

Six Sigma: A Product Differentiator in the market for Manufacturing Industries

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Abstract

Global competitiveness has compounded pressure on a lot of organizations to perform in their own local markets as competitive products are landing in the markets with enhanced features and competitive prices. Many businesses embark on business improvement approaches to extricate themselves from the competitive jungle that they find themselves in, by deploying superior or cutting edge methodologies like Six Sigma. Six Sigma's success in saving companies millions of dollars has been proven for a very long time and its relevance as a product differentiator in the product market is still valid currently. The basic creeds of Six Sigma are able to carry an organization to competitive advantage if it is successfully implemented by an organization and the results are measured as per the methodology. This paper's aim is to unravel the product differentiation prowess of Six Sigma in the market and its capability to render competitive advantage to the business through its performance attributes. A comprehensive literature review was done pertaining to the basic tenets of Six Sigma and its applicability in the manufacturing industries. Published articles and recent books on Six Sigma were reviewed to extract the dominancy and relevance of Six Sigma as a business competitive tool. With many business improvement approaches at the disposal of manufacturing organizations, the literature review and case study sought to unveil the underlying advantages embedded in applying the Six Sigma approach and why it is still the option of choice. Organizational decision-makers are granted a platform to evaluate the Six Sigma practices and the limitations posed by ineffective implementation.

Keywords

Six Sigma, Differentiation, Product Market, Applicability, bottom-line.

1. Introduction

Each enterprise should generate cash in one formula or alternative to remain in business and if the enterprise expends further than it earns, then it will go out of business, leaving the task of each business being to become cost-effective at whatsoever it does so it can stay doing whatever it does, this then pins Six Sigma (SS) experts to learn a master the first principle of the S-bar calculation: $\$!$ (Munro, 2008). Out of the numerous approaches meant for productivity enhancement and cost diminution, LM and SS are widely acknowledged as exceptional due to their ability to unswervingly transmit waste alleviation and variability decline as a technique of backing business effectiveness and competitiveness (Pacheco et al, 2015:161). The application of SS and Lean Manufacturing (LM)

in business is quite broad globally and nevertheless project catastrophes are rampantly reported with these failures attributed to pathetic project selection ((Eaidgah et al, (2016:193), Kornfeld and Kara, (2013:4)).

Projects culminate from the strategic intent of the business and their selection is meant to operationalize corporate strategy but that link is not clearly evident in a majority of firms as proffered in a study for Italian manufacturers by Cagliano and Spina (2000) that only 43 percent of the time did they make allied improvement programs with business strategy, yet researchers like Chou (2008) and Antony and Banuelas (2002) signify that proper project choice is prominent as a key success factor in any continuous improvement initiative (Kornfeld and Kara, 2013:4). Project selection methodologies like the analytic hierarchy process (AHP) have been broadly appraised by scholars as recommended frameworks to link corporate strategy to SS projects selection criteria on the basis of potentiality to realizing perceived future longings and therefore it is believable that skipping of a systematic framework to project selection spells of projects disaster (Kornfeld and Kara, 2013:6). Kornfeld and Kara (2013:15) concluded that even though projects that consist of SS projects eventually express corporate strategy, it was identifiable that there are concealed gaps when it comes to industrial implementation of projects of which enterprise strategy connivance is disregarded due to practitioners merely obligating themselves to casual systems and subjectivity to project choice criteria.

