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Al al-Bayt University

Faculty of Finance and Business

Department of Business Administration

The Extent of Six Sigma Implementation in " Organizations that have been Awarded the King "Abdullah II Award for Excellence

"مدى تطبيق ستة سيجما في المنظمات الحائزة على جائزة الملك عبد الله الثاني للتميز في الاردن"

Researcher:

Nidal Rashid Awad

Supervisor:

Dr. Bahjat Eid Jawazneh

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اعداد الطالب:

نضال رشيد عوض

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اشراف:

الدكتور بهجت عيد الجوازنة

اعضاء لجنة المناقشة:		التوقيع
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د.سليمان الحوري	عضوا	
د.زياد الصمادي	عضوا	
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The Researcher

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The Extent of the Six Sigma Implementation in Organizations that have been awarded the King Abdullah II Award for Excellence

Researcher: Nidal R. Awad

Supervisor: Dr. Bahjat E. Jawazneh

ABSTRACT

This study has investigated whether Six Sigma is implemented in Jordan, and to evaluate the extent to which it has been implemented in the private organizations that have been awarded the "King Abdullah II Award for Excellence (KAAE)". These organizations are the ideal population for this study due to the exceptional standards required in order to be awarded this Award, which is considered one of the most honored awards in Jordan.

105 questionnaires was distributed to the study population, 5 questionnaires have been distributed to each industrial/service organization has been awarded the (KAAE). The questionnaire was divided into 3 schemes and two open-ended questions to achieve the study objectives by establishing the existence and /or the level of implementation of the Six Sigma in Jordan. The Statistical Package for the Social Sciences (SPSS) was used to test the questions.

The study found that there is a low implementation of Six Sigma (role structured (belts holders), structured improvement (DMAIC cycle), and focuses on metrics), leading, accordingly, to a low level of Six Sigma implementation in the population of study. There are a selective implementation of some Six Sigma practices that overlap with other quality systems. Such practices are similar in characteristics but are

different in measurement methods.

The study recommends adopting the Six Sigma practices and systems as a strategy to maintain and increase the competitive advantage of the organization within globalization through establishing institutions that encourage adopting and publish the six sigma theme.

Key Words: *Six Sigma, Sigma extent, King Abdulla II award for excellence, DAMIC cycle, questionnaire, statistical Analysis.*

Chapter one
Introduction to the study

Introduction to the study:

The world is currently living in an unprecedented period of human evolution, underpinned by an escalation in the forces of change in many habitats, an enhancement of human knowledge, and an opening up of international markets through the removal of barriers to the movement of goods and products.

Six Sigma has been characterized as the latest management fad, repackaging old quality management principles, practices, and tools/techniques [(1)]. At first glance Six Sigma looks strikingly similar to prior quality management approaches; however, leading organizations with a track record in quality have adopted Six Sigma and claimed that it has transformed their organization[(2)].

Organizations require intensive attention, planning, and research to facilitate their ability to compete and penetrate various markets. This can only be achieved in the presence of international quality assurance standards and systems to enhance the local product quality.

(1) Clifford, L., 2001. Why you can safely ignore Six Sigma. Fortune 143 (2), P 140.
(2) Aldred, K., 1998. Baldrige Award recognizes four U.S. companies. IIE Solutions 30(3), P. 8.

It has been identified as a process improvement approach that dramatically improves performance, enhances process capability, and produces bottom line results for organizations[(1)(2)(3)].

Quality today has come to signify high profits and zero defects, and in this sense and context as become the function and responsibility of everyone within the organization, regardless of the location and nature of his work.

Most companies today operate between three and four sigma where the cost of quality is 15% to 25% of revenue. As a company moves towards Six Sigma quality levels, these costs of quality decrease to one or two percent of revenue[(4)].

Renowned organizations with a quality track record, such as Ford, Honeywell, and American Express, have adopted Six Sigma as a way of further enhancing business performance[(5)] . It is now used across almost all industries, to include the service industries such as health care management[(6)(7)(8)(1)(2)].

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(1) Dasgupta, T., 2003. Using the Six Sigma metric to measure and improve the performance of a supply chain. Total Quality Management 14 (3), P. 355-366

(2) 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.

(3) Pantano, V., O'Kane, P., Smith, K., 2006. Cluster-based Six Sigma development in small and medium sized enterprises. In: Proceedings of 2006 IEEE International Conference on Management of Innovation and Technology, June 21–23, Singapore.

(4)Paul Keller) www.qualityamerrica.com/knowledgecente/article/packSmallcompanys.

(5) Hahn, G.J., Doganakosy, N., Hoerl, R., 2000. The evolution of Six Sigma Quality Engineering 12 (3), 317-326.

(6) Krupar, J., 2003. Yes, Six Sigma can work for financial institutions. ABA Banking Journal 95 (9), 93–94.

(7) Antony, J., Fergusson, C., 2004. Six Sigma in a software industry: results from a pilot study. Managerial Auditing Journal 19, 1025–1032.

(8) Antony, J. (2004). Some pros and cons of Six Sigma: An academic perspective. The TQM Magazine, 16(4), 303–306.

There is no doubt that Jordanian organizations are aiming to penetrate new markets and reach leading business positions must seek and initiate the implementation of Six Sigma comprehensive quality systems in order to achieve a competitive advantage within the increasing international competition, particularly when Jordan is granted special trade conditions with many international markets.

Six Sigma has proven to be the best complementary and comprehensive quality system to different managerial systems, such as National Quality Awards, TQM, ISO series, Lean Production and Quality Cost.

1.2 Research Significance:

Many related studies proved the importance of implementing Six Sigma in the organizations and its positive effect on the financial and managerial results. Through the study, the researcher will discuss Six Sigma and its implementation in the Jordanian organizations within the study sample, using his expertise in the managerial processes within the industrial/ service sector through:

1. Highlighting the importance of implementing Six Sigma in the organizations that have been awarded the (KAAE) in Jordan, specifically from a managerial point of view.
2. Discussing the research subject based on own experience and knowledge in quality and managerial topics.

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(1) Moorman, D.W., 2005. On the quest for Six Sigma. The American Journal of Surgery 189, 253–258.

(2) Frings, G.W., Grant, L., 2005. Who moved my Sigma… effective implementation of the Six Sigma methodology to hospitals? Quality and Reliability Engineering International 21, 311-328.

3. Anticipating that the research would encourage decision makers in the organizations to implement a Six Sigma comprehensive system, or at the very least, to have a partial implementation of it.

4. Addition to the Arabic knowledge and articles.

1.3 Research Problem:

In order for organizations to maintain its competitiveness, it must employ new quality systems to increase its strength and achieve a competitive advantage over other organizations, which would thereby sustain its position and continue its development and growth. Six Sigma is one of these quality systems and is a system newly introduced in Jordan.

The implementation of Six Sigma in Jordan suffers from many obstacles and looks to answer the following important questions:

1. Do the organizations that have been awarded the (KAAE) have implemented Six Sigma (role structure, structured improvement procedure, and focus on metrics) as a comprehensive program significantly **($\alpha \geq 0.05$)?**

This question consequented some sub-questions:

1. Do the organizations that have been awarded the (KAAE) have implemented six sigma role structure significantly **($\alpha \geq 0.05$)?**

2. Do the organizations that have been awarded the (KAAE) have implemented the Six Sigma (structured improvement procedure) significantly **($\alpha \geq 0.05$)?**

3. Do the organizations that have been awarded the (KAAE) have implemented the Six Sigma (focus on metrics) significantly ($\alpha \geq$ **0.05**)?

The answers to these questions will enable the researcher to assess the obstacles accompanying the implementation of Six Sigma from a managerial and financial point of view.

1.4 Research objectives:

The research primary purpose is to study the Six Sigma system in Jordan through:

1. Evaluating the level of Six Sigma implementation in the organizations that have been awarded the (KAAE) in Jordan.
2. Determine the gaps between Six Sigma and other quality system and how to overlap these gaps.
3. Determine the obstacles and the reasons of not implementing Six Sigma in the organizations that have been awarded the (KAAE) in Jordan and,
4. Propose remedies to overcome these obstacles.

1.5 Research methods:

1.5.1 The Study population:

A Complete coverage (Censes Method) principle has been used for entailing Jordanian manufacturing/service organizations that have been awarded the (KAAE). These organizations have been selected in response to the researcher's belief that these organizations are the most suitable and useful for this study. Since the (KAAE) is considered as one of the highest quality standards in the Kingdom, qualified and recognized by the European award for quality.

The population study was constrained to the organizations that have been awarded the prize from 1999 to date.

Table 1.1 shows the Award winners[1](Study population table) :

• **Cycle**	• **Service organizations**	• **Manufacturing organizations**
• First cycle 1999-2000	• The Housing Bank. • Citibank-Amman. • Arab Center for Engineering Studies.	• Modern Aluminum Industries Co. • Pro-Tech Establishment
• Second cycle 2001-2002	• Citibank-Amman. • Mid Contracting Co.	• Petra Engineering Co. • Saueressing Jordan
• Third cycle 2003-2004	• Arabtech Jardaneh Engineering and Architects • The School of Islamic Educational College • Alissar.	• Petra Engineering Co.
• Fourth Cycle 2005-2006	• Royal Jordanian. • The Specialty Hospital. • Consulting Engineering Center (Sajdi & Partners). • Alissar.	• Alkeena Hygienic Paper Mill Company. • Modern Aluminum Industries Co. • Nippon Jordan Fertilizer Company.
• Fifth Cycle 2008-2009	• The Specialty Hospital. • Arab Center for	• Jordan Ice and Aerated Water Company

(1) http://www.kaaps.jo/fundamental-concepts-excellence.

	Engineering Studies. • Consulting Engineering Center (Sajdi & Partners).	(Pepsi). • Jordan Light Vehicle Manufacturing
• Sixth Cycle 2010-2011	• Consolidated Consultants for Engineering And Environmental Services. • Med labs Consultancy Group	• Jordan Ice and Aerated Water Company (Pepsi). • Petra Engineering Co. • Jordan Manufacturing and Service Solutions

The study relied on the analytic, descriptive, and field-work methodology. The descriptive methodology was utilized in describing the questions of the study to answer its questions related to Six Sigma. While the field-work, through the questionnaires in order to obtain data on the level of implementation of Six Sigma in the organizations covered by the study, aiming to reveal the practices implemented in reality. In order to complete our statistical analysis and conclude to this study's questions, confidence level of 95% and significance level of 0.05 were used.

The researcher distributed 105 questionnaires, received 62, while 10 questionnaires were ignored for invalidity for analysis. Five organizations have not return there questionnaires. Hence, 52 valid (49%) questionnaires were ultimately the basis on which the research was conducted.

Table 1.2 shows the distributed, returned, and valid questionnaires for statistical analytic purposes.

Sector	Distributed questionnaires	Returned questionnaires	Valid questionnaires
Manufacturing organizations	45	28	25

Service organizations	60	34	27
Total	105	62	52

1.5.2 The instrument study tool:

Zu et al[1][2] studies have been used to create new items during the construction of the research survey to use this primary data to achieve the study objectives.

This study emphasizes on the descriptive and inferential analytical approaches in testing its questions, in order to determine the answers of its questions. Empirical measures are utilized to establish this relationship through the aid of the statistical analysis software.

This descriptive research involves attempting to define or measure the level of Six Sigma implementation in Jordan, usually through reviewing previous studies that have measured the implementation of Six Sigma in other words, this study describes the target population in a comprehensive way.

1.6 Research Terminology:

- Critical to quality CTQ: A structured approach is used to uncover the root cause of problems using the DMAIC (Define-Measure-Analyze-Improve-Control) methodology: Define the problem within a process, Measure the defects, Analyze the cause of defects, Improve the process performance to remove causes of defects[3].
- Design for Six Sigma (DFSS) is used to determine the needs of customers and the organization, and drive those needs into the

(1) Zu, X., Fredendall, L., Douglas, T., 2008, The Evolving Theory of Quality Management: The Role of Six Sigma. Journal of Operations Management 26 (2008) 630–650.

(2) Zu, X., Fredendall, L., Robbins, T., 2010, Mapping the Critical Links between Organizational Culture and TQM/Six Sigma Practices.. Int. J. Production Economics 123 (2010) 86–106

(3) Source: Matthew J. Liberatore, Six Sigma In Healthcare Villanova School of Business, Villanova University, Villanova, PA, USA .msom.technion.ac.il/sig_papers/HC/27.

process solution developed. DFSS is applied for process generation in contrast with process improvement, and replaces DMAIC with the DMADV methodology: Define-Measure-Analyze-Design-Verify[1].

- DMAIC is a data-driven process that uses various quality and process improvement tools that have been developed over time, including: statistical analysis, cause and effect diagrams (fishbone, Ishikawa), control charts, design of experiments, Pareto Analysis, process mapping, Failure Modes and Effects Analysis (FMEA), Quality Function Deployment (QFD)/House of Quality, and Suppliers, Inputs, Process, Outputs, and Customers (SIPOC diagrams), among others[2].
- Green belts: individuals that have completed basic training and participate in Six Sigma projects.
- Black belts: individuals competent to serve as on-site consultants and lead project teams.
- Master Black belts: individuals who have mastered the Six Sigma process and are capable of teaching it to others and acting as resources for project teams[3][4].
- Six Sigma role structure: a group of improvement specialists, typically referred to as champions, master black belts, black belts, and green belts[5][6]. Those specialists receive intensive differentiated training that is tailored for their ranks and is designed to improve

(1) Source: Matthew J. Liberatore, Six Sigma In Healthcare .op.cit.
(2) Source: Matthew J. Liberatore, Six Sigma In Healthcare, op.cit.
(3) Eckes, G., 2001. The Six Sigma Revolution: How General Electric and Others Turned Process into Profits. Wiley, New York.
(4) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. The Six Sigma way: op. cit.
(5) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit.P 193–203.
(6) Henderson, K.M., Evans, J.R., Successful implementation of Six Sigma: benchmarking general electric company benchmarking. op.cit,P 260–281.

their knowledge and skills in statistical methods, project management, process design, problem-solving techniques, leadership skill, and other managerial skills.

- Six Sigma structured improvement procedure: a structured approach to managing improvement activities, which is represented by Define–Measure–Analyze–Improve–Control (DMAIC) used in process improvement or Define–Measure– Analyze–Design–Verify (DMADV) used in product/ service design improvement[(1)].
- Six Sigma focuses on metrics: Six Sigma emphasizes using a variety of quantitative metrics in continuous improvement, such as process Sigma measurements, critical-to-quality metrics, defect measures, and 10* improvement measures as well as traditional quality measures like process capability[(2)(3)(4)(5)].

1.7 Limitations of the study:

Lack of resources and case studies in the Arab region that tackle the core issues of this thesis to link the concept of Six Sigma, as a new terminology in management, and the application and extent of application of Six Sigma in reality. Hence, the study had to rely upon foreign previous studies, articles, and case studies when discussing the theoretical part of this study.

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(1) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S.. Six Sigma: A goal-theoretic perspective. op.cit. P 193–203.

(2) Breyfogle III, F. W. (2003). Implementing Six Sigma: Smarter solutions using statistical methods, (2nd Ed.) New York, Wiley.

(3) Dasgupta, T. Using the Six-Sigma metric to measure and improve the performance of a supply chain. op.cit. p 355–366.

(4) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit. p193–203.

(5)Pyzdek, T. (2003). The Six Sigma project planner**.** New York, NY: McGraw-Hill.

The study aims to conduct a pilot study in the field of management, specifically in quality improvements in order to eliminate defects, which leads to increased profitability.

Also, the respondents did not provide enough support in the distribution of study questionnaires within their organizations. Therefore, it was a great challenge being able to first grab the attention and then ultimately get the consent of the general manager, operation manager, quality manager, production manager, and HR manager, since these positions realize the future planning for this new fad within their organizations.

