TOTAL QUALITY MANAGEMENT PRINCIPLES AND INNOVATION IN SOUTH AFRICAN CONSULTING ENGINEERING FIRMS

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ABSTRACT

Total quality management (TQM) has been adopted by firms as a management practice and in the past decade, there has been an increase in adoption particularly in the service industry. However, to compete in the current and future economy, firms may have to look beyond total quality and be willing to adopt new technologies and refined management practices.

On the other hand, innovation has been and continues to be an important topic of study in various disciplines. The narrow description that innovation has to do with science and technology, that is, research and development (R&D) efforts, is being discarded and instead of a much broader system approach that brings about capability building, learning, and new technologies, are being embraced. Governments are amongst those who recognise the value brought by innovation from a socio-economic perspective, however, a deeper understanding and systematic approach to innovation is needed together with the ability to use that knowledge to fully exploit its (innovation) effects. The acquisition of knowledge cannot take place in isolation, there has to be an understanding of how innovation is managed at a firm level first and then progress to identifying ways in which a broader society can benefit from it.

Innovation at the firm level is brought about by the need to stay ahead of the competition, to contribute to a firms' growth strategy, and to respond to the external environment and/or customer demands. Regardless of intent, more insights into how to successfully manage innovation need to be explored in detail.

This research study investigated the possible impact of total quality management principles on innovation and reviewed how this relates to consulting engineering firms' competitive advantage in the South African market. Consulting engineering firms (in this instance, the focus is on infrastructure projects) in South Africa compete amongst others, on a basis of quality work and service, price and on the firms' empowerment make-up. Within this context, it is relevant to investigate the impact that TQM has on innovation to enable managers to use the strengths of TQM to manage and deliver innovative solutions, and to improve their organisations and/or society as a whole.

To fulfil the objectives of this study, a quantitative research method was followed and a non-experimental design employed through the use of a modified survey questionnaire. To measure the extent to which all the items on the survey questionnaire measured the same construct, content validity was tested using Cronbach value and it found the instrument used, to be reliable. A survey questionnaire was sent to 200 randomly sampled consulting engineering firms in South Africa from the target population and data collected was then analysed with the aim to generalise from the sample to the population.

Only 34 participants responded to the survey, giving a response rate of 17% which is considered adequate for this type of analysis. StatPlus (StatPlus: mac, Version v6) software was used to test the hypotheses through descriptive statistics, regression analysis and correlation results. Hypotheses testing revealed that all TQM principles have an impact on business and technological innovation and only the principle of engagement of people, evidence-based decision-making, and improvement significantly and positively impacts business and technological innovation from the surveyed firms. The study has developed a new model for the impact of TQM principles on business and technological innovation in consulting engineering firms that can be used for future research. Hypotheses testing also revealed a positive influence of TQM principles and innovation on a firms' competitive advantage.

The study contributes to the body of knowledge in the field of operational management and strategic management of innovation within the South African context by looking into the contribution of TQM to innovation. This contribution will give managers an opportunity to use the strengths of TQM to deliver innovative solutions in order to tackle the challenges they face in the market. It is recommended that a similar research study is undertaken by covering a broader population and not just Consulting Engineers South Africa (CESA) member firms focused on infrastructure projects, as was the case in this research study, to test whether the same inference can be drawn from such a study.

KEYWORDS

Total Quality Management| Business Innovation| Technological Innovation| Services Firms| Consulting Engineering Firms| Competitive Advantage

DECLARATION

I, Ntheng G. Sebesho declare that this dissertation is my own unaided work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Innovation Studies at the Wits Business School in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other University.

Signature: ……………………………………………….. Sebesho.

Revised on this 06th day of September 2018.

DEDICATION

I dedicate this work to my son, David Hamilton and to my mother, Refone Sebesho.

ACKNOWLEDGEMENTS

I would like to acknowledge all those who have made a contribution in a form of finance, motivation, proofreading my work including moral support. Firstly, thank you to my family (mother, sister, brothers, nephews and, son) for the support they provided and walking with me throughout this journey. Each family member had their role to play in ensuring that I get through this process and a special thank you to my brother, Emmanuel who has demonstrated his faith in me in more ways than one.

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LIST OF ABBREVIATION AND ACRONYMS

ANOVA	Analysis of Variance
CESA	Consulting Engineers South Africa
CeSTII	Centre for Science Technology and Innovation Indicators
DTi	Department of Trade and Industry
EFQM	European Foundation for Quality Management
GDP	Gross Domestic Product
IDC	Industrial Development Corporation
IICC	Industry Insight CC
ISO	International Organisation for Standardisation
MBNQA	Malcolm Bridge National Quality Awards
OECD	Organisation for Economic Co-operation and Development
SA	South Africa
SABS	South African Bureau of Standards
StatsSA	Statistics South Africa
TQM	Total Quality Management
Wits	University of the Witwatersrand

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY

The purpose of this research study is to investigate the impact of total quality management principles on innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market. The study focuses on consulting engineering firms that participate in infrastructure projects and the type of innovation applicable to this study is business and technological innovation as a combined factor. A conceptual framework is developed as a means to outline the possible impact.

1.2 CONTEXT OF THE STUDY

South Africa's economy is divided into three sectors, namely:

- The primary sector,
- The secondary sector and
- The tertiary sector.

Source: (Statistics South Africa [StatsSA], 2016)

South African's primary sector includes mining and agriculture whilst the secondary sector includes manufacturing, construction and energy. The service industry falls under the tertiary sector classification, which includes finance, transport, trade, government and personal service (StatsSA, 2017a). Consulting engineering firms in South Africa fall under the tertiary sector and are represented by many different sub-disciplines. Their economic sectors include all associated infrastructure within a sector and also includes non-engineering services such as feasibility studies (Industry Insight CC [IICC], 2017). Figure 1 below outlines the sectoral composition of the South African economy in 2016.

