Prioritization of Six Sigma Project Selection: A Resource-Based View and Institutional Norms Perspective

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Abstract

Purpose: With increasing choice from a range of programs, improvement project selection within broader supply chain context and resource constraints has become a major research challenge. This study aims to investigate the different criteria for selecting Six-Sigma (SS) projects based on previous studies. The study is supported by two grounded theories: resource-based view and institutional norms. The criteria include: (i) business drivers for improvement and the common performance metrics deployed, (ii) the organization's stakeholders needs, and (iii) process owner's needs.

Design/methodology/approach: To determine the relative importance of influencing factors, opinions were collected from 30 experienced practitioners including SS champions/master black-belts, company directors, consultants, and process owners through a series of interviews in small, medium and large organizations including multi-national organizations. The evaluation of criteria is based on Analytical Hierarchy Process (AHP).

Findings: The results show that impact on customer, financial impacts, and impact on operational goals are the most significant factors in selecting SS improvement project.

Originality/value: This study is a first attempt to determine the relative weight among SS project selection criteria, which help the practitioner to allocate their limited resources in implementing SS project.

Keywords: Six-Sigma (SS), Project Selection, Analytic Hierarchy Process (AHP), Resource based view, Institutional norms

1. Introduction

Performance improvement is an integral part of overall business strategy for many organizations across service and manufacturing focused industries. Various improvement programs such as Six-Sigma, Total Quality Management, and Lean involve a number of

philosophies and methods such as BPR, Statistical Process/Quality Control, Quality Circles, ISO9001 PDCA and Just in Time (JIT). In this context, continuous improvement has become a major element of strategy formulation in organisations across a range of industry sectors. It aims to provide improvements across a range of functional areas with the focus on both internal and external performance measures. Among various improvement methods, Six-Sigma (SS) is well-established and one of the most recognized continuous improvement methods. Many companies including General Electric (Pande *et al*., 2000), Texas Instruments, Honeywell, and Johnson and Johnson (Kwak and Anbari, 2006) have successfully implemented this method. Six-Sigma takes a holistic and multi-dimensional systems approach towards understanding and providing solutions for problems, and thus develops close links between organizational competitiveness, customer satisfaction, and continual improvement. By implementing SS, companies could achieve breakthrough improvement (Juran, 1988) with a dramatic impact, not only on financial benefits, but also customer satisfaction, and operational capability (Harry and Schroeder, 2000).

To implement SS successfully, companies need to ensure that an appropriate organizational strategy, structure, process architecture (Hammer, 1999), and culture has been well established (Cronemyr *et al*., 2014; Krueger *et al.*, 2014). These include leadership, the linkages among SS and business objectives and customer needs, and capability of members in the supply chain. It is also important to note that selecting the right SS project and providing adequate resources (finance, time, human, and technology) are other enablers in implementing this technique (Kumar *et al*., 2009). However, a number of studies have investigated how to achieve the expected outcomes of SS program. These studies have identified the following: the importance of the SS project selection process (Kumar *et al*., 2009), having clear objectives for targeting improvement efforts (Kornfeld and Kara, 2011), the need for alignment to the strategic goals of the organisation (Kendrick and Saaty, 2007) and selection of appropriate method for SS project selection (Kazemi *et al*., 2012). Organizations typically have limited resources to be dedicated to a wide range of potential improvement projects. Such resources would typically include time, finance and human resources. It is not conceivably possible to address all potential areas for improvement at any one particular time or over a period of time and therefore, there is a need to be selective in application of SS projects. Consequently, there is a need to prioritize which potential SS projects would be availed of the resources within the organization. However, there

is currently very little understanding of the relative importance of the various criteria for SS project selection. The implication is that six sigma project selection is not necessarily being carried out based on the comparison of multiple organizational factors or an understanding of multiple theoretical perspectives. In this study, two organizational behavior theories are considered through a broader spectrum of SS project selection criteria, associated with financial impact; impacts on customer, operational goals, employees, customers, suppliers; as well as technical and resource feasibility. Therefore, it is important to propose this study which uses Analytical Hierarchy Process (AHP) to rank and compare six sigma selection criteria. Consequently, this study seeks to understand the perceptions of SS practitioners about the relative importance of criteria for project selection. The study is based on the experiences of organisations in Thailand.

Sandholm and Sorqvist (2002) and Bilgen and Sen (2012) suggested that the prioritization and selection of projects for product/process evaluation and improvement is critical to successful SS implementation. Antony and Banuelas (2002) cited project prioritization and selection as one of the key ingredients of SS program implementation which if it is not done properly will lead to delays and frustration. However, previous studies only quantify experience using selected uni-dimensional measures (Easton and Rosenzweig, 2012). In addition, most of the criteria for project selection are based on either random choice without justification or a theoretical perspective such as RBV, institutional, and network theory (Auh and Menguc, 2006). Thus, this study addresses this gap in understanding the criteria for SS project selection. The study draws from RBV and institutional theory and links project selection criteria to the strategic objectives of the organization. The structure of the paper is as follows: a literature review on key areas of continuous improvement, project selection criteria from RBV and institutional theory perspective is presented and followed by research methodology, findings, discussion and conclusion.

2. Literature Review

In recent times, continuous improvement initiatives have gained increased popularity in many industry sectors across the globe (Tickle *et al*., 2015). This has led to increased level of research activity/investigations with a range of studies on various aspects of improvement strategies and

their supporting projects. These studies indicate that there are a number of improvement methods being adopted across a range of industries for gaining competitive advantage through (i) the identification of resources and capabilities (Wilk and Fensterseifer, 2003), (ii) assessment of motivation for the adoption of Six-Sigma (Henderson and Evans, 2000; Moosa and Sajid, 2010; Braunscheidel *et al*., 2011) and (iii) collaboration and partnerships developed with suppliers and evolving relations with customers (De Toni and Tonchia, 2003). In addition, supplier selection is also considered to be a key improvement factor (Chan *et al*., 2008).

The primary reasons why organisations adopt improvement methods such as Six-Sigma are to improve performance in key areas such as quality, cost, flexibility, and customer service levels (Thawani, 2004, Karim *et al*., 2010). In this regard, Six-Sigma and other improvement methods and philosophies are being adopted across a range of industry sectors with a varying degree of success from both internal and external performance perspectives (Arif-Uz-Zaman and Ashan, 2014). Adoption of such approaches and methods for continuous improvement and their varying levels of success have led many researchers to investigate the selection of improvement methods, for providing the best outcomes such as cost reduction (Bilgen and Sen, 2012), improved efficiency (Banuelas *et al*., 2005), and return on investment (Swink and Jacobs, 2012). This study focused on Six-Sigma which was defined by Pande *et al*. (2000) as follows

> *"A comprehensive and flexible system for achieving, sustaining, and maximizing business success. Six-Sigma is uniquely driven by close understanding of customer needs, disciplined used of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes*".

The importance of studying Six-Sigma partly lies in its uniqueness among other improvement methods. According to Shafer and Moeller (2012) there are theoretical differences between Six-Sigma and other improvement methodologies and Parast (2011) argued that the advantage of Six-Sigma lay in its ability to underpin cross-organisation problem solving by enabling a suitable organizational context. Jin et al. (2011) suggested that the ability of Six-Sigma to incorporate statistical tools in problem solving gave it an advantage over other

problem solving tools. However, for all the advantages it can bring to an organization, the implementation of Six-Sigma is also an expensive and disruptive endeavor. This is because it typically involves major changes to organizational activities as well as the responsibility for these activities (Jacobs *et al*., 2015).