Another major constraint was the nature of study population the differentiations in its characteristics, i.e., (culture, work, norms, beliefs…) it is clearly found that each organization have its own charisma.

In addition, the organizations would not disclose information regarding the lack of knowledge of respondents within an organization about Six Sigma programs.

The rare implementation of Six Sigma in the target population was a restriction on the study. The researcher believes that some of the Jordanian organizations might have partially or fully implemented the Six Sigma schemes, but were not involved in the target population since they were not screened, due to their failure to comply with the required prerequisite of being awarded the (KAAE).

Finally, the restriction of the population nature that there are organizations awarded the award many years ago, does these organizations still have commitment to the quality standards.

1.8 Thesis structure:

The rest of the research is structured as follows:

- Chapters 2 discuss the previous studies Arabic & foreign related studies.
- Chapters 3 discuss the literature review of the frameworks relevant to the research.
- Chapters 4 discuss the questions testing & analysis of statistical.
- Chapter 5 discusses the conclusions/results of the research and the researcher's recommendations for Six Sigma adopting companies.
- Appendices include a list of the questionnaire, list of acronyms, references.

The structure of the thesis is depicted in Figure 1.3

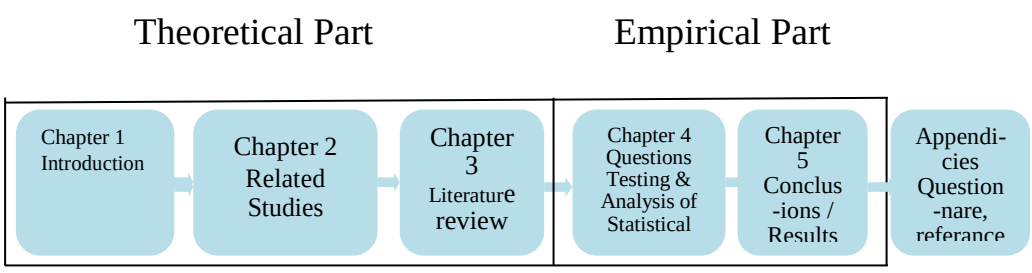

Figure 1.3 Thesis Structure

Chapter Two Related Studies Arabic Studies

Foreign Studies

2. Related Studies:

2.1 Arabic References:

1. (Ahmad, 2010)[1]

Using Six Sigma Style as a Strategic Input to Improve Quality and Competitiveness (Field Study).

The researcher explored the impact of using the Six Sigma style as a strategic approach in the process of quality improvement, and its role in supporting the competitiveness of the target companies. Results were supportive to the hypnotized relationships of all the dimensions, by measuring their impact on the components and results of applying the style in the processes of improving quality. It also helped in identifying the proposed quantitative style's components for application and setting a work plan, as per the desired project and started its implementation in accordance with its principles through a questionnaire in the service sector and selling cars in Egypt. The researcher selected assumptions of learning and training required and the role of Six Sigma in supporting competitiveness and the appropriate conditions for the application of Six Sigma. The researcher discussed the characteristics required of employees and the appropriate timing for application and the role of leadership.

(1) Ahmad, Hamada, 2010, Using Six Sigma Style as a Strategic Input to Improve Quality and Competitiveness (field study); unpublished doctoral dissertation,Banha university.

2. (Ahmad, 2010)[1]

Using Six Sigma as Input Variables to Improve Quality of Health Service. (A Comparative Study Between University and Private Hospitals In Cairo).

The study explored the regularly used variables of the Six Sigma style as an input to improve health services compared university and private hospitals in Cairo. The study also discussed the level of a health service, the degree of applying the variables of the Six Sigma style in the target hospitals on the quality of health service.

The study population was 380 individuals working in the private and public hospitals and 384 customers in these hospitals.

The study revealed significant immaterial effects of the nine Six Sigma variables (support of senior management, customer focus, focus on suppliers, focus on information quality, focus on the design of the service, focus on processes, organization of quality management and focus on the measurements) on the level of quality health service provided to patients.

3. (Abu Khzeim, 2009)[2]

Achieving Quality in Woven Fabrics by Using Six Sigma System.

The research explored the possibility of using Six Sigma in achieving the required quality for internal or external client, where the thought of Six Sigma begins and ends at the customer's requirements, thus can be accessed so as to achieve zero defect quality in the institution for the customer

(1) Ahmad, Mohammd, 2010, Using Six Sigma as Input Variables to Improve Quality of Health Service. (A Comparative Study Between University and Private Hospitals In Cairo).unpublished master dissertation,Al-Mansora university.

(2) Abu Khzeim,Adel, 2009. Achieving Quality in Woven Fabrics by Using Six Sigma Systems. unpublished doctoral dissertation,Helwan University.

requirements in their own time and at the right price and quality required. The questions of the research:

1- Applying the Six Sigma will achieve the client's requirements and reduce defects to zero defects, thus increase demand on the product.

2- Applying the Six Sigma will lead to the production in a timely manner and at the right price and quality.

3- Reducing the percentage of blending will reduce the cost of the final product.

4- Applying the Six Sigma will lead to increased production.

5- The application of Six Sigma will lead to improving the atmosphere and work environment.

Quality today means high profits and zero defects, and has become, in this sense and context, the function and the work of everyone within an organization regardless of location and nature of his work. Quality is no longer used as test only, rather became part of united and linked to the production process, where the researcher had a pilot study of a project to reduce defects of woven fabrics in Egypt. The research has proven his questions.

2.2. Foreign References:

1. (Kwak & Anbari, 2006)[1]

Benefits, Obstacles, and Future of Six Sigma Approach.

The objective of this paper is to review and examine the evolution, benefits, and challenges of Six Sigma practices and identify the key factors influencing successful Six Sigma project implementation. The paper also integrates the lessons learned from successful Six Sigma projects and their potential applications in managing traditional projects, and considers further improvements to the methodologies used for managing Six Sigma projects. Wider applications of Six Sigma principles to the organization will succeed through senior management involvement, organizational commitment, cultural change, and effective project management however; integrating the data-driven, structured Six Sigma processes into organizations still has room for improvement. Cultural changes require time and commitment before they are strongly implanted into the organization. Effective Six Sigma principles and practices are more likely to succeed by refining the organizational culture continuously.

(1) Kwak, Y.H., Anbari, F.T., 2006. benefits, obstacles and future of Six Sigma''. Technovation: The International Journal of Technological Innovation, Entrepreneurship and Technology Management 26 (5-6), 708–715.

2. (Kumar et al, 2006)[1]

On the Optimal Selection of Process Alternatives in a Six Sigma Implementation.

The objective of this paper is to develop mathematical models that can be used to select the process improvement techniques in an optimal way. Two mathematical programming models have been developed in the paper, one finds an optimal sigma quality level using yield as a surrogate revenue measure and another model maximizes the profit from a Six Sigma project by selecting the best processes for Six Sigma implementation This paper underscores the need to perform both economic and non-economic analyses to evaluate the value of selecting competing in India quality improvement alternatives. Experience has shown that the initial, Perceived euphoria of implementing a Six Sigma initiative, e.g., can bear little resemblance to its resulting economic consequences. Six Sigma continues to be a predominate target to try and obtain a competitive advantage. However, not all companies are successful in implementing many of these quality improvement strategies. Although many companies attribute their success to following a quality improvement program such as TQM and Six Sigma, there are a significant number of companies that fail to gain any measurable benefit after implementing these quality strategies.

3. (Yang & Hsieh, 2009)[2]

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(1) Kumar,u,D;Nowicki,D;Rarmirez,M,J,E;Verma,D; 2008.On the Optimal Selection of Process Alternatives in a Six Sigma Implementation. Int. J. Production Economics 111 456–467

(2) Yang, taho; Hsieh, Chiung, 2009. Six-Sigma Project Selection Using National Quality Award Criteria and Delphi Fuzzy Multiple Criteria Decision-Making Method. Institute of Manufacturing Engineering, National Cheng Kung University, No. 1 University Road, Tainan 70101, Taiwan. journal homepage: www.elsevier.com/locate/eswa.

Six-Sigma Project Selection Using National Quality Award Criteria and Delphi Fuzzy Multiple Criteria Decision-Making Method.

Present study, innovatively adopted national quality award criteria as the Six-Sigma project selection criteria. In addition, the hierarchical decision process for the strategic Criteria and the tactical sub-criteria by the top management team and by the Champion, respectively, can integrate both the strategic and tactical objectives. Furthermore, results indicate that the Delphi FMADM is both flexible and robust for the group decision-making process.

The present study showed that the higher a project's priority is, the greater the financial gain from completion of the project. Accordingly, the proposed methodology can prioritize the financial gain – which is the key performance indicator for a Six-Sigma project. In addition to the tactical benefits of the financial gains, the selection process will also meet strategic benefits due to its deliberate criteria mapping with TNQA.

4. (Su & Chou, 2008)[1]

A Systematic Methodology for the Creation of Six Sigma Projects:

(Case Study of Semiconductor Foundry).

This study aims to develop a systematic methodology to generate the project on the basis of the company's strategic policies and VOCs and determine the benefits and risk priorities of each project. Finally, the projects can be grouped into low hanging fruit, non-value, GB, BB or laborious projects. This study has two advantages. First, a complete procedure from project generation to project mapping is provided which

(1) Su,C.,Chou.,C., 2008. A Systematic Methodology for the Creation of Six Sigma Projects:(Case Study of Semiconductor Foundry). Department of Industrial Engineering and Engineering Management, National Tsing Hua University, Hsinchu, Taiwan.

can assist top management in deciding on the critical projects. Second, the proposed approach is without complicated mathematical inference and can be easily implemented. The proposed approach, however, was applied to just one case, the semiconductor foundry service. Moreover, the study proposed approach can be employed as a framework to develop computer software for general industrial application in the future.

5. (Gowen III & Tollon, 2005)[(1)]

Sigma Design, Electronic-Business, And Competitive Advantage:

(A Dynamic Capabilities Model Study).

This research of the effects of technological intensity for Six Sigma program design factors and e business factors has several important implications for corporate policy makers charged with achieving superior sustainable competitive advantage. The overall results suggest that Six Sigma programs have successfully integrated e-business practices, although differently for high-tech companies than for low tech organizations. Secondly, greater SCA has resulted for more of the Six Sigma program design factors for high-tech corporations than for low-tech firms. Finally, high-tech companies have exploited the six types of e-business factors for SCA, whereas the low-tech organizations have not achieved SCA for any of the e-business factors.

At the same time, these results suggest vast opportunities for low technology organizations to better exploit the design factors of Six Sigma systems and the applications for e-business and supply chain management.

(1) Gowen, R.C., Tallon, W.J., 2005. Effect of technological intensity on the relationship among Six Sigma design, electronic business, and competitive advantage**:** a dynamic capability model. Journal of High Technology Management Research 16, 59–87.

6. (Parast, 2010)[1]

The Effect of Six Sigma Projects on Innovation and Firm Performance.

The paper addressed the effect of Six Sigma projects on innovation and firm performance using theories from process management and innovation. It is believed that empirical research is needed to further validate the propositions. It is recommended that the type of industry (service, manufacturing), the environment (stable, dynamic) and the customer base (stable, evolving) be taken into account. In addition, the size of the organization should be considered as a control variable in future research. One of the challenges in conducting research in Six Sigma is to clearly distinguish between Six Sigma projects and other process improvement initiatives. Organizations may refer to their process improvement programs as Six Sigma programs, where in reality they may not be true Six Sigma projects. Therefore, attention should be devoted to carefully select organizations that implement Six Sigma programs. Another possible avenue for research is to determine the effect of other quality initiatives on the success of Six Sigma projects.

7. (Schroder ,Linderman & Chon, 2007)[2]

Six Sigma: Definition and Underlying Theory.

This paper finds that indeed the philosophy and tools/ techniques of Six Sigma are strikingly similar to prior quality management approaches. However, the way Six Sigma is practiced represents a new organization structural approach to improvement. Furthermore, the structure of Six

(1) Parast.,,M.,M, 2011, The effect of Six Sigma projects on innovation and firm performance, International Journal of Project Management 29 45–55

(2) Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: definition and underlying theory. Journal of Operations Management 26 (4), 536–554.

Sigma employs numerous mechanisms that simultaneously promote the conflicting demand s of exploration and control in the improvement effort. As a result, what is new in Six Sigma when compared to prior quality management approaches is more its organizational implementation rather than the underlying philosophy or the quality tools/techniques employed.

8. (Zu, Fredendall & Douglas, 2008)[1]

The Evolving Theory of Quality Management: The Role of Six Sigma.

This study explores what is new in Six Sigma by identifying the practices that are critical for implementing Six Sigma's concept and method in an organization. It then develops a model of how the Six Sigma practices integrate with traditional QM practices to improve performance. The model was tested using survey data collected from 226 manufacturing plants in the US. The empirical findings of this study strengthen our understanding of Six Sigma's key practices and how it complements traditional QM, and provide practitioners with rigorous research-based answers about Six Sigma implementation this study contributes to the scholarly research beginning to examine Six Sigma.). Furthermore, this study used a large-scale survey to test these Six Sigma practices and their relationships with traditional QM practices, and we found empirical support for these Six Sigma constructs and their importance to QM and performance improvement, which can provide a basis for more research on Six Sigma.

9. (Zu, Fredendall & Robbins, 2008)[1]

(1) Zu, X., Fredendall, L., Douglas, T., 2008, the Evolving Theory of Quality Management: The Role of Six Sigma. Journal of Operations Management 26 630–650.

Mapping the Critical Links between Organizational Culture and TQM/Six Sigma Practices.

The empirical results of this study reveal that different culture types influence different TQM/Six Sigma practices. The group culture, with its emphasis on commitment and cooperation, is found to be the important culture type for overall TQM/Six Sigma implementation. The model shows that the group culture is significantly related to seven of the 10 practices: top management support, supplier relationship, workforce management, product/service design, process management, Six Sigma structured improvement procedure, and Six Sigma focus on metrics. This study extended previous studies of culture and quality management by including the Six Sigma practices as well as the traditional TQM practices in the analysis, which helps to advance our knowledge of the influence of organizational culture on contemporary quality management practices. This study has important implications for management practices. Based on the results of this study, different culture types affect different practices. Before adopting TQM/Six Sigma initiatives, managers need to be aware of the cultural values emphasized in their organization so that the multiple TQM/Six Sigma practices can be effectively implemented in the organization. The findings of this study provide the managers some guidelines to design their policies or adjust their systems to better adopt different TQM/Six Sigma practices.

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(1) Zu, X., Fredendall, L., Robbins, T., 2010, Mapping the Critical Links between Organizational Culture and TQM/Six Sigma Practices... Int. J. Production Economics 123 86–106

Chapter Three

Literature Review

Introduction:

Literature of the study was collected from various available secondary resources that include published articles, books, previous studies, and internet materials. Due to limited empirical research on Six Sigma, we reviewed both practitioner publications e.g., Bhote[(1)]; Breyfogle et al[(2)]; Pande et al[(3)(4)] and academic studies e.g., Linderman et al[(5)]; Schroeder[(6)];

This section reviews the available relevant literature, which consists of two major parts. The first part reviews some fundamental definitions, the six sigma framework, DMAIC process, comparative between six sigma and other quality systems, advantages obstacles and limitation of six sigma and properties of six sigma. The second part reviews the awards of King Abdullah II for excellences.

3.1 What is Six Sigma?

Six Sigma has been characterized as the latest management fad to repackage old quality management principles, practices, and

(1) Bhote, K.R., 2003. The Power of Ultimate Six Sigma: Keki Bhote's Proven System for Moving beyond Quality Excellence to Total Business Excellence. AMACOM American Management Association, New York, NY.

