A dynamic model for sustainable Lean Six Sigma implementation

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Abstract

Lean Six Sigma (LSS) methodology is becoming popular in South African companies, motivated by the drive to reduce costs and optimise operational processes. There are indications from literature of various challenges experienced by companies in their journey to implement and sustain LSS. There is no authoritative statistics around the scale of LSS implementations in South African organisations or on the success and failure rates of these implementations. This research's chief objective was the development of a dynamic model which could be used to predict and sustain LSS deployments in local companies. The research also purposed to expand the body of knowledge on factors affecting the sustainability of LSS.

Multiple case studies were employed for concept building in this research. A three phased approach using interviews and a survey was employed in conducting the research.

The research confirmed that companies were experiencing various challenges including lack of top management buy-in and support and lack of skilled and knowledgeable employees. Positive feedback was received, as the measures of LSS sustainability and existence of the predictors for LSS sustainability received generally high scoring. The data collected from the case studies was limited as the population of employees who have received various levels of LSS and actively participating in LSS projects was limited within organisations. This research contributed to the body of knowledge by increasing understanding on the sustainability of LSS implementations and by developing a dynamic model which could be used to predict and sustain LSS deployments.

Keywords
Lean Six Sigma, Implementation strategy, Sustainability, Institutionalisation, Routinisation, Change management forces.

1. Introduction
In their attempt to continuously improve their operations, many organisations around the world have embarked on various business improvement methodologies, ranging from simple quality inspection to complex business improvement methodologies. According to Byrne (2007) the following common business improvement methodologies were implemented by different companies over the years: statistical quality in the 1950s; Toyota Production System (TPS) in the 1960s/1970s; Just-in-time (JIT), Total Quality Management (TQM) and Six Sigma in the 1980s; Lean Production and Business Process Reengineering (BPR) in the 1990s and LSS in the 2000s. Some business improvement methodologies were observed to have performed better than others. Accenture Global Management Consulting observed that desirable improvements from these business improvement methodologies were short-lived in most organisations (Iversen & McCoy, 2010). Whilst some of the business improvement methodologies have survived, others were reported to have fallen away to be replaced by a successor.

Factors crucial to the successful implementation of LSS in organisations of various sizes and across various industry sectors were discussed in the literature by various authors and practitioners (Albliwi, Antony, Lim, & van der Wiele, 2014; Alidris, 2014; Näslund, 2013; Laureani & Antony, 2012; Coronado & Antony, 2002). The factors identified are similar, although the level of detail varies from author to author. However, authors Firka (2010) and Soti, Shankara, and Kaushal, (2009) observed that the majority of the available literature on LSS critical success factors (CSFs) focused on the deployment or "kick-off" phase whilst the success factors critical for the maintenance or sustainability of the methodology, received limited attention.

The infancy of the methodology and the radical change of practices, which LSS provides were found to be amongst some of the probable reasons why it is difficult to sustain. Pillet and Maire (2008) found that many companies reported to have achieved substantial improvements in their operations when they managed to sustain LSS beyond implementation. Duarte (2011) observed many companies are certain of the decision to implement LSS, but are unclear of exactly how to implement it.

Most South African organisations have implemented a number of business improvement methodologies to deal with operational challenges. It is apparent that many businesses in South Africa are implementing or considering LSS as an initiative to achieve operational excellence.

Indications of LSS implementation in South Arica are evident in:

- Papers presented on LSS at various conferences;
- A rise on LSS consultancy companies providing training and deployment support; and
- Advertised jobs requiring LSS certified specialists, such as green belts, yellow belts, black belts and master black belts.

2. Literature Review

Lean Six Sigma is commonly known by the acronym LSS. This incorporates a combination of Lean and Six Sigma methodologies (Sherinda, 2000).The complementary relationship between the individual methodologies, Six Sigma was observed by Pepper and Spedding (2010) to equip the organisation with the means and expertise to resolve complex problems, which had been identified during Lean projects. Lean and Six Sigma are undeniably very powerful tools, but it is evident that when used effectively together, their power is exponentially increased. Andersson, et al. (2006) observed that though the defintions of the two methodologies differ substantially, they share the common objectives of keeping the customer happy and net income improvements, through continuous improvement, minimising waste and the use of resources.

George (2002) defined LSS as a methodolgy that maximises shareholder value by improving customer satisfaction, cost, quality, process speed, and invested capital. He further highlighted that the incorporation of these methodologies is crucial for enhanced outcomes. This recommendation was supported by Antony (2011). The incorporation is crucial since George (2002) mentioned:

- Lean alone is not able eliminate process variation; and
- Six Sigma is unable to radically improve process output or decrease invested capital.