SS boasts of an organized and methodical practice premeditated to provide impeccable products and services on a reliable foundation and its intent is to increase the organizational financial well-being by discovery and eradicating the sources of errors and deficiencies in the industry processes as it aims to attain process capability of $C_{pk} > 1.5$, which is regarded first-rate performance (Munro, 2008). SS emanates from statistics and the Greek alphabetic letter σ (sigma) denotes the standard deviation, which is the dispersal of the statistics from the mean average with 6 σ level equating to 3.4 defects per million opportunities (99.999660% success rate) and SS apart from being statistical, applies numerous non statistical implements and methods (Ismyrlis and Moschidis, 2013:109). The pioneering implementation and commercialization of SS is attributed to Motorola and then GE who pioneered it with the mandate to diminish variability in industrial processes with the objective of serving the company clients with goods or services with greater reliability and less faults, and the journey did not end there as some airline companies are currently trying to embrace 7 σ (Chakraborty and Chuan, (2013:141), Ismyrlis and Moschidis, (2013:109)). SS entails pursuit of a statistical regime and is project focused with targets on well detailed project that impact on business profitability, championed by highly trained statistical and projects personnel whose designation in the SS world is called "Black Belts." (Munro, 2008). They thrive on the DMAIC methodology to issue resolution which is phased into the define, measure, analyze, improve, and control stages (Munro, 2008).

The toolset of SS comprise of qualitative and quantitative practices utilized by the SS professionals to pursue process enhancement and the likes of SPC, control charts, FMEA, and process mapping make the list of such tools which are used to achieve SS quality measure of 3.4 defects per million opportunities (responsible for a 1.5-sigma move in the mean) (Munro, 2008). The forte of SS is bedded in its soundly distinct structure encompassing approaches exploiting diverse apparatuses and methods (Chakraborty and Chuan, (2013:141). Nowadays, SS is widely used in conjunction with lean manufacturing (LM) and the double benefit of process variability lessening and waste lessening have been the hallmark of the combined system termed Lean Six Sigma (LSS) (Munro, 2008).

Though SS is ranked as one of the most recently added business/quality improvement initiatives, it is not globally prevalent as might be projected by others, but it is highly esteemed in the USA whereas in other regions like Europe, it is the ISO standards that are mostly used and cherished in industries (Ismyrlis and Moschidis, 2013:108). The uniqueness of SS is seen by the structured outline that standardizes processes and quantifying outcomes with a monetary attribute and with the application of quantitative practices and implements, and this has engrossed the devotion of researchers and practitioners alike (Ismyrlis and Moschidis, 2013:108).

2. 2. Six Sigma Flexibility

SS is not a rigid system that solitarily exists and it has been demonstrated that it can be effortlessly pooled with other systems like lean manufacturing to formulate even sturdier systems. SS exceeds the metric-based issue resolving and practice upgrading implements and it has attained the adorable status of a management system for endless corporate perfection that centers management and the business on fundamental areas that seeks to apprehend and accomplish consumer desires; bring into line vital practices to realize consumer needs; exploiting arduous data exploration to recognize and diminish variation in crucial processes and motivating swift and maintainable advance to the industry systems (McCarty et al., 2005). Marques et al., (2013:36) who defined SS as a process-centered methodology meant at realizing industry enhancement as it is targeted on explicit essential processes on an individual project basis which

entails capturing customer desires and delivering goods and services to satisfy them, reconnoitered the harmonious acquaintance between SS and ISO 9000 QMS. For SS to be entirely comprehended and its proficiencies realized, it is commended that it be regarded in three standpoints which are metric, system/methodology and management classifications angles (McCarty et al., (2005), Marques et al., (2013:38)). The bulk of SS specialists in SS establishments that embrace black and green belts have had definite training on the metric and methodology facets of SS but it is not so when it comes to the management system facet of SS which is an enterprise practice ideal of structure that applies a data-driven managing style built on a distinctive functional measurement scheme (McCarty et al., 2005).

