

Lean six sigma, crises management and innovation: A theoretical Frame work

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Abstract

Lean Six Sigma (LSS) is now treated as a business model in service and manufacturing sector. LSS is the aim of removing waste and decreasing the defects and variations in organization's processes. The aim of this paper is to describe a theoretical foundation for LSS with innovation and define a process to resolve the crises which produced as results of malfunctioning of system. It has been anticipated that Six Sigma projects improve technological innovation of the organizations but only where while steady environments with in the firm. Since Six Sigma programs are focused on variance reduction and efficiency, these initiatives are not very effective in dynamic environments, where the rate of technological change is dramatic. In addition, due to the focus of Six Sigma projects on existing customers, they may inhibit innovation for new customers. Accordingly, implementation of lean in Six Sigma projects in dynamic environments the level of innovation often have to face some challenges, therefore could not give an effective outcome. We have developed a theoretical frame work for lean six sigma in business world regarding innovation and discusses all challenges and difficulties during implementation of lean six sigma in all types of sectors either dynamic or stable technology changes. The developed framework comprises of innovation, six sigma and crises management can handle these challenges effectively.

Keywords

Lean six sigma, Innovation, challenges, crises management, and business excellence

1. Introduction

Six Sigma (SS) and Lean are two prominent Quality Improvement (QI) methodologies that have been demonstrated across several areas of healthcare since 1998 (DelliFraine et al., 2010). The use of Lean and Six Sigma has increased markedly with more than half of studies published within the past four years (Nicolay et al., 2012). The Six Sigma is a business model which recently achieved extreme attention from the business world and academic research in recent years(Choo et al., 2007)(Schroeder et al., 2008). Lean is a Quality improvement methodology developed from the Toyota Production System in 1990,(Womack et al., 1991) which uses an on-going cycle of improvement to focus on mapping out and adapting process pathways to preserve the steps which provide 'value' and to eliminate sources of waste. This concept is complimentary to Six Sigma and they can be combined to create Lean Six Sigma (LSS), where a 5-stage system known as DMAIC (Define, Measure, Analyze, Improve, control) is employed. This methodology benefits from the statistical rigor of SS as well as the cyclical waste reduction seen in Lean(DelliFraine et al., 2010).

Lean Six Sigma (LSS) has been seen as a business improvement methodology (Pamfilie et al., 2012) incorporating two distinguishing management methodologies: Lean and Six-sigma (M.P.J. Pepper and T.A. Spedding, 2010)accompanying each other in order to improve business processes. This combination has been attained by merging their methods and principles (George, 2003) using the DMAIC (define, measure, analyze, improve, control) cycle as the joining with continuous improvement framework (Cheng and Chang, 2012)and creating efforts to reduce production defects and process variation alongside with process simplification and standardization and waste

reduction (Qu et al., 2011). Some efforts to expanding DMAIC cycle to project management practices and process improvement has been made. Puga, Soler, Maximiano and Wagner (2005) contend that Six Sigma enterprises are projects agreed out to make a single result, such as the project management, while there is a countless potential for incorporation between the DMAIC and project management tools, in which DMAIC mainly deals on finding solutions to the problems and opportunities based on data related decisions and project management standards will provide the proper technique for the implementation of these solutions. (Rever, 2015) incorporated DMAIC steps individually with project that should help project managers to become not only more effective but also to attain innovative outcomes.

The main aim of Six Sigma is defect reduction. Reduced defects lead to yield improvement; higher yields improve customer satisfaction. Six Sigma defect reduction is intended to lead to cost reduction. It has a process focus and aims to highlight process improvement opportunities through systematic measurement. Six Sigma implementation can have negative consequences if applied in the wrong project. Six Sigma is a toolset, not a management system and is best used in conjunction with other more comprehensive quality standards such as the Baldrige Criteria for Performance Excellence or the European Quality Award.

The aim of this research is to develop a frame work for lean and six sigma after reviewing a through literature. We evaluate the literature with respect to the use and effectiveness of both Lean and Six Sigma Quality improvement methodologies in manufacturing and service sector.

2. The concept of Lean Six Sigma

The Business Management called Lean which creates a relations of performance in term of productivity and quality with the flexibility of a business and aims entrepreneur to optimize and maintain all of its processes. Stakeholders of Lean needs performance using idea of continuous improvement and continuous improvement by waste elimination (COLLECTIF, 2004), Figure 1.

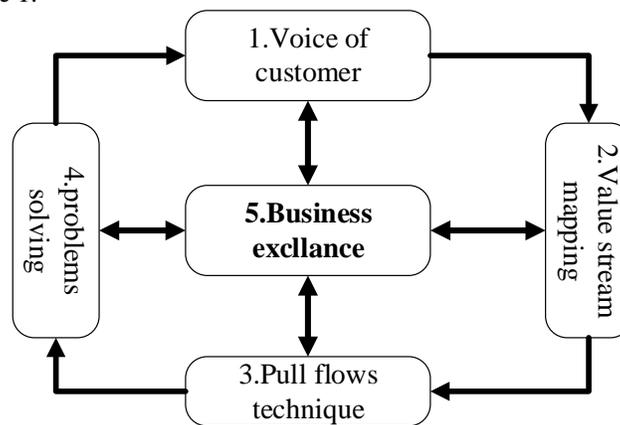


Figure 1: Lean six sigma approach

Six Sigma takes a more data-based and analytical approach by using tools to deliver error-free products and services, such as the following examples: Voice of the Customer (VOC), Measurement Systems Analysis (MSA), Statistical hypothesis testing, Design of Experiments (DoE) and Failure Modes and Effects Analysis (FMEA).