When implementing LSS, Gates (2007) considered that there is no one right deployment model and suggested the following four generic deployment models:

1. Organisation wide - This is the conventional top-down model which is centrally managed. All divisions of the organisation participate. The deployment quickly gets to a critical mass and produces results;
2. Business unit – Six Sigma is implemented in a single division or business unit in a larger organisation. It has many characteristics of deployment within an organisation, only on a smaller scale;
3. Targeted – The implementation is dedicated to a particular problem or a collection of problems within an organisation. The approach can involve many parts of the organisation or just one;
4. Grass roots – A small group lower down in the organisation that deploys LSS. The model is easily implemented, often with a passionate sponsor and a specific problem to solve.

Ham, Kipping, McLeod and Meredith (2002) cautioned that it takes longer than anticipated for quality improvement initiatives such as LSS to become embedded within the organisation. Not having a model to guide the efforts of implementation can result in fruitless and wasteful activities; which can create significant challenges with the execution. If the organisation fails to plan for the road ahead and not recognise vital milestones or obstacles, nor manage them accordingly, the efforts to implement may inevitably fail. Freedman (2003) concurs and cautions that being impatient about the time it takes to execute a strategy can lead to unrealistic expectations. This can also occur where leaders force strategy execution without the knowledge of execution capabilities or the lack of such ability.

2.1. Challenges in implementing Lean Six Sigma

Raje (2006) cautioned that for LSS to be successful, it must be sustained over a lengthy period of time. He recognised sustainability to be influenced by the level of the organisation within the maturity model. A number of LSS implementations were reported to have either disappeared or were terminated, of which the following were identified as common causes: rapid change due to external factors such as a new chief executive, and change of company ownership with diverse values; LSS becomes secluded and loses prominence in the organisation, with less significant projects; modifying the approach to focus on Lean, resulting in the dislike and abandonment of Six Sigma Firka (2010).

When selecting business improvement methodologies such as LSS, the following four principles were identified as useful (Rigby & Bilodeau, 2005:12): get the facts, understand the effects (and side effects) of each tool, then combine the right tools in the right way at the right time; champion enduring strategies, not fleeting fads; choose the best tools for the job; adapt tools to your business system (not vice versa). It is apparent that for LSS to be successful the long-term outlook is necessary. Antony (2011) concurs and suggested that sustained and long-term commitment is required for LSS to achieve the quality goals within a pre-set time framework.

2.2. Measuring Lean Six Sigma success

Many ways of measuring LSS success are driven by an organisation's objectives when implementing LSS. Other organisations measure the success of LSS by the number of completed LSS related projects rather than the financial return (Gupta, 2005). As top management wants to see the return on investment of implementing LSS, many organisations measure the benefits of LSS's financially. Jayaraman et al. (2012) identified operational performance and organisational performance as the dependent variables representing the level of performance of LSS in organisations.

According to Eckes (2000) the ultimate measure for Six Sigma's success is the savings in monetary value as a result of the implemented Six Sigma projects. Henderson and Evans (2000) caution that measuring Six Sigma's success financially leads to a situation where only projects with more than hundred thousand Rand savings are preferred rather than process improvement projects. De Koning, et al. (2008) and Miguel and Andrietta (2010) recommend the following measures for LSS success: overall quality, process efficiency, responsiveness and the cost of LSS projects, all of which makes perfect sense. However, as noted by Huq (2006), the bulk of the measures identified in the literature as discussed above, are short-term focused. He believes this could have resulted in some companies altering their implementation by replacing LSS with other improvement methodologies or separating Lean from Six Sigma to only concentrate on Lean.

According to Firka (2010), to standardise LSS implementation, the following factors must be monitored regularly: organisational culture, perception of the methodology, economical results of projects, and visibility and knowledge transfer in the organisation, market conditions, benchmarking with other Six Sigma organisations, and attainment of LSS tools.

Jaca; Viles, Mateo, Santos and Javier (2012) concluded that many companies pay more attention to those critical success factors that are linked to the attainment and control of improvement objectives, whereas the factors related to employee recognition or their involvement in improvement projects, receive less consideration.

