciality component, their appropriate judgment, and the integrity of analyzed prior experiences and expertise are assured. If these answers are insignificant, the company will continue to incur substantial losses (Sin et al., 2015).

### 3.5. Control Phase

Documentation, examination of change, and development of Improve phase findings into a durable framework are the most critical aspects of this phase. Moreover, group organization, accumulation and induction of lessons, prospective understandings, and the proposal of future manoeuvres are the systems of this stage that have a significant association with KM (Brown & Duguid, 2000). Change protection combines filed reports with the exploitation of tacit and explicit knowledge. Insofar as the Control stage is concerned, the knowledge and comprehension of Control Charts, Out-of-Control Action Plans, and Capability Flow-up are crucial (O'Dell & Grayson, 2004). Utilizing KM permits the incorporation of learned knowledge during the develop and control phase and the assumption of responsibility for their categorization, coding, storage, and dissemination. By continuously utilizing the KM learning cycle, businesses can be all-inclusive and promptly rebuild their course of action and schedule (Jalali et al., 2008).

### 2.4.5 Chapter Summary

This chapter reviewed the literature on the research subject in detail. The research relied on two separate topics: knowledge management and a Lean Six Sigma methodology. In a sense, these two topics are considered separate. Therefore, the literature related to each of them was studied separately. The last subchapter studied the available literature, which examined the possibility of linking the two topics. Also, this chapter extensively reviewed the literature related to LSS methodology because it is mostly unknown or there is no sufficient orientation in Jordan and most developing countries to apply it. This chapter introduced aspects of the LSS methodology and how each Lean Manufacturing and Six Sigma were synergized. Most of the tools used in this methodology were also acquainted, including DMAIC. On the other hand, knowledge management's development and the most important models used in knowledge management were identified. Finally, the interrelationships between knowledge management and LSS methodology were identified.

# CHAPTER THREE: Research Methodology

## 3.1 Introduction

This chapter deals with a description of the study's methodology through which its objectives can be achieved. A statement of the study's approach and society, the selected sample, and its characteristics are tackled in this chapter. Moreover, various statistical techniques used in this study are described in this chapter, including reliability and normal distribution.

## 3.2 Research Methods

The research methodology effectively organizes a group of diverse ideas to reveal that this phenomenon is formed (Anderson & Poole, 2019). The study employed an inferential (analytical) approach, concerned with procedures that infer the existence of findings in the statistical population through representative samples and, subsequently, the generation of quantitative data. This strategy seeks to create a database from which it can infer attributes or connections. It is included in the sample, and its features are inferred to be similar to the original population. The interpretation task primarily concerns the inferential analysis, " inferring and concluding." (Cooper et al., 2014).
Moreover, this study took an exploratory approach. This technique is beneficial for clarifying and analyzing the nature of a problem by defining its conditions, components, and dimensions, describing their interactions, doing data analysis, measuring, comprehending, and accurately describing the phenomena or problem holistically. As a result, it assists in generalizing the facts or knowledge retrieved and gives ideas and recommendations for resolving the issue (Sekaran & Bougie, 2016). The study also used the descriptive approach. This approach is concerned with collecting data through a sample and then organizing it, and it was described quantitatively and then presented in recursive tables. This approach summarizes and analyses the data by measuring the central tendency and dispersion (Cooper et al., 2014).

Some of the questionnaire items were based on the Summated Scales. This scale seeks to identify a matter's degree of agreement or disapproval. It is often referred to as the Likert scale and is shown in Figure 16. Outcome scales consist of several statements expressing a positive or negative attitude toward a particular subject. The participant is asked to respond accordingly and indicate his opinion, agreeing with the given statements on the scale. Each response is given a numerical score indicating a preference. Scores are collected to measure the participant's attitude toward an issue. We find that these five points constitute the scale; at the end of the scale, there is a strong agreement; on the other end, there is a strong disagreement, and between them, there are intermediate points. Each point on the scale bears a degree. The response that indicates the lowest degree of agreement is given 1, the most agreeable degree is given 5, and the same is given for each of the five responses (Kothari, 2020: 85).

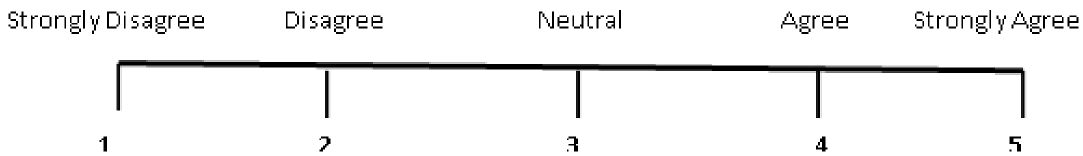


**Figure 16. Likert scale**

### 3.3 Population & Sample

The study population is defined as the complete enumeration of all the elements in any field of research. In many cases, it is impossible to study all members of the study population. Still, it is possible to obtain sufficiently accurate results by examining a part of the study population (a sample), considering time and cost. The participants selected should represent the entire study population to obtain a reduced cross-section (Saunders et al., 2009).

The primary purpose of sampling, which represents a small number of units, is to be representative of the study population and that events or facts are prevalent in this population (Kumar, 2019). The accuracy of the results depends mainly on how the sample is chosen. Therefore, sampling is the process of selecting a small number (sample) from a larger group to become a basis for estimating the result related to the larger group.

The study population consisted of government institutions counted 110 according to the Prime Minister's report 2020 (Prime Minister, 2020), and service institutions in the private sector. Their number is 1653 (Department of Statistics, 2020), and their registered capital with the Jordanian Ministry of Industry and Trade is 100,000 Jordanian dinars, representing medium-sized and large-sized organizations (CBJ, 2020). The researcher prepared an electronic questionnaire (Online Questionnaire) and published it via (Google forms) using the random sampling method. Only one employee in the upper and middle management within the available positions (managers and their assistants, heads of departments, and supervisors) can answer the questionnaire on behalf of their organization. Each company received only one questionnaire. After 60 days, 207 thoroughly answered electronic questionnaires were received. After checking and reviewing the questionnaires, the number of questionnaires represented by the study sample was 207, which constituted 11.7% of the study population. KMO (Kaiser-Mayers-Olkin) analysis was used to analyze the research sample statistically. This test is an analytical instrument used to determine the suitability of the sample size employed in the study (Field, 2018). A value of (KMO≥0.5) indicates that the study sample size is adequate.

**Table 3. KMO and Bartlett's Test**

| **KMO** | | **0.858** |
|---|---|---|
| **Bartlett's Test** | Approx. Chi-Square | 5190.125 |
| | degree of freedom (df) | 990 |
| | Sig. | 0.00 |

Source: Own Research 2022

The (KMO) test resulted in a value of 0.858 Table 3, which is larger than the expected value of sample size sufficiency. This result demonstrates that the study's sample size is adequate.

### 3.4 Data Sources:

1) **Secondary Data:**

The researcher consulted books and scientific research on the subject of the study and the World Wide Web (Internet), and numerous publication databases to gather the most recent and suitable worldwide research on the subject.

2) **Primary Data** :

A questionnaire designed in proportion to the study's factors served as the primary data source. The questions for the study instrument were developed uniquely for the current research following an intensive review of Knowledge management and Lean Six Sigma literature (see Chapter 2), followed by multiple brainstorming sessions with my supervisor and fellow academics in the field. The questionnaire's design was based on previous research published by researchers in the field of quality improvement and KM (i.e. (Al-Refaie & Hanayneh, 2014; Albliwi et al., 2015; Alhuraish et al., 2017; Arumugam et al., 2013; Chawla & Joshi, 2010; Delgado et al., 2010; Gowen Iii et al., 2008; Gutierrez

Gutierrez et al., 2016; Jeyaraman & Teo, 2010; Karamitri et al., 2020; Laureani & Antony, 2010; Lertwattanapongchai & William Swierczek, 2014; Mangotra & Mahajan, 2014; Modi & Doyle, 2012; Muhammad & Chin, 2020; Pamfilie et al., 2012; Raval et al., 2018; Rehman et al., 2015; Sony & Mekoth, 2019; Stankalla et al., 2018; Tsironis & Psychogios, 2016).

- Questions related to the basic information were as follows:

- What is your current position within the organization?
- What type of organization?
- The sector in which the organization operates?
- The age of the organization?
- Identify the three most important factors that determine the organisation's strategic goal?
- How many employees of the organization?

- Questions related to the level of application of Lean Six Sigma or quality standards were as follows:

- Which organization uses continuous improvement methodologies?
- Tools and methods used in quality development programs (use, benefit, which phase this tool was used for).

- Questions related to the level of knowledge management application were as follows:

- How did you know quality improvement methods, tools, and techniques?
- Measuring critical success factors (LSS) using (10) five-question alternatives according to the Five Likert Scale.

- Critical Success Factors (LSS) questions were as follows:

  - Measuring critical success factors (LSS) using (10) five-question alternatives according to the Five Likert Scale.

- Questions related to knowledge of knowledge management tools and (LSS) and their uses for quality improvement methods, their answer alternatives according to the Five Likert Scale. There were five questions for each phase of DMAIC to measure the application of KM in each phase.

A copy of the original questionnaire is provided in appendix A.

**3.5 Validity:**

The study instrument was presented to academic arbitrators to express their opinions (Appendix B). Therefore, they checked the study instrument from different aspects, including its suitability, adequacy, and comprehensiveness. Any other observations they deem appropriate concerning the amendment, change or deletion as the arbitrator deems necessary. This step helps ensure its content's diversity and evaluate the language formulation level.

The arbitrators' observations were studied, and modifications were made, such as clarifying some terms, amending some items to make them appropriate, and correcting some language errors.

### 3.6 Construct Validity：

Structural validity is one of the measures of validity of the tool, which measures the extent to which the objectives the instrument wants to reach and checks whether the instrument can measure the content for which it was designed. Table 4 shows the result of the structural validity. The value of the correlation coefficient (Pearson Correlation) was extracted, showing the extent to which each item is related. The scale with the total score determines the ability of each item on the scale to distinguish. The negative items or their correlation coefficient less than 0.30 are considered low, and it is preferable to delete them, while the items with more than 0.70 are considered distinct (Miller et al., 2013).

**Table 4. The degrees of correlation of the items of the scale with the total score of their axis**

| Knowledge Management | | |
|---|---|---|
| **N** | **Item** | **Correlation** |
| 1 | The Organization holds training sessions for workers on how to use knowledge to achieve specific goals | 0.793 |
| 2 | The Organization classifies data and then converts it into information to support decisions | 0.745 |
| 3 | The Organization's managers are aware that the Organization has a large stock of knowledge that is not invested and needs to be managed and organized | 0.811 |
| 4 | The Organization's opinions and experiences of the Organization are recorded and kept in databases | 0.807 |
| 5 | The organization is trying to gain knowledge from the surrounding regional institutions | 0.798 |
| 6 | The Organization has ways to distribute knowledge to its staff and make it available to all (notes, reports, e-mails, public meetings) | 0.727 |
| 7 | There is a department within the Organization to provides studies and research | 0.725 |
| 8 | Facilitate all employees' access to knowledge bases that you own | 0.839 |
| 9 | The Organization's strategic plan promotes the application of knowledge management | 0.816 |
| 10 | Transforming the tacit knowledge (residing in the employee's mind) of | 0.820 |

| N | Item | Correlation |
|---|---|---|
| | the experience owners into explicit knowledge through sharing and exchanging experiences. | |
| **Critical Success Factors** | | |
| **N** | **Item** | **Correlation** |
| 1 | Top management commitment and involvement | 0.613 |
| 2 | Adequate Training/coaching | 0.640 |
| 3 | Linking quality development to human resources (HR) reward system | 0.536 |
| 4 | Choosing the most talented people | 0.584 |
| 5 | Informal communication and open discussion | 0.697 |
| 6 | Linking quality development to business strategy | 0.686 |
| 7 | Adequate knowledge of quality development tools | 0.735 |
| 8 | high employee retention | 0.533 |
| 9 | Sufficient Organizational infrastructure | 0.660 |
| 10 | Understanding and awareness about quality development benefits the business | 0.482 |
| **Define Phase** | | |
| **N** | **Item** | **Correlation** |
| 1 | Hiring employees with a continuous improvement mindset is essential when employing quality development drivers | 0.719 |
| 2 | Do you think you can contribute to organizational performance with your ability to interpret, understand and use quality development know-how? | 0.736 |
| 3 | There are Formal channels for knowledge sharing (like meetings, courses, tours and similar activities) | 0.732 |
| 4 | An employee takes much time to get the relevant knowledge | 0.671 |
| 5 | Some tools help discover and obtain knowledge related to quality development from various sources. | 0.754 |
| **Measurement Phase** | | |
| **N** | **Item** | **Correlation** |
| 1 | There is/was a well-defined process for tracking and measuring the performance of quality development projects. | 0.634 |
| 2 | There are Well-defined processes for creating, capturing, and acquiring knowledge during the measure phase. | 0.789 |
| 3 | Technology is vital to disseminate knowledge related to measuring process performance. | 0.689 |
| 4 | knowledge sharing is seen as vital in the measure phase | 0.769 |
| 5 | Employees are trained to use appropriate tools and techniques to measure alternatives to work implementation procedures. | 0.717 |
| **Analyze Phase** | | |
| **N** | **Item** | **Correlation** |
| 1 | the role of appropriate Continuous Improvement Consultants/Experts is essential in quality development | 0.571 |
| 2 | The quality development expert help & coaching are/were sufficiently readily available for quality development projects. | 0.731 |
| 3 | Cooperation when creating new knowledge reduces the anxiety of responsibility in case of an error. | 0.824 |
| 4 | Organization employees realize the importance of knowledge | 0.812 |

| | | |
|---|---|---|
| | management in support of quality improvement activities | |
| 5 | Use past experiences and expertise as a basis for future work without starting from scratch | 0.817 |
| **Improvement Phase** | | |
| **N** | **Item** | **Correlation** |
| 1 | Process improvement is given high importance in the Organization. | 0.617 |
| 2 | The need to embark on Value-added Continuous improvement investments is critical in quality development | 0.832 |
| 3 | quality development has /had helped the Organization to be more customer-focused | 0.822 |
| 4 | Quality development improvements have /had resulted in the efficient utilization of resources (human, financial and system). | 0.849 |
| 5 | Quality development has/had considerably reduced process lead times & cycle times. | 0.812 |
| **Control Phase** | | |
| **N** | **Item** | **Correlation** |
| 1 | The review of appropriate Continuous improvement activities is critical in quality development | 0.750 |
| 2 | Top management takes an active interest in quality development and supports it continuously | 0.789 |
| 3 | The organization's strategy is reviewed based on research and studies aimed at improving services and customer satisfaction | 0.789 |
| 4 | Mistakes in work procedures are documented to be circulated and avoided in the future. | 0.655 |
| 5 | Internal best practices in the business are documented and circulated | 0.634 |

Source: Own Research 2022

We note from Table 4 that the value of the correlation coefficient for the items of the study tool ranged between (0.482-0.849), and all of them are more than 0.30 and bear a direct (+) trend. Therefore, this result indicates excellence for all the scale items, which is considered constructively proper.

**3.7 Reliability :**

The Cronbach Alpha Coefficient confirmed the reliability of the study instrument. This parameter is used to check the reliability and stability of the scale. It is one of the most common measurement scales of correlation between the scale components. It measures the respondents' answers' consistency to all the questions and the extent to which each question measures the concept. The questionnaire is considered stable if the Cronbach alpha value exceeds 0.70. A higher value of the correlation coefficient indicates a higher degree of stability. A number nearer to one indicates that the research instrument is more stable (Sekaran & Bougie, 2016).

**Table 5. Reliability statistics**

| Variable | Cronbach Alpha | N of Items |
|---|---|---|
| Knowledge Management | 0.932 | 10 |
| Critical Success Factors | 0.818 | 10 |
| Define Phase | 0.763 | 5 |
| Measurement Phase | 0.770 | 5 |
| Analysis Phase | 0.809 | 5 |
| Improvement Phase | 0.842 | 5 |
| Control Phase | 0.771 | 5 |
| **All Phases** | **0.913** | **25** |
| **All Items** | **0.928** | **45** |

Source: Own Research 2022

As seen in table 5, the value of (Cronbach Alpha) varied between (76.3% - 93.2 %). They are great values since they exceed the allowed percentage of 70 per cent and are highly reliable. We discover that for all objects, Cronbach Alpha equals 92.8%. As a result, the study instrument may be defined as reliable, and the data collected can be used to quantify variables.

### 3.8 Test Normal Distribution:

The Kolmogorov-Smirnov test was performed to check whether the data fell under a normal distribution. One of the normal distribution conditions for this test is that the Sig value of the data is higher than (0.05), which indicates that the data fall within the normal distribution (Field, 2018). The results are shown in Table 6.

**Table 6. Normal distribution of data based on (K-S)**

| Variable | Mean | SD | K-S | Sig |
|---|---|---|---|---|
| Knowledge Management | 3.69 | 0.754 | 1.134 | 0.153 |
| Critical Success Factors | 3.92 | 0.487 | 1.216 | 0.104 |
| Define Phase | 3.97 | 0.583 | 1.276 | 0.077 |
| Measure Phase | 3.86 | 0.622 | 1.256 | 0.085 |
| Analysis Phase | 3.85 | 0.673 | 1.347 | 0.053 |
| Improve Phase | 3.96 | 0.707 | 1.288 | 0.072 |
| Control Phase | 4.02 | 0.636 | 1.225 | 0.099 |

Source: Own Research 2022

The test data shown in Table 6 indicates that the data distribution was normal, where the Sig value was higher than (5%).

The value of the Skewness coefficient test was extracted, which is the degree of distance from symmetry. This test is used to determine the distribution's symmetry. A positive value (+) indicates that the distribution has reached a relative peak, and a negative value (-) indicates that the distribution is relatively flat. Outside the range of (±1) implies that the distribution is highly skewed. Moreover, the extracted Kurtosis value measures the degree of height at the top of the distribution or the flatness degree. Furthermore, the distribution is normal if the kurtosis value does not exceed ±2.58 (at the level of 0.01) and ±1.96 (at the level of 0.05) (Hair et al., 2018). The results are shown in Table 7.

**Table 7. Skewness and Kurtosis test.**

| Variable | Skewness | Kurtosis |
|---|---|---|
| Knowledge Management | -0.279 | -0.292 |
| Critical Success Factors | -0.002 | 0.217 |
| Define Phase | -0.127 | 0.023 |
| Measure Phase | -0.298 | 0.426 |
| Analysis Phase | -0.318 | -0.329 |
| Improve Phase | -0.480 | -0.332 |
| Control Phase | -0.118 | -0.572 |

Source: Own Research 2022

According to the test data in Table 7, the data distribution was normal, with Skewness values remaining within the range of (±1) and not exceeding the value of (Kurtosis) (±1.96).

### 3.9 Statistical methods used in the study

Table 8 shows the statistical methods utilized in the Statistical Package of Social Sciences (SPSS) programming. These tools were used to conduct deductive descriptive analysis to answer the study's questions.

**Table 8. Statistical methods used in this study**

| Statistical Method | Discerption |
|---|---|
| Frequencies and percentages | It determines the relative frequency distributions of the sample members' attributes and responses to questionnaire statements. |
| Arithmetic mean | It is employed as the primary measure of central tendency to determine the sample members' average responses to questionnaire items. |
| Standard Deviation | Standard deviation represents a dataset's dispersion compared to its mean. The standard deviation is computed as the square root of variance by calculating the relative deviation of each data point from the mean. |
| Pearson Correlation | Pearson Correlation is used to assess the structural validity of the scale by demonstrating the extent to which each item's degree is connected to the overall degree of its axis and determining the scale's capacity to identify individual items. |
| Cronbach Alpha | To test the reliability of the study instrument. |
| Skewness and Kurtosis | To find out whether the data fall within the normal distribution or not |
| One Sample T-test | The one-sample t-test is a statistical hypothesis test designed to assess if an unknown population mean differs from a given value. |
| One Way ANOVA | To determine the difference between the respondents' answers on a nominal scale and their answers on an interval scale. |
| Simple Regression | To assess the connection between two quantitative variables. Simple linear regression may determine the strength of the relationship between two variables. |

## 3.10 Chapter Summary

This chapter outlined the methodology, research design, and study instruments utilized in this quantitative research. All facets of the study technique, including demographic and sample selection, data collecting, and data analysis, were categorized. The next chapter presents the study's data analysis and findings.

# CHAPTER FOUR: Results

## 4.1 Introduction

The preceding chapters presented the study's orientation (Chapter 1), a literature review (Chapter 2), and the research methodology (Chapter 3). This chapter presents the results and interpretations of the primary research. The presentation of results is consistent with the study's aims. The outcomes of the propositions/hypotheses are given. The statistical application SPSS was utilized.

## 4.2 Descriptive statistics for demographic information

This section of the study will quantify the frequency and percentages of basic information provided by participants in their responses to the first section of the questionnaire. The following is a breakdown of their responses.

- ### 4.2.1 Descriptive statistics for the job position within the organization.

**Table 9. Descriptive statistics for a job position within the organization**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| Position within the Organization | 1 | CEO/ Director/ GM | 33 | %15.9 |
| | 2 | Quality Manager | 51 | %24.6 |
| | 3 | Assistant Manager | 46 | %22.2 |
| | 4 | HR Manager | 15 | %7.2 |
| | 5 | Departmental Head | 35 | %16.9 |
| | 6 | Supervisor | 16 | %7.7 |
| | 7 | Other | 11 | %5.3 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

As shown in Table 9, the most considerable portion of the sample was quality managers, which amounted to 24.6%, and their number was 51, followed by 22.2% assistant managers numbering 46, followed by 16.9% heads of departments and their number 35. followed by 15.9% for chief executives and managers, numbering 33, 7.7 for supervisors, numbering 16, followed by 7.2% for human resource managers, a total of 15, while 5.3%, which is the lowest percentage, was for those who work in other positions. That mentioned were distributed between an engineer, an operations management officer, a quality coordinator, and a consultant. The job title and the responsibility assigned to it differ from one organization to another due to the difference in the organization's size, the number of employees, and the nature of the organization's work. For example, in some organizations, there may be a specialized quality manager, while others perform these duties, the general manager or his deputy.

- **4.2.2 The descriptive statistics for the type of organization.**

**Table 10. Descriptive statistics for the type of organization**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **Type of Business** | 1 | Sole trader | 15 | %7.2 |
| | 2 | Limited Liability Company | 104 | %50.2 |
| | 3 | NGOs | 24 | %11.6 |
| | 4 | Government | 62 | %30 |
| | 5 | Other | 2 | %1 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

According to Table 10, the sample's peak percentage was for limited liability companies, which comprised 104 companies and accounted for 50.2% of the total. The government sector ranked second, which accounted for 30% of the sample, 11.6% of non-governmental organizations, and 7.2% of individual establishments. In contrast, the military and the sector of benevolent societies only made up 1%, the lowest percentage.

**Are there statistically significant differences at the level ($\alpha \leq 0.05$) of the sample responses average towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the type of organization?**

To answer this question, the arithmetic means and standard deviations of the sample answers towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase were calculated according to (type of organization). The results of which are shown in Table 11.

**Table 11. Descriptive analysis of the responses towards (KM, CSFs, and DMAIC phases) according to the type of organization.**

| Scope | Type of Business | Frequency | Mean | SD |
|---|---|---|---|---|
| **Knowledge Management** | Sole trader | 15 | 3.73 | 0.714 |
| | Limited Liability Company | 104 | 3.64 | 0.743 |

| Scope | Type of Business | Frequency | Mean | SD |
|---|---|---|---|---|
| | NGOs | 24 | 3.77 | 0.736 |
| | Government | 62 | 3.73 | 0.807 |
| | Other | 2 | 4.05 | 0.071 |
| **CSF** | Sole trader | 15 | 4.02 | 0.487 |
| | Limited Liability Company | 104 | 3.91 | 0.485 |
| | NGOs | 24 | 3.85 | 0.390 |
| | Government | 62 | 3.93 | 0.530 |
| | Other | 2 | 3.75 | 0.495 |
| **Define Phase** | Sole trader | 15 | 3.99 | 0.612 |
| | Limited Liability Company | 104 | 4.02 | 0.628 |
| | NGOs | 24 | 3.73 | 0.428 |
| | Government | 62 | 3.98 | 0.542 |
| | Other | 2 | 3.60 | 0.000 |
| **Measurement Phase** | Sole trader | 15 | 3.93 | 0.425 |
| | Limited Liability Company | 104 | 3.88 | 0.652 |
| | NGOs | 24 | 3.75 | 0.535 |
| | Government | 62 | 3.87 | 0.654 |
| | Other | 2 | 3.70 | 0.424 |
| **Analysis Phase** | Sole trader | 15 | 3.96 | 0.606 |
| | Limited Liability Company | 104 | 3.83 | 0.703 |
| | NGOs | 24 | 3.75 | 0.688 |
| | Government | 62 | 3.87 | 0.642 |
| | Other | 2 | 4.10 | 0.707 |
| **Improvement Phase** | Sole trader | 15 | 4.05 | 0.661 |
| | Limited Liability Company | 104 | 3.93 | 0.759 |
| | NGOs | 24 | 3.89 | 0.566 |
| | Government | 62 | 4.01 | 0.688 |
| | Other | 2 | 3.70 | 0.707 |
| **Control Phase** | Sole trader | 15 | 4.05 | 0.588 |
| | Limited Liability Company | 104 | 4.09 | 0.628 |
| | NGOs | 24 | 3.83 | 0.552 |
| | Government | 62 | 3.98 | 0.690 |
| | Other | 2 | 4.10 | 0.707 |

Source: Own Research 2022

The arithmetic means in Table 11 indicate apparent differences in the answers of the sample members towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the type of organization. One-way ANOVA was used to determine the statistical significance of differences in the sample estimates.

**Table 12. One Way ANOVA towards KM, CSFs, and the DMAIC Phases according to (type of organization).**

| | Variation source | Sum of Squares | DF | Mean Squares | F | Sig. |
|---|---|---|---|---|---|---|
| **Knowledge Management** | Between groups | 0.819 | 4 | 0.205 | 0.356 | 0.840 |
| | within groups | 116.192 | 202 | 0.575 | | |
| | Total | 117.011 | 206 | | | |
| **CSF** | Between groups | 0.347 | 4 | 0.087 | 0.362 | 0836 |
| | within groups | 48.470 | 202 | 0.240 | | |
| | Total | 48.817 | 206 | | | |
| **Define Phase** | Between groups | 1.866 | 4 | 0.467 | 1.385 | 0.240 |
| | within groups | 68.043 | 202 | 0.337 | | |
| | Total | 69.910 | 206 | | | |
| **Measurement Phase** | Between groups | 0.462 | 4 | 0.115 | 0.294 | 0.881 |
| | within groups | 79.177 | 202 | 0.392 | | |
| | Total | 79.638 | 206 | | | |
| **Analysis Phase** | Between groups | 0.612 | 4 | 0.153 | 0.334 | 0.855 |
| | within groups | 92.644 | 202 | 0.459 | | |
| | Total | 93.256 | 206 | | | |
| **Improvement Phase** | Between groups | 0.639 | 4 | 0.160 | 0.316 | 0.867 |
| | within groups | 102.187 | 202 | 0.506 | | |
| | Total | 102.826 | 206 | | | |
| **Control Phase** | Between groups | 1.420 | 4 | 0.355 | 0.875 | 0.480 |
| | within groups | 81.989 | 202 | 0.406 | | |
| | Total | 83.409 | 206 | | | |

Source: Own Research 2022

The results in Table 12 indicate no statistically significant differences at the level ($\alpha \leq 0.05$) in the sample members' response towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the organization type. The significance level (Sig) for all domains was higher than 0.05. These results indicate no association between the type of organisations and any KM or LSS factors. All tested organisations share the same level of implementation/knowledge about KM and LSS.