Given the potential disruption that implementation of Six-Sigma can cause as well as the significant investment required for such implementation, it is important that organisations make every effort to ensure its success. There is common acknowledgement that selection of the right project is important to Six-Sigma success (Kwak and Anbari, 2006). The following section examines previous studies that have examined Six-Sigma project selection but does not describe the fundamental nature of Six-Sigma as such description is widely available in extant literature (e.g. Tjahjono *et al*., 2010; Kwak and Anbari, 2006).

2.1. Six-Sigma project selection

The selection of projects within a Six-Sigma programme has been described as an important concern for organisations irrespective of whether they are new to the initiative or not (Ray and Das, 2010). According to Padhy and Sahu (2011), the ability to successfully deploy a Six-Sigma initiative is commonly linked with the selection of the right project and they went further to analyse the importance of making the right choices. They argued that organisations have limited resources and there is an imperative to achieve multiple objectives and maximum business impact within the constraints of such resources. The implication, therefore, is that poor selection of projects can result in expending scarce resources on projects that deliver limited benefits.

Given the importance of the acknowledged link between Six-Sigma project selection and success, various studies have attempted to address project selection from different perspectives. These include, using analytical methods (Kumar *et al*., 2007; Kendrick and Saaty, 2007; Yang and Hsieh, 2009; Buyukozkan and Ozturkcan, 2010; Bilgen and Sen, 2012), case studies of implementation of SS in different industries (Motwani *et al*., 2004; McAdam and Lafferty, 2004) and analyses of SS implementation from a theoretical perspective such as RBV and institutional theory (Braunscheidel *et al*., 2011; Wilk and Fensterseifer, 2003; De Toni and Tonchia, 2003). However, many of these studies are limited to selection criteria that are based on singular theoretical perspective or performance perspective. They, therefore lack a focus on

the multiple objective dimensions that Padhy and Sahu (2011) suggested are important to project selection.

Thus, there is a need for research on SS project selection based on multiple performance perspectives and theoretical underpinnings. This is because, in practice, organisations are unlikely to only consider one performance perspective when evaluating potential projects. Essentially, different potential projects could lead to improvements in different dimensions of performance and organisations will consider these different dimensions of performance before deciding which projects to prioritize. Thus, there is a limitation in current project selection approaches, as they lack of consideration of influencing factors from a broad perspective.

2.2. Six-Sigma project selection criteria: RBV and Institutional theory perspective

The adoption of organizational theory in understanding SS success was strongly advocated by McAdam and Hazlett (2010) when they suggested that although there were many studies on SS, the link between theory and practice had not been consistently examined. Aside from the study of McAdam and Hazlett (2010) which considered SS from the theoretical perspective of absorptive capacity, Linderman *et al*. (2003) concluded that goal theory is one of the theories for understanding the SS phenomenon. Other studies that have examined SS from a theoretical perspective include studies by Krueger *et al*. (2014) which considered a grounded theory approach to analyzing SS, and Braunscheidel *et al*. (2011) which examined Six-Sigma adoption from an Institutional Theory perspective. However, this study examines SS project selection from a different theoretical perspective by arguing that resource-based view (RBV) theory can be applied and used for the purpose of sustaining competitive advantage within the context of Six-Sigma, while Institutional Theory can be used to better understand the firm's motivations for selecting projects. The application of such theoretical perspectives to SS project selection is lacking in industry despite the acknowledged importance of project selection and the suggested importance of linking theory to practice (McAdam and Hazlett, 2010).

Tables 1 summarizes the link between decision making criteria for SS project selection and the two identified theoretical perspectives and also describes the two theories. Table 2 provides a justification and description of the project selection criteria used in this study. Six criteria are identified, which are project feasibility, financial impacts, impacts on employees, impact on operational goals, impact on customers and impact on suppliers respectively. The

first three criteria are linked with RBV theory because feasibility and financial impacts have a direct link with the resource efficiency and financial benefits of Six-Sigma projects while employees are a core resource for the implementation and success of Six-Sigma projects. The importance of financial impacts and impacts on employees as a result of SS implementation have been identified by studies which include those by de Carvalho et al. (2014), Tjahjono et al. (2010) and Padhy and Sahu (2011).

From the perspective of institutional theory, impact on operational goals, impact on customers and impact on suppliers are important and relevant as these are objectives that could influence the selection of projects and which are attributable to institutional forces. The importance of suppliers, customers and operational goals in Six-Sigma implementation and success have been identified by a number of studies including Ray and Das (2010), van der Wiele et al. (2010), and Wu et al. (2012).

(Insert Table 1-2 about here)

(Insert Figure 1 about here)

3. Research methodology

This study extends the study of Kendrick and Saaty (2007) by considering two organizational theories – RBV and Institutional theory - to identify decision making criteria in SS project selection. The research methodology consisted of two stages. In the first stage, six decision making criteria, which consist of twelve sub-criteria were identified and prioritized by using Analytical Hierarchy Process (AHP). In the second stage, semi structured interviews were carried out to provide deeper insight into the findings from the first stage.

The analytic hierarchy process (AHP) proposed by Saaty (1977) is a multiple-criteria decision technique that is capable of combining qualitative and quantitative information in evaluating decision alternatives. It consists of three parts: the hierarchy structure, the pairwise comparisons matrix, and calculating the priorities (through the synthesis of normalised priority weights). Since this study examines multiple decision making criteria consisting of qualitative and quantitative data, AHP was an appropriate research method. Figure 1 presents the hierarchy structure of SS project selection. Based on the view that most decision makers are

not able to handle many factors associated with complex problems (David and Saaty, 2007; Chan *et al*., 2008), the problem of SS selection, subject to many factors, is broken down into more manageable sub-problems. As such, the SS project selection considered here has three levels of hierarchy: the main goal, criteria and sub-criteria. At the top level, prioritization of SS selection is set as the main goal, followed by six criteria at the second level of hierarchy. Each criterion of the second level is represented by two factors at the third level of hierarchy.

To construct the pair wise comparison matrices, a panel of thirty practitioners were selected based on their experience. They have been involved in SS projects as master black-belt, back-belt, process owners, green-belts in thirty Lean SS Listed Good Practice Companies awarded by Technology Promotion Association (Thailand-Japan) or TPA (www.tpa.or.th). They were either middle or top managers in manufacturing organisations. Table 3 presents the details of the practitioners who provided input for this study. All practitioners were interviewed personally in order to determine the relative weight across six criteria and twelve sub-criteria of SS project selection by using Expert Choice Software. First the relative importance of each criterion with respect to goal was obtained. Next the relative importance of sub criteria with respect to immediate higher level criteria was obtained. The final weights of each sub-criterion with respect to goal are obtained through the synthesis of normalised priority weights. The acceptable level of inconsistency index among practitioners was 0.10 or less (Bilgen and Sen, 2012).

(Insert Table 3 about here)

In the second stage, fourteen semi-structured interviews were conducted in five organisations to better understand how SS project was selected based on the research findings from first stage (McAdam and Lafferty, 2004; Su and Chou, 2008). These companies include two Golden Award winners, one Silver Award winner, and two Bronze Award winners given by TPA in 2013. The interviewees were from different management levels or were professional SS practitioners and included project team leaders, senior executives, and master black-belts (Table 4). The experiences of the interviewees in hands-on implementation of SS project(s) made them appropriate candidates to provide the rich detail required by the study.

