Impact of the ISO 9001:2008 Quality Management System on Project Success in a South African Construction Firm

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Abstract

The study evaluated the impact of the ISO 9001:2008 International Quality Management Standard on Project Success. Project success was defined from the viewpoint of the contractor; and Cost, Billing, Profitability, Schedule, Quality, Safety and Environmental performance are measures of project management success. Case study research was conducted in a South African construction firm which evaluated the impact of the ISO 9001:2008 International Standard on two projects within the firm. Data collection was enabled through document review, a survey and performance index calculations. The ISO 9001:2008 clauses that were determined to have the most impact on project success were ISO Clause 4 Quality Management System and ISO Clause 5 Management Responsibility. The case study projects were also deemed successful by the determination of the Project Management Success performance indices, using actual project data.

Keywords
Quality Management System and Project Success

1. Introduction

Construction is comprised of various professions and production processes that present difficulties in ensuring quality assurance (Pheng and Teo, 2003). Traditional approaches toward the management of quality within the construction sector were deemed inadequate to address the needs of modern day projects and society (Rounds and Chi, 1985). Currently, as quality management systems become mandatory for construction firms to bid on both public and private projects (Aichouni, Ait Messaoudene, Al-ghonamy and Touahmia, 2014), the allure of having a certified ISO 9001 quality management system for external benefits only, such as marketing purposes, and not invest in the system's further development within the company, has hindered the perception and effectiveness of quality management systems (Sampaio, Saraiva and Rodrigues, 2009). Furthermore, within the quality assurance community, the assumption that implementing the ISO 9001 International Standard aids in the increase of a project's performance remains to be proven (Samsudin, Ayop, Sahab and Ismail, 2012).

The argument surrounding the value of ISO 9001:2008 certification presented the problem statement of the research, namely "To what extent does the ISO 9001:2008 international standard contribute towards project success in a construction firm within South Africa?". The objectives of the research were to determine how the ISO 9001:2008 quality management system contributes to project success in a selected construction firm in South Africa; and which ISO 9001:2008 clauses have the highest impact on project success. To enable these objectives, it was necessary to determine the composition and measurement of project success.

2. Literature Review

The literature reviewed previous research regarding quality management systems, the ISO 9001 International Standard and Project Success.

2.1 Conceptualization – ISO 9001 International Standard

The conception of the ISO 9000 series occurred during the system quality paradigm shift, where the need arose for the standardization of formal quality management systems (Weckenmann, Akkasoglu and Werner, 2015). ISO stands for the "International Organization for Standardization" and is a recognized global federation of national standard bodies (ISO 9000, 2005). The headquarters of ISO are based in Geneva, Switzerland.

ISO is an international voluntary organization that establishes sets of generic standards for application across a broad range of industries (Bubshait and Al-Atiq, 1999). The ISO 9001 International Standard stipulates the requirements of a quality management system. The initial ISO 9001 standard was published in 1987 and further revisions were made in the years 1994, 2000, 2008 and recently in 2015 (Lambert and Ouedraogo, 2008). The fundamental principles in which an ISO 9001 quality management system is based upon is as follows (ISO 9000, 2005):

- Customer focus
- Leadership
- Involvement of people
- Process approach
- System approach to management
- Continual improvement
- Factual approach to decision making
- Mutually beneficial supplier relationship

The ISO 9001:2008 Standard consists of five main clauses and further sub-clauses that stipulate the requirements of a quality management system. Table 1 below lists the main clause descriptions and related ethos.

Table 1. ISO 9001:2008 Main Clause Description and Ethos (ISO 9001, 2008)

ISO 9001:2008 Clause Description	Clause Ethos
Clause 4: Quality Management System – stipulates the requirements of the quality management system in relation to the system manual and associated procedures.	The ethos of clause 4 is concerned with the identification of the required processes within the quality management system and the overall organization, furthermore, establishing the interaction and sequence of such processes (ISO 9001, 2008). ISO 9000 (2005, p. 7) describes a process as *a "set of interrelated or interacting activities which transforms inputs into outputs".* An understanding of the inputs and outputs of these processes is important and establishing controls for these processes is a requirement by the standard (ISO 9001, 2008).
Clause 5: Management Responsibility – stipulates the requirements related to the organization's top management such as its commitment to quality and involvement in the management review process amongst other requirements.	The ethos of clause 5 deals with the organization's top management, in specific, their commitment to the implementation and maintenance of the system. Commitment from top management can be expressed in the establishment of the organization's quality policy which sets the tone for the formation and review of organization's quality objectives (ISO 9001, 2008). Clause 5 requires top management to actively participant in the review of the quality management system's effectiveness.
Clause 6: Resource Management – defines the requirements related to resources (i.e. training, infrastructure).	The ethos of clause 6 is concerned with the provision of resources required for the system implementation and maintenance, resources can be related to human resources and infrastructure (ISO 9001, 2008). Clause 6 is explicit in its requirement for the organization to identify its training needs and ensure that personnel are competent in their execution of their functions within the organization. In addition, the maintenance of an appropriate work environment is also a requirement of the standard. Work environment is inclusive of physical, environmental and other factors (i.e. noise, temperature, humidity) (ISO 9001, 2008).
	The ethos of clause 7 deals with the design and development of processes needed for product realisation and further ensuring that planning and development of