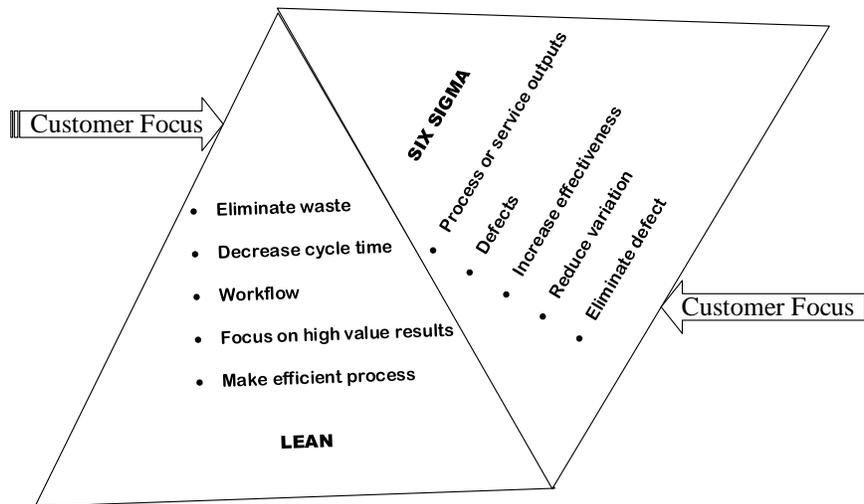


Figure 2: Lean vs Six Sigma

3. The lean philosophy

Lean manufacturing covers the range of the Toyota production philosophy in case an enterprise-wide term that draws together the five elements of “the product development process, the supplier management process, the customer management process, and the policy focusing process for the whole enterprise” ((Peter Hines et al., 2004). The foundation of the lean vision is still a focus on the individual product and its value stream (identifying value-added and non-value added activities), and to eliminate all waste, or muda, in all areas and functions within the system – the main target of lean thinking (Womack and Jones, 2003). Seven forms of waste have been identified

- (1) Over-production;
- (2) Defects;
- (3) Unnecessary inventory;
- (4) Inappropriate processing;
- (5) Excessive transportation;
- (6) Waiting
- (7) Unnecessary motion.

4. Statistical concept:

The Greek letter δ (sigma) indicates the statistical inconsistency, which also denoted as a standard deviation to measure the dispersion of products around the mean specification, with the help of measuring scale from (0 to 6). The main constituent of six sigma are (1- Voice of the customer 2-Value stream Mapping 4- problems solving 3- Pull flows technique 5- Business excellence) while the product is outside the limits set by the tolerance interval IT, it is supposed as a trash. The number of sigma is greater the production is consistent with values close to the average as shown in figure below.

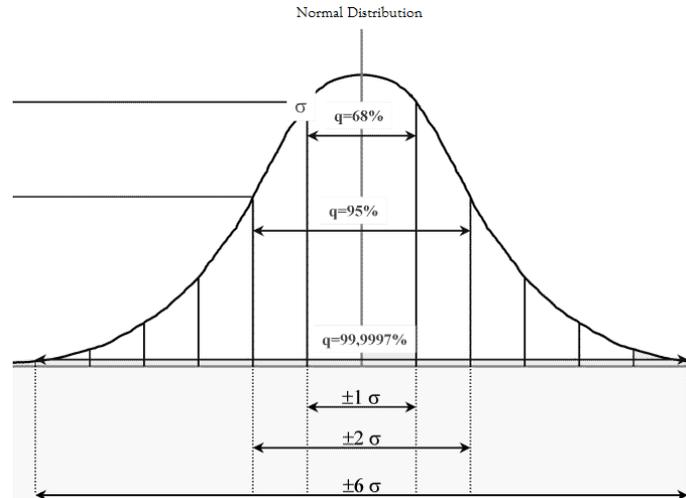


Figure 3: Lean six sigma and Normal Distribution (Vivekananthamoorthy and S, 2011)

5. The DMAIC approach and appropriate tools:

The Six Sigma proposes to use a method of problem solving to pilot projects, Figure 3. This method follows a conductive five-step necessary to obtain reliable results, contracted in the acronym DMAIC for: Define, Measure, Analyze, Improve or Innovate and Check. The DMAIC approach of Six Sigma is with his toolbox as a filter to pass from a complex problem with many uncontrolled variables to a situation where quality is controlled. It is as follows:

5.1 D for Define:

This phase helps clarify the issues of the project, to identify customer expectations, to set goals and designated project stakeholders. In this first step, it is necessary to focus on the process that generates the product or service and the map in order to be familiar.

5.2 M for Measure:

This is a step of collecting data on measurable parameters of the process. The objective is to determine what is able to provide the process in question namely its sigma. During this stage, it is important to focus on critical parameters for the quality, that is, those whose influence on the result is the largest.

5.3 A for Analyze:

Data obtained during the previous step are analyzed to calculate performance gaps, that is to say the differences between what is done every day and what can be achieved. We must then study the origins of the variability of the process and determine the root cause. At this stage, improvement solutions to remove the root causes of process variability concerned are proposed to meet objectives;

5.4 I for Innovation:

The solutions to the dysfunctions proposed are validated by the project team and the ability of the optimized process is evaluated to ensure their impact. Finally, an action plan detailing the implementation of chosen solutions must be developed to best manage the changes induced by the solutions implemented.

5.5 C for Check:

This last step is to control the process to ensure that the problem is solved and stay in quality level achieved. During this step, we must maintain the benefits gained by standardizing the process.

Finally, the financial statement is prepared in order to quantify the made gains. DMAICS means the DMAIC approach to which is added a step for Standardization, designed to sustain the actions and solutions implemented in the first five steps.