Furthermore, in order to obtain information from multiple perspectives and consequently, enable triangulation (Yin, 2009), interviews were also conducted with suppliers and professional consultants with experience and involvement in SS projects. Each interview lasted between 30 minutes and an hour. Interviewees also provided some documented data obtained from their experience in implementing SS project(s) to support their viewpoints. The primary focus of the interviews was to understand the perceptions of the interviewees on whether the (i) the criteria/sub-criteria were suitable or applicable to their organisations in determining whether a SS project should be selected, and, (ii)how and why do these criteria/sub-criteria influence the success of SS project(s)?

(Insert Table 4 about here)

Interviews were conducted in 2014 with five multinational companies with manufacturing plant(s) in Bangkok, Ayutthaya, and Patumtanee, Thailand. Besides the face-to-face interviews, secondary information from company archives was examined to supplement the study. The details of the interview participants are presented in (Table 4). Among the five companies, Company A (the Japanese owned company) produces IC chips. Company B and C manufacture automotive parts/components and supply to Japanese and American Auto-maker respectively. Companies D and E are tier-I suppliers of American and European consumer electrical appliances (i.e. refrigerator, television, air-conditioner, and washing machine).

4. Findings

4.1. Findings from AHP analysis

Figures 2 and 3 present the relative weight among six criteria and twelve sub-criteria for SS project selection (stage 1). The results indicate that Impact on customer (0.443), financial benefits (0.21), and achieving operational goals (0.173) are the prominent criteria in justifying which SS project should be selected. Together, these three criteria account for more than 80% of the weighting for prioritization of SS project selection. In contrast, the other three criteria, project feasibility (0.082), impact on employees (0.057) and impact on suppliers (0.034) account for less than 20% of the weighting. The very distinct differences between these two sets of criteria indicate that SS project selection is primarily performance driven. Customer outcomes,

financial outcomes and operational outcomes are important dimensions of output performance for many organisations. It can be argued that these dimensions have a significant direct impact on the results achieved by an organisation, and consequently, its level of success. On the other hand, project feasibility, employees and suppliers can be argued to be more representative of enablers of success rather than dimensions of output performance.

(Insert Figure 2 about here)

From a theoretical perspective, Institutional Theory represented by Impact on customers, Impact on operational goals and Impact on suppliers is the more dominant theory accounting for almost two-thirds of the weighting for selection of SS project. On the other hand, RBV, represented by Project Feasibility, Financial Impacts and Impact on Employees accounts for only one-third of the overall weighting importance. However, within this classification, financial impacts is particularly prominent and this suggests, that when it comes to resources related to SS, financial resources are seen as being pre-eminent.

Within the Impact on customer category, increasing customer satisfaction (0.344) is the most prominent sub-criteria in contrast to new business (0.069) while cost reduction (0.163) is the most important sub-criteria in the Financial impact category in contrast to revenue generation (0.086). Within the Impact on operational goals category, improved compliance and controls (0.134) is seen as more important than reduction in cycle time (0.031). The implications of these prioritizations are clear – the second level drivers of SS project selection are retention of current customers by improving compliance and control while also reducing cost. This is in stark contrast to using SS to drive new business and improve top line performance by increasing revenue. At the other end of the scale, the least important of the twelve sub-criteria were, improved capability of suppliers (0.006), attraction and retention of employees (0.009) and availability of appropriate resources (0.024). The suggestion, therefore, is that these sub-criteria are not important considerations when it comes to SS project selection.

(Insert Figure 3 about here)

4.2. Findings from the structured interviews

Findings from the structured interviews are presented in this section. In many ways they support the findings from AHP analysis. In particular, the importance of the customer is indicated above all others. According to the executive from company A:

> "*Our key customers always request us to implement breakthrough improvement program including SS project(s) because they expect to receive the superior products with the minimal cost of production. They (customers) also consider how much achievement (i.e. customer satisfaction level, cost saving, and production yield) we can commit before and after implementing SS as one of order-winner criteria*".

This statement suggests that customers are key drivers of the need to consider initiatives such as SS. Perhaps, more importantly, it suggests that customers are seeking achievement of certain objectives such as customer satisfaction and cost saving. This concurs with the findings from the AHP analysis which suggests that customer satisfaction and cost reduction are seen as more important than new business and revenue generation. The implication, therefore, is that not only are customers important drivers of improvement initiatives such as SS, they are also increasingly responsible for determining the objectives that such initiatives should achieve. From the theoretical perspective, the reason why Institutional theory is more dominant is customer pressure. A similar view was expressed by Company C which has been very successful in implementing SS and was a winner of "Supplier Achievement Program (in 2011, 2012, and 2013)" – recognition from their key customer which is an American automaker. The company's approach to SS project selection was expressed as follows:

> *"From our five years' experience in implementing SS, we do agree that the most important stage is 'project selection". If you or your team decide which project(s)/area(s) of improvement should be selected correctly, 95 per cent achievement will be guaranteed. In our company, we consider two main reason,*

which are: (i) impact on our major customers (key accounts), and (ii) how much we gain in term of monetary (i.e. cost saving, increasing of sales) and non-monetary (i.e. productivity indexes, customer satisfaction level). Finally, technical feasibility will be carried out among project team members to ensure that we are able to close all selected project(s) within timeframe given by customers".

This view by Company C indicates that the key criteria they consider relate to the three most important criteria identified in the AHP analysis – customers, financial impacts and operational goals. However, it is important to note that the company also identifies technical feasibility as an important enabler of success. Company E, however, examined project selection from a different perspective. The senior executive for company E, based on his experience in implementing SS as a professional consultant (10 years as ASQ certified master black-belt) and project leader (5 years as Vice President of operations), summarized his concerns on how much benefit the company gains from implementing SS program in terms of human capital as follows:

"As both external consultant and full-time senior executive, I do believe that one of the most influential decision making criteria in SS project selection is how much your human capital assets will be enhanced. As we know, SS project requires high-skill and knowledgeable team who can think, analyse, and suggest all potential opportunities for improvement logically. Therefore, impact of selected SS project in term of knowledge (technical and non-technical) and skill (problem-solving) development need to be considered before selecting the right project".

This perspective therefore suggests that Impact on employees should be seen as important. However, this is not the perspective of the majority of experts, based on the findings from AHP analysis. Table 5 presents further quotations from the structured interviews related to all six selection criteria considered in this study.

5. Discussion

This study makes an important contribution to knowledge by investigating six sigma project selection and examining a combination of organisational and theoretical viewpoints. It is also a unique study that examines the topic from two theoretical perspectives (Institutional Theory and RBV). Furthermore, these two theoretical perspectives are contrasted in order to understand any differences in their impact on six sigma project selection. Therefore, this study makes an original contribution to understanding the selection and prioritization of six sigma projects. While previous studies (e.g. Kwak and Anbari, 2006; Miguel and de Carvalho, 2014) have suggested that project selection is important for SS and also identified a range of potential criteria for selection (e.g. de Carvalho *et al*., 2014; Bilgen and Sen, 2012; Grima *et al*, 2014), this study has set out to prioritise the importance of different criteria while also considering the theoretical drivers that underpin selection. The findings suggest that the selection criteria can be classified into two. The first category relates to performance outcomes and is represented by impact on customer, financial impact and impact on operational goals.