### 4.2.3 Descriptive statistics for the business sector.

**Table 13. Descriptive statistics of the business sector.**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **Business sector** | 1 | Governmental | 43 | %20.8 |
| | 2 | Healthcare | 15 | %7.2 |

| | | | | |
|---|---|---|---|---|
| | 3 | Banking and Finance | 12 | %5.8 |
| | 4 | Accommodations | 20 | %9.7 |
| | 5 | Telecommunications | 7 | %3.4 |
| | 6 | Transport and travel | 22 | %10.6 |
| | 7 | Educations | 10 | %4.8 |
| | 8 | Agriculture | 2 | %1.0 |
| | 9 | Automotive | 4 | %1.9 |
| | 10 | Business Consultancy | 7 | %3.4 |
| | 11 | Computing | 4 | %1.9 |
| | 12 | Domestic services | 7 | %3.4 |
| | 13 | Electronics | 2 | %1.0 |
| | 14 | Retail | 6 | %2.9 |
| | 15 | Energy | 4 | %1.9 |
| | 16 | Entertainment | 4 | %1.9 |
| | 17 | Environment | 4 | %1.9 |
| | 18 | Food | 8 | %3.9 |
| | 19 | Law and Legislation | 5 | %2.4 |
| | 20 | Property and Building | 11 | %5.3 |
| | 21 | Technical services | 9 | %4.3 |
| | 22 | Other | 1 | %0.5 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

As shown in Table 13, the maximum percentage of the sample is the governmental services sector of 20.8%, and their number is 43. followed by 10.6% in transportation and travel, numbering 22, and 9.7% in hotels, numbering 20. It is followed by 7.2% in health care, numbering 15. 5.8% of the sample was in banking and finance, 5.3% in real estate and construction and 4.8% in education, respectively, numbering 10. In contrast, 1.9% of their field of work is in the automotive, computing, energy, entertainment and environment sectors, and their number is 4 for each industry. Followed by 1% in their field of work in the agricultural and electronics sector, their number is 2 for each industry.

**Are there statistically significant differences at the level (α≤0.05) for the sample responses average towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to (the business sector)?**

The arithmetic mean and standard deviations of the sample responses toward KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase were calculated according to the business sector in which the organization operates. The arithmetic means in (Appendix C) indicate that there might be differences in the sample responses towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the business sector in which the organization operates. To know the statistical significance of differences in the sample estimates' arithmetic means, one-way ANOVA was used, and the results are shown in Table 14.

**Table 14. Way ANOVA for the sample responses towards KM, CSFs, and the LSS five phases according to the business sector.**

| | Variation source | Sum of Squares | DF | Mean Squares | F | Sig. |
|---|---|---|---|---|---|---|
| **KM** | Between groups | 8.213 | 21 | 0.391 | 0.665 | 0.863 |
| | within groups | 108.798 | 185 | 0.588 | | |
| | Total | 117.011 | 206 | | | |
| **CSFs** | Between groups | 2.664 | 21 | 0.127 | 0.509 | 0.965 |
| | within groups | 46.153 | 185 | 0.249 | | |
| | Total | 48.817 | 206 | | | |
| **Define phase** | Between groups | 5.352 | 21 | 0.255 | 0.730 | 0.798 |
| | within groups | 64.558 | 185 | 0.349 | | |
| | Total | 69.910 | 206 | | | |
| **Measure phase** | Between groups | 7.551 | 21 | 0.360 | 0.923 | 0.562 |
| | within groups | 72.088 | 185 | 0.390 | | |
| | Total | 79.638 | 206 | | | |
| **Analysis phase** | Between groups | 8.382 | 21 | 0.399 | 0.870 | 0.630 |
| | within groups | 84.874 | 185 | 0.459 | | |
| | Total | 93.256 | 206 | | | |
| **Improve phase** | Between groups | 8.447 | 21 | 0.402 | 0.788 | 0.732 |
| | within groups | 94.379 | 185 | 0.510 | | |
| | Total | 102.826 | 206 | | | |
| **Control phase** | Between groups | 8.440 | 21 | 0.402 | 0.992 | 0.476 |
| | within groups | 74.969 | 185 | 0.405 | | |
| | Total | 83.409 | 206 | | | |

Source: Own Research 2022

Table 14 indicate that there are no statistically significant differences at the level ($\alpha \leq 0.05$) of the study sample responses towards (KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase) according to the business sector in which the organization operates. The significance level (Sig) for all domains was higher than (0.05). This result emphasizes that not only does the organisational type have a limited preference/applicability to any of the KM and LSS components, but also, the sector has no impact. This indicates that all sectors and organisation types are exposed to the same load of input from those topics. Hence, prioritization based on LSS/CSF current implementation levels is not feasible for the Jordanian market and should rather follow a different proxy/indicator, such as economic productivity.

### 4.2.4 Descriptive statistics for the organization's age.

**Table 15. Descriptive statistics of the organization's age**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **Organization's Age** | 1 | 1 – 5 | 1 | %0.5 |
| | 2 | 6 – 10 | 5 | %2.4 |
| | 3 | 11 – 15 | 14 | %6.8 |
| | 4 | More than 15 years | 187 | %90.3 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

As shown in Table 15, the highest percentage of the study sample is the organization in which they worked for more than 15 years, amounting to 90.3% and their number 187. followed by 6.8% the age of the organization ranges between 11-15 years, and their number is 14, followed by 2.4% The age of the organization ranges between 6-10 years, and their number is 5, while 0.5% the age of the organization ranges between 1-5 years, and it was one. This indicates that most of the sample is from older companies, which presumably have sufficient resources for implementing LSS. This fact will be considered in the discussion.

**Are there statistically significant differences at the level ($\alpha \leq 0.05$) for the sample responses average towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to (the organization age)?**

The arithmetic mean and standard deviations of the sample responses towards knowledge management, critical success factors, define phase, measure phase, analysis phase, improve phase, and control phase were calculated according to the organization's age. The results of which are shown in Table 16.

**Table 16. Statistical analysis of the KM, CSFs, and LSS five phases according to the organization age**

| | Age group | Frequencies | Mean | SD |
|---|---|---|---|---|
| **KM** | 1 – 5 | 1 | 3.00 | - |
| | 6 – 10 | 5 | 3.58 | 0.716 |
| | 11 – 15 | 14 | 3.96 | 0.803 |
| | More than 15 years | 187 | 3.68 | 0.751 |
| **CSFs** | 1 – 5 | 1 | 4.00 | . |
| | 6 – 10 | 5 | 3.94 | 0.498 |
| | 11 – 15 | 14 | 3.79 | 0.556 |
| | More than 15 years | 187 | 3.92 | 0.484 |

| | Age group | Frequencies | Mean | SD |
|---|---|---|---|---|
| **Define phase** | 1 – 5 | 1 | 4.00 | - |
| | 6 – 10 | 5 | 3.72 | 0.363 |
| | 11 – 15 | 14 | 3.83 | 0.660 |
| | More than 15 years | 187 | 3.99 | 0.582 |
| **Measure phase** | 1 – 5 | 1 | 5.00 | - |
| | 6 – 10 | 5 | 3.60 | 0.510 |
| | 11 – 15 | 14 | 3.83 | 0.692 |
| | More than 15 years | 187 | 3.87 | 0.617 |
| **Analysis phase** | 1 – 5 | 1 | 4.40 | - |
| | 6 – 10 | 5 | 3.48 | 0.502 |
| | 11 – 15 | 14 | 3.80 | 0.684 |
| | More than 15 years | 187 | 3.86 | 0.677 |
| **Improve phase** | 1 – 5 | 1 | 4.20 | - |
| | 6 – 10 | 5 | 3.68 | 0.576 |
| | 11 – 15 | 14 | 3.86 | 0.658 |
| | More than 15 years | 187 | 3.97 | 0.716 |
| **Control phase** | 1 – 5 | 1 | 4.40 | - |
| | 6 – 10 | 5 | 3.80 | 0.529 |
| | 11 – 15 | 14 | 4.01 | 0.620 |
| | More than 15 years | 187 | 4.03 | 0.643 |

Source: Own Research 2022

The arithmetic means in Table 16 indicate apparent differences in the sample responses towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the organization age. To know the level of statistical significance of differences in the arithmetic means of the sample estimates, one-way ANOVA was used. The results are shown in Table 17.

**Table 17. One Way ANOVA for the sample responses towards KM, CSFs, and the LSS five phases according to the organization age.**

| | Variation source | Sum of Squares | DF | Mean Squares | F | Sig. |
|---|---|---|---|---|---|---|
| **KM** | Between groups | 1.608 | 3 | 0.536 | 0.943 | 0.421 |
| | within groups | 115.403 | 203 | 0.568 | | |
| | Total | 117.011 | 206 | | | |
| **CSFs** | Between groups | 0.261 | 3 | 0.087 | 0.364 | 0.779 |
| | within groups | 48.556 | 203 | 0.239 | | |
| | Total | 48.817 | 206 | | | |
| **Define phase** | Between groups | 0.635 | 3 | 0.212 | 0.620 | 0.603 |
| | within groups | 69.275 | 203 | 0.341 | | |
| | Total | 69.910 | 206 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Measure phase** | Between groups | 1.659 | 3 | 0.553 | 1.439 | 0.232 |
| | within groups | 77.980 | 203 | 0.384 | | |
| | Total | 79.638 | 206 | | | |
| **Analysis phase** | Between groups | 1.032 | 3 | 0.344 | 0.757 | 0.519 |
| | within groups | 92.224 | 203 | 0.454 | | |
| | Total | 93.256 | 206 | | | |
| **Improve phase** | Between groups | 0.620 | 3 | 0.207 | 0.410 | 0.746 |
| | within groups | 102.206 | 203 | 0.503 | | |
| | Total | 102.826 | 206 | | | |
| **Control phase** | Between groups | 0.396 | 3 | 0.132 | 0.323 | 0.809 |
| | within groups | 83.013 | 203 | 0.409 | | |
| | Total | 83.409 | 206 | | | |

Source: Own Research 2022

The results in table 17 indicate that there are no statistically significant differences at the level ($\alpha \leq 0.05$) in the answers of the study sample towards (KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase) according to the organization age. The significance level (Sig) for all domains was higher than (0.05), indicating a non-existing relationship between the organisation's age and KM and LSS.

### 4.2.5 Descriptive statistics for the factors determining the organization's strategic goal.

**Table 18. Descriptive statistics of the critical factors that determine the organization's strategic goal**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **The factors that define the company's strategic objective** | 1 | Profitability | 15 | %7.2 |
| | 2 | Flexibility | 5 | %2.4 |
| | 3 | Quality | 24 | %11.6 |
| | 4 | Market Share | 5 | %2.4 |
| | 5 | Innovation | 12 | %5.8 |
| | 6 | Other | 4 | %1.9 |
| | 7 | Flexibility+ Quality+ Innovation | 49 | %23.7 |
| | 8 | Profitability+ Flexibility+ Quality | 61 | %29.5 |
| | 9 | Market Share+ Profitability+ Quality | 32 | %15.5 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

As shown in Table 18, the highest percentage of the study sample had answers towards (profitability, flexibility, and quality), which amounted to 29.5%. 23.7% of answers were towards flexibility, quality, and innovation. In comparison, 15.5% were about increasing market share, profitability, and quality. On the other hand, 4.8% of answers were equally divided towards flexibility and the increase in market share, and their number was 10.

**Are there statistically significant differences at the level ($\alpha \leq 0.05$) for the sample responses average towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to (the organization's strategical goal)?**

The arithmetic mean and standard deviations of the sample responses towards knowledge management, critical success factors, define phase, measure phase, analysis phase, improve phase, and control phase were calculated according to the organization's strategic goal. The results of which are shown in Table 19.

**Table 19. Statistical analysis of the KM, CSFs, and LSS five phases according to the organization's strategic goal.**

| | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| KM | Profitability | 15 | 3.56 | 0.721 |
| | Flexibility | 5 | 3.94 | 0.958 |
| | Quality | 24 | 3.70 | 0.677 |
| | Market Share | 5 | 4.04 | 0.568 |
| | Innovation | 12 | 3.58 | 0.980 |
| | Other | 4 | 2.83 | 1.028 |
| | Flexibility+ Quality+ Innovation | 49 | 3.80 | 0.706 |
| | Profitability+ Flexibility+ Quality | 61 | 3.63 | 0.780 |
| | Market Share+ Profitability+ Quality | 32 | 3.77 | 0.690 |
| CSFs | Profitability | 15 | 3.87 | 0.279 |
| | Flexibility | 5 | 4.10 | 0.539 |
| | Quality | 24 | 3.97 | 0.436 |
| | Market Share | 5 | 4.20 | 0.316 |
| | Innovation | 12 | 3.92 | 0.678 |
| | Other | 4 | 3.73 | 0.984 |
| | Flexibility+ Quality+ Innovation | 49 | 3.96 | 0.491 |
| | Profitability+ Flexibility+ Quality | 61 | 3.89 | 0.506 |
| | Market Share+ Profitability+ Quality | 32 | 3.84 | 0.430 |
| Define phase | Profitability | 15 | 4.04 | 0.668 |
| | Flexibility | 5 | 4.08 | 0.438 |
| | Quality | 24 | 3.85 | 0.480 |
| | Market Share | 5 | 4.04 | 0.410 |
| | Innovation | 12 | 3.78 | 0.770 |
| | Other | 4 | 4.00 | 0.432 |
| | Flexibility+ Quality+ Innovation | 49 | 4.01 | 0.570 |
| | Profitability+ Flexibility+ Quality | 61 | 4.02 | 0.660 |
| | Market Share+ Profitability+ Quality | 32 | 3.91 | 0.471 |
| Measure | Profitability | 15 | 4.15 | 0.493 |

| | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| **phase** | Flexibility | 5 | 3.88 | 0.268 |
| | Quality | 24 | 3.92 | 0.595 |
| | Market Share | 5 | 4.16 | 0.261 |
| | Innovation | 12 | 3.90 | 0.756 |
| | Other | 4 | 3.65 | 0.379 |
| | Flexibility+ Quality+ Innovation | 49 | 3.84 | 0.681 |
| | Profitability+ Flexibility+ Quality | 61 | 3.83 | 0.676 |
| | Market Share+ Profitability+ Quality | 32 | 3.76 | 0.532 |
| **Analysis phase** | Profitability | 15 | 4.15 | 0.437 |
| | Flexibility | 5 | 4.12 | 0.179 |
| | Quality | 24 | 3.95 | 0.599 |
| | Market Share | 5 | 4.68 | 0.303 |
| | Innovation | 12 | 3.73 | 1.003 |
| | Other | 4 | 3.80 | 0.432 |
| | Flexibility+ Quality+ Innovation | 49 | 3.89 | 0.592 |
| | Profitability+ Flexibility+ Quality | 61 | 3.74 | 0.772 |
| | Market Share+ Profitability+ Quality | 32 | 3.64 | 0.564 |
| **Improve phase** | Profitability | 15 | 4.07 | 0.700 |
| | Flexibility | 5 | 4.20 | 0.721 |
| | Quality | 24 | 3.92 | 0.637 |
| | Market Share | 5 | 4.56 | 0.329 |
| | Innovation | 12 | 3.93 | 1.080 |
| | Other | 4 | 4.15 | 0.526 |
| | Flexibility+ Quality+ Innovation | 49 | 4.01 | 0.670 |
| | Profitability+ Flexibility+ Quality | 61 | 3.87 | 0.729 |
| | Market Share+ Profitability+ Quality | 32 | 3.86 | 0.663 |
| **Control phase** | Profitability | 15 | 4.33 | 0.368 |
| | Flexibility | 5 | 4.04 | 0.623 |
| | Quality | 24 | 3.89 | 0.572 |
| | Market Share | 5 | 4.76 | 0.358 |
| | Innovation | 12 | 3.83 | 0.687 |
| | Other | 4 | 3.80 | 0.816 |
| | Flexibility+ Quality+ Innovation | 49 | 4.10 | 0.668 |
| | Profitability+ Flexibility+ Quality | 61 | 3.96 | 0.663 |
| | Market Share+ Profitability+ Quality | 32 | 3.96 | 0.598 |

Source: Own Research 2022

The arithmetic means in Table 19 indicate apparent differences in the sample responses towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the organization's strategic goal. To know the level of statistical significance of differences in the arithmetic means of the sample estimates, one-way ANOVA was used. The results are shown in Table 20.

**Table 20. One Way ANOVA for the sample responses towards KM, CSFs, and the LSS five phases according to the organization's strategic goal.**

| | Variation source | Sum of Squares | DF | Mean Squares | F | Sig. |
|---|---|---|---|---|---|---|
| **KM** | Between groups | 5.354 | 8 | 0.669 | 1.187 | 0.309 |
| | within groups | 111.657 | 198 | 0.564 | | |
| | Total | 117.011 | 206 | | | |
| **CSFs** | Between groups | 1.182 | 8 | 0.148 | 0.614 | 0.765 |
| | within groups | 47.635 | 198 | 0.241 | | |
| | Total | 48.817 | 206 | | | |
| **Define phase** | Between groups | 1.258 | 8 | 0.157 | 0.453 | 0.887 |
| | within groups | 68.652 | 198 | 0.347 | | |
| | Total | 69.910 | 206 | | | |
| **Measure phase** | Between groups | 2.380 | 8 | 0.297 | 0.762 | 0.636 |
| | within groups | 77.259 | 198 | 0.390 | | |
| | Total | 79.638 | 206 | | | |
| **Analysis phase** | Between groups | 7.046 | 8 | 0.881 | 1.903 | 0.064 |
| | within groups | 68.969 | 198 | 0.463 | | |
| | Total | 76.015 | 206 | | | |
| **Improve phase** | Between groups | 3.349 | 8 | 0.419 | 1.900 | 0.574 |
| | within groups | 99.477 | 198 | 0.502 | | |
| | Total | 102.826 | 206 | | | |
| **Control phase** | Between groups | 5.837 | 8 | 0.730 | 1.862 | 0.068 |
| | within groups | 77.572 | 198 | 0.392 | | |
| | Total | 83.409 | 206 | | | |

Source: Own Research 2022

The results in Table 20 indicate that there are no statistically significant differences at the level ($\alpha \leq 0.05$) of the study sample towards (KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase) according to the organization's strategic goal. The significance level (Sig) for all domains was higher than (0.05), indicating that the strategic goal has little to no impact on KM or LSS.

### 4.2.6 Descriptive statistics for the number of employees.

**Table 21. Descriptive statistics for the number of the organization's employees**

| Variable | No | Group | Frequency | Percentage |
|---|---|---|---|---|
| **Number of the organization's employees** | 1 | 1-10 | 13 | %6.3 |
| | 2 | 11-49 | 62 | %30 |
| | 3 | 50-249 | 75 | %36.2 |
| | 4 | 250-1000 | 28 | %13.5 |
| | 5 | More than 1000 | 29 | %14 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

It is noted from Table 21 that the highest percentage of the study sample had their answers about the number of employees within the organization, ranging between 50-249 employees, amounting to 36.2% and their number 75. followed by 30% of employees number ranges between 11-49 and their number is 62, followed by 14% the number of employees more than 1000, and their number is 29, while 6.3%, which is the lowest percentage, answered that the number of employees ranged between 1-10. The sample suggests that the answers were normally distributed among all company sizes, with the highest weight leaning towards the 11-249 employee category.

**Are there statistically significant differences at the level ($\alpha \leq 0.05$) for the sample responses average towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to (the organization's number of employees)?**

The arithmetic means and standard deviations of the sample responses towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase were calculated according to the number of employees. The results of which are shown in Table 22.

**Table 22. Statistical analysis of the KM, CSFs, and LSS five phases according to the organization's number of employees.**

| | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| **KM** | 1-10 | 13 | 4.07 | 0.682 |
| | 11-49 | 62 | 3.68 | 0.733 |
| | 50-249 | 75 | 3.53 | 0.772 |
| | 250-1000 | 28 | 3.84 | 0.724 |
| | More than 1000 | 29 | 3.82 | 0.747 |
| **CSFs** | 1-10 | 13 | 3.94 | 0.482 |
| | 11-49 | 62 | 3.94 | 0.455 |
| | 50-249 | 75 | 3.94 | 0.489 |
| | 250-1000 | 28 | 3.82 | 0.544 |
| | More than 1000 | 29 | 3.88 | 0.511 |
| **Define phase** | 1-10 | 13 | 4.09 | 0.661 |
| | 11-49 | 62 | 3.98 | 0.660 |
| | 50-249 | 75 | 3.97 | 0.550 |
| | 250-1000 | 28 | 3.80 | 0.516 |
| | More than 1000 | 29 | 4.05 | 0.512 |
| **Measure** | 1-10 | 13 | 3.75 | 0.601 |

| | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| phase | 11-49 | 62 | 3.85 | 0.603 |
| | 50-249 | 75 | 3.94 | 0.670 |
| | 250-1000 | 28 | 3.71 | 0.526 |
| | More than 1000 | 29 | 3.88 | 0.634 |
| Analysis phase | 1-10 | 13 | 3.86 | 0.670 |
| | 11-49 | 62 | 3.86 | 0.735 |
| | 50-249 | 75 | 3.85 | 0.653 |
| | 250-1000 | 28 | 3.68 | 0.640 |
| | More than 1000 | 29 | 3.95 | 0.632 |
| Improve phase | 1-10 | 13 | 3.89 | 0.885 |
| | 11-49 | 62 | 4.01 | 0.710 |
| | 50-249 | 75 | 3.93 | 0.672 |
| | 250-1000 | 28 | 3.69 | 0.751 |
| | More than 1000 | 29 | 4.21 | 0.594 |
| Control phase | 1-10 | 13 | 4.29 | 0.575 |
| | 11-49 | 62 | 4.08 | 0.665 |
| | 50-249 | 75 | 3.92 | 0.568 |
| | 250-1000 | 28 | 3.79 | 0.625 |
| | More than 1000 | 29 | 4.29 | 0.667 |

Source: Own Research 2022

The arithmetic means in Table 22 indicate apparent differences in the sample responses towards KM, CSFs, define phase, measure phase, analysis phase, improve phase, and control phase according to the number of employees. To know the level of statistical significance of differences in the arithmetic means of the sample estimates, one-way ANOVA was used. The results are shown in Table 23.

**Table 23. One Way ANOVA for the sample responses towards KM, CSFs, and the LSS five phases according to the number of employees.**

| | Variation source | Sum of Squares | DF | Mean Squares | F | Sig. |
|---|---|---|---|---|---|---|
| **KM** | Between groups | 4.806 | 4 | 1.202 | 2.163 | 0.074 |
| | within groups | 112.204 | 202 | 0.555 | | |
| | Total | 117.011 | 206 | | | |
| **CSFs** | Between groups | 0.395 | 4 | 0.099 | 0.412 | 0.800 |
| | within groups | 48.423 | 202 | 0.240 | | |
| | Total | 48.817 | 206 | | | |
| **Define Phase** | Between groups | 1.188 | 4 | 0.297 | 0.873 | 0.481 |
| | within groups | 68.722 | 202 | 0.340 | | |
| | Total | 69.910 | 206 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Measure Phase** | Between groups | 1.219 | 4 | 0.305 | 0.785 | 0.536 |
| | within groups | 78.419 | 202 | 0.388 | | |
| | Total | 79.638 | 206 | | | |
| **Analysis phase** | Between groups | 1.137 | 4 | 0.284 | 0.623 | 0.646 |
| | within groups | 92.119 | 202 | 0.456 | | |
| | Total | 93.256 | 206 | | | |
| **Improve Phase** | Between groups | 4.183 | 4 | 1.046 | 2.141 | 0.077 |
| | within groups | 98.643 | 202 | 0.488 | | |
| | Total | 102.826 | 206 | | | |
| **Control phase** | Between groups | 3.177 | 4 | 0.794 | 2.112 | 0.084 |
| | within groups | 40.606 | 202 | 0.376 | | |
| | Total | 43.783 | 206 | | | |

Source: Own Research 2022

Table 23 indicate there are no statistically significant differences at the level ($\alpha \leq 0.05$) in the study sample responses towards (KM, success factors, definition phase, measure phase, analysis phase, improve phase, and control phase) according to the number of employees organization. The significance level for all dimensions was higher than 0.05. although, on a higher significance level ($\alpha \leq 0.05$), KM, in addition to both the improve and control phases, shows a statistically significant result, meaning that the number of employer might partially impact the improvement and control phases.

### 4.3 Descriptive statistics for the level of the LSS implementation.

This part of the study aims to indicate the frequencies and percentages of respondents' answers to the questions related to the second part of the questionnaire. The following is an explanation of their answers.

#### 4.3.1 Descriptive statistics for the organisation's continuous improvement methodologies.

**Table 24. Descriptive statistics of continuous improvement methodologies used in the organization**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **Continuous improvement methodologies** | 1 | Lean Management | 27 | %13 |
| | 2 | Six Sigma | 5 | %2.4 |
| | 3 | Lean Six Sigma | 6 | %2.9 |
| | 4 | Total Quality Management (TQM) | 58 | %28 |
| | 5 | Business Process Management (BPM) | 14 | %6.8 |
| | 6 | Business Process Re-engineering (BPR) | 8 | %3.9 |
| | 7 | PDCA | 6 | %2.9 |
| | 8 | TQM+BPR | 42 | %20.3 |

| | | | | |
|---|---|---|---|---|
| | 9 | Six Sigma + TQM + BPR | 33 | %15.9 |
| | 10 | BPM + BPR | 2 | %1 |
| | 11 | LM + TQM+BPR | 1 | %0.5 |
| | 12 | TQM+BPM+BPR | 5 | %2.4 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

Table 24 shows that 28% of the sample respondents chose TQM as their preferred technique for ongoing improvement. Where 20.3% chose TQM and process re-engineering. 15.9% chose Six Sigma, TQM, and process re-engineering, and 13% chose Lean management. 3.9% of the sample used process re-engineering, and 6.8% used business process management. On the other hand, 2.9% were equally distributed between the LSS and PDCA, and their number was only 6. Followed by 2.4% of answers were for TQM, business process management, and process re-engineering as an approach to continuous improvement. The same percentage and number were for Six Sigma, followed by 1% for managing work processes. The process re-engineering number was 2, while 0.5% of its answer was towards Lean management, TQM, and process re-engineering as an approach for continuous improvement.

If we look at the above result differently, we will find that the LSS methodology use is very little. In comparison, TQM was the most used tool among 139 organizations. This is due to a weakness in keeping pace with and researching the various new quality methodologies, as TQM was adopted early in Jordan as an integrated methodology for developing services.

### 4.3.2 Descriptive statistics for the tools and methods used in quality development programs.

This part of the study aims to show the frequencies, percentages, arithmetic means, standard deviations, and ranks of the respondents' answers regarding the tools and methods used in quality development programs. The following is an explanation of their answers.

