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Full Length Research Paper

A multivariate analysis of success factors for Six Sigma deployment: The South African mining industry as a case

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The Six Sigma continuous improvement methodology has been successfully deployed in many organisations on a global basis. This has resulted in significant reduction in cost and increases in revenue as a result of the improvement in operational excellence associated with improved business practices, the removal of variance in systems and processes and the reduction in waste generation and poor product quality. By virtue of the financial meltdown in 2007/2008 Lonmin PLC, which operates within the South African Mining Environment, embarked on a restructuring and reorganisation initiative and decided to transform its Six Sigma deployment from a centralised centre of excellence approach to one where the core competencies and drive behind the deployment programme (black belts and master black belts) are re-integrated into the line functions of the organisation. This transformation has provided the opportunity to analyse the differences between the two approaches and to explore the factors which are critical to a successful deployment. The empirical results have identified twelve success factors within the operational context of the Six Sigma deployment undertaken by Lonmin PLC. Practical recommendations are made regarding the approach to be followed based on these factors during a Six Sigma deployment.

Key words: Six Sigma deployment, change management, success factors.

INTRODUCTION

Since the late 1800's, the South African Mining industry has been the cornerstone of the development of the South African economy (Nattrass, 1995). With the discovery of gold (from 1870 to 1886) and diamonds (1867) in Kimberley, mining became the hub around which the South African economy was built and this has been the single most important factor in past economic growth of the country. The 2007/2008 global economic crisis has resulted in a significant reduction in productivity. Efficiency and effectiveness has also been experienced due to factors such as higher production costs, the restructuring of operations and the decline in the availability of credit or liquidity (Baxter, 2008).

Moreover, the current international subprime financial crisis resulted in the commodity process being propelled upwards. For example, the Economist's Metals Index rose by 384 between October 2001 and mid-2007. This build-up in stockpiles of various minerals indicates that the financial crisis has affected the global demand for minerals and undermines the commodity cycle (Baxter, 2008). South Africa, which is dependent on foreign trade, is therefore unlikely to remain isolated from the global financial crisis-induced economic slowdown.

The impacts of the global economic crisis on the South African mining sector can be seen from the job losses due to the restructuring of operations. Lower revenues and higher production costs caused some mines or shafts to close because their costs of production exceed their revenues (Baxter, 2008). Of equal concern is the potential impact of reduced demand on the prices of these commodities (Hodge, 2009). A well-co-ordinated and focussed approach by all mining industry

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stakeholders is required to mitigate the impact of the financial crisis.

Many transformation and change initiative projects aimed at achieving the representation required by the Mining Charter and at improving worker and organisational productivity have been launched within the various mining houses. For example, in 2006 Lonmin PLC (one of South Africa's largest mining houses) proposed a transformation initiative which provided a structured process to ensure the effective use of (limited) capital, improved labour productivity, and improved quality of products which are produced in South Africa. Lonmin's top management proposed that the transformation initiative can be compiled from three complimentary approaches which, when integrated into a single transformation intervention, would significantly enhance the chances of a successful outcome. These approaches (or methodologies) are:

1. Six Sigma continuous improvement methodology
2. Kotter's theory on change management
3. Kaplan and Norton's balanced score card and strategy map theory.

Lonmin PLC integrated these three approaches and developed a seven step deployment process for the successful implementation of Six Sigma. Past research has shown that many organisations have reported that the Six Sigma methodology brings significant benefits, e.g. General Electric and Motorola. On the other hand, not all companies can claim the same benefits (Coronado and Antony, 2002) and some research indicate that "Six Sigma is a trend that has had an especially negative effect on the quality profession" (Dalgleish, 2003).

Due to these opposing views on the benefits of Six Sigmain organisations, past Six Sigma literature has focused on the identification of Six Sigma success factors with the aim to reveal this complex process (Coronel et al., 2009). Aboelmaged (2010) reviewed the literature on Six Sigma from 417 referred journal articles. He found 33 articles have 'success factors' as their major theme or subject. He however, concluded that very little empirical studies using survey or triangulation approaches exist in the literature. His recommendation for future study leads this paper to use a triangulation approach.

During 2006, Lonmin was structured as an entity with accountability defined under a Centre of Excellence (COE) model. The reason for this approach was the belief that there were significant benefits that could accrue from providing the Six Sigma initiative with its own leadership and resources. Projects would be based on business requirements but dedicated Six Sigma Black Belts would be assigned to each project and they would be incentivised to manage the projects through the define, measure, analyse, improve and control (DMAIC) process and embed the outcomes on a sustainable basis within the business. This clearly ensured that Black Belts were highly motivated and had a direct line to decision makers and resources to ensure that their projects were successfully concluded. This is evident in the results that were achieved during the initial implementation in 2005 to 2007.

Feedback was rapid, support was immediately available and there was active planning and participation from leadership within the COE. Six Sigma black belts had a unique identity and were considered the cream of the crop. The economic downturn in 2008 forced Lonmin to review its operating model and during a process of downsizing and reorganization the decision was taken to close the Six Sigma COE and reintegrate the initiative as a line function within business. This brought with it a number of unintended consequences. Six Sigma black belts were now forced to compete with a number of potentially conflicting initiatives.

Cost saving drives resulted in fewer resources being available and the Six Sigma focused reward systems were discontinued. The identity that had been created which saw Six Sigma black belts of the future leaders of the business became tarnished and the motivation levels became eroded. The approach appeared to change from a leadership initiated approach to a more management focused one. This is evident in the move from continuous engagement to monthly reviews, the need for initiative alignment as opposed to a single point of focus and the continual tension created by the competing for scarce resources and therefore there is much to learn from the successes and failures of the two approaches.

The objective of this paper is to review the Six Sigma deployment undertaken by Lonmin PLC in 2006 (when it was initiated with a centralised centre of excellence structure) and 2010 (after the structure was changed in 2008 to a structure where the core competencies were re-integrated back into the line functions of the organisation) and answer the following research question:

"*Do the success factors for Six Sigma deployment change when changing the deployment structure from a centralised Centre of Excellence to one where the core competencies are re-integrated into the line functions and business units; and if so, in what way do they change?*"

The remainder of this paper is structured as follows: Subsequently, the study provides a brief review of the three methodologies which were used by the Lonmin executive team. Also, a seven step deployment process, which was developed from the three methodologies by the Lonmin executive team, is discussed as a framework to identify indicators that would determine the level of success associated with a Six Sigma deployment initiative. Furthermore, the paper reviews several models of success factors for deployment of Six Sigma in the literature. These factors form the basic framework for further identification of success factors during

brainstorming sessions. Then, it describes the research methodology and the data analysis techniques that are applied in this study. Afterwards, it presents reports the empirical results from the factor analysis and multivariate regression analysis. Finally, the study provides some concluding remarks.

THEORETICAL FRAMEWORK

This section reviews the three approaches which were integrated by the Lonmin executive team to develop a seven step deployment process. Thirteen (13) indicators were identified during this reviewing process and these are detailed in this section. The second part of this section reviews the success factors models in the past Six Sigma literature. These models form the basis for further identification of success factors during the brainstorming sessions and semi structured interviews in Lonmin. As a result of brainstorming and interviews, forty (40) items/factors were identified that were required to ensure the success of Six Sigma deployment in Lonmin.

Six Sigma methodology

The Six Sigma process improvement methodology was developed by Smith et al. (2003) of the Motorola Corporation (Barney, 2002). In 1981, the semiconductor industry was under severe strain with the cost of manufacture exceeding the revenue generated from the sale of semi-conductor chips. Interest rates were extremely high at 18 to 20%, and the Motorola Corporation Semi-conductor Division financial statements indicated a company in serious financial difficulty. It was clear that a new approach was required to improve the performance of the organisation.

Smith et al. (2003) at Motorola started developing tools and methodologies aimed at improving product quality. Six Sigma today focuses on establishing world-class business performance benchmarks, and on providing an organisational structure and road map by which these can be realised (Desai and Shrivastava, 2010). This is mainly achieved on a project-by-project basis, using a workforce trained in performance-enhancement techniques with a receptive company culture and perpetuating infrastructure.

Although particularly relevant to the enhancing of value of products and services from a customer perspective, Six Sigma is also directly applicable to improving the effectiveness and efficiency of all processes, tasks and transactions within any organisation (Truscott, 2003). The Six Sigma methodology has successfully been used as a quality control methodology in many organisations such as Lean Manufacturing, Total Quality Management and the International Organisation for Standardisation (ISO) quality system standards.

The Six Sigma methodology has also been successfully applied as a continuous improvement methodology by applying a rigorous set of tools within a continuous improvement methodology called define, measure, analyse, improve and control (DMAIC). Six Sigma has its origin in the introduction of the normal distribution as defined by Carl Fredrick Gauss (1777 to 1855).

Walter (1891 to 1967) expanded this concept further by introducing product variation from the mean value as a key control mechanism for quality control. In the early 1980's, engineers at Motorola decided that the traditional method of measuring defects relative to a scale of thousands did not provide sufficient granularity for effective quality management and variance control, and decided to increase the scale to defects per million opportunities (DPMO). Motorola developed the Six Sigma concept and the methodologies that support it and registered the Six Sigma trademark as their own.

Many companies around the world have successfully implemented the Six Sigma methodology with the most successes experienced in Northern America and to a lesser extent in Europe. Global corporations such as General Electric and Allied Signal have attributed billions of dollars of savings and productivity improvements to the methodology.