(2) Breyfogle, F.W., Cupello, J.M., Meadows, B., 2001. Managing Six Sigma: A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success. Wiley, NY.

(3) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. (2000). The six sigma way: How GE, Motorola, and other companies are honing their performance. New York: McGraw-Hill.

(4) Pande, S; Rpert, P; Roland, R, (2002).The Six Sigma Way**,** New York: McGraw-Hill

(5) 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.

(6) Schroeder, R.G., 2000. Six Sigma quality improvements: what is Six Sigma and what are the important implications? In: Proceeding of the Fourth Annual International POMS Conference, Seville, Spain, August 27-September 1.

tools/technique[1]. At first glance Six Sigma looks strikingly similar to prior quality management approaches however; leading organizations with a track record in quality have adopted Six Sigma and claimed that it has transformed their organization. For example, 3M's Dental Division won the Baldrige Award[2] and then later adopted Six Sigma to improve performance even further[3]. The financial performance of 3M since Six Sigma adoption has been very impressive[4]. Other organizations with a quality track Six Sigma as a way to further enhance business performance[5]. It is now used by almost all industries including service industries such as health care management[6][7][8][9][10]. Six Sigma is a concept that was originated by Motorola Inc. in the USA in about 1985.

At the time, they were facing the threat of Japanese competition in the electronics industry and needed to make drastic improvements in their quality levels[11].

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(1) Clifford, L., Why you can safely ignore Six Sigma. op.cit.P.140.
(2) Aldred, K., Baldrige Award recognizes four U.S. companies. op.cit. P.8.
(3) McClenahen, J.S., 2004. New world leader. Industry Week 253 (1), P 36–39.
(4) Fiedler, T., 2004. Mopping up profits: With 3M sitting on solid earnings, CEO James McNerney handled his fourth annual meeting like a contented company veteran. Star Tribune, Metro ed., May 12, Minneapolis, `MN.
(5) Hahn, G.J., Doganakosy, N., Hoerl, R. The evolution of Six Sigma Quality Engineering , op.cit.P.317-326.
(6) Krupar, J., Yes, Six Sigma can work for financial institutions, op,cit. P.93-97.
(7) Antony, J., Six Sigma in the UK service organizations: results from a pilot survey. op.cit. P.303-306.
(8) Antony, J., Fergusson, C., Six Sigma in a software industry: results from a pilot study. op.cit. P.1025-1032.
(9) Moorman, D.W., On the quest for Six Sigma. op.cit. P.253-258.
(10) Frings, G.W., Grant, L., Who moved my Sigma … effective implementation of the Six Sigma methodology to hospitals? op.cit. P.311-328.
(11) Harry, M.J., Schroeder, R., 2000. Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, Currency, New York, NY.

"Sigma (ó) is the Greek letter used by statisticians to denote the Standard deviation for a set of date" and "is used to describe how well the process variation meets the customers' requirements"[(1)]. This measurement focuses on defects per million opportunities (DPMO). Most companies operate between a four and three sigma level, allowing 6,210 to 66,807 DPMA[(2)], whereas Six Sigma level processes only allow 3.4 defects, bringing the quality level of that process to 99.9997%.

While Six Sigma programs have their roots in the quality movement, they are different from other quality programs (e.g. lean systems or ISO-9000) due to their limited time-frame, measurable and quantifiable goals, and the project structure[(3)(4)].

A survey of CEOs and other executives about Six Sigma programs reveals an awareness level of 85% for manufacturing, 34% for healthcare and other services, and 22% for education[(5)] . The current use of Six Sigma is only 33% for manufacturing, 8% for healthcare and other services, and 6% for education. However those manufacturing and transaction Six Sigma programs have proven to be one of the most successful process improvement systems in recent years[(6)]. Most companies today operate between three and four sigma where the cost of quality is 15% to 25% of revenue .as company to moves to

(1) Keller, P.A., 2001. Six Sigma Deployment: A guide For Implementing Six Sigma in Your Organization. Quality Publishing, Tucson.

(2) Lucier, G. T. and S. Seshadri. 2001. GE takes Six Sigma beyond the bottom line. *Strategic Finance* (May): 40-46.

(3) Anderson, J.C., Rungtusanatham, M., Schroeder, R.G., 1994. Theory of quality management underlying the Deming management method. Academy of Management Review 19 (3), 472–509.

(4) Dahlgaard, J.J., Dahlgaard-Park, S.M., 2006. Lean production, Six Sigma quality, TQM and company culture. The TQM Magazine 18 (3), 263–281.Das, A.,

(5) Weiler, G. (2004). CEOs think about quality? Quality Progress, 37(5), 52–56.

(6) Snee, R.D., Hoerl, R.W., 2003. Leading Six Sigma: A Step-by-Step Guide Based on Experience with GE and Other Six Sigma Companies. Person Education, Upper Saddle River.

Six Sigma quality levels, there cost of quality decrease to one or two of revenue[1].

Six Sigma implementation uses a systematic procedure[2] conducted a study of 13 high profile corporate houses in the US from a wide variety of Industries and reported that Six Sigma programs returned more than double the investment. It has been claimed that Six Sigma enables organizations to become more ambidextrous by switching structure, act organically when being challenged by new ideas and operate mechanically in focusing on efficiency[3].

During the 1980s, Motorola joined the quality movement seeking to reduce product defects on the manufacturing floor and received help from engineers Bill Smith and Mikel Harry[4] who are credited with developing Six Sigma. In 1988, Motorola won the Malcom Baldrige Quality Award and published its result along with its use of Six Sigma. Six Sigma was different from quality initiatives of the past in that it became about "helping the organization make more money by improving customer value and efficiency" with the benefits going "straight initiative, its popularity was primarily due to other large organization, utilization of the initiative and their successes with it. After some internal pilot implementation, Galvin, in 1987, formulated the goal of "achieving Six-Sigma capability by 1992" in a memo to all Motorola employees [5]. The results in terms of reduction in process variation were on-track and cost savings totaled US$13 billion and

(1)(PaulKeller) www.qualityamerrica.com/knowledgecente/article/packSmallcompanys.
(2) Anon, 2003. Revealing study of Six Sigma: gains but missed opportunities. Strategic Direction 19 (8), 34–36.
(3) Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: definition and underlying theory. Journal of Operations Management 26 (4), 536–554.
(4) Eckes, G.2005.Six Sigma execution.Boston: McGraw-Hill
(5) Bhote Keki R 1989, Motorola's long march to the Malcolm Baldrige National Quality Award National Productivity Review Volume 8, Issue 4, pages 365–376, Autumn (Fall) 1989.

improvement in labor productivity achieved 204 % increase over the period 1987-1997[1].

Specifically, Allied Signal and General Electric (GE) become pioneers in the Six Sigma quality initiative, reporting significant benefits. Allied Signal reported productivity gains of 6% in the first two years using Six Sigma[2] , and GE Medical Systems reporting $91.2 million in customer benefits on more than 466 projects in one year [3]. Many other companies have since adopted Six Sigma and reported similar results.

The implications of Six Sigma in industry are profound. For example, in 1999 General Electric Company [4] spent over half a billion in Six Sigma initiatives and received over two billion in benefits for the fiscal year [5]. While Six Sigma has made a big impact on industry, the academic community lags behind in its understanding of Six Sigma. In early 1997, the Samsung and LG Groups in Korea began to introduce Six Sigma within their companies. The results were amazingly good in those companies. For instance, Samsung SDI, which is a company under the Samsung Group, reported that the cost saving by Six Sigma projects totaled US$150 million[6].

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(1) Losianowycz G. (1999). Six Sigma Qualities: A Driver to Cultural Change & Improvement, an invited lecture by Korean Standards Association at Seoul.

(2) DeFeo, J. A. (2000). An ROI story. Training and Development, 54(7), 25–27.

(3) Gregory T. Lucier, Sridhar Seshadri, 2011 GE Takes Six Sigma Beyond the Bottom Line http://findarticles.com/p/articles/mi_hb6421/is_11_82/ai_n28839232/.

(4) General Electric Company, 1999. General Electric Company 1999 Annual Report. General Electric Company, Fairfield, CT.

(5) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. (2000). The Six Sigma way: How GE, Motorola, and other op companies are honing their performance. New York: McGraw-Hill.

(6) Samsung SDI. (2000a). Explanation Book of the Current Status of Six Sigma, Prepared for the National Quality Prize of Six Sigma for 2000 by Samsung SDI.

As Six Sigma is a project-driven methodology, it is essential to prioritize projects which provide maximum financial benefits to the organization[(1)]?

At the present time, the number of large companies applying Six Sigma in Korea is growing exponentially, with a strong vertical deployment into many small- and medium-size enterprises as well[(2)].

Further, many of its achievements have been attributed to senior management support and the leaders that carry out Six Sigma initiatives because they tend to provide clear values and objectives while following fact-based management concepts[(3)].

3.2 Definitions:

Six Sigma may be defined in several ways. Tomkins [(4)] defines Six Sigma to be "a program aimed at the near-elimination of defects from every product, process and transaction"[(5)]. Harry defines Six Sigma to be "a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tool that can lead to breakthrough quantum gains in quality. Quality Progress called Six Sigma a "high-

(1) Coronado, R.B., & Antony, F. (2002). Critical Success factors for the successful implementation of Six Sigma projects in organizations. *The TQM Magazine,14(2), 92-99.*

(2) Park, H. Sung, 2003.Six Sigma for quality and productivity promotion, Asian Productivity Organization1-2-10 Hirakawacho, Chiyoda-ku, Tokyo 102-0093, Japan.p.2

(3) Caulcutt, R. (2001). Why is Six Sigma so successful? Journal of Applied Statistics. 28(3/4), 301- 306.

(4) Tomkins, R. (1997, October 10). "GE beats expected 13% rise", Financial Times.

(5) Harry, M., 1998. Six Sigma: a breakthrough strategy for profitability. Quality Progress 31 (5), 60-64.

performance, data-driven approach to analyzing the root cause of business problems and solving them"[1].

Harry and Schroeder[2] in their popular book on Six Sigma, described it as a "business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction".

Hahn et al[3], described Six Sigma as a disciplined and statistically based approach for improving product and process quality. On the other hand, Sanders & Hild[4], called it a management strategy that requires a culture change in the organization". Neumann and Hoisington[5] have indicated that the concept of Six Sigma is the development of a uniform way to measure and monitor performance and set extremely high expectations and improvement goals. Treichler et al.[6], have concluded that Six Sigma is a highly disciplined process that helps an organization to focus on developing and delivering near-perfect products and services. It has been identified as a process improvement approach that dramatically

(1) Blakeslee Jr., J.A., 1999. Implementing the Six Sigma solution. Quality Progress 32 (7), 77–85.

(2) Harry, M.J., Schroeder, R., 2000. Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, Currency, New York, NY.

(3) Hahn, G.J., Doganakosy, N., Hoerl, R., The evolution of Six Sigma Quality Engineering, op.cit. P.317-326.

(4)Sanders, D., Hild, C.R., 2000. Six Sigma on business processes: common organizational issues. Quality Engineering 12 (4), 603–610.

(5) Naumann, E., & Hoisington, S.H.Customer Centered Six Sigma linking Costumers process improvement and financial results. op.cit.

(6) Treichler, D., Carmicheal, R., Kusmanoff, A., Lewis, J., & Berthiez, G. (2002). Design for Six Sigma, op.cit.

improves performance, enhances process capability, and produces bottom line results for organizations[1][2][3].

According to Hammer[4] Six Sigma employs a project-based methodology to solve a specific performance problem recognized by an organization. Anbari and Kwak & Anbari[5][6] summarize Six Sigma as a strategy, which includes TQM, strong customer focus, additional data analysis tools, financial results and project management, to satisfy customer needs.

Many of the definitions of Six Sigma found in the literature are very general and do not provide elements-or factors (variables, constructs, concepts), as[7] Whetten described them. Hahn et al[8] noted that Six Sigma has not been carefully defined in either the practitioner or academic literature.

3.3 Defect rate, ppm and DPMO

(1) Dasgupta, T., Using the Six Sigma metric to measure and improve the performance of a supply chain. op.cit.

(2) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit.

(3) Pantano, V., O'Kane, P., Smith, K, Cluster-based Six Sigma development in small and medium sized enterprises. op.cit.

(4) Hammer, M., 2002. Process management and the future of Six Sigma. MIT Sloan Management Review 43 (2), 26-32

(5) 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,

(6) Kwak, Y.H., Anbari, F.T., 2006. Benefits, obstacles and future of Six Sigma''. Technovation: The International Journal of Technological Innovation, Entrepreneurship and Technology Management 26 (5-6), 708–715.

(7) Whetten, D.A., 1989. What constitutes a theoretical contribution? Academy of Management Review 14 (4), 490–495.

(8) Hahn, G.J., Doganakosy, N., Hoerl, R., The evolution of Six Sigma Quality Engineering, op.cit.

The Six Sigma concept for process improvement originated at Motorola[1]. Before Motorola benchmarked against world- class Japanese electronics corporations in the mid-1980s, the overall product error rate was approximately before sigma (6200 defects per million opportunities, DPMO), as opposed to about Six Sigma (3.4 DPMO) at those Japanese companies[2].

Six Sigma was a way for Motorola to express its quality goal of 3.4 DPMO where a defect opportunity is a process failure that is critical to the customer). Motorola set this goal so that process variability is ±6 S.D. from the mean[3]. They further assumed that the process was subject to disturbances that could cause the process mean to shift by as much as 1.5 S.D. off the target[4]. Factoring a shift of 1.5 S.D. in the process mean then results in a 3.4 DPMO. (See figure 1.9)

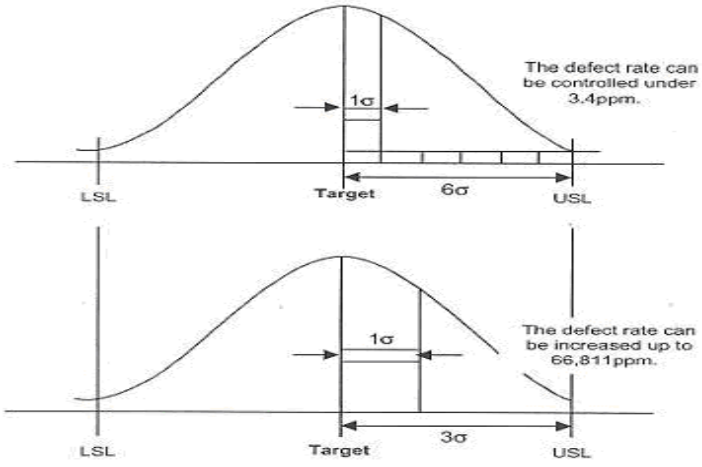

Figure 1.9. Sigma quality levels of 6σ and 3σ

(1) Folaron, J., & Morgan, J. P. (2003). The evolution of Six Sigma. ASQ Six Sigma Forum Magazine, 2(4), 38–44.

(2) Behara, R. S., Fontenot, G. F., & Gresham, A. (1995). Customer satisfaction measurement and analysis using Six Sigma. International Journal of Quality and Reliability Management, 12(3), 9–18.

(3) Breyfogle, F.W., Cupello, J.M., Meadows, B., 2001. Managing Six Sigma: A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success. Wiley, NY.

(4) Montgomery, D.C., 2001. Introduction to Statistical Quality Control, 4th Edition. Wiley, NY.P 42-44.

3.4 Sigma quality level

This goal was far beyond normal quality levels and required very aggressive improvement efforts. For example, 3 sigma results in a 66,810 DPMO or 93.3% process yield, while Six Sigma is only 3.4 DPMO and 99.99966% process yield (these computations assume a 1.5 S.D. shift in the process mean[1].