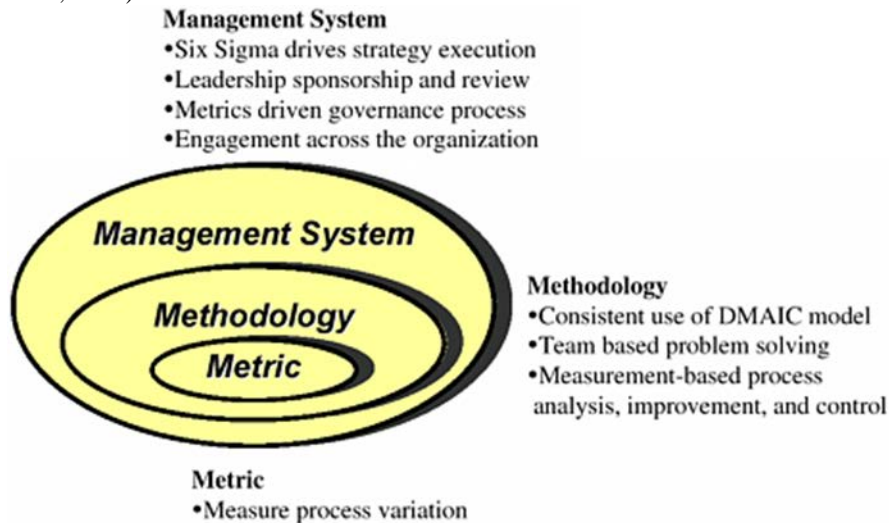


Figure 1. Six Sigma depicted as a Metric, Methodology and Management Arrangement: Source - McCarty et al., (2005).

Metric aspect: variation in SS is statistically measured by the sigma standard deviation as the degree of control of processes to meet specified performance standards in critical to quality (CTQ) characteristics (Marques et al., 2013:37). SS deals with Defects Per Million Opportunities (DPMO) and 6 sigma accounts for 3.4 defects per million opportunities, but it should be distinguished that not all processes are required to run at 6s level, as the recognized quality strides of performance are directed by the strategic connotation and the budget of enhancement comparative to its value (McCarty et al., (2005), Marques et al., (2013:38)).

Methodology aspect: A structured, disciplined, customer-centered and profit-focused system are the hallmarks of SS and the project choices are consequential to corporate objectives and strategy with their execution sequential and phased with selective tools applied at each stage. Proven SS methodologies are:

- (1) DMAIC (define-measure-analyze-improve-control) and,
- (2) DFSS (Design for Six Sigma).

DFSS can be deployed to design or redesign fresh goods/facilities and the identify-design-optimize-validate (IDOV) and define-measure-analyze-design-verify (DMADV) are among the prevalently applied tactics in DFSS projects (Marques et al., 2013:38, Laux et al, (2015:146)).

Management system aspect: leadership establishment for SS corporate wide application is the major intent of SS with such notable leadership excursion accomplished by the likes of Jack Welch of GE and Bob Galvin of Motorola strategically deployed SS in their organizations in expansive application latitude (Laux et al, (2015:146), Marques et al., (2013:39)). When SS is coupled with the business strategic undertakings then its greatest impact on business results is realized and this is attained by highlighting and picking projects that give the furthestmost to the establishment's business performance and as such, the SS management system comprises both the SS metric and the SS methodology and it is when it is employed as a management system that businesses grasp the utmost impression (McCarty et al., (2005), Marques et al., (2013:38)).

The active amalgamation of SS suite with prevailing management arrangements like ISO 9000 QMS has been accepted as a vital feature to the effective utilization of SS in enterprises reciprocal paybacks are reaped in merging

and articulating SS with the desires of the ISO 9001 standard (Marques et al., 2013:54). The global competitive era has not only exerted pressure on the manufacturing enterprises from their consumers (to condense product costs) and opponents (so as to gain the marketplace amplified stake), but this has affected other industry segments as well and this have attributed to the integration of SS with other manufacturing attributes such as LM to form hybrid systems such as Lean Six Sigma in a more synergistic mode (Reosekar and Pohekar, 2014:392 – 405).