An early USA convert to Six Sigma, the Chief Executive Officer of General Electric, Jack Welch describes Six Sigma as "the most challenging and potentially rewarding initiative we have ever undertaken at General Electric" (Lowe, 1998). The Six Sigma methodology could potentially be a tool for improving organisational and employee productivity in the South African Mining environment.

Kotter's theory of change management

Kotter (1996) stated that "by any objective measure, the amount of significant, often traumatic change in organisations has grown tremendously over the past two decades". The amount of change that has taken place within the South African context since this statement has created further stress within the social structure of South Africa, and the impact on the business and mining community has been equally vast.

The introduction of the South African Mining Charter, Black Economic Empowerment (BEE), Affirmative Action legislation and finally the 2007/2008 global economic crisis have placed enormous pressure on corporations operating within the South African mining industry. It is clear that a structured and sustainable approach to change management is required if South African companies are to remain competitive and survive in the long run.

In addition, Kotter (1996) states that "to date, major change efforts have helped some organisations adapt significantly to shifting conditions, have improved the

competitive standing of others, and have positioned a few for a far better future. But in too many situations the improvements have been disappointing and the carnage has been appalling, with wasted resources and burn-out, scared or frustrated employees".

Kotter (1996) suggests that eight common errors are the source of the failure of transformation and change efforts. These errors are listed as follows:

1. Allowing too much complacency.
2. Failing to create a sufficiently powerful guiding coalition.
3. Underestimating the power of vision.
4. Under communicating the vision by a factor of 10 (or 100 or even 1,000).
5. Permitting obstacles to block the new vision.
6. Failing to create short term wins.
7. Declaring victory too soon.
8. Neglecting to anchor changes firmly in the corporate culture.

Kotter states that "none of these errors would be costly in a slower moving and less competitive world. Handling new initiatives quickly is not an essential component of success in relatively stable or cartel-like environments. The problem for us today is that stability is no longer the norm and most experts agree that over the next few decades the business environment will become only more volatile" (Kotter, 1996).

Kotter provides valuable insight to the process of Six Sigma deployment. At the systems level Six Sigma is a well defined methodology which uses statistical tools and project based processes to improve product quality by reducing variance. Change management is an essential part of creating a sustainable deployment. Integrating Kotter's theory into the Six Sigma deployment process would improve the chances of a lasting transformation significantly.

Kaplan and Norton's balanced score card (BSC) and strategy map theory

With the advent of the internet, e-commerce and the social media such as Facebook and Twitter customers have become increasingly demanding and business has become increasingly competitive. The focus has thus moved from the traditional forms of competitive advantage such as technology leapfrogging, cost leadership and economies of scale to more intangible advantages such a customer relationship, innovative and high quality products that are brought to market rapidly, and a highly motivated and skilled workforce that apply their knowledge and experience in delivering products and services to specifically targeted customer segments through the use of systems based on databases and information technology. This shift of focus implies that a new approach is required to position organisations in such a way that they are able to compete in a global real time market. Such organisations are called strategy focused organisations (Kaplan and Norton, 2004).

Strategy focused organisations follow five management principles to become strategy focused. They are (Kaplan and Norton, 2004):

1. Translate strategy to operational terms.
2. Align the organisation to the strategy.
3. Make strategy everyone's everyday job.
4. Make strategy a continual process.
5. Mobilise change through executive leadership

According to Kaplan and Norton (2001), a strategy map for a Balance Scorecard makes an explicit strategy's hypothesis. Each measure of a Balance Scorecard becomes embedded in a chain of cause-and-effect logic that connects the desired outcomes from the strategy with the drivers that will lead to the desired outcomes. While listing the objectives in the four perspectives, executives instinctively draw arrows to link the objectives. They could now articulate their strategy of how improving employee capabilities and skills in certain job positions, coupled with new technology, would enable a critical internal process to improve (Kaplan and Norton, 2004).

A common failure in organisations is the lack of connection between the outputs generated by internal processes and the needs and value proposition of the customer. Equally, poorly addressed are innovation, employee skills development, and the role of information technology. Strategy maps address this shortcoming. This puts intangible assets in a framework where it can be managed effectively. Moreover, a strategy map provides a single-page view of how objectives in the four perspectives integrate and combine to describe the strategy (Kaplan and Norton, 2004).

Quality measurements play a vital role in strategy maps. They are essential to customer and internal perspectives. "A well-functioning quality measurement programme provides critical measurements to internal and customer objectives in most organisations' strategy maps" (Kaplan and Norton, 2004). Strategy maps provide a unique opportunity to organisations that plan to, or have already implemented a continuous improvement or quality management programme. This can be achieved in four ways:

1. The BSC provides an explicit casual linkage through strategy maps and cascaded objectives. Through the process of determining and defining the organisational goals, targets and initiatives, executives are able to create alignment in their approach, gain team commitment to the outcomes required and provide clarity to themselves and ultimately the employees within the organisation of the road ahead. The chosen objectives must be customer focused and the quality management

system must be focused around strategic objectives. Often quality management systems focus on short terms wins at the expense of long term sustainable performance. This shortcoming must be eliminated if the quality system is to be successful.

2. The BSC established targets for breakthrough performance not merely to match existing best practice. Optimising existing systems within the context of best practice is often not enough. Radical transformation might be the only way in which an organisation can guarantee its survival. Matching the benchmark set by competitor organisations implies that one's own organisation can never be the industry benchmark. Clearly becoming the industry benchmark is the best way to guarantee sustainable performance. Set bold and stretch targets and align the organisation and its resources around achieving them.

3. The BSC often identifies entirely new processes that are critical for achieving strategic objectives. "Quality models strive to improve existing organisational processes, making them better, faster and cheaper" (Kaplan and Norton, 2004). Often the only way forward is to develop or invent new processes that can provide a leapfrog advantage. Once these processes have been integrated into the business the quality programme can be used to improve and optimise the new process.

4. The BSC sets strategic priorities for process enhancements. A gap analysis by means of benchmarking can be conducted in order to identify the key strategic processes that drive value creation within the organisation. This enables the organisation to assign scarce resources to those processes that are essential to the role out of the organisational strategy. "A properly developed strategy map provides strategic focus to activity based management and quality management programmes. It embeds these improvement programmes within a strategic framework that provides clear line-of-sight impact from process improvements to important organisational outcomes" (Kaplan and Norton, 2004).

Seven step deployment process

The three methodologies were integrated by the Lonmin executive team into a deployment plan for the successful implementation of Six Sigma. A seven-step deployment process was then developed by the team. These steps are described under the following subheadings:

Step 1

Lonmin embarked on a self-assessment test to establish a common understanding of its "as was" state and to help it identify various opportunities for improvement. Use was made of a generic quality and self-assessment methodology and the data gathered was supplemented with interviews with key organisational leaders. Once the assessment was completed the key findings were shared with all employees within the organisation to create a burning platform for organisational change. This was important for the success of the initiative as it created the driving force that was required to sustain the organisation during periods of self-doubt and significant change.

Step 2

On the completion of Step 1, Lonmin had a clear understanding of the issues and problems that it was facing. This allowed it to formulate a new strategic direction and strategic intent. The strategic formulation process as depicted in Figure 1 was followed. Once the strategy had been defined, a new set of goals and targets were formulated for the organisation.

Step 3

Once the strategy formulation process was completed, Lonmin made use of Kaplan and Norton's (2004) four perspective model to analyse its business. A process model for the organisation was then created which provided the building block for the development of the organisational strategy map. This model used is defined in Figure 2.

Step 4

Based on the data gathered and the analysis conducted in Step 3, Lonmin was able to define a strategy map for the organisation. The strategy map for Lonmin is depicted in Figure 3. A reassessment of the historical metrics had to be undertaken to ensure that the metrics were convertible into the Six Sigma methodology and to ensure that the successful execution of the metrics would result in the achievement of the organisational strategy.

Step 5

The next part of the process required the development of high level process maps for the key core and support processes making use of the supplier, input, process, output and customer (SIPOC) Methodology (Gitlow and Levine, 2005). A generic high level process model for the mining industry is depicted in Figure 4. Once the model was completed, key metrics were defined for each of the processes. These metrics were related to the voice of the customer (VOIC) feedback and were converted to Six Sigma metrics such as defects per million opportunities (DPMO), sigma level or rolled throughput yield (RTY). A good mix of lead and lag metrics were defined to

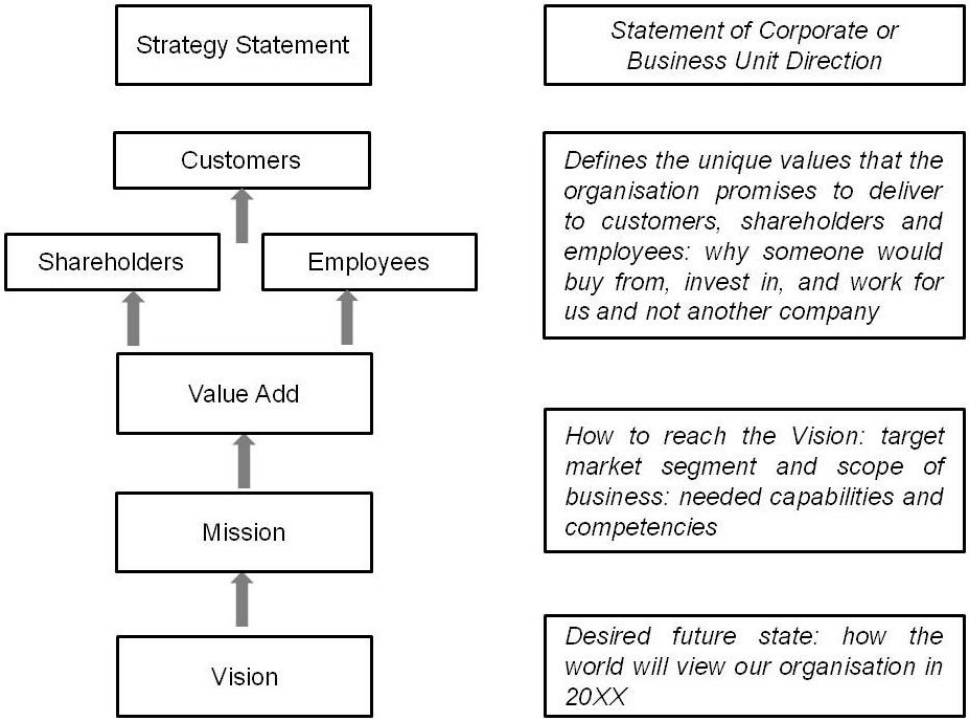

Figure 1. Strategy formulation process.