ISO 9001:2008 Clause Description	Clause Ethos
Clause 7: Product Realisation – stipulates the requirements related to the product realisation process such as relevant design and process controls, controls of nonconforming products, storage and handling of material and controls in the purchasing of resources.	operational controls are in place for these processes (ISO 9001, 2008). In addition, the clause is explicit in its requirement of the organization to have controls in its purchasing regime through the evaluation of suppliers and verification of purchased goods (ISO 9001, 2008).
Clause 8: Measurement, analysis and improvement – stipulates the requirements related to product and process monitoring and measurement, data analysis, system appraisals (i.e. internal auditing) and corrective and preventative actions.	The ethos of clause 8 is embedded in the theme of continuous improvement which stems from outputs from the monitoring and measurement of processes. A typical measurement of an organizational process can be conducted through an internal audit. The clause is explicit in its requirement of the analysis of data, the organization needs to collect and analyze appropriate data in order to illustrate the suitability of the quality management system (ISO 9001, 2008).

2.2 Motivation for ISO 9001 Certification

In recent years, it has become apparent that companies have different motivations in securing ISO 9001 certification; these motivations can be categorized into two parts, being internal and external benefits (Feng, Terziovski and Samson *et al.,* 2007; Zaramdini, 2007; Ismyrlis and Moschidis, 2015; Paul and Musbah, 2016). The internal benefits focus towards organizational improvement and external benefits focus on marketing and promotional matters (Zaramdini, 2007). Furthermore, Jones, Arndt, and Kustin (1997) defined the two types of companies that were led either by internal benefits or external benefits as "developmental companies" and "non-developmental" companies respectively. Developmental companies were led by the belief that attaining certification could derive internal benefits for their organization and non-developmental companies focused on the external benefits of attaining certification (Jones *et al.,* 1997). According to Ismyrlis and Moschidis (2015), organizations seem to mostly value the external benefits in the attainment of ISO 9001 certification, in particular, customer satisfaction, access to new markets, corporate image improvement and using the certification status as an effective marketing tool. In contrast, Zaramdini (2007), in his research on construction firms based in the UAE, revealed that firms are mostly led by the internal benefits that the ISO certification can provide for their organizations.

In a study conducted by Paul and Musbah (2016) surrounding a development framework for the ISO 9000 standard, their findings revealed that SME contractors who were motivated by internal beliefs in attaining ISO certification showed better results in comparison to contractors who were led by external benefits. Similarly, Sampaio *et al.* (2011), made a similar conclusion that companies that were led by internal motivations had an increase in financial performance in contrast to companies that were led by external motivations.

The allure of having a certified ISO 9001 quality management system for external motivations only, such as marketing purposes, and not invest in the system's further development post certification, has greatly hindered the effectiveness of the quality management system employed (Zeng *et al.,* 2005; Feng *et al.,* 2007; Sampaio *et al.,* 2009).

2.3 Impact of ISO 9001 Quality Management Systems

One of the main contentions in the literature surrounding the ISO 9001 quality management system is that of its effectiveness and impact on organizational performance, which has been investigated over the past years (Willar, Trigunarsyah and Coffey, 2015; Hadidi, Assaf, Aluwfi and Akrawi, 2017). The benefits of implementing a quality management system and attaining ISO 9001 certification for construction firms are shadowed by the misconception that the system itself is accompanied by overladen costs to operations and that the system has

insignificant value to organizational performance (Tam, Deng, Zeng, and Ho, 2000; Frank and Vos, 2001; Sampaio, Saraiva, and Rodrigues, 2011).

In contrast, research conducted by Iwaro and Mwasha (2012) indicates a positive correlation between ISO certified construction companies having improved workmanship performance in comparison to non-ISO 9001 certified construction companies. Also, Kafetzopoulos, Psomas, and Gotzamani (2015) and Feng *et al.*, (2007), in their findings, revealed a positive impact on operational performance through the implemented use of an effective quality management system. In similar investigations, researchers, Moturi and Mbithi, (2015), Vishal and Koilakuntla (2017) and Prakash, Sanjay, Kapil, and Abhishek (2017), reveal similar findings concerning the positive impact experienced in company operations in the use of quality management systems.