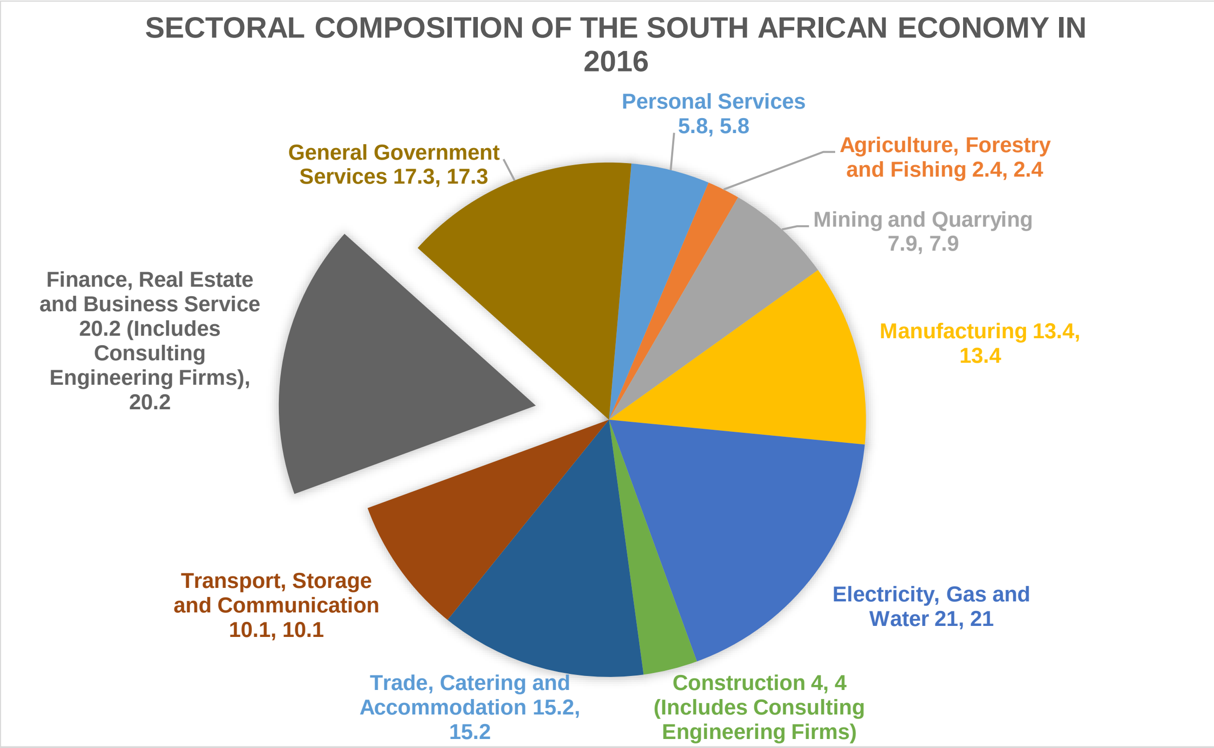


FIGURE 1: THE SECTORAL COMPOSITION OF THE SOUTH AFRICAN ECONOMY IN 2016. [Source: (Industrial Development Corporation [IDC], 2017), compiled from stats SA data]

The source of infrastructure projects is both the government and the private sector; however, the country's economic performance in the past financial year has seen investment by government and the private sector decrease by 12% and 6% respectively (IICC, 2017). Consulting engineering firms are affected by all the reduced spending on infrastructure projects, forcing reviews on existing strategies that will drive sustainable growth.

The consulting engineering firms are not only faced with the challenge of competition but also of unemployment in the country. According to StatsSA (2017b), the employment level in South Africa decreased by 48 000 quarter-on-quarter, from 9 692 000 in December 2016 to 9 644 000 in March 2017 and there has been a further decline to 9 617 000 in the third quarter of 2017. The third quarter decline was attributed to various industries including the mining, services and trade. However, growth was seen in the construction industry where 4 000 jobs were created in September 2017 following a decline of 15 000 jobs in June 2017, whilst the employment rate for consulting engineering firms increased by 4% in the first 6 months of the last financial year (IICC, 2017).

Various factors contributed to the overall decline in unemployment, but SA’s economic performance in the past year is key. The South African economy has been on a decline since 2016 and the GDP continued to decline in the first quarter of 2017 by 0.6%. GDP however, increased by 2.0% in the third quarter of 2017 (StatsSA, 2017c) and has continued to grow, with the fourth quarter experiencing the highest growth rate of the year 2017 (StatsSA, 2018). However, growth in the construction industry declined by 1.4% in the same period (StatsSA, 2018).

According to StatsSA (2017d), South Africa has experienced eight recessions since 1961 and the most recent one was in 2016/17. This has put pressure on industries as a whole, therefore to compete, capture and maintain market share and gain competitive advantage, consulting engineering firms need to provide high quality and innovative services (Mustafa, 2015).

1.3 PROBLEM STATEMENT

Organisations aim to be competitive both locally and internationally in the products and services they offer their customers and total quality management is often adopted as a key strategic factor in order to drive organisational success (Ghobadian & Gallear, 1997; Kim *et al*., 2012; Zandhessami and Jalili, 2013). In addition, other organisations add international organisation of standardisation (ISO) certification as a means to provide confidence in the organisation’s ability to consistently provide products and services conforming to their customer requirements (South African Bureau of Standards[SABS], 2015b). Looking at the global landscape, Germany, Japan and China are leaders in quality management certification (Charlet, 2016), while Africa remains an underperforming continent compared to other countries. The ISO survey conducted (Charlet, 2016) revealed the top five industrial sectors with ISO certification in descending order as; basic metal and fabricated metals, electrical and optical equipment, construction, wholesale and retail trade and machinery and equipment.

The authors (Mohanty & Behera, 1996; Psomas *et al*., 2013) have argued that total quality management started in the manufacturing industry and was later adopted by the service industry. In South Africa, the adoption has been driven either by the government's bidding requirements, strategic intent or body association requirements. Consulting Engineers South Africa ([CESA], 2011) requires that all its member firms attain ISO 9001 certification or implement a quality management system. The decline in infrastructure investment has resulted in stiff competition amongst consulting engineering firms, who are dependent on government contracts for infrastructure investment (IICC, 2017) as a source of income. Firms, therefore, have to look beyond quality management as a means to gain competitive advantage and perhaps consider innovation (Kafetzopoulos *et al*., 2015). It is therefore important to investigate in more detail the impact TQM has on innovation.

The authors (Bon & Mustafa, 2013) argue that TQM and innovation plays a vital role in business' success, stemming from the fact that TQM and innovation create and strengthen competitiveness. Harrington and Voehl (2013) further argue that firms have tried to find alternatives but are now accepting innovation management as an operational discipline for their organisations. Whilst other authors (Kafetzopoulos *et al., 2015)* argue that with the implementation of quality management, many of the necessary internal factors affecting innovation in a firm are developed at the required level. Therefore, it is meaningful to study these two concepts (TQM and innovation) together. Thus, the purpose of this research study is to investigate the impact of total quality management principles on business and technological innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market.

1.4 SIGNIFICANCE OF THE STUDY

To be able to deal with the external turbulence and competition, organisations have to adopt a more process, organisational and technical approach to innovation (Kafetzopoulos *et al*., 2015). The study aims to contribute to the body of knowledge in the field of operational management and innovation management within the South African context by looking into the contribution of TQM to innovation. The research will

further expand the role of TQM in consulting engineering firms participating in infrastructure projects, giving the opportunity for managers to use the strengths of TQM to deliver innovative solutions in order to tackle the challenges they face.
The significance of the study can be modelled into three components;

- Economic benefit;
- Social benefit and;
- Capability building.

With the South African government's plan to grow the economy and triple GDP by 2030, consulting engineering firms have a significant role to play in achieving this growth through infrastructure development (CESA, 2011). It is thus important to ensure continued growth of the industry and its contribution to the GDP through innovation.

Economic growth will also bring about social benefits such as job creation and service delivery through government infrastructure developments whilst building capabilities for innovation at a firm level.

1.5 DELIMITATIONS OF THE STUDY

The study will only focus on consulting engineering firms in operation for more than five years. More specifically where these are either ISO 9001 certified or have a functional quality management system in place. The rationale behind the number of years in operations stems from the fact that this research study intends to exclude start-up companies, whose quality systems may not have reached a stage of maturity that allows adequate adoption and/or implementation of the total quality management principles.

Furthermore, the study seeks to reveal the impact that TQM principles have on innovation and to achieve this, a company should have first adopted and/or implemented a quality management system. Ways to measure adoption or implementation include an ISO certification or self-declaration.

The study will not cover the founder or single director operated firms and companies with employee headcount that is less than seven.