(Insert Table 5 about here)

This category is dominant and accounts for an importance weighing of more than 80%. However, closer analysis of these criteria combined with findings from the interview provides a number of interesting insights. Firstly, customers are dominant in the need to implement improvement initiatives such as SS and, secondly, customers, to some extent, specify the expected objectives of such implementation (e.g. cost reduction). Thirdly, SS project selection is primarily driven by the need to retain customers and reduce costs as opposed to seeking new business and increasing revenue. This is an important finding as it suggests that while businesses typically seek to get new customers and increase their income stream, these are not seen as the most important drivers of SS projects. Rather, companies that implement SS are more likely to seek to gain financially by eliminating waste via cost reduction rather than top-line growth.

The second category of criteria comprises project feasibility, impact on employees and impact on suppliers. Together, these criteria account for less than 20% of selection weighting importance and this study has classified them as enablers. In many ways, the low weights

attributed to these criteria come as an unexpected outcome. In particular, the almost negligible importance of attracting and retaining employees is surprising given the criticality of trained SS black and green belts to the implementation of SS projects and the amount of time, resource and training required to achieve this status. This caveat was expressed in the interviews by the executive from Company E who insisted that employee skills should be an important consideration in SS project selection. The low importance given to impact on employees concurs with the finding by de Carvalho *et al*. (2014) that linking 'SS to human resources' is not very important. However other studies such as Buch and Tolentino (2006) and Tjahjono et al. (2010) identified the centrality of employees and their skills to SS success. Therefore, there is still a lack consensus about the relationship between SS project selection and the impact on employees.

The results also show that impact on suppliers, which included gaining mutual benefits with and enhancing capability of supplier is the least important criterion. Given that suppliers and their inputs count as significant contributors to the organization's "transformation tasks", their role was expected to be high but was not. The findings contrast with the findings of Van de Wiele (2010) and de Carvalho *et al*. (2014) that SS implementation impacts strongly on suppliers. The findings indicate that from the Institutional theory point of view, the impact on customers is much more important than the impact on suppliers. Therefore this study finds that with respect to SS project selection, companies are much more concerned about how the project will impact customers than how it impact suppliers, even though suppliers are important contributors to the processes of an organisation.

5.1 Sensitivity analysis

To observe whether variations in the decision criteria would change the final weights of criteria in SS project prioritisation, a sensitivity analysis was performed. It is especially important in this study since the weights for criteria and sub-criteria are obtained based on experts' judgements. First, the change in the feasibility weight was observed. Figure 4 presents how the final weights varied with respect to the change in the feasibility. By increasing the feasibility weight, the *Technical feasibility* still is more important than *Availability of appropriate* resources. By increasing the financial impact weight (Figure 5), *Cost reduction* is still more important than *Revenue generation*. For the other four criteria, Impact on customer, Impact on

operational goals, Impact on employees and Impact on the supplier, the changes in final weights do not change the priority of sub-criteria. Figures 6 to 9 present these results respectively. Finally, the overall performance of the sensitivity analysis is presented in (Figure 10). Customer satisfaction is the most important factor in prioritising SS project selection. The conclusion, therefore is that the findings from AHP analysis provide a robust indication of importance of selection criteria for SS prioritisation.

6. Conclusions

The selection of the right project has been widely acknowledged as an important factor in the success of SS initiatives. Given that selection of such projects can be influenced by different criteria, this study set out to identify if some selection criteria are considered to be more important than others. The study found that impact on customers, financial impact and impact on operational goals were the most important selection criteria. In contrast, project feasibility, impact on employees and impact on suppliers were all seen as significantly less important criteria in SS project selection. The study also found that SS project selection is primarily driven by the need to retain customers and reduce costs rather than attain new customers and grow revenue.

The study has important practical and academic implications. From an industrial perspective, there are implications for drivers of implementation of six sigma projects. Organizations need to be aware of the different drivers and potential outcomes that relate to six sigma implementation. Therefore, when faced with a range of potential improvement projects, there is a need to understand the primary driver and outcomes of each potential project and prioritize selection based on the objectives of the organization (e.g. customer satisfaction). In particular, the finding suggests that organizations need to heed the voice of the customer when it comes to SS project selection. They also need to, simultaneously understand how the project will deliver financial and non-financial benefits to the organization. However, at present, in the drive to satisfy customers, organisations may be failing to adequately attain benefits related to new customers and revenue growth. Therefore, in the selection of SS projects, organisations should seek a better balance between the defensive strategy of customer satisfaction/retention and the offensive strategy of customer growth. In addition,

more attention should be given to the impacts on employees and suppliers as these are major contributors to organizational success.

From an academic perspective, the study has implications for the application of theory to six sigma selection projects. It suggests that there are multiple theoretical drivers for six sigma selection (e.g. Institutional Theory, RBV) but that there are significant differences in the importance and influence of these theoretical drivers. This implies that the relationship between theory and six sigma project selection is not simplistic **and** needs to be further examined. In particular, given the high levels of skills required for SS certification and the resources necessary for such certification, the relationship between employee retention and skills and SS project selection and success requires further investigation. In addition, given the indicated low importance given to impact on suppliers, there needs to be better understanding of how SS projects affects suppliers and the strategies and approaches that they adopt to compensate for disruptive changes.

(Insert Figure 4-10 about here)

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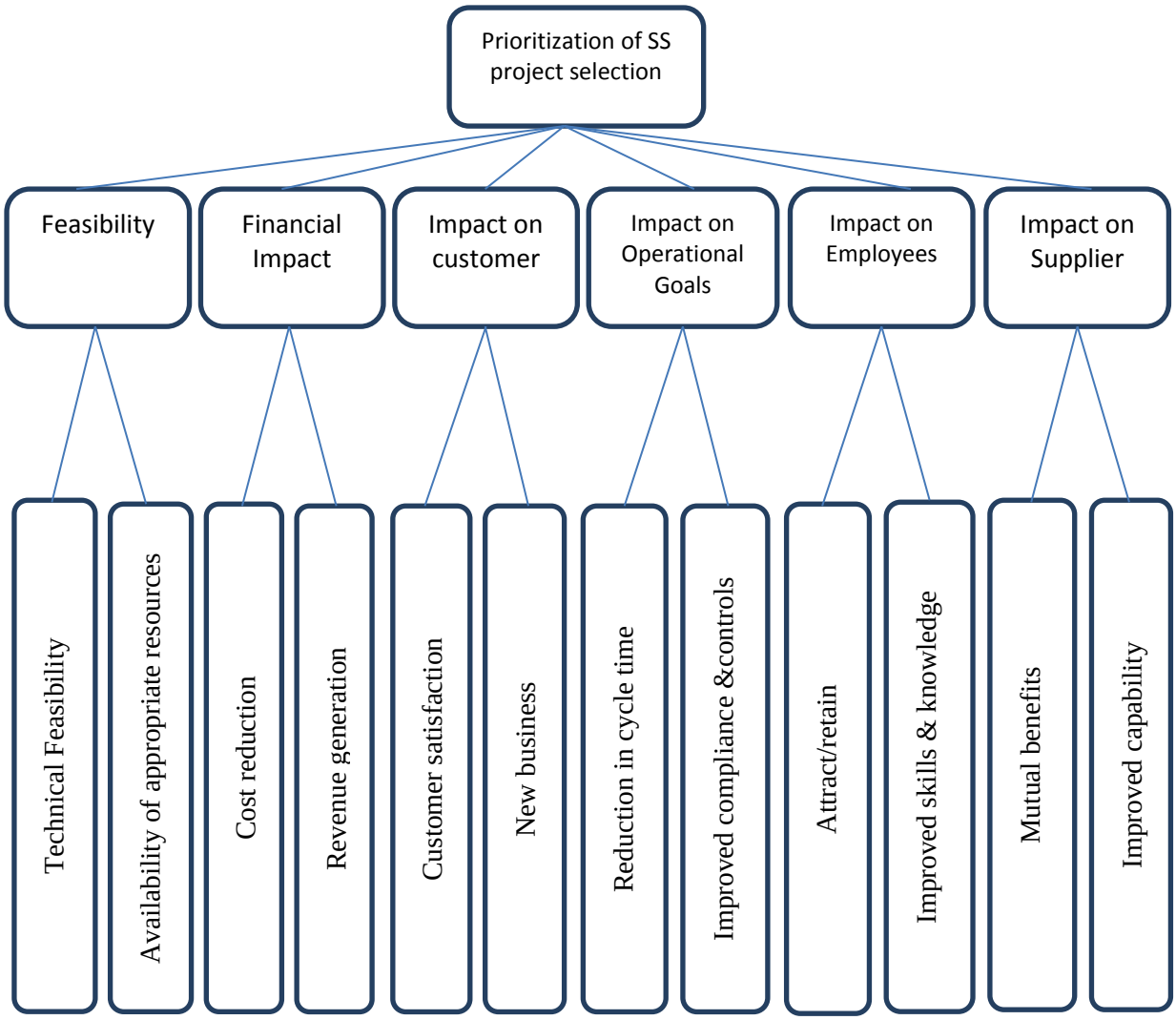