2.4 Project Management Success

In the understanding of Project Success definitions and its measures, literature separates Project Success into two distinct forms, being Project Product Success and Project Management Success (Heravi and Ilbeigi, 2012; Nixon, Harrington and Parker, 2012). Project Product Success is concerned with the effect of the project's final product and Project Management Success places emphasis on the project management process, specifically looking at time, cost and quality (Nixon *et al.*, 2012). Heravi and Ilbeigi (2012) have expanded the measures into Performance Indices which are reliable tools that can be used in the measurement of both Project Product Success and Project Management Success. Table 2 below lists the Performance Indices and related equations that form part of the measurement of Project Management Success (Heravi and Ilbeigi, 2012).

Table 2. Project Management Success Performance Indices

Performance Index	Equation	Equation Terms
Cost Performance Index. The CPI is used as a measure of the project's cost efficiency.	(BCWP) / (ACWP)	BCWP – is the budged cost of work performed for the project. ACWP – is the actual cost of work performed for the project.
Billing Performance Index. The BPI is used as a measure of the contractor's performance in respect to the collection of project claims and demands.	(CRWP) / (PRWP)	CRWP – is the cash revenue of work performed. PRWP – is the potential revenue of work performed.
Profitability Performance Index. The PPI is used as a measure of the contractor's performance in respect to the project's profitability.	(PRWP) / (ACWP)	PRWP – is the potential revenue of work performed. ACWP – is the actual cost of work performed for the project.
Schedule Performance Index. The SPI is used as a measure of the contractor's scheduling efficiency for the project.	[(BCWP) / (BCWS)] x [(DUR) / (DUR + DLY)]	BCWP – is the budged cost of work performed for the project. BCWS – is the budgeted cost of work scheduled. DUR – is the primary duration of the project measured in calendar days. DLY – is the amount of delay after the primary date of the project's finish date measured in calendar days.
Process Quality Performance Index. The QPI is used as a measure of the project's quality process efficiency.	(ELSO) / (TECP)	$SELQ_{Prs}$ – is the summation of all direct and indirect costs related to inadequate quality during the project process. Emphasis is placed on rework costs incurred during project construction. TECP – refers to the total direct costs related to the project construction phases such as materials and plant and is exclusive of financial and overhead costs.

Performance Index	Equation	Equation Terms
Safety Performance Index The SFI is used as a measure of the contractor's performance in respect to safety on the project	$SFI = (X_1 \times SFI_{cost}) + (X_2 \times SFI_{schedule})$	SFI is the summation of two separate sub-indices, being SFI_{cost} and $SFI_{schedule}$. SFI_{cost} is a safety performance sub-index reflecting the contributed cost of a lack of safety observance in the total project cost. $SFI_{schedule}$ is the safety performance sub-index reflecting the contributed dismissed working hours within the total project man-hours due to a lack of safety observance.
Environmental Performance Index. The EPI is used as a measure of the contractor's performance in respect to environmental matters on the project.	(SELE) / (TECP)	SELE – is the sum of the direct and indirect expenses due to lack of environmental protection observance. TECP – is the total expenses of project construction phases which is exclusive of financial and overhead costs.

For the purpose of the research, Project Success was defined from the viewpoint of the contractor, specifically considering the metrics of Cost, Billing, Profitability, Schedule, Safety, Quality and Environmental performance.

2.5 Performance Index Ranges and Ratings

Once the Performance Indices have been calculated, individual index ranges are then determined in order to ascertain the rating of the index calculated (Nassar and AbouRizk, 2014). The index ranges can be determined and adjusted by the project manager in accordance to the company policy and project execution philosophy (Heravi and Ilbeigi, 2012; Nassar and AbouRizk, 2014). For the purposes of this research and in agreement with both project managers of projects ABC and XYZ, the index ranges and ratings were adopted from Nassar and AbouRizk (2014). Table 3 below are adopted index ranges and ratings, used by Nassar and AbouRizk (2014), for the Performance Indexes that were calculated in this research.