- **Usage.**

**Table 25. Rank and descriptive analysis towards the tools used in quality development programs.**

| No | Tool | Frequency& percentage | Never used | Used once | Used rarely | Used Frequently | Used continuously | Means | SD | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Histogram | **Frequency** | 8 | 12 | 91 | 81 | 15 | 3.40 | 0.858 | 2 |
| | | **%** | 3.9 | 5.8 | 44 | 39.1 | 7.2 | | | |
| 2 | Scatter Diagram | **Frequency** | 17 | 87 | 69 | 31 | 3 | 2.59 | 0.892 | 17 |

| No | Tool | Frequency& percentage | Never used | Used once | Used rarely | Used Frequently | Used continuously | Means | SD | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| | (correlation) | **%** | 8.2 | 42 | 33.3 | 15 | 1.4 | | | |
| 3 | Tally charts (collecting data) | **Frequency** | 48 | 20 | 74 | 47 | 18 | 2.84 | 1.257 | 10 |
| | | **%** | 23.2 | 9.7 | 35.7 | 22.7 | 8.7 | | | |
| 4 | Statistical Process Control (SPC) | **Frequency** | 40 | 18 | 58 | 78 | 13 | 3.03 | 1.222 | 6 |
| | | **%** | 19 | 8.7 | 28 | 37.7 | 6.3 | | | |
| 5 | Pareto Diagram | **Frequency** | 56 | 27 | 63 | 61 | - | 2.62 | 1.171 | 16 |
| | | **%** | 27.1 | 13 | 30.4 | 29.5 | - | | | |
| 6 | Trend Chart | **Frequency** | 43 | 25 | 58 | 72 | 9 | 2.90 | 1.213 | 8 |
| | | **%** | 20.8 | 12.1 | 28 | 34.8 | 4.3 | | | |
| 7 | Measurement System Analysis (MSA) | **Frequency** | 33 | 25 | 84 | 50 | 15 | 2.95 | 1.137 | 7 |
| | | **%** | 15.9 | 12.1 | 40.6 | 24.2 | 7.2 | | | |
| 8 | ANOVA | **Frequency** | 90 | 27 | 59 | 31 | - | 2.15 | 1.141 | 24 |
| | | **%** | 43.5 | 13 | 28.5 | 15 | - | | | |
| 9 | Regression analysis | **Frequency** | 90 | 13 | 67 | 34 | 3 | 2.26 | 1.219 | 23 |
| | | **%** | 43.5 | 6.3 | 32.4 | 16.4 | 1.4 | | | |
| 10 | Process Flowchart/Mapping | **Frequency** | 13 | 25 | 66 | 80 | 23 | 3.36 | 1.038 | 3 |
| | | **%** | 6.3 | 12.1 | 31.9 | 38.6 | 11.1 | | | |
| 11 | Brainstorming | **Frequency** | 22 | 17 | 53 | 71 | 44 | 3.47 | 1.218 | 1 |
| | | **%** | 10.6 | 8.2 | 25.6 | 34.3 | 21.3 | | | |
| 12 | Relation diagrams | **Frequency** | 49 | 25 | 64 | 50 | 19 | 2.83 | 1.287 | 11 |
| | | **%** | 23.7 | 12.1 | 30.9 | 24.2 | 9.2 | | | |
| 13 | 5S Practice | **Frequency** | 83 | 20 | 52 | 43 | 9 | 2.40 | 1.314 | 19 |
| | | **%** | 40.1 | 9.7 | 25.1 | 20.8 | 4.3 | | | |
| 14 | Matrix diagram | **Frequency** | 53 | 30 | 79 | 27 | 18 | 2.65 | 1.237 | 15 |
| | | **%** | 25.6 | 14.5 | 38.2 | 13 | 8.7 | | | |
| 15 | FMEA (Failure Mode and Effect Analysis) | **Frequency** | 93 | 10 | 66 | 33 | 5 | 2.26 | 1.250 | 22 |
| | | **%** | 44.9 | 4.8 | 31.9 | 15.9 | 2.4 | | | |
| 16 | Kaizen | **Frequency** | 98 | 20 | 60 | 29 | - | 2.10 | 1.149 | 25 |
| | | **%** | 47.3 | 9.7 | 29 | 14 | - | | | |
| 17 | Cause & Effect /Fishbone (Ishikawa) Diagram | **Frequency** | 63 | 25 | 51 | 49 | 19 | 2.69 | 1.362 | 14 |
| | | **%** | 30.4 | 12.1 | 24.6 | 23.7 | 9.2 | | | |
| 18 | Project Priority Calculator | **Frequency** | 68 | 25 | 55 | 45 | 14 | 2.57 | 1.323 | 18 |
| | | **%** | 32.9 | 12.1 | 26.6 | 21.7 | 6.8 | | | |
| 19 | Benchmarking | **Frequency** | 34 | 29 | 63 | 58 | 23 | 3.03 | 1.236 | 5 |
| | | **%** | 16.4 | 14 | 30.4 | 28 | 11.1 | | | |
| 20 | 5-Why Analysis | **Frequency** | 64 | 14 | 55 | 57 | 17 | 2.75 | 1.363 | 12 |
| | | **%** | 30.9 | 6.8 | 26.6 | 27.5 | 8.2 | | | |
| 21 | Error-Proofing Poka-yoke | **Frequency** | 87 | 20 | 48 | 46 | 6 | 2.34 | 1.301 | 20 |
| | | **%** | 42 | 9.7 | 23.2 | 22.2 | 2.9 | | | |
| 22 | A3 Report | **Frequency** | 123 | 24 | 34 | 26 | - | 1.82 | 1.111 | 26 |
| | | **%** | 59.4 | 11.6 | 16.4 | 12.6 | - | | | |
| 23 | Control Plan | **Frequency** | 49 | 43 | 53 | 45 | 17 | 2.70 | 1.272 | 13 |
| | | **%** | 23.7 | 20.8 | 25.6 | 21.7 | 8.2 | | | |
| 24 | Standardized Work | **Frequency** | 48 | 15 | 72 | 58 | 14 | 2.88 | 1.242 | 9 |
| | | **%** | 23.2 | 7.2 | 34.8 | 28 | 6.8 | | | |
| 25 | Value Stream Analysis | **Frequency** | 88 | 24 | 51 | 38 | 6 | 2.28 | 1.264 | 21 |
| | | **%** | 42.5 | 11.6 | 24.6 | 18.4 | 2.9 | | | |
| 26 | VOC (Voice of Customer) | **Frequency** | 43 | 10 | 49 | 77 | 28 | 3.18 | 1.330 | 4 |
| | | **%** | 20.8 | 4.8 | 23.7 | 37.2 | 13.5 | | | |
| **The general indicator of the tools and methods used in quality development programs** | | | | | | | | **2.69** | **0.750** | |

Source: Own Research 2022

It is clear from Table 25 that the general indicator of the tools and methods used in quality development programs in the use phase has achieved an arithmetic mean of 2.69 and a standard deviation of 0.750, which indicates that service organizations in Jordan use the tools of quality development programs. The results showed that the most used tool is Brainstorming, which occupied the first place with an arithmetic mean of 3.47 and a standard deviation of 1.218. The tool Histogram came in second place with an arithmetic mean of 3.40 and a standard deviation of 0.858. While The Process Flowchart/Mapping ranked third in use with an arithmetic mean of 3.36 and a standard deviation of 1.038. The tool Voice of Customer (VOC) achieved the fourth usage rank with an arithmetic mean of 3.18 and a standard deviation of 1.330. The tool (Benchmarking) achieved the fifth usage rank with an arithmetic mean of 3.03 and a standard deviation of 1.236.

On the other hand, the (A3 Report) tool obtained the lowest arithmetic mean, which amounted to 1.82 and a standard deviation of 1.111. The arithmetic means indicate that this tool was not among the most used in service organizations in Jordan. The tool (Kaizen) came in the penultimate rank with an arithmetic mean of 2.10 and a standard deviation of 1.149, as this tool was not used mainly in service organizations in Jordan. Brainstorming, Histogram and Process Flowchart/Mapping were the most abundantly used tools, which is expected given that those tools require minimal implementation training.

- **Usefulness**.

**Table 26. Rank and descriptive analysis towards the benefit of the tools used in the quality development programs**

| No | Tool | Frequency and ratio | Not useful | Little useful | More useful | Very useful | mean | SD | Rank |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Histogram | **Frequency** | 14 | 58 | 75 | 60 | 2.87 | 0.910 | 5 |
| | | **%** | 6.8 | 28 | 36.2 | 29 | | | |
| 2 | Scatter Diagram (correlation) | **Frequency** | 19 | 88 | 70 | 30 | 2.54 | 0.852 | 14 |
| | | **%** | 9.2 | 42.5 | 33.8 | 14.5 | | | |
| 3 | Tally charts (collecting data) | **Frequency** | 14 | 93 | 70 | 30 | 2.56 | 0.821 | 12 |
| | | **%** | 6.8 | 44.9 | 33.8 | 14.5 | | | |
| 4 | Statistical Process Control (SPC) | **Frequency** | 15 | 77 | 60 | 55 | 2.75 | 0.932 | 7 |
| | | **%** | 7.2 | 37.2 | 29 | 26.6 | | | |
| 5 | Pareto Diagram | **Frequency** | 25 | 92 | 60 | 30 | 2.46 | 0.885 | 15 |
| | | **%** | 12.1 | 44.4 | 29 | 14.5 | | | |
| 6 | Trend Chart | **Frequency** | 20 | 72 | 85 | 30 | 2.60 | 0.852 | 9 |
| | | **%** | 9.7 | 34.8 | 41.1 | 14.5 | | | |
| 7 | Measurement System Analysis (MSA) | **Frequency** | 19 | 98 | 50 | 40 | 2.54 | 0.907 | 13 |
| | | **%** | 9.2 | 47.3 | 24.2 | 19.3 | | | |
| 8 | ANOVA | **Frequency** | 30 | 112 | 45 | 20 | 2.27 | 0.826 | 25 |
| | | **%** | 14.5 | 54.1 | 21.7 | 9.7 | | | |
| 9 | Regression analysis | **Frequency** | 35 | 92 | 55 | 25 | 2.34 | 0.899 | 22 |
| | | **%** | 16.9 | 44.4 | 26.6 | 12.1 | | | |
| 10 | Process Flowchart/Mapping | **Frequency** | 14 | 49 | 69 | 75 | 2.99 | 0.935 | 2 |
| | | **%** | 6.8 | 23.7 | 33.3 | 36.2 | | | |

| No | Tool | Frequency and ratio | Not useful | Little useful | More useful | Very useful | mean | SD | Rank |
|---|---|---|---|---|---|---|---|---|---|
| 11 | Brainstorming | **Frequency** | 19 | 44 | 55 | 89 | 3.03 | 1.007 | 1 |
| | | **%** | 9.2 | 21.3 | 26.6 | 43 | | | |
| 12 | Relation diagrams | **Frequency** | 25 | 93 | 59 | 30 | 2.45 | 0.885 | 16 |
| | | **%** | 12.1 | 44.9 | 28.5 | 14.5 | | | |
| 13 | 5S Practice | **Frequency** | 29 | 103 | 45 | 30 | 2.37 | 0.898 | 19 |
| | | **%** | 14 | 49.8 | 21.7 | 14.5 | | | |
| 14 | Matrix diagram | **Frequency** | 35 | 97 | 50 | 25 | 2.31 | 0.894 | 23 |
| | | **%** | 16.9 | 46.9 | 24.2 | 12.1 | | | |
| 15 | FMEA (Failure Mode and Effect Analysis) | **Frequency** | 30 | 97 | 45 | 35 | 2.41 | 0.935 | 17 |
| | | **%** | 14.5 | 46.9 | 21.7 | 16.9 | | | |
| 16 | Kaizen | **Frequency** | 39 | 99 | 24 | 45 | 2.36 | 1.024 | 20 |
| | | **%** | 18.8 | 47.8 | 11.6 | 21.7 | | | |
| 17 | Cause & Effect /Fishbone (Ishikawa) Diagram | **Frequency** | 19 | 74 | 49 | 65 | 2.77 | 0.996 | 6 |
| | | **%** | 9.2 | 35.7 | 23.7 | 31.4 | | | |
| 18 | Project Priority Calculator | **Frequency** | 20 | 83 | 54 | 50 | 2.65 | 0.953 | 8 |
| | | **%** | 9.7 | 40.1 | 26.1 | 24.2 | | | |
| 19 | Benchmarking | **Frequency** | 5 | 73 | 69 | 60 | 2.89 | 0.855 | 4 |
| | | **%** | 2.4 | 35.3 | 33.3 | 29 | | | |
| 20 | 5-Why Analysis | **Frequency** | 24 | 88 | 45 | 50 | 2.58 | 0.981 | 11 |
| | | **%** | 11.6 | 42.5 | 21.7 | 24.2 | | | |
| 21 | Error-Proofing Poka-yoke | **Frequency** | 39 | 98 | 45 | 25 | 2.27 | 0.905 | 24 |
| | | **%** | 18.8 | 47.3 | 21.7 | 12.1 | | | |
| 22 | A3 Report | **Frequency** | 27 | 140 | 25 | 15 | 2.14 | 0.725 | 26 |
| | | **%** | 13 | 67.6 | 12.1 | 7.2 | | | |
| 23 | Control Plan | **Frequency** | 43 | 69 | 70 | 25 | 2.37 | 0.946 | 18 |
| | | **%** | 20.8 | 33.3 | 33.8 | 12.1 | | | |
| 24 | Standardized Work | **Frequency** | 28 | 69 | 70 | 40 | 2.59 | 0.950 | 10 |
| | | **%** | 13.5 | 33.3 | 33.8 | 19.3 | | | |
| 25 | Value Stream Analysis | **Frequency** | 33 | 89 | 65 | 20 | 2.35 | 0.862 | 21 |
| | | **%** | 15.9 | 43 | 31.4 | 9.7 | | | |
| 26 | VOC (Voice of Customer) | **Frequency** | 14 | 63 | 60 | 70 | 2.90 | 0.952 | 3 |
| | | **%** | 6.8 | 30.4 | 29 | 33.8 | | | |
| **The general usefulness indicator of using the tools and methods of quality development programs** | | | | | | | **2.55** | **0.610** | |

Source: Own Research 2022

It is evident from Table 26 that the general indicator of the usefulness of the tools and methods of quality development programs has achieved an arithmetic mean of 2.55 and a standard deviation of 0.610. The results showed that the most helpful tool (Brainstorming) ranked first, with a mean of 3.03 and a standard deviation of 1.007. The Process Flowchart/Mapping tool came in second place in terms of interest, with a mean of 2.99 and a standard deviation of 0.935. In comparison, the Voice of Customer (VOC) tool achieved the third rank of interest with an arithmetic mean of 2.90 and a standard deviation of 0.952. The Benchmarking tool achieved the fourth order of interest with a mean of 2.89 and a standard deviation of 0.855. The tool Histogram achieved the fifth order of interest with a mean of 2.87 and a standard deviation of 0.910.

On the other hand, the tool A3 Report obtained the lowest arithmetic mean of 2.14, with a standard deviation of 0.725. The arithmetic means value indicates that this tool has not been used in service organizations in Jordan. The tool ANOVA came in the penultimate rank with a mean of 2.27 and a standard deviation of 0.826. This tool was rarely used in service organizations in Jordan, which can be attributed to a lack of understanding as a consequence of inadequate field training.

- **The phases were the tools used.**

**Table 27. Frequencies and percentages towards the phases in which the tools were used on quality development programs.**

| No. | Tool | Frequency and ratio | Don't Know | Define | Measure | Analyze | Improve | Control | More than phase |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Histogram | **Frequency** | 10 | 2 | 55 | 60 | 1 | - | 79 |
| | | **%** | 4.8 | 1 | 26.6 | 29 | 0.5 | - | 38.2 |
| 2 | Scatter Diagram (correlation) | **Frequency** | 13 | 10 | 9 | 105 | 50 | - | 20 |
| | | **%** | 6.3 | 4.8 | 4.3 | 50.7 | 42.2 | - | 9.7 |
| 3 | Tally charts (collecting data) | **Frequency** | 12 | 12 | 73 | 77 | 13 | - | 20 |
| | | **%** | 5.8 | 5.8 | 35.3 | 37.2 | 6.3 | - | 9.7 |
| 4 | Statistical Process Control (SPC) | **Frequency** | 12 | 5 | 56 | 70 | 4 | 40 | 20 |
| | | **%** | 5.8 | 2.4 | 27.1 | 33.8 | 1.9 | 19.3 | 9.7 |
| 5 | Pareto Diagram | **Frequency** | 7 | 12 | 70 | 73 | 2 | - | 43 |
| | | **%** | 3.4 | 5.8 | 33.8 | 35.3 | 1 | - | 20.8 |
| 6 | Trend Chart | **Frequency** | 12 | 33 | 90 | 44 | 12 | 2 | 14 |
| | | **%** | 5.8 | 15.9 | 43.5 | 21.3 | 5.8 | 1 | 6.8 |
| 7 | Measurement System Analysis (MSA) | **Frequency** | 39 | 22 | 92 | 29 | 5 | 8 | 12 |
| | | **%** | 18.8 | 10.6 | 44.4 | 14 | 2.4 | 3.9 | 5.8 |
| 8 | ANOVA | **Frequency** | 59 | 20 | 8 | 70 | 48 | - | 2 |
| | | **%** | 28 | 9.7 | 3.9 | 33.8 | 23.2 | - | 1 |
| 9 | Regression analysis | **Frequency** | 72 | 11 | 19 | 77 | 20 | 3 | 5 |
| | | **%** | 34.8 | 5.3 | 9.2 | 37.2 | 9.7 | 1.4 | 2.4 |
| 10 | Process Flowchart/Mapping | **Frequency** | 13 | 30 | 15 | 40 | 28 | 4 | 77 |
| | | **%** | 6.3 | 14.5 | 7.2 | 19.3 | 13.5 | 1.9 | 37.2 |
| 11 | Brainstorming | **Frequency** | - | 26 | 7 | 71 | 61 | 12 | 30 |
| | | **%** | - | 12.6 | 3.4 | 34.3 | 29.5 | 5.8 | 14.5 |
| 12 | Relation diagrams | **Frequency** | 52 | 91 | 10 | 33 | 7 | 9 | 5 |
| | | **%** | 25.1 | 44 | 4.8 | 15.9 | 3.4 | 4.3 | 2.4 |
| 13 | 5S Practice | **Frequency** | 81 | 66 | 5 | 6 | 43 | 1 | 5 |
| | | **%** | 39.1 | 31.9 | 2.4 | 2.9 | 20.8 | 0.5 | 2.4 |
| 14 | Matrix diagram | **Frequency** | 82 | 16 | 20 | 16 | 64 | 5 | 4 |
| | | **%** | 39.6 | 7.7 | 9.7 | 7.7 | 30.9 | 2.4 | 1.9 |
| 15 | FMEA (Failure Mode and Effect Analysis) | **Frequency** | 66 | 26 | 30 | 39 | 30 | 6 | 10 |
| | | **%** | 31.9 | 12.6 | 14.5 | 18.8 | 14.5 | 2.9 | 4.8 |
| 16 | Kaizen | **Frequency** | 102 | 6 | 10 | 3 | 32 | 44 | 10 |
| | | **%** | 49.3 | 2.9 | 4.8 | 1.4 | 15.5 | 21.3 | 4.8 |
| 17 | Cause & Effect /Fishbone (Ishikawa) Diagram | **Frequency** | 37 | 16 | 10 | 106 | 20 | 8 | 10 |
| | | **%** | 17.9 | 7.7 | 4.8 | 51.2 | 9.7 | 3.9 | 4.8 |
| 18 | Project Priority Calculator | **Frequency** | 62 | 91 | 15 | 13 | 19 | 2 | 5 |
| | | **%** | 30 | 44 | 7.2 | 6.3 | 9.2 | 1 | 2.4 |
| 19 | Benchmarking | **Frequency** | 37 | 52 | 35 | 16 | 50 | 7 | 10 |
| | | **%** | 17.9 | 25.1 | 16.9 | 7.7 | 24.2 | 3.4 | 4.8 |
| 20 | 5-Why Analysis | **Frequency** | 72 | 20 | 10 | 63 | 22 | - | 20 |
| | | **%** | 34.8 | 9.7 | 4.8 | 30.4 | 10.6 | - | 9.7 |

| No. | Tool | Frequency and ratio | Don't Know | Define | Measure | Analyze | Improve | Control | More than phase |
|---|---|---|---|---|---|---|---|---|---|
| 21 | Error-Proofing Poka-yoke | **Frequency** | 84 | 6 | 4 | 13 | 51 | 31 | 18 |
| | | **%** | 40.6 | 2.9 | 1.9 | 6.3 | 24.6 | 15 | 8.7 |
| 22 | A3 Report | **Frequency** | 121 | 32 | - | 4 | 42 | 3 | 5 |
| | | **%** | 58.5 | 15.5 | - | 1.9 | 20.3 | 1.4 | 2.4 |
| 23 | Control Plan | **Frequency** | 42 | 7 | 13 | 9 | 16 | 113 | 7 |
| | | **%** | 20.3 | 3.4 | 6.3 | 4.3 | 7.7 | 54.6 | 3.4 |
| 24 | Standardized Work | **Frequency** | 47 | 12 | 34 | 7 | 24 | - | 83 |
| | | **%** | 22.7 | 5.8 | 16.4 | 3.4 | 11.6 | - | 40.1 |
| 25 | Value Stream Analysis | **Frequency** | 50 | 93 | 15 | 24 | 13 | 2 | 10 |
| | | **%** | 24.2 | 44.9 | 7.2 | 11.6 | 6.3 | 1 | 4.8 |
| 26 | VOC (Voice of Customer) | **Frequency** | 66 | 11 | 10 | 48 | 36 | 16 | 20 |
| | | **%** | 31.9 | 5.3 | 4.8 | 23.2 | 17.4 | 7.7 | 9.7 |

Source: Own Research 2022

It is clear from Table 27 that the highest percentage of answers from the study sample about "I don't know" was for the tool (A3 Report), with a rate of 58.5% and a frequency of 121. The (Kaizen) tool ranked second with a percentage of 49.3 and a frequency of 102. On the other hand, the (Pareto Diagram) tool achieved the lowest responses rate of the study sample towards "I don't know", with a percentage of 3.4% and a frequency of 7. The tools (Tally charts (collecting data), Statistical Process Control (SPC), and Trend Chart) came in second place with a percentage of 5.8% and a frequency of 12 for each tool.

It turns out that the highest percentage of 44.9% and frequency of 93 was for the tool (Value Stream Analysis) used in the define phase. (Relation diagrams, Project Priority Calculator) ranked second with a percentage of 44% and a frequency of 91 for each tool. On the other hand, the Histogram achieved a minuscule rate of use in the define phase by 1%. The (Statistical Process Control (SPC)) tool came in the penultimate rank with a percentage of 2.4% and a frequency of 5.

The highest percentage of44.4% and frequency of 92 was for the tool (Measurement System Analysis (MSA)) used in the measurement phase. The (Trend Chart) tool ranked second with a percentage of 43.5% and a frequency of 90. On the one hand, the study sample responded that the tool (A3 Report) is not used in the measurement phase. The (Error-Proofing Poka-yoke) tool ranked last with a percentage of 1.9% and a frequency of 4. We note that the highest rate of 51.2% and frequency of 106 was for the tool (Cause & Effect / Fishbone (Ishikawa) Diagram) used in the analysis phase. The Scatter Diagram ranked second with a percentage of 50.7% and a frequency of 105. On the other hand, Kaizen achieved the lowest use rate in the analysis phase with 1.4%, and A3 Report came in the penultimate rank with 1.9%.

It was found that the highest percentage of 30.9% and frequency of 64 was for the tool (Matrix diagram) used in the improvement phase. In comparison, the (Brainstorming) tool came in second place with a percentage of 29.5% and a frequency of 61. On the other hand, the (Histogram) tool achieved a minuscule rate of use in the improvement phase by a percentage of 0.5% and by repetition 1. The (Pareto Diagram) tool came in the penultimate rank with a rate of 1% and frequency of 2. It is clear from the results of Table 17 that the highest percentage of 54.6% and frequency of 113 were for the (Control Plan) tool, which is used in the control phase.

In contrast, the tool (Kaizen) came in second place with a percentage of 21.3% and a frequency of 44. On the other hand, (Histograms, Scatter Diagrams (correlation), Tally charts (collecting data), Pareto Diagram, ANOVA, 5-Why Analysis, and Standardized Work) did not achieve any use in the control phase. The tool (5S Practice) came in second to last with a percentage of 0.5% and a frequency of 1.

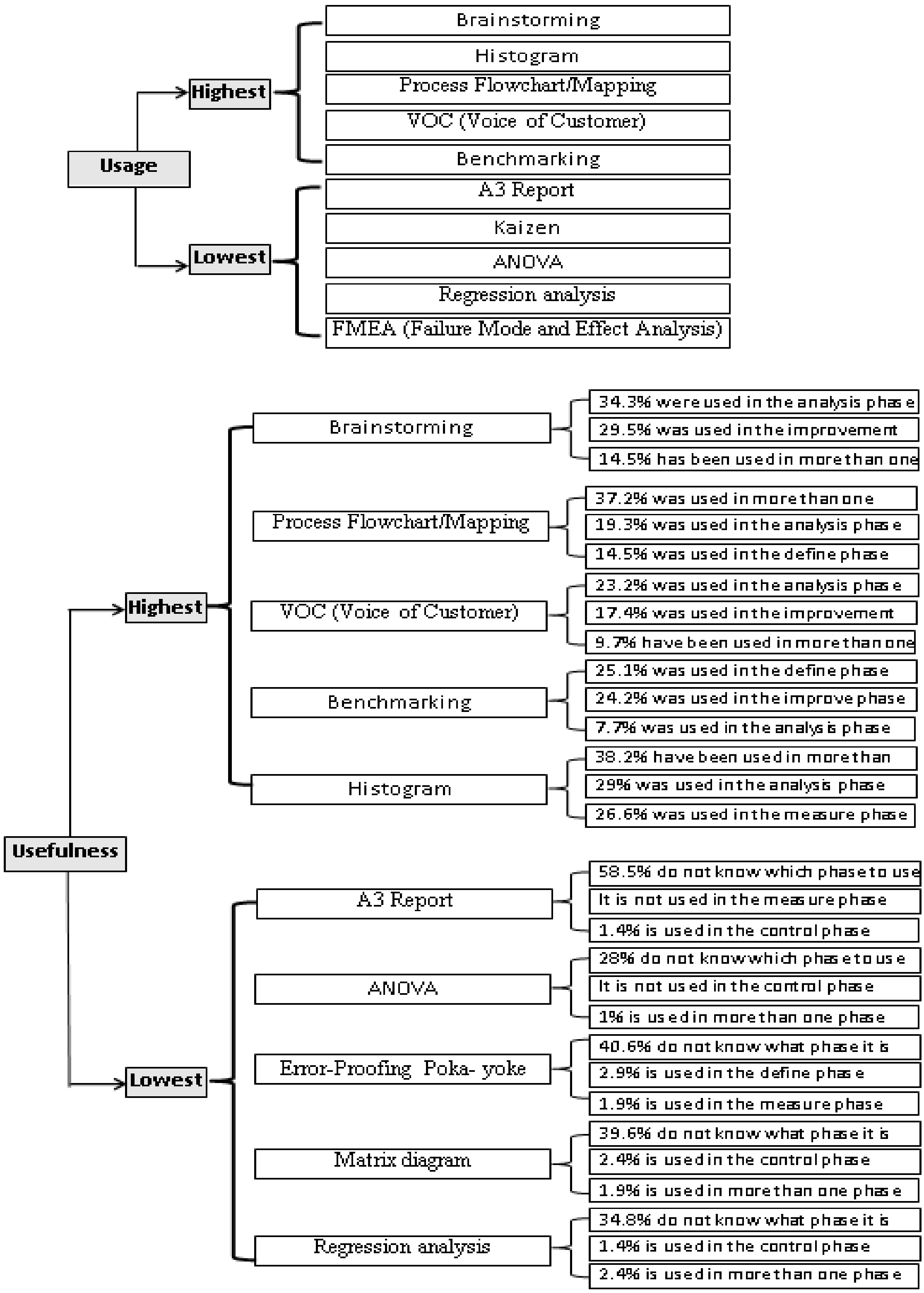


**Figure 17. Most and Least tools used in quality development programs**

Source: Own Research 2022

We note that the highest percentage of 40.1% and frequency of 83 was for the tool (Standardized Work), which is used in more than one phase. The (Histogram) tool came in second place with a percentage of 38.2% and a frequency of 79. On the other hand, the (ANOVA) tool achieved the lowest rate of use in more than one phase, with a percentage of 1% and a frequency of 2. The (Matrix diagram) tool came in the penultimate rank with a rate of 1.9% and a frequency of 4.