Figure 1. Hierarchy structure of SS project selection

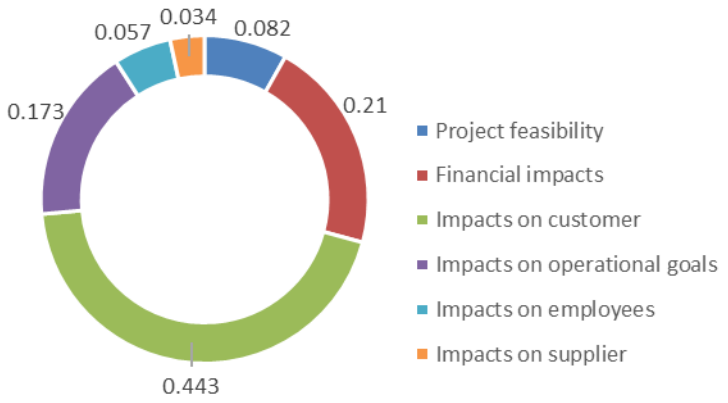

Figure 2. The relative weights among 6 criteria for SS project selection (Inconsistency index = 0.09)

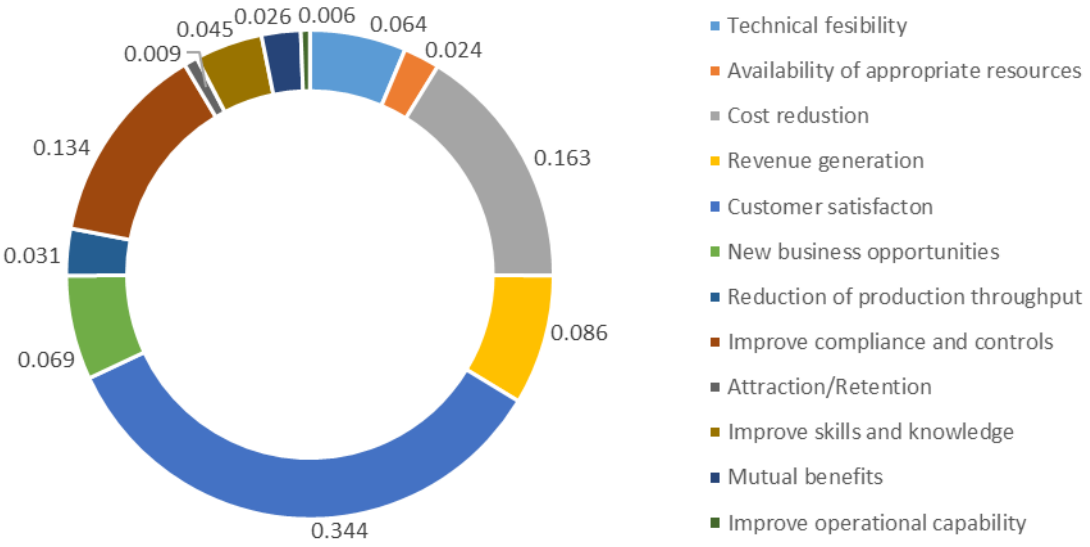

Figure 3. The relative weights among 12 sub-criteria for SS project selection (Inconsistency index = 0.04)

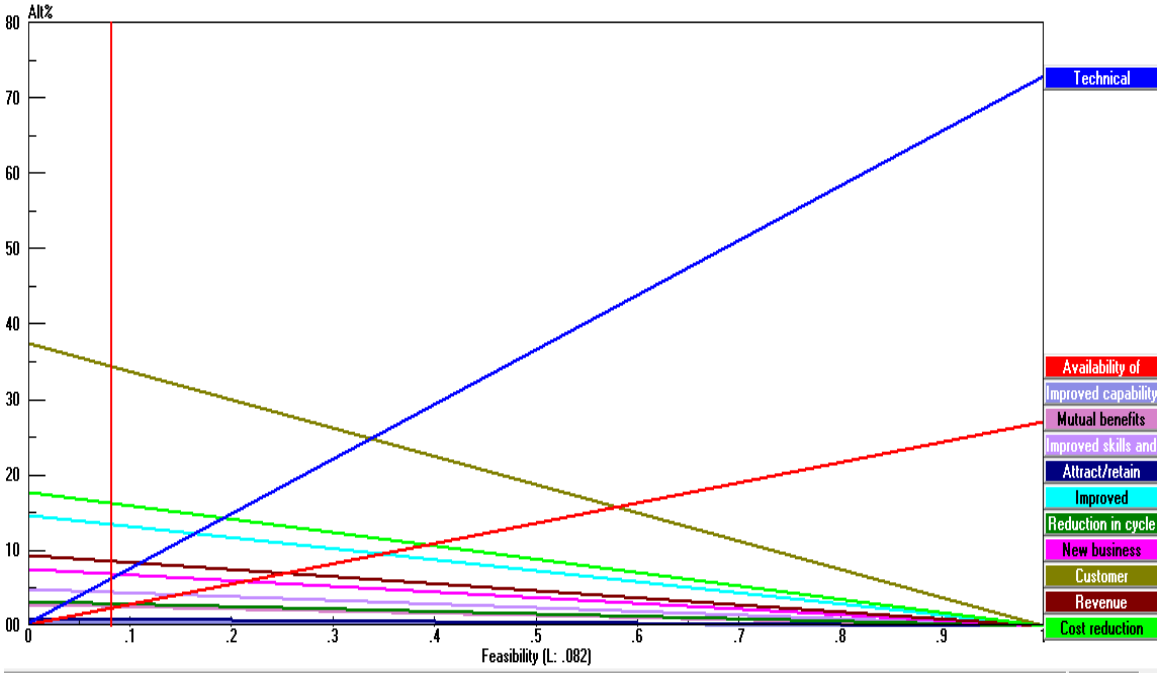

Figure 4. Sensitivity analysis of final priorities when Feasibility weight is varied