3. Six Sigma Implementation Failure Prevention

The structured approach of SS generally takes the following constituents:

- (1) The DMAIC tactic
- (2) CTQ focus, which entails understanding consumer requirements and establishing those features of the product which are essential for satisfying the needs.
- (3) DFSS/ DMADV, for errors or defects elimination during product or process design phase
- (4) The outcomes of its employment are conveyed in monetary expressions and this includes: market performance, cost reduction, performance on customer satisfaction, inventory levels, cycle time reduction, defects rate reduction, delivery velocity and production rate.
- (5) Presence of a categorized belt classification, with licensed personnel (champion, master black belt, black belt, green belt, etc.).
- (6) Top-down style. This entails that its application is driven by the requisite guarantee and involvement of the top management.
- (7) Performance metrics. Metrics are exploited to expose the business performance in its processes, and the most frequently used are: Sigma level, DPMO, and defect per unit (DPU) (Ismyrlis and Moschidis, 2013:110).

Despite the existence of a structured approach for SS, failures are always imminent in the industrial set-up when it comes to its implementation. Miscarried application projects of SS execution cause financial harm and impending opposition towards transformation amongst the participants taking part, it is hence important that the application approaches utilized are soundly adapted (Chakraborty and Chuan, (2013:143).

Corporates have reaped different outcomes after having employed SS owing to the intricacy of the approach, and hence to ensure an effective application, consideration must be given to the critical fundamentals of SS (Ismyrlis and Moschidis, 2013:111). These key fundamentals are stipulated below:

- 1) Management participation and obligation.** Reflected as the most essential aspect, as SS is a top-down methodology and any endeavor for enhancement emanates from the top leadership
- (2) Applicable Development and education.** SS with its belt system entails targeted training and continuous development of the implementation team members.
- (3) Cultural transformation.** This signifies the capability of the business to embrace and apply effortlessly fresh notions, models, approaches and to be elastic in captivating resolutions for continuous improvement.
- (4) Ascribing the attainment to monetary benefits.** SS utilizes techniques of evaluating performance subsequently to denote the realization of its application and monetary measures are employed.
- (5) Deployment of quality-statistical apparatuses and statistical examination.** The utilization of tools and practices for root cause exploration, statistical data analysis and resolution are reflected to be vital. The tools apart from statistical ones also include logical or systematic ones like process mapping, etc.
- (6) Relating SS to enterprise strategy.** The connection between SS and the enterprise strategy must be indissoluble so that every action taken for SS project must have an impact on the business strategy (Ismyrlis and Moschidis, 2013:111, Laux et al, (2015:146)).

Chakraborty and Chuan, (2013:154) specified some critical success factors (CSFs) for SS implementation as per the figure below.



Figure 2. Critical Success Factors for SS Implementation (Chakraborty and Chuan, 2013:154)

According to a comprehensive survey it was recognized that CSFs from service establishments showed that management obligation and participation, and relating SS to enterprise strategy have utmost average tally amongst the CSFs (Chakraborty and Chuan, (2013:154). The European Foundation for Quality Management (EFQM) model specifies five enablers for successful quality system deployment and these are in line with the fundamentals listed above and they are as listed below:

- (1) Leadership. Entails top leadership originating and enabling the strategic vision and mission of the business and this is driven through employee inspiration and dynamic leadership involvement.
- (2) Strategy. Entails the deployment of the enterprise's vision and mission.
- (3) People. Entails people development and stimulus to attain set goals.
- (4) Partnership and resources. Efficacious employment of collaboration with external partners and suitable usage of assets.
- (5) Processes, products/services. Activities relative to design, realization of goods/services and process enhancement concerning the activities (Ismaylis and Moschidis, 2013:111).

In a separate research study, Siddiqui et al, (2016:181) identified 22 CSFs as decisive for efficacious SS execution. Below are the key performance indicators, difficulties and reasons for not effectively applying SS, and the impact of organizational sizing on SS on a study carried out by Chakraborty and Chuan (2013).