1.6 ASSUMPTIONS

The assumptions made in the study are:

- The chosen organisations will participate and provide accurate information;
- The organisations will remain as they are in the period of study, i.e. no acquisitions, mergers or liquidation;
- The organisations have a skilled workforce;
- Participants have knowledge of the subject matter; and,
- The organisations have a steady financial performance.

1.7 DEFINITION OF KEY TERMS

1.7.1. Business/Organisational Innovation

Business innovation and organisational innovation have similar definitions. The definition by Martinez Lorente *et al*. (1999, p. 12) states “Business innovation deals with innovation in management thinking and its primary purpose is to create new value and wealth for all stakeholders and thereby increase economic prospects. Organisational innovation is defined as “the implementation of a new organisational method in the firms’ business practices, workplace organisation or relations in external environment” (Organisation for Economic Co-operation and Development [OECD], as cited by Goffin & Mitchell, 2017, p. 5). The study will adopt both definitions under one title to be referred to as business innovation.

The business practices stated may include; establishing databases of best practices, improving worker retention or introducing management systems (Camison & Villar-Lopez, 2014). On the other hand, relations in the external environment refer to the mutual supplier relationship and collaboration with customers. Business innovation is motivated by changes in external and internal environmental conditions, customers, competitors, suppliers and employees" (Martinez Lorente *et al*., 1999). Management thinking refers to the traditional approaches to management. Hamel (2006) defines innovation in management practices "as a departure from traditional management principles, processes, and practices or a departure from customary organisational forms that significantly alters the way the work of management is performed" (Hamel, 2006, p. 4).

1.7.2. Competitive Advantage

The definition for this study was taken from Kafetzopoulos *et al*. (2015), who defines competitive advantage as "a factor which determines the firms' position in a market" (Al-Qudah, 2012 as cited in Kafetzopoulos *et al*., 2015, p. 1183). It results from an approach that creates a strategy which generates augmented value for an organisation as compared to its competition and the status quo remains the same till competition takes over (Bon & Mustafa, 2014).

1.7.3. Service Firms/Organisations

In his study of the service sector in Malaysia, Mustafa (2015) defines a service organisation from two perspectives, the narrow definition and the broader definition. The broader definition states "that the service sector includes construction, public administration and defence and utilities" (Mustafa, 2015, p. 12).

This study will adopt the narrow definition, which states "that the service sector includes all economics activities other than manufacturing, mining, forestry, agriculture, fishing and hunting, quarrying and construction, public administration and defence and utilities" (Mustafa, 2015, p. 12). This definition fits well with the South African sector differentiation as highlighted in section 1.2.

1.7.4. Technological Innovation

The definition adopted for this study was taken from Younghong *et al*. (2005). The authors define technological innovation as "the adoption of new technologies that are integrated into products or processes". Golmohammadi *et al*. (2014) argue that technological innovation consists of two dimensions, namely product and process innovation. Kim *et al*. (2012) take it a step further by breaking it down into radical and incremental technological innovation.

1.7.5. Total Quality Management

The definition adopted for this study was taken from a book by Steenkamp (2012). The author stated that “total quality consists of the continual improvement of people, processes, products (including services) and environments” (Steenkamp, 2012, p. 11). When the total quality concept is effectively applied, the result can include organisational excellence, superior value and global competitiveness.

1.8 RESEARCH QUESTIONS

The decline in infrastructure investment has resulted in stiff competition amongst consulting engineering firms, who are dependent on government contracts in infrastructure investment (IICC, 2017) as a source of income. Firms, therefore, have to look beyond quality management as a means to gain competitive advantage and perhaps consider innovation (Kafetzopoulos *et al*., 2015). It is therefore important to investigate in more detail the impact that TQM has on innovation.

Guided by the problem statement as outlined in section 1.3, the following research questions were formulated:

- What is the impact of TQM on business and technological innovation?
- How do these relate to the firms’ competitive advantage?

1.10 OUTLINE AND STRUCTURE OF THE REPORT

This research study consists of six chapters.

Chapter 1: Research Introduction

The introduction covers some background on the topic in the South African context. The context provided outlined the significance of the study in the consulting engineering industry in South Africa and details the necessity to have total quality and innovation management in this industry.

Chapter 2: Literature review

The literature seeks to review scholarly articles related to TQM and, innovation and their relation to competitive advantage. It will further look at what conclusions have been drawn from similar studies. The information will be used to explore what might have been missed or proposed by other researchers in the field.

Chapter 3: Research strategy and methodology

This section describes the research strategy and methodology followed in the study in order to answer the research questions. Elements to be covered under the chapter include the selection of participants in the study, how data will be analysed, limitations and ethical considerations and how the study ensures validity and reliability.

Outlined below (figure 2) are process activities undertaken for data collection and analysis.

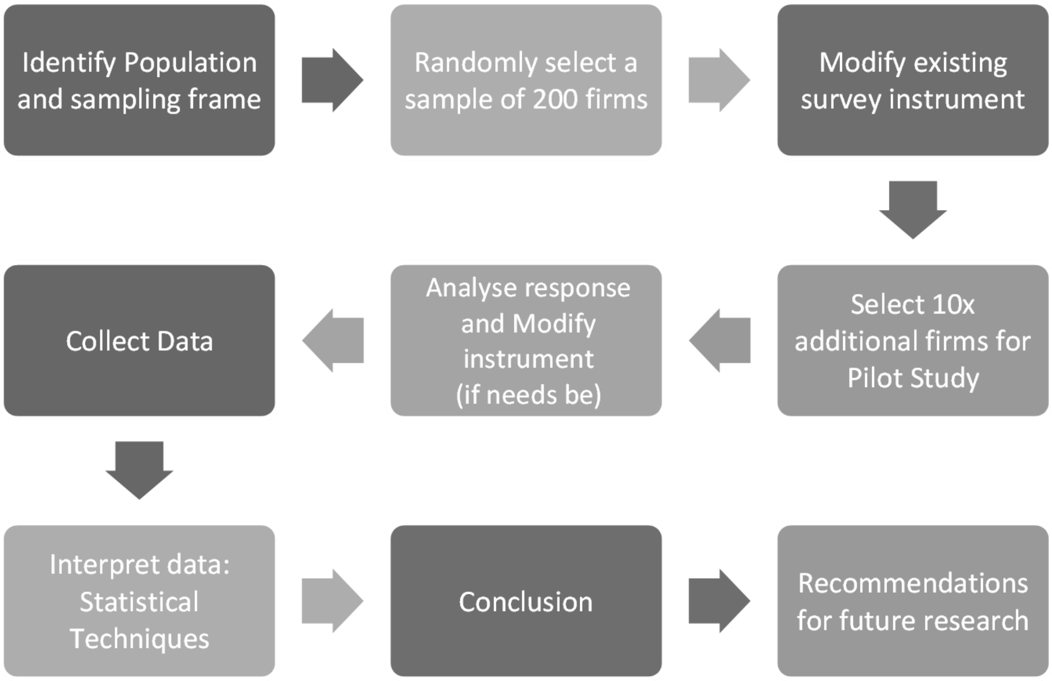


FIGURE 2: PROCESS FLOW FOR RESEARCH DATA COLLECTION AND ANALYSIS. (Source: Researcher)

Chapter 4: Statistical Analysis and Results

This chapter outlines the findings and results from the research survey, carried out to answer research questions. Topics covered under this chapter include raw data analysis, non-response analysis, respondent profile, descriptive data analysis and testing of the conceptual model.