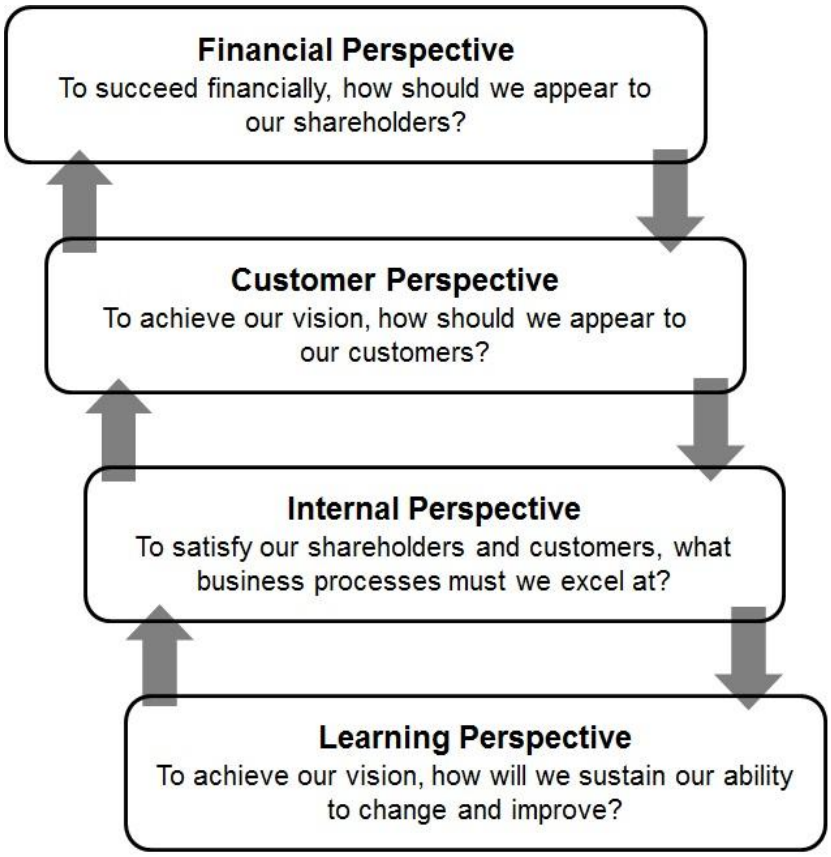

Figure 2. Kaplan and Norton's four perspectives (Kaplan and Norton, 2004).

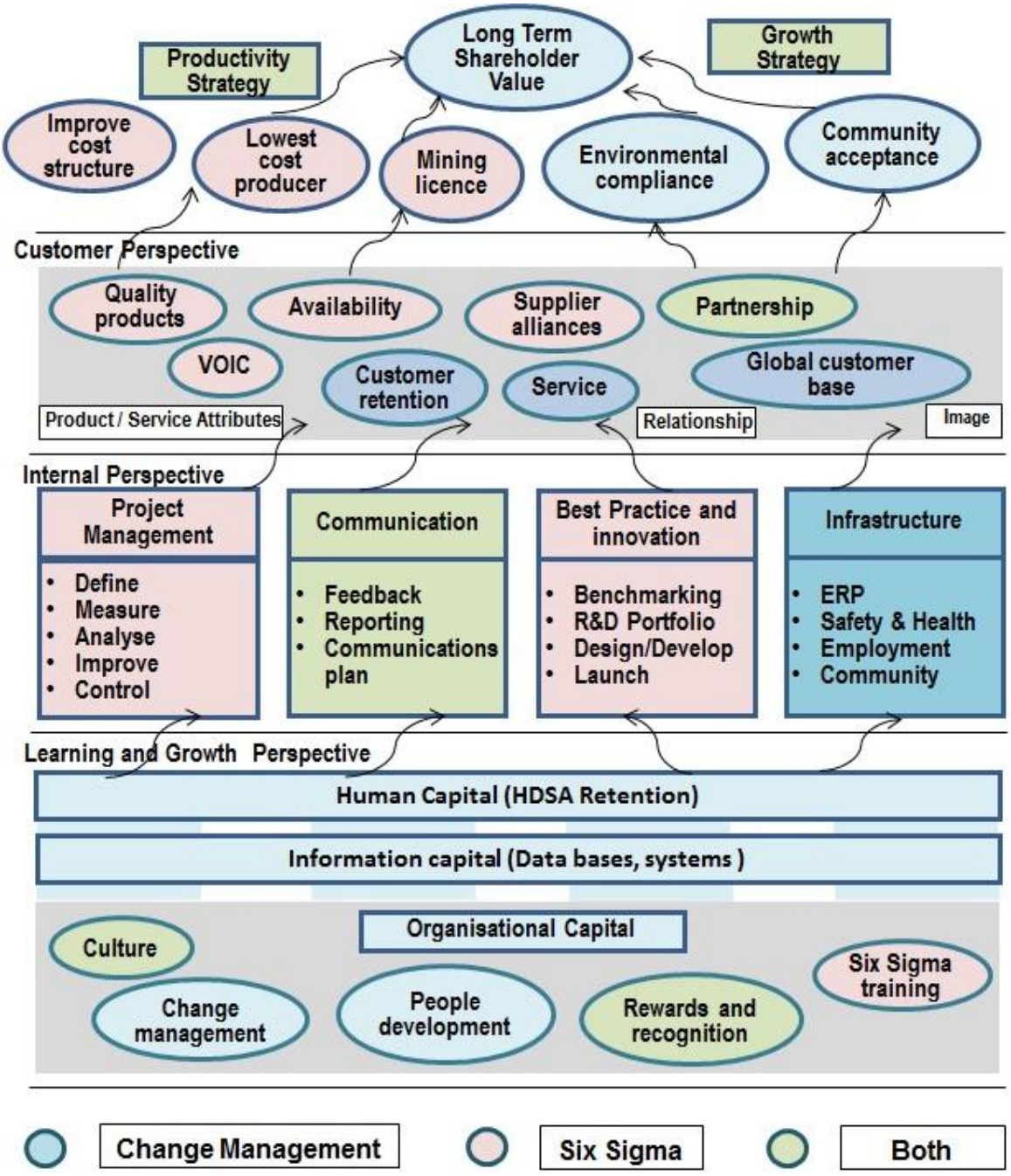

Figure 3. Lonmin's strategy map.

measure on-going performance.

Step 6

Use was then made of the Kaplan and Norton (1996) Balanced Scorecard methodology as depicted in Figure 5, to cascade the organisational score card to all levels within the organisation and to align the metrics at the departmental or sub group level with those of the organisation. This ensured that the selected metrics were aligned at both a vertical and horizontal level to ensure an integrated reward strategy that optimised the system or organisation in a holistic manner.