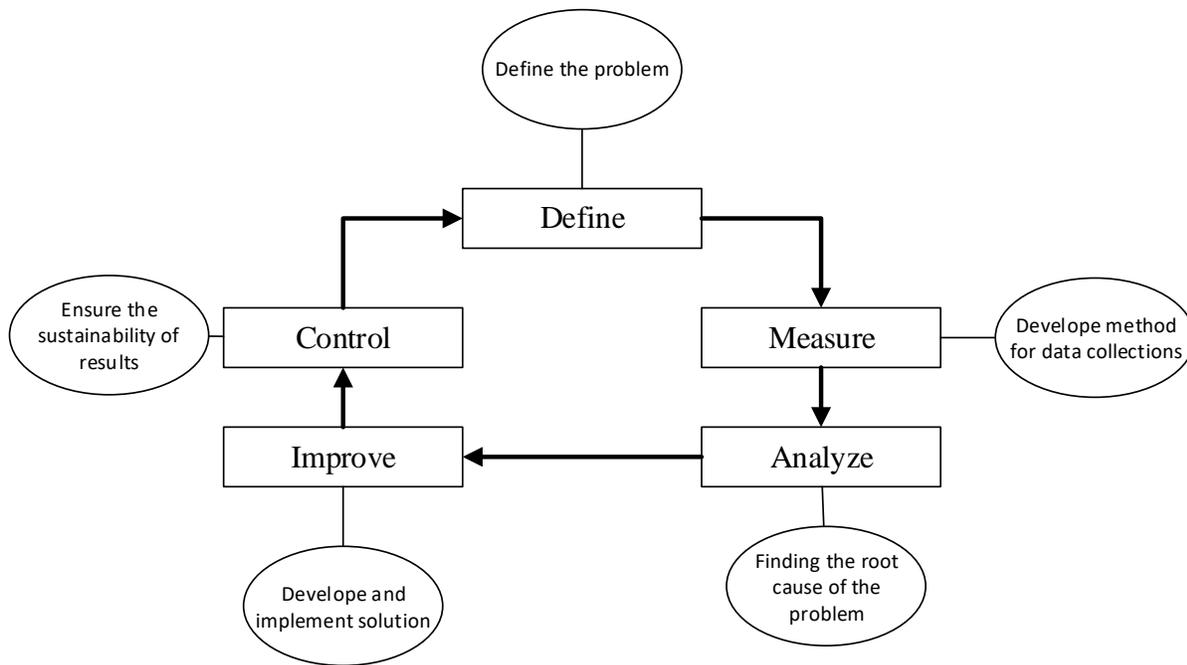


Figure 4: DMAIC Approach

5.6 Risk Management:

Risk Management is an area, where we identify and regularly control the identified risks. The Risk management plan is created with the team so that all the identified risk shall be controlled with a suitable mitigation plan.

In the concerned research, there were many policies and plan were designed by the Saudi government in order to control the expatriate's level, consecutively the purpose was to create job opportunities for the locals. Although these policies worked to some extent but still there is a gap which could not be filled and consequently it knockout the business sector very badly. Therefore the crises begun to starts when for the business sector when they were unable to align with the Saudization percentages defined by the government. There are also no firmed legitimate rules which stick the locals to work as per the business sector philosophy. Therefore crises begun in business sector and which led many companies to either shrink their business or to quit in one or other way.

5.7 Crises Management:

5.7.1 Introduction:

Policymakers are faced with the difficulty of if and how they should respond to an unforeseen and sudden downturn in tourism industry(Blake and Sinclair, 2003). (Zurba and Trimble, 2014) suggested that adult community members highlighted material dimensions of wellbeing when referring to their expectations for the youth, subjective components including values and cultural identity seem to affect the way in which the youth connect with the fishery and forestry.

(Pomfret, 2014) analyzed the impact of recent financial crises in Europe on the Asian economies. What is often abbreviated to GFC included three distinct crises: the 2007–2008 North Atlantic financial crisis, a 2008–2009 global economic crisis and public finance crises which became increasingly focused on the Eurozone in 2010–2012. Asia did not experience significant financial crises, and the open economies recovered relatively rapidly from the global economic crisis. The relative weight of Asian economies in the global economy, which had been increasing for several decades, grew even more rapidly in 2009–2011 as the economies of the USA and Europe faltered. This poses challenges for global economic governance, although there are constraints on Asia being a more assertive force. Problems in the Eurozone hold lessons for Asia; the euro and the Schengen zone are positive responses to the emergence of increasingly complex supply chains. In a similar context, East Asia is moving hesitantly toward financial cooperation and adopting second-best approaches, such as de facto dollar pegs, to reducing bilateral exchange rate volatility.

Economic crises are also results of all types of crises mentioned in this literature review, which directly or indirectly effect once stability.(Bjørnskov, 2016) estimated that the effects of economic freedom on crisis risk in the post-Cold War period 1993–2010. I further estimate the effects on the duration, peak-to-trough GDP ratios and recovery times of 212 crises across 175 countries within this period. Estimates suggest that economic freedom is robustly associated with smaller peak-to-trough ratios and shorter recovery time. These effects are driven by regulatory components of the economic freedom index.

One of the most dangerous type of crises is humanitarian crises,(Gross, 2017) studied that Wars and natural disasters causing thousands of deaths and forcing millions to flee occur frequently and are widely reported to a global audience. However, responses in terms of charity donations, demonstrations, political response and military intervention are dramatically different between one case and the next.

Rapid economic development and a population boom have resulted in an average annual growth rate of 1.43% in water resource demand, which has further accelerated water pollution by a substantial growth in sewage discharge (Liu et al., 2018). There is another form of crises related to service sector like banks, the empirical results show that for a set of 49 developing and developed countries, the model would have correctly predicted the vast majority of crises (Hamdaoui, 2017).