Chapter 5: Analysis and Discussion of the Research Findings

This chapter discusses the findings and results from the research survey, carried out to answer research questions.

Chapter 6: Conclusions and Recommendations

This chapter summarises the major findings of the study and conclusions drawn from the statistical analysis carried out and from the reviewed literature. The chapter will also include recommendations to senior managers in consulting engineering firms, based on the outcome of the research. The study concludes by suggesting focus areas for future research.

1.10 CONCLUSION

This study is complex in its nature and requires enough rigour that will ensure optimal results are interpreted and inferences are made. The key element that will determine the achievement of this study's objectives are the design of the measuring instrument, thorough literature review, the researcher's experience in the field of quality management and assistance from senior industry experts.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This literature review examines existing theories on total quality management and innovation. It covers five sub-topics which include total quality management, ISO 9001 in consulting engineering firms, innovation, TQM and innovation and TQM, innovation and competitive advantage.

2.2 TOTAL QUALITY MANAGEMENT

Quality is dynamic, however, its dynamic state has to do with the notion that quality lies in the eyes of the beholder, that is, quality in every aspect is defined by customers and will change from time to time. People and organisations define quality in a number of ways as outlined below (Steenkamp, 2012, p. 9-10):

- The CEO of Federal Express defined quality as “ performance to the standard expected by the customer”
- The General Services Administration (GSA) defined quality as “ meeting the customer’s needs the first time and every time and
- W. Edwards Deming’s description said quality can be defined only in terms of the agent, that is, who is the judge of quality?

Regardless of who defines quality, its history and the role it plays in organisations cannot be ignored. The total quality concept has been around for over a 100 years (Golmohammadi *et al*., 2014; Steenkamp, 2012) and it started in the manufacturing sector (Mohanty and Behera, 1996). However, with time there was a need to harmonise existing national and international quality standards around the world and the ISO 9000 series of quality standards were developed (Steenkamp, 2012, p. 482). The series included three standards for quality assurance and these were seen as a model for quality assurance in design, development, production, installation, and servicing (Manders *et al*., 2016). In the late year 2000, the ISO 9000 was rewritten to incorporate TQM concepts (Steenkamp, 2012, p. 13). To date, organisations around the world continue to seek certification to the said ISO standard in order to provide confidence to their customers that their products and services will consistently meet customer requirements (SABS, 2015a). According to the ISO survey conducted, there is a total of 1 519 952 company certifications around the world and of that, 1 034 936 are certified according to the ISO 9001:2015 quality management standard (Charlet, 2016).

On the other hand, total quality management and quality management systems have managed to operate as separate entities. In his book, Steenkamp (2012, p. 483-484) had stated that ISO 9000 and TQM were developed from different perspectives and their difference comes from the degree to which the total organisation is involved. It is from this perspective, that we see various elements used in literature to measure TQM and quality management using ISO standards. Table 1 below outlines the different TQM measures used by various scholars in the measurement of quality.

TABLE 1: TQM MEASURES BY DIFFERENT AUTHORS (source adapted from Bon & Mustafa, 2013)

7 TMQ Principles	Maistry *et al*., 2017	Flynn *et al*., 1995	Saraph *et al*., 1989	Fernandes *et al*., 2012	SABS, 2015b	Kafetzopoulos *et al*., 2015	Demirbag *et al*., 2006
1.Customer Focus	Stakeholder focus	Customer Relationship	N/A	Customer Focus	Customer Focus	Customer Focus	N/A
2.Engagement of People	Training, Teamwork, Employee involvement, Employee appraisal, HRM issues, Employee empowerment and Employee satisfaction	Workforce management	Employee Relations and Training	Involvement and Development of people	Engagement of people	Employee training and involvement	Employee relations and Training
3.Evidence-based decision making	N/A	N/A	Quality data reporting	Result Analysis	Evidence-based decision making	Information and learning	Quality data and reporting
4.Improvement	Continuous improvement	N/A	N/A	Continuous Improvement	Improvement	N/A	N/A
5.Leadership	Top management commitment and leadership	Top management support	Top management leadership	Leadership	Leadership	Leadership and Top management support	Role of Top Management
6.Process Approach	N/A	Process flow	Process management	Process Management	Process Approach	Process Management	Process management
7.Relationship Management	Supplier/partnership management	Supplier relationship	Supplier's quality management	Supplier Relationship	Relationship Management	N/A	Supplier quality management
	Quality culture	work attitudes management	Design and control	Product Design			
	Communication	Statistical control and feedback - Product design	Role of the quality department				
	Social Responsibility						

Based on the information in table 1 above, it is evident that measures used by ISO 9000, classified as quality principles were relatively similar to measures used for TQM. As a result, ISO quality principles (SABS, 2015a) will be used as TQM measures in this study. These principles will include:

Customer Focus

The rationale behind customer focus is to drive the main objective of quality management, which is about meeting customer's requirements and striving to exceed expectations (SABS, 2015b). Zandhessami and Jilili (2013) further argue that organizations' need to exceed customer's expectations, in order to ensure their long-term success and survival. However, meeting customer's requirements begins with studying and understanding the customer's needs and demands (Bon & Mustafa, 2013). Hoang *et al*. (2006) see customer focus as one of the most influential dimensions of TQM.

Engagement of People

People are the main ingredient to driving organisational success. TQM recognises that competent, empowered and engaged people at all levels throughout the organisation are essential to enhance the organisation's capability to create and deliver value (SABS, 2015b). Flynn *et al*. (1995) argue that employees who are loyal, have a positive work attitude and are proud of their work and the organisation they work for, are more likely to take risks that will improve the organisation. However, all of this must be supported by an enabling organisational culture.

Evidence-Based Decision Making

This principle is the glue that ties up most of the TQM principles together to drive better decision making within an organisation. Decisions based on the analysis and evaluation of data and information are more likely to produce desired results (SABS, 2015b). Decisions will vary from process improvement, customer requirements, skills, strategic direction, etc. Therefore the manner in which the organisation selects, collects and analyses given data (Fernandes *et al*., 2012) can be the difference between success and failure.

Improvement

Improvement covers products, services, people, processes and environments. Successful organisations have an ongoing focus on improvement (SABS, 2015b). Zandhesami and Jalili (2013) argue that improvement, rather continuous improvement lies with the organisation's ability to search for never-ending improvements and developing processes that find better methods in the process of converting inputs to outputs. This is done to drive the concept of customer focus.

Leadership

Leadership determines whether an organisation becomes successful or not. The rationale behind leadership in TQM is that leaders at all levels establish unity of purpose and create conditions in which people are engaged in achieving the organisation’s objectives (SABS, 2015b). To achieve this, leaders need to establish long-term goals for the organisation, cascade them down to all employees, provide the necessary resources and create an enabling environment.

Process Approach

Consistent and predictable results are achieved more effectively and efficiently when activities are understood and managed as interrelated processes that function as a coherent system (SABS, 2015b). A systematic approach to operational excellence will ensure that activities in the organisation are executed efficiently in order to achieve desired outcomes.

Relationship Management

For sustained success, organisations manage their relationship with relevant interested parties, such as service providers or suppliers. Flynn *et al*. (1995) further argue that suppliers can contribute to the organisation’s quality performance and this is best achieved through a mutually beneficial relationship.