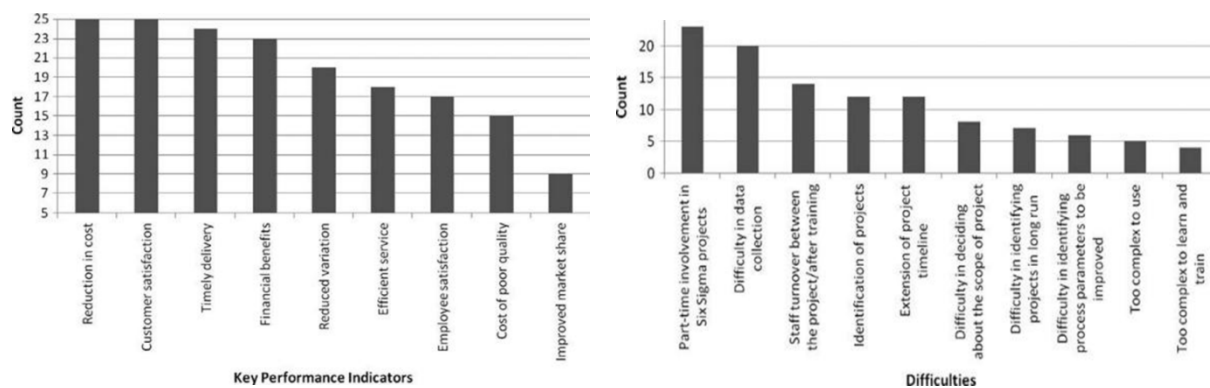


Figure 3. KPIs and Difficulties in SS deployment (Chakraborty and Chuan, 2013:157)

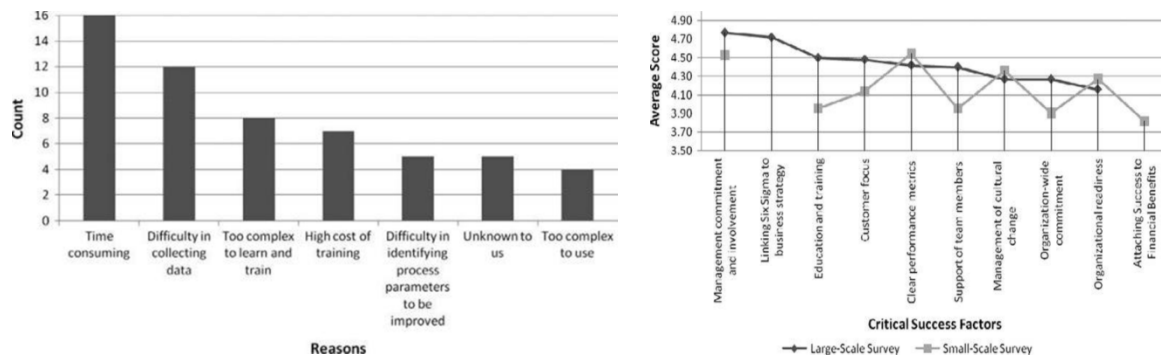


Figure 4. Practical reasoning by businesses and average score of CSFs in large-scale and small-scale survey (Chakraborty and Chuan, 2013:157/9).

Though the cultural and managerial facets cannot be disregarded or undervalued, the fundamental prerequisite to attainment in SS is engrained in arduous exploitation of the implements of the SS toolbox, therefore possession of appropriate comprehension of the SS tools and appropriately picking and applying the most proper ones from within this toolset is fundamental to sustain the advancement in the SS initiative (Uluskan, 2016: 407).