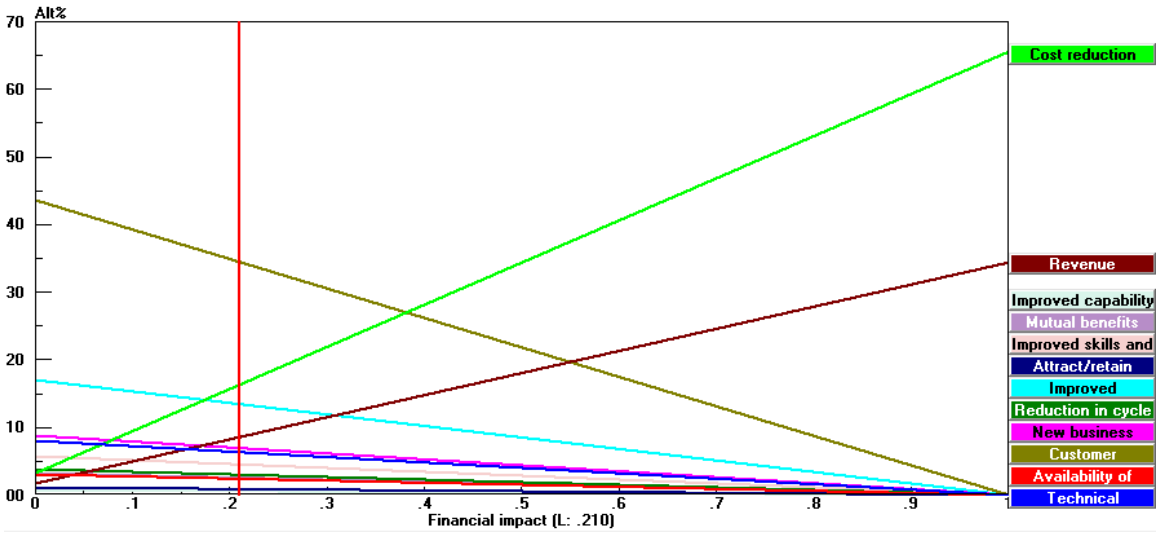

Figure 5. Sensitivity analysis of final priorities when Finacial impact weight is varied

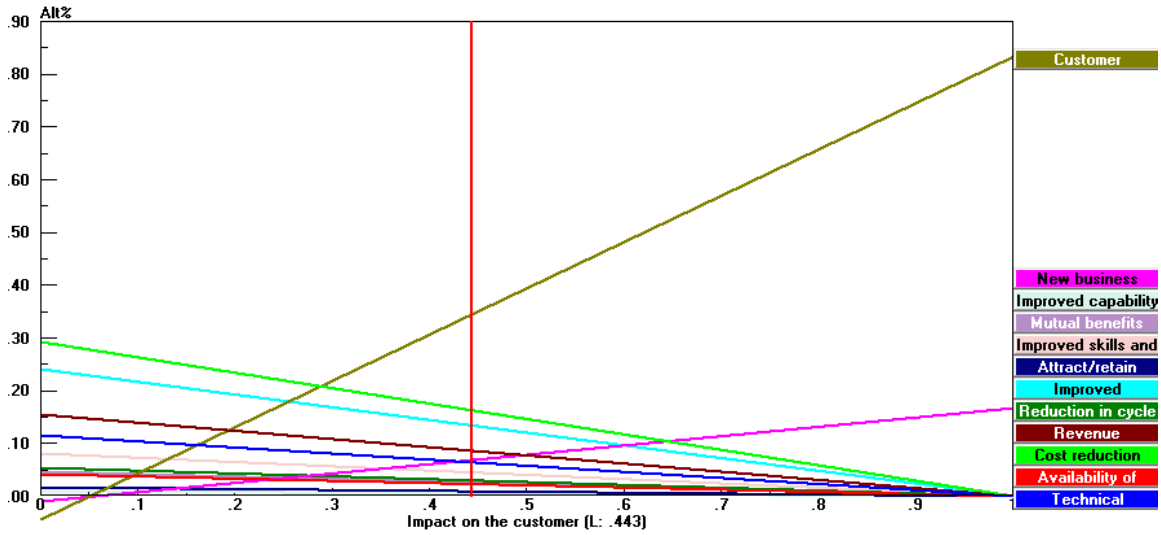

Figure 6. Sensitivity analysis of final priorities when Impact on customer weight is varied

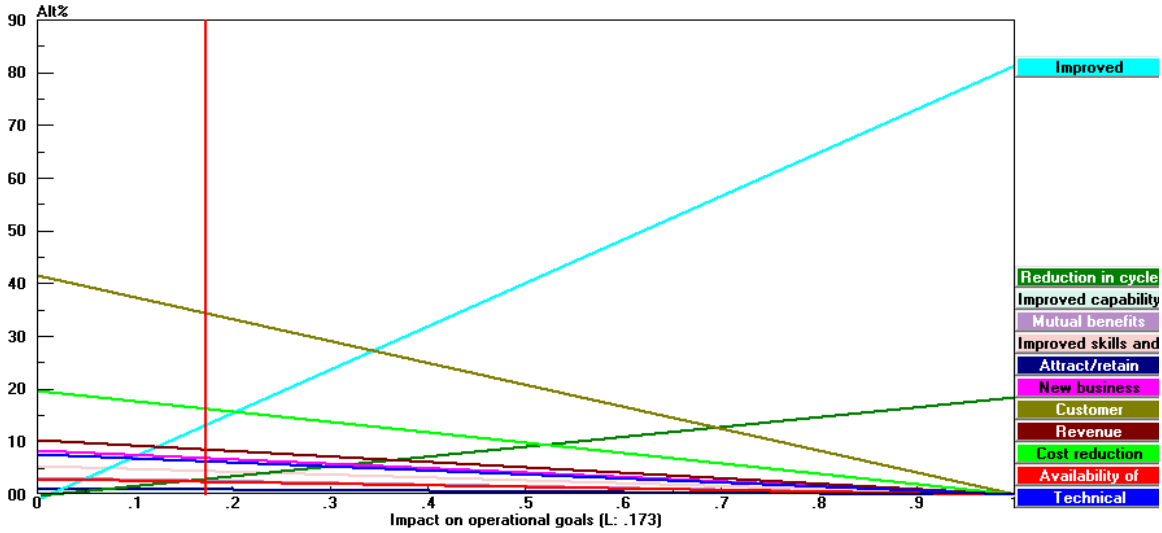

Figure 7. Sensitivity analysis of final priorities when Impact on oprational goals weight is varied