Step 7

The final step involved the gathering and analysis of data

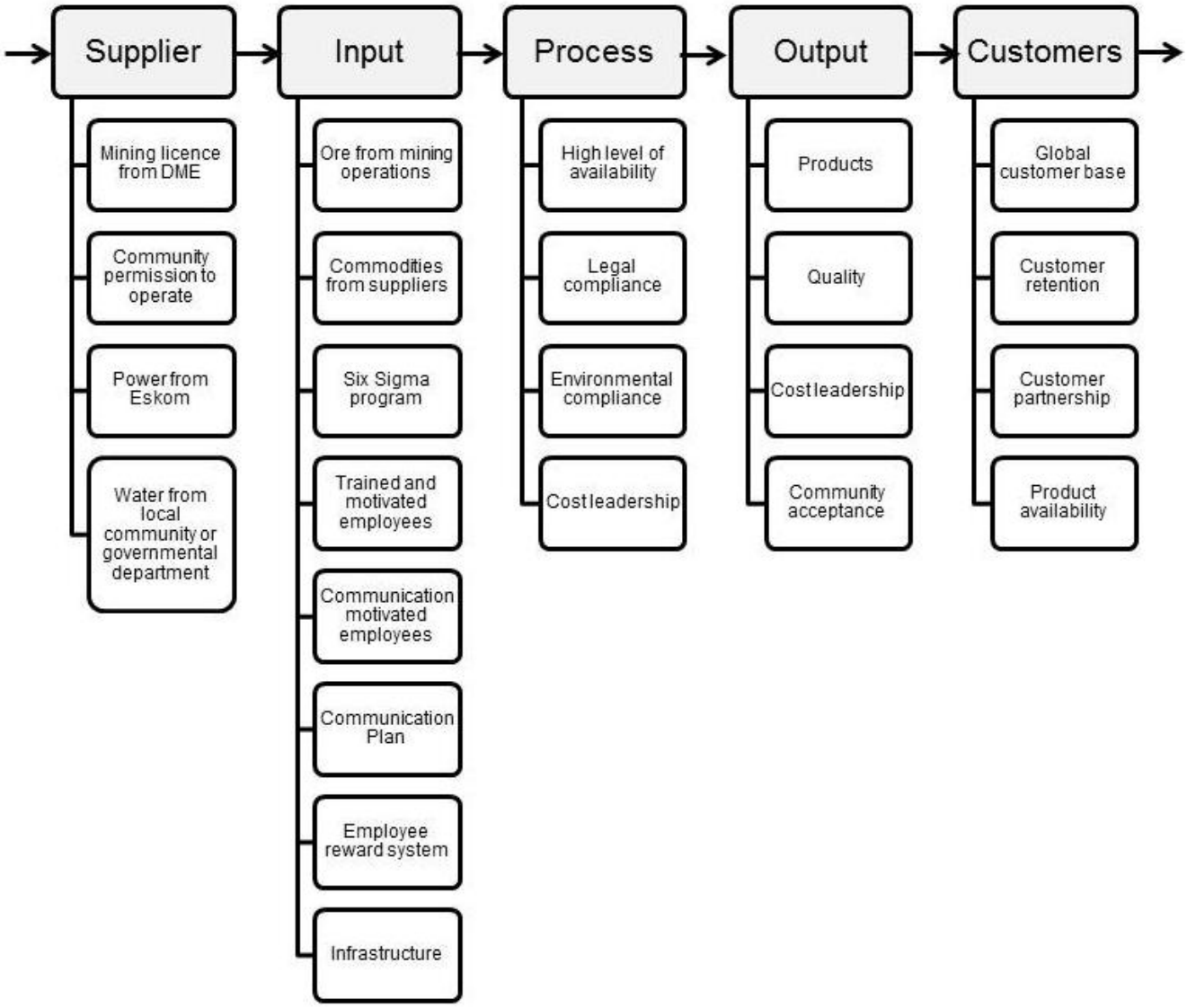

Figure 4. Generic process model for the mining industry.

relative to the key metrics, identifying and analysing the gaps between the “as was” state and the “desired future state”, and the formulation of projects to rectify the shortcomings. This approach integrated the concept of sustainable change and the balanced scorecard concepts into a single model for Six Sigma deployment.

Indicators for Six Sigma deployment

By using the seven step process, Lonmin’s execute team identified 13 key indicators for Six Sigma deployment. The 13 key Six Sigma deployment indicators are listed as follows:

1. A clearly defined Six Sigma deployment plan.
2. Active participation and the commitment of the senior executives in the Six Sigma deployment.
3. Regular Six Sigma project reviews.
4. Technical support from Six Sigma master black belts and black belts.
5. Full time Six Sigma master black belts and black belts.
6. Six Sigma training programmes for all employees.
7. A plan to communicate the Six Sigma programme to the entire organisation.
8. A Six Sigma project selection methodology.
9. A system to track all Six Sigma projects.
10. A Six Sigma incentive programme.
11. A safe environment that allows employees to tell the truth regarding their respective areas of responsibility.
12. A clear plan for dealing with internal and external suppliers.

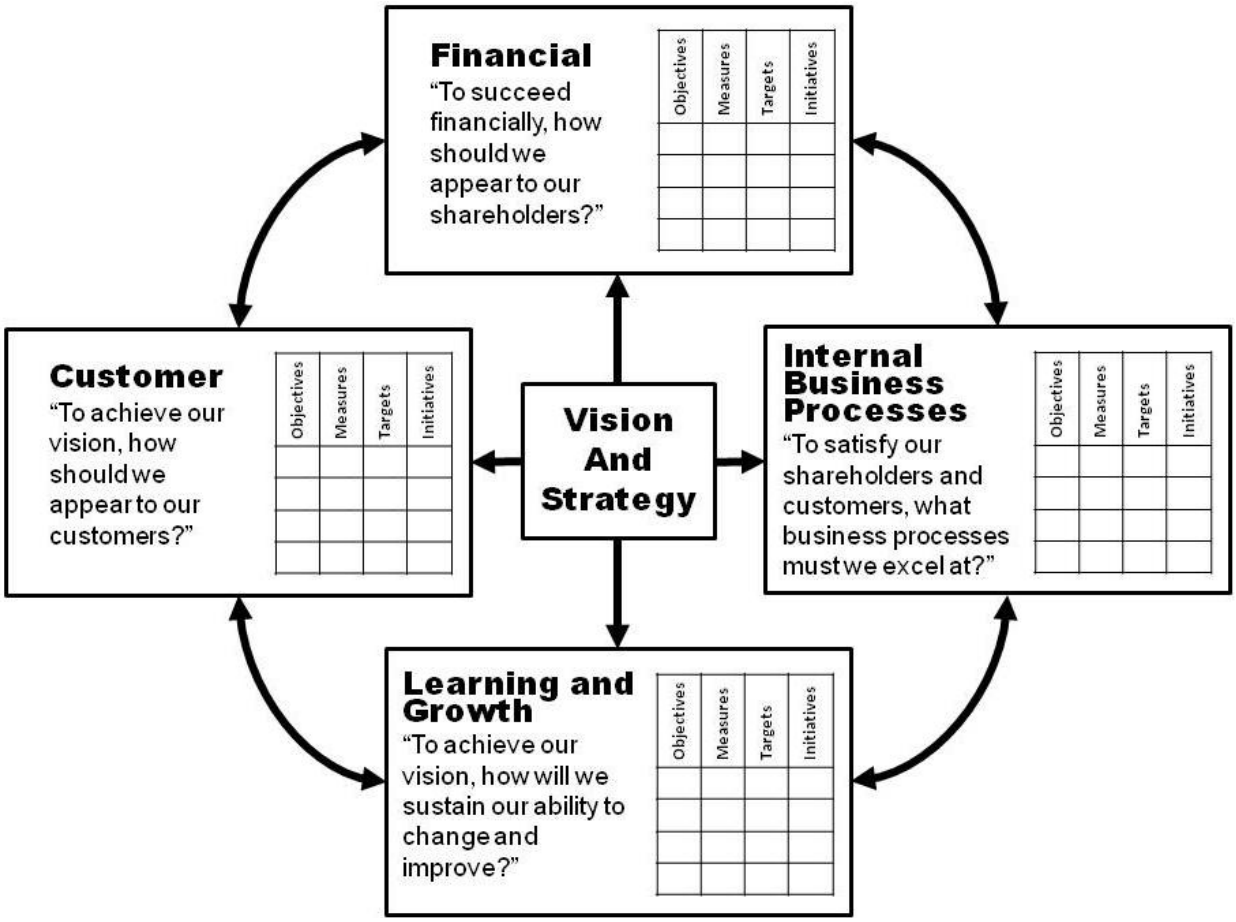

Figure 5. Balanced Scorecard (Kaplan and Norton, 1996).

13. A Six Sigma programme that focuses on the needs of the internal and external customers.

This study will further explore the previous indicators identified by Lonmin's execute team.

Literature review on success factors for Six Sigma deployments

Recent studies have reviewed the past Six Sigma literature as an approach to identify key factor for success during Six Sigma deployment. Antony and Banuelas (2002) carried out an exploratory study and identified eleven critical success factors (CSFs) from the studies performed by authors such as Pande et al. (2000), Henderson and Evans (2000) and Eckes (2000). Their lists are:

1. Management involvement and commitment.
2. Cultural change.
3. Organisation infrastructure.
4. Training.
5. Project management skills.
6. Project prioritisation and selection, reviews and tracking.
7. Understanding the Six Sigma methodology, tools and techniques.
8. Linking Six Sigma to business strategy.
9. Linking Six Sigma to the customer.
10. Linking Six Sigma to human resources.
11. Linking Six Sigma to suppliers.

The study done by Coronado and Antony (2002) has the similar list of success factors as from Antony and Banuelas' (2002) list with the addition of 'Communication'.

Antony (2004) extracted 40 variables or statements from the literature (Breyfogle et al., 2001; Eckes, 2000; Harry and Schroeder, 2000; Pande et al., 2000; Smith et al., 2003; Snee and Hoerl, 2003) and grouped them under 13 critical success factors using the affinity diagram tool. This set of CSFs is similar to the previous set with slightly different modifications. He did a pilot survey in the UK service organisations and reported the list of CSFs in descending order:

1. Liking Six Sigma to business strategy.
2. Customer focus.

3. Project management skills.
4. Executive leadership and senior management commitment.
5. Organisational infrastructure.
6. Project selection and prioritisation.
7. Management of cultural change.
8. Integration of Six Sigma with financial accountability.
9. Understanding the DMAIC methodology.
10. Training and education.
11. Project tracking and reviews.
12. Incentive programme.
13. Company-wide commitment.

Kwak and Anbari (2006) proposed four key elements of successful Six Sigma applications based from the literature by Antony and Banuelas (2002), Coronado and Antony (2002), Johnson and Swisher (2003) and Starbird (2002). These four key elements are:

1. Management involvement and organisational commitment.
2. Project selection, management, and control skills.
3. Encouraging and accepting cultural change.
4. Continuous education and training.