With its successful application around the world, the question however still remains as to whether quality is at all sufficient to provide a firms’ sustained competitive advantage. According to Demirbag *et al*. (2006), the intensity of global competition and increased demand for better quality by customers had ensured that companies realised the importance of high-quality products and/or services as a way to successfully compete in the marketplace. Raja and Wei (2014), on the other hand, believes that adopting a comprehensive model for quality implementation, evaluation and results will bring about competitive advantage. Though Kafetzopoulos *et al*. (2015) urge that many studies done by cited authors contend that quality management could be one of the prerequisites for innovation. Zhang *et al*. (2016) argue that firms need quality management to maintain market position and innovation to gain sustained competition.

2.3 ISO 9001 IN CONSULTING ENGINEERING FIRMS

The manufacturing industry has been an early adopter of the ISO standard compared to the service sector (Psomas *et al*., 2013). Parker (1994) argue that the manufacturing industry lead the way due to the tangible nature of their product, therefore the degree of quality is easily identified, whilst with the service industry, it is more difficult to gauge. However, the perception of service quality has become more prevalent as a quality scale (Parker, 1994). The author further equates service quality to product quality, which is defined as “fitness for use” (Juran & Gryna, 1988, p. 36). This fitness for use can mean different things to different customers, it’s all about perception. The authors (Goffin & Mitchell, 2017, p. 86) state: “The customer’s perception of the quality and utility of a service product is dependent on the service augmentation, which is the production and delivery mechanism for the service product”.

In a consulting engineering industry, the delivery mechanism is allocated mostly in infrastructure projects. The production of an engineering service typically includes the following activities:

- Pre-feasibility studies,
- Feasibility,
- Stage 1: Inception (including scientific studies),
- Stage 2: Preliminary design,
- Stage 3: Detailed design,
- Stage 4: Documentation and procurement,
- Stage 5; Construction management,
- Stage 6: Project loseout, and
- Facility management

ISO 9001 is implemented at various stages of production or service delivery stages (IICC, 2017). However, engineering design has become more complex and advanced for consulting engineering firms, meaning this process needs to produce quality projects in less time (Mezher *et al*., 2005). Consulting engineering firms need to continuously explore opportunities that will improve their service and project performance.

Given the rate of adoption, Psomas *et al*. (2013) have urged that the gap between the two industries (manufacturing and service) is decreasing as far as ISO certification is concerned. This is reflected in the number of service firms' certification as recorded in the ISO survey. Service firms account for 364 590 in 2015 compared to 89 531 in 1998 (Charlet, 2016). Therefore service firms have recognised the importance of quality management. Quality certification is believed to have a positive effect on firm performance such as financial and operational results, customer satisfaction and people results (Casadesus & Karapetrovic, 2005).

2.4 INNOVATION

Like quality, innovation has been described in a number of ways. The understanding that, it is more than just an idea (Leavengood & Anderson, 2010) is supported by various studies (Maistry *et al*., 2017; Manders *et al*., 2016; McAdam *et al*., 1998; Hoang *et al*., 2006; Zhang *et al*., 2016) conducted over the years. Freeman (1995) defined innovation as a combination of technology, the organisation and experimentation. Organisational innovation is defined as "the implementation of a new organisational method in the firms' business practices, workplace organisation or relations in external environment" (Organisation for Economic Co-operation and Development [OECD], as cited by Goffin & Mitchell, 2017, p. 5)

Mushtaq *et al*. (2011) further outlined the various types of innovation based on the OECD manual as:

- Product innovation
- Process innovation
- Marketing innovation
- Organisational innovation

Others used other types of innovation, such as administration innovation (Bon & Mustafa, 2014b) service innovation (Arshad & Su, 2015) business model innovation (Goffin & Mitchell, 2017) and technological innovation (Golmohammadi *et al*., 2014).

The types of innovation adopted for this study are business/organisation innovation and technological innovation.

Business/Organisational innovation

This study will use business innovation and organisational innovation interchangeably, due to their similarities. Even though there may be an increase in research studies dealing with organisational innovation (Kumar & Saini, 2017), researchers have defined organisational innovation in a number of ways. Camison and Villar-Lopez (2014) argue that the definition of managerial innovation, organisational innovation and administrative innovation overlap (Armbruster *et al*., 2008 as cited by Camison & Villar-Lopez, 2012), whilst others have defined it as new managerial practices, new organisation, new marketing concepts and new corporate strategies(Battisti & Stoneman, 2010).

Kumar and Saini (2017) argue that organisational innovation is intended to increase the firms' performance and the author later considers it as a source of competitive advantage (Hamel, 2006,2007; Mol M et Birkinshaw, 2009)). Maritez-Lorente *et al*. (1999) believe that the application of information technology is one of the most important factors which creates the need for business innovation.

Technological Innovation

The definition adopted for this study was taken from Yonghong *et al*. (2005). The authors define technological innovation as "the adoption of new technologies that are integrated into products or processes". Golmohammadi *et al*. (2014) argue that technological innovation consists of two dimensions, namely product and process innovation. Kim *et al*. (2012) take it a step further by breaking it down into radical and incremental technological innovation. Process innovation is described as changes in the way that an organisation produces products or services (Koberg *et al*.,2003; Utterback, 1994 as cited by Kim *et al*., 2012).

Golmohammadi *et al*. (2014) describe product innovation as a boost in quality of a product or service or an innovation in creating a new product (Burgelman *et al*., 2009 as cited by Golmohammadi *et al*., 2014). Organisations focus on this type of innovation as it is believed to have a long-term success in competitive advantages in the market (Damanpour, 1988).

Since the late 1980s, a systematic understanding of innovation and diffusion was sought and its emphasis was on the relationship between the firms' innovation activities and characteristics of the environment in which it is embedded (Fagerberg *et al*., 2013, p. 3). Later on, the topic of innovation systems was investigated and the initial work was done by Freeman (1995) in the late 1980s, followed by Lundvall and Nelson in the early 1990s, mainly focusing on innovation at a national level (Lundvall *et al*., 2009, p. 2), that is, macro level. Other scholars moved to study innovation at a meso (regional) and micro (firm) levels as the driving forces behind growth (Lundvall *et al*., 2009). The system of innovation starts at a firm level and progresses to a national level. It is important to continue to do research on innovation at a firm level in order to contribute to national objectives. The innovation survey conducted has indicated that only 65.4% of South African enterprises were engaged in innovation activities (Centre for Science Technology and Innovation Indicators[CeSTII], 2011). Firms need an understanding of the importance of innovation as a driver of the economy.

Section 1.3 covered the significance of the consulting engineering firms in South Africa and for this reason, innovation in the industry is vital. It is however understood that organisations will innovate based on both internal and external factors. While some organisations view innovation as a means to attain customer satisfaction through higher quality products and increase profitability through efficient processes (Leavengood & Anderson, 2010), others see innovation as a driver of development and it strengthens their competitive advantage (Bon & Mustafa, 2013). The study aims to equip managers with sufficient information to apply within their operations in order to enable innovation in the firm.