Furthermore the conjunction of social networks and mobile computing has generated new horizons to explore and use the capabilities of mobile social networking in humanitarian crises(Al Omoush, 2017).(Zhu et al., 2017) elaborates that how McDonald's and KFC used social media to manage their 2012 crises in China. Important findings of the study include: 1) crisis response strategies should be based on cultural insiders' assessment of attribution of blame; 2) perception and use of specific response strategies (e.g., apology) have cross cultural variations; and 3) the role of influential social media users' needs to be contextualized by culture. (Bicaba et al., 2014) said that regarding debt crises, the real interest rate is observed to be the best predictor. The time between systemic financial crises appears to be prolonged through government interventions and through IMF program participation, while bank recapitalization has a negative impact.("Determinants of the real impact of banking crises," 2018).

(Vrchota and Řehoř, 2016) revealed that planning and project management is an effective tools for managing risk. Project management is one of the most important management tool in many companies. In the past decade, the word project has become widely known and used, and its importance has greatly expanded. Most often, it is used to name a sequence of related activities with a given beginning and an end, the purpose of which is the realization of a certain objective.

5.8 Crises Management:

CM is a terminology which is used to manage the emergency situation in any type of environment. Most of the research work is conducted regarding crises management in the field of health and safety, weather crises, business or organizational crises and behavior crises.

Some crises could not be managed, but their impact could be minimized by imperative future planning. The effective future planning and management of resources towards the construction, business development and organizational development could mitigate or at least minimized the impact of those crises.

In the recent scenario, there is needs to develop and manage the behavior of population, which in terms a lot would help in the management of crises.

There is following below process which could create a crises and any situation which would result similar loss.

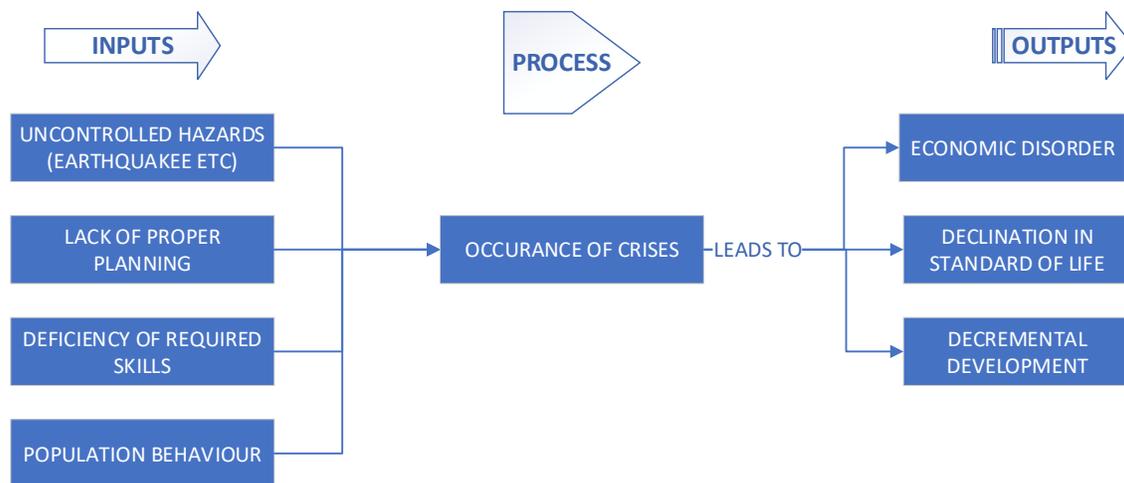


Figure 5: Process of Crises

CASE STUDY:

We have taken the current scenario of Saudi Arabia, which is undergoing through certain crises. The major reason for downfall in every sector, is due to lowering of oil prices in international market. Saudi Arabia economy depends upon oil prices, higher oil price is a signal of economic growth in Saudi Arabia due to their heavy dependence on oil revenues. This study has perused the relationship between oil price and employment in Saudi Arabia by using sample period of 1980. Further, employment effects of increasing and decreasing oil price are found asymmetrical in the non-linear. Accompanying with oil prices Saudi Arabia has biggest challenge, which is their dependency on expatriates. In every field, expatriates are running major portion of corporates sectors.

We conducted a study and question of case study were concerning 1) Does expatriates employees are a burden to the Saudi economy and a vital reason for overall crises. These two questions were asked in the form of survey from 05 industrial sectors stakeholders to collect their valuable outcomes. From each company we collected the 250 responses against each questions from each company. The criteria for response collection was free from biasedness and it was solely based on the response. Below are the response for different industrial sectors with respect to age, education and nationality.

COMPANY-1:

H0= EXPATRIATES EMPLOYEES ARE A BURDEN TO THE SAUDI ECONOMY AND A VITAL REASON FOR OVERALL CRISES

H1: EXPATRIATES EMPLOYEES ARE NOT A BURDEN TO THE SAUDI ECONOMY AND A VITAL REASON FOR OVERALL CRISES

Mean=41.67

Table 1: Oil & Gas Industry Response

OIL & GAS INDUSTRY		
Criteria	Age	Responses
YES	20-25	28
YES	26-35	24
YES	36-60	78
NO	20-25	22
NO	26-35	26
NO	36-60	47

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Using category names in Criteria

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
YES	130	0.5	112.5	2.72222
NO	95	0.5	112.5	2.72222