Ho et al. (2008) did a survey study using questionnaires containing 70 items/questions. The survey was done on 113 employees who have attended Green Belt training at a company in Taiwan. The authors performed factor analysis on the 70 items/questions and extracted five success factors, namely:

1. Incentive/reward system.
2. Investment of essential resources.
3. Business strategy based on customer demands.
4. The use of data analysis with data that is easily obtainable.
5. Top management's commitment and participation.

Later, Coronel et al. (2009) used the same set of questions as Ho et al. (2008) and did a survey using the sample of ten local companies which belong to the export manufacturing sector in Spain. The factor analysis results show five latent variables/success factors as:

1. Top management's commitment.
2. Team work and cooperation.
3. Six Sigma role structure.
4. Mentoring.
5. Execution and reward.

A more recent study from Brun (2011) made two small modifications from the list by Anthony and Banuelas (2002). They expanded 'training' to 'education and training' and 'organisational infrastructure' to 'organisational infrastructure and culture'. Brun (2011) then did a statistic of the frequency of the various CSF out of a sample of 18 papers and verified that indeed these CSFs were mentioned several times in the literature.

Sambhe (2011) identified fifteen CSFs for Six Sigma implementation and ranked them based from the survey results he obtained from medium scale automotive industries in India. These are (in descending order):

1. Top management leadership and commitments.
2. Team selection for Six Sigma project.
3. A well-developed strategic planning system.
4. Employee training and education on Six Sigma methodology and utilisation of quality tools.
5. Effective communication on Six Sigma programme.
6. Project prioritisation and selection.
7. Linking Six Sigma to business strategy.
8. Organisational infrastructure.
9. A well-implemented customer management system.
10. Culture of collaboration and cooperation.
11. Project management skills.
12. Empowerment and authority at all levels.
13. Linking Six Sigma to suppliers.
14. Linking Six Sigma to business strategy.
15. Role of information technology.

Based from the combined list of the success factors identified in the previous research (Table 1), semi structured interviews were undertaken with 14 Six Sigma master black belts and black belts from Lonmin who were involved in the original deployment programme. They were requested to comment on the success of the Six Sigma deployment and to identify factors that are applicable in Lonmin's context. As a result, forty items/factors were identified which relate to the success of Six Sigma deployment within the company. Details of these items/factors are shown in Appendix 1. These items will be tested in this research to formulate a success model for the South African mining industry.

Research hypotheses

To answer the research question, this study needs to identify the success factors for both the periods prior and post the restructuring and reorganisation programme which was conducted in 2008 and resulted from a centralised Six Sigma Centre of Excellence to a structure where the core competencies are re-integrated into the business units and line functions. By comparing these two sets of success factors, this study will be able to test the following hypothesis:

H_0: The set of success factors from 2006, where a centralised Six Sigma centre of excellence was present, does not change as compared to 2010 where a re-integrated structure was present.
H_1: The set of success factors from 2006, where a centralised Six Sigma centre of excellence was present, changes as compared to 2010 where a re-integrated structure was present.

Table 1. Success factors identified in literature.

Success factors	Studies
Top management leadership, involvement, participation and commitment	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Kwak and Anbari (2006), Ho et al. (2008), Coronel et al. (2009), Brun (2011), and Sambhe (2011)
Company-wide (organisational) commitment	Antony (2004), and Kwak and Anbari (2006)
Management of cultural change; Encouraging and accepting cultural change	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Kwak and Anbari (2006), and Brun (2011)
Organisation infrastructure and culture	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Brun (2011), Brun (2011), and Sambhe (2011)
Empowerment and authority at all levels	Sambhe (2011)
Continuous education and training on Six Sigma methodology and utilisation of quality tools	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Kwak and Anbari (2006), Brun (2011), and Sambhe (2011)
Project management skills	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Brun (2011), and Sambhe (2011)
Project prioritisation and selection, reviews, tracking and control skills	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Kwak and Anbari (2006), Brun (2011), and Sambhe (2011)
Understanding the Six Sigma methodology, tools and techniques; Understanding the DMAIC methodology	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), and Brun (2011)
Linking Six Sigma to business strategy	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Brun (2011), Sambhe (2011), and Sambhe (2011)
Linking Six Sigma to the customer; Customer focus; Business strategy based on customer demand; A well-implemented customer management system	Antony and Banuelas (2002), Coronado and Antony (2002), Antony (2004), Ho et al. (2008), Brun (2011), and Sambhe (2011)
Linking Six Sigma to human resources	Antony and Banuelas (2002), Coronado and Antony (2002), and Brun (2011)
Linking Six Sigma to suppliers	Antony and Banuelas (2002), Coronado and Antony (2002), Brun (2011), and Sambhe (2011)
Effective communication on Six Sigma programme	Coronado and Antony (2002), and Sambhe (2011)
Integration of Six Sigma with financial accountability	Antony (2004)
Execution of incentive and reward system	Antony (2004), Ho et al. (2008), and Coronel et al. (2009)
Investment of essential resources	Ho et al. (2008)
The use of data analysis with data that is easily obtainable	Ho et al. (2008)
Culture of team work, collaboration and cooperation	Coronel et al. (2009), and Sambhe (2011)

Table 1. Cond.

Mentoring	Coronel et al. (2009)
A well-developed strategic planning system	Sambhe (2011)
Role of information technology	Sambhe (2011)

RESEARCH METHODOLOGY

Sample and data collection

This research follows a methodological triangulation approach by using more than one method to gather data. A literature review on 417 referred journal articles by Aboelmaged (2010) suggests that "it is desirable to see more papers apply triangulation approach in Six Sigma research through the use of multiple data collection methods" (Aboelmaged, 2010).

Questionnaire

102 questionnaires were e-mailed to a randomly selected group of employees that were selected from the company's email list. To qualify as a potential respondent, the employee had to have been employed at Lonmin at the conclusion of the original deployment phase of the Six Sigma programme, and had to still be in the employment of the organisation in 2010 (post the restructuring and reorganisation programme which was conducted in 2008). The respondents were requested to complete the questionnaire and to return it by e-mail to the researchers. Of the 102 questionnaires that were sent out for completion, 54 were returned resulting in a completion rate of 52.94%. The data was collated into an Excel spread sheet which was then analysed by means of the SPSS statistical analysis tool.

Deployment archive

The deployment data was stored within the portfolio management software (E-track) that was purchased at the onset of the deployment to manage project execution with the DMAIC toll gating process, and to form a knowledge base of all the activities associated with the deployment programme. This has provided a rich source of information regarding the deployment process and the strategy adopted in order to maximise the chances of success.

Data analysis techniques

The data obtained from the returned questionnaire was subjected to statistical analysis by making use of the SPSS software package. Responses to the statements are captured in a two dimensional matrix with the statements listed on the horizontal axis and the scores reflected on the questionnaire tabulated on the vertical axis.

Respondents are asked to indicate their agreement to the statements using a 5-points Likert scale. Two statistical techniques are used, namely factor analysis and multivariate regression analysis. Factor analysis is used to find the underlying subset of variables (or called as 'components' in this paper) from which the observed variables were generated. The set of 13 indicators and 40 items/factors is subjected to factor analysis respectively to identify any underlying components.

To answer the research question of whether the success factors for Six Sigma deployment change when changing the organisational deployment structure and if so, in what way do they change, a multivariate regression analysis using ordinary least squares (OLS) will be conducted to explore the relationship between the independent and dependent variables in a linear regression model. A simple linear regression model can be represented as: $y_i=\alpha+\beta_i x_i+\varepsilon_i$.

In this study, the dependent (y) and independent (x) variables will be the Six Sigma deployment indicators and the success factors, respectively. The impact of a specific independent variable on a specific dependent variable will be seen from the beta coefficient (β) value and its associated significant level. Moreover, by looking at the R^2 value (the coefficient of determination), one will observe how much the independent variables explains the variance to the total variance of the dependent variable.

EMPIRICAL RESULTS

Indicators of successful Six Sigma deployment in 2006 and 2010

Indicators of a successful deployment in 2006 (Centralised deployment structure)

A reliability test is performed to all 13 indicators and resulted in a Cronbach's Alpha value of 0.328. This low Cronbach's Alpha value implies that all 13 indicators do not represent a single construct for the indicators in 2006. In other words, underlying components may exist and therefore a factor analysis is performed which resulted in three components for the indicators of 2006 (Table 2).

Indicator component No 1 (Indicator 2, 1, 4 and 9) relates to questions regarding the deployment plan, participation and commitment of the senior executives, technical support from master black belts and black belts, and a system to track Six Sigma projects. This component can be described as the "Motivating" component.

Indicator component No 2 (Indicators 12, 11, 13 and 3) relate to questions regarding internal and external suppliers, a safe environment for employees, internal and external customers, and regular projects review. This component can best be described by "Engagement".

Indicator component No 3 (Indicators 6, 7 and 10) relate to Six Sigma training, communication, and an incentive programme. This can best be described as the "Empowering "component.

Table 2. Factor analysis for indicators in 2006.

Indicator components (IC) in 2006		
IC 1	**IC 2**	**IC 3**
Motivation	**Engagement**	**Empowerment**
Indicator 2	Indicator 12	Indicator 6
Indicator 1	Indicator 11	Indicator 7
Indicator 4	Indicator 13	Indicator 10
Indicator 9	Indicator 3	

Table 3. Factor analysis for indicators in 2010.

Indicator components (IC) in 2010		
IC 1	**IC 2**	**IC 3**
Systems	**Competence**	**Empowerment**
Indicator 1	Indicator 6	Indicator 11
Indicator 2	Indicator 4	Indicator 12
Indicator 7	Indicator 8	
Indicator 5	Indicator 9	
Indicator 10		
Indicator 3		
Indicator 13		

Indicators 5 and 8 did not load onto any of the components identified during the factor analysis. Indicator 5 relates to the use of full time Six Sigma master and black belts within the deployment programme, and Indicator 8 describes the use of a project selection methodology to identify projects for execution via the DMAIC process.