2.3. Lean Six Sigma sustainability

Routinisation and institutionalisation were found to be primary or fundamental processes of sustainability (Slaghuis, Strating, Bal, & Nieber, 2011; Pluye et al., 2004). However (Slaghuis et al., 2011) observed that the two concepts are understudied in the domain of quality improvement and organisational change where this research is based.

The factors or processes that influence sustainability are still not well understood (Wiltsey-Stirman et al., 2012; Savaya & Spiro, 2012; Shediac-Rizkallah & Bone, 1998). However, for sustainability to become a routine component of programme evaluation there is a need for greater clarity about obstacles to sustainability and their causes (Savaya et al., 2008).

Shediac-Rizkallah and Bone (1998) concluded that a planned approach is required to formulate sustainability goals and objectives. This includes developing and implementing strategies specifically to foster sustainability, and assessment or evaluation where both objectives and strategies are continuously monitored and revised. From the models of LSS maturity discussed in literature, sustainability is viewed as the last phase of LSS adoption, where the expectation is for LSS to be fully imbedded in the organisation as the programme continues. Pluye et al. (2004) caution that this linear, latent and sequential approach to sustainability can inhibit early or sufficient sustainability planning, they suggest that a sustainability strategy should be given priority much earlier in the adoption process. This is also true for the Lean methodology, where Chaudhari (2011) cautioned that Lean should not be seen as a final destination to work towards, but as a dynamic approach to sustain the company.

Despite the increasing body of literature on sustainability, there is still no single definition of sustainability. Related but not entirely equivalent terms are used in literature to define sustainability in various fields (Wiltsey-Stirman et al., 2012; Newman, 2012; Harris, 2011; Quinn & Dalton, 2009). Furthermore, there are no standard approaches to lead and manage programmes for sustainability (Wiltsey-Stirman et al., 2012; Newman, 2012; Harris, 2011 & Quinn & Dalton, 2009). The factors and processes that foster sustainability are still not sufficiently understood (Pluye, Potvin & Denis, 2004; Savaya et al., 2008).

3. Research design, method and data collection

Social constructionism paradigm was adopted, employing multiple case studies. A phased approach involving four phases was followed to collect mixed data. In the introductory phase, various sources such as LSS experts and professional sites were consulted for case company identification and selection. Six case companies belonging to various industries included mining, healthcare, banking and non-banking financial institutions, were identified to participate in the study.

In phase 1, comprehensive case studies were conducted with the case companies. To collect primary data, the researcher conducted semi-structured interviews with the case companies' LSS deployment leaders. The focus areas were: LSS deployment background, LSS enabling and inhibiting factors, LSS sustainability factors and LSS success measures.

In phase 2, the researcher elicited considered views and suggestions from LSS experts. Interviews were carried out with the subject matter experts on the implementation of LSS.

Finally, in phase 3 the researcher revisited some case companies, to assess employee perceptions of the factors contributing to the sustainability of LSS. Semi-structured interviews were conducted with the deployment leaders. To understand their perceptions of factors affecting LSS sustainability in organisations, a survey questionnaire was completed by LSS employees at various organisational levels of the selected case companies.

4. State of LSS deployment in South Africa

4.1 LSS deployment background

The empirical findings suggested that LSS was gaining popularity in South African companies, with the earliest adoption in 2004. The motivation for implementing LSS was based on different factors, but the following two were common: the drive to reduce costs, and optimisation of operational processes.

Two of the four generic LSS deployment models suggested by Gates (2007) were observed in the case companies throughout the organisation, the conventional top-down driven with strong central management and business unit, deploying LSS in one part or a business unit within the larger organisation. Companies that deployed the organisation wide model agreed that it was more successful and supported the model for bringing an all-inclusive focus of the organisation resources to maintain momentum. There was disparity on the success of the business unit

model as one company felt that it was successful because the targeted business unit was used as a reference point where all business units could learn and replicate what they were doing. Whereas another company concluded that the LSS deployment model could be more successful if a centralised model was applied, i.e. organisation wide until the basics were in place, and then later changed to a decentralised model, i.e. business unit model.

The two implementation approaches suggested by Furterer were both observed in the case companies, i.e.: using Lean and Six Sigma as complementary approaches by first implementing Lean to identify and eliminate waste, and then implement Six Sigma in the later stage to reduce the variation using the DMAIC improvement process and a Six Sigma DMAIC improvement process framework, which were integrated with Lean to focus on cycle time reduction and Lean tools and projects. It is clear that all companies had a certain direction to select the Lean strategy in the early stages of the LSS deployment.