N	DF	Chi-Sq	P-Value
225	1	5.44444	0.020

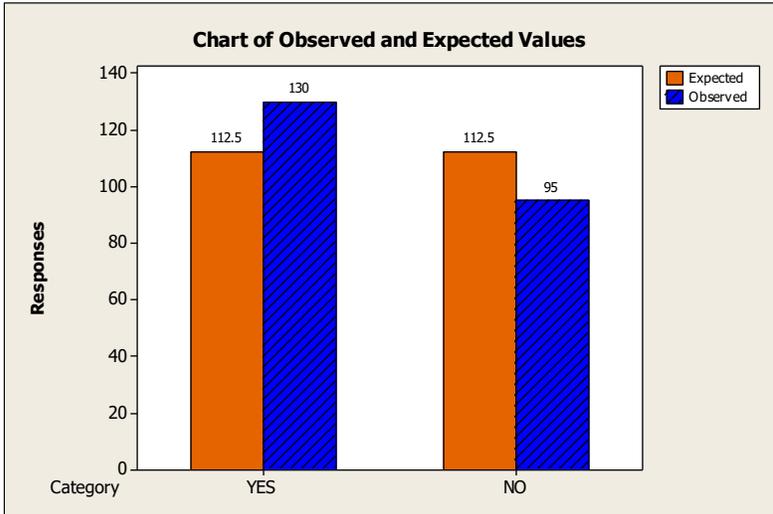


Figure 6: Chart of Contribution to the Chi-Square Value by Category

Result:

As the P is less than 0.05 so Null shall must not sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

Mean = 62.5

Table 2: Oil & Gas Industry Response

OIL & GAS INDUSTRY		
Nationality	Response Category	Response
SAUDI	YES	111
SAUDI	YES	119
NON-SAUDI	NO	24
NON-SAUDI	NO	6

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Response

Using category names in Response_Category

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
YES	230	0.5	130	76.9231
NO	30	0.5	130	76.9231
N	260			
DF	1			
Chi-Sq	153.846			
P-Value	0.000			

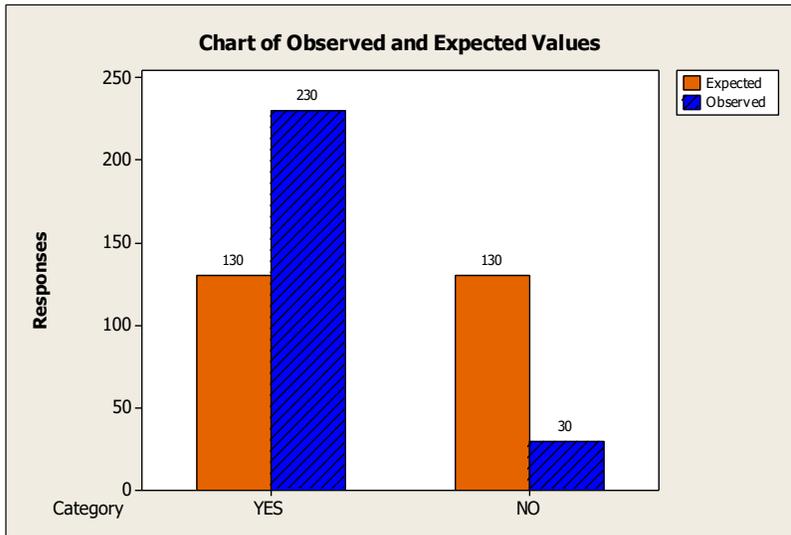


Figure 7: Chart of Contribution to the Chi-Square Value by Category

Result:

As the P is less than 0.05 so Null shall not be sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

Mean= 62.5

Table 3: Education Industry Responses

EDUCATION		
EDUCATION LEVEL	RESPONSE CATEGORY	RESPONSES
GRADUATED	YES	66
GRADUATED	YES	88
UNDERGRADUATED	NO	59
UNDERGRADUATED	NO	37

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
GRADUATED	154	0.5	125	6.728
UNDERGRADUATED	96	0.5	125	6.728

N	DF	Chi-Sq	P-Value
250	1	13.456	0.000

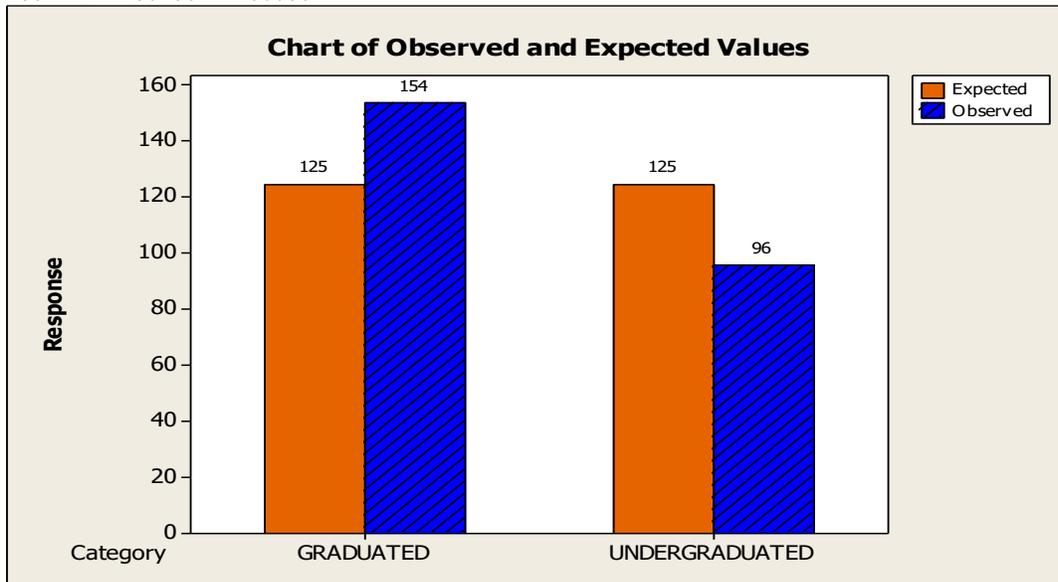


Figure 8: Chart of Contribution to the Chi-Square Value by Category

Mean=41.67

Table 4: SMALL& MEDIUM ENTERPRISES (SMEs)