Indicators of a successful deployment in 2010 (Re-integrated deployment structure)

As opposed to the analysis of the 2006 data, the Cronbach's Alpha value is 0.931 for the 13 items in the 2010 data. This high value implies that all 13 items represent a single construct which can be described as the "Level of Six Sigma deployment in 2010". Further factor analysis yielded three components (Table 3) with Cronbach's Alpha values of greater than 0.70.

Indicator component No 1 (Indicator 1, 2, 7, 5, 10, 3 and 13) relates to questions regarding the deploymentplan (1), participation and commitment of the senior executives (2), communication (7), full time master black belts and black belts (5), an incentive programme (10), and a Six Sigma programme that focuses on the needs to internal and external customers, regular Six Sigma projects reviews (3), and a Six Sigma programme that focuses on the needs of the internal and external customers (13). This component can be described as the "Systems" component.

Indicator component No 2 (Indicators 6, 4, 8 and 9) relates to questions regarding a training programme for all employees (6), Technical support from Six Sigma master black belts and black belts (4), a Six Sigma project selection methodology (8), and a system to track Six Sigma projects (9). This component can best be described by "Competence".

Indicator component No 3 (Indicators 11 and 12) relates to a safe environment that allows employees to tell the truth (11), and a clear plan for dealing with internal and external suppliers (12). This can best be described as the "Empowering "component.

Success factors of Six Sigma deployment in 2006 and 2010

Factor analysis was performed on forty success factors and resulted in specific underlying factor groupings, also called as 'components' for this study. Factor analysis is performed for both sets of success factors for 2006 and 2010, respectively. The factor analysis results for both sets of success factors for 2006 and 2010 are depicted in Tables 4 and 5, respectively. The components were given names based on the commonality of the success factors that were loaded onto the components.

Multivariate regression analysis for 2006 and 2010

All the models presented in this section are estimated by

Table 4. Factor analysis for success factors in 2006.

Success factor components (SFC) in 2006		
Index	**Name of SFC**	**Items / factors in the questionnaire**
SFC 1	Resources	Factors 11, 15, 40, 13, 35, 16, 2, 18, 6
SFC 2	Communication	Factors 32, 38, 36, 10, 39, 12, 29
SFC 3	Selection	Factors 37, 17, 14, 28, 27, 26
SFC 4	Feedback	Factors 5, 1, 34, 8, 30, 3
SFC 5	Participation	Factors 9, 22, 20
SFC 6	Commitment	Factors 4, 7, 33
SFC 7	Planning	Factors 31, 21
SFC 8	Support	Factors 19, 25, 23
SFC 9	Tolerance	Factors 24

Table 5. Factor analysis for success factors in 2010.

Success factor components (SFC) in 2010		
Index	**Name of SFC**	**Items / factors in the questionnaire**
SFC 1	Stakeholders	Factors 32, 7, 38, 30, 34, 29, 33, 37, 4, 36, 22, 39, 8, 28
SFC 2	Reviews	Factors 10, 2, 3, 21, 19, 26
SFC 3	Resources	Factors 15, 11, 13, 40, 35, 16, 18, 6, 27
SFC 4	Management	Factors 23, 20, 24, 9, 5, 31
SFC 5	Alignment	Factors 12, 14, 17, 25, 1

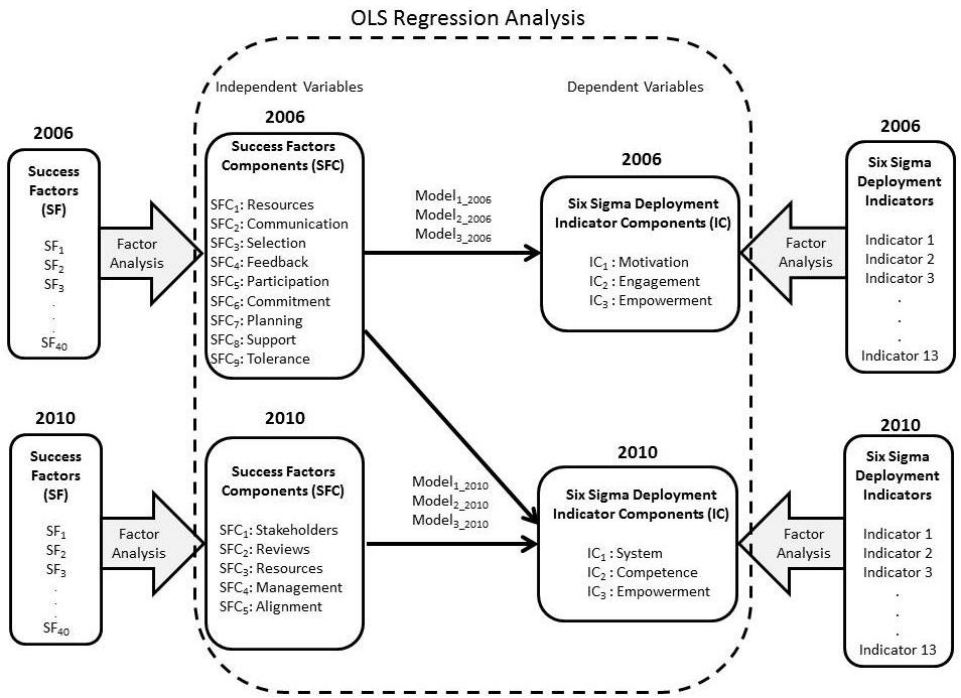

Figure 6. OLS regression analysis framework.

using SPSS to perform ordinary least square-based regression analyses. An overview of the framework for the multivariate regression is presented in Figure 6.

OLS regression analysis for 2006

The linear regression models for year 2006 are shown as

Table 6. Results of OLS regression analysis for 2006 (N=54).

	Dependent variables (in 2006)		
	Motivation	**Engagement**	**Empowerment**
Constant	0.044	-0.006	-0.011
	Independent variables		
Resources in 2006	0.306**	0.060	0.612***
Communication in 2006	0.046	0.361***	0.039
Selection in 2006	0.294**	0.363***	0.060
Feedback in 2006	0.086	0.439***	-0.085
Participation in 2006	0.271**	-0.153	0.098
Commitment in 2006	0.163	0.137	0.178
Planning in 2006	0.135	0.193**	-0.021
Support in 2006	0.119	0.252***	-0.002
Tolerance in 2006	-0.151	0.137	-0.003
R^2	34.5%	61.9%	43%
F-value	2.513**	7.771***	3.6**

*p< 0.10; **p < 0.05; ***p < 0.001.

follows:

$Model_{1\_2006}$:IC_{1_2006} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+… $\beta_9(SFC_{9\_2006})$
$Model_{2\_2006}$:IC_{2_2006} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+… $\beta_9(SFC_{9\_2006})$
$Model_{3\_2006}$:IC_{3_2006} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+… $\beta_9(SFC_{9\_2006})$

Take note that the same independent variables are entered into the three models which contain three different dependent variables, respectively. The β value and its significance will determine which independent variable (that is, success factors) is relevant for each model.

Table 6 shows the results for the OLS regression analysis for 2006. All F-values are statistically significant, meaning that all the three estimated regression models fit the data. Amongst the three models, the model with engagement as the dependent variable has the best model fit ($p<0.001$). In this model, communication, selection, feedback and support have positive and significant ($p<0.001$) impact on the dependent variable of engagement.

Planning also has a positive impact but less significant ($p<0.05$) as compared with the previously mentioned variables. These independent variables contribute to 61.9% of variance in the dependent variable (engagement).

When comparing all the nine success factors (independent variables) this study examines the associated β values and the significant levels to the dependent variables in order to identify the critical success factors for the Six Sigma deployment success in 2006. The ranking criteria for the success factors are as follows:

1. Number of dependent variables that a specific success factor has impact on (the higher the number, the higher the ranking);
2. Significance level of the β values (the smaller the p-value, the higher the ranking); and
3. β values (the larger the value, the higher the priority).

The following are the critical success factors for Six Sigma deployment in 2006 in ranked order:

1. Resources.
2. Selection.
3. Feedback.
4. Communication.
5. Support.
6. Participation.
7. Planning.

OLS regression analysis for 2010

It can be postulated that the success level of the Six Sigma deployment in 2010 is path dependent, meaning that both the past (2006) and present (2010) factors can impact on the level of deployment (the dependent variable). The linear regression models for year 2010 are shown as follows:

$Model_{1\_2010}$:IC_{1_2010} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+…$\beta_9(SFC_{9\_2006})$
+ $\beta_{10}(SFC_{1\_2010})$+ $\beta_{11}(SFC_{2\_2010})$+… $\beta_{14}(SFC_{9\_2010})$

$Model_{2\_2010}$:IC_{2_2010} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+… $\beta_9(SFC_{9\_2006})$
+ $\beta_{10}(SFC_{1\_2010})$+ $\beta_{11}(SFC_{2\_2010})$+… $\beta_{14}(SFC_{9\_2010})$
$Model_{3\_2010}$:IC_{3_2010} = α + $\beta_1(SFC_{1\_2006})$+ $\beta_2(SFC_{2\_2006})$+…

Table 7. Results of OLS regression analysis for 2010 (N=54).