Table 3. Adopted Ratings and Sample Index Ranges for the Performance Indexes (Nassar and AbouRizk, 2014:4)

Ratings	Performance Index Ranges						
	Cost Performance Index	**Schedule Performance Index**	**Billing Performance Index**	**Profitability Performance Index**	**Safety Performance Index**	**Environmental Performance Index**	**Quality Performance Index**
Outstanding Performance	≥ 1.15	≥ 1.15	≥ 0.98	≥ 1.30	0.00	≤ 0.50	≤ 0.50
Exceeds Target	1.05–1.14	1.05–1.14	0.95–0.97	1.20–1.29	0.00–0.10	0.51–1.00	0.51–1.00
Within Target	0.95–1.04	0.95–1.04	0.90–0.94	1.05–1.19	0.11–0.30	1.01–2.00	1.01–2.00
Below Target	0.85–0.94	0.85–0.94	0.85–0.89	0.90–1.04	0.31–1.00	2.01–4.00	2.01–4.00
Poor Performance	≤ 0.84	≤ 0.84	≤ 0.84	≤ 0.89	≥ 1.01	≥ 4.01	≥ 4.01

3. Case Study Overview

The research was conducted on projects of a prominent South African construction company. Due to agreed anonymity between the company representatives and the researcher, the construction company was referred to as "Company X". Company X is an ISO 9001:2008 certified construction company based in South Africa. The company obtained its initial ISO certification in the year 2013 and has implemented its quality management system on all of its projects. The certification encompasses all the requirements of the ISO 9001:2008 international standard with the afforded exclusion of ISO sub-clause 7.3 (Design and development). The International Standard affords for exclusions to be made for certification purposes only within the ISO Clause 7 requirements and provided that the exclusion does not hinder the organization's ability to meet client and applicable statutory requirements (ISO 9001, 2008). Company X has excluded the requirements of ISO sub-clause 7.3 due to its core business not involving design related work activities.

3.1 Selected Projects

Two projects were selected as part of the case study in order to determine how the ISO 9001:2008 international standard contributes to project success. Due to anonymity concerns, the two projects were referred to as Project ABC and Project XYZ respectively. The following text provides the projects' background.

Project ABC – Background

The commencement date of Project ABC was in January 2017 and its contractual practical completion was scheduled for April 2018 making the overall intended duration of the project 16 Months. The tendered project value was ZAR 110 521 670.

Project ABC's scope of work consisted of the following:

The construction of a new Rapid Loadout Station (RLOS) with an associated loading balloon which was constructed to the north of the existing rail loop. The existing siding and exchange yard were remodelled in order to access the new RLOS and accommodate 200 wagon trains in the siding.

Project XYZ – Background

The commencement date of Project XYZ was in May 2017 and its contractual practical completion was scheduled for May 2019 making the overall intended duration of the project 36 Months. The tendered project value was ZAR 360 617 972.

Project XYZ's scope of work consisted of the following:

The rehabilitation of an approximately 13 km dual carriageway road. The road crossed eight (four on each carriageway) bridge structures. There was one interchange (commercial road) and 11 at-grade intersections along the route.

4. Case Study

A case study research methodology was selected to ensure an in-depth knowledge and understanding of the phenomena in a contemporary context and a rigid case study design was established to ensure the reliability and validity of the case findings. In conducting the case study research, the following case study process points that was adapted from (Yin, 2014; Noor, 2008) were followed:

- The formulation of the case study theory which encompasses the planning of the research and establishment of the research objectives.
- The selection of single or multiple cases and an understanding of the data collection process through the development of a clear study design.
- The collection of data from the cases using multiple sources.
- Analysis and assessment of the data collection.
- Drafting of the case study report and drawing conclusions from the data collection.
- Modification of theory.

4.1 Data Collection

The following four main data collection methodologies were employed for the research:

- Literature review;
- Survey questionnaire;
- Formal documentation inspection of records from both project cases; and
- Project management success calculations.

4.1.1. Survey questionnaire – instrument design

The survey questionnaire was derived from the ISO 9001:2008 international standard and guided by literature. Furthermore, the survey questionnaire was additionally guided in specific by the first research objective, which is the determination of the highest impacting ISO clauses on project success, therefore, the respondents were asked a series of questions that tested the implementation of the five ISO main clauses which were described in table 1. The Likert scale was employed to scale the responses for the survey questionnaire in order to measure the extent of implementation (Fink, 2002). The scale ranged from 1 to 5 with preselected responses associated with each scale point as mentioned below (Fink, 2002):

- 1 – Strongly Disagree;
- 2 – Disagree;
- 3 – Undecided;
- 4 – Agree,
- 5 – Strongly Agree.

The survey questionnaire had a total of 53 questions, the questions were divided and grouped per ISO main clause and each question was derived from a related ISO sub-clause requirement that satisfied its related ISO main clause.

Table 4 below is a breakdown of the number of questions used to operationalize the ISO main clauses (Fink, 2003).