2.5 TQM AND INNOVATION

There has been some research done over the past twenty years aimed at establishing the relationship between TQM and innovation. There seem to be conflicting outcomes from the research community. This literature review revealed more studies in agreement with a positive linkage (Fernandes *et al*., 2014; Arshad & Su, 2015; Zandhessami Jalili, 2013; Kaynak, 2003; Maistry *et al*., 2017; Martinez-Costa and Martinez-Lorente, 2008; Mushtaq *et al*., 2011; Raja & Wei, 2014; Satish & Srinivasan, 2009; Hoang *et al*., 2006; Vasiliki, 2014; Zhang *et al*., 2016). In the empirical study, Hoang *et al*. (2006) confirmed that specific TQM practices such as leadership, people, process, strategy and open organisation had a positive impact on firms' innovativeness and Demirbag *et al*. (2006) found training, employee relations, and quality data and reporting to be the key TQM factors impacting innovation. However, in the study of the relationship between ISO 9001 and product innovation, Manders *et al*. (2016) argue that product innovation is influenced by the extent ISO 9001 is adopted, including the size of the organisation, sector, region and the company's motivation. The author summarised (Table 2) how ISO 9001 influences product innovation in the table below:

TABLE 2: THE INFLUENCE OF ISO 9001 QUALITY MANAGEMENT PRINCIPLES ON PRODUCT INNOVATION [Source: (Manders *et al*., 2016)]

Principles	Outcome
Customer Focus	• Promotes an understanding of customers' needs and expectation, facilitating product innovation • Causes companies to be reactive in the short term, hindering radical innovation • Promotes understanding of the expectations of lead users, facilitating radical innovations • Promotes provocativeness, which allows companies to develop new markets, facilitating radical innovation
Leadership	• Promotes innovation culture, facilitating incremental and radical innovation • Stimulates idea generation, facilitating incremental and radical innovation • Supports company training to empower employees, leading to higher levels of innovation
Involvement of People	• Empowers people, facilitating incremental and radical innovation • Supports autonomy and self-measurement, facilitating incremental and radical innovations • Fosters two-way communication where employees share their problems and the organisation helps them to solve these, facilitating radical and incremental product innovation • Promotes shared knowledge and experience among employees, facilitating innovation
Process Approach	• Leads to process standardisation, hindering innovation, especially radical innovation • Leads to analysing and measuring the capabilities of key activities and focusing on how these activities can be improved, hindering radical innovation
System approach to management	• Causes a shift in culture from downstream inspection to upstream prevention, hindering radical innovation • Causes the involvement of other departments and increases the knowledge base about current and future customers' needs and expectations, facilitating incremental and radical innovation
Continual Improvement	• Promotes an analytical, structural, planned approach, facilitating incremental innovation, but hindering radical innovation due to higher levels of risk aversion • Promotes employee training, facilitating incremental and radical innovation
Factual approach to decision making	• Promotes innovation efficiency, facilitating incremental rather than radical innovation
Mutually beneficial supplier relationships	• Promotes sharing expectations, resources, and information with suppliers, increasing product innovation performance

Prajogo and Sohal (2003) argue for a causal relationship between product quality and product innovation performance and further suggests that TQM at least establishes a ‘pre-condition’ for innovation in order to achieve a real competitive edge. One would wonder if there are any pre-conditions that drive such a relationship. McAdam *et al*. (1998) argue that organisations which have a history of continuous improvement (a TQM practice) are more likely to build a successful innovative culture.

The contradiction in these relationships was highlighted in Prajogo and Sohal’s (Flynn *et al*., 1995; Williams, 1992 as cited by Prajogo & Sohal, 2003) study, where the author cites work by Flynn *et al*. (1995) and Williams (1992), as cited by Prajogo & Sohal, 2003), who questioned whether organisations can excel in both innovation and quality. The former argue that fast product innovation and quality cannot be simultaneously achieved and the latter argue that organisations that focus their strategy on making frequent and fast innovation would not have the time to learn about the process in order to statistically control them to achieve a high level of conformance. That said, Singh and Smith study (2004) resulted in insufficient statistical evidence that could suggest that TQM is related to innovation and indicated that there may be a more complex relationship between these concepts. Some claim that different elements of TQM will have a different impact on innovation (Fernandes *et al*., 2012, 2014).

Martinez-Lorente *et al*. (1999) explored the relationship between TQM and business innovation and claimed that TQM does not hinder business innovation and that some of its dimensions can assist an organisation to be more innovative. These dimensions include customer focus, training, empowerment and teamwork. Martinez-Costa and Martinez-Lorente (2008) stated a positive impact. An empirical study by Kim *et al*. (2012) for both service and manufacturing firm confirmed that a set of TQM practices, with emphasis on process management, has a positive relationship with the types of innovation under study, including technological innovation. Galende *et al*. (2009) urge that the positive relationship is driven by human resource management. Whilst Hoang *et al*. (2006) and Feng (2004) highlighted mixed outcomes on this relationship between TQM and innovation, with the latter indicating that a multidimensional view of this relationship might be an explanation of the conflict found in the study, which suggests that TQM can either support or hinder innovation.

Studies carried out investigating the link between TQM and innovation for service firms or mixed industries either focused on all the types of innovation from the Oslo manual (Raja & Wei, 2014), product and process innovation (Demirbag *et al*., 2006), organisational innovation (Martinez-Costa & Martinez-Lorente, 2008), product innovation (McAdam *et al*., 1998), service innovation, process innovation and administrative innovation, (Mustafa, 2015) product innovation, process innovation, administrative and technological innovation (Golmohammadi *et al*., 2014). A study carried out in South Africa involved the foundry/steel industry and the author (Toga, 2017) investigated the relationship between TQM and product and process innovation. This study aims to contribute to the body of knowledge by investigating the said impact in consulting engineering firms and focusing only on business and technological innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market.

2.6 TQM, INNOVATION and COMPETITIVE ADVANTAGE

In studying the relationship between quality, innovation and performance, the authors (Kafetzopoulos *et al*., 2015) revealed quality's direct contribution to product and process innovation and proved that quality management is an opportunity for a firm to improve its innovation and consequently its competitiveness. However, the basis for sustainable competitive advantage has shifted from quality to innovation as a fundamental component to entrepreneurship (Hoang *et al*., 2006).

In his study, Hilmy (2016) found a moderate impact of TQM on competitive advantage and recommends organisations to look beyond the TQM practices. The authors (Kafetzopoulos *et al*., 2015) argue that TQM gives firms an opportunity to innovate and this inevitably results in competitiveness. The type of innovation under investigation included product and process innovation. Galende *et al*. (2009) support this argument, stating that TQM and innovation are operational management elements that can increase a firms' competitive advantage.

2.7 SUMMARY

The literature has revealed the various ways in which quality was measured over the past decade and how much it has evolved to date to include a set of variables for total quality management. These seven TQM principles consist of leadership, customer focus, engagement of people, evidence-based decision making, process approach and relationship management. This study adopts these variables as a measurement for TQM. Though TQM was predominately practised in the manufacturing industries, its adoption of TQM has since increased in the service sector and this is demonstrated by the number of service firms' certification as recorded in the ISO survey.

On the topic of TQM and innovation, most of the articles found covered studies conducted for companies (both in the manufacturing and service sector) in the USA, Asia and Europe and captured conflicting perspectives as to whether there exists a relationship between TQM and innovation or not and/or whether TQM influences innovation in any way. Studies with a focus on the service sector, mainly put their emphasis on product and process innovation. However, there was very little research done in South Africa on the same topic. One local article found was from an unpublished manuscript and the author (Toga, 2017) investigated the relationship between TQM and innovation (product and process innovation) for the foundry/steel industry in South Africa.