SMALL& MEDIUM ENTERPRISES(SMEs)		
Age	Response Category	Responses
20-25	YES	37.5
26-35	YES	60
36-60	YES	110
20-25	NO	12.5
26-35	NO	15
36-60	NO	15

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Using category names in Age

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
20-25	50	0.333333	83.3333	13.3333
26-35	75	0.333333	83.3333	0.8333
36-60	125	0.333333	83.3333	20.8333

N DF Chi-Sq P-Value
 250 2 35 0.000

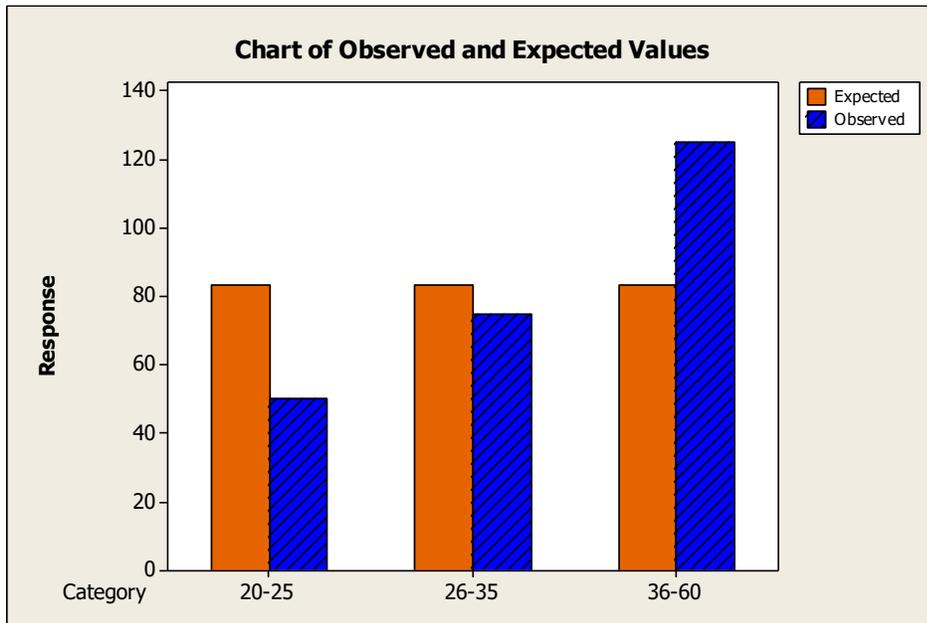


Figure 9: Chart of Contribution to the Chi-Square Value by Category

Result:

As the P is low so Null shall must not sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

Table 5: PHARMACEUTICAL INDUSTRY RESPONSES

PHARMACEUTICAL INDUSTRY		
Age	Response Category	Responses
20-25	YES	38.5
26-35	YES	49.5
36-60	YES	70
20-25	NO	11.5
26-35	NO	25.5
36-60	NO	55

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Using category names in Age

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
20-25	50	0.333333	83.3333	13.3333
26-35	75	0.333333	83.3333	0.8333
36-60	125	0.333333	83.3333	20.8333

N DF Chi-Sq P-Value
 250 2 35 0.000

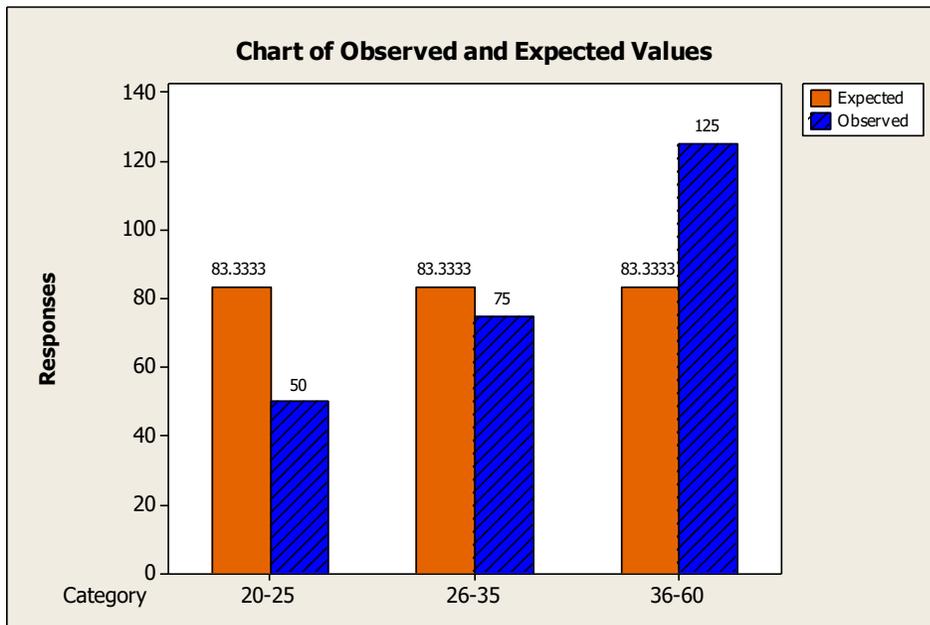


Figure 10: Chart of Contribution to the Chi-Square Value by Category

Result:

As the P is low so Null shall must not sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