Table 4. Survey questionnaire - Number of operational questions per ISO main clause

ISO 9001:2008 main clauses	**No. of questions**
ISO Clause 4 – Quality Management System	3
ISO Clause 5 – Management Responsibility	9
ISO Clause 6 – Resource Management	4
ISO Clause 7 – Product Realization	25
ISO Clause 8 – Measurement, Analysis and Improvement	12
Total questions	53

A reliability analysis was conducted to determine the Cronbach's Alpha for each group of questions within the questionnaire. A brief introductory message was included within the survey questionnaire to communicate the purpose of the research to respondents and to clarify the instructions for the completion of the questionnaire. A general comment section was made available at the end of the questionnaire for respondents to give open comments in relation to their views and experiences concerning the role of the quality management system as it was operated within their project. The collected survey questionnaire data was analyzed with the use of a statistical package for social sciences (SPSS) computerized program.

4.1.2 Survey Questionnaire – Sampling and participants

Fink (2003) states that a survey should have a distinct eligibility criterion in order to include and exclude participants. For this research, the eligibility for participants of the survey were based on the following criteria:

- Project function involvement – Participant's job function must form part of the operational project management team.
- Years of work experience – Participants must have a minimum of two years formal work experience within the construction industry.
- Years of exposure to formal quality management systems – Participants must have a minimum of two years exposure to formal quality management systems.

The total team sizes of projects ABC and XYZ were 44 and 48 respectively. Table 5 and 6 below are a breakdown of the total project team complements.

Table 5. Project ABC team complement

Project team member profiles	**Number of personnel**
Site Agent	3
Commercial Manager	1
Site Engineers	15
Foremen	17
QA Manager	1
Document Controller	2
Land Surveyor	3
Wage Clerk	1
Site Administrator	1
Total team members	44

Table 6. Project XYZ team complement

Project team member profiles	**Number of personnel**
Site Agent	3
Site Engineers	18
Foremen	20
QA Manager	1
Document Controller	3
Land Surveyor	1
Wage Clerk	1
Site Administrator	1
Total team members	48

From the set eligibility criteria described above, a total sample group of 22 and 25 eligible participants from projects ABC and XYZ emerged. Table 7 below indicates the survey sample participant profiles and participation split for projects ABC and XYZ.

Table 7. Survey sample participant profiles and split for projects ABC and XYZ

Project ABC			**Project XYZ**		
Participant Profile	**No. of Personnel**	**Respondent Rate**	**Participant Profile**	**No. of Personnel**	**Respondent Rate**
Commercial Manager	1/1	100%	Commercial Manager	n/a	n/a
QA Managers	1/1	100%	QA Managers	1/1	100%
Site Agent	3/3	100%	Site Agent	3/3	100%
Site Engineers	12/15	80%	Site Engineers	16/18	89%

Project ABC			**Project XYZ**		
Participant Profile	**No. of Personnel**	**Respondent Rate**	**Participant Profile**	**No. of Personnel**	**Respondent Rate**
Document Controllers	2/2	100%	Document Controllers	3/3	100%
Project ABC total survey participants and respondent rate %.				19/22	86%
Project XYZ total survey participants and respondent rate %.				23/25	92%
Total research survey participants and respondent rate %.				42/47	89%

5. Research Results

5.1 Literature Review Outcome

It is apparent from the literature review that quality management systems employed within the manufacturing and service industries have been attempted to be duplicated within the construction industry with some proven empirical success. Various studies were conducted by researchers and the related ISO 9001:2008 clause(s) that were applied to which a positive impact on organizations was revealed (Deffenbaugh 1993; Escanciano et al. 2001; Low and Wee 2001; Lakhal et al. 2006; Feng et al. 2007; Marín et al. 2011; Prajogo et al. 2012; Kafetzopoulos et al. 2015; Prakash et al. 2017; Vishal and Koilakuntla 2017). Studies show benefits associated with effective quality management implementation such as reduced rework, repeat customers, increased customer satisfaction, improved productivity, improved schedule performance and improved relationships with professional team members and engineering firms (Hoonakker *et al.*, 2010; Samsudin *et al.*, 2012).

In addition, the literature revealed that researchers have different measurements of organizational performance that ultimately summate to organizational or project success. In narrowing the measures of project success, two distinct forms of project success emerged in literature, being, Project Product Success and Project Management Success (Heravi and Ilbeigi, 2012; Nixon et al., 2012). Project product success is concerned with the effect of the project's final product and project management success places emphasis on the project management process. Further observations in literature revealed that Heravi and Ilbeigi (2012) determined performance indices which are reliable tools that can be used in the objective measurement of both project product success and project management success. For the purposes of this research, project success was defined from the viewpoint of the contractor in relation to Project Management Success, specifically looking at cost, billing, profitability, schedule, safety, quality and environmental performance in relation to the indices as described in table 2. The individual performance index values can further be rated through the adoption of Nassar and AbouRizk (2014) index ranges and associated ratings as reflected in table 3. The index ranges can be determined and adjusted by the project manager in accordance to the company policy and project execution philosophy (Heravi and Ilbeigi, 2012; Nassar and AbouRizk, 2014).