	Dependent variables (in 2010)		
	Systems	**Competence**	**Empowerment**
Constant	0.006	-0.005	0.015
	Independent variables		
Resources (in 2006)	-0.048	-0.054	0.198
Communication (in 2006)	-0.016	0.066	-0.130
Selection (in 2006)	-0.054	0.027	-0.002
Feedback (in 2006)	0.053	-0.035	-0.268**
Participation (in 2006)	-0.010	-0.107	-0.036
Commitment (in 2006)	-0.106	0.188*	0.159
Planning (in 2006)	-0.064	0.119	0.040
Support (in 2006)	0.118	-0.021	-0.212*
Tolerance (in 2006)	-0.023	0.073	0.056
Stakeholder (in 2010)	0.482***	0.160	0.041
Reviews (in 2010)	0.484***	0.033	0.397***
Resources (in 2010)	-0.066	0.729***	-0.073
Management (in 2010)	0.276***	0.258**	0.111
Alignment (in 2010)	0.027	0.217*	0.263*
R^2	66.7%	63.4%	50.1%
F-value	5.439***	4.698***	2.727**

*p< 0.10; **p < 0.05; ***p < 0.001.

Table 8. Indicator components in 2006 and 2010.

Indicator component	2006	2010
1	Motivation	Systems
2	Engagement	Competence
3	Empowerment	Empowerment

$\beta_9(SFC_{9\_2006})$
$+ \beta_{10}(SFC_{1\_2010}) + \beta_{11}(SFC_{2\_2010}) + \ldots \beta_{14}(SFC_{9\_2010})$

The results are shown in Table 7. Discussion will start with the three models which have the three components as dependent variables, namely systems, competence and empowerment. The two models with the dependent variables systems and competence, respectively have the best model fit (F-value with p<0.001).

The success factors that have positive and significant (p<0.001) impact on the dependent variable systems are: reviews in 2010, stakeholders in 2010 and management in 2010. All these factors contribute to 66.7% of the variance in systems. For Competence as the dependent variable, resources in 2010, management in 2010, alignment in 2010 and commitment in 2006 have positive impacts with significant level ranging from p<0.001 to p<0.01. Interesting to note that one of the factor from the past, namely commitment in 2006, have a significant and positive impact on the competence in 2010.

If one looks at the two models that have the best model fit (that is, $Model_{1\_2010}$ and $Model_{2\_2010}$) and the ranking criteria as previously used, the following are the critical success factors for Six Sigma deployment in 2010 in ranked order:

1. Management.
2. Resources.
3. Reviews.
4. Stakeholder.
5. Alignment.
6. Commitment (in 2006).

Conclusion

Indicators for Six Sigma deployment in 2006 and 2010

From Table 8, one can observe that there has been a movement in tone between the indicators identified in 2006 and 2010. This change can be described as a move

Table 9. Critical success factors in 2006 and 2010.

S/N	Critical success factors in 2006	Critical success factors in 2010
1	Resources	Management
2	Selection	Resources
3	Feedback	Reviews
4	Communication	Stakeholder
5	Support	Alignment
6	Participation	Commitment (in 2006)
7	Planning	

from one of personal heartfelt involvement and "buy in" to a mechanistic performance based culture. Common to both periods is the concept of empowerment. However, when reviewing the opinions provided by the respondents, it is observed that the shift in 2010 is away from personal empowerment. The focus in 2006 was to empower the workforce and the individual to be engaged in the deployment and to drive Six Sigma performance and consequently organisation performance and rewards aggressively.

A shift has taken place in the hearts and minds of employees. In an industry that still remains highly reliant of employee relationships, engagement and motivation to be successful, a systematised approach should be considered risky. Systems are enablers of performance but without the motivation, engagement and empowerment of the workforce a sustainable transformation to improved performance is unlikely to take place.

Following discussions with the Six Sigma master black belt and black belt experts at Lonmin as well as analysing the information in the deployment archive, some insights about these indicators are provided subsequently.

Motivation in 2006 is generated by the presence of the opportunity for participation in project definition, a clearly articulated and shared deployment plan, strong technical support from Six Sigma black and master black belts and a clearly defined tracking system that allows employees the opportunity to monitor their performance within the context of project and incentive performance. A road map which describes the journey of transformation and the Six Sigma deployment allows individuals the opportunity to align their own vision and values with that of the organisation creating a high level of personal and corporate motivation.

Engagement in 2006 relates to the regular contact with suppliers and customers both internal and external to the organisation, a safe environment within which to challenge colloquial wisdom, (essential for continuous improvement) and regular, inclusive project reviews which allows the opportunity for all employees to engage with management in a constructive yet challenging dialogue around company performance. This is uncommon in many organisations today with employees who reaffirm management decisions and reflect poor performance as being acceptable or exceptional, when the reality is starkly different to be rewarded for their "compliance" with promotion or to provide an exceptional reward. The failure of some organisations since 2007 can be attributed to this phenomenon.

Empowerment in 2006 relates to the provision of training for employees, a rewarding incentive programme and a strong communication system which provides forums for discussion, and which makes use of both formal and informal channels of communication. The growth of modern communication in the form of Facebook, Twitter and blogging creates a new and unique opportunity in South Africa where cell phone technology has saturated the corporate landscape with 42.3 million cell phones in circulation in 2007, within a population of 49.9 million (2010).

Systems in 2010 refers to the presence of a deployment plan, participation in the programme, communication, full time resources, an incentive programme, project reviews and customers. There has, however, been a significant shift in the individual views from the respondents in that the programme was viewed as a mechanistic and systems based approach which failed to capture the hearts or the imagination of the employees. This approach when viewed in the light of the success of the 2006 focus on individual and team motivation clearly shows why the common view in 2010 was that Six Sigma had been sacrificed during the re-organisation and re-engineering initiatives that took place in 2008 during the world economic crisis.

Competence in 2010 refers to the provision of training, technical support, project selection and tracking systems and reaffirms the fundamental shift from employee motivation, engagement and empowerment to a systems approach which is less personal and more mechanistic in nature.

Success factors for Six Sigma deployment in 2006 and 2010

The critical success factors (in ranked order) for Six Sigma deployment in 2006 and 2010 are summarised in Table 9. The critical success factors listed in Table 9 are in line with the critical success factors in Table 1 from the

literature survey, except the focus on ‘Resources’.

In this study, common to both periods is the factor ‘Resources’. Prior to 2006 Lonmin had an extremely strong production focus and any initiatives that were perceived as external to the production focus were poorly supported and resourced. With the decision to introduce the Six Sigma initiative executive management made a conscious decision to resource the programme effectively by providing sufficient funds and the most talented employees to the programme. This confirmed to the Lonmin employee base the urgency and the value being ascribed to the programme by the executive management team. Consequently, “resources” was ranked in the number 1 position in 2006.

Clearly, there is a shift of focus in the success factors in the two periods, thus H_1 is supported and H_0 is rejected. The differences in the changes of success factors during the two periods can be ascribed to the change in approach which resulted from the economic downturn in 2007. This put severe pressure on the financial performance of the company and in 2008 the decision was taken to embark on a restructuring and rightsizing exercise in order to reduce costs and improve efficiencies. The decision was taken to re-assign the Six Sigma programme to the business as part of the line function and disband the centralised support structures.

Many of the promises made regarding promotion and advancement and Six Sigma bonuses were discontinued. This clearly had a significant impact on the credibility of the programme and the changes were construed as a lack of commitment by management to the programme. In 2010, resources ranked second as a critical success factor indicating the value ascribed by people operating within the programme to the associated view that availability of resources signifies the commitment and support of executive management to the programme.

Some insights of the critical success factors identified in this study, based on the information in the deployment archive and the discussion with Six Sigma experts in Lonmin, are discussed subsequently.

1. Resources (2006 and 2010) must be provided to the deployment programme and these must include full time Six Sigma resources, incentive programmes and the Six Sigma tools required to analyse data and track project progress and success. Training opportunities and the opportunity to be incorporate back into the business at a more senior level than the employee was being engaged in, within the Six Sigma programmes will also confirm the level of commitment that is being shown by the Senior and Executive management teams.

2. Selection (2006) of high value projects and the company’s top talent into the programme is essential to ensure a sustainable deployment. Projects that lead to quick wins will create an environment of success. It is a well-documented phenomenon that success breads confidence and confidence results in success so the development of high performing teams requires quick wins as spark to sustainable performance. Selecting the best employees and providing them with “Low hanging fruit” projects is best way to achieve this. Selection is therefore a key ingredient for the success of Six Sigma deployment.

3. Feedback (2006) on the company’s performance in terms of Six Sigma savings and revenue projects, the impact on the bottom line, and the potential rewards that the incentives programmes will be paying out needs to be undertaken on a regular basis. Systems that provide real time feedback would be beneficial and aid in empowering the teams to be successful.

4. Communication (2006) must take place via a series of initiatives such as newsletters, personal interaction, quarterly performance reviews, and individual couching and mentoring. Communication needs to address the full spectrum of opportunities with both formal and informal approaches being encouraged. The availability of accurate and real time information is essential to the success of communication. In the absence of reliable information employees create their own reality and during processes of significant and sustainable change this is often negative in nature. Openness and transparency are essential to the success of the communication process.

5. Support (2006) can be viewed as a proxy for the factors discussed in this section of the report. Clearly access to resources, training, incentive programmes, and redeployment to the business in a more senior level than the incumbent is current in, are all tacit evidence of a supportive environment. By the same token regular and clear communication, participation, planning and tolerance are all also evidence of a supportive and inclusive operating system. Initiatives that have the full support of management and the organisational infrastructure have an above average chance of success.