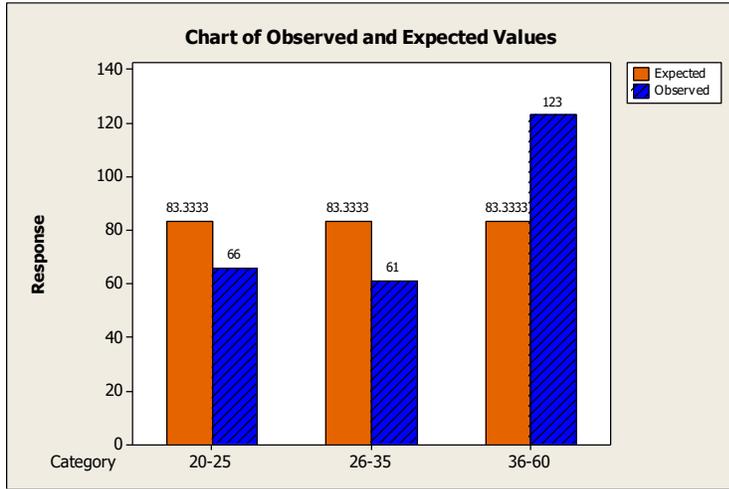
Table 6: ENTERTAINMENT AND MEDIA INDUSTRY

ENTERTAINMENT AND MEDIA INDUSTRY		
Age	Response Category	Responses
20-25	YES	22
26-35	YES	28
36-60	YES	33
20-25	NO	44
26-35	NO	33
36-60	NO	90

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Using category names in Age

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
20-25	66	0.333333	83.3333	3.6053
26-35	61	0.333333	83.3333	5.9853
36-60	123	0.333333	83.3333	18.8813
N	250			
DF	2			
Chi-Sq	28.472			
P-Value	0.000			



Result:
As the P is less than 0.05 so Null shall not be sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

Figure 11: Chart of Contribution to the Chi-Square Value by Category

Table 7: FOOD INDUSTRY RESPONSES

FOOD INDUSTRY		
Age	Response Category	Responses
20-25	YES	42
26-35	YES	35
36-60	YES	66
20-25	NO	22
26-35	NO	22
36-60	NO	63

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: Responses

Using category names in Response Category

Category	Observed	Test Proportion	Expected	Contribution to Chi-Sq
YES	143	0.5	125	2.592
NO	107	0.5	125	2.592

N	DF	Chi-Sq	P-Value
250	1	5.184	0.023

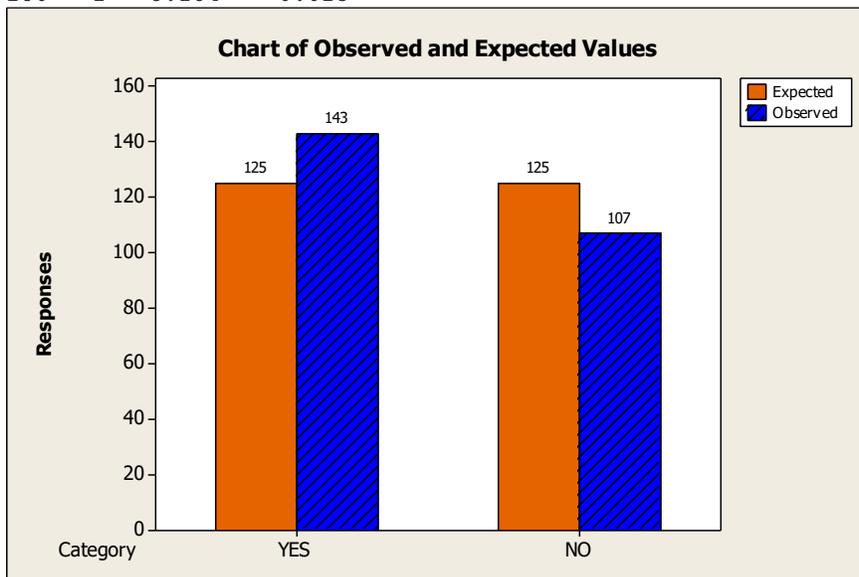


Figure 12: Chart of Contribution to the Chi-Square Value by Category

Result:

As the P is less than 0.05 so Null shall not be sustained as which is “expatriates employees are a burden to the Saudi economy and a vital reason for overall crises”.

Conclusion and Finding:

Our literature review findings shows that innovation is at its best for the wellbeing of society and it reduces the defect level in many sector. In the early stages the adaptability of innovative techniques is quite difficult. The financial impact of adopting new system also increases cost in the short run but in long run it give a lots of benefits like reduction in waste level, just in time delivery, low bottle neck. In service sector it reduces the service time and increases the efficiency of the overall system.

Our overall findings for six sigma in innovation and crises managements shows that proper project management in any field will gives entrepreneurs the best possible result with minimum risk of loss. All other techniques have more risk and productivity. As the project management is the only solution which is preventive unlike for other techniques.

This study recommends the government of Saudi Arabia to save oil revenues in time of prosperity to support employment level in the oil price crisis period.

The case for crises management study shows that Null hypothesis does not sustain which elaborates that expatriates are not a burden on Saudi economy. Therefore we suggest to have new policies which should sustain the economy and expatriates level, for like other foreign countries who are taking benefits from outsiders by bringing the top talent from all over the world. The top talent brought outside for any country is a major driver for the development of the country.