Based on the descriptive analysis of the ninth question (tools and methods used in quality development programs), The most critical highest and lowest five tools used, the extent of their usefulness, and at what stage they were used are summarized as shown in Figure 17.

### 4.4 Descriptive statistics for the level of KM implementation.

This part of the study aims to indicate the frequency and percentages of respondents' answers to the questions related to the third part of the questionnaire. The following is an explanation of their responses.

#### 4.4.1 Descriptive statistics for quality improvement methods, tools and techniques awareness.

**Table 28. Descriptive statistics for methods, tools and techniques for quality improvement**

| Variable | No | Category | Frequency | Percentage |
|---|---|---|---|---|
| **Learning ways of quality improvement methods, tools and techniques** | 1 | In-house training | 57 | %27 |
| | 2 | Company-sponsored training in organizations or institutes | 59 | %28.5 |
| | 3 | Conferences | 40 | %19.3 |
| | 4 | Internet / Distance learning | 32 | %15.5 |
| | 5 | Self-education, media, books or research articles | 16 | %7.7 |
| | 6 | Other | 3 | %1.4 |
| | **Total** | | **207** | **%100** |

Source: Own Research 2022

Table 28 shows that 28.5% of the survey sample indicated that they had learned about quality improvement methods, tools, and procedures through company-sponsored training in organizations or institutes. In-house training came in second with 27.5%, followed by Conferences with 19.3%. On the other hand, 15.5% used the Internet or distant learning, and 7.7% used media for self-learning. As a result of their bachelor's and master's studies and specialized training courses, 1.4% of respondents were aware of quality improvement methodologies, tools, and procedures.

We observe that the organisations place a lot of reliance on the training initiatives managed by them. At the same time, the majority of the percentage was for conferences, internal training programs, or programs run by external institutions. This assures the organization of training and educational outputs on the instruments employed to enhance the calibre of services.

### 4.4.2 Descriptive, inferential statistics for knowledge management.

This part aims to indicate the arithmetic means, standard deviations, the degree of agreement, the paragraphs rank at the arithmetic means, and the (T) value to describe the trends of the study sample towards knowledge management, which were measured based on ten questions.

The descriptive and inferential analysis results for knowledge management are shown in Table 29. The arithmetic means, standard deviations, rank, relative weight, and degree of approval were calculated to determine the sample members' opinions on the study variables. The degree of relative agreement was determined according to the following equation: Category length = upper limit of the alternative - minimum alternative/number of levels = 5-1/3 = 1.33. If the arithmetic means falls between (1-2.33), it is considered within the low level, and if it ranges between (2.34-3.66), it falls within the medium level. It is considered high if it exceeds 3.66 (Subedi, 2016).

**Table 29. Ranks and relative agreement of the responses toward KM.**

| Item No | Items | Mean | SD | Relative Weight | T value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | The Organization holds training sessions for workers on how to use knowledge to achieve specific goals | 3.82 | 0.963 | 76.4 | 12.198 | 0.00 | High | 3 |
| 2 | The Organization classifies data and then converts it into information to support decisions | 3.95 | 0.840 | 79 | 16.291 | 0.00 | High | 1 |
| 3 | The Organization's managers are aware that the Organization has a large stock of knowledge that is not invested and | 3.58 | 0.986 | 71.6 | 8.456 | 0.00 | medium | 8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | needs to be managed and organized | | | | | | | |
| 4 | The Organization's opinions and experiences of the Organization are recorded and kept in databases | 3.67 | 0.954 | 73.4 | 10.122 | 0.00 | High | 5 |
| 5 | The organization is trying to gain knowledge from the surrounding regional institutions | 3.63 | 0.971 | 72.6 | 9.302 | 0.00 | medium | 7 |
| 6 | The Organization has ways to distribute knowledge to its staff and make it available to all (notes, reports, e-mails, public meetings) | 3.69 | 0.962 | 73.8 | 10.261 | 0.00 | High | 4 |
| 7 | There is a department within the Organization to provides studies and research | 3.84 | 0.981 | 76.8 | 12.252 | 0.00 | High | 2 |
| 8 | Facilitate all employees' access to knowledge bases that you own | 3.56 | 0.963 | 71.2 | 8.373 | 0.00 | medium | 9 |
| 9 | The Organization's strategic plan promotes the application of knowledge management | 3.56 | 0.983 | 71.2 | 8.130 | 0.00 | medium | 10 |
| 10 | Transforming the tacit knowledge (residing in the employee's mind) of the experience owners into explicit knowledge through sharing and exchanging experiences. | 3.65 | 0.953 | 73 | 9.769 | 0.00 | medium | 6 |
| **Total Indicator** | | **3.69** | **0.754** | **73.8** | **13.234** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 29 that KM has achieved an arithmetic mean of 3.69 with a relative weight of 73.8% of the total index and a standard deviation of 0.754. This indicates that the level of knowledge management came within the high level from the sample point of view. The T value at the total indicator 13.234 is higher than its tabular value of 1.960 and statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 2 states: The Organization classifies data and then converts it into information to support decisions. It ranked first with a mean of 3.95 and a high level of approval. Its relative weight was 79% with a standard deviation value is 0.840, where it achieved the value of (T) in this paragraph 16.291, which is higher than its tabular value of 1.960 and is statistically significant at the level ($\alpha \leq 0.05$).

On the other hand, item 9, which states: The Organization's strategic plan promotes the application of knowledge management, obtained the lowest arithmetic means, which reached 3.56, with an average level of approval and a standard deviation of 0.983, and the relative weight reached 71.2%, where the value of (T) at this item 8.310, which is greater than its tabular value 1.96 and is statistically significant at the level ($\alpha \leq 0.05$). Hence, most organisations classify data and convert it into information to support decisions, meaning that they are wired for implementation as indicated by rank. At the same time, a significant emphasis should be set on the initial organizational strategic plan in order to reflect on the different company functions by aligning their goals towards promoting the application of knowledge management within the workflow.

### 4.5 Descriptive and inferential statistics towards the CSF.

- **4.5.1 Descriptive, inferential statistics for the CSFs.**

This part aims to indicate the arithmetic averages, standard deviations, degree of agreement, the rank of items at the arithmetic averages, and the (T) value to describe the study sample's trends towards CSF, which were measured based on ten questions. The descriptive and inferential analysis results for CSFs were as shown in Table 30.

**Table 30. Ranks and approvals degrees towards the CSF**

| Item No. | Items | Mean | SD | Relative Weight | T value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | Top management commitment and involvement | 4.02 | 0.730 | 80.4 | 20.076 | 0.00 | High | 3 |
| 2 | Adequate Training/coaching | 3.88 | 0.865 | 77.6 | 14.631 | 0.00 | High | 7 |
| 3 | Linking quality development to human resources (HR) reward system | 3.92 | 0.695 | 78.4 | 18.992 | 0.00 | High | 6 |
| 4 | Choosing the most talented people | 3.97 | 0.634 | 79.4 | 21.931 | 0.00 | High | 4 |
| 5 | Informal communication and open discussion | 3.83 | 0.794 | 76.6 | 14.976 | 0.00 | High | 9 |
| 6 | Linking quality development to business strategy | 4.03 | 0.772 | 80.6 | 19.268 | 0.00 | High | 2 |
| 7 | Adequate knowledge of quality development tools | 4.04 | 0.891 | 80.8 | 16.764 | 0.00 | High | 1 |
| 8 | high employee retention | 3.87 | 0.649 | 77.4 | 19.388 | 0.00 | High | 8 |
| 9 | Sufficient Organizational infrastructure | 3.67 | 0.954 | 73.4 | 10.122 | 0.00 | High | 10 |
| 10 | Understanding and awareness about quality development benefits the business | 3.93 | 0.851 | 78.6 | 15.770 | 0.00 | High | 5 |
| **Total Indicator** | | **3.92** | **0.487** | **78.4** | **27.071** | **0.00** | **High** | |

Source: Own Research 2022

Table 30 shows that CSF has an arithmetic mean of 3.92, a relative weight of 78.4% of the overall indicator, and a standard deviation of 0.487. This shows that the CSF level was excessive among the sample participants. The T value at the total indicator 27,071 is statistically significant at level (0.05) and greater than its tabular value of 1.960. The results showed that item 7, adequate knowledge of quality development tools, occupied the first rank with an arithmetic mean of 4.04 and a high approval level. The relative weight then reached 80.8% with a standard deviation of 0.891, where it achieved the (T) value at this item 16.764, which is greater than its tabular value of 1.960 and is statistically significant at the level ($\alpha \leq 0.05$). On the other hand, item 9, which states: Sufficient Organizational infrastructure, obtained the lowest arithmetic mean, which reached 3.67, with a high level of approval, with a standard deviation of 0.954, and the relative weight reached 73.4%. The value of (T) was at this item 10.122, which is greater than its tabular value of 1.96 and statistically significant at the level ($\alpha \leq 0.05$). All the CSF in the success of the LSS implementation are very important. However, we find that the sample focus on knowledge of the tools used in applying the LSS methodology confirms the questions of the study

## 4.6 Descriptive Inferential Statistics for LSS Phases.

### 4.6.1 Define Phase:

This part aims to indicate the arithmetic means, standard deviations, the degree of agreement, the rank of paragraphs at the arithmetic averages, and the (T) value to describe the study sample trends towards the identification stage, which was measured based on five questions. The descriptive and inferential analysis results towards the definition stage are shown in Table 31.

**Table 31. Rank and approval degree of the responses towards the define phase**

| Item No. | Items | Mean | SD | Relative Weight | T Value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | Hiring employees with a continuous improvement mindset is essential when employing quality development drivers | 3.99 | 0.766 | 79.8 | 18.504 | 0.00 | High | 2 |
| 2 | Do you think you can contribute to organizational performance with your | 3.99 | 0.842 | 79.8 | 16.926 | 0.00 | High | 3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ability to interpret, understand and use quality development know-how? | | | | | | | |
| 3 | There are Formal channels for knowledge sharing (like meetings, courses, tours and similar activities) | 4.12 | 0.690 | 82.4 | 23.381 | 0.00 | High | 1 |
| 4 | An employee takes much time to get the relevant knowledge | 3.86 | 0.946 | 77.2 | 13.157 | 0.00 | High | 5 |
| 5 | Some tools help discover and obtain knowledge related to quality development from various sources. | 3.88 | 0.800 | 77.6 | 15.804 | 0.00 | High | 4 |
| **Total Indicator** | | **3.97** | **0.583** | **79.4** | **23.910** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 31 that the define phase has achieved an arithmetic mean of 3.97, a relative weight of 79.4% of the total indicator, and a standard deviation of 0.583. This indicates that the level of the define phase came within the high level from the study sample's point of view. The T value of the total indicator is 23.910, which is greater than its tabular value of 1.960 and is statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 3, which states: There are Formal channels for knowledge sharing (like meetings, courses, tours and similar activities), ranked first with a mean of 4.12 and a high level of approval. The relative weight was 82.4% and with a standard deviation of 0.690, where the value of (T) was achieved in this item 23.381, which is greater than its tabular value of 1.960 and is statistically significant at the level ($\alpha \leq 0.05$).

On the other hand, item 4, which states: "An employee takes much time to get the relevant knowledge", obtained the lowest arithmetic mean, which amounted to 3.86, with a high level of approval and a standard deviation of 0.946 and the relative weight was 77.2%. The value of (T) in this item was 13.157, which is greater than its tabular value of 1.96 and is statistically significant at the level ($\alpha \leq 0.05$).

### 4.6.2 Measure Phase:

This part aims to indicate the arithmetic averages, standard deviations, the degree of agreement, the rank of items at the arithmetic averages, and the (T) value to describe the trends of the study sample towards the measurement phase, which was measured based on five questions. The descriptive and inferential analysis results towards the measurement stage are shown in Table 32.

**Table 32. Ranks and approval degrees of the responses towards the measure phase**

| Item No. | Items | Mean | SD | Relative Weight | T value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | There is/was a well-defined process for tracking and measuring the performance of quality development projects. | 3.95 | 0.749 | 79 | 18.285 | 0.00 | High | 2 |
| 2 | There are Well defined processes for the creation, capture, and acquisition of knowledge during the measurement phase | 3.75 | 0.899 | 75 | 12.063 | 0.00 | High | 5 |
| 3 | Technology is vital to disseminate knowledge related to measuring process performance. | 3.97 | 0.836 | 79.4 | 16.720 | 0.00 | High | 1 |
| 4 | knowledge sharing is seen as vital in the measure phase | 3.76 | 0.970 | 75.2 | 11.247 | 0.00 | High | 4 |
| 5 | Employees are trained to use appropriate tools and techniques to measure alternatives to work implementation procedures. | 3.88 | 0.840 | 77.6 | 15.149 | 0.00 | High | 3 |
| **Total Indicator** | | **3.86** | **0.622** | **77.2** | **19.987** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 32 that the (measurement phase) has achieved an arithmetic mean of 3.86, a relative weight of 77.2% of the total index, and a standard deviation of 0.622. This indicates that the level of the measurement phase came within the high level from the study sample members' point of view. The T value of the total indicator is 19.987, which is greater than its tabular value of 1.960 and statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 3, which states: "Technology is important to disseminate knowledge related to measuring process performance", ranked first with a mean of 3.97 and a high level of approval, and relative weight of 79.4% and a standard deviation of 0.836, where it achieved the value of (T) in this item 16,720, which is greater than its tabular value 1.960 and is statistically significant at the level ($\alpha \leq 0.05$), on the other hand, item 2, which states: "There are Well defined processes for creation, capture, and acquisition of knowledge during measurement phase" obtained the lowest arithmetic averages, which amounted to 3.75, with a high level of approval, with a standard deviation of 0.899, and the relative weight 75%, where the value of (T) in this item is 12.063, higher than its tabular value 1.96 and is statistically significant at the level ($\alpha \leq 0.05$).

### 4.6.3 Analysis Phase:

This part aims to indicate the arithmetic averages, standard deviations, the degree of agreement, the rank of the paragraphs at the arithmetic averages, and the (T) value to describe the trends of the study sample towards the analysis phase, which was measured based on five questions. The descriptive and inferential results towards the analysis phase are shown in Table 33.

**Table 33. Ranks and approval degrees of the responses towards the analysis phase**

| Item No. | Items | Mean | SD | Relative Weight | T Value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | The role of appropriate Continuous Improvement Consultants/Experts is essential in quality development | 3.97 | 0.832 | 79.4 | 16.698 | 0.00 | High | 1 |
| 2 | The quality development expert help & coaching are/were sufficiently readily available for quality development projects. | 3.88 | 0.924 | 77.6 | 13.686 | 0.00 | High | 2 |
| 3 | Cooperation when creating new knowledge reduces the anxiety of responsibility in case of an error. | 3.85 | 0.866 | 77 | 14.132 | 0.00 | High | 3 |
| 4 | Organization employees realize the importance of knowledge management in support of quality improvement activities | 3.75 | 0.925 | 75 | 11.716 | 0.00 | High | 5 |
| 5 | Use past experiences and expertise as a basis for future work without starting from scratch | 3.79 | 0.915 | 75.8 | 12.375 | 0.00 | High | 4 |
| **Total Indicator** | | **3.85** | **0.673** | **77** | **18.119** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 33 that the analysis phase has achieved an arithmetic mean of 3.85, a relative weight of 77% of the total index, and a standard deviation of 0.673. This indicates that the level of the analysis phase came within the high level from the study sample members' point of view. The T value at the total indicator is 18.119, higher than its tabular value of 1.960 and statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 1, which states: The role of appropriate Continuous Improvement Consultants/Experts is essential in quality development, ranked first with a mean of 3.97, a high level of approval, and a relative weight of 79.4% with a standard deviation of 0.832, where it achieved the value of (T) in this item 16.698, which is greater than its tabular value 1.960 and is statistically significant at the level ($\alpha \leq 0.05$).
On the other hand, item 4 states: “Organization employees realize the importance of knowledge management in support of quality improvement activities”, obtained the lowest arithmetic means, which amounted to 3.75 and with a high level of agreement and a standard deviation of 0.925 and the relative weight was 75 %, where the value of (T) in this item was 11.716, which is greater than its tabular value (1.96) and is statistically significant at the level ($\alpha \leq 0.05$).

### 4.6.4 Improve Phase:

This part aims to indicate the arithmetic means, standard deviations, degree of agreement, the rank of items at the arithmetic averages, and the (T) value to describe the study sample trends towards the improvement stage, which was measured based on five questions. The descriptive and inferential analysis results were towards the improvement phase, as shown in Table 34.

**Table 34. Ranks and approval degrees of the responses towards the improvement phase**

| Item No. | items | Mean | SD | Relative Weight | T value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | Process improvement is given high importance in the Organization. | 3.86 | 0.954 | 77.2 | 12.890 | 0.00 | High | 5 |
| 2 | The need to embark on Value-added Continuous improvement investments is critical in quality development | 4.00 | 0.911 | 80 | 15.715 | 0.00 | High | 2 |
| 3 | quality development has | 3.88 | 0.924 | 77.6 | 13.686 | 0.00 | High | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | /had helped the Organization to be more customer-focused | | | | | | | |
| 4 | Quality development improvements have /had resulted in the efficient utilization of resources (human, financial, and system). | 3.97 | 0.910 | 79.4 | 15.268 | 0.00 | High | 3 |
| 5 | Quality development has/had considerably reduced process lead times & cycle times. | 4.09 | 0.804 | 81.8 | 19.531 | 0.00 | High | 1 |
| **Total index** | | **3.96** | **0.707** | **79.2** | **19.498** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 34 that the improve phase has achieved an arithmetic mean of 3.96 and a relative weight of 79.2% of the total indicator, and a standard deviation of (0.707). This indicates that the level of the improvement phase came within the high level from the study sample members' point of view. The T value at the total indicator is (19.498), which is higher than its tabular value (1.960) and statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 5 states: Quality development has/had considerably reduced process lead times & cycle times, occupied the first rank with a mean of 4.09 with a high level of approval and relative weight of 81.8%. Its standard deviation of 0.804 is higher than its tabular value (1.960) and is statistically significant at the level ($\alpha \leq 0.05$).

On the other hand, item (1) states: Process improvement is given high importance in the Organization; obtained the lowest arithmetic mean, which amounted to 3.86, with a high level of approval and a standard deviation of 0.954, and the relative weight reached (77.2%), where the value of (T) at this paragraph (12.890), which is greater than its tabular value (1.96) and is statistically significant at the level ($\alpha \leq 0.05$).

### 4.6.5 Control Phase:

This part aims to indicate the arithmetic averages, standard deviations, degree of agreement, the rank of the paragraphs at the arithmetic averages, and the (T) value to describe the trends of the study sample towards the control phase, which was measured based on five items. The descriptive and inferential analysis results for the control phase are shown in Table 35.

**Table 35. Ranks and approval degrees of the responses towards the control stage**

| Item No | Items | Mean | SD | Relative Weight | T Value | (T) Sig | Relative Agreement | Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | The review of appropriate Continuous improvement activities is critical in quality development | 4.05 | 0.918 | 81 | 16.434 | 0.00 | High | 3 |
| 2 | Top management takes an active interest in quality development, controls it, and supports it continuously | 3.76 | 1.032 | 75.2 | 10.641 | 0.00 | High | 5 |
| 3 | The organization's strategy is reviewed based on research and studies aimed at improving services and customer satisfaction | 3.85 | 1.034 | 77 | 11.828 | 0.00 | High | 4 |
| 4 | Mistakes in work procedures are documented to be circulated and avoided in the future. | 4.21 | 0.661 | 84.2 | 26.279 | 0.00 | High | 2 |
| 5 | Internal best practices in the business are documented and circulated | 4.25 | 0.684 | 85 | 26.209 | 0.00 | High | 1 |
| **Total Indicator** | | **4.02** | **0.636** | **80.4** | **23.135** | **0.00** | **High** | |

Source: Own Research 2022

We note from Table 35 that the control phase has achieved an arithmetic mean (4.02) and a relative weight of 80.4% of the total index, with a standard deviation of 0.636. This indicates that the level of the control stage came within the high level from the study sample members' point of view. The T value at the total indicator is 23.135, which is higher than its tabular value (1.960) and is statistically significant at the level ($\alpha \leq 0.05$). The results showed that item 5, Internal best practices in the business are documented and circulated, occupied the first rank with an arithmetic mean of 4.25 and a high level of approval. The relative weight reached 85% with a standard deviation of 0.684, where it achieved the value of (T) in this item (26.209) which is higher than its tabular value (1.960) and is statistically significant at the level ($\alpha \leq 0.05$).

On the other hand, item 2 states: Top management takes an active interest in quality development, controls it, and supports it continuously has the lowest arithmetic mean, which reached 3.76, with a high level of approval, with a standard deviation of 1.032. The relative weight was 75.2%. The value of (T) in this item was 10.641, which is greater than its tabular value (1.96) and is statistically significant at the level ($\alpha \leq 0.05$).

## 4.7 The relationship between KM and the LSS phases.

The correlation coefficient (Pearson Correlation) was extracted to identify the relationship between knowledge management and the LSS phases. The results of which are shown in Table 36.

**Table 36. The correlation between KM and the LSS phases**

| | | Define | measure | Analysis | Improve | Control |
|---|---|---|---|---|---|---|
| **KM** | Pearson Correlation | **0.287 | *0.154 | **0.300 | **0.286 | **0.288 |
| | Sig | 0.00 | 0.026 | 0.00 | 0.00 | 0.00 |
| | N | 207 | | | | |
| ****Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).** | | | | | | |

Source: Own Research 2022

Zikmund et al. (2013) indicated that if the correlation coefficient value ranged between (0.30 - less than 0.60), the correlation strength is medium. While if it is less than 0.30, the correlation strength is low, and if it ranges between (0.60 - 0.80), the correlation is high. Table 28 indicate a medium significant correlation between knowledge management and the analysis phase through the value of the Pearson correlation coefficient, which is 0.3 and is statistically significant at the level ($\alpha \leq 0.05$). It was also found that there is a low considerable correlation between knowledge management and the define phase. The value of the Pearson correlation coefficient is 0.287 and is statistically significant at the level ($\alpha \leq 0.05$). We note a considerably low correlation between knowledge management and the measurement phase. The value of the Pearson correlation coefficient is 0.154 and is statistically significant at the level ($\alpha \leq 0.05$). It was found that there is a low considerable correlation between knowledge management and the improvement phase, which appears through the value of the Pearson correlation coefficient, which is 0.286 and is statistically significant at the level ($\alpha \leq 0.05$). It was found that there is a low considerable correlation between knowledge management and the control phase, which appears through the value of the Pearson correlation coefficient, which is 0.288 and is statistically significant at the level ($\alpha \leq 0.05$).

## 4.8 The relationship between CSFs and the LSS phases.

The Pearson Correlation coefficient was extracted to identify the correlation between the CSF and LSS phases. The results of which are shown in Table 37.

Table 37. The correlation between CSF and LSS phases

| | | Define | Measure | Analysis | Improve | Control |
|---|---|---|---|---|---|---|
| **CSF** | Pearson Correlation | **0.439 | **0.314 | **0.403 | **0.519 | **0.366 |
| | Sig | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | N | 207 | | | | |
| ****Correlation is significant at the 0.01 level (2-tailed).** | | | | | | |

Source: Own Research 2022

The results of Table 37 indicate a medium significant correlation between the CSF and the define phase through the value of the Pearson correlation coefficient of 0.439, and it is statistically significant at the level ($\alpha \leq 0.05$). It was also found that there is a considerable medium correlation between the CSF and the measurement phase, which appears through the value of the Pearson correlation coefficient, which is 0.314 and is statistically significant at the level ($\alpha \leq 0.05$). We note that there is a medium considerable correlation relationship between the CSF and the analysis phase, which appears through the value of Pearson's correlation coefficient of 0.403 and is statistically significant at the level ($\alpha \leq 0.05$). It was found that there is a considerable medium correlation between the CSFs and the improvement phase, which appears through the value of the Pearson correlation coefficient of 0.519 and a statistical function at the level ($\alpha \leq 0.05$). It was found that there is a medium significant correlation between the CSFs and the control phase, which appears through the value of the Pearson correlation coefficient, which is 0.366 and is statistically significant at the level ($\alpha \leq 0.05$).

### 4.9 The role of KM in the LSS phases.

To identify the role of knowledge management in LSS phases in service organizations. In this part, knowledge management and LSS phases were subjected to simple linear regression analysis, and the following results were reached:

Table 38. Simple Regression of KM and the LSS phases

| KM | R | $R^2$ | Adj $R^2$ | DF | F Calculated | F. Sig | Constant | B | Std. Error | T calculated | T Tabulated | T. Sig |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Define | 0.287 | 0.082 | 0.078 | 206 | 18.336 | 0.00 | 3.150 | 0.221 | 0.052 | 4.282 | 1.96 | 0.00 |
| Measurement | 0.154 | 0.024 | 0.019 | 206 | 4.996 | 0.026 | 3.394 | 0.127 | 0.057 | 2.235 | 1.96 | 0.026 |
| Analysis | 0.300 | 0.090 | 0.085 | 206 | 20.230 | 0.00 | 2.859 | 0.268 | 0.059 | 4.498 | 1.96 | 0.00 |
| Improvement | 0.286 | 0.082 | 0.078 | 206 | 18.325 | 0.00 | 2.966 | 0.269 | 0.063 | 4.281 | 1.96 | 0.00 |
| Control | 0.288 | 0.083 | 0.078 | 206 | 18.514 | 0.00 | 3.126 | 0.243 | 0.056 | 4.303 | 1.96 | 0.00 |

Source: Own Research 2022

It is clear from the results of Table 38 that there is a statistically significant role for knowledge management in the define phase through the value of T equal to 4.282, which is greater than its tabular value of 1.96 and significant at the level of significance ($\alpha \leq 0.05$). It is noted that the value of the correlation coefficient (R = 0.287) indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.082) indicates that knowledge management explained 8.2% of the variance in the define phase. From the previous, the form of the prediction equation is as follows: define phase = 3.150 + 0.221 x KM. The interpretation of this effect is more straightforward when the coefficient is calculated after using the standard sign (Z-Scores) for each variable. In this case, this coefficient is equal to the value of the correlation coefficient between the two variables, called (Beta) and is used to predict the standard value of the dependent variable through the standard values of the independent variable. The value of Beta = 0. 287 indicates that an increase in KM by one degree is accompanied by the defined phase's rise of 0.287. Figure 18 shows the simple linear regression equation.