There is, therefore, no single research in South Africa that encompasses and relates TQM, technological innovation and business innovation and how it relates to consulting engineering firms' competitive advantage. A few studies conducted have confirmed that either TQM or innovation contribute to the firms' competitive advantage.

Therefore, this study aims to contribute to the body of knowledge regarding the impact of total quality management principles on innovation, by expanding on the existing research and exploring other elements that may have been missing in previous studies. This is achieved by reviewing how TQM and innovation relate to consulting engineering firms' competitive advantage in the South African market.

2.8 THEORETICAL FRAMEWORK

TQM theoretical framework (figure 3) was developed by consultants who are now classified as gurus in quality. The authors (Bou-Llusar *et al*., 2008) mentioned a few gurus and they include, W. Edwards Deming, Philip B. Crosby and Joseph M. Juran whose work dates back to the 1950-1970s. However, these frameworks have since evolved to include standardised frameworks such as the ISO 9000 series and excellence frameworks such as the European Foundation for Quality Management (EFQM) (Bou-Llusar *et al*., 2008).

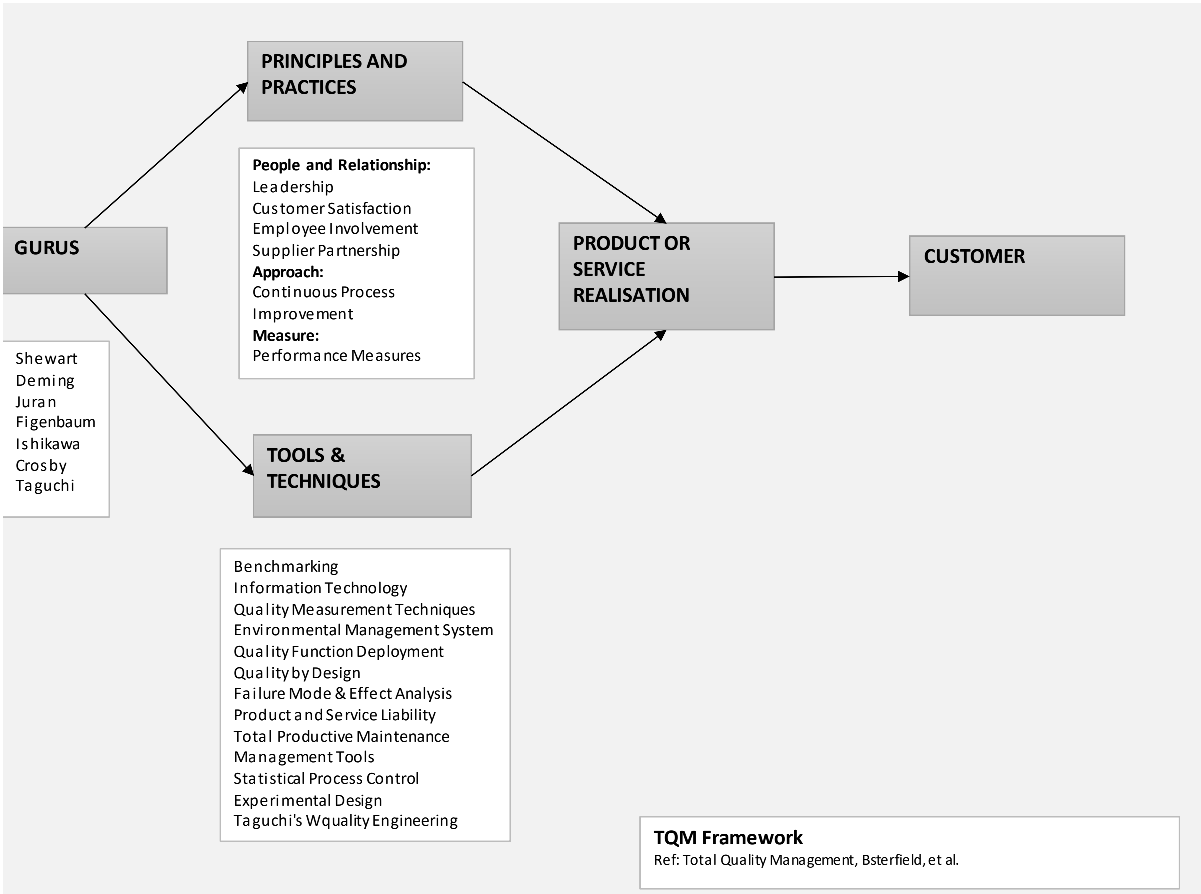


FIGURE 3: TQM FRAMEWORK DEVELOPED BY CONSULTANTS [Source: (Dale et a., 1999)]

In the last decade, several studies have been conducted using TQM frameworks to investigate the relationship between TQM practices and innovation. Prajogo and Sohal (2003) conducted an empirical study for both manufacturing and non-manufacturing companies in Australia and urge that only continuous improvement, customer focus and human resource management has an impact on innovation whilst Martinez-Costa and Martinez-Lorente (2008), whose interest was to investigate whether quality management fosters or hinders innovation and Kim *et al*. (2012) whose investigation centred on quality practices' direct and indirect relations with innovation, explored the impact of TQM on new product and services using researcher's conceptual frameworks. The conceptual framework developed by Kim *et al*. (2012) was later adopted by Bon and Mustafa (2013), whose intent was reviewing the relationship between total quality management (TQM) and innovation in services organisation. The authors considered a number of studies done on the subject matter and proposed a conceptual framework that consisted of TQM concepts (management leadership, employee involvement, employee empowerment, information and analysis, training and education, customer focus and continual improvement) as independent variables and product innovation, process innovation and administrative innovation as dependent variables of the study. A quantitative study was carried out and resulted in a positive relationship between TQM and innovation. A literature review by Manders *et al*. (2016) looked at the impact of ISO 9001 on product innovation and developed a framework (figure 4) to be adopted for future research.

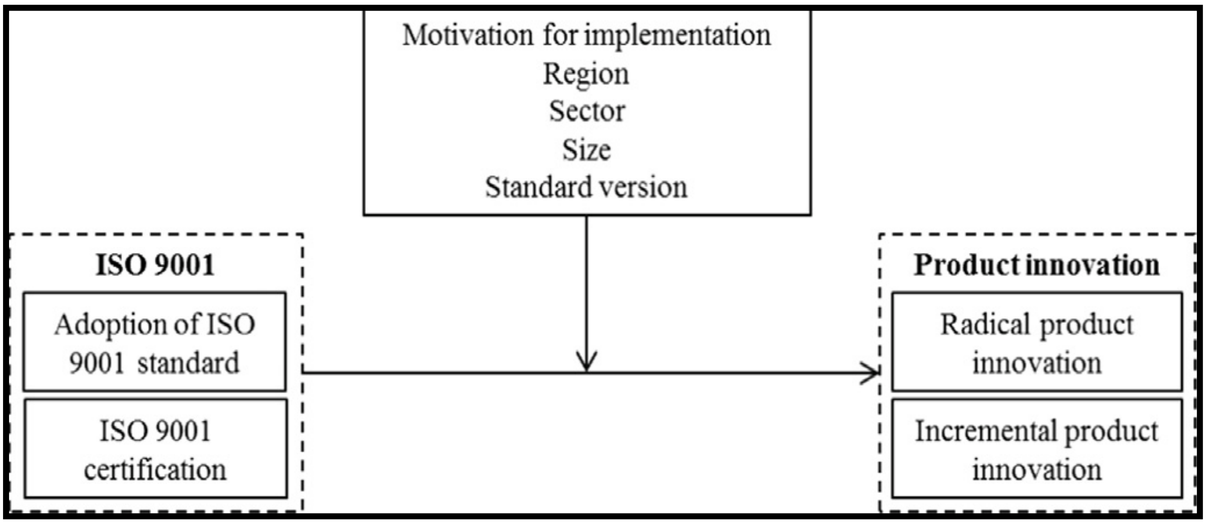


FIGURE 4: RESEARCH FRAMEWORK FOR A RELATIONSHIP BETWEEN ISO 9001 IMPLEMENTATION AND PRODUCT INNOVATION [Source: (Manders *et al*., 2016)]