References

1. Al Omoush, K.S., 2017. Harnessing mobile-social networking to participate in crises management in war-torn societies: The case of Syria. *Telemat. Inform.* <https://doi.org/10.1016/j.tele.2017.12.002>
2. Bicaba, Z., Kapp, D., Molteni, F., 2014. Stability periods between financial crises: The role of macroeconomic fundamentals and crises management policies. *Econ. Model.* 43, 346–360. <https://doi.org/10.1016/j.econmod.2014.08.013>
3. Bjørnskov, C., 2016. Economic freedom and economic crises. *Eur. J. Polit. Econ., On Institutions and Well Being* 45, 11–23. <https://doi.org/10.1016/j.ejpoleco.2016.08.003>
4. Blake, A., Sinclair, M.T., 2003. TOURISM CRISIS MANAGEMENT: US Response to September 11. *Ann. Tour. Res.* 30, 813–832. [https://doi.org/10.1016/S0160-7383\(03\)00056-2](https://doi.org/10.1016/S0160-7383(03)00056-2)
5. Cheng, C.-Y., Chang, P.-Y., 2012. Implementation of the Lean Six Sigma framework in non-profit organisations: A case study. *Total Qual. Manag. Bus. Excell.* 23, 431–447. <https://doi.org/10.1080/14783363.2012.663880>
6. Choo, A.S., Linderman, K.W., Schroeder, R.G., 2007. Method and Psychological Effects on Learning Behaviors and Knowledge Creation in Quality Improvement Projects. *Manag. Sci.* 53, 437–450. <https://doi.org/10.1287/mnsc.1060.0635>
7. COLLECTIF, 2004. OBJECTIF LEAN: RÉUSSIR L'ENTREPRISE AU PLUS JUSTE ENJEU TECHNIQUES ET CULTURELS. D'ORGANISATION, Paris.
8. DelliFraine, J.L., Langabeer, J.R., Nembhard, I.M., 2010. Assessing the evidence of Six Sigma and Lean in the health care industry. *Qual. Manag. Health Care* 19, 211–225. <https://doi.org/10.1097/QMH.0b013e3181eb140e>
9. Determinants of the real impact of banking crises: A review and new evidence, 2018. *North Am. J. Econ. Finance* 43, 54–70. <https://doi.org/10.1016/j.najef.2017.10.005>
10. George, M., 2003. *Lean Six Sigma for Service : How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions*, 1 edition. ed. McGraw-Hill, New York.
11. Gross, M., 2017. Caring about humanitarian crises. *Curr. Biol.* 27, R123–R125. <https://doi.org/10.1016/j.cub.2017.02.005>
12. Hamdaoui, M., 2017. Financial liberalization and systemic banking crises: A meta-analysis. *Int. Econ.* 152, 26–54. <https://doi.org/10.1016/j.inteco.2017.08.002>
13. Liu, B., Peng, S., Liao, Y., Long, W., 2018. The causes and impacts of water resources crises in the Pearl River Delta. *J. Clean. Prod.* 177, 413–425. <https://doi.org/10.1016/j.jclepro.2017.12.203>
14. M.P.J. Pepper, T.A. Spedding, 2010. The evolution of lean Six Sigma. *Int. J. Qual. Reliab. Manag.* 27, 138–155. <https://doi.org/10.1108/02656711011014276>

15. Nicolay, C.R., Purkayastha, S., Greenhalgh, A., Benn, J., Chaturvedi, S., Phillips, N., Darzi, A., 2012. Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. *Br. J. Surg.* 99, 324–335. <https://doi.org/10.1002/bjs.7803>
16. Pamfilie, R., (Draghici), A.J.P., Draghici, M., 2012. The Importance of Leadership in Driving a Strategic Lean Six Sigma Management. *Procedia - Soc. Behav. Sci.*, 8th International Strategic Management Conference 58, 187–196. <https://doi.org/10.1016/j.sbspro.2012.09.992>
17. Peter Hines, Matthias Holweg, Nick Rich, 2004. Learning to evolve. *Int. J. Oper. Prod. Manag.* 24, 994–1011. <https://doi.org/10.1108/01443570410558049>
18. Pomfret, R., 2014. European crises and the Asian economies. *J. Asian Econ.* 31–32, 71–81. <https://doi.org/10.1016/j.asieco.2013.12.005>
19. Qu, L., Ma, M., Zhang, G., 2011. Waste Analysis of Lean Service, in: 2011 International Conference on Management and Service Science (MASS). Presented at the 2011 International Conference on Management and Service Science (MASS), pp. 1–4. <https://doi.org/10.1109/ICMSS.2011.5998793>
20. Rever, H., 2015. Six Sigma Can Help Project Managers Improve Results.
21. Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S., 2008. Six Sigma: Definition and underlying theory. *J. Oper. Manag.*, Special Issue: Research in Supply Chain Quality 26, 536–554. <https://doi.org/10.1016/j.jom.2007.06.007>
22. Vivekananthamoorthy, V., S, S., 2011. Lean Six Sigma, in: Coskun, A. (Ed.), *Six Sigma Projects and Personal Experiences*. InTech.
23. Vrchota, J., Řehoř, P., 2016. Project Management and the Importance of Crises in the Sectors of the National Economy. *Procedia Comput. Sci.*, International Conference on ENTERprise Information Systems/International Conference on Project MANAgement/International Conference on Health and Social Care Information Systems and Technologies, CENTERIS/ProjMAN / HCist 2016 100, 362–368. <https://doi.org/10.1016/j.procs.2016.09.170>
24. Womack, J.P., Jones, D.T., 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Revised and Updated, 2nd edition. ed. Productivity Press, New York.
25. Womack, J.P., Jones, D.T., Roos, D., 1991. *The Machine That Changed the World: The Story of Lean Production*. HarperCollins.
26. Zhu, L., Anagondahalli, D., Zhang, A., 2017. Social media and culture in crisis communication: McDonald's and KFC crises management in China. *Public Relat. Rev.* 43, 487–492. <https://doi.org/10.1016/j.pubrev.2017.03.006>
27. Zurba, M., Trimble, M., 2014. Youth as the inheritors of collaboration: Crises and factors that influence participation of the next generation in natural resource management. *Environ. Sci. Policy* 42, 78–87. <https://doi.org/10.1016/j.envsci.2014.05.009>

Acknowledgements

Advanced manufacturing institute at King Saud University and KACST (King Abdulaziz City for Science and Technology) is highly acknowledged for continuous financial support of the present work. Information and Culture Ministry in Saudi Arabia and Saudi Broadcasting Corporation. We would like to thank Dr. Mohammed Sharaf for his supports and helping.

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