For the purposes of this research and in agreement with both project managers from projects ABC and XYZ, the adoption of the performance indices by Heravi and IIbeigi (2012) were undertaken to serve as an objective measurement of project success in association with the performance index ranges and ratings as determined by Nassar and AbouRizk (2014). The undertaking served to achieve the second research objective, which is to determine the composition and measurement of project success.

5.2 Survey Results

Yin (2014) offers analytical techniques that can be employed during the data analysis process which aid in the improvement of internal validity of the research. Pattern matching is one of those analytical techniques which involves the comparison of empirical patterns based on the findings of a case against a predicted pattern made before data collection (Yin, 2014).

To start the pattern matching process, a Pearson's Correlation analysis was conducted to test for correlation between the five ISO main clauses based on the survey data from both Projects ABC and XYZ. In order to derive more meaningful deductions, the survey data sets were then consolidated. Table 8 below is a breakdown of the highest to lowest correlations experienced for the consolidated survey data set analysed.

Table 8. Highest to lowest ISO inter-clause correlations for consolidated survey data set

Rank	ISO inter-clause correlation	Pearson's Coefficient Value
1	ISO Clause 4 and 5	0.81
	ISO Clause 5 and 4	0.81
2	ISO Clause 5 and 7	0.79
	ISO Clause 7 and 5	0.79
3	ISO Clause 7 and 8	0.79
	ISO Clause 8 and 7	0.79
4	ISO Clause 6 and 7	0.78
	ISO Clause 7 and 6	0.78
5	ISO Clause 5 and 8	0.76
	ISO Clause 8 and 5	0.76
6	ISO Clause 5 and 6	0.75
	ISO Clause 6 and 5	0.75
7	ISO Clause 4 and 8	0.73
	ISO Clause 8 and 4	0.73
8	ISO Clause 4 and 7	0.71
	ISO Clause 7 and 4	0.71
9	ISO Clause 6 and 8	0.62
	ISO Clause 8 and 6	0.62
10	ISO Clause 4 and 6	0.51
	ISO Clause 6 and 4	0.51

From the table above, it was established that all the ISO main clauses have a positive linear correlation with each other at varying degrees of strength. The correlations were further ranked from highest to lowest with deductions made to understand the correlational relationships determined. For example, the highest ISO inter-clause correlations were experienced between ISO Clauses 4 and 5, the strong and positive correlation observed between the two clauses, reiterate the sentiments that the quality management system is made a priority within an organization if commitment towards high quality standards are driven from the top management downwards (Yeung, Lee and Chan, 2003). Top management commitment is seen as a leading critical success factor towards successfully achieving quality management system implementation (Patil, Ullagaddi, and Jugati, 2012). The role and commitment of the organization's top management is the foremost starting point for successful system implementation (Kaynak , 2003; Elghamrawy and Shibayama, 2008); workforce commitment towards quality implementation is largely shaped and steered by top management perception of the quality management system (Patil *et al.*, 2012).

5.3 Document Review

In order to further substantiate the actual implementation of the ISO 9001:2008 international standard on projects ABC and XYZ, a formal documentation inspection was conducted. A total of 146 project records were reviewed in relation to the applicable ISO clauses for both projects ABC and XYZ. The project records ranged from project

plans, project letters, project statistics and financial records. The most important use of documentation is its ability to supplement and corroborate other sources of evidence (Yin, 2009), therefore, through the formal documentation inspection, it was further established that the ISO 9001:2008 international standard was effectively implemented for both projects ABC and XYZ through the review of actual project records related to the requirements of each ISO main clause.

5.4 Project Management Success Calculations

In order to quantify Project Success for projects ABC and XY, project success was defined from the viewpoint of the contractor, which was in relation to Project Management Success. Specifically assessing the Cost, Billing, Profitability, Schedule, Safety, Quality and Environment in relation to the performance indices as described in Table 2.

Each of the performance indices has an exact equation used for the calculation of the index and furthermore, the index ranges stipulated in Table 3 were used to determine the ratings of the performance indices. Tables 9 and 10 below represent all the calculated performance index values and associated index ratings for projects ABC and XYZ respectively.