Six Sigma was a way for Motorola to express its quality goal of 3.4 DPMO where a defect opportunity is a process failure that is critical to the customer). Motorola set this goal so that process variability is ±6 S.D. from the mean[2]. They further assumed that the process was subject to disturbances that could cause the process mean to shift by as much as 1.5 S.D. off the target. Factoring a shift of 1.5 S.D. in the process mean then results in a 3.4 DPMO[3].

Figure 1.10[4] shows the relationship between DPMO and Process Sigma assuming the normal distribution.

(1) Breyfogle, F.W., Cupello, J.M., Meadows, B., 2001. Managing Six Sigma: A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success. Wiley, NY. P 40

(2) Breyfogle, F.W., Cupello, J.M., Meadows, B., 2001. Managing Six Sigma: op.cit. P 39

(3) Montgomery, D.C., 2001. Introduction to Statistical Quality Control, 4th Edition. Wiley, NY. P 39-40.

(4) **source:** Park, H. Sung, 2003.Six Sigma for quality and productivity promotion. op.cit. P.15

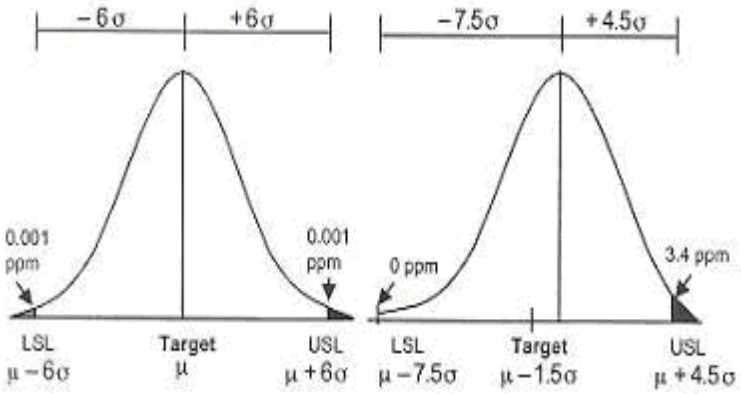

Figure 1.10. Effects of a 1.5σ shift of process mean when 6σ quality level is achieved

Table 3.1 illustrates how sigma quality levels would equate to other defect rates and organizational performances.

Sigma quality level	Process mean, fixed		Process mean, with 1.5σ shift	
	Non-defect rate (%)	Defect rate (ppm)	Non-defect rate (%)	Defect rate (ppm)
1 б	68.26894	317,311	30.2328	697,672
2 б	95.44998	45,500	69.1230	308,770
3 б	99.73002	2,700	93.3189	66,811
4 б	99.99366	63.4	99.3790	6,210
5 б	99.999943	0.57	99.97674	233
6 б	99.9999998	0.002	99.99966	3.4

(Table 3.1)[1]

3.5 Six Sigma Framework:

3.5.1 Elements of the Six Sigma Framework:

The Six Sigma structured improvement procedure is expected to support product/service design and process management. Both product/service design and process management practices involve using different managerial and technical tools and their effectiveness is

(1) **source:** Park, H. Sung, 2003.Six Sigma for quality and productivity promotion, op cit. P,16

dependent on how well teams actually use these tools[1]. The DMAIC/DMADV procedures offer a standardized approach for the teams to follow, and prescribe appropriate tools to use at each step, as well as systematic project management tools, which enhances their problem-solving ability[2][3][4].

In addition, these structured procedures guide the teams search for solutions to complicated problems by breaking complex tasks into elementary components to reduce task complexity so that the teams can be focused, which will increase their productivity[5]. Likewise, the use of Six Sigma metrics is more effective and efficient when teams follow the structured procedures in conducting Six Sigma projects.

These procedures not only entail a 'measure' step to identify measurable customer requirements and to develop baseline defect measures, but also request using metrics throughout the project, e.g., from determining project goals in the 'define' step to establishing on-going process measures to continuously control the key processes in the 'control' step[6][7] found that when teams strictly follow the DMAIC steps and

(1) Ahire, S.L., Dreyfus, P., 2000. The impact of design management and process management on quality: an empirical examination. Journal of Operations Management 18, 549–575.

(2) Antony, J., Banuelas, R., 2002. Key ingredients for the effective implementation of Six Sigma program. Measuring Business Excellence 6 (2), 20–27.

(3) Choo, A.S., Linderman, K.W., Schroeder, R.G., 2007a. Method and context perspectives on learning and knowledge creation in quality management. Journal of Operations Management 25 (4), 918–931.

(4) Kwak, Y.H., Anbari, F.T. Benefits, obstacles and future of Six Sigma''. op.cit,P 708–715.

(5) Linderman, K.W., Schroeder, R.G., Choo, A.S., Six Sigma: the role of goals in improvement teams. op.cit, 779–790.

(6) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. The Six Sigma way: How GE, Motorola, and other op companies are honing their performance. op.cit.

(7) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit, 193–203.

faithfully complete each step, they are more likely to meet the project goals, especially those challenging goals, and to achieve improved project performance.

The DMAIC cycle comes into play to meet the customer needs consistently and perfectly[1]. Su et al.[2] have summarized the unique features of the Six Sigma approach include (1) sequences and links improvement tools into an overall approach (known as DMAIC); (2) integration of the human and process elements for improvement using a belt based organization (Champion, Master Black Belt, Black Belt and Green Belt), and (3) attention to bottom-line results and the sustaining of gains over time.

Snee and Rodebaugh[3] have exhibited four key phases to maturation of the project selection process. Those phases include: identify Black Belt projects; create a project hopper; examine the project portfolio; and create an improvement system.

Six Sigma uses the following five major phases to achieve process improvement: Define, Measure, Analyze, Improve and Control (DMAIC). The DMAIC cycle has a lot of similarities with Deming's 'Plan-Do-Check-Act'' cycle[4].

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(1) Kuei, C.H., & Madu, C.N. (2003). Customer-centric Six Sigma quality and reliability management. The International Journal of quality & Reliability Management, 20, 954-964.

(2) Su, C.T., Chiang, T.L., & Chiaok. (2005). Optimizing the IC delamination quality via six-sigma approach. IEEE Transactions on Electronics Packaging Manufacturing, 28,241-248.

(3) Snee, R. D., & Rodebaugh, W. F. (2002). The project selection process. Quality Progress, 35(9), 78–80.

(4) Bertels, T. (Ed.), 2003. Rath and Strong's Six Sigma Leadership Handbook. Wiley, New Jersey.

Management strategies, such as TQC, TQM, and Six Sigma, are distinguished from each other by their underlying rationale and framework. As far as the corporate framework of Six Sigma is concerned, it embodies the five elements of top-level management commitment, training schemes, project team activities, and measurement system and stakeholder involvement

As shown in Figure 2.1[1].

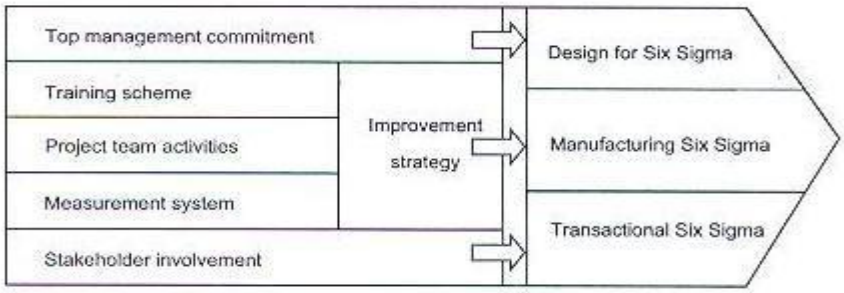

Figure 2.1. The corporate framework of Six Sigma

3.5.2 Top-level Management Commitment and Stakeholder Involvement

3.5.2.1 Top-level management commitment:

Harry and Schroeder[2] stated that managers should make a serious commitment when the Six Sigma system is initially introduced. Henderson and Evans[3] found that at GE, top management support and participation is a significant factor determining success with Six Sigma.

(1) **source:** Park, H., Sung, 2003.Six Sigma for quality and productivity promotion, op.cit. P.30

(2) Harry, M.J., Schroeder, R.. Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, op cit.

(3) Henderson, K.M., Evans, J.R., 2000. Successful implementation of Six Sigma: benchmarking general electric company. Benchmarking: An International Journal 7 (4), 260–281.Slater, R., 1999.

Top management support is crucial in Six Sigma implementation, as demonstrated by chief executives such as Jack Welch of GE, Bob Galvin of Motorola, and Lawrence Bossidy of Allied Signal, who each led Six Sigma implementation in their firm[(1)] Top management makes the strategic decisions required for Six Sigma adoption[(2)]. Six Sigma role structure can only be established if top management uses its authority and power to integrate the Six Sigma black and green belt system into the organization's human infrastructure, to adjust the performance appraisal and compensation policy to incorporate Six Sigma performance, and to provide resources for Six Sigma training[(3)(4)(5)(6)].

Top management support drives QM implementation by providing direction and resources for quality improvement [(7)(8)].Top management support reflects on fostering a cooperative and learning environment needed for QM implementation [(9)(1)]. The QM literature has found strong

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(1) Jack Welch and the GE Way: Management Insights and Leadership Secrets of the Legendary CEO. McGraw-Hill, NY.

(2) Lee, K.C., Choi, B., 2006. Six Sigma management activities and their influence on corporate competitiveness. Total Quality Management & Business Excellence 17 (7), 893–911.

(3) Antony, J., Banuelas, R., 2002. Key ingredients for the effective implementation of Six Sigma program. Measuring Business Excellence 6 (4), 20–27.

(4) Bhote, K.R., 2003. The Power of Ultimate Six Sigma: Keki Bhote's Proven System for Moving beyond Quality Excellence to Total Business Excellence. AMACOM American Management Association, New York, NY

(5) Breyfogle, F.W., Cupello, J.M., Meadows, B., Managing Six Sigma: op.cit.

(6) Hendricks, C.A., Kelbaugh, R., 1998. Implementing Six Sigma at GE. The Journal of Quality and Participation 21 (4), 43–53.

(7) Ahire, S.L., O'Shaughnessy, K.C., 1998. The role of top management commitment in quality management: an empirical analysis of the auto parts industry. International Journal of Quality Science 31, 5–37.

(8) Yeung, A.D.L., Cheng, T.C.E., Lai, K.H., 2005. An empirical model for managing quality in the electronics industry. Production and Operations Management 14 (2), 189–204.

(9) Anderson, J.C., Rungtusanatham, M., Schroeder, R.G.Theory of quality management underlying the Deming management method. Op.cit, 472–509.

empirical support for the effects of top management support on traditional QM infrastructure practices such as customer relationship, supplier relationship, and workforce management. Top management support nurtures customer relationship by inviting customers to visit the plant and meeting with key customers, providing resources for employees to visit customer plants, requiring the collection of detailed information about customer needs and expectations, and involving customers in product design teams(2). A long-term cooperative relationship with suppliers is possible only when top management prioritizes quality and delivery performance over price in supplier selection and retention policies, requires suppliers to be certified for quality, and provides the assessment tools for supplier quality(3)(4).Top management support facilitates workforce management by allocating resources for training, instituting a quality-based compensation policy, and supporting employee involvement(5).

3.5.2.2 Stakeholder involvement

Stakeholder involvement means that the hearts and minds of employees, suppliers, customers, owners and even society should be involved in the improvement methodology of Six Sigma for a company(6)

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(1) Beer, M., 2003. Why total quality management programs do not persist? The role of management quality and implication for leading a TQM transformation. Decision Sciences 34 (4), 623–642.

(2) Flynn, B.B., Sakakibara, S., Schroeder, R.G., 1995. Relationship between JIT and TQM: practices and performance. Academy of Management Journal 38 (5), 1325–1360.

(3) Flynn, B.B., Sakakibara, S., Schroeder, R.G. Relationship between JIT and TQM: practices and performance. Op.cit, 1325–1360.

(4) Kaynak, H., 2003. The relationship between total quality management practices and their effects of firm performance. Journal of Operations Management 21, 405–435.

(5) Handfield, R.B.; Walton, S.V.; Seegers, L.K. and Melnyk, S.A. (1997): 'Green' value chain practices in the furniture industry, Journal of Operations Management, 15 (1997), 293-315.

(6) Park, H., Sung. Six Sigma for quality and productivity promotion, op.cit. P.33

In order to provide products and services that meet customer needs and expectations, it is critical to establish and maintain a close relationship with customers[1]. Open communication with key customers allows companies to quickly identify customers' requirements and determine whether these requirements are being met and what improvement to make[2][3] ·The importance of having close relationships with customers is demonstrated by facilitating the collection and use of quality information. When managers and employees have direct contacts with customers, they can readily obtain firsthand information about product and service quality and use such information in making quality decision[4]. The creation of a partnership with key suppliers is one major intervention that companies should make to realize continuous improvement[2]. When the buying firm involves its suppliers in the product/service design process, the suppliers can provide inputs about product or component simplification and standardization and the capabilities of prospective materials and parts[5][6][7].

(1) Hackman, J. Richard, Wageman, Ruth 2005, Total quality management: empirical, conceptual, and practical issues http://www.getcited.org/pub/103386643

(2) Flynn, B.B., Schroeder, R.G., Sakakibara, S., 1994. A framework for quality management research and an associated measurement instrument. Journal of Operations Management 11 (4), 339–366.

(3) Mohrman, S.A., Tenkasi, R.V., Lawler, E.E., Ledford Jr., G.G., 1995. Total quality management: practice and outcomes in the largest US firms. Employee Relations 17 (3), 26–41

(4) Flynn, B.B., Schroeder, R.G., Sakakibara, S. A framework for quality management research and an associated measurement instrument. op.cit, 339–366.

(5) Flynn, B.B., Sakakibara, S., Schroeder, R.G. Relationship between JIT and TQM: practices and performance. op.cit, p1325–1360.

(6) Forza, C., & Flippini, R. (1998).TQM impact on quality conformance and customer satisfaction: a causal model. International Journal of Production Economics 55, 1–20.

(7) Kaynak, H., The relationship between total quality management practices and their effects of firm performance, op.cit, p 405–435.

Also, an improved supplier relationship enhances process management through timely delivery of high quality materials and part[1]. By selecting suppliers based on quality, firms encourage the suppliers to continuously improve their quality and thus provide high quality parts, which helps to reduce process variability due to purchased materials and parts[2]. Workforce management develops competent and committed employees who are loyal to the organization's goals of quality improvement[3].

A long-term cooperative relationship with suppliers is possible only when top management prioritizes quality and delivery performance over price in supplier selection and retention policies, requires suppliers to be certified for quality, and provides the assessment tools for supplier quality[4][5]

3.5.3 Training Scheme and Measurement System:

The use of a significant number of full-time improvement specialists in Six Sigma is new to many organizations. In the past, organizations were reluctant to make the investment in full-time specialists and often assigned improvement tasks to already overworked staff on a part-time basis[6].

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(1) Kaynak, H., 2003. The relationship between total quality management practices and their effects of firm performance. Journal of Operations Management 21, 405–435.
(2) Flynn, B.B., Sakakibara, S., Schroeder, R.G. Relationship between JIT and TQM: op.cit.p 1325–1360.
(3) Flynn, B.B., Schroeder, R.G., Sakakibara, S., A framework for quality management research and an associated measurement instrument. Op.cit.p 339–366.
(4) Flynn, B.B., Sakakibara, S., Schroeder, R.G. Relationship between JIT and TQM: op.cit.p 1325–1360.
(5) Kaynak, H.. The relationship between total quality management practices and their effects of firm performance. op.cit, p405–435.
(6) Park ,H., Sung, 2003.Six Sigma for quality and productivity promotion, op.cit.P.34

Some organizations used full-time specialists but provided little or no training in structured improvement methods. By contrast, in 1997 GE invested $250 million in training nearly 4000 Black Belts and 60,000 Green Belts out of a workforce of 220,000 employees[1] . This large investment paid off in 1997 alone by adding $300 million to net income. Since investments are converted immediately to bottom-line results, management is able to justify the commitment of extensive training and full-time employees. The training cost can be up to $30,000 per project The Black Belt program results have been reported as an average of $175,000 cost savings per project[2], but as much as $25 million for an outstanding project at Honeywell[3]. The payback is estimated at approximately $1 million in direct cost reduction per Black Belt[4]. Improvement goals and makes the goals more achievable. This increases the commitment of organizational members in attaining the goals since they are now viewed as more "realistic" [5][6].