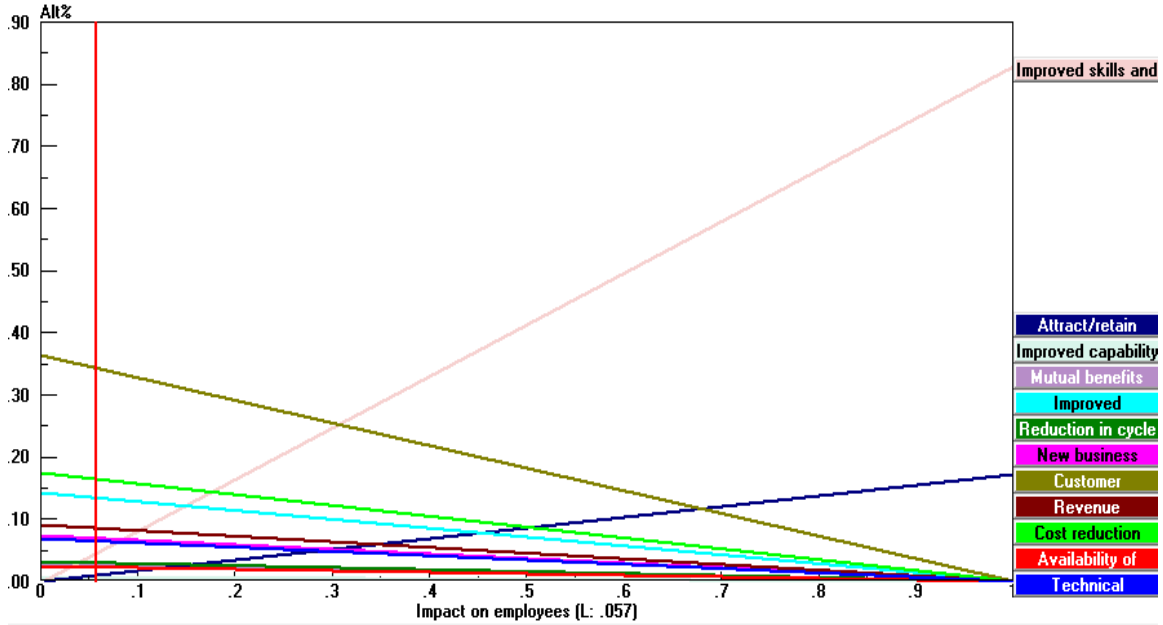

Figure 8. Sensitivity analysis of final priorities when Impact on employees weight is varied

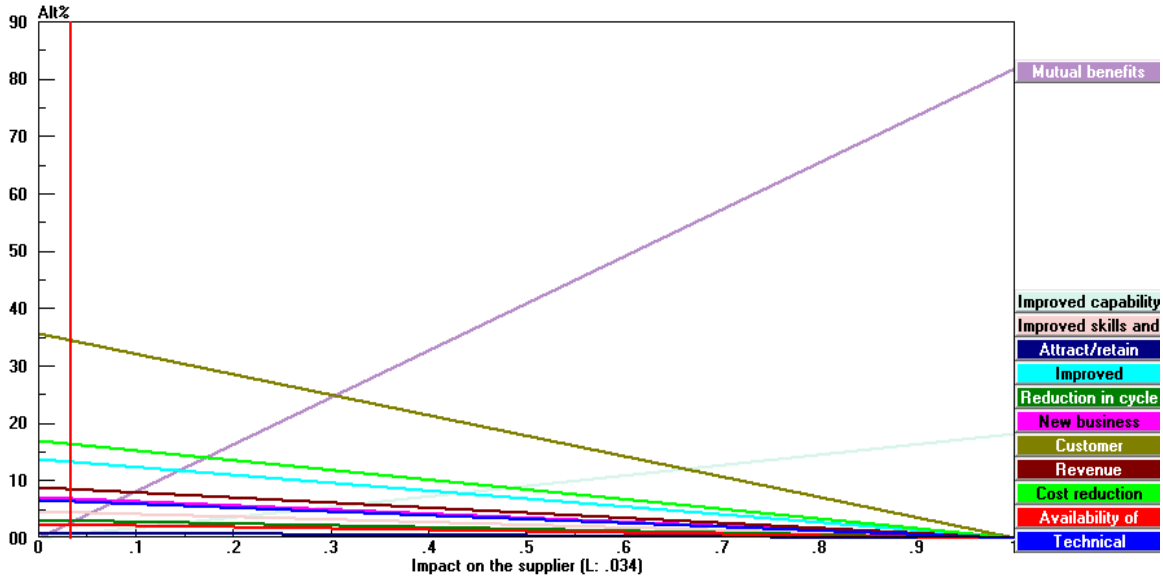

Figure 9. Sensitivity analysis of final priorities when Impact on supplier weight is varied

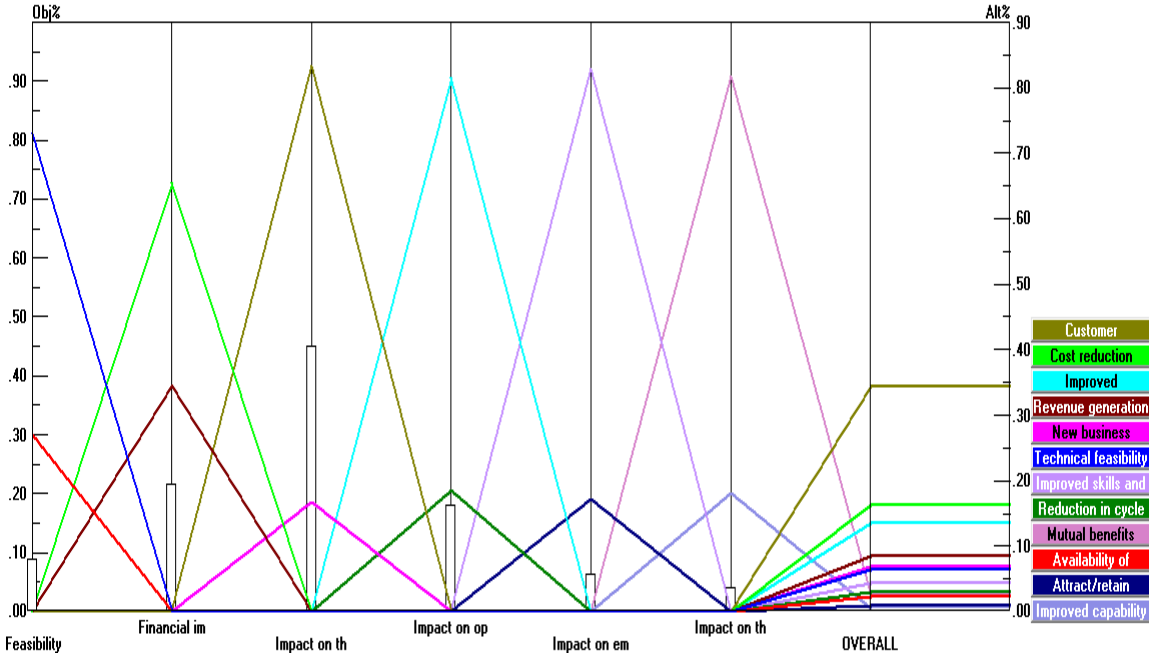

Figure 10. Overall performance of sensitivity analysis of final weigh priorities

Table 1. Justification of SS project selection criteria reflecting the applicability of RBV and Institutional theory