From the inception, all companies partnered with external consultancy support for expert facilitation. This was reported to have resulted in the avoidance of many costly mistakes with the LSS deployment programme. Some companies mentioned co-owning the training process with the external consultant, and training was conducted in the adult training way and not the university training way. It was however observed that the external support was reported to have continued long after the initially agreed period and this was the case for all the case companies. This is not sustainable as MIME (2010) cautioned that extensive and lengthy use of external support can leave an organisation dependent upon that support. All case companies continued to deliver Black Belt level training and projects to support transformation, ranging from one training wave to 23 waves.

4.2 LSS enabling and inhibiting factors

Both operational performance and organisational performance as suggested by Jayaraman et al. (2012) were used by the case companies to measure sustainable LSS implementation. Some of the operational performance measures used, included the number of completed LSS projects, percentage utilisation of resources, and improved performance. Actual savings being realised through projects and return on investment (ROI) were some of the organisational performance measures used. It can be noted that only financial measures were used for organisational performance, while non-financial measures such as perception of the methodology were not used by any of the case companies.

Of the factors to be constantly monitored to standardise LSS implementation, all case companies believed that the performance measures must be monitored. There was a focus on only tangible measures such as economical results of projects and its visibility. There was no focus on intangible measures such as organisational culture or perception of the methodology.

4.3 Assessment of LSS sustainability

The manifestation of sustainability was described and measured as continuation, institutionalisation, and routinisation. It was confirmed that 78% of the respondents believed that the LSS programme will be maintained in their organisation for the next five years. Majority of the respondents believed that there is room for growth within the scope of the LSS programme during the next five years in their organisation. With 61% of the respondents believing that the scope of LSS will increase.

5. Lean Six Sigma Sustainable Model

Predictors includes, variables pertaining to the organisation, the people, the implementation process, and the principles & practices of LSS. Their level of implementation influences the sustainability level measured as continuation, institutionalisation and routinisation.

5.1 Change management forces, i.e. enabling and inhibiting factors

These forces allow or prevent LSS changes to take place. Three methods are recommended entrench the change in the organisation: 1) increase inhibiting forces that move people from the old way of doing things, 2) decease inhibiting forces that preventing movement to from the existing situation and 3) using a combination of the above mentioned

5.2 Measurement

Self-assessment in the form of surveys, to ascertain employee's perceptions on how LSS predictors and change management forces are contributing to LSS success inside a company. Also include benchmarking with-self or other companies.

5.3 Relationship amongst factors

Relationship 1 (R1) – the impact of the level of LSS predictors on sustainability
Relationship 2 (R2) – the impact of the strategies to entrench the change in the organisation
Relationship 3 (R3) – sustainability measures defined as: continuation, institutionalisation and routinisation.