4. Prevailing Competitive Strengths of Six Sigma

SS is premeditated to contribute to swelling the business competitiveness by shrinking losses in the manufacturing system through refining the general quality and eradicating deficiencies, botches and mistakes and by this SS targets to increase the quality centered on grounds such as the decrease of variation and to emphasize on the practices and consumer contentment (Pacheco et al, 2015:162). SS was formerly dedicated to the manufacturing sector but conversely, as its usage propagated through the years, other industries like the services sector embraced it and this was propelled by the management's quest to present measurement and quantitative systems as a strategic maneuver to enhance enterprise competitiveness (Pacheco et al, 2015:163). Even though SS was initially meant for the production processes more than thirty five years ago, nowadays virtually all sectors are applying SS to advance interrelated revenues and competitiveness (Singh and Bakshi, 2014:187). The acceptance of SS in other industrial segments is propagating at a tremendous rate and it is now prevalently applied in the banking, health, commercial, aviation, utility amenities and others previously untamed segments of the economy (Reosekar and Pohekar , 2014:392). Nowadays, SS is reputable in virtually all industries and several corporates globally have altered the system and tools to be appropriate for their particular processes (Reosekar and Pohekar , 2014:394). The prominence of SS is mounting by each and every passing day as it is renowned for its constructive impression on productivity of enterprises and the gratification of client needs (Reosekar and Pohekar, 2014:392 – 408).

SS is typically applied to resolve multifaceted complications to which a resolution is indefinite (Pacheco et al, 2015:167). SS implementation has for many years yielded momentous savings to the financial bottom-line of various big and small enterprises and with its structured and data-centric slant to process enhancement whose ideal is the near-riddance of deficiencies from all products, processes and business deals, it has been broadly applied to progress and sustain competencies and diminish costs for numerous industrial segments Gijo et al, (2014: 193).

The use of SS is mounting and voyaging from the production sector to embrace entirely all enterprise maneuvers and the likes of service delivery, transactional tasks, administrative tasks, product conception and realization, and consumer interactive services such as selling and marketing Gijo et al, (2014: 194). SS is depicted as a leap forward process perfection strategic system that earns vivid diminutions in deficiencies and faults in industrial processes with the objective of enhanced consumer fulfillment coupled with progression in market share and enterprise financial bottom-line improvement, and as such, SS is reflected as a potent strategy established to quicken enhancement in produce, process and service provision quality by insistently concentrating on decreasing variation and eradicating waste (Reosekar and Pohekar , 2014:392). In essence SS is directly linked to enterprise strategy and culminates in top-down execution, with a momentous impression on profit if efficaciously deployed and as a project-centered organizational method, the scope of SS uses is likewise budding from lessening of faults in a company's processes,

products and services to be converted to an enterprise strategy that emphasizes on cultivating appreciation of consumer desires, organizational effectiveness and monetary performance progression Gijo et al, (2014: 194).

The SS approach established a culture towards continuous improvement and data-centered paradigm shift within the business and outcomes such as decrease of raw material stock levels, decreasing lead time in raw material purchasing, decreasing customer complaints resolution time, are easily attained, but the CSFs that comprise of top leadership obligation and involvement, visible leadership and employee development are imperative even in a small-scale industries for efficacious SS implementation Gijo et al, (2014: 208).

In terms of the benefits, SS enjoys the advantage above other improvement suites in that it permits personnel implementing the system to precisely eradicate encumbering concerns and validate the progress by means of statistical tools such as control charts; and further advantages such as emphasis on monetary and business outcomes, application of an organized mode for process enhancement or fresh offerings introduction, application of explicit metrics e.g. DPMO, and utilization of a substantial figure of full-time trained experts like blackbelts, etc. and additionally its core advantage over other quality approaches is that SS is more profit leaning, whereas TQM concentrates on fixing the quality issues irrespective of the costs involved (Reosekar and Pohekar , 2014:394). The capability of SS to upsurge performance and shrink process variation results in defect lessening and upliftment in profits, enhanced employee self-esteem, better quality of products, and ultimately business excellence (Yang and El-Haik, 2009).

Organizations have realized the following tangible benefits after SS application: genuine headway in the quality of the goods and services delivered to clients, curbing cycle intervals, dropping lead times, and eradicating superfluous inventories, meeting or surpassing on-time delivery obligations, and radically decreasing defect rates; and once customers notice these developments they reciprocate with boosted customer allegiance and market share growth with the employees also gaining contentment from executing winning formulae (McCarty, et al., 2005). Honeywell have renamed their SS program to Six Sigma Plus as a means to retain its place with its clients as a premier business, and Valley Baptist Medical Center (Harlingen, TX) has assimilated SS as one of its Seven Strategic Resourcefulness and they have already reaped several awards for their top drawer performance in overall quality in their care (McCarty, et al., 2005).