Six Sigma organizations provide extensive training programs in process improvement methods and tools[7].

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(1) Harry, M.J., Schroeder, R.,Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations. Op.cit.

(2) Maguire, M. (1999). Cowboy quality: Mikel Harry's riding tall in the saddle as Six Sigma makes its mark. Quality Progress, 32(10), 27–34.

(3) Hoerl, R.W., 1998. Six Sigma and the Future of quality profession. Quality Progress 31 (6), 35-42.

(4) Wood, A. (1999). New tools for making it: Tightening process variables. Chemical Week, 161(8), 26–28.

(5) Bandura, A., 1982. Self-efficacy mechanism in human agency. American Psychologist 37, 122–147.

(6) Bandura A., 1986. Social Foundations of Thought and Action: A Social-Cognitive View. Prentice-Hall, Englewood Cliffs, NJ.

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

A Six Sigma program depends on intensive statistical and managerial training for Black Belt teams and assigning teams to process improvement projects(1) Employees are trained as Green Belts who are assigned to project teams(2). Selected high-potential professionals receive greater training in quantitative and leadership skills as a prestigious Black Belt(3).

Six Sigma uses a group of improvement specialists, typically referred to as champions, master black belts, black belts, and green belts(4)(5). Those specialists receive intensive differentiated training that is tailored for their ranks and is designed to improve their knowledge and skills in statistical methods, project management, process design, problem-solving techniques, leadership skill, and other managerial skills(6)(7)(8). With assigning the improvement specialists to take different levels of roles and responsibilities in leading the continuous improvement efforts, the organization builds a Six Sigma role structure for quality improvement.

In the Six Sigma role structure, there is a hierarchical coordination mechanism of work for quality improvement across multiple organizational levels (9). For example, the senior executives serve as champions for

(1) Pande, P. S., Neumann, R. P., & Cavanugh, R. R.. The Six Sigma way: op.cit.
(2) Breyfogle, F.W., Cupello, J.M., Meadows, B. Managing Six Sigma: op.cit.
(3) Pyzdek, T. (2001). *The Six Sigma handbook*. New York: McGraw-Hill.
(4) Henderson, K.M., Evans, J.R. Successful implementation of Six Sigma: benchmarking general electric company benchmarking. op.cit, 260–281
(5) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. (2003). Six Sigma: A goal-theoretic perspective. op.cit. P 193–203.
(6) Barney, M., 2002a. Macro, meso, micro: Six Sigma. The Industrial Organizational Psychologist 39 (4), 104 107.
(7) Gowen III, C.R., Tallon, W.J., 2005. Effect of technological intensity on the relationship among design, electronic-business, and competitive advantage: a dynamic capabilities model study. Journal of High Technology Management Research 16 (1), 59–87.
(8) Snee, R.D., Hoerl, R.W. Leading Six Sigma. op.cit.
(9) Sinha, K.K., Van de Ven, A.H., 2005. Designing work within and between organizations. Organization Science 16 (4), 389–408.

making the organization's strategic improvement plans and black belts under them lead Six Sigma projects and mentor green belts in problem solving[1][2] . This mechanism helps to coordinate and control work across organizational levels to ensure that the tactical tasks match with the overall business strategy[3].

"The WB course gives a basic introduction to Six Sigma. Typically, it is a 2–3 day course and is offered to all employees. It covers a general introduction to Six Sigma, framework, structure of project teams and statistical thinking. The GB course is a median course in content and the participants also learn to apply the formalized improvement. Methodology in a real project. It is usually a 1–2 week course, and is offered to foremen and middle management. The BB course is comprehensive and advanced, and aims at creating full-time improvement project leaders. Black Belts are the experts of Six Sigma, and they are the core group in leading the Six Sigma program. The duration of a BB course is around 4–6 months with about 20 days of study seminars. In-between the seminar blocks, the participants are required to carry out improvement projects with specified levels of DMAIC steps. The BB candidates are selected from the very best young leaders in the organization" [4].

3.6 DMAIC Process:

Early in its development, a team at Motorola developed a four-phase process for improving the quality of its products looking at ''Definition,''

(1) Barney, M., 2002b. Motorola's second generation. Six Sigma Forum Magazine 1 (3), 13–16.
(2) Barney, M.., Macro, meso, micro: Six Sigma. op.cit, P 104- 107.
(3) Barney, M.., Macro, meso, micro: Six Sigma. Op.cit, P 104- 107.
(4) Park, H., Sung., Six Sigma for quality and productivity promotion, op.cit.P.35

‘‘Analysis,’’ ‘‘Optimization,’’ and ‘‘Control’’[1]. Based on this four-phase process, two additional major processes were developed: the ‘‘Define, Measure, Analysis, Improve, and Control’’ (DMAIC) and the ‘‘Design for Six Sigma’’ (DFSS) processes[2] also known as the ‘‘Define, Measure, Analysis, Design, and Verify’’ (DMADV) process[3] .This DMAIC process works well as a breakthrough strategy. The DMAIC cycle has a lot of similarities with Deming’s “Plan-Do-Check-Act” cycle[4] Six Sigma companies everywhere apply this methodology as it enables real improvements and real results. The methodology works equally well on variation, cycle time, yield, design, and others. As stated in the Six Sigma for Dummies hand book, “no matter how hard you try to accomplish anything, it’s always easier when you follow a proven methodology” [5]. When undertaking a new Six Sigma project, the key format to follow is Define-Measure-Analyze-Improve-Control (DMAIC). “In DMAIC, business processes are improved by following a structured method with set steps” During the Define stage, the problem is identified with clear goals and objectives set for the project.

Project selection and prioritization is an important element of Six Sigma programs, the prioritization of project is determined by many criteria, such as a cost benefit analysis or the Pareto priority index[6].

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(1) Harry, M. J. and Lawson J. R. (1992). Six Sigma Producibility Analysis and Process Characterization. New York: Addison-Wesley.

(2) Harry, M.J., Schroeder, R.., Six Sigma: The Breakthrough Management Strategy Revolutionizing the World’s Top Corporations.,

(3) Keller, P.A., 2001. Six Sigma Deployment: A guide For Implementing Six Sigma in Your Organization. op.cit.

(4) Bertels, T. (Ed.)., Rath and Strong’s Six Sigma Leadership Handbook. op.cit.

(5) DeCarlo, N ; Gygi, G and Williams ,B , 2005. Six Sigma for Dummies. Willy Publishing ,Inc.

(6) Banuelas, R., Antony, J., Brace, M., 2005. An application of Six Sigma to reduce waste. Quality and Reliability Engineering International 21, 553–570.

As the above definition notes, Six Sigma uses a structured method, whether the task is process improvement or new product design. In the case of process improvement, the method is patterned after the plan, do, check, and act (PDCA) cycle[(1)(2)]. One popular method uses define measure, analyze, improve, and control (DMAIC) as the five steps in process improvement. A somewhat different set of steps called Design for Six Sigma is used for radical or incremental product design (define, measure, analyze, design and verify).

Whatever method is chosen, however, it is important that the method be carefully followed and a solution not offered until the problem is clearly defined. Data and objective measurement is critical at each step of the method. The Standard statistical quality tools are incorporated into the structured method as needed. However, Six Sigma guidelines demonstrate an integration of proper tools at each step of the method[(3)(4)(5)(6)(7)].

Improvement procedures provide teams a methodological framework to guide them in the conduct of improvement projects[(8)(9)].

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(1) Shewhart, W.A., 1931. Economic Control of Quality of Manufactured Product, D. Van Nostrand, NY.
(2) Shewhart, W.A., 1939. Statistical Method from the Viewpoint of Quality Control. Graduate School of the Department of Agriculture, Washington, DC.
(3) Breyfogle III, F. W. (1999). Implementing Six Sigma: Smarter solutions using statistical methods, New York7 Wiley.
(4) Ishikawa, K., 1985. What is Total Quality Control? The Japanese Way. Prentice-Hall, Englewood Cliffs, NJ.
(5) Kume, H., 1985. Statistical Methods for Quality Improvement. Loftus, J.H. (Trans.). AOTS, the Association for Overseas Technical Scholarship, Tokyo, Japan.
(6) Kume, H., 1985. Statistical Methods for Quality Improvement. Loftus, J.H. (Trans.). AOTS, the Association for Overseas Technical Scholarship, Tokyo, Japan.
(7) Hoerl, R.W., Six Sigma and the Future of quality profession. Op.cit., P 35-42.
(8) Pande, P. S., Neumann, R. P., & Cavanugh, R. R.. The Six Sigma way: How GE, Motorola, and other op companies are honing their performance .op.cit.
(9) Pyzdek, T. (2003). The Six Sigma project planner. New York, NY: McGraw-Hill.

This careful integration of tools with the methods is unique to Six Sigma Six Sigma applies a structured approach to managing improvement activities, which is represented by Define–Measure–Analyze–Improve–Control (DMAIC) used in process improvement or Define–Measure–Analyze–Design–Verify (DMADV) used in product/ service design improvement. Both of these procedures are grounded in the classic Plan–Do–Check–Act (PDCA) cycle, but Six Sigma specifies the QM tools and techniques to use within each step, which is unique to Six Sigma[1] .

3.7 Six Sigma role structure:

Six Sigma uses a group of improvement specialists, typically referred to as champions, master black belts, black belts, and green belts[2][3]. Those specialists receive intensive differentiated training that is tailored for their ranks and is designed to improve their knowledge and skills in statistical methods, project management, process design, problem-solving techniques, leadership skill, and other managerial skills[4][5][6][7]. With assigning the improvement specialists to take different levels of roles and responsibilities in leading the continuous improvement efforts, the organization builds a

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(1) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S.. Six Sigma: A goal-theoretic perspective. op.cit.P 193–203.

(2) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit.P 193–203.

(3) Henderson, K.M., Evans, J.R.., Successful implementation of Six Sigma: benchmarking general electric company benchmarking. Op.cit,P 260–281.

(4) Barney, M., 2002a. Macro, meso, micro: Six Sigma. The Industrial Organizational Psychologist 39 (4), 104–107.

(5) Gowen, R.C., Tallon, W.J., 2005. Effect of technological intensity on the relationship among Six Sigma design, electronic business, and competitive advantage: a dynamic capability model. Journal of High Technology Management Research 16, 59–87.

(6) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit.P 193–203.

(7) Snee, R.D., Hoerl, R.W., 2003. Leading Six Sigma. Prentice-Hall, Upper Saddle River, NJ.

Six Sigma role structure for quality improvement. In the Six Sigma role structure, there is a hierarchical coordination mechanism of work for quality improvement across multiple organizational levels[1] for example, the senior executives serve as champions for making the organization's strategic improvement plans and black belts under them lead Six Sigma projects and mentor green belts in problem solving[2][3]. This mechanism helps to coordinate and control work across organizational levels to ensure that the tactical tasks match with the overall business strategy[4].

3.8 Six Sigma structured improvement procedure:

Six Sigma applies a structured approach to managing improvement activities, which is represented by Define–Measure–Analyze–Improve–Control (DMAIC) used in process improvement or Define–Measure–Analyze–Design–Verify (DMADV) used in product/ service design improvement[5].The Six Sigma structured improvement procedures provide teams a methodological framework to guide them in the conduct of improvement projects[6][7]. Extensive use of the Six Sigma structured procedures and the associated tools and techniques in quality improvement projects is shown to facilitate the teams in learning and knowledge acquisition[8][1].

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(1) Sinha, K.K., Van de Ven, A.H., Designing work within and between organizations. op.cit.389–408.

(2) Barney, M., 2002a. Macro, meso, micro: Six Sigma. op.cit, P 104–107.

(3) Sinha, K.K., Van de Ven, A.H.., Designing work within and between organizations. op.cit P 389–408.

(4) Sinha, K.K., Van de Ven, A.H.., Designing work within and between organizations. op.cit P 389–408.

(5) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S.. Six Sigma: A goal-theoretic perspective. op.cit. P 193–203.

(6) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. The Six Sigma way: op.cit.

(7) Pyzdek, T. The Six Sigma project planner. op.cit.

(8) Choo, A.S., Linderman, K.W., Schroeder, R.G., Method and context perspectives on learning and knowledge creation in quality management. op.cit.P 918–931.

3.9 Six Sigma focus on metrics:

Six Sigma emphasizes using a variety of quantitative metrics in continuous improvement, such as process Sigma measurements, critical-to-quality metrics, defect measures, and 10* improvement measures as well as traditional quality measures like process capability[2][3][4][5]. Six Sigma metrics are used to set improvement goals[6][7]. Using objective data should reduce corporate use of political agendas to drive solutions[8]. As suggested by Linderman et al.[9]using explicit, challenging goals in Six Sigma projects can increase the magnitude of improvements; reduce performance variability of the projects, and increase employees' improvement efforts and commitment to quality. Moreover, Six Sigma integrates business-level performance, process measures, and project metrics into a systematic review process so that managers can manage the organization quantitatively and translate the business strategy into tactical tasks[10].

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(1) Choo, A.S., Linderman, K.W., Schroeder, R.G., 2007b. Method and psychological effects on learning behaviors and knowledge creation in quality improvement projects. Management Science 53 (3), 437–450.

(2) Breyfogle III, F. W. (2003). Implementing Six Sigma: Smarter solutions using statistical methods, (2nd Ed.) New York, Wiley.

(3) Dasgupta, T. Using the Six-Sigma metric to measure and improve the performance of a supply chain. op.cit. p 355–366.

(4) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. S. Six Sigma: A goal-theoretic perspective. op.cit. p193–203.

(5) Pyzdek, T.. The Six Sigma project planner. op.cit.

(6) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. Six Sigma: A goal-theoretic perspective. op.cit.p 193–203.

(7) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. The Six Sigma way: op.cit.

(8) Brewer, P.C., 2004. Six Sigma helps a company create a culture of accountability . Journal of Organizational Excellence 23 (3), 45–59.

(9) Linderman, K., Schroeder, R. G., Zaheer, S., & Choo, A. Six Sigma: A goal-theoretic perspective. op.cit.p 193–203.

(10) Barney, M., 2002a. Macro, meso, micro: Six Sigma. The Industrial Organizational Psychologist 39 (4), 104–107.

Also there are other tools :[1]

5 Whys
Analysis of variance
ANOVA Gage R&R
Axiomatic design
Apollo Root Cause Analysis ARCA
Business process mapping
Catapult exercise on variability
Cause & effects diagram (also known as fishbone or Ishikawa diagram)
Chi-square test of independence and
Control chart
Correlation
Cost-benefit analysis
CTQ tree
Customer survey through use of Enterprise Feedback Management (EFM) systems Design of experiments
Failure mode and effects analysis
General linear model
Histograms
Homogeneity of variance
Pareto chart
Pick chart
Process capability
Regression analysis
Run charts
SIPOC analysis (Suppliers, Inputs, Process, Outputs, Customers)
Stratification
Taguchi methods
Thought process map

(1) Park, H., Sung., Six Sigma for quality and productivity promotion, op.cit.P 74-87.