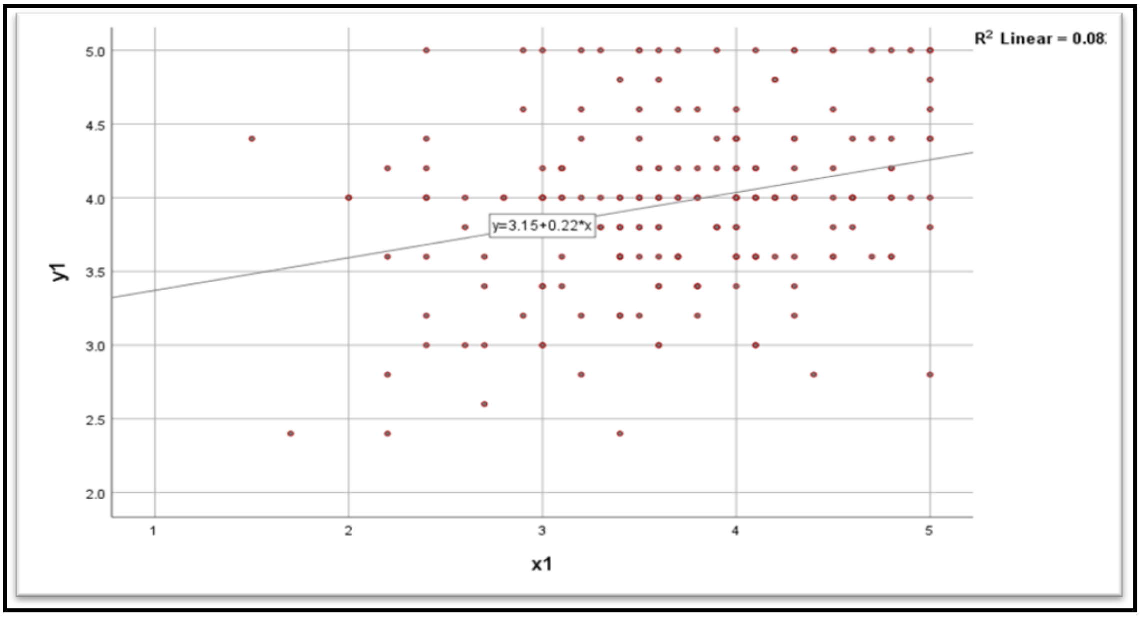


**Figure 18. Simple Regression of KM and Define phase**

Source: Own Research 2022

Through the value of T of 2.235, which is higher than its tabular value of 1.96 and significant at the significance level (0.05), it was discovered that KM plays a statistically significant influence in the measure phase. The correlation coefficient R = 0.154 should be noted, indicating a weak correlation between the two variables. KM explained 2.4% of the variation in the measure phase, according to the coefficient of determination ($R^2$ = 0.024).

The prediction equation has the following form based on the previous: Phase of measurement = 3.394 + 0.127 x KM. The interpretation of this effect is more straightforward when the coefficient is calculated after using the Z-Scores for each variable. In this case, this coefficient is equal to the value of the correlation coefficient between the two variables, called (Beta) and is used to predict the standard value of the dependent variable through the standard values of the independent variable. The value of Beta = 0.154 indicates that the increase in KM by one degree is accompanied by an increase in the measurement phase by 0.154. Figure 19 shows the simple linear regression equation.

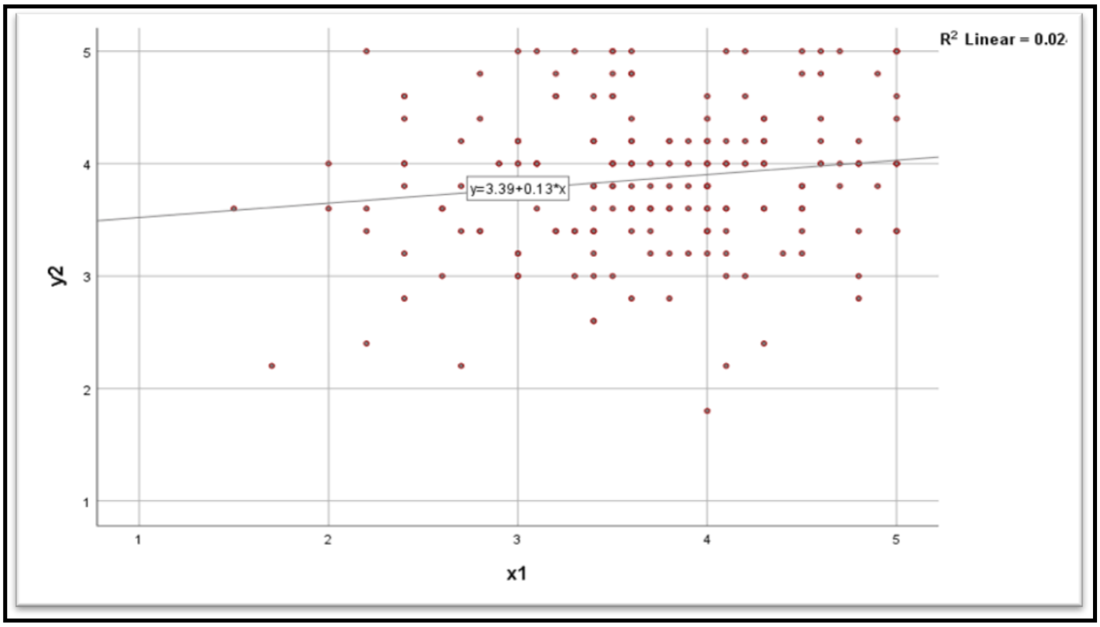


**Figure 19. Simple Regression of KM and measure phase**

Source: Own Research 2022

It was found that there is a statistically significant role for KM in the analysis phase through the value of T = 4.498, which is greater than its tabular value of 1.96 and significant at the significance level ($\alpha \leq 0.05$). It is noted that the value of the correlation coefficient R = 0.30 indicates that there is a medium relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.090) indicates that knowledge management has explained 9% of the variance in the analysis phase. Therefore, the form of the prediction equation is as follows: Analysis phase = 2.859 + 0.268 x KM. The interpretation of this effect is more straightforward when the coefficient is calculated after using the Z-Scores for each variable. In this case, this coefficient is equal to the value of the correlation coefficient between the two variables, called (Beta) and is used to predict the standard value of the dependent variable through the standard values of the independent variable. The Beta value of 0. 30 indicates that the increase in KM by one degree is accompanied by a 0.30 rise in the analysis phase. Figure 20 shows the simple linear regression equation.

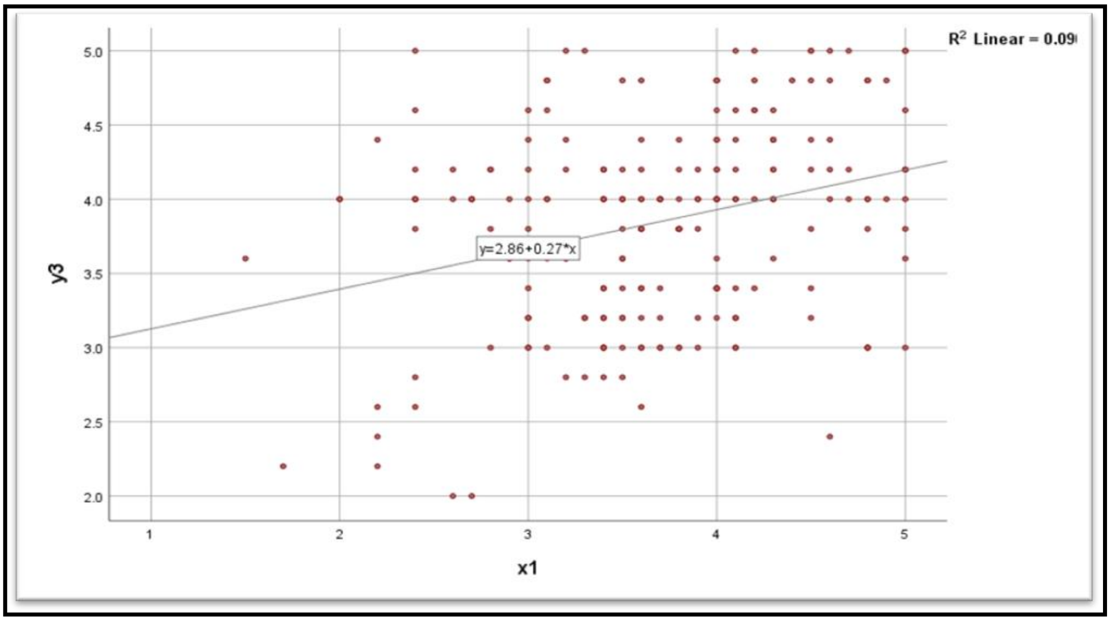


**Figure 20.** **Simple Regression of KM and the analysis phase**

Source: Own Research 2022

The T = 4.281, higher than its tabular value of 1.96 at the significance level (0.05), was discovered to show that KM contributes statistically to the improve phase. It should be noticed that the correlation coefficient, R = 0.286, shows there is little correlation between the two variables. KM accounted for 8.2% of the improve phase variance, according to the coefficient of determination ($R^2$ = 0.082). Consequently, the following is how the prediction equation is expressed: Improve phase is equal to 2.966 + 0.269 x KM. The interpretation of this effect is easier when the coefficient is calculated after using the standard sign (Z-Scores) for each variable. For the independent variable. The Beta value of 0. 286 indicates that the increase in KM by one degree is accompanied by an increase in the improvement phase of 0.286.  Figure 21 shows the equation of simple linear regression.

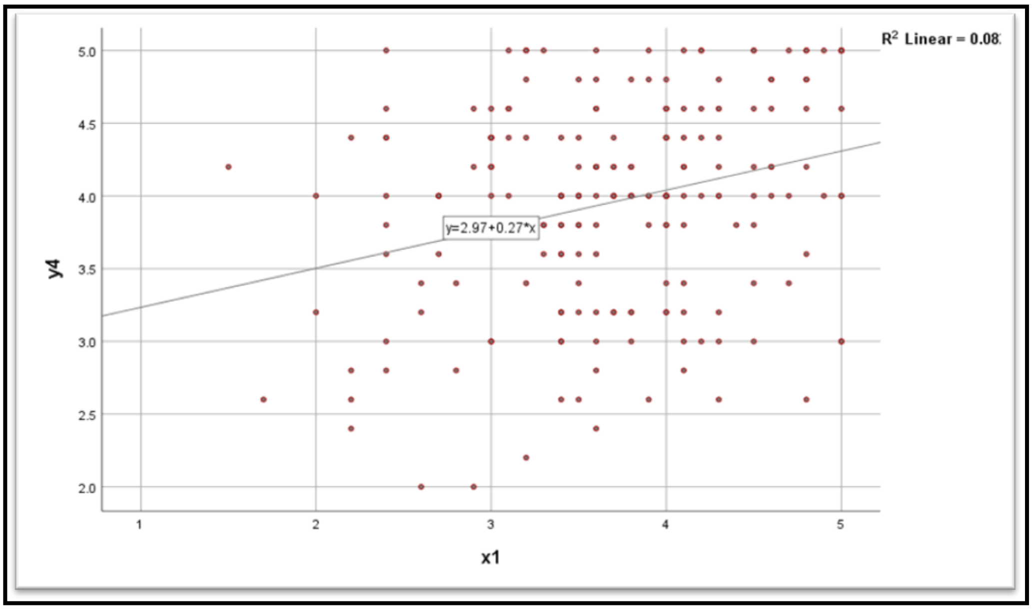


**Figure 21. Simple Regression of KM and the improve phase**

Source: Own Research 2022

It was found that there is a statistically significant role for knowledge management in the control phase through the value of T, which is equal to 4.303, which is greater than its tabular value of 1.96 and significant at the significance level (α≤0.05). It is noted that the value of the correlation coefficient R = 0.288 indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2 = 0.083$) indicates that KM has explained 8.3% of the variance in the control phase. From the above, the form of the prediction equation is as follows: Control phase = 3.126 + 0.243 x KM, and the interpretation of this effect is more straightforward when the coefficient is calculated after using the standard (Z-Scores) for each of the two variables. In this case, this coefficient is equal to the value of the correlation coefficient between the two variables, called (Beta) and is used to predict the standard value of the dependent variable through the standard values of the independent variable. The Beta value of 0.288 indicates that the increase in KM by one degree is accompanied by an increase in the control phase by 0.288. Figure 22 shows the simple linear regression equation.

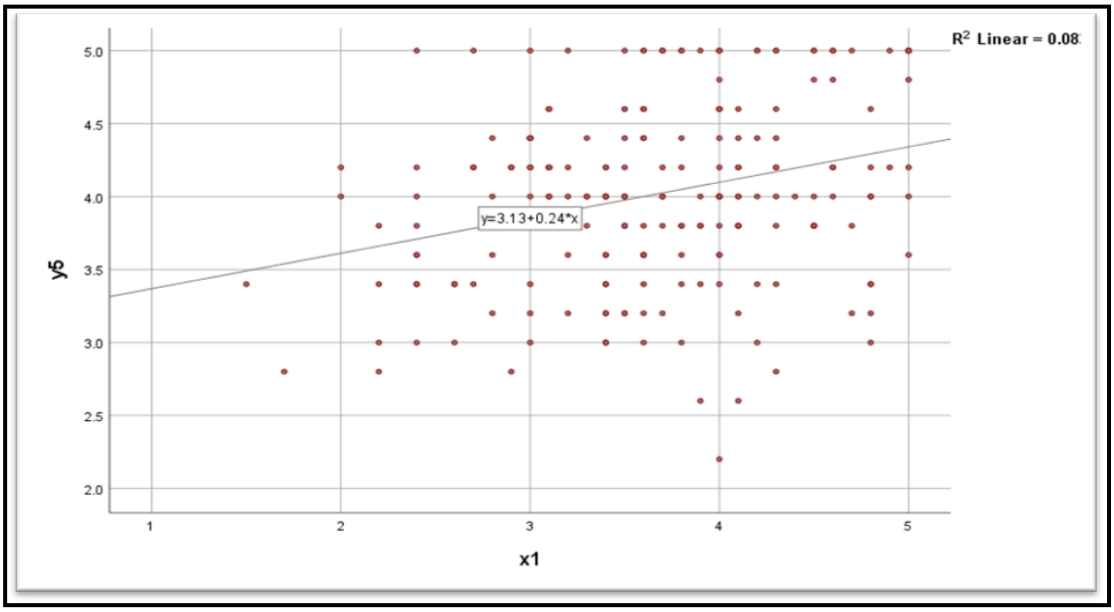


**Figure 22. Simple Regression of KM and the control phase**

Source: Own Research 2022

# CHAPTER FIVE: Discussion, Conclusion and Recommendations

This chapter concludes this investigation by proposing answers to the primary research questions raised in Chapter 1. This chapter addresses the research's quality and highlights the study's primary contribution to theory, knowledge, and practice. Additionally, the study's shortcomings are discussed, followed by an agenda for future research that might assist other researchers in focusing their efforts on narrowing the gaps in the current literature. Finally, a critical assessment of the research trip is offered to demonstrate the techniques and personal experiences obtained by the researcher and the problems and barriers encountered along the way.

## 5.1 Judging the hypothesis

To identify the role of knowledge management in LSS phases in service organizations. Knowledge management and LSS phases were subjected to simple linear regression analysis, and the following decisions were reached:

**Hypothesis 1: There is a significant relationship at the level of ($\alpha \leq 0.05$) between knowledge management practice, and LSS define phase.**

Data analysis points out a significant positive correlation between knowledge management and the define phase at the significant level of $\alpha \leq 0.05$. Therefore, we **accept** the hypothesis. It is noted that the value of the correlation coefficient R = 0.287 indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.082) indicates that knowledge management explained 8.2% of the variance in the define phase. From the previous, the form of the prediction equation is as follows: define phase = 3.150 + 0.221 x KM. The value of Beta = 0. 287 indicates that an increase in KM by one degree is accompanied by the defined phase's rise of 0.287.

**Hypothesis 2: There is a significant relationship at the level of ($\alpha \leq 0.05$) between knowledge management practice and the LSS measure phase.**

Data analysis points out a significant positive correlation between knowledge management and the measure phase at the significant level of $\alpha \leq 0.05$. Therefore, we **accept** the hypothesis. It is noted that the value of the correlation coefficient R = 0.154 indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.024) indicates that knowledge management explained (2.4%) of the variance in the measurement phase. From the previous, the form of the prediction equation is as follows: Measure phase = 3.394 + 0.127 x KM. The Beta value = 0.154 indicates that the increase in KM by one degree is accompanied by an increase in the measure phase by 0.154.

**Hypothesis 3: There is a significant relationship at the level of (α≤0.05) between knowledge management practice and the LSS analysis phase.**

Data analysis points out a significant positive correlation between knowledge management and the analysis phase at the significant level of α≤0.05. Therefore, we **accept** the hypothesis. It is noted that the value of the correlation coefficient R = 0.30 indicates that there is a medium relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.090) indicates that knowledge management has explained 9% of the variance in the analysis phase. Therefore, the form of the prediction equation is as follows: Analysis phase = 2.859 + 0.268 x KM. The Beta value of 0.30 indicates that the increase in KM by one degree is accompanied by a 0.30 rise in the analysis phase.

**Hypothesis 4: There is a significant relationship at the level of (α≤0.05) between knowledge management practice and the LSS improve phase.**

Data analysis points out a significant positive correlation between knowledge management and the improve phase at the significant level of α≤0.05. Therefore, we **accept** the hypothesis. It is noted that the value of the correlation coefficient R = 0.286 indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2$ = 0.082) indicates that knowledge management explained 8.2% of the variance in the improvement stage. Therefore, the form of the prediction equation is as follows: Improvement phase = 2.966 + 0.269 x KM. The Beta value of 0. 286 indicates that the increase in KM by one degree is accompanied by an increase in the improve phase 0.286.

**Hypothesis 5: There is a significant relationship at the level of (α≤0.05) between knowledge management practice and the LSS control phase.**

Data analysis points out a significant positive correlation between knowledge management and the control phase at the significant level of α≤0.05. Therefore, we **accept** the hypothesis. It is noted that the value of the correlation coefficient R = 0.288 indicates a low relationship between the two variables. The value of the coefficient of determination ($R^2$ =

0.083) indicates that KM has explained 8.3% of the variance in the control phase. From the above, the form of the prediction equation is as follows: Control phase = 3.126 + 0.243 x KM. The Beta value of 0.288 indicates that the increase in KM by one degree is accompanied by an increase in the control phase by 0.288.

## 5.2 Discussion

The use of LSS was a specific question that was put to the respondents. Some gave a positive answer; however, the straightforward implementation of LSS in Jordan might be uncommon. Therefore, the researcher relied on the LSS tools, and the respondents were questioned about these tools' usage and the phase at which it occurs. As a result, organizations in Jordan only partially use the LSS methodology.

Moreover, This study's results agree with (Pinjari & Teli, 2018), which confirms that KM is crucial in this heavily based knowledge information sector. Consequently, the organisation requires the maintenance of employees' specialised technical knowledge and problem-solving skills to maintain the organisation's smooth operation. Technical expertise must be mastered, and tacit knowledge must be improved through continuous training and experience. Specialist expertise includes performing procedural knowledge, such as LSS problem-solving procedural knowledge training ( Albliwi et al., 2014).

One crucial practice for KM implementation in LSS is proper knowledge implementation as providing interactive module notations and training manuals, having top executives deliver an opening speech, and teaching using innovative theoretical approaches. While for best practices of KM in LSS, the idea revolves around knowledge creation through brainstorming and daily performance reviews. Furthermore, utilizing LSS knowledge enables the creation of new knowledge for problem-solving and continuous improvement (Sin et al., 2015; Zhang & Chen, 2016). Additionally, knowledge storage is essential in indexing knowledge in easily usable forms and standardized formats, leveraging the utility of stored knowledge to employees (Muhammad & Chin, 2020). Moreover, human capital's acquired skills would be lost within months without proper, regular application of the human capital knowledge, skills, and experience during the LSS training.

Employee capabilities and attitudes are critical to the success of Lean efforts (Worley & Doolen, 2006). The most crucial necessity for LSS is proper employee training and communication (Laureani & Antony, 2016). Additionally, employees must sufficiently understand their responsibilities and tasks' what, how, and proper order (Pepper & Spedding, 2010). Although six Sigma training is critical to its success, it is considered prohibitively expensive and time-consuming (Ranjan Senapati, 2004). This can be attributed to the fact it is not yet standardised, leading to its efficacy being questioned. Similarly, employee responsibilities play a part in the success of LSS (Spasojevic Brkic & Tomic, 2016). Without a general framework for implementing LSS (Pepper & Spedding, 2010), employee roles become even more crucial. Additionally, the installation of LSS dynamically changes the duties of individual employees, their assignments, work organizations, employment relationships, tasks, and activities (Drotz & Poksinska, 2014).

## 5.3 Conclusion

Lean Six Sigma (LSS) methodology has been used in many organisations worldwide to reduce product or service defects and eliminate waste in the process. By implementing LSS, the organisation gains many advantages, including competitive advantages and improving financial and operational performance. Knowledge is one of the organisation’s crucial resources and primary assets. Knowledge is a blend of information and practice. Knowledge management aims to provide the right people with exact knowledge at the right time. KM is the process of creating, distributing, sharing, and saving staff knowledge.

The central questions for this research were as follows:

1- *What is the current level of LSS adoption in the services organization in Jordan?*
2- *What is the current level of KM concept adoption in the services organization in Jordan?*
3- *What are the obstacles and failure factors facing the Jordanian services organization during the implementation of LSS?*
4- *Is there a significant role of the KM in the success of LSS in the services organization in Jordan?*

This research aimed to assess the level of Lean Six Sigma adopted by the services organisations and the level of knowledge management employed by the organisations concurrent with Lean Six Sigma. Through the developed model, the services organisations can fill the gap in using LSS, enhance the services provided to their customers, and improve the process within the organisation. Investigating the interaction between Lean Six Sigma and the Knowledge management phenomenon is one of this research aims.

Knowledge management and Lean Six Sigma reduce defects and adapt to new possibilities. Both KM and LSS are pretty effective in boosting organizational performance. Any organization's objective is to enhance customer satisfaction by adjusting services and goods to new standards that align with customers' desires. To achieve this objective, organizations must rely on the synergy of KM and LSS. The research confirms that Knowledge Management is an important factor in implementing Lean Six Sigma performance improvement initiatives.

**5.4 Recommendations**

According to the results obtained from the theoretical framework and the statistical data analysis, the following recommendations were made:

1- Paying attention to the concept of Lean Six Sigma and emphasizing the possibility of using it in service organizations because of its scientific importance in reducing errors and improving the quality of services commensurate with customer expectations.

2- Working on investing in training and providing workers with knowledge in the field of Lean Six Sigma, the basics on which Lean Six Sigma is based, and its importance and benefit for service organisations.

3- The organizations' managers should emphasize to quality departments the necessity to concentrate on Knowledge of the LSS methodology's tools, with a stronger emphasis on the measurement stage tools.

4- Adopting the concept of workers’ participation in the decision-making process through good suggestions made by organizations workers. Therefore, this avoids their resistance to new management ideas, including Lean Six Sigma.

5- Confirm the support and commitment of senior management regarding implementing projects related to improving services and increasing the satisfaction of service recipients.

6- That service organizations have to support the participation of workers in making decisions related to improving services and the satisfaction of workers as they are in direct contact with service recipients, in addition to improving communication processes between administrative levels

## 5.5 Research limitation

1- One restriction is that the research is limited to Jordanian organizations. However, because this country has a significant number of organizations, a higher depth of information may be used for this study. As a result, similar research will need to be undertaken in other Middle Eastern nations.

2- Another limitation during the implementation of this study is that data were obtained via the internet (google forms), and hence no deeper insights could be gained.

3- Another difficulty is that this study was conducted during the pandemic period. Where preventive measures were imposed by the state, including the disruption of institutions, this caused delays in data collection and made the international comparison impossible.

## 5.6 Future Research

This study gives us a foundation for understanding Lean Six Sigma and the elements that make it effective. However, no information or support in this research body can be used to decide whether or not to apply Lean Six Sigma. Future research may focus on the ongoing evaluation of Lean Six Sigma conditions. Based on performance metrics, service applications can do an ongoing assessment of the current situation. This evaluation may take the shape of an intuitive application. A database of the performance metrics and a set of analysis tools could make up this application. The presence of such a system would increase Lean Six Sigma's advantages. However, this line of inquiry is only pertinent if Lean Six Sigma is necessary.

The training methods would be another area for exploration. Typically, classroom instruction is the preferred training technique for Lean Six Sigma. The recent training versions have given the learners meaningful face time with instructors and practitioners. Assessing the effectiveness and performance of a novel idea is an intriguing study topic (Antony et al., 2007). The training approach and its efficacy are crucial because they will enable service organizations to identify the areas in which the training should be concentrated. Any additional investigation into efficient training techniques and creating such a mechanism would be beneficial in this regard.

Future research is required to overcome the limitations revealed in this study and to allow for the generalization of the research findings. Among these are the following points:

1- The researcher intends to expand this study to include more MENA nations to determine the present degree of LSS deployment and to compare the findings to Jordanian organizations and Western countries. This will facilitate the exchange of knowledge and best practices across countries.

2- Further study will determine the critical performance differences between LSS and non-LSS organizations.

This agenda is a significant research result that will assist other field researchers in directing their future studies in the following areas:

1- LSS and its impact on organisational performance (financial performance, operational performance)

2- Comparison between LSS and TQM.

3- Change Management and Lean Six Sigma in Today's Business

**5.7 Thesis Summary**

The purpose of this dissertation (Integrating Lean Six Sigma with Knowledge Management within Services Organisations) is to assess the level of Lean Six Sigma adopted by the services organisations and the level of knowledge management employed by the services organisations concurrent with Lean Six Sigma. Investigating the interaction between Lean Six Sigma and the Knowledge management phenomenon is one of this research aims.

The graduation dissertation is composed of five chapters, each of them dealing with a different aspect.

**Chapter one** is introductory and gives the reader an overview of the research context, aims, and objectives. This research began from the research problem, which indicated that LSS is a valuable quality and management methodology; not all organisations successfully benefit from applying Lean Six Sigma. Lack of proper skills and training- which are parts of knowledge- and lack of top management support are the main factors that cause the failure of implementing LSS. Four key questions To achieve the research objectives were formulated as the following:

1- What is the current level of LSS adoption in the services organization in Jordan?
2- What is the current level of KM concept adoption in the services organization in Jordan?
3- What are the obstacles and failure factors faced by the services organization during the implementation of LSS?
4- Is there a significant role of the KM in the success of LSS in the services organization?

The quantitative method has been presented in this research to find the statistical measurements and the hypothesis. The qualitative method has been employed to analyse the literature review of Lean Six Sigma and Knowledge management, formulate the proposed conceptual framework (LSS-KM), and structure the research questionnaire. Moreover, using previously mentioned methodologies gives a clear image of the Lean Six Sigma and KM phenomenon that the researcher desires to collect data about and describe characteristics of the population or phenomenon.

**Chapter two** examines and reviews the most authoritative literature related to the research topic. The chapter focuses on the LSS approach, including Lean Manufacturing, Six Sigma, and the development of the LSS development and its background. Moreover, this study Investigates the literature related to Knowledge Management. Finally, this chapter addresses the correlation between knowledge management and LSS.

**Chapter three** provides an outline with a description of the study's methodology through which its objectives can be achieved. A statement of the study's approach and society, the selected sample, and its characteristics are tackled in this chapter. Moreover, various statistical techniques used in this study are described in this chapter, including reliability and normal distribution.

**Chapter four** concentrates on problems resulting in the frequency and percentages of information provided by participants in their responses to the questionnaire. Moreover, this chapter identified the role of knowledge management in LSS phases in service organizations. In this part, knowledge management and LSS phases were subjected to simple linear regression analysis, Conclusions are drawn in **chapter five**. The main aim of the dissertation has been reached. This chapter addresses the research's quality and highlights the study's primary contribution to theory, knowledge, and practice. Additionally, the research limitations are addressed, and suggestions for future research are provided. Finally, a critical assessment of the research trip is offered to demonstrate the techniques and personal experiences obtained by the researcher and the problems and barriers encountered along the way.

**References**

Abdulmalek, F. A., & Rajgopal, J. (2007). Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of Production Economics*, *107*(1), 223–236.

Aboelmaged, M. G. (2010). Six Sigma quality: a structured review and implications for future research. *International Journal of Quality & Reliability Management*.