Table 9. Project ABC - Performance indices and ratings

Project ABC			
Performance Index	Calculation	Actual Values	Index Ratings
Cost Performance Index	(BCWP) / (ACWP)	0.99	Within Target
Billing Performance Index	(CRWP) / (PRWP)	0.99	Outstanding Performance
Profitability Performance Index	(PRWP) / (ACWP)	1.14	Within Target
Schedule Performance Index	[(BCWP) / (BCWS)] x [(DUR) / (DUR + DLY)]	0.95	Within Target
Process Quality Performance Index	(ELSO) / (TECP)	0.00008	Outstanding Performance
Safety Performance Index	SFI = (X_1 x SFIcost) + (X_2 x SFIschedule)	0.00	Outstanding Performance
Environmental Performance Index	(SELE) / (TECP)	0.00	Outstanding Performance

Table 10. Project XYZ - Performance indices and ratings

Project XYZ			
Performance Index	Calculation	Actual Values	Index Ratings
Cost Performance Index	(BCWP) / (ACWP)	1.01	Within Target
Billing Performance Index	(CRWP) / (PRWP)	0.99	Outstanding Performance
Profitability Performance Index	(PRWP) / (ACWP)	1.05	Within Target
Schedule Performance Index	[(BCWP) / (BCWS)] x [(DUR) / (DUR + DLY)]	1	Within Target
Process Quality Performance Index	(ELSO) / (TECP)	0.004	Outstanding Performance
Safety Performance Index	SFI = (X_1 x SFIcost) + (X_2 x SFIschedule)	0.00	Outstanding Performance
Environmental Performance Index	(SELE) / (TECP)	0.00	Outstanding Performance

Reviewing Tables 9 and 10, all the performance index ratings for both projects ABC and XYZ span from *Within Target* to *Outstanding Performance* indicating an objective measurement of the Project Management Success. The overall conclusion can be stated that projects ABC and XYZ were successful in accordance to the performance indices measured for Project Management Success.

5.5 Data Analysis

The actual data analysis process was initiated with the literature review which served the purpose of understanding and determining the existence of theoretical information surrounding the effects that the ISO 9001 clauses have on the performance of organizations and projects and to further establish the different measures of project success. Once a theoretical understanding that certain ISO sub-clauses have a positive impact on projects and organizations was concluded from literature, the intent of the survey questionnaire was to ascertain the extent of theoretical implementation of the project quality management system on projects ABC and XYZ. The survey questionnaire data was evaluated by means of a computerized statistical package for social science (SPSS) program that categorized and sorted the data and further allowed for reliability analysis of the data. Pattern matching and further explanation building of the survey questionnaire data deductions were subsequently established.

Furthermore, a formal documentation inspection was conducted in order to substantiate the actual implementation of the ISO 9001:2008 international standard on projects ABC and XYZ. Lastly, the calculation of the project management success indices with actual project information and records was conducted in order to quantify and measure project success objectively.

The aims and outcomes of the data analysis are summarized in Table 11 below.

Table 11. Data analysis aims and outcomes

Methodology	Aim	Outcome
Literature Review	To understand and determine the existence of theoretical information surrounding the effects that the ISO 9001 clauses have on the performance of organizations and projects. To establish the different measures of Project Success.	Theory exists that certain ISO 9001 clauses have positive impacts on organizational performance. An additional observation is that the researchers have different measurements of organizational performance that ultimately summate to organizational or project success.
Survey Questionnaire	To ascertain the theoretical extent of the ISO 9001:2008 implementation from the two project case respondents.	It was observed that all respondents, from both projects ABC and XYZ, gave clear indications of their agreement in terms of the implementation of the related five ISO main clauses tested, observing that the average ratings fell in the "4 – Agree" rating category based on the survey questionnaire data results.
	To determine the highest to lowest correlating ISO 9001:2008 clauses and explain the correlating relationships.	It was established that all the ISO main clauses have a positive linear correlation with each other at varying degrees of strength. Explanations of each correlation were given. The highest correlating ISO clauses were experienced between the following clauses: • ISO Clause 4 and 5
Formal documentation inspection – Projects ABC and XYZ.	All respondents from projects ABC and XYZ indicated a relatively high rating of each ISO main clause being implemented within their respective projects, therefore, a formal documentation inspection was conducted in order to substantiate the actaul implemented five ISO main clauses.	It was further established that the ISO 9001:2008 International Standard was effectively implemented for both projects ABC and XYZ through the review of actual project records related to the requirements of each ISO main clause.
Project management success calculations	For the purposes of the research and in order to quantify Project Success for projects ABC and XYZ; Project Success was defined from the viewpoint of the contractor which was in relation to Project Management Success (Heravi and Ilbeigi, 2012). Specifically assessing the Cost, Billing, Profitability, Schedule, Safety, Quality and Environment in relation to the performance indexes as described in table 2.	All the performance indices ratings for both projects ABC and XYZ span from "Within Target" to "Outstanding Performance" indicating an objective measurement of the overall Project Management Success. The overall conclusion can be stated that projects ABC and XYZ were successful in accordance to the performance indices measured for Project Management Success.