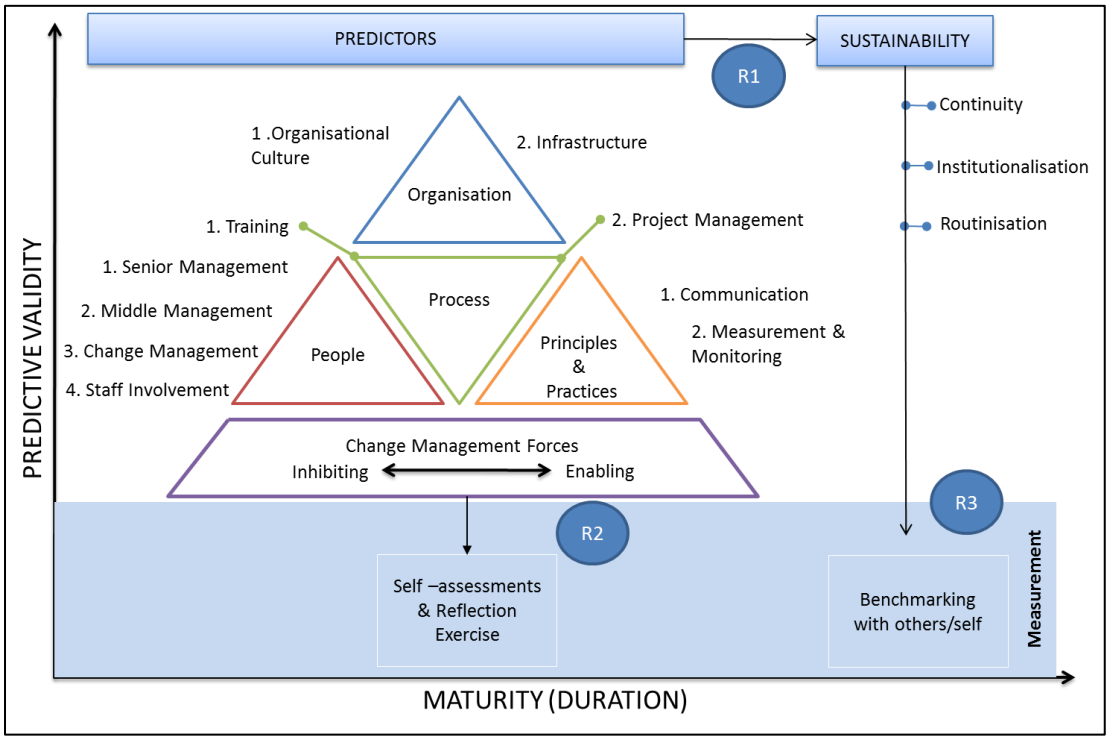

Figure 1: Conceptual model for Lean Six Sigma sustainability

Finally, the Lean Six Sigma sustainability model presented in in Figure 1 can be used as a decision support tool by deployment champions looking to deploy Lean Six Sigma in a global enterprise. It will enable the decision makers to plan for Lean Six Sigma sustainability and to test various scenarios by playing "what-if" games. Decisions on the deployment strategy, change management and factors affecting sustainability will be tested. In summary, the model can be used as a useful tool in developing the overall strategy for the sustainable implementation of Lean Six Sigma in South African companies.

6. Discussion and further research

This research contributes to the body of knowledge by increasing understanding on the sustainability of LSS implementations. An empirically tested model for sustaining LSS implementations in the South African business environment was developed. Also, there was limited information on the implementations of LSS, or on the success and failure rates of LSS implementations in South African Companies. This study also contributes authoritative statistics on the scale and success of LSS implementations in South Africa. A practical model and recommendations for organisations and researchers to sustain LSS was made. These recommendations will provide guidance on the practical steps that could be taken to implement LSS successfully.

In practice, the proposed theory model should therefore provide a better understanding for managers to clarify, develop and implement sustainable LSS methodology. The model provides a constructive foundation for further

development of operational evaluation, assisting practitioners to more systematically assess the outcomes of LSS sustainability on regular intervals. To illustrate the value and practicality of this aspect, an evaluation framework is proposed for future research. A dynamic feedback model to prove and predict the condition for LSS sustainability was developed. The model may be used to predict from the industry research data which companies will succeed or fail to sustain LSS implementation in time.

References

Albliwi, S., Antony, J., Lim, S. & van der Wiele, T. (2014). Critical failure factors of Lean Six Sigma: a systematic literature review. International Journal of Quality & Reliability Management, 31(9):1012 - 1030.

Alidrisi, H. (2014). Prioritizing Critical Success Factors for Six Sigma Implementation Using Interpretive Structural Modeling. American Journal of Industrial and Business Management, Volume 4: 697-708.

Andersson, R., Eriksson, H. & Torstensson, H. (2006). Similarities and differences between TQM, Six Sigma and Lean. The TQM Magazin, 51(1): 282-296.

Antony, J. (2011). A SWOT analysis on Six Sigma: some perspectives form leading academics and practitioners. International Journal of Productivity and Performance Management, 61(6): 691-698.

Bendell, T. (2006). A review and comparison of six sigma and the lean organisations. The TQM Magazine, 18(3): 255-262.

Byrne, G. L. D. a. B. A. (2007). Using a Lean Six Sigma approach to drive innovation. Strategy & Leadership, 35(2): 5-10.

Chovav, H. & Weinstein, T. (1997). Continuation or cessation? A follow-up study of projects in neighborhoods where Project Renewal has ended, Jerusalem: Ministry of Housing, Department of Neighborhood Social Rehabilitation.

Coronado, R. & Antony, J. (2002). Critical Success Factors for the Successful Implementation of Six Sigma Projects in Organizations. The TQM Magazine, Volume 14: 92-99.

de Koning, J., Does, R. & Bisgaard, S. (2008). Lean Six Sigma in financial services'. Int. J. Six Sigma and Competitive Advantage, 4(1): 1-17.

Duarte, B. (2011). An Analytical Approach to Lean Six Sigma Deployment Strategies: Project Identification and Prioritization. Arizona: Arizona State University.

Eckes, G. (2000). Six Sigma the Revolution, New York: Wiley.