Abolhassani, A., Layfield, K., & Gopalakrishnan, B. (2016). Lean and US manufacturing industry: popularity of practices and implementation barriers. *International Journal of Productivity and Performance Management*.

Achanga, P., Shehab, E., Roy, R., & Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, *17*(4), 460–471. https://doi.org/10.1108/17410380610662889

Adina-Petruța, P., & Roxana, S. (2014). Integrating six sigma with quality management systems for the development and continuous improvement of higher education institutions. *Procedia-Social and Behavioral Sciences*, *143*, 643–648.

Ahmed, S., Manaf, N. H. A., & Islam, R. (2013). Effects of Lean Six Sigma application in healthcare services: a literature review. *Reviews on Environmental Health*, *28*(4), 189–194.

Ahuja, I. S., & Singh, H. (2018). Evaluating the effectiveness of 5S implementation practices in Indian manufacturing industry. *International Journal of Productivity and Quality Management*, *25*(4), 506–555.

Akbari, N., & Ghaffari, A. (2017). Verifying relationship of knowledge management initiatives and the empowerment of human resources. *Journal of Knowledge Management*.

Al-Mhasnah, A., Salleh, F., Afthanorhan, A., & Ghazali, P. (2018). The relationship between services quality and customer satisfaction among Jordanian healthcare sector. *Management Science Letters*, *8*(12), 1413–1420.

AL-Nawafleh, E. A., ALSheikh, G. A. A., Abdulllah, A. A., & Tambi, A. M. bin A. (2019). Review of the impact of service quality and subjective norms in TAM among telecommunication customers in Jordan. *International Journal of Ethics and Systems*.

Al-Refaie, A., & Hanayneh, B. (2014). Influences of TPM, TQM, Six Sigma practices on firms performance in Jordan. *International Journal of Productivity and Quality Management*, *13*(2), 219–234.

Al-Rousan, M. R., & Mohamed, B. (2010). Customer loyalty and the impacts of service quality: The case of five star hotels in Jordan. *International Journal of Human and Social Sciences*, *5*(13), 886–892.

Albliwi, S. A., Antony, J., & Lim, S. A. halim. (2015). A systematic review of Lean Six Sigma for the manufacturing industry. *Business Process Management Journal*, *21*(3), 665–691. https://doi.org/10.1108/bpmj-03-2014-0019

Albliwi, S., & Antony, J. (2013). Implementation of a lean six sigma approach in the manufacturing Sector: a systematic literature review. *Proceedings of the 11th International Conference on Manufacturing Research*, 431–436.

Albliwi, S., Antony, J., AbdulHalimLim, S., & van der Wiele, T. (2014). Critical failure factors of Lean Six Sigma: a systematic literature review. *International Journal of Quality & Reliability Management*, *31*(9), 1012–1030. https://doi.org/10.1108/ijqrm-09-2013-0147

Aldairi, J., Khan, M. K., & Munive-Hernandez, J. E. (2017). Knowledge-based Lean Six Sigma maintenance system for sustainable buildings. *International Journal of Lean Six Sigma*.

Aleem, S., Torrey, W. C., Duncan, M. S., Hort, S. J., & Mecchella, J. N. (2015). Depression screening optimization in an academic rural setting. *International Journal of Health Care Quality Assurance*.

Alhuraish, I., Robledo, C., & Kobi, A. (2016). Assessment of Lean Manufacturing and Six Sigma operation with Decision Making Based on the Analytic Hierarchy Process. *IFAC-PapersOnLine*, *49*(12), 59–64. https://doi.org/10.1016/j.ifacol.2016.07.550

Alhuraish, Ibrahim, Robledo, C., & Kobi, A. (2016a). Impacts of lean manufacturing and six sigma. *22nd ISSAT International Conference on Reliability and Quality in Design (RQD 2016)*.

Alhuraish, Ibrahim, Robledo, C., & Kobi, A. (2016b). The effective of lean manufacturing and six sigma implementation. *Proceedings of 2015 International Conference on Industrial Engineering and Systems Management, IEEE IESM 2015, October*, 453–460. https://doi.org/10.1109/IESM.2015.7380197

Alhuraish, Ibrahim, Robledo, C., & Kobi, A. (2017). A comparative exploration of lean manufacturing and six sigma in terms of their critical success factors. *Journal of Cleaner Production*, *164*, 325–337. https://doi.org/10.1016/j.jclepro.2017.06.146

Alhuraish, Ibrahim, Robledo, C., & Kobi, A. (2015). The effective of lean manufacturing and six sigma implementation. *2015 International Conference on Industrial Engineering and Systems Management (IESM)*, 453–460.

Ali, B., & Omar, W. (2016). Relationship between E-Banking Service Quality and Customer Satisfaction in Commercial Banks in Jordan. *American Based Research Journal, December*.

Allway, M., & Corbett, S. (2002). Shifting to lean service: Stealing a page from manufacturers' playbooks. *Journal of Organizational Excellence*, *21*(2), 45–54.

Alnadi, M., & McLaughlin, P. (2021). Critical success factors of Lean Six Sigma from leaders' perspective. *International Journal of Lean Six Sigma*.

Alolayyan, M. N., Al-Hawary, S. I. S., Mohammad, A. A. S., & Al-Nady, B. A.-H. A. (2018). Banking service quality provided by commercial banks and customer satisfaction. A structural equation modelling approaches. *International Journal of Productivity and Quality Management*, *24*(4), 543–565.

Alomari, K. M., Mansour, A. M., Almohtaseb, A. A., Salah, A. A., & Alshaketheep, K. M. (2020). Lean Six Sigma in Jordanian Organizations. *International Journal of*

*Economics & Business Administration (IJEBA)*, *8*(3), 429–447.

Anbari, F. T. (2002). Six sigma method and its applications in project management. *Proceedings of the Project Management Institute Annual Seminars and Symposium [Cd], San Antonio, Texas. Oct*, *3*(10).

Anderson, J., & Poole, M. (2019). *Assignment and thesis writing* (4th ed.). CBS Publishers & Distributors Pvt. Ltd.

Andersson, R., Eriksson, H., & Torstensson, H. (2006). Similarities and differences between TQM, six sigma and lean. *The TQM Magazine*.

Antony, J. (2004). Some pros and cons of six sigma: an academic perspective. *The TQM Magazine*.

Antony, J. (2006). Six sigma for service processes. *Business Process Management Journal*.

Antony, J. (2011). Six Sigma vs Lean: Some perspectives from leading academics and practitioners. *International Journal of Productivity and Performance Management*.

Antony, J. (2014). Readiness factors for the Lean Six Sigma journey in the higher education sector. *International Journal of Productivity and Performance Management*.

Antony, J. (2015). Challenges in the deployment of LSS in the higher education sector: Viewpoints from leading academics and practitioners. *International Journal of Productivity and Performance Management*.

Antony, J. (2017). Lean Six Sigma for higher education. *International Journal of Productivity and Performance Management*.

Antony, J., Antony, F. J., Kumar, M., & Cho, B. R. (2007). Six sigma in service organisations: Benefits, challenges and difficulties, common myths, empirical observations and success factors. *International Journal of Quality & Reliability Management*.

Antony, J., Douglas, A., & Antony, F. J. (2007). Determining the essential characteristics of Six Sigma black belts: results from a pilot study in UK manufacturing companies. *The TQM Magazine*.

Antony, J., Escamilla, J. L., & Caine, P. (2003). Lean Sigma [production and supply chain management]. *Manufacturing Engineer*, *82*(2), 40–42.

Antony, J., Ghadge, A., Ashby, S. A., & Cudney, E. A. (2018). Lean Six Sigma journey in a UK higher education institute: a case study. *International Journal of Quality & Reliability Management*.

Antony, J., Krishan, N., Cullen, D., & Kumar, M. (2012). Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques. *International Journal of Productivity and Performance Management*.

Antony, J., & Kumar, M. (2012). Lean and Six Sigma methodologies in NHS Scotland: an empirical study and directions for future research. *Quality Innovation Prosperity*, *16*(2), 19–34.

Antony, J., Manville, G., Greatbanks, R., Krishnasamy, R., & Parker, D. W. (2012). Critical success factors for Lean Six Sigma programmes: A view from middle management. *International Journal of Quality & Reliability Management, 29*(1), 7–20. https://doi.org/10.1108/02656711211190846

Antony, J., Rodgers, B., & Gijo, E. V. (2016). Can Lean Six Sigma make UK public sector organisations more efficient and effective? *International Journal of Productivity and Performance Management*.

Antony, J., Snee, R., & Hoerl, R. (2017). Lean Six Sigma: yesterday, today and tomorrow. *International Journal of Quality & Reliability Management*, *34*(7), 1073–1093. https://doi.org/10.1108/ijqrm-03-2016-0035

Anttila, J., Kajava, J., & Miettinen, J. E. (2001). *Changes in ITC Security Education due to Changing Technology*.

Arlbjørn, J. S., Freytag, P. V., & De Haas, H. (2011). Service supply chain management: A survey of lean application in the municipal sector. *International Journal of Physical Distribution & Logistics Management*.

Arnheiter, E. D., & Maleyeff, J. (2005). The integration of lean management and Six Sigma. *The TQM Magazine, 17*(1), 5–18. https://doi.org/10.1108/09544780510573020

Arqawi, S., Abu-Naser, S. S., & Al Shobaki, M. J. (2018). *Obstacles to the Application of Knowledge Management from the Point of View of the Employees at the Technical University of Palestine (Kadoorei)*.

Arumugam, V., Antony, J., & Kumar, M. (2013). Linking learning and knowledge creation to project success in Six Sigma projects: An empirical investigation. *International Journal of Production Economics*, *141*(1), 388–402. https://doi.org/10.1016/j.ijpe.2012.09.003

Asada, J. C. B. T. (2000). *Implementing ABM with Hoshin Management*.

Assarlind, M., Gremyr, I., & Bäckman, K. (2013). Multi-faceted views on a Lean Six Sigma application. *International Journal of Quality & Reliability Management*.

Badri, M. A., Davis, D., & Davis, D. (1995). A study of measuring the critical factors of quality management. *International Journal of Quality & Reliability Management*, *12*(2), 36–53. https://doi.org/10.1108/02656719510080604

Balodi, K. C. (2014). Strategic orientation and organizational forms: an integrative framework. *European Business Review*.

Bandyopadhyay, J. K. (2014). A framework for design, development, and delivery of high quality on-line higher education program in the US using six sigma approach. *Journal of Business and Behavioral Sciences*, *26*(3), 43.

Bandyopadhyay, J. K., & Lichtman, R. (2007). Six Sigma approach to quality and productivity improvement in an institution for higher education in the United States. *International Journal of Management*, *24*(4), 802.

Bargerstock, A. S., & Richards, S. R. (2015). Case study: application of DMAIC to academic assessment in higher education. *Quality Approaches in Higher Education*, *6*(2), 31–40.

Benedetto, A. R. (2003). Adapting manufacturing-based six sigma methodology to the service environment of a radiology film library. *Journal of Healthcare Management*, *48*(4), 263.

Bennet, D., & Bennet, A. (2004). The Rise of the Knowledge Organization [w]: Handbook on Knowledge Management: Knowledge matters. *CH Holssapple Springer, Berlin–Heidelberg–New York*.

Bhat, S., Gijo, E. V, & Jnanesh, N. A. (2014). Application of Lean Six Sigma methodology in the registration process of a hospital. *International Journal of Productivity and Performance Management*.

Bhat, S., & Jnanesh, N. A. (2014). Application of Lean Six Sigma methodology to reduce the cycle time of out-patient department service in a rural hospital. *International Journal of Healthcare Technology and Management*, *14*(3), 222–237.

Bhuiyan, N., & Baghel, A. (2005). An overview of continuous improvement: from the past to the present. *Management Decision*.

Bicheno, J., & Holweg, M. (2009). The lean toolbox–the essential guide to lean transformation, 4. *Aufl. PICSIE, Buckingham*.

Black, J. (2009). Transforming the patient care environment with Lean Six Sigma and realistic evaluation. *Journal for Healthcare Quality*, *31*(3), 29–35.

Bott, C., Keim, E., Kim, S., & Palser, L. (2000). Service quality six sigma case studies. *ASQ World Conference on Quality and Improvement Proceedings*, 225.

Boutros, T., & Cardella, J. (2017). *The basics of process improvement*. CRC Press.

Boynton, A. C., & Zmud, R. W. (1984). Assessment of Critical Success Factors. *Sloan Management Review, 25*(4), 17–27.

Bożek, M., & Hamrol, A. (2012). Analysis of efficiency of Lean Manufacturing and Six Sigma in a production enterprise. *Management and Production Engineering Review*, *3*, 14–25.

Brady, J. E., & Allen, T. T. (2006). Six Sigma literature: a review and agenda for future research. *Quality and Reliability Engineering International*, *22*(3), 335–367.

Brewer, P. C., & Eighme, J. E. (2005). Using Six Sigma to improve the finance function. *Strategic Finance*, *86*(11), 26.

Breyfogle III, F. W. (2003). *Implementing six sigma: smarter solutions using statistical methods*. John Wiley & Sons.

Brotherton, B., & Shaw, J. (1996). Towards an identification and classification of Critical Success Factors in UK Hotels Plc. *International Journal of Hospitality Management, 15*(2), 113–135. https://doi.org/10.1016/0278-4319(96)00014-X

Brown, J. S., & Duguid, P. (2000). Balancing act: How to capture knowledge without killing it. *Harvard Business Review*, *78*(3), 73–80.

Brun, A. (2011). Critical success factors of Six Sigma implementations in Italian companies. *International Journal of Production Economics*, *131*(1), 158–164. https://doi.org/10.1016/j.ijpe.2010.05.008

Byrne, G., Lubowe, D., & Blitz, A. (2007). Using a Lean Six Sigma approach to drive innovation. *Strategy & Leadership*.

Caiado, R., Nascimento, D., Quelhas, O., Tortorella, G., & Rangel, L. (2018). Towards sustainability through green, lean and six sigma integration at service industry: Review and framework. *Technological and Economic Development of Economy*, *24*(4), 1659–1678.

Camp, R. C., & Camp Robert, C. (1989). *Benchmarking: the search for industry best practices that lead to superior performance*. Quality Press Milwaukee, WI.

CBJ. (2020). *No Title*. Central Bank of Jordan. http://www.cbj.gov.jo/Pages/viewpage.aspx?pageID=46

Chakrabarty, A., & Tan, K. C. (2007). The current state of six sigma application in services. *Managing Service Quality*, *17*(2), 194–208. https://doi.org/10.1108/09604520710735191

Chang, C. L., & Lin, T.-C. (2015). The role of organizational culture in the knowledge management process. *Journal of Knowledge Management*.

Chaplin, L., & O'Rourke, S. T. J. (2014). Lean Six Sigma and marketing: a missed opportunity. *International Journal of Productivity and Performance Management*.

Chawla, D., & Joshi, H. (2010). Knowledge management initiatives in Indian public and private sector organizations. *Journal of Knowledge Management*.

Chen, C.-J., Shih, H.-A., & Yang, S.-Y. (2009). The role of intellectual capital in knowledge transfer. *IEEE Transactions on Engineering Management*, *56*(3), 402–411.

Chen, D. C., & Holsapple, C. W. (2009). Knowledge shared is power: Utilizing knowledge management activities to replicate lean sigma best practices. *Knowledge Management & E-Learning: An International Journal*, *1*(2), 90–102.

Chen, M., & Lyu, J. (2009). A Lean Six-Sigma approach to touch panel quality improvement. *Production Planning and Control*, *20*(5), 445–454.

Chen, S.-C., Al-rawahna, A. S. M., & Hung, C.-W. (2018). The barriers of e-government success: An empirical study from Jordan. *International Journal of Managing Public Sector Information and Communication Technologies (IJMPICT) Vol*, *9*.

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A., & Benhida, K. (2016). The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, *139*, 828–846.

Cheser, R. N. (1998). The effect of Japanese Kaizen on employee motivation in US manufacturing. *The International Journal of Organizational Analysis*.

Chiarini, A. (2012). Japanese total quality control. In *From Total Quality Control to Lean Six Sigma* (pp. 15–16). Springer.

Chittipaka, V., & Sagi, D. (2012). Relationship between kaizen events and perceived quality performance in Indian automobile industry. *International Journal of Management & Business Studies*, *2*(1).

Cooper, D. R., Schindler, P. S., & Sun, J. (2014). *Business research methods* (12 th, Vol. 9). Mcgraw-hill New York.

Coowar, R., Furterer, S., Akinrefon, T., Ferreras, A., Gibson, K., Lakkoju, R., & Meza, K. (2006). Lean Six Sigma as an improvement tool in academia. *2006 Annual Conference & Exposition*, 11–867.

Cournoyer, M. E., Nobile, A. O., Williams, G. M., Monsalve-Jones, R. A., Renner, C. M., & George, G. L. (2013). Application of lean six sigma business practices to an Air Purifying Respirator process. *Journal of Chemical Health & Safety*, *20*(2), 34–39.

Curatolo, N., Lamouri, S., Huet, J.-C., & Rieutord, A. (2014). A critical analysis of Lean approach structuring in hospitals. *Business Process Management Journal*.

D'Andreamatteo, A., Ianni, L., Lega, F., & Sargiacomo, M. (2015). Lean in healthcare: a comprehensive review. *Health Policy*, *119*(9), 1197–1209.

Dalkir, K. (2005). The knowledge management cycle. *Knowledge Management in Theory and Practice. Oxford: Elsevier*, 25–46.

Dalkir, K. (2013). *Knowledge management in theory and practice*. Routledge.

Danish, R. Q., Nawaz, M. M., & Munir, Y. (2012). Impact of knowledge management practices on organizational performance; An Evidence from Pakistan. *International Journal of Scientific & Engineering Research*, *3*(8), 1–6.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business Press.

De Feo, J. A. (2017). *Juran's quality handbook: The complete guide to performance excellence*. McGraw-Hill Education.

de Freitas, J. G., Costa, H. G., & Ferraz, F. T. (2017). Impacts of Lean Six Sigma over organizational sustainability: A survey study. *Journal of Cleaner Production*, *156*, 262–275.

De Koning, H., De Mast, J., Does, R. J. M. M., Vermaat, T., & Simons, S. (2008). Generic Lean Six Sigma project definitions in financial services. *Quality Management Journal*, *15*(4), 32–45.

De Koning, H., Does, R. J. M. M., & Bisgaard, S. (2008). Lean Six Sigma in financial services. *International Journal of Six Sigma and Competitive Advantage*, *4*(1), 1–17.

de Koning, H., Verver, J. P. S., van den Heuvel, J., Bisgaard, S., & Does, R. J. M. M. (2006). Lean Six Sigma in Healthcare. *Journal for Healthcare Quality*, *28*(2), 4–11. https://doi.org/10.1111/j.1945-1474.2006.tb00596.x

De Mast, J. (2006). Six Sigma and competitive advantage. *Total Quality Management and*

*Business Excellence*, *17*(04), 455–464.

de Sousa, M. C., & Van Dierendonck, D. (2010). Knowledge workers, servant leadership and the search for meaning in knowledge-driven organizations. *On the Horizon*.

de Souza, L. B., & Pidd, M. (2011). Exploring the barriers to lean health care implementation. *Public Money & Management*, *31*(1), 59–66.

Delgado, C., Ferreira, M., & Castelo Branco, M. (2010). The implementation of lean Six Sigma in financial services organizations. *Journal of Manufacturing Technology Management*, *21*(4), 512–523. https://doi.org/10.1108/17410381011046616

Department of Statistics. (2020). *The Economic Establishments Census 2018*. http://dosweb.dos.gov.jo/

Does, R., van den Heuvel, E., De Mast, J., & Bisgaard, S. (2002). Comparing nonmanufacturing with traditional applications of Six Sigma. *Quality Engineering*, *15*(1), 177–182.

Dombrowski, U., Mielke, T., & Engel, C. (2012). Knowledge management in lean production systems. *Procedia Cirp*, *3*, 436–441.

Doran, C. (2003). Using six sigma in the credit department. *Credit Management*, *32*.

Douglas, J., Antony, J., & Douglas, A. (2015). Waste identification and elimination in HEIs: the role of Lean thinking. *International Journal of Quality & Reliability Management*.

Drotz, E., & Poksinska, B. (2014). Lean in healthcare from employees' perspectives. *Journal of Health Organization and Management*, *28*(2), 177–195. https://doi.org/10.1108/jhom-03-2013-0066

Eckhouse, J. (2003). In pursuit of perfection. *Bechtel Briefs*, *58*(2), 24–27.

Elsberry, R. B. (2000). Six sigma: applying a corporate model to radiology. *Decisions in Imaging Economics*, *13*(7), 56–66.

Erdil, N. O., Aktas, C. B., & Arani, O. M. (2018). Embedding sustainability in lean six sigma efforts. *Journal of Cleaner Production*, *198*, 520–529.

Essawi, M., & Tilchin, O. (2013). *A model of knowledge management culture change*.

Ettinger, W. H. (2001). Six Sigma: adapting GE's lessons to health care. *Trustee*, *54*(8), 10.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5 th). sage.

Folinas, D., & Ngosa, J. (2013). Doing more with less: a pharmaceutical supplier case. *International Journal of Productivity and Quality Management*, *11*(4), 412–433.

Freitag, A. E. B., & de Oliveira, A. B. (2021). Underutilization of workers: an analysis according to the lean management philosophy in basic education. *Independent Journal of Management & Production*, *12*(9), s940–s959.

Fryer, K. J., Antony, J., & Douglas, A. (2007). Critical success factors of continuous improvement in the public sector: A literature review and some key findings. *TQM Magazine*, *19*(5), 497–517. https://doi.org/10.1108/09544780710817900

Gershon, M., & Rajashekharaiah, J. (2013). How many steps to quality? From Deming cycle to DMAIC. *International Journal of Productivity and Quality Management*, *11*(4), 475–489.

Ghaziri, H., & Awad, E. (2005). Is there a future for knowledge management. *Journal of Information Technology Management*, *16*(1), 31–38.

Girard, J., & Girard, J. (2015). Defining knowledge management: Toward an applied compendium. *Online Journal of Applied Knowledge Management*, *3*(1), 1–20.

Glasgow, J. M., Scott-Caziewell, J. R., & Kaboli, P. J. (2010). Guiding inpatient quality improvement: a systematic review of Lean and Six Sigma. *The Joint Commission Journal on Quality and Patient Safety*, *36*(12), 533-AP5.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems*, *18*(1), 185–214.

Gordon, G. A., & Fischer, M. (2011). Accounting strategy to improve public higher education management. *Journal of Accounting and Finance*, *11*(3), 11–25.

Gowen Iii, C. R., Stock, G. N., & McFadden, K. L. (2008). Simultaneous implementation of Six Sigma and knowledge management in hospitals. *International Journal of Production Research*, *46*(23), 6781–6795.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, *17*(S2), 109–122.

Griffin, R. K. (1995). A categorization scheme for critical success factors of lodging yield management systems. *International Journal of Hospitality Management*, *14*(3–4), 325–338. https://doi.org/10.1016/0278-4319(95)00039-9

Gupta, A., & Gupta, S. (2017). Kaizen, a continuous improvement for reduction of wastes: a case study. *International Journal of Productivity and Quality Management*, *21*(3), 300–324.

Gupta, S., & Jain, S. K. (2014). The 5S and kaizen concept for overall improvement of the organisation: a case study. *International Journal of Lean Enterprise Research*, *1*(1), 22–40.

Gutierrez-Gutierrez, L., De Leeuw, S., & Dubbers, R. (2016). Logistics services and Lean Six Sigma implementation: a case study. *International Journal of Lean Six Sigma*.

Gutierrez Gutierrez, L., Barrales-Molina, V., & Tamayo-Torres, J. (2016). The knowledge transfer process in Six Sigma subsidiary firms. *Total Quality Management & Business Excellence*, *27*(5–6), 613–627.

Hahn, G. J., & Doganaksoy, N. (2011). *The role of statistics in business and industry*. John Wiley & Sons.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2018).

*Multivariate data analysis* (8th ed.). Cengage Learning EMEA.

Haldin-Herrgard, T. (2000). Difficulties in diffusion of tacit knowledge in organizations. *Journal of Intellectual Capital*, *1*(4), 357–365.

Harmon, P., & Trends, B. P. (2010). *Business process change: A guide for business managers and BPM and Six Sigma professionals*. Elsevier.

Harrison, J. (2006). Six Sigma vs. Lean manufacturing: Which is right for your company. *Foundry Management & Technology*, *13*(7), 31–32.

Harry, M. J., & Schroeder, R. R. (2005). *Six Sigma: The breakthrough management strategy revolutionizing the world's top corporations*. Crown Pub.

Hauck, Z., Rabta, B., & Reiner, G. (2021). Analysis of screening decisions in inventory models with imperfect quality items. *International Journal of Production Research*, *59*(21), 6528–6543. https://doi.org/10.1080/00207543.2020.1818862

Hauck, Z., & Vörös, J. (2015). Lot sizing in case of defective items with investments to increase the speed of quality control. *Omega*, *52*, 180–189.

Heckl, D., Moormann, J., & Rosemann, M. (2010). Uptake and success factors of Six Sigma in the financial services industry. *Business Process Management Journal*.

Hess, P. W., & Siciliano, J. (2007). A research-based approach to continuous improvement in business education. *Organization Management Journal*, *4*(2), 135–147.

Higgins, K. T. (2005). Lean builds steam. *Food Engineering: The Magazine for Operations and Manufacturing Management*, *1*(1), 1–5.

Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: a review of contemporary lean thinking. *International Journal of Operations & Production Management*.

Hoerl, R. W. (2001). Six Sigma black belts: what do they need to know? *Journal of Quality Technology*, *33*(4), 391–406.

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management*, *25*(2), 420–437. https://doi.org/10.1016/j.jom.2006.04.001

Huang, Y., & Klassen, K. J. (2016). Using six sigma, lean, and simulation to improve the phlebotomy process. *Quality Management Journal*, *23*(2), 6–21.

Huddle, M. G., Tirabassi, A., Turner, L., Lee, E., Ries, K., & Lin, S. Y. (2016). Application of lean sigma to the audiology clinic at a large academic center. *Otolaryngology--Head and Neck Surgery*, *154*(4), 715–719.

Indrawati, S., & Ridwansyah, M. (2015). Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application. *Procedia Manufacturing*, *4*(Iess), 528–534. https://doi.org/10.1016/j.promfg.2015.11.072

Jalali, S. M. J., Shafieezadeh, M., & Naiini, M. A. S. (2008). Using knowledge management in DMAIC methodology of six sigma projects. *2008 1st International Conference on Information Technology*, 1–4.

Jensen, M. B., Johnson, B., Lorenz, E., Lundvall, B.-Å., & Lundvall, B. A. (2007). Forms of knowledge and modes of innovation. *The Learning Economy and the Economics of Hope*, *155*.

Jeyaraman, K., & Teo, L. K. (2010). A conceptual framework for critical success factors of lean Six Sigma: Implementation on the performance of electronic manufacturing service industry. *International Journal of Lean Six Sigma*, *1*(3), 191–215. https://doi.org/10.1108/20401461011075008

Johnson, A., & Swisher, B. (2003). Managers at Work: How Six Sigma Improves R&D. *Research-Technology Management*, *46*(2), 12–15.

Jugulum, R., & Samuel, P. (2010). *Design for lean six sigma: A holistic approach to design and innovation*. John Wiley & Sons.

Kalashnikov, V., Benita, F., López-Ramos, F., & Hernández-Luna, A. (2017). Bi-objective project portfolio selection in Lean Six Sigma. *International Journal of Production Economics*, *186*, 81–88. https://doi.org/10.1016/j.ijpe.2017.01.015

Känsäkoski, H. (2017). Information and knowledge processes as a knowledge management framework in health care: Towards shared decision making? *Journal of Documentation*.