The outcomes to the data analysis expressed in Table 11 above guided the related overall conclusion of the research which is expressed in section 6 below.

6. Research Conclusion and Recommendations

Research was conducted to understand which of the ISO 9001:2008 clauses have the highest impact on Project Success and in addition to objectively quantify and measure Project Success. The research data outcomes summarized in table 11 indicate that ISO clause 4 (Quality management system) and ISO clause 5 (Management responsibility) have the highest impact on project success and in addition, project success was objectively quantified and measured through the determination of the project management success indices.

Based on the data analysis expressed in section 5.5, a valid academic inference can be drawn to substantiate that an effectively implemented ISO 9001:2008 International Standard can contribute positively to Project Success in a South African construction environment. The research recommendations, contributions and limitations are indicated below.

The following recommendations were derived from the outcomes of the research study. The first recommendation addresses the effective implementation and sustainability of the ISO 9001:2008 International Standard, referring to the outcomes of the survey questionnaire, it would be recommended that upon implementation of the standard, increased emphasis can be placed on ISO Clauses 4 and 5 during the implementation process.

The ethos of ISO Clause 4 is concerned with the identification of the required processes within the quality management system and the overall organization, furthermore, establishing the interaction and sequence of such processes (ISO 9001, 2008). The effective implementation of ISO Clause 4 requirements will aid in ensuring a robust framework for the system's functionality. Furthermore, the ethos of ISO Clause 5 deals with the organization's top management, in specific, their commitment to the implementation and maintenance of the system.

Commitment from top management can be expressed in the establishment of the organization's quality policy which sets the tone for the formation and review of organization's quality objectives (ISO 9001, 2008). Clause 5 requires top management to actively participant in the review of the quality management system's effectiveness. ISO 9000 (2005) summaries the role of top management within the quality management system as follows:

- The establishment and maintenance of the quality policy and quality objectives.
- The promotion of the quality policy and quality objectives within the organization in order to elevate quality awareness and engagement.
- To prioritize customer requirements within the organization.
- To make certain that processes needed to fulfil customer and interested parties' requirements are implemented.
- To assure that the system is effective in order to achieve the organization's quality objectives.
- To provide sufficient resources as required for the system.
- To periodically review the effectiveness of the system.
- To action and decide on improvements needed to the system.

An organization or project based top management team should strive to support the system's implementation and sustained maintenance by executing the above responsibilities. As reported in the research outcomes, ISO Clause 4 and 5 have the highest positive correlation, therefore, the effective interface of the two clauses would result in mutually beneficial outcomes.

The second recommendation addresses the quantification of Project Success for contracting project management teams in a South African construction environment. It would be recommended that project management teams endeavour to apply the performance indices as illustrated in the research study, the performance indices are pragmatic and objective quantifications of defining Project Success and can further be used as a project success monitoring tool for construction projects.

6.1. Contributions of the Research

The significant contribution of the research lies in shedding light on the potential value that an effectively implemented quality management system, aligned to the ISO 9001:2008 International Standard, can have towards the success of a construction project. The research findings may also serve as an educational training guideline for top management within South African construction companies.

Top management commitment is seen as a leading critical success factor towards successfully achieving quality management implementation (Patil et al. 2012). Top management oversee four key aspects that affect quality performance, namely: Setting of policies inclusive of the quality policy, sovereignty over resources, training of human resources and the allocation of project managers to projects (Jha and Iyer 2006). Furthermore, the study intends to improve the existing project management practices within the construction sector by identifying objective quantifiable measures of Project Success.

6.2. Research Study Limitations

The major limitation of this study is that a single case study does not allow generalisation of the results to other construction companies in South Africa. Nevertheless, the study applied rigorous methods of multiple data collection and analyses strategies which enhanced the reliability and validity of the findings.

6.3. Future Research

Additional empirical research and investigation needs to the conducted to substantiate the impact that the ISO 9001 International Standard has on Project Success, particularly within the construction sector of South Africa. Possible future research can be conducted on the impact that the newly revised ISO 9001:2015 International Standard has on Project Success. The research design should aim at including construction companies of various sizes and operating in diverse sectors of the economy, while still ensuring multiple methods of data collection. In this way, variations in the success factors can be adequately accounted for.

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