6. The participation (2006) of all employees and management in the programme would ensure a consistency of purpose and goal alignment. Participation empowers employees and creates a form where their voices can be heard. This is a key factor in creating an empowered and motivating environment, key to the success of any business initiative.

7. Planning (2006): Creating the deployment, communication, internal and external customer plans are clearly important. Involving the appropriate level of employee and management will insure that the planning process is inclusive and holistic and will assist in the process of gaining acceptance and commitment to the plan. This is also the ideal time to create the set of goals, targets and metrics that will enable tracking of progress and performance against the plan and will enable project managers the opportunity to communicate the need for extra resources should projects be in trouble.

A clear escalation policy is required to ensure that the appropriate level within the organisation is notified timeously of any deviation to enable the leadership team

to take the appropriate action.

8. Management (2010): A shift has taken place from a leadership focus to a systemised management environment. This approach has associated with it the risk of reducing the level of involvement and commitment to the programme and transforming it into one of the many systems in place to manage daily operations.

Maintaining an environment of continuous improvement and the associated continuous change that is required to sustain innovation requires both the hearts and minds of employees. Leadership is essential to the on-going sustainability of the programme and this move to a management focus approach would be considered negative by employees who were previously accommodated in the centralised programme where strong leadership was present.

9. Reviews (2010): Regular reviews are essential to ensure that activities and efforts are aligned to well-articulated and defined goals. Assimilation of the Six Sigma systems into business would have the unintended consequence of daily competition for resources between production, maintenance, human capital and the Six Sigma programme. Clearly regular reviews would be necessary to ensure that the Six Sigma programme receives its fair share of management's time and attention.

Effective change management is essential during the initial phases of the reincorporation of the programme to convince the reassigned Six Sigma black and master black belts that continuous improvement remains key to the continued and future success of the company, and that Six Sigma remained a key strategic initiative for Lonmin. Failure to entrench this view will result in a demoralised and unhappy Six Sigma contingent.

10. Stakeholder (2010): As the programme was re incorporated into the line function the number of stakeholders competing for attention increased significantly. Daily management decisions would involve all the activities associated with producing Platinum and Six Sigma will be one of many initiatives requiring attention. Consequently, this could be construed as a reduction in the importance of the programme and this will result in the employees engaged in Six Sigma activities feeling disempowered and less valued, and consequently less motivated.

11. Alignment (2010): In the new environment gaining alignment from the various role players and with the various activities will be essential for the survival of the Six Sigma methodology. This will require effective change management as the Six Sigma resources have moved from an environment where they were able to prioritise their own work and have the resources required for their success under their direct control. They will now be forced to negotiate with a number of stakeholders for the required resources which could potentially be de-motivating and disempowering.

12. Commitment (2006) by senior management and the executive is essential to the success of a deployment. They create the vision and by walking the talk indicate their commitment to the initiative. By personally attending all Six Sigma functions, training programmes and certification ceremonies and by achieving a level of Six Sigma certification themselves they are clearly signalling that the initiative is sustainable and is essential to the success of the organisation. This will have to be maintained as any deviation from the practices in place during 2006 will be viewed as a reduction in importance of the programme with a concomitant reduction in motivation and empowerment. Clearly the change management practices advocated by Kotter will be essential in this area.

CONTRIBUTIONS TO THEORY AND PRACTICE

The Six Sigma methodology has found great support in Northern and Central America and to a lesser extent in Europe and Asia. In the South African, context there has been very little penetration into the corporate environment with the ISO and local standards still being favoured for quality and continuous improvement management. The Six Sigma continuous improvement methodology could therefore represent an opportunity for the South African mining industry which is experiencing a period of declining productivity, profits and safety standards. This study contributes to the field of Six Sigma in four folds.

Firstly, this study is the first attempt in exploring the application of Six Sigma in the mining industry in South Africa by taking Lonmin, the biggest mining company who is the pioneer in implementing Six Sigma in the mining industry, as a case study. Thus, this study fulfils the need in Six Sigma research covering various disciplines and domains (Aboelmaged, 2010). The research has identified a set of factors that should lead to a successful deployment of Six Sigma. These factors are consistent with those identified within the literature and which have been identified during a number of successful deployments.

Moreover, the success factors model developed in this study is associated with an integrated initiative of the Six Sigma methodology with Kotter's change management process and the Kaplan and Norton strategy maps. This is a unique approach used by Lonmin and may be valuable to other mining companies in South Africa if they plan to manage an integrated deployment initiative.

Secondly, this study applies statistical techniques to explore the critical success factors by means of multivariate analysis. Past research has focused only on factor analysis in identification of success factors by looking at the factor loadings (Ho et al., 2008; Coronel et al., 2009). This study uses more sophisticated approach in ranking the success factors in terms of their associated beta (β) coefficients in the regression models.

Thirdly, these success factors (variables) are identifiable within the social sciences. The choices of these variables are in line with the argument that human elements are essential for Six Sigma deployment (Antony, 2006) and Six Sigma programmes have been abandoned because of inadequate attention paid to human issues (Chakravorty, 2009).

Fourthly, this is one of the few studies that report and discuss Six Sigma deployments in countries with emerging economy. Researchers pointed out that there is little data published about Six Sigma's utilisation in a developing country and there is a need to expand knowledge on this subject (Miguel and Andrietta, 2010; Antony and Desai, 2009). Thus, this study contributes to Six Sigma literatures in countries with emerging economies, especially those in the mining industry which have not yet experienced Six Sigma implementations to become aware of the success factors behind Six Sigma deployments.

LIMITATIONS OF THE STUDY

The study focuses on Lonmin PLC, which is a company operating within the South African mining environment. The results may consequently not be typical or generalisable to all companies operating within the mining industry. As Six Sigma has not been deployed in a many mining companies within South Africa, a comparative study is extremely difficult. The learning's gained from the study can however be compared with those gained from the literature review and access to Lonmin's deployment database could reveal insights that could assist companies about to embark on their own deployments.

The semi-structured interviews were conducted with the employees that were intimately involved in the Six Sigma deployment process and the quantitative interviews were conducted with a sample of employee's dawn from the all employees at Lonmin on a random basis. Due to the significant turnover of employees during the transformation process which started in 2004 the sample may be biased by the fact that those employees who remained with the company supported the deployment and transformation and may consequently respond to the interviews more positively than those who chose to leave the company.

FUTURE RESEARCH RECOMMENDATIONS

Many continuous improvement and strategy formulation models exist. Consequently, additional studies related to the efficacy of these different models in various combinations and their success or otherwise on the deployment of strategy and continuous improvement within organisations will enable organisations with existing structures in these fields to maximise the benefit of their investments by optimising their strategy and continuous improvement efforts.

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Appendix 1. Description of items/success factors (SF) used in the questionnaire.

SF	Description
1	Understanding the requirements of internal and external customers
2	Master Black Belts and Black Belts meet on a weekly basis to analyse progress on Six Sigma projects
3	Financial reward for successful Six Sigma projects
4	Visible commitment from the CEO for the Six Sigma deployment
5	Having regular feedback on the state of the Six Sigma deployment
6	Sufficient Black Belt and Master Black Belts to provide support to all Six Sigma projects
7	A recognition programme that rewards Six Sigma successes
8	Monthly Six Sigma project reviews with the departmental operational teams
9	Employees, Supervisors and Managers are all involved in Six Sigma projects
10	Quarterly feedback to the Board regarding Six Sigma projects performance
11	A Six Sigma training programme is in place that ensures that all employees are appropriately trained for their level within the organisation
12	An integrated ERP package that provides suitable information to support Six Sigma Projects
13	Master Black Belts and Black Belts act as teachers, mentors and coaches
14	A clear set of business metrics which enables the selection of high value Six Sigma projects
15	Master Black belts and Black belts are always available to assist with Six Sigma projects
16	A software program that manages Six Sigma projects using the DMAIC stage gate approach
17	Projects are linked to the organisational goals and objectives
18	A certification process is in place that certifies Six Sigma belts
19	An external trainer and facilitator are used for Six Sigma training
20	A Six Sigma champion who is a member of the organisational executive committee
21	The deployment plan includes training, required infrastructure, communication and reward strategies
22	Management have a hands on approach and are involved in weekly and monthly Six Sigma reviews
23	Six Sigma reports are an essential part of on-going communication
24	Mistakes on Six Sigma projects are considered a part of the learning culture
25	An open and safe environment that sees defects as improvement opportunities has been cultivated
26	An effective communication plan regarding progress on the Six Sigma deployment is in place
27	All employees are trained in the DMAIC process
28	All Six Sigma projects begin with the determination of the requirements of the customer
29	Reported Six Sigma project results include failures and success stories
30	Suppliers are encouraged to have their own Six Sigma programmes in place
31	Schedule, costs and revenue generation are the key deliverables of every Six Sigma project
32	A communication programme describing what should be communicated by whom and how often regarding the Six Sigma deployment is in place
33	Six Sigma projects are linked to customers core processes and competitiveness
34	Suppliers share in the successes of Lonmin‟s Six Sigma deployment
35	All Six Sigma projects are resourced with Black Belts and Master Black belts who support the project till it is completed
36	Strategic alliances are developed with Six Sigma suppliers
37	Six Sigma project objectives include the quality requirements of the internal and external customers
38	The Six Sigma deployment plan has been made available to all employees
39	Progress against the Six Sigma deployment plan is tracked on a monthly basis
40	Master Black Belts and Black Belts are always available to provide support on projects