3.10 Six Sigma and Other Management Initiatives

3.10.1 Quality Cost and Six Sigma

Quality costs are the costs incurred for quality management. Quality costs consist of three major categories: prevention, appraisal, and failure. In addition, the area of failure cost is typically broken up into two subcategories: internal failure and external failure[(1)].

Prevention costs are devoted to keeping defects from occurring in the first place. They include quality training, quality planning and vendor surveys. Appraisal costs are associated with efforts such as quality audits, testing, and inspection to maintain quality levels by means of formal evaluations of quality systems. Failure costs refer to after-the-fact efforts devoted to products that do not meet specifications or that fail to meet customers' expectations[(2)].

3.10.2 TQM and Six Sigma:

Discriminating Six Sigma from TQM has been widely debated. Some would argue that Six Sigma is the latest banner of TQM[(3)]. Others claim that Six Sigma is something new[(4)]. Another important difference between Six Sigma and TQM is that Six Sigma is mostly a business results oriented model compared to a return on investment orientation of TQM[(5)].For manufacturing companies the direct benefit of Six Sigma, results from the reduction in the number of defects due to improved manufacturing processes.

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(1) Feigenbaum (1961) Total Quality Control.
(2) Park H Sung. Six Sigma for quality and productivity promotion, op.cit.P 122
(3) McManus, K., 1999. Is quality dead? IIE Solutions 31 (7), 32–35.
(4) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. The Six Sigma way: op.cit.
(5) Bertels, T. (Ed.), 2003. Rath and Strong's Six Sigma Leadership Handbook. op.cit.

The focus on financial and business results is to some extent unique. Deming[1] warned against focusing on results and instead preferred a process focus. On the other hand, the Baldrige Award and related quality awards around the world have focused extensively on results[2].

The difference is that Six Sigma usually requires financial returns from most projects and from each full-time Six Sigma specialist. Thus the financial focus is at the project level, in contrast to being on the organizational level in TQM and the Baldrige award. In addition, results are tracked on a pre-project and post-project audit basis by the financial organization. This aggressive insistence on a financial return from improvement projects is new to most organizations. However, Six Sigma recognizes that not all projects produce short term financial returns; therefore, projects with purely strategic value may also be undertaken[3].

While TQM is oriented to the final result of a process, Six Sigma aims at preventing errors, reducing the variability of the processes; TQM mostly provides broad guide lines for quality management, while Six Sigma commends precise applicative methodologies (DMAIC for existing processes and DFSS for new ones) and focuses its attention on numeric certification of improvements and associated savings in Six Sigma[4].

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(1) Deming, W.E., 1986. Out of Crisis. MIT Center for Advanced Engineering Study, Cambridge, MA.

(2) National Institute of Standards and Technology, 2006. Malcolm Baldrige National Quality Award: 2006 Criteria for Performance Excellence. National Institute of Standards and Technology of the United States Department of Commerce, Gaithersburg, MD.

(3) Pande, P. S., Neumann, R. P., & Cavanugh, R. R. (2000). The Six Sigma way: How GE, Motorola, and other op companies are honing their performance. New York: McGraw-Hill.

(4) Park H Sung,2003.Six Sigma for quality and productivity promotion, op.cit.

3.10.3 ISO series and Six Sigma:

ISO (International Organization for Standardization) 9000 series standards were first published in 1987, revised in 1994, and re-revised in 2000 by the ISO. The 2000 revision, denote by ISO 9000:2000, has attracted broad expectations in industry. As of the year 2001, more than 300,000 organizations worldwide have been certified to the ISO 9000 series standards(1).

Both Six Sigma and Self-Assessment (ISO) can be traced back to Walter A. Shewhart and his work on variation and continuous improvement in the 1920s.It was Japanese industry that pioneered a broad application of these ideas from the 1950s through to the 1970s. When variation and continuous improvement caught the attention of some of the American business leaders in the late 1980s, it took the form of the Malcolm Baldrige National Quality Award, on national level, and of Six Sigma at Motorola(2).

Standards do not represent a significant change to this perspective. Six Sigma on the other hand, aims at world-class performance, based on a pragmatic framework for continuous improvement.

3.10.4 Lean Manufacturing and Six Sigma:

3.10.4.1 Lean and Six Sigma are promoted as different approaches and different thought processes.

Yet, upon close inspection, both approaches attack the same enemy and behave like two links within a chain – that is, they are dependent on each other for success. They both battle variation, but from two different points of view. The integration of Lean and Six Sigma takes two powerful problem-solving techniques and bundles them into a powerful package. The two approaches should be viewed as complements to each other rather than

(1) Park H Sung,2003.Six Sigma for quality and productivity promotion, op.cit.P 128-129.

(2) http://www.articledashboard.com.kelvin keegan www.iso9001store.com

as equal-*Six Sigma and Other Management Initiatives* Lents of or replacements for each other[1]. In practice, manufacturers that have widely adopted lean practices record performance metrics superior to those achieved by plants that have not adopted lean practices. Those practices cited as lean in a recent industrial survey[2].

3.10.4.2 Differences between Lean and Six Sigma:

There are some differences between Lean and Six Sigma as noted below.

• Lean focuses on improving manufacturing operations in variation, quality, and productivity. However, Six Sigma focuses not only on manufacturing operations, but also on all possible processes including R&D and service areas.

• Generally speaking, a Lean approach attacks variation differently than a Six Sigma system does[3]. The implementation of quality management programs (such as lean or the Baldrige model) provides organizations with the ability to more systematically focus on Organizational processes so that they can effectively implement total quality philosophy[4].

3.10.5 National Quality Awards and Six Sigma

A comparison between the national quality award and the Six Sigma program conducted by Prezkop[5] shows that the core emphases of both are similar. For example, similarities are evident in the procedure focusing,

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(1) Pyzdek, T. (2003). The Six Sigma project planner. op.cit.

(2) Jusko, J. (1999). A Look at Lean, Industrial Week, December 6.

(3) Denecke, J. (1998). 6 Sigma and Lean Synergy, Allied Signal Black Belt Symposium, AlliedSignal Inc., pp.1-16.

(4) Dahlgaard, J.J., Dahlgaard-Park, S.M.., Lean production, Six Sigma quality, TQM and company culture. op cit, p 263–281.

(5) Prezkop, P. (2006). *Six Sigma for Business excellence*. New York: McGraw-Hill.

customer focusing, cooperation, data, driven management, and the strategic planning. Therefore, the quality award criteria are also logically exacting for the project selection criteria of a successful Six Sigma program. The project selection is a priori for the implementation of a Six Sigma program. In fact, the project selection for Six Sigma program is often the most important and difficult part[1].

3.11 Obstacles, and Limitations of Six Sigma:

The research deals with the possibility of using Six Sigma In achieving the required quality for the internal or external client, where the thought of Six Sigma Begins and ends at the customer's requirements and thus can be accessed so as to achieve zero defect quality in the institution for the customer requirements in their own time and at the right price and quality required.

3.11.1 Obstacles & limitations:

After 24 years of implementing Six Sigma in the world there is some researchers have some limitations:

Not surprising that many implementations of Six Sigma programs have failed. Survey of aerospace companies concluded that less than 50% of the respondents were satisfied with their Six Sigma programs[2]. Another survey of healthcare companies revealed that 54% do not intend to embrace Six Sigma programs[3]. Companies such as 3M and Home Depot were not

(1) Pande, S; Rpert, P ; Roland ,R, (2002).The Six Sigma Way, op.cit

(2) Zimmerman, J.P., Weiss, J., 2005. Six Sigma's Seven Deadly Sins. Quality 44 (1), 62-66

(3) Feng, Q., Manuel, C.M., 2007 under the Knife: a National Survey of Six Sigma Programs in U.S. Healthcare Organizations. *International Journal of Health Care Quality Assurance*, 21(6), 535-547, 2008.

satisfied with their implementation of Six Sigma programs[1][2]. Considering this, many authors question the return on investment of Six Sigma programs[3].

The real question is not whether Six Sigma programs have value, but why do so many Six Sigma programs fail?

One reason many Six Sigma programs fail is because we lack a model on how to effectively guide the implementation of these programs[4].

Second, improvement specialists are trained or hired at different Six Sigma competency levels (e.g.; Black Belt or Green Belt). Their primary responsibility is to provide technical expertise and leadership in facilitating a specific Six Sigma implementation[5].

Third, as Keller[6] points out, Six Sigma programs have performance metrics and measurements based on cost, quality, and schedules.

The March 2003 issue of quality digests magazines[7]:

"*Explored the results of their Six Sigma survey: what did they discover?*

(1) Hindo, B. (2007, June 11). At 3M, a struggle between efficiency and creativity. Business Week. Retrieved September 3, 2007, from http://www.businessweek.com_24/8406.htm?chan=gl.
(2) Hindo B. & Grow B., (2007). Six Sigma: So yesterday?, Business Week, June 11, 2007, p. IN 11.
(3) Gupta, P., 2008. Reducing the cost of failures. Quality Digest 47 (1),22.
(4) Wurtzel, M., 2008. Reasons for Six Sigma deployment failures. BPM Institute
(5) Pyzdek, T. (2003). The Six Sigma handbook: A complete guide for green belts black belts and managers at all levels. New York: McGraw-Hill.
(6) Keller, P.A. Six Sigma Deployment: A guide For Implementing Six Sigma in Your Organization. op cit.
(7) The March 2003 issue of quality digests magazines.

1- Small companies aren't pursuing Six Sigma. It costs too much using the traditional Six Sigma. It can cost 250,000 $ to train black belt and bring them up to speed.

2- Companies pursuing Six Sigma seem to aband on it after two or three years. One reason might be that average lifespan of CEO is only 2-3 years.

3- Six Sigma is under performing the media hype:-

a- Only 64% of respondents agreed that Six Sigma had significantly improved profitability.

b- Only 50% agreed that Six Sigma had improved customers satisfaction.

c- Only 43% agreed that Six Sigma had improved job satisfaction among employees.

4- You don't need black belts to get results.

1. 80% agreed that you should use whatever tools are necessary to get job done.

2. 87% use cause effect analysis (line pare to fishbone).

3. 35% process mapping (flowcharts).

4. 26% lean manufacturing.

5. *25% benchmarking*.

6. *20% statically process control and process management (flowcharts control charts and histograms).*

7. *21% use 1SO 9000 standards"* [1].

"*There are factors that can be disadvantages for implementing Six Sigma in a small business rather than a large business, such as lack of resources and expertise in change initiative, there are also characteristics inherent in small business that can speed up the effective implementation of Six Sigma more than in large business,*

(1) The March 2003 issue of quality digests magazines.

such as flexible process flows a short decision-making chain, and higher visibility of senior management.

Small businesses do have constraints that limit their ability to initiate a large scale Six Sigma implementation. However, there are ways to overcome these limitations. Small Business doesn't have large reserves of excess cash to earmark for the massive training programs employed by the large corporations in implementing Six Sigma programs.

Small Business generally can't afford to have full-time Master Black Belts on stuff and may not have the personal with the skills and expertise to step into the role of Black Belts without extensive training"(1)

"*The following are some limitations of Six Sigma which creates opportunities for future research:*

1- The challenge of having quality data available especially in process where no data is available.

2- The right selection and prioritization of projects is one of the critical success factors of Six Sigma program. The prioritization of projects in many organizations is still based on pure subjective judgment very few powerful tools are available for prioritizing projects.

3- The statistical definition of Six Sigma is 3.4 defects or failures per million opportunities. In service processes, a defect may define as anything which does not meet customers' needs or expectations.

4- Assumption of 1.5 sigma shift for all business processes does not make much sense."(2)

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(1)PaulKeller www.qualtyamerica.com/knowledgecente/articles/paksmallcompanyss.htm.

(2) Paul Keller. op.cit

3.12 King Abdullah II Center for Excellence :[1][2]

The (KACE) for the private sector was established in 1999 as the highest level of quality and excellence recognition in Jordan. It aims at enhancing the competitiveness of Jordanian businesses by promoting quality awareness and performance excellence, as well as recognizing quality and business achievements of Jordanian organizations. The Award also aims at sharing the experiences and success stories of participating organizations.

3.12.1 The Award Categories[3]

The Award is granted to one or more winning organizations in each of the following categories:

Large manufacturing organizations or their sub-units (number of workers 250 or more and registered capital of JOD 30,000 or more).

Large service organizations or their sub-units (number of workers 250 or more and registered capital of JOD 30,000 or more).

- Small and medium size manufacturing organizations (number of workers 249 or less and registered capital of JOD 30,000 or less).
- Small and medium size service organizations (number of workers 249 or less and registered capital of JOD 30,000 or less).
- Agriculture and agricultural marketing organizations.
- The winning organization for two cycles or more·

3.12.2 The Award Criteria

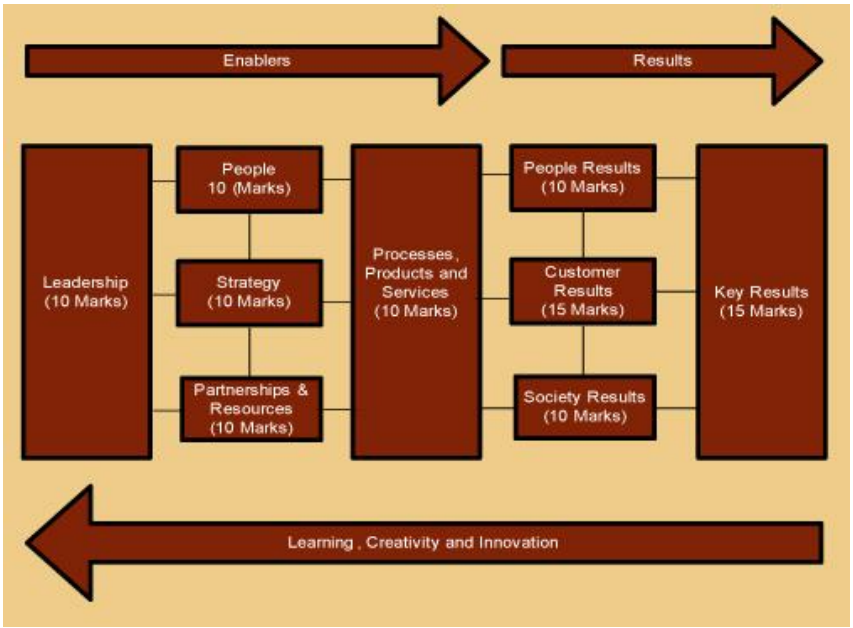
The Award is based on nine criteria

(1) http://www.kaaps.jo/programs-and-training.
(2) http://www.kaaps.jo/fundamental-concepts-excellence
(3) for more details you can visit http://www.kaaps.jo/programs-and-training.

1. Leadership
2. Strategy
3. People
4. Partnerships & Resources
5. Processes, Products and Services
6. Customer Results
7. People Results
8. Society Results
9. Key Results

3.12.3 The King Abdullah II Award for Excellence (KAAE) for Private Sector criteria[1]

The (KAAE) for Private Sector criteria were developed according to the EFQM Excellence Model (2010) which is based on the new Eight Fundamental Concepts of Excellence.



(1) for more details you can visit http://www.kaaps.jo/programs-and-training.

Chapter Four
Data analysis and results

4.1 Analysis of data:

This chapter presents the analysis of the data gathered from the field-work, which tested the level of implementation of Six Sigma in the Jordanian business organizations awarded the (KAAE) in the industrial and service sectors. It also explains the statistical analysis performed on the data gathered from the sample study, through analyzing the answers in the valid questionnaires, summarizing data, analyzing the questionnaire components, and ending up with testing the questions.

4.2 Statistical Methods:

The Statistical Package for Social Sciences (SPSS) was used in the authoring, deployment, and testing the of the study, besides other statistical methods, e.g.:

- Cronbach's Alpha to assess the reliability of the questionnaire answers.
- Descriptive statistics to identify the sample study characteristics and prioritizing based on the percentage and variance.
- One sample T–test.