5. Discussion of Results of Six Sigma Implementation

The SS approach was applied by a chemical manufacturing enterprise in South Africa through deployment of the DMAIC framework. The fruitful application of the approach generated variable consequences for the diverse missions that were executed by the business. A specific project to address low production rates in their milling process, culminated with the resulting outcomes stipulated below:

The Project Charter targeted to attain a Current Y Capability $Y = EMKP \text{ Tyre } MTBR$. Obtainable data after execution and with worthy accomplishment is depicted below;

$DPMO = 1,000,000$; $Z_{lt} = -6.6$

$DPMO = 2,339$; $Z_{lt} = 2.83$

The target was to realize 35% above objective.

The aftermaths of the application of the DMAIC process of the SS approach for the milling process are summarized in the table 1 below and this noticeably illustrates how effectual SS is with respect to realizing superior performance for manufacturing establishments.

Table 1. Project Conclusion Position for Milling Project

DMAIC deliverables accomplished for each stage	Accomplished – Control report was up-to date
Complete application of process variations	Finishing variations were executed in 2016
Project attains primary project objectives	Project attained past objectives
Transitioned to process owners	Transition attained smoothly and systems updated
Validated capability to sustain achievements	Achievements sustenance proven
Financial profits validated	Financial gains reported in database

Project moved into S2MART	Project up-to-date in S2MART database
Documents and records updated	Business System procedures updated
Transformation suite communicated	Concluding team consultation done

Noteworthy progress was managed owing to effective application of the SS framework through the business with seven projects that were identified and the outcomes exposed that there was strategic expansion, market expansion and financial as well as quality successes that were reaped through the key performance metrics such as Process Yield, process capability and OEE that were enhanced. The efficacious outcomes of SS application for the chemical manufacturing enterprise were recorded as follows:

- Process yield improved by 7. 85% overall and due to process scrap reduction
- OEE improved by 5.73%
- Process changeover time reduced by 16.42%
- Total cycle time was condensed by 8.79%
- Environmental impact reduction as landfill material was condensed by 10.22%
- Manpower reduced by 3%.
- Customer complaints dropped from 25 Complaints per month to less than 5 per month
- Production rate improved by 11%
- Inventory levels reduced by 6.4%
- Unit cost of chemical product sold dropped by a substantial 14. 35% culminating in 8% reduction in product price
- Market share rose by a whopping 7.5% in 2016

6. Conclusion

SS is has been deployed efficaciously by organizations that have displayed market leadership for their products, it therefore means that any business that meaningfully embarks on SS is setting itself for market or global preeminence. SS is a regulated approach and it is branded by the pursuit of the DMAIC and DFSS schemes. Deviation from the tenets of the structural approach is tantamount to executorial miscarriage of SS. Also, the impact of the application of SS was assessed for a chemical manufacturing business in South Africa and the successful implementation of SS projects rendered competitive advantages as quality differentiation was realized in the market and the company grew in terms of cost effectiveness, delivery performance, customer satisfaction, market share and positively impacting on other stakeholders like employees and shareholders.

Apparently, documented organizations present a conducive atmosphere for SS application than undocumented organizations, and in this respect, the business warranted that their ISO 9001 QMS certification was fully exploited for guaranteeing the systematic application of SS projects.

This research signifies that SS is an effective approach in differentiating the businesses' products in the market and that it can be used effectively by any organization to attain competitive advantage in the market place.

Above all, SS can be compiled into a compendium of enterprise-wide strategic toolbox, to attain organizational goals to counteract market threats posed by competitors, and as such, further research into the strategic flexibility of SS need to be further pursued to harness its contemporary fit with prevailing strategic thrusts.

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Biography

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