Firka, D. (2010). Six Sigma: an evolutionary analysis through case studies. The TQM Journal, 22(4),: 423-434.

Freedman, M. (2003). The genius is in the implementation. Journal of Business Strategy, 24(2): 6-31.

Gates, R. (2007). Deployment: Start Off on The Right Foot. Quality Progress, Volume 10: 51-57.

George, M. (2002). LSS: Combining Six Sigma Quality with Lean Speed. New York: McGraw-Hill.

Gupta, P. (2005). Innovation: The key to a successful project. Six Sigma Form Magazine, 4(4): 13-17.

Ham, C., Kipping, R., McLeod, H. & Meredith, P. (2002). Capacity, Culture and Leadership: Lessons from Experience of Improving Access to Hospital Services. Birmingham, Birmingham: Health Services Management Centre.

Harris, M. (2011). Strategic planning in an international non-governmental Strategic planning in an international non-governmental development organization: The creation of a meta-identity. Administration and Society, 43(2).

Harry, M. & Schroeder, R. (2000). Six Sigma - The Breakthrough Strategy Revolutionizing the World's Top Corporations, New York,: Doubleday.

Huq, Z. (2002). Six-Sigma implementation through competency based perspective (CBP). Journal of Change Management, Volume 6: 277-89.

Jaca, C., Viles, E., Mateo, R. & Santos, J. (2012). Components of sustainable improvement systems: theory and practice. The TQM Journal Oxford English dictionary (2018). Sv. 'sustainability'. [Online]

Available from: https://en.oxforddictionaries.com/definition/sustainability

Jayaraman, K., Kee, T. & Soh, K. (2012)). The perceptions and perspectives of Lean Six Sigma (LSS) practitioners: An empirical study in Malaysia. The TQM Journal,: 433-446.

Kumar, M., Antony, J. & Tiwari, M. (2011). Six Sigma implementation framework for SMEs – a roadmap to manage and sustain the change. International Journal of Production Research, 49(18): 5449–5467.

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

Miguel, P. & Andrietta, J. (2010). Outcomes from a descriptive survey of Six Sigma management practices in Brazil. International Journal of Lean Six Sigma, 1(4), pp. 358-377.

Näslund, D. (2013). Lean and six sigma – critical success factors revisited. International Journal of Quality and Service Sciences, 5(1): 86-100.

Newman, J. (2012). An organizational change management framework for sustainability. Greener Management International, Volume 57.

Oke, S. (2007). Six Sigma: A Literature Review. South African Journal of Industrial Engineering, 18(2): 109-129.

Pepper, M. & Spedding, T. (2010). The evolution of lean Six Sigma. International Journal of Quality & Reliability Management, 27(2): 138-155.

Pillet, M. & Maire, J. (2008). How to sustain improvement at high level, Application in the field of statistical process control. The TQM Magazine , 20(6): 570-587.

Pluye, P., Potvin, L. & Denis, J. (2004). Making public health programs last: conceptualizing sustainability, Evaluation and Program Planning. 27(2): 121-133.

Quinn, R. & Spreitzer, G. (1991). "The psychometrics of the competing values culture instrument and an analysis of the impact of organizational culture on quality of life". Research in Organizational Change and Development, Volume 5: 115-142.

Raje, P. (2006). Maturity model describes stages of Six Sigma evolution. [Online]

Available at: http:///www.isixsigma.com/implementation/basics/maturity-model-describes-stages-sixsigma-evolution

[Accessed 25 March 2014].

Rigby, D. & Bilodeau, B. (2005). The Bain 2005 management tool survey. Strategy & Leadership, 33(4): 4 - 12.

Savaya, R., Spiro, S. & Elran-Barak, R. (2008). Sustainability of Social Programs A Comparative Case Study Analysis. American Journal of Evaluation, 29(4): 478-493.

Shediac-Rizkallah, M. & Bone, L. (1998). Planning for sustainability of community-based health programs: conceptual frameworks and future directions for research, practice, and policy.

Sherinda, J. (2000). Lean Sigma' synergy. Industry Week, 249(17): 81-2.

Soti, A., Shankar, R. & Kaushal, O. (2009). Modeling the enablers of Six Sigma using interpreting structural modelling. Journal of Modeling in Management, 5(2): 121-141.

Wiltsey Stirman, S. et al. (2012). The sustainability of new programs and innovations: a review of the empirical literature and recommendations for future research. Implementation Science: 7-17.

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