The questionnaire tool that was used in this study comprised of 5 main sections. The first section tackles factors which include:

A. Respondent's Characteristics:

- Gender.
- Current position.
- Level of education.
- Years of experience.

B. Organizations' Characteristics:

- Ownership structure.
- Business Job.
- Certifications.
- Export %.

Section two was then measured through the following Likert Scale:

5= strongly Agree 4= Agree 3= Modulate agree 2= Disagree 1= strongly Disagree

In specific, section two discussed the Six Sigma

1. *Role structure factor* that includes questions [A1 throughout A6].
2. *Structured improvement procedure factor* of Six Sigma which was addressed throughout [B1 through B6] in the questionnaire.
3. *Focus on matrices factor* in the course of Six Sigma [C1 – C13] of the questionnaire, and it was developed through measuring the mean value of the related questions of this section.

Finally, section three of the questionnaire was developed to measure the research's two open end questions.

4.3 Research methods:

As previously mentioned, the organizations awarded (KAAE) was inspected by international organization for the implementation of nine bases of the award criteria (mentioned in chapter 3). Accordingly, the

researcher based the questionnaire on the remaining basis of the Six Sigma to measure the level of implementation, which differentiates the Six Sigma from other quality standards.

The initial questioner draft has been reviewed by four scholars from Al al-Bayt University in management and strategic management for stability and consistency.

The main limitation of the analysis was that the researcher assumed (if there is an implementation of six sigma, the mean will not be less than (<3.5) and this assumption was used as a cornerstone to all of the analysis.

One reason for this assumption is the respondents had a misunderstanding of the quality terminologies used in different methodologies (TQM, ISO series, Lean Productions …). This resulted in unreasonable answers, e.g. the respondents didn't know the Black Belt terminology, but some of the answers were in contradiction of such response, which resulted in misleading the overall answers. Misleading didn't affect the overall analysis.

4.4 Reliability of the factors:

Reliability of the factors of Six Sigma using (Cronbach's Alpha) for internal consistency.

Table 4.1 ~ Output of Frequency Analysis of the Cronbach's Alpha

	Six Sigma	No. of Items	Cronbach's Alpha
A	Six Sigma role structure	6	0.91
B	six structured improvement procedure	6	0.91

C	Six Sigma focus on metrics	13	0.912
	Six Sigma implementation **total**	25	0.906

The Cronbach's Alpha is provided in table (4.1) indicates a high internal consistency for each factor of Six Sigma. Noticeably the Cronbach's Alpha value for Six Sigma role structure was (0.91), six structured improvement procedure was (0.91), Six Sigma focus on metrics was (0.912), and the factors as a whole was (0.906). Obviously, all the values exceeded the most critical values (0.60)[1] to determine the good internal consistency (hence concluding good reliability).

4.5 Descriptive demographic characteristics

This section aims to analyze the selected sample's demographic characteristics. The following statistics were noticed from the analysis:

Table 4.2 describing the sample through respondents' profiles

variable	category	count	%
gender	Male	35	67.3
	Female	17	32.7
	Total	52	100
Current position	Department head	6	11.5
	General Manager	19	36.5
	Deputy General Manager	25	48.1
	Others	2	3.9
	Total	52	100
education	High school	0	0
	Diploma	9	17.3
	BA	24	46.2

(1) Uma Sekran, Research méthodes of business,3rd Edition, Jon Willy & Sons,2000

	Master Degree	19	36.5
	Others	0	0
	Total	52	100
Number of years in the company / service experience	1 – 5 years	8	15.4
	6 – 10 years	23	44.2
	11 – 15 years	8	15.4
	More than 16 years	13	25.0
	Total	52	100

Table 4.2 shows that 32.7% of sample responses were received from females while 67.3% from males.

It is noticed that 48.1% of the respondents were of companies' GM assistant positions; 36.5% of general managers' position; 11.5% were heads of departments position, and 3.8% were from other positions within the organizations.

Table apparently reflects that the sample professionals within all organizations include 46.2% of Bachelors degree, 46.2% of Master degree, and 17.3% Diploma. None of them held less, which also reflects the importance of the academic and personal development of organizations.

With regards to years of experience, it is evident that most of the responses received were from employees that have been in their respective companies for 6-10 years, with the percentage of 44.2%, compared with 15.4% of those working for less than a year. Also, 15.4% have been working from 11-15 years, and 25.0% who have been working for more than 16 years.

Table (4.3) Describing the sample through organizations' profiles

Variable	Category	Count	%

Ownership structure	Sole Proprietorship	3	5.8
	Partnership	23	44.2
	Limited liability	3	5.8
	Public limited company	3	5.8
	Others	20	38.4
	Total	52	100
Business job	Electromechanical	1	1.9
	Food	1	1.9
	Mining	2	3.8
	Construction	13	25.0
	Service	18	34.6
	Others	17	32.7
	Total	52	100
Certification	ISO	27	51.9
	HACCP	7	13.5
	King Abdullah Excellence	52	100
	Others	0	0
	Total	52	100
% export	1 – 20 %	7	13.5
	21 – 40 %	10	19.2
	41 – 60 %	16	30.8
	More than 60 %	19	36.5
	Total	52	100

As for the equity, it was noticed that 44.2% of the respondents were partnership, 5.8% were sole proprietorship, limited liability, and public limited company/service, and 38.5% were others.

Table 4.3 shows to nature of respondents' jobs, 34.6% working in services, 25% in construction, 3.8% in mining, 1.9% in electromechanical and food, while 34.6% in different fields.

This table shows that 52.9% of the respondents have ISO series certificate, and 13.5% have HACCP certificates, 100% have been awarded the (KAAE), which supports the target study sample that all of them were awarded the (KAAE).

The last demographic characteristic, shows the percent of respondent's export, which shows that 36.5% of the organizations were exporting more than 60% their products or services, 30.8% exporting between 41-60%, 19.2% exporting between 21-40% and 13.5% were exporting between 1-20%. This concludes that if 19.2% exported 21-40% and 13.5% exported between 1-20%, the conclusion is that if those are interested in the export market, then they must be interested in quality certification.

Since the implementation of the Six Sigma is very low in Jordan, the researcher assumed that the demographic factors in regards to age, experience, positions, ownership structure…etc have no impact on the research results.

Table (4.4) Mean and Standard Deviation and the order of each item in the Six Sigma role structure

Rank	Item	Mean	Sd.	Implement Degree	Order
A1	Our plant/service uses differentiated training so that employees who have different roles in the black/green belt role structure (or equivalent structure) can obtain the	2.83	1.72	Low	2

	necessary knowledge and skills to fulfill their job responsibilities.				
A2	We use a black/green belt role structure (or equivalent structure) to prepare and deploy individual employees for continuous improvement programs.	2.83	1.72	Low	2

A3	The black/green belt role structure (or equivalent structure) helps our plant/ service to recognize the depth of employees' training and experience.	2.79	1.68	Low	4
A4	We employ a black/green belt role structure (or equivalent structure) for continuous improvement.	2.48	1.23	Low	6
A5	In our plant/service, members of a quality improvement team have their roles and responsibilities specifically identified.	3.00	1.67	Low	1
A6	In our plant/service, an employee's role in the black/green structure (or equivalent structure) is considered when making compensation and promotion decisions.	2.69	1.72	Low	5
	Six Sigma role structure	**2.77**	**1.36**	**Low**	

The Mean in table (4.4) suggests that the item "A5" which states "In our plant/service, members of a quality improvement team have their roles and responsibilities specifically identified." have ranked the first order by a Mean of (2.83). This Mean expresses a low degree of implementation (< 3.5), while the item "A4" which states "We employ a black/green belt role structure (or equivalent structure) for continuous improvement" has ranked

the last order by a Mean of (2.48), which expresses a low degree of implementation.

The Six Sigma role structure Mean was (2.77) expressing a low degree of implementation (<3.5). Items A1 and A6 were specific and targeted common quality practices, accordingly the answers were higher on the Mean scale comparing to ranks A2, A3, A4, and A5, which were specific to the Six Sigma programs.

Respondents have to be familiar with the implementation of Six Sigma to answer items A2, A3, A4, and A5, which led the researcher to predict the analysis to be less than 2 on Likert scale for the Mean, but the result of the analysis was higher than expected due to the misleading mentioned above.

Table (4.5) Mean and SD and the order of each item in the six structured improvement procedure

Rank	Item	Mean	Sd.	Implement degree	Order
B1	All improvement projects are reviewed regularly during the process.	2.58	1.58	Low	2
B2	In our plant/service, continuous improvement projects are conducted by following a formalized procedure (such as DMAIC—Define, Measure, Analyze, Improve and Control).	1.87	0.91	Low	6
B3	In our plant/service, the product /service design process follows a formalized procedure.	2.02	1.13	Low	5
B4	We have a formal planning process to decide the major quality improvement projects.	2.17	1.17	Low	4
B5	We use a structured approach to manage quality improvement activities.	2.33	1.23	Low	3
B6	We keep records about how each continuous improvement project is conducted.	2.69	1.38	Low	1
	six structured improvement procedure	**2.28**	**1.04**	**Low**	

The Mean in table (4.5) suggests that the item "B6" which states “We keep records about how each continuous improvement project is conducted" has ranked the first order by a Mean of (2.69). This Mean expresses a low degree of implementation (<3.5) while the item "B2" which states “Projects are conducted by following a formalized procedure (such as DMAIC—Define, Measure, Analyze, Improve and Control).” has ranked the last order by a mean of (1.87) which expresses a low degree of implementation.

The six structured improvement procedure Mean was (2.28) expressing a low degree of implementation (<3.5).

As mentioned before, the respondents' drawback was related to the lack of differentiating between the quality terms and systems in Jordan (TQM, ISO, Lean, Low Cost Leadership, King Abdullah II for Excellence, etc). The respondents assume they have the best procedure and the best quality system that can be implemented without considering any benchmarking (ROI, Revenues, Sales Size, Export Markets, Six Sigma Level...). The Jordanian organizations need an internationally accredited institution focusing on metrics to determine the organization quality level, in order to compare Jordanian organization with others inside and outside Jordan.

Table (4.6) Mean and SD and the order of each item in the Six Sigma focus on metrics

Rank	Item	Mean	Sd.	Implement degree	Order
C1	Our plant/service sets strategic goals for quality improvement in order to improve service’s financial performance.	3.08	1.48	Low	3

C2	Our plant/service has a comprehensive goal-setting process for quality.	2.96	1.37	Low	7
C3	Quality goals are clearly communicated to employees in our plant.	2.83	1.12	Low	11
C4	In our plant/service, quality goals are challenging.	2.77	1.41	Low	12
C5	Our plant/service systematically uses a set of measures (such as defects per million opportunities, sigma level, process capability indices, defects per unit, and Yield) to evaluate process improvements.	2.75	1.37	Low	13
C6	Our plant/service translates customers' needs and expectation into quality goals.	2.88	1.35	Low	10
C7	We make an effort to determine the appropriate measures for each quality improvement project.	3.04	1.25	Low	6
C8	In our plant/service, measures for quality performance are connected with the plant/service service's strategic quality goals.	3.06	1.14	Low	5
C9	The expected financial benefits of a quality improvement project are identified during the project planning phase.	3.27	1.22	Low	2

C10	Financial performance (e.g., cost savings, sales) is part of the criteria for evaluating the outcomes of quality improvements in our plant/service.	3.08	1.31	Low	3
C11	The measures for quality performance are connected with critical-to-quality (CTQ) characteristics.	2.96	1.24	Low	7
C12	We assess the performance of core processes against customers' requirements.	3.31	1.29	Low	1
C13	In our plant/service, quality goals are clear and specific.	2.96	1.63	Low	7
	Six Sigma focus on metrics	**3.00**	**0.93**	**Low**	

The Mean in table (4.6) suggests that the item "C12" which states "We assess the performance of core processes against customers' requirements" has ranked the first order by a Mean of (3.31). This Mean expresses a low degree of implementation (<3.5) while the item "C5" which states "Our plant/service systematically uses a set of measures (such as defects per million opportunities, sigma level, process capability indices, defects per unit, and Yield) to evaluate process improvements" has ranked the last order by a Mean of (2.75) which expresses a low degree of implementation.

The Six Sigma focus on metrics Mean was (3.00) expressing a low degree of implementation (<3.5).

4.6.1 Inferential Statistical Analysis

Main question:

Q_1: Do the organizations that have been awarded the (KAAE) have implemented Six Sigma (role structure, structured improvement procedure, and focus on metrics) as a comprehensive program significantly **($\alpha \geq 0.05$)?**

Testing the question

1. Testing the main question

One sample T-Test with a reference value of (3.5) was used to test this question; the results are included in table (4.7).

To answer the above question, the researcher used all the data in the subsidiary questions in the clarification:

Table 4.7 ~ one sample T-Test for the main question dose Six Sigma implemented as a comprehensive program significantly?

Variable	mean	St.dv	t-test	df	Sig*	result
Six Sigma implementation	2.77	0.77	6.83	51	0.000	**accept**

The implementation of Six Sigma was assessed by a Mean of (2.77) by the sample, this Mean was compared to a reference value of (3.5) representing the Mean used as a categorizing point for low implementation (below 3.5) and high implementation (above 3.5). The Six Sigma implementation Mean equals (3.5) suggesting low implementation, and the significance level (0.000) aligned with the T value was less than 0.05 suggesting statistical differences of between the Six Sigma implementation Mean and the reference value, as a result the alternative (study) question was accepted and the result of implementation the Six Sigma as a comprehensive program is rejected.

2. Testing the first subsidiary question

Subsidiary Question 11

Q_{11}: Do the organizations that have been awarded the (KAAE) have implemented six sigma role structure significantly **($\alpha \geq 0.05$)?**

One sample T-Test with a reference value of (3.5) was used to test this question; results are included in table (4.8)

Table 4.8 ~ one sample T-Test for the subsidiary question does Six Sigma role structure implemented significantly?

variable	mean	St.dv	t-test	df	Sig*	result
Six Sigma role structure	2.77	1.36	3.88	51	0.000	**accept**

The implementation of role structure was assessed by a Mean of (2.77) by the sample. This Mean was compared to a reference value of (3.5) representing the minimum Mean used as a categorizing point for low implementation (below 3.5) and high implementation (above 3.5). The role structure Mean was less than (3.5), suggesting low implementation. The significance level (0.000) aligned with the T value was less than 0.05, suggesting statistical differences between the role structure Mean and the reference value. As a result, the alternative (study) question was accepted, and the result of implementation Six Sigma role structure is rejected.

Subsidiary Question 12

Q_{12}: Does the organizations that have been awarded the (KAAE) have implemented the Six Sigma (structured improvement procedure) significantly **($\alpha \geq 0.05$)?**

One sample T-Test with a reference value of (3.5) was used to test this question; results are included in table (4.9).

Table 4.9 ~ one sample T-Test for the subsidiary question does Six Sigma structured improvement procedure implemented significantly?

variable	Mean	St.dv	t-test	df	Sig*	result
Six Sigma structured improvement procedure	2.28	1.04	8.50	51	0.000	**accept**

The implementation of structured improvement procedure was assessed by a Mean of (2.28) by the sample. This Mean was compared to a reference value of (3.5) representing the Mean used as a categorizing point for low implementation (below 3.5) and high implementation (above 3.5). The structured improvement procedure Mean was less than 3, suggesting low implementation. The significance level (0.000), aligned with the T value was less than 0.05, suggesting statistical differences between the structured improvement procedure Mean and the reference value. As a result, the alternative (study) question was accepted, and the conclusion of implementing the structured improvement procedure is rejected.