Karamitri, I., Kitsios, F., & Talias, M. A. (2020). Development and validation of a knowledge management questionnaire for hospitals and other healthcare organizations. *Sustainability*, *12*(7), 2730.

Keller, P. (2011). *Six Sigma Demystified®*. McGraw-Hill Education.

Khalili, A., Ismail, M. Y., & Karim, A. N. M. (2017). Integration of lean manufacturing and quality management system through structural equation modelling. *International Journal of Productivity and Quality Management*, *20*(4), 534–556.

Khan, S. K., & Rashid, M. Z. A. (2012). The Mediating Effect of Organizational Commitment in the Organizational Culture, Leadership and Organizational Justice Relationship with Organizational Citizenship Behavior: A Study of Academicians in Private Higher Learning Institutions in Malaysia. *International Journal of Business and Social Science*, *3*(8).

Khanna, V. K., & Gupta, R. (2014). Comparative study of the impact of competency-based training on 5 "S" and TQM: a case study. *International Journal of Quality & Reliability Management*.

Khlat, M., Harb, A. H., & Kassem, A. (2014). Lean manufacturing: Implementation and assessment in the Lebanese Pharmaceutical Industry. *International Journal of Computing and Optimization*, *1*(2), 47–62.

Kianto, A., Vanhala, M., & Heilmann, P. (2016). The impact of knowledge management on job satisfaction. *Journal of Knowledge Management*.

King, W. R. (2009). Knowledge management and organizational learning. In *Knowledge management and organizational learning* (pp. 3–13). Springer.

Klefsjo, B., Bergquist, B., & Edgeman, R. L. (2006). Six Sigma and Total Quality Management: different day, same soup? *International Journal of Six Sigma and*

*Competitive Advantage*, *2*(2), 162–178.

Kobayashi, K., Fisher, R., & Gapp, R. (2008). Business improvement strategy or useful tool? Analysis of the application of the 5S concept in Japan, the UK and the US. *Total Quality Management*, *19*(3), 245–262.

Kordab, M., & Raudeliūnienė, J. (2018). Knowledge management cycle: a scientific literature review. *10th International Scientific Conference „Business and Management 2018 “*.

Kothari, C. R. (2020). *Research Methodology: Methods and Techniques*. New Age Intl., New Delhi.

Kotler, P., & Turner, R. E. (1997). *Marketing management: Analysis, planning, implementation, and control* (Vol. 9). Prentice hall Upper Saddle River, NJ.

Kovach, J., Stringfellow, P., Turner, J., & Cho, B. R. (2005). The house of competitiveness: the marriage of agile manufacturing, design for Six Sigma, and lean manufacturing with quality considerations. *Journal of Industrial Technology*, *21*(3), 1–10.

Kovács, T., Kő, A., & Demeter, K. (2020). Measuring the impact of lean practices on manufacturing performance–case study from the process industry. *International Journal of Lean Six Sigma*.

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan Management Review*, *30*(1), 41–52.

Kraszewski, R. (2005). Quality management–conceptions, methods and tools used by the world’s business leaders. *Scientific Society of Management Published, Toru*.

Kucza, T. (2001). *Knowledge management process model*. VTT Technical Research Centre of Finland.

Kumar, Maneesh, & Antony, J. (2008). Comparing the quality management practices in UK SMEs. *Industrial Management & Data Systems*, *108*(9), 1153–1166. https://doi.org/10.1108/02635570810914865

Kumar, Mike, Antony, J., Singh, R. K., Tiwari, M. K., & Perry, D. (2006). Implementing the Lean Sigma framework in an Indian SME: a case study. *Production Planning and Control*, *17*(4), 407–423.

Kumar, R. (2019). *Research methodology: A step-by-step guide for beginners* (5th ed.). Sage.

Kumar, S., & Gupta, Y. P. (1993). Statistical process control at Motorola’s Austin assembly plant. *Interfaces*, *23*(2), 84–92.

Kurdve, M., Zackrisson, M., Wiktorsson, M., & Harlin, U. (2014). Lean and green integration into production system models–experiences from Swedish industry. *Journal of Cleaner Production*, *85*, 180–190.

Kwak, Y. H., & Anbari, F. T. (2006). Benefits, obstacles, and future of six sigma approach. *Technovation*, *26*(5–6), 708–715. https://doi.org/10.1016/j.technovation.2004.10.003

Lam, A. (2000). Tacit knowledge, organizational learning and societal institutions: An integrated framework. *Organization Studies*, *21*(3), 487–513.

Laudon, K. C., & Laudon, J. P. (2004). *Management information systems: Managing the digital firm*. Pearson Educación.

Laureani, A., & Antony, J. (2010). Reducing employees' turnover in transactional services: a Lean Six Sigma case study. *International Journal of Productivity and Performance Management*, *59*(7), 688–700. https://doi.org/10.1108/17410401011075666

Laureani, A., & Antony, J. (2012). Critical success factors for the effective implementation of Lean Sigma: Results from an empirical study and agenda for future research. *International Journal of Lean Six Sigma*, *3*(4), 274–283. https://doi.org/10.1108/20401461211284743

Laureani, A., & Antony, J. (2016). Leadership – a critical success factor for the effective implementation of Lean Six Sigma. *Total Quality Management & Business Excellence*, *29*(5–6), 502–523. https://doi.org/10.1080/14783363.2016.1211480

Laureani, A., Antony, J., & Douglas, A. (2010). Lean six sigma in a call centre: a case study. *International Journal of Productivity and Performance Management*.

Laureani, A., Brady, M., & Antony, J. (2013). Applications of lean six sigma in an Irish hospital. *Leadership in Health Services*.

Leavitt, P. (2002). Knowledge management and six sigma: Exploring the potential of two powerful disciplines. *American Productivity & Quality Centre (APQC)*.

Leggat, S. G., Bartram, T., Stanton, P., Bamber, G. J., & Sohal, A. S. (2015). Have process redesign methods, such as Lean, been successful in changing care delivery in hospitals? A systematic review. *Public Money & Management*, *35*(2), 161–168.

Lertwattanapongchai, S., & William Swierczek, F. (2014). Assessing the change process of Lean Six Sigma: a case analysis. *International Journal of Lean Six Sigma*, *5*(4), 423–443. https://doi.org/10.1108/ijlss-07-2013-0040

Li, N., Laux, C. M., & Antony, J. (2019). How to use lean Six Sigma methodology to improve service process in higher education: A case study. *International Journal of Lean Six Sigma*.

Lian, Y.-H., & Van Landeghem, H. (2002). An application of simulation and value stream mapping in lean manufacturing. *Proceedings 14th European Simulation Symposium*, 1–8.

Liker, J. (2001). *K., 2004, The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. McGraw-Hill.

Lin, S. Y., Gavney, D., Ishman, S. L., & Cady-Reh, J. (2013). Use of lean sigma principles in a tertiary care otolaryngology clinic to improve efficiency. *The Laryngoscope*, *123*(11), 2643–2648.

Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. (2003). Six Sigma: a goal-theoretic perspective. *Journal of Operations Management*, *21*(2), 193–203.

Lueg, C. (2001). Information, knowledge, and networked minds. *Journal of Knowledge Management*.

Lummus, R. R., Vokurka, R. J., & Rodeghiero, B. (2006). Improving quality through value stream mapping: A case study of a physician's clinic. *Total Quality Management*, *17*(8), 1063–1075.

Lundvall, B.-Å. (2006). *Knowledge management in the learning economy*. Danish Research Unit for Industrial Dynamics Aalborg.

Madhani, P. M. (2018). Lean Six Sigma deployment in BFSI sector: synthesising and developing customer value creation models. *International Journal of Electronic Customer Relationship Management*, *11*(3), 272–314.

Magnusson, K., Kroslid, D., Bergman, B., Häyhänen, P., & Mills, D. (2003). *Six Sigma: the pragmatic approach*. Studentlitteratur.

Majchrzak, A., Cooper, L. P., & Neece, O. E. (2004). Knowledge reuse for innovation. *Management Science, 50*(2), 174–188.

Maleszka, A., & Linke, M. (2016). Improvement of management process by using Lean Six Sigma tools in some big organisation of food industry. *Polish Journal of Natural Sciences*, *31*(1), 101–112.

Malik, S. A., Li-bin, L. U., Ye-zhuang, T., & Xiao-lin, S. U. N. (2007). Continuous improvement practices in Asian developing countries a comparative analysis between Chinese & Pakistani manufacturing Industry. *2007 International Conference on Management Science and Engineering*, 692–697.

Mancosu, P., Nicolini, G., Goretti, G., De Rose, F., Franceschini, D., Ferrari, C., Reggiori, G., Tomatis, S., & Scorsetti, M. (2018). Applying Lean-Six-Sigma Methodology in radiotherapy: Lessons learned by the breast daily repositioning case. *Radiotherapy and Oncology*, *127*(2), 326–331.

Mandahawi, N., Al-Araidah, O., Boran, A., & Khasawneh, M. (2011). Application of Lean Six Sigma tools to minimise length of stay for ophthalmology day case surgery. *International Journal of Six Sigma and Competitive Advantage*, *6*(3), 156–172.

Mangotra, M., & Mahajan, R. (2014). Assessing the impact of knowledge management practices on organizational learning and performance: a study of Govt. Medical College Jammu. *International Journal of Management and International Business Studies*, *4*(1), 101–108.

McAdam, R., & Donegan, S. (2003). A comparative analysis of trilateral and concurrent business improvement methodologies in the high technology sector. *International Journal of Manufacturing Technology and Management*, *5*(3), 210–231.

McIver, D., Lengnick-Hall, C. A., Lengnick-Hall, M. L., & Ramachandran, I. (2013). Understanding work and knowledge management from a knowledge-in-practice perspective. *Academy of Management Review*, *38*(4), 597–620.

Melton, T. (2005). The Benefits of Lean Manufacturing. *Chemical Engineering Research and Design*, *83*(6), 662–673. https://doi.org/10.1205/cherd.04351

Mertins, K., Heisig, P., Vorbeck, J., Mertins, K., Heisig, P., & Vorbeck, J. (2001). *Knowledge management: Best practices in Europe*.

Michael, G. (2003). *Lean six sigma for service: how to use lean speed and six sigma quality to improve services and transactions* (1st ed.). McGraw-Hill.

Michalska, J., & Szewieczek, D. (2007). The 5S methodology as a tool for improving the organization. *Journal of Achievements in Materials and Manufacturing Engineering*, *24*(2), 211–214.

Mikel, H., Lurie, J., & Schroeder, R. R. (2000). *Six sigma: The breakthrough management strategy revolutionizing the world's top corporations*. Recorded Books.

Miller, M. D., Linn, R., & Gronlund, N. (2013). *Measurement and assessment in teaching* (11th ed.). Pearson.

Mills, A. M., & Smith, T. A. (2011). Knowledge management and organizational performance: a decomposed view. *Journal of Knowledge Management*.

Modi, A., & Doyle, L. (2012). Applicability of lean-sigma in IT service delivery system. *IFAC Proceedings Volumes*, *45*(10), 154–159.

Mohajan, H. (2017). *The roles of knowledge management for the development of organizations*.

Molnar, V. (2020). Waiting as Waste in Lean Production Processes. *The International Symposium for Production Research*, 429–437.

Molnár, V., Deszpoth, I., & Kundrák, J. (2019). *Lead time reduction in manufacturing process of toothed parts*.

Molnár, V., Szabó, G., & Kundrák, J. (2018). *Waste reduction possibilities in a manufacturing process*.

Montgomery, D. C. (2016). Why Do Lean Six Sigma Projects Sometimes Fail? *Quality and Reliability Engineering International*, *32*(4), 1279. https://doi.org/10.1002/qre.2009

Moradi, M., Abdollahzadeh, M. R., & Vakili, A. (2011). Effects of implementing 5S on total productive maintenance: a case in Iran. *2011 IEEE International Conference on Quality and Reliability*, 41–45.

Moreton, M. (2003). Featured company: bechtel. *Lean & Six Sigma Review*, *3*(1), 44.

Mousa, A. (2013). Lean, Six Sigma and lean Six Sigma overview. *International Journal of Scientific and Engineering Research*, *4*(5), 1137–1153.

Mozammel, A., & Mapa, L. (2011). Application of lean six sigma in healthcare-nursing shift directors process improvement. *Journal of Management & Engineering Integration*, *4*(2), 58.

Mualla, N. D. (2011). Measuring quality of bank services in Jordan: gap analysis. *International Journal of Business and Social Science*, *2*(1).

Muhammad, N. A., & Chin, J. F. (2020). Exploring knowledge management in a Lean Six

Sigma organisation. *International Journal of Management Concepts and Philosophy*, *13*(1), 20–38.

Nash, M., Poling, S. R., & Ward, S. (2006). Six Sigma speed: faster results come from a lean culture. *Industrial Engineer*, *38*(11), 40–45.

Näslund, D. (2008). Lean, six sigma and lean sigma: Fads or real process improvement methods? *Business Process Management Journal*, *14*(3), 269–287. https://doi.org/10.1108/14637150810876634

Nave, D. (2002). How to compare six sigma, lean and the theory of constraints. *Quality Progress*, *35*(3), 73–80.

Nawanir, G., Binalialhajj, M., Lim, K. T., & Ahmad, M. H. (2019). Becoming lean: the way towards sustainability of higher educations institutions. *KnE Social Sciences*, 603–626.

Newman, B. D., & Conrad, K. W. (2000). A Framework for Characterizing Knowledge Management Methods, Practices, and Technologies. *PAKM*.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14–37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review*, *40*(3), 40–54.

Nonaka, I., & Takeuchi, H. (1995). The Knowledge Creating. *New York*, *304*.

Nonthaleerak, P., & Hendry, L. (2008). Exploring the Six Sigma phenomenon using multiple case study evidence. *International Journal of Operations & Production Management*.

Nunes, I. L. (2015). Integration of ergonomics and lean six sigma. A model proposal. *Procedia Manufacturing*, *3*, 890–897.

O'Dell, C., & Grayson, C. J. (2004). Identifying and transferring internal best practices. In *Handbook on Knowledge Management 1* (pp. 601–622). Springer.

O'Dell, C., & Hubert, C. (2011a). Building a knowledge-sharing culture. *The Journal for Quality and Participation*, *34*(2), 22.

O'Dell, C., & Hubert, C. (2011b). *The new edge in knowledge: How knowledge management is changing the way we do business*. John Wiley & Sons.

Ohno, T. (1988). *Toyota Production System: Beyond Large Large-scale Production*. Productivity Press, Portland.

Oliver, J., Oliver, Z., & Chen, C. (2019). Applying lean six sigma to grading process improvement. *International Journal of Lean Six Sigma*.

Pacheco, D., Pergher, I., Vaccaro, G. L. R., Jung, C. F., & ten Caten, C. (2015). 18 comparative aspects between lean and Six Sigma: complementarity and implications. *International Journal of Lean Six Sigma*.

Paliszkiewicz, J. (2021). Knowledge management: enterprise-wide strategies. In *A* *research agenda for knowledge management and analytics* (pp. 31–41). Edward Elgar Publishing.

Pamfilie, R., (Draghici), A. J. P., & Draghici, M. (2012). The Importance of Leadership in Driving a Strategic Lean Six Sigma Management. *Procedia - Social and Behavioral Sciences*, *58*, 187–196. https://doi.org/10.1016/j.sbspro.2012.09.992

Panayiotou, N. A., & Stergiou, K. E. (2021). A systematic literature review of lean six sigma adoption in European organizations. *International Journal of Lean Six Sigma*, *12*(2), 264–292. https://doi.org/10.1108/IJLSS-07-2019-0084

Pande, P., Neuman, R., & Cavanagh, R. (2000). The Six Sigma Way McGraw-Hill. *New York, NY*.

Patil, S., Sapkal, A., & Sutar, M. (2016). Execute 5S methodology in small scale industry: a case study. *International Journal of Research in Advent Technology*, *4*(3), 47–51.

Patton, F. (2005). Does six sigma work in service industries? *Quality Progress*, *38*(9), 55.

Peñarroja, V., Sánchez, J., Gamero, N., Orengo, V., & Zornoza, A. M. (2019). The influence of organisational facilitating conditions and technology acceptance factors on the effectiveness of virtual communities of practice. *Behaviour & Information Technology*, *38*(8), 845–857.

Pepper, M. P. J., & Spedding, T. A. (2010). The evolution of lean Six Sigma. *International Journal of Quality & Reliability Management*, *27*(2), 138–155. https://doi.org/10.1108/02656711011014276

Pfeffer, J. (2010). Building sustainable organizations: The human factor. *Academy of Management Perspectives*, *24*(1), 34–45.

Pfeffer, J., & Sutton, R. I. (2000). *The knowing-doing gap: How smart companies turn knowledge into action*. Harvard business press.

Piercy, N., & Rich, N. (2009). Lean transformation in the pure service environment: the case of the call service centre. *International Journal of Operations & Production Management*.

Pinjari, H., & Teli, S. N. (2018). Integrated approach of Six Sigma and Knowledge Management. *International Journal of Scientific & Engineering Research*, *9*(5).

Poister, T. H., & Streib, G. D. (2018). Strategic Management in the Public Sector: Concepts, Models, and Processes. In *Performance-Based Budgeting* (pp. 283–305). Routledge.

Powell, W. W., & Snellman, K. (2004). The knowledge economy. *Annual Review of Sociology*, 199–220.

prime Minister. (2020). *Ministries and government departments*. http://www.pm.gov.jo

Pryor, M. G., Alexander, C., Taneja, S., Tirumalasetty, S., & Chadalavada, D. (2012). The Application of Six Sigma Methodologies to University Processes: The Use of Student Teams. *Journal of Case Studies in Accreditation and Assessment*, *2*.

Psychogios, A. G., Atanasovski, J., & Tsironis, L. K. (2012). Lean Six Sigma in a service context. *International Journal of Quality & Reliability Management*, *29*(1), 122–139. https://doi.org/10.1108/02656711211190909

Qian, L. (2014). Market-based supplier selection with price, delivery time, and service level dependent demand. *International Journal of Production Economics*, *147*, 697–706.

Quast, L. (2012). Why knowledge management is important to the success of your company. *Retrieved September*, *7*, 2013.

Raisinghani, M. S., Ette, H., Pierce, R., Cannon, G., & Daripaly, P. (2005). Six Sigma: concepts, tools, and applications. *Industrial Management & Data Systems*.

Rajagopalan, R., Francis, M., & Suárez, W. (2004). Managers at work: Developing novel catalysts with Six Sigma. *Research-Technology Management*, *47*(1), 13–16.

Randhawa, J. S., & Ahuja, I. S. (2017). 5S implementation methodologies: literature review and directions. *International Journal of Productivity and Quality Management*, *20*(1), 48–74.

Ranjan Senapati, N. (2004). Six Sigma: myths and realities. *International Journal of Quality & Reliability Management*, *21*(6), 683–690. https://doi.org/10.1108/02656710410542070

Rashid, A. S., Tout, K., & Yakan, A. (2021). The critical human behavior factors and their impact on knowledge management system–cycles. *Business Process Management Journal*.

Raudeliūnienė, J., Davidavičienė, V., & Jakubavičius, A. (2018). Knowledge management process model. *Entrepreneurship and Sustainability Issues*, *5*(3), 542–554.

Raval, S. J., Kant, R., & Shankar, R. (2018). Lean Six Sigma implementation: modelling the interaction among the enablers. *Production Planning & Control*, *29*(12), 1010–1029. https://doi.org/10.1080/09537287.2018.1495773

Rehman, W. ul, Asghar, N., & Ahmad, K. (2015). IMPACT OF KM PRACTICES ON FIRMS'PERFORMANCE: A MEDIATING ROLE OF BUSINESS PROCESS CAPABILITY AND ORGANIZATIONAL LEARNING. *Pakistan Economic and Social Review*, 47–80.

Reid, R. A. (2006). Productivity and quality improvement: an implementation framework. *International Journal of Productivity and Quality Management*, *1*(1–2), 26–36.

Revere, L. (2003). Integrating Six Sigma with total quality management: a case example for measuring medication errors. *Journal of Healthcare Management*, *48*(6).

Roberts, C. M. (2004). Six sigma signals. *Credit Union Magazine*, *70*(1), 40–43.

Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review*, *57*(2), 81–93.

Rodgers, B., & Antony, J. (2019). Lean and Six Sigma practices in the public sector: a review. *International Journal of Quality & Reliability Management*.

Rodgers, B., Antony, J., Edgeman, R., & Cudney, E. A. (2021). Lean Six Sigma in the public sector: yesterday, today and tomorrow. *Total Quality Management & Business Excellence*, *32*(5–6), 528–540. https://doi.org/10.1080/14783363.2019.1599714

Rother, M., & Shook, J. (2003). *Learning to see: value stream mapping to add value and eliminate muda*. Lean Enterprise Institute.

Saini, M. (2015). *A framework for transferring and sharing tacit knowledge in construction supply chains within lean and agile processes*. University of Salford.

Salah, S., & Rahim, A. (2019). The integration of six sigma and lean. In *An Integrated Company-Wide Management System* (pp. 49–93). Springer.

Salah, S., Rahim, A., & Carretero, J. A. (2010). The integration of Six Sigma and lean management. *International Journal of Lean Six Sigma*.

Samawi, G. A., Abu-Tayeh, B. K., Yosef, F., Madanat, M., & Al-Qatawneh, M. I. (2018). Relation between total quality management practices and business excellence: evidence from private service firms in Jordan. *International Review of Management and Marketing*, *8*(1), 28–35.

Sandner, K., Sieber, S., Tellermann, M., & Walthes, F. (2020). A Lean Six Sigma framework for the insurance industry: insights and lessons learned from a case study. *Journal of Business Economics*, *90*(5), 845–878.

Sangari, M. S., Hosnavi, R., & Zahedi, M. R. (2015). The impact of knowledge management processes on supply chain performance: An empirical study. *The International Journal of Logistics Management*.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Schroeder, R. G., Linderman, K., Liedtke, C., & Choo, A. S. (2009). Six Sigma: Definition and underlying theory. *Quality Control and Applied Statistics*, *54*(5), 441–445.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach* (7th ed.). John Wiley & Sons.

Shah, R., Chandrasekaran, A., & Linderman, K. (2008). In pursuit of implementation patterns: the context of Lean and Six Sigma. *International Journal of Production Research*, *46*(23), 6679–6699.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, *21*(2), 129–149.

Shahin, A., & Alinavaz, M. (2008). Integrative approaches and frameworks of lean Six Sigma: a literature perspective. *International Journal of Process Management and Benchmarking*, *2*(4), 323–337.

Shahzad, K., Bajwa, S. U., Siddiqi, A. F. I., Ahmid, F., & Sultani, A. R. (2016). Integrating knowledge management (KM) strategies and processes to enhance organizational creativity and performance: An empirical investigation. *Journal of Modelling in Management*.

Sharma, R. K., Kumar, D., & Kumar, P. (2007). Modeling and analysing system failure behaviour using RCA, FMEA and NHPPP models. *International Journal of Quality & Reliability Management*.

Sharma, U. (2003). Implementing lean principles with the Six Sigma advantage: how a battery company realized significant improvements. *Journal of Organizational Excellence*, *22*(3), 43–52.

Simons, N. (2013). The business case for Lean Six Sigma in higher education. *ASQ Higher Education Brief*, *6*(3), 1–6.

Sin, A. B., Zailani, S., Iranmanesh, M., & Ramayah, T. (2015). Structural equation modelling on knowledge creation in Six Sigma DMAIC project and its impact on organizational performance. *International Journal of Production Economics*, *168*, 105–117.

Singh, B., Garg, S. K., & Sharma, S. K. (2011). Value stream mapping: literature review and implications for Indian industry. *The International Journal of Advanced Manufacturing Technology*, *53*(5), 799–809.

Sivakumar, V. M., Devadasan, S. R., Murugesh, R., & Maharaja, R. (2008). Design and development of knowledge managed total failure mode and effects analysis technique. *International Journal of Productivity and Quality Management*, *3*(4), 413–429.

Smith, B. (2003). Lean and Six Sigma--a one-two punch. *Quality Progress*, *36*(4), 37.

Snee, R. D. (1999). Why should statisticians pay attention to Six Sigma? *Quality Progress*, *32*(9), 100.

Snee, R. D. (2004a). Can Six Sigma boost your company’s growth? *Harvard Management Update*, *9*(6), 3–5.

Snee, R. D. (2005). When worlds collide: lean and Six Sigma. *Quality Progress*, *38*(9), 63–65.

Snee, R. D. (2010). Lean Six Sigma – getting better all the time. *International Journal of Lean Six Sigma*, *1*(1), 9–29. https://doi.org/10.1108/20401461011033130

Snee, R. D. (2004b). The future of six sigma. *Six Sigma Forum Magazine, August*, 39.

Snee, R. D., & Hoerl, R. W. (2007). Integrating lean and Six Sigma-a holistic approach. *Six Sigma Forum Magazine*, *6*(3).

Snee, Ron, & Hoerl, R. (2004). Leading Six Sigma - A Step-by-Step Guide Based on Experience with GE and Other Six Sigma Companies. *International Journal of Quality & Reliability Management*, *21*. https://doi.org/10.1108/02656710410530136

Snee, Ronald, Hoerl, R., & Hoerl, R. W. (2004). *Six Sigma beyond the factory floor: deployment strategies for financial services, health care, and the rest of the real economy*. Pearson.

Sony, M., & Mekoth, N. (2019). Broadening the Lean Six Sigma concept through employee adaptability: a literature review. *International Journal of Productivity and Quality Management*, *28*(3), 279–298.

Spasojevic Brkic, V., & Tomic, B. (2016). Employees factors importance in Lean Six

Sigma concept. *The TQM Journal*, *28*(5), 774–785. https://doi.org/10.1108/tqm-10-2015-0131

Stankalla, R., Koval, O., & Chromjakova, F. (2018). A review of critical success factors for the successful implementation of Lean Six Sigma and Six Sigma in manufacturing small and medium sized enterprises. *Quality Engineering*, *30*(3), 453–468. https://doi.org/10.1080/08982112.2018.1448933

Stoner, J. A. F., & Werner, F. M. (1994). *Managing finance for quality: bottom-line results from top-level commitment*. Quality Press.

Strubelt, H., & Mollenhauer, F. (2019). Identifying and evaluating synergies of Lean Six Sigma and knowledge management in deliberately interlocking application. *International Journal of Quality & Reliability Management*.

Subedi, B. P. (2016). Using Likert type data in social science research: Confusion, issues and challenges. *International Journal of Contemporary Applied Sciences*, *3*(2), 36–49.

Sukharev, O. (2021). Measuring the contribution of the "knowledge economy" to the economic growth rate: Comparative analysis. *Journal of the Knowledge Economy*, *12*(4), 1809–1829.

Sunder, M. V. (2016). Lean Six Sigma in higher education institutions. *International Journal of Quality and Service Sciences*.

Sutrisno, A., & Lee, T. J. (2011). Service reliability assessment using failure mode and effect analysis (FMEA): survey and opportunity roadmap. *International Journal of Engineering, Science and Technology, 3*(7), 25–38.

Sveiby, K. (2001). A knowledge-based theory of the firm to guide in strategy formulation. *Journal of Intellectual Capital*.

Svensson, C., Antony, J., Ba-Essa, M., Bakhsh, M., & Albliwi, S. (2015). A Lean Six Sigma program in higher education. *International Journal of Quality & Reliability Management*.

Taghaboni-Dutta, F., & Moreland, K. (2004). Using six-sigma to improve loan portfolio performance. *The Journal of American Academy of Business*, *5*(1/2), 15–20.