Organizational theory	Descriptions of theory	SS project selection criteria
RBV	RBV theory has emerged as one of the theoretical perspectives used to explain persistency in inter-firm performance differences (Barney and Griffin, 1992). It is important to note companies have collections of unique resources and capabilities that are valuable, rare, inimitable, and non-substitutable. These lead company to be able to achieve a sustainable competitive advantage and increase the capabilities. Resources could be tangible and intangible assets that are either owned or controlled by a firm, whereas capabilities refer to its ability to exploit and combine resources through operational routines in order to achieve its objectives (Amabile et al, 1996). In order to make the right decision in selecting SS project, this study examines how much the project impact to company's resources, which include technology, financial, and human factor.	Feasibility Financial impacts Impact on employees
Institutional Theory	Institutional theory suggests that adoption of operational routines is an institutional process subject to the influence of three pressures or forces – coercive (refers the influence of regulatory authorities to influence conformity), mimetic (refers to the pressure to 'mimic' more successful competitors in the industry, and normative (refers to market forces usually typified by pressure from customers). It has been argued that normative pressures typically move along the supply chain from customers to suppliers with the customer usually wielding the power (DiMaggio and Powell, 1983; Hill, 1997). Consequently, some companies may use the leverage of institutional pressures to improve performance while others may seemingly adopt practices to conform to expectations of the market or regulation. In this study, main factors that force company to select the right SS project are: an inquiry made by key and potential customers, benchmarking of operational performances with key competitors, and enhancing supplier's capabilities to sure that the overall performance will be achieved along the entire supply chain.	Impact on operational goals Impact on customers Impact on suppliers

Table 2. Six sigma project selection criteria and factors

Main Goal	Criteria	Factors	Description/Classification
Prioritization of SS project selection	Feasibility	Technical feasibility Availability of appropriate resources	Closely aligned to the feasibility of the project which is one of the five business drivers for prioritizing business process improvement projects (Kendrick and Saaty, 2007)
	Financial Impact	Cost reduction Revenue generation	Identified as one of the most important strategies for extending the market share, through process and reliability improvement and eliminating the cost of poor quality (Adam et al., 2003; Saghaei and Didehkhani, 2011)
	Impact on customer	Customer satisfaction New business	Impact on customer and associated factors are directly related to reaching business excellence and competitive competencies which are recognized as main aims of implementing SS projects (Saghaei and Didehkhani, 2011)
	Impact on operational goals	Reduction in cycle time Improved compliance and controls	Direct relationships between effects of management practices on internal process quality and product quality performance (QP) and their effects on operational performance (OP) and business performance (BP) (Brady and Allen, 2006)
	Impact on employees	Attract/retain Improved skills & knowledge	Closely aligned to the human resources perspective of the balanced scorecard which is one of the five business drivers for prioritizing business process improvement projects (Kendrick and Saaty, 2007)
	Impact on supplier	Mutual benefits Improved capability	Globalisation and inter-organisational linkages is enabling diffusion of SS throughout the supply chain including suppliers (van der Wiele et al., 2010). The ability of a supplier to link sig sigma efforts to customers is important to success (de Carvalho et al.2014).

Table 3. Qualification of practitioners who carried AHP

No	Section/Dept.	Position	Experience	Types Of Industry
1	Design and Engineering	Engineer	1Y7M	Home Appliance
2	Design and Engineering	Senior Engineer	8Y7M	Electronics
3	Optical Supply Chain	Engineer	7Y	Communication devices
4	Product Development	Engineer	3Y4M	Telecommunications
5	Facility Department	Engineer	2Y6M	Automotive
6	Marketing and Sales	Engineer	6Y	Automotive
7	Engineering	Engineer	5Y9M	Electronics
8	Mechanical Assembly	QA	5Y8M	Electronics
9	Mechanical Assembly	QC	5Y2M	Electronics
10	Quality System	QMR/EMR	10Y	Automotive
11	Draught Beer and Service	Department MGR	8Y	Beverage
12	Production	Engineer	3Y	Electronics
13	Product	Product Engineer	7Y	Automotive
14	Planning	Production Control	2Y10M	Electronics
15	Production	Production Engineer	7Y10M	Electronics
16	Quality Control	QC	3Y6M	Automotive
17	Process Engineer	Process Engineer	10Y	Electronics
18	Marketing Department	Sales Executive	3Y	Automotive
19	Operations Department	Engineer	3Y	Electronics
20	Manufacturing Engineering	Process Engineer	3Y3M	Electronics
21	Customer service	Engineer	4 M	Automotive
22	Middle process section (FPC)	Engineer	4Y	Electronics
23	Quality Management System	Senior Engineer II	3Y3M	Electronics
24	Production Dept.	Section Manager	15Y5M	Cement
25	Product Quality Engineer	Engineer	3Y	Electronics
26	Production Control Section	Engineer	9Y10M	Electronics
27	Business Development	Ops Manager	9Y	Agriculture
28	System Development	Engineer	2Y8M	Communication devices
29	New Product Introduction	Engineer	8Y	Electronics
30	Regional Production Control	Engineer	6Y	Automotive

Table 4. Company profiles – Semi-structured interviews

Company (Interviewees)	**Nationality**	**Industry**	**Experience** (in implementing SS (years))
Company A (Master Black-Belt, Black-Belt, Process Owner)	Japanese	IC chips	6
Company B (Mfg Div Director, Master Black-Belt)	Thai	Automotive parts	4
Company C (Master Black-Belt, Project Mgr, Consultant)	American	Automotive parts	10
Company D (Country Mgr, Black-Belt, Green-Belt)	Japanese	Electrical appliances	8
Company E (Vice President, Master Black-Belt, Consultant)	European	Electrical appliances	7

Table 5. Criteria for SS Project Selection – Findings from interviews

Criteria	Observations (Company)
Customer Satisfaction	"Major customers always push us to implement breakthrough improvement initiative on annual basis"(A, B, and C). "Efforts in implementing SS Way is one of the supplier evaluation criteria" (A and E). "Voice of the customer, a common feature of process improvement projects" (D).
Cost Reduction	"The main objective in selecting SS project is how much cost can be reduced" (A, D, and E). "Specified sets of KPIs (including cost reduction) to search and implement process improvements" (A and C).
Improve Compliance and Control /Cycle time reduction	"Our SS project team frequently apply this initiative to re-design operations process" (D). "SS project leader created to act as change agents and to spread breakthrough improvement culture" (B and E).
Technical Feasibility and Availability of Appropriate Resources	"Selection of highly motivated employees as trainees". "Professional consultants are very important for the successful of SS project" (A, C, and E). "Experts in a specific area (i.e.IT, Engineering Design) frequently included in SS project team" (B and C).
Improve Skills and Knowledge/ Job Retention	"The high level of counter measures in implementing SS project leads to improve skills and knowledge of our project team. (i.e. SPC, FMEA, Mistake-proofing, and mathematical modelling)" (B, C, and D). "Front-line employees trained to work on improved processes by process" (A and E). "Well defined paths for professional development of full-time SS project team members" (B and E).
Revenue Generation	"New major customer always ask for SS implementing plan or some example of susses stories as a part of supplier selection criteria" (A, D, and E). "Special emphasis placed on data/information to incorporate trade-offs of functional goals in the interest of organizational performance" (B, D, and E).
New Business Opportunity	"Implementing SS project is one of order-winner for major customer(s)" (C and E). "SS implementing plan need to be submitted to customer(s) in order to maintain the business contract" (D and E).
Mutual Benefits/ Improve Capability of Supplier	"Use of SS projects to target specific process improvement goals for all of our existing suppliers" (A, B, and E). "Selection of highly capable suppliers as our long-term business partners" (B, D, and E).