Subsidiary Question 13

Q13: Does the organizations that have been awarded the (KAAE) have implemented the Six Sigma (focus on metrics) significantly **($\alpha \geq 0.05$)?**

One sample T-Test with a reference value of (3.5) was used to test this question; results are included in table (4.10).

Table 4.10 ~ one sample T-Test for the subsidiary question focuses on metrics significantly?

Variable	Mean	St.dv	t-test	df	Sig*	result
Six Sigma focus on metrics	3.00	0.93	3.92	51	0.000	**accept**

The implementation of focus on metrics was assessed by a Mean of (3.00) by the sample. This Mean was compared to a reference value of (3.5), representing the Mean used as a categorizing point for low implementation (below 3.5), and high implementation (above 3.5). The focus on metrics Mean equals (3.5), suggesting low implementation. The significance level (0.000) aligned with the T value was less than 0.05, suggesting statistical differences between the focus on metrics Mean and the reference value. As a result, the alternative (study) question was accepted and the result of implementing Six Sigma focus on metrics is rejected.

Two open end questions:

Q1: What are the problems encountered during the implementation stage of Six Sigma?

Q2: What is the level of sigma implanting do you have in your plant/service?

Not all the respondents have answered these questions. The majority have returned the questionnaire blank. Some respondents declared that their organizations are not implementing Six Sigma; few respondents have answered the questions (for the second question there no one answered the question) .The answers can be summarized as follows:

4.7 Organizational Obstacles:

1. There is no top management awareness to this new fad.

2. There is no model or clear vision to adopt Six Sigma.

3. There is no education or training on this program.

4. Many senior managers can't distinguish between quality terms (ISO series-Lean production –HACCP-TQC-TQM-Six Sigma-Management strategies are distinguished from each other by their underlying rationale and framework).

5. The Six Sigma implementation needs (black belt, green belt, yellow belt) holders to start implementing the system. It came to the researcher's attention that there are only some persons in Jordan who have black belt training.

Phases to implement Six Sigma include: identify Black Belt projects; create a project hopper; examine the project portfolio; and create an improvement system.

6. There is no government or private sector that encourages adopting this program, explain the benefits, determine the criteria for Six Sigma, announce and market the program, and certificate the organizations that want to implement the program.

4.8 Financial Obstacles:

1. High cost of training programs. Small companies aren't pursuing Six Sigma. High costs of using the traditional Six Sigma. It can cost $250,000 to train black belt and bring them up to speed(1).

2. Most of Jordanian companies are categorized as SMEs, compared with international companies, most of which still have the characteristics of a family-owned business. (The classifications criteria of King Abdullah II for excellence).

(1) www.qualtyamerica.com/knowledgecente/articles/paksmallcompanyss.htm

Chapter Five
Conclusions & Recommandations

5.1 Conclusions & Recommandations:

One factor that can set an organization apart from its competitors in the private or public sector in the various industries is the strategy towards quality, the implementation of which can enhance customer satisfaction, decrease costs and increase profitability.

This study revealed and statistically proved in chapter four, that there is no organization, within the target population, adopting Six Sigma as a comprehensive system. There are some practices, within the target population, of adopting without knowing their similarities to other systems.

In other words, we need to explore the possibility of overcoming the reasons and obstacles that resulted in the lack of implementation of the Six Sigma programs.

5.2 Conclusions:

In order to formulate appropriate competitive advantages from a managerial point of view, it is essential to analyze the organization's competitive strategy or business strategy and organizational practices. The organization should create a complete model of managerial structure to create a comprehensive system to avoid any mistakes in their organizations. Also, it should support a long-term strategy, build "core competencies", and develop "sensing" capabilities.

A champion is the person who will adopt the high risk and the very expensive quality program in the world (Six Sigma) undertaking the responsibility to lead his organization to the best and more profitable program, with a very short payback period.

Belt holders in every department confront daily quality issues and are responsible, not only for interactions within their own department,

but also interaction between all departments of the organization. The primary function of quality management today is to ensure the effective and efficient use of quality to accomplish an organization's goals and objectives to increase customer satisfaction.

Accordingly, it is the responsibility of black belt and green belt to ensure that all the team work will be successful to get the right system at the right time using the right statistical tools.

Small businesses do have constraints that limit their ability to initiate a large scale Six Sigma implementation. However, there are ways to overcome these limitations.

The statistical aspects of Six Sigma must complement business perspectives and challenges to the organization to implement Six Sigma projects successfully. Various approaches to Six Sigma have been applied to increase the overall performance of different business sectors. However, integrating the Six Sigma (structured, improvement, metrics) processes into organizations, still have room for improvement. Cultural changes require time and commitment before they are strongly implanted into the organization. Effective Six Sigma principles and practices are more likely to succeed by continuous review of the organizational culture.

5.3 Recommendations:

1. Establish a national institution to educate business organizations about the importance of implementing Six Sigma to encourage them to adopt this new fad.
2. Establish a national institution to measure business organizations' quality level compared with the national and international levels.
3. Financial and managerial support to the organizations working on implementing the Six Sigma by the government.
4. Include the statistical analysis practices in the different education levels, since it represents a cornerstone for Six Sigma analysis and measurement.
5. Provide Arabic references at libraries for academic and non-academic researchers to cover the Six Sigma theory and methodology.

Future Studies

1. A comparative study between Six Sigma and King Abdullah II for excellence.
2. Study the extent of Six Sigma implementation in another population in Jordan.
3. Study the extent of Six Sigma implementation in the Arab World.

Appendixes & References

The Survey

Al al-Bayt University

Finance and Business College

Date:

Company/Service Name: _____

Dear Respondent,

This survey is intended to assess the possibility of implementing the Six Sigma Program in Jordan. Six Sigma is a comprehensive system/program, which aims to reach an error percentage of 3.4 for every million unit produced. The survey will focus on the companies/service awarded the (KAAE) assuming that this company/service had implemented the Award standards.

The survey is to complete the requirements for the Master Degree in Business Administration and was designed to collect the necessary data to complete this research "Implementing Six Sigma in Jordan".

I appreciate your assistance in accurately answering the following questions considering that these answers will be used only for the research purposes.

Best regards and thanks for your time,

Nidal Awad

Part I. Profile of the Respondent:

Direction: Kindly fill up the following with the correct details about yourself. Please don't leave any item unanswered.

1. Gender:

( ) Male ( ) Female

2. Current position in the company/service:

( ) General Manager ( ) Deputy General Manager ( ) Departmental Heads specify……..

3. Education:

( ) High School ( ) Diploma ( ) BA ( ) Master Degree ( ) Other, Specify ……

4. Number of years in the company/service:

( ) 1 – 5 years ( ) 6 – 10 years ( ) 11 – 15 ( ) more than 16 years

Part II. Profile of the firms:

1. Date of Establishment…

2. Ownership Structure:

( ) Sole Proprietorship ( ) Limited Liability ( ) Public Limited Company/service ( ) Other, Specify……..

3. Number of Employees…

4. Business job:

( ) Electromechanical ( ) Food ( ) Mining ( ) Construction ( ) service ( ) Other Specify……

5. Certification:

( ) ISO (9001, 9002, 14000, 22000….) ( ) HACCP ( ) King Abdulla Excellence Certificate ( ) Other, Specify ……

Note: it could be for the organization to hold more than one certificate.

6. Percentage of export sales/service to total sales:

( ) 1 - 20% ( ) 21 - 40% ( ) 41 – 60% ( ) more than 61%

Part Two:

This part of the survey focuses on the product /service design and the implementation of Six Sigma, Kindly fill (X) with you suitable answer.

Note:

5= strongly agree **4**= agree **3**=moderately agree **2**=disagree

1= strongly disagree

A	Six Sigma role structure.	1	2	3	4	5
١	Our plant/service uses differentiated training so that employees who have different roles in the black/green belt role structure (or equivalent structure) can obtain the necessary knowledge and skills to fulfill their job responsibilities.					
٢	We use a black/green belt role structure (or equivalent structure) to prepare and deploy individual employees for continuous improvement programs.					
٣	The black/green belt role structure (or equivalent structure) helps our plant/ service to recognize the depth of employees' training and experience.					

٤	We employ a black/green belt role structure (or equivalent structure) for continuous improvement.					
٥	In our plant/service, members of a quality improvement team have their roles and responsibilities specifically identified.					
٦	In our plant/service, an employee's role in the black/green structure (or equivalent structure) is considered when making compensation and promotion decisions.					
B	Six Sigma structured improvement procedure.	1	2	3	4	5
1	All improvement projects are reviewed regularly during the process.					
٢	Projects are conducted by following a formalized procedure (such as DMAIC—Define, Measure, Analyze, Improve and Control).					
٣	In our plant/service, the product /service design process follows a formalized procedure.					
٤	We have a formal planning process to decide the major quality improvement projects.					
٥	We use a structured approach to manage quality improvement activities.					
٦	We keep records about how each continuous improvement project is conducted.					

C	Six Sigma focus on metrics.	1	2	3	4	5
١	Our plant/service sets strategic goals for quality improvement in order to improve service's financial performance.					
٢	Our plant/service has a comprehensive goal-setting process for quality.					
٣	Quality goals are clearly communicated to employees in our plant.					
٤	In our plant/service, quality goals are challenging.					
٥	Our plant/service systematically uses a set of measures (such as defects per million opportunities, sigma level, process capability indices, defects per unit, and Yield) to evaluate process improvements.					
٦	Our plant/service translates customers' needs and expectation into quality goals.					
٧	We make an effort to determine the appropriate measures for each quality improvement project.					
٨	In our plant/service, measures for quality performance are connected with the plant/service service's strategic quality goals.					
٩	The expected financial benefits of a quality improvement project are identified during the project planning phase.					

١٠	Financial performance (e.g., cost savings, sales) is part of the criteria for evaluating the outcomes of quality improvements in our plant/service.					
١١	The measures for quality performance are connected with critical-to-quality (CTQ) characteristics.					
١٢	We assess the performance of core processes against customers' requirements.					
١٣	In our plant/service, quality goals are clear and specific.					

Part Three: please answer questions?

1. What are problems you encountered during the implementation stage of Six Sigma?

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2. What's the implantation level of Six Sigma do have in your plant/service?

Thanks a lot for your time,

The Researcher

Nidal Awad

List of Acronyms:

ABB Asea Brown Boveri

ANOVA Analysis of Variance

BB Black Belt

BSC Balanced Score Card

3C Change, Customer, and Competition in quality and productivity

CEO Chief Executive Officer

CFR Critical Functional Response

CL Center Line

COPQ Cost of Poor Quality

Cp, Cpk Process Capability Index

CPL Lower Capability Index

CPM Critical Parameter Method

CPT Color Picture Tube

CPU Upper Capability Index

CRM Customer Relationship Management

CST Critical Success Theme

CSUE Creating & Capturing, Storing & Sharing, Utilization, and Evaluation.

CTC Critical-to-customer

CTQ Critical-to-quality

DBMS Data Base Management System

DFM Design for Manufacturability

DFR Design for Reliability

DFSS Design for Six Sigma

DIDES Define-Initiate-Design-Execute-Sustain

DMADV Define-Measure-Analyze-Design-Verify

DMAIC Define-Measure-Analyze-Improve-Control

DMARIC Define-Measure-Analyze-Redesign-Implement-Control

DOE Design of Experiments

DPMO Defects per Million Opportunities

DPO Defects per Opportunity

DPU Defects per Unit

DR Design Review

DT Data Technology

EPA European Productivity Agency

ERP Enterprise Resources Planning

FMEA Failure Modes and Effects Analysis

GB Green Belt

GE General Electric

IDOV Identify-Design-Optimize-Validate

ISO International Organization for Standardization

IT Information Technology

JIT Just-in-time

KAAE King Abdullah II Award for Excellence

KBSS Knowledge Based Six Sigma

KM Knowledge Management

KPIV Key Process Input Variable

KPOV Key Process Output Variable

LCL Lower Control Limit

LGE-DA the Digital Appliance Company of LG Electronics

LSL Lower Specification Limit

MAIC Measure-Analyze-Improve-Control

MBB Master Black Belt

MBNQA Malcolm Baldrige National Quality Award

MRP Material Requirement Planning

MSA Measurement System Analysis

PDM Product Data Management

PI Process Innovation

Ppm Parts per million

QC Quality Control

QFD Quality Function Deployment

R&D Research and Development

RPN Risk Priority Number

RSS Root Sum of Squares

RTY Rolled Throughput Yield

4S Systematic, Scientific, Statistical, and Smarter

SCM Supply Chain Management

SPC Statistical Process Control

SQC Statistical Quality Control

TPC Total Productivity Control

TPM Total Productive Maintenance

TQC Total Quality Control

TQM Total Quality Management

TSS Transactional Six Sigma

UCL Upper Control Limit

USL Upper Specification Limit

VOC Voice of Customer

WB White Belt

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Abstract in Arabic

الملخص بالعربية

مدى تطبيق ستة سيجما في المنظمات الحائزة على جائزة الملك عبد الله الثاني للتميز في الاردن

الباحث: نضال رشيد عوض

المشرف: الدكتور بهجت عيد جوازنة

تهدف الدراسة إلى معرفة مدى تطبيق برنامج (ستة سيجما) في الأردن وما مستوى هذا التطبيق، وذلك في منظمات الأعمال الخاصة التي حازت على جائزة الملك عبد الله للتميّز، بوصف هذه المنظمات قد حازت على أرفع جائزة في الدولة الأردنية للتميّز، باعتبار هذا المجتمع يعد الافضل في مجال تطبيق الجودة في الاردن وتم تقييم ومنح الاعتمادية لهذا المجتمع من قبل مركز الملك عبد الله الثاني للتميّز.

تكونت عينة الدراسة من ١٠٥ استبانة، تم توزيعها بواقع خمس استبانات لكل منظمة خاصة حازت على جائزة الملك عبد الله للتميّز، وقد تم تصميم استبانة الدراسة من قبل الباحث والتي ارتكزت على ثلاثة أبعاد وسؤالين من النوع المفتوح ، استطاعت الدراسة من خلالها البحث في مدى وجود تطبيق لبرنامج (ستة سيجما) في الأردن. وقد تم استخدام برنامج الحزمة الإحصائية (SPSS) لاختبار فرضيات الدراسة.

وقد وجدت الدراسة أن هنالك تطبيقا منخفضا في بعد (هيكل ستة سيجما التنظيمي (حملة الاحزمة) الذي يعمل على تحسين الجودة)، وأيضاً تطبيقا منخفضا في بعد (الإجراءات ديماك التي يجب عملها في حال تطبيق نظام ستة سيجما) وكذلك الحال بالنسبة لبعد (طرق القياس المستخدمة في حال تطبيق نظام ستة سيجما)، ومن ثم فإن التطبيق الكلي لبرنامج ستة سيجما منخفض في مجتمع الدراسة (المنظمات الخاصة التي حازت على جائزة الملك عبد الله للتميّز).

وجدت الدراسة أيضاً أن هنالك تطبيقا لبعض الممارسات المشتركة ما بين نظام ستة سيجما وأنظمة الجودة الأخرى، ولكن هذه الممارسات تتشابه في المسميات ،ولكنها تختلف عند المقارنة مع برنامج (ستة سيجما).

وخلصت الدراسة الى جملة من التوصيات أهمها: ضرورة تبني منهج (ستة سيجما) كاستراتيجية مثلى للمحافظة على القدرة التنافسية لمنظمات الأعمال في ظل العولمة، وذلك بإنشاء مؤسسات تعمل على نشر ثقافة برنامج (ستة سيجما) وتشجع على تبنيها.

الكلمات المفتاحية: ستة سيجما، مستوى سيجما،جائزة الملك عبد الله الثاني للتميز، حلقة ديماك، استبانة، التحليل الاحصائي.