Tenera, A., & Pinto, L. C. (2014). A Lean Six Sigma (LSS) Project Management Improvement Model. *Procedia - Social and Behavioral Sciences*, *119*, 912–920. https://doi.org/10.1016/j.sbspro.2014.03.102

Tetteh, G. A. (2015). Improving learning outcome using Six Sigma methodology. *Journal of International Education in Business*.

Tjahjono, B., Ball, P., Vitanov, V. I., Scorzafave, C., Nogueira, J., Calleja, J., Minguet, M., Narasimha, L., Rivas, A., Srivastava, A., Srivastava, S., & Yadav, A. (2010). Six sigma: A literature review. *International Journal of Lean Six Sigma*, *1*(3), 216–233. https://doi.org/10.1108/20401461011075017

Topuz, C., & Arasan, Z. (2013). Kaizen-educational: an awareness-raising and motivational-enhancement group counseling model. *Procedia-Social and Behavioral*

*Sciences*, *84*, 1356–1360.

Trakulsunti, Y., & Antony, J. (2018). Can Lean Six Sigma be used to reduce medication errors in the health-care sector? *Leadership in Health Services*.

Trakulsunti, Y., Antony, J., Ghadge, A., & Gupta, S. (2020). Reducing medication errors using LSS Methodology: A systematic literature review and key findings. *Total Quality Management & Business Excellence*, *31*(5–6), 550–568.

Tsironis, L. K., & Psychogios, A. G. (2016). Road towards Lean Six Sigma in service industry: a multi-factor integrated framework. *Business Process Management Journal*.

Vörös, J., & Rappai, G. (2016). Process quality adjusted lot sizing and marketing interface in JIT environment. *Applied Mathematical Modelling*, *40*(13–14), 6708–6724.

Waring, J. J., & Bishop, S. (2010). Lean healthcare: rhetoric, ritual and resistance. *Social Science & Medicine*, *71*(7), 1332–1340.

Wary, B., & Hogan, B. (2002). Why Six Sigma insecurities operation. *Bank of America, USA*.

Wee, J. C. N., & Chua, A. Y. K. (2013). The peculiarities of knowledge management processes in SMEs: the case of Singapore. *Journal of Knowledge Management*.

Welch, J., & Byrne, J. A. (2003). *Jack: Straight from the gut*. Business Plus.

Westwood, N., & Silvester, K. (2007). Eliminate NHS losses by adding Lean and some Six Sigma. *Operations Management*, *5*, 26–30.

Womack, J. P., & Jones, D. T. (1997). Lean thinking—banish waste and create wealth in your corporation. *Journal of the Operational Research Society*, *48*(11), 1148.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking: banish waste and create wealth in your corporation (2nd*. Free Press.

Womack, J. P., Jones, D. T., & Roos, D. (2007). *The machine that changed the world: The story of lean production--Toyota's secret weapon in the global car wars that is now revolutionizing world industry*. Simon and Schuster.

Womak, J., Jones, D. T., & Roos, D. (1990). The machine that changed the world. *New York: Rawson Associates*.

Worley, J. M., & Doolen, T. L. (2006). The role of communication and management support in a lean manufacturing implementation. *Management Decision*, *44*(2), 228–245. https://doi.org/10.1108/00251740610650210

Xue, Y., Bradley, J., & Liang, H. (2011). Team climate, empowering leadership, and knowledge sharing. *Journal of Knowledge Management*.

Yeh, S.-T., Arthaud-Day, M., & Turvey-Welch, M. (2021). Propagation of lean thinking in academic libraries. *The Journal of Academic Librarianship*, *47*(3), 102357.

Yildirmaz, H., Öner, M. A., & Herrmann, N. (2018). Impact of knowledge management capabilities on new product development and company performance. *International*

*Journal of Innovation and Technology Management*, *15*(04), 1850030.

Youssouf, A., Rachid, C., & Ion, V. (2014). Contribution to the optimization of strategy of maintenance by lean six sigma. *Physics Procedia*, *55*, 512–518.

Zailani, S., Shaharudin, M. R., & Saw, B. (2015). Impact of kaizen on firm's competitive advantage in a Japanese owned company in Malaysia. *International Journal of Productivity and Quality Management*, *16*(2), 183–210.

Zeithaml, V. A., Parasuraman, A., & Berry, L. L. (1985). Problems and strategies in services marketing. *Journal of Marketing*, *49*(2), 33–46.

Zhang, L., & Chen, X. (2016). Role of lean tools in supporting knowledge creation and performance in lean construction. *Procedia Engineering*, *145*, 1267–1274.

Zikmund, W. G., Carr, J. C., & Griffin, M. (2013). *Business Research Methods (Book Only)* (9th ed.). Cengage Learning.

Zu, X., & Fredendall, L. D. (2009). Enhancing six sigma implementation through human resource management. *Quality Management Journal*, *16*(4), 41–54.

Zu, X., Fredendall, L. D., & Douglas, T. J. (2008). The evolving theory of quality management: the role of Six Sigma. *Journal of Operations Management*, *26*(5), 630–650.

**Appendix A: Research instrument**

**Survey Invitation Letter**

Dear Sir/ Madam

I would like to take this opportunity to thank you for accepting to participate in and supporting the PhD research in the quality and knowledge management field.

Lean Six Sigma is considered a tool for modern service/product quality and management methodology to achieve efficiency and effectiveness and improve overall business performance. Meanwhile, Knowledge management has emerged as a saving factor and may guarantee the success of organizations.

My Doctoral study aims to critically assess the level of implementation of Lean Six Sigma and Knowledge management within Jordanian organizations. After data collection and analysis, I will develop a Lean Six Sigma Knowledge management Model for the service organizations. Studying the possibility of integrating LSS and KM is also under consideration.

The questionnaire has been developed to be completed by the Top/quality management responsible. The questionnaire will take around 5-10 minutes to complete. Your time is appreciated.

I will gladly send you the survey results for your participation.

Kind Regards

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**Background information**

Part 1: This section asks for some background details about yourself and your Organization

**Q1:** What is your current position within the Organization? (Check all that apply)

- ☐ CEO/ Director/ General Manager
- ☐ Quality Manager
- ☐ Assistant Manager
- ☐ HR Manager
- ☐ Departmental Head
- ☐ Supervisor
- ☐ Other (please specify) ______________________

**Q2: Name of the Organization** (optional)

**Q3: Type of business**

| | | | |
|---|---|---|---|
| Sole trader | | Limited Liability Company | |
| NGOs | | Government | |
| Other | | | |

**Q4: Which business sector is your Organization?**

| | | | | | |
|---|---|---|---|---|---|
| Government and politics | | Healthcare | | Banking and Finance | |
| Accommodations and hotels | | Telecoms | | Transport and travel | |
| Education | | Agriculture | | Automotive | |
| Business Consultancy | | Computing | | Domestic services | |
| Electronics | | Retail | | Energy | |
| Entertainment | | Environment | | Food | |
| law and legislation | | property and Building | | Technical services | |
| other | | | | | |

**Q5: Length of organization service**

□ 1-5 years □ 6-10 years □ 11-15 years □ 15+ years

**Q6: Select the top three most considerable factors that define the company's strategic objective (Tick up to 3 boxes that you consider are the most massive issues)**

□Profitability
□Flexibility
□Quality
□Market Share
□Customer satisfaction

□Innovation

□Other (please specify)

**Q7: How many employees does your organization have?**
□ 1- 10 □ 11 to 49 □ 50 - 249 □ 250 to 1000 □ More than 1000

**Part 2: level of applying LSS**

**Q8: Which of the following continuous improvement methodologies have been used by your Organisation? (check all that apply)**
□ Lean
□ Six Sigma
□ Lean Six Sigma
□ Total Quality Management (TQM)
□ Business Process Management (BPM)
□ Business Process Re-engineering (BPR)
□ PDCA (Plan-Do-Check-Act)
□ Other ______________________

**Q9: Tools and Techniques Used Within the quality development Programs**

| | **Usage** How often is this tool used in your company? 1 – Never been used 2 – Used only once 3 – Used rarely 4 – Used frequently 5 – Used continuously | **Usefulness** How do you assess the usefulness of this tool? 1 – Not useful 2 – Slightly useful 3 – More useful 4 – Very useful 5 – Extremely useful | **In which phase use this tool?** 1- Define phase 2- Measurement phase 3- Analyze phase 4- Improvement phase 5- Control phase 6- I don't know |
|---|---|---|---|
| | **1 2 3 4 5** | **1 2 3 4 5** | **1 2 3 4 5 6** |
| Histogram | □□□□□ | □□□□□ | □□□□□□ |

| | | | |
|---|---|---|---|
| Scatter Diagram (correlation) | □□□□□ | □□□□□ | □□□□□□ |
| Tally charts (collecting data) | □□□□□ | □□□□□ | □□□□□□ |
| Statistical Process Control (SPC) | □□□□□ | □□□□□ | □□□□□□ |
| Pareto Diagram | □□□□□ | □□□□□ | □□□□□□ |
| Trend Chart | □□□□□ | □□□□□ | □□□□□□ |
| Measurement System Analysis (MSA) | □□□□□ | □□□□□ | □□□□□□ |
| ANOVA | □□□□□ | □□□□□ | □□□□□□ |
| Regression analysis | □□□□□ | □□□□□ | □□□□□□ |
| Process Flowchart/Mapping | □□□□□ | □□□□□ | □□□□□□ |
| Brainstorming | □□□□□ | □□□□□ | □□□□□□ |
| Relation diagrams | □□□□□ | □□□□□ | □□□□□□ |
| 5S Practice | □□□□□ | □□□□□ | □□□□□□ |
| Matrix diagram | □□□□□ | □□□□□ | □□□□□□ |
| FMEA( Failure Mode and Effect Analysis) | □□□□□ | □□□□□ | □□□□□□ |
| Kaizen | □□□□□ | □□□□□ | □□□□□□ |
| Cause & Effect /Fishbone (Ishikawa) Diagram | □□□□□ | □□□□□ | □□□□□□ |
| Project Priority Calculator | □□□□□ | □□□□□ | □□□□□□ |
| Benchmarking | □□□□□ | □□□□□ | □□□□□□ |
| 5-Why Analysis | □□□□□ | □□□□□ | □□□□□□ |
| Error-Proofing / Poka-Yoke | □□□□□ | □□□□□ | □□□□□□ |
| A3 Report | □□□□□ | □□□□□ | □□□□□□ |
| Control Plan | □□□□□ | □□□□□ | □□□□□□ |
| Standardized Work | □□□□□ | □□□□□ | □□□□□□ |
| Value Stream Analysis | □□□□□ | □□□□□ | □□□□□□ |
| VOC (Voice of Customer) | □□□□□ | □□□□□ | □□□□□□ |

**Part 3: level of applying Knowledge Management**

**Q10: How have you learned about quality improvement methods, tools and techniques?**

□ In-house training
□ Company-sponsored training in organizations or institutes
□ Conferences
□ Internet / Distance learning
□ Self-education, media, books or research articles
□ Other ______________________

**Q11: Please indicate the extent of your agreement/disagreement with the statements by using the following scale:**

[ 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree] based on your feelings about the statement.

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | The Organization holds training sessions for workers on how to use knowledge to achieve specific goals | 1 | 2 | 3 | 4 | 5 |
| **2** | The Organization classifies data and then converts it into information to support decisions | 1 | 2 | 3 | 4 | 5 |
| **3** | The Organization's managers are aware that the Organization has a large stock of knowledge that is not invested and needs to be managed and organized | 1 | 2 | 3 | 4 | 5 |
| **4** | The Organization's opinions and experiences of the Organization are recorded and kept in databases | 1 | 2 | 3 | 4 | 5 |
| **5** | The organization is trying to gain knowledge from the surrounding regional institutions | 1 | 2 | 3 | 4 | 5 |
| **6** | The Organization has ways to distribute knowledge to its staff and make it available to all (notes, reports, e-mails, public meetings) | 1 | 2 | 3 | 4 | 5 |
| **7** | There is a department within the Organization to provides studies and research | 1 | 2 | 3 | 4 | 5 |
| **8** | Facilitate all employees' access to knowledge bases that you own | 1 | 2 | 3 | 4 | 5 |
| **9** | The Organization's strategic plan promotes the application of knowledge management | 1 | 2 | 3 | 4 | 5 |
| **10** | Transforming the tacit knowledge (residing in the employee’s mind) of the experience owners into explicit knowledge through sharing and exchanging experiences. | 1 | 2 | 3 | 4 | 5 |

**Part 4: LSS Critical Success Factors**

**Q12: The motivational factors (Critical Success Factors) that lead to the success of Lean/ Six Sigma (improvement methodology)** to your business process (es) **in your Organization.** Please tick the appropriate box according to the following code:

[ 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree] based on your feelings about the statement.

| **Critical Success Factors** | | | | | | |
|---|---|---|---|---|---|---|
| **1** | Top management commitment and involvement | 1 | 2 | 3 | 4 | 5 |
| **2** | Adequate Training/coaching | 1 | 2 | 3 | 4 | 5 |
| **3** | Linking quality development to human resources (HR) reward system | 1 | 2 | 3 | 4 | 5 |
| **4** | Choosing the most talented people | 1 | 2 | 3 | 4 | 5 |
| **5** | Informal communication and open discussion | 1 | 2 | 3 | 4 | 5 |
| **6** | Linking quality development to business strategy | 1 | 2 | 3 | 4 | 5 |
| **7** | Adequate knowledge of quality development tools | 1 | 2 | 3 | 4 | 5 |
| **8** | high employee retention | 1 | 2 | 3 | 4 | 5 |
| **9** | Sufficient Organizational infrastructure | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **10** | Understanding and awareness about quality development benefits the business | 1 | 2 | 3 | 4 | 5 |

**Part 5: KM and LSS tools** Knowledge and Usage of Quality Improvement Methods,

**Q13: Please indicate the extent to which you agree /disagree with the below with respect to the LSS initiatives in your Organization. Do you believe:**
[1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree] based on your feelings about the statement.

| | **1- Define Phase** | | | | | |
|---|---|---|---|---|---|---|
| **1** | Hiring employees with a continuous improvement mindset is essential when employing quality development drivers | 1 | 2 | 3 | 4 | 5 |
| **2** | You can contribute to organizational performance with your ability to interpret, understand and use quality development know-how. | 1 | 2 | 3 | 4 | 5 |
| **3** | There are formal channels for knowledge sharing (like meetings, courses, tours and similar activities) | 1 | 2 | 3 | 4 | 5 |
| **4** | An employee takes much time to get the relevant knowledge | 1 | 2 | 3 | 4 | 5 |
| **5** | Some tools help discover and obtain knowledge related to quality development from various sources. | 1 | 2 | 3 | 4 | 5 |

| | **2- Measurement Phase** | | | | | |
|---|---|---|---|---|---|---|
| **1** | There is/was a well-defined process for tracking and measuring the performance of quality development projects. | 1 | 2 | 3 | 4 | 5 |
| **2** | There are well-defined processes for the creation, capture, and acquisition of knowledge during the measurement phase | 1 | 2 | 3 | 4 | 5 |
| **3** | Technology is important for disseminating knowledge related to measuring process performance. | 1 | 2 | 3 | 4 | 5 |
| **4** | Knowledge sharing is seen as vital in the measure phase | 1 | 2 | 3 | 4 | 5 |
| **5** | Employees are trained to use appropriate tools and techniques to measure alternatives to work implementation procedures. | 1 | 2 | 3 | 4 | 5 |

| | **3- Analyze Phase** | | | | | |
|---|---|---|---|---|---|---|
| 1 | The role of appropriate Continuous Improvement Consultants/Experts is essential in quality development | 1 | 2 | 3 | 4 | 5 |
| 2 | The quality development expert help & coaching are/were | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | sufficiently readily available for quality development projects. | | | | | |
| 3 | Cooperation when creating new knowledge reduces the anxiety of responsibility in case of an error. | 1 | 2 | 3 | 4 | 5 |
| 4 | Organization employees realize the importance of knowledge management in support of quality improvement activities | 1 | 2 | 3 | 4 | 5 |
| 5 | Use past experiences and expertise as a basis for future work without starting from scratch | 1 | 2 | 3 | 4 | 5 |

| | **4- Improvement Phase** | | | | | |
|---|---|---|---|---|---|---|
| **1** | Process improvement is given high importance in the Organization. | 1 | 2 | 3 | 4 | 5 |
| **2** | The need to embark on Value-added Continuous improvement investments is critical in quality development | 1 | 2 | 3 | 4 | 5 |
| **3** | Quality development has /had helped the Organization to be more customer-focused | 1 | 2 | 3 | 4 | 5 |
| **4** | Quality development improvements have /had resulted in the efficient utilization of resources (human, financial and system). | 1 | 2 | 3 | 4 | 5 |
| **5** | Quality development has/had considerably reduced process lead times & cycle times. | 1 | 2 | 3 | 4 | 5 |

| | **5- Control Phase** | | | | | |
|---|---|---|---|---|---|---|
| **1** | The review of appropriate Continuous improvement activities is critical in quality development | 1 | 2 | 3 | 4 | 5 |
| **2** | Top management takes an active interest in quality development, controls it, and supports it continuously | 1 | 2 | 3 | 4 | 5 |
| **3** | The organization's strategy is reviewed based on research and studies aimed at improving services and customer satisfaction | 1 | 2 | 3 | 4 | 5 |
| **4** | Mistakes in work procedures are documented to be circulated and avoided in the future. | 1 | 2 | 3 | 4 | 5 |
| **5** | Internal best practices in the business are documented and circulated | 1 | 2 | 3 | 4 | 5 |

**Thanks for your patience!**

If you are interested in the results of this survey, please provide your email. Your email will be confidential and solely used to send you the survey results!

**Appendix B: Academic arbitrators**

| | Name | Affiliation |
|---|---|---|
| 1- | Dr Roland Schmuk (Supervisor) | University of pecs<br>Schmuck.roland@ktk.pte.hu |
| 2- | Prof. Feras Suliman Alshalabi | Al Balqa Applied University<br>Dr.feras_shalabi@bau.edu.jo |
| 3- | Dr. Dojanah Mohammd Qadri | Al Balqa Applied University<br>dojanah@bau.edu.jo |
| 4- | Dr Khalid Banyhamdan | Amman Arab University<br>Banyhamdan@aau.edu.jo |

**Appendix C: Statistic analysis of the KM, CSFs, and LSS five phases according to the business sector**

| Scope | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| KM | Governmental | 43 | 3.74 | 0.844 |
| | Healthcare | 15 | 3.67 | 0.698 |
| | Banking and Finance | 12 | 3.33 | 0.401 |
| | Accommodations | 20 | 3.49 | 0.778 |
| | Telecommunications | 7 | 3.54 | 1.125 |
| | Transport and travel | 22 | 3.70 | 0.789 |
| | Educations | 10 | 3.82 | 0.807 |
| | Agriculture | 2 | 4.30 | 0.424 |
| | Automotive | 4 | 3.58 | 0.457 |
| | Business Consultancy | 7 | 3.81 | 0.576 |
| | Computing | 4 | 3.83 | 0.737 |
| | Domestic services | 7 | 3.76 | 0.479 |
| | Electronics | 2 | 3.00 | 0.424 |
| | Retail | 6 | 4.12 | 0.703 |
| | Energy | 4 | 3.58 | 0.350 |
| | Entertainment | 4 | 4.18 | 0.640 |
| | Environment | 4 | 3.88 | 1.081 |
| | Food | 8 | 3.90 | 0.513 |
| | Law and Legislation | 5 | 3.60 | 1.166 |
| | Property and Building | 11 | 3.50 | 0.756 |
| | Technical services | 9 | 3.89 | 0.843 |
| | Other | 1 | 3.40 | - |
| CSFs | Governmental | 43 | 3.91 | 0.468 |
| | Healthcare | 15 | 3.93 | 0.587 |
| | Banking and Finance | 12 | 3.96 | 0.375 |
| | Accommodations | 20 | 3.90 | 0.405 |
| | Telecommunications | 7 | 3.94 | 0.489 |
| | Transport and travel | 22 | 3.85 | 0.540 |
| | Educations | 10 | 4.02 | 0.583 |
| | Agriculture | 2 | 4.05 | 0.071 |
| | Automotive | 4 | 3.85 | 0.311 |
| | Business Consultancy | 7 | 3.60 | 0.387 |
| | Computing | 4 | 3.70 | 0.548 |
| | Domestic services | 7 | 4.03 | 0.461 |
| | Electronics | 2 | 4.50 | 0.707 |
| | Retail | 6 | 3.88 | 0.376 |
| | Energy | 4 | 4.10 | 0.949 |
| | Entertainment | 4 | 3.80 | 0.316 |
| | Environment | 4 | 4.13 | 0.222 |
| | Food | 8 | 3.99 | 0.352 |
| | Law and Legislation | 5 | 3.90 | 0.735 |
| | Property and Building | 11 | 3.91 | 0.561 |

| Scope | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| | Technical services | 9 | 3.97 | 0.606 |
| | Other | 1 | 3.40 | - |
| **Define Phase** | Governmental | 43 | 4.02 | 0.496 |
| | Healthcare | 15 | 3.85 | 0.553 |
| | Banking and Finance | 12 | 3.77 | 0.510 |
| | Accommodations | 20 | 3.97 | 0.585 |
| | Telecommunications | 7 | 4.14 | 0.458 |
| | Transport and travel | 22 | 4.04 | 0.737 |
| | Educations | 10 | 4.06 | 0.582 |
| | Agriculture | 2 | 4.00 | 0.000 |
| | Automotive | 4 | 4.65 | 0.473 |
| | Business Consultancy | 7 | 3.83 | 0.496 |
| | Computing | 4 | 3.90 | 0.622 |
| | Domestic services | 7 | 4.06 | 0.772 |
| | Electronics | 2 | 4.30 | 0.990 |
| | Retail | 6 | 3.93 | 0.589 |
| | Energy | 4 | 3.65 | 0.985 |
| | Entertainment | 4 | 4.15 | 0.737 |
| | Environment | 4 | 3.70 | 0.416 |
| | Food | 8 | 4.00 | 0.524 |
| | Law and Legislation | 5 | 3.88 | 0.657 |
| | Property and Building | 11 | 4.00 | 0.551 |
| | Technical services | 9 | 3.67 | 0.663 |
| | Other | 1 | 3.60 | - |
| **Measure phase** | Governmental | 43 | 3.84 | 0.645 |
| | Healthcare | 15 | 3.75 | 0.563 |
| | Banking and Finance | 12 | 3.98 | 0.508 |
| | Accommodations | 20 | 3.91 | 0.744 |
| | Telecommunications | 7 | 3.71 | 0.576 |
| | Transport and travel | 22 | 3.85 | 0.781 |
| | Educations | 10 | 4.36 | 0.580 |
| | Agriculture | 2 | 4.10 | 0.141 |
| | Automotive | 4 | 3.85 | 0.300 |
| | Business Consultancy | 7 | 3.60 | 0.416 |
| | Computing | 4 | 3.55 | 0.379 |
| | Domestic services | 7 | 3.91 | 0.445 |
| | Electronics | 2 | 4.20 | 1.131 |
| | Retail | 6 | 3.90 | 0.576 |
| | Energy | 4 | 3.80 | 0.980 |
| | Entertainment | 4 | 4.35 | 0.473 |
| | Environment | 4 | 3.45 | 0.500 |
| | Food | 8 | 4.18 | 0.897 |
| | Law and Legislation | 5 | 3.68 | 0.335 |
| | Property and Building | 11 | 3.78 | 0.363 |
| | Technical services | 9 | 3.67 | 0.424 |

| Scope | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| | Other | 1 | 3.40 | - |
| **Analysis phase** | Governmental | 43 | 3.87 | 0.588 |
| | Healthcare | 15 | 3.91 | 0.604 |
| | Banking and Finance | 12 | 3.92 | 0.413 |
| | Accommodations | 20 | 3.77 | 0.790 |
| | Telecommunications | 7 | 3.86 | 0.728 |
| | Transport and travel | 22 | 3.82 | 0.819 |
| | Educations | 10 | 4.18 | 0.577 |
| | Agriculture | 2 | 4.10 | 0.141 |
| | Automotive | 4 | 3.85 | 0.574 |
| | Business Consultancy | 7 | 3.63 | 0.725 |
| | Computing | 4 | 3.55 | 0.640 |
| | Domestic services | 7 | 4.11 | 0.576 |
| | Electronics | 2 | 4.50 | 0.707 |
| | Retail | 6 | 3.77 | 0.950 |
| | Energy | 4 | 3.40 | 0.432 |
| | Entertainment | 4 | 4.15 | 0.755 |
| | Environment | 4 | 4.10 | 1.013 |
| | Food | 8 | 4.13 | 0.534 |
| | Law and Legislation | 5 | 3.76 | 0.654 |
| | Property and Building | 11 | 3.71 | 0.817 |
| | Technical services | 9 | 3.40 | 0.624 |
| | Other | 1 | 3.00 | - |
| **Improve phase** | Governmental | 43 | 4.02 | 0.662 |
| | Healthcare | 15 | 3.84 | 0.790 |
| | Banking and Finance | 12 | 3.97 | 0.481 |
| | Accommodations | 20 | 4.00 | 0.659 |
| | Telecommunications | 7 | 4.06 | 0.700 |
| | Transport and travel | 22 | 3.84 | 0.949 |
| | Educations | 10 | 4.42 | 0.485 |
| | Agriculture | 2 | 4.10 | 0.141 |
| | Automotive | 4 | 3.65 | 0.526 |
| | Business Consultancy | 7 | 4.03 | 0.571 |
| | Computing | 4 | 3.75 | 0.772 |
| | Domestic services | 7 | 3.71 | 0.878 |
| | Electronics | 2 | 4.50 | 0.707 |
| | Retail | 6 | 4.23 | 0.480 |
| | Energy | 4 | 3.30 | 0.346 |
| | Entertainment | 4 | 4.45 | 0.526 |
| | Environment | 4 | 4.05 | 0.915 |
| | Food | 8 | 3.78 | 0.688 |
| | Law and Legislation | 5 | 4.00 | 0.906 |
| | Property and Building | 11 | 3.82 | 0.767 |
| | Technical services | 9 | 3.87 | 0.825 |
| | Other | 1 | 3.60 | - |

| Scope | Category | Frequencies | Mean | SD |
|---|---|---|---|---|
| **Control phase** | Governmental | 43 | 3.96 | 0.688 |
| | Healthcare | 15 | 3.95 | 0.742 |
| | Banking and Finance | 12 | 4.27 | 0.421 |
| | Accommodations | 20 | 4.06 | 0.551 |
| | Telecommunications | 7 | 3.71 | 0.414 |
| | Transport and travel | 22 | 4.08 | 0.799 |
| | Educations | 10 | 4.40 | 0.525 |
| | Agriculture | 2 | 4.60 | 0.566 |
| | Automotive | 4 | 4.05 | 0.300 |
| | Business Consultancy | 7 | 3.83 | 0.860 |
| | Computing | 4 | 3.75 | 0.772 |
| | Domestic services | 7 | 4.06 | 0.500 |
| | Electronics | 2 | 4.50 | 0.707 |
| | Retail | 6 | 4.37 | 0.344 |
| | Energy | 4 | 3.45 | 0.526 |
| | Entertainment | 4 | 4.05 | 0.681 |
| | Environment | 4 | 4.30 | 0.476 |
| | Food | 8 | 4.10 | 0.659 |
| | Law and Legislation | 5 | 3.84 | 0.780 |
| | Property and Building | 11 | 3.98 | 0.603 |
| | Technical services | 9 | 3.76 | 0.410 |
| | Other | 1 | 3.40 | - |