This study will adopt a theoretical framework as adopted by Manders *et al*. (2016), Bon and Mustafa (2013) and include the EFQM excellence framework (Kim *et al*., 2010) in figure 5. Manders *et al*. (2016) had applied standardised framework from the ISO 9001:2008 standard as TQM practices, therefore, a modified framework to be used in this study will apply ISO 9001 latest version (SABS, 2015a).

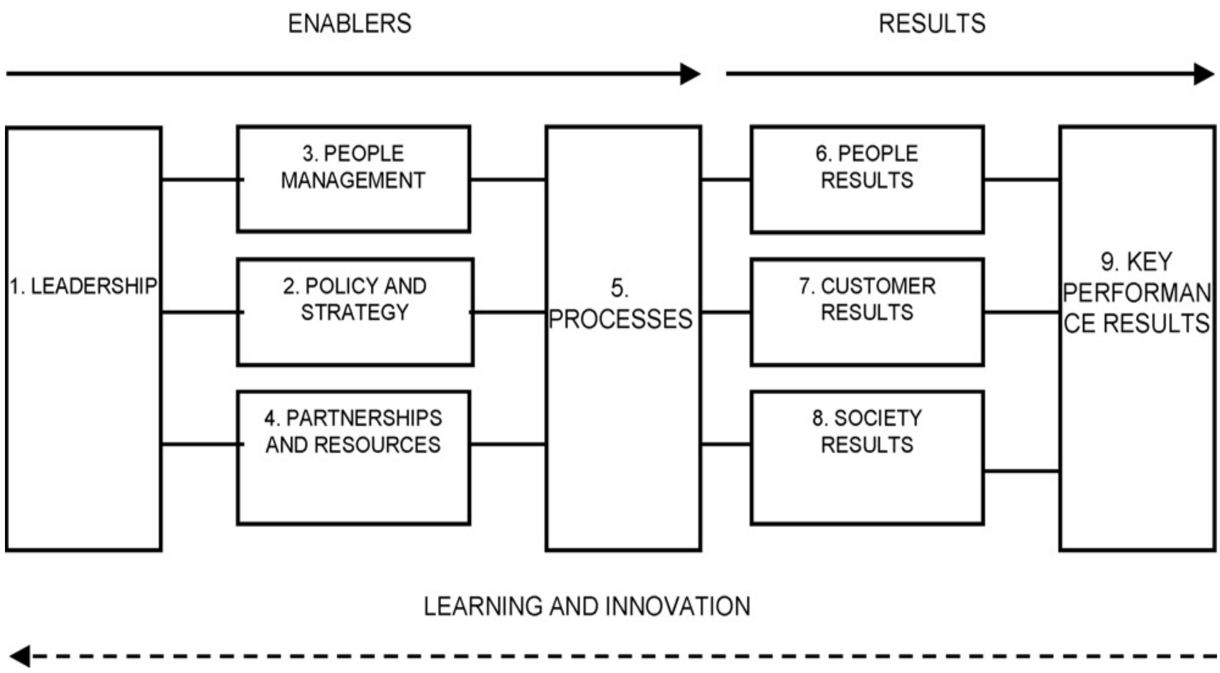


FIGURE 5: EFQM EXCELLENCE FRAMEWORK [Source: (Bou-Llusar *et al*., 2008)]

The integrated framework cover TQM principles as outlined in figure 6 below.

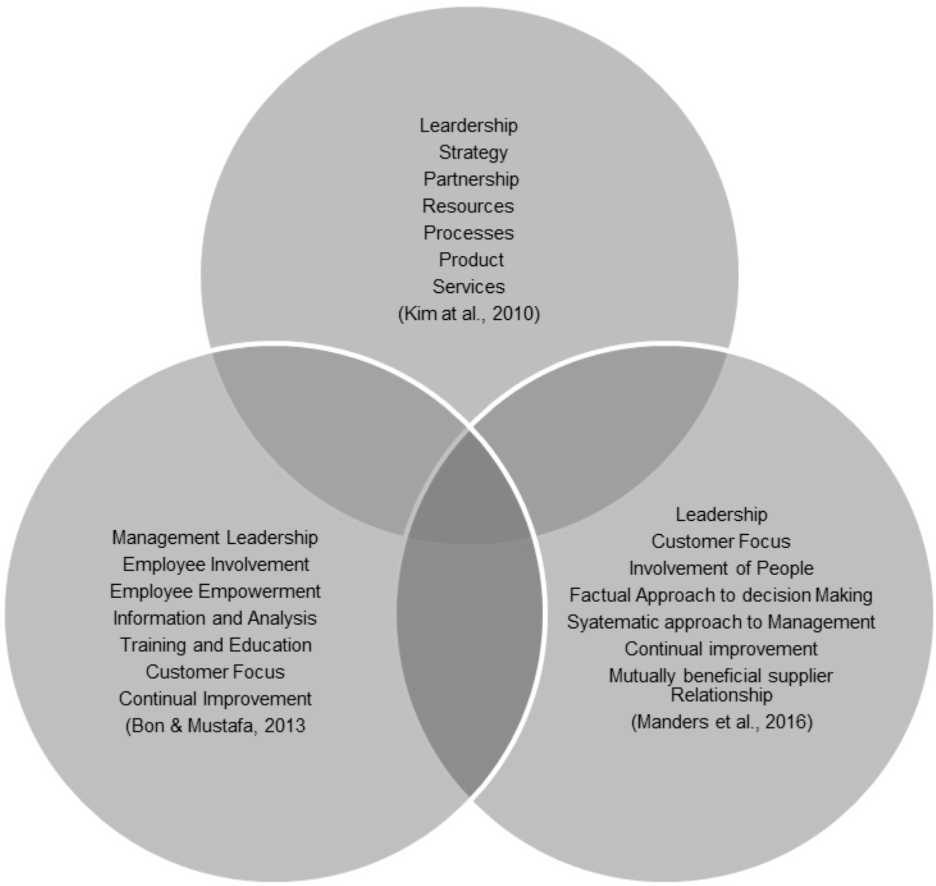


FIGURE 6: COMPARISON OF TQM THEORETICAL FRAMEWORKS [Source: (Bon & Mustafa, 2013; Kim *et al*., 2010; Manders *et al*., 2016)]

2.9 CONCEPTUAL FRAMEWORK

Despite existing literature that supports a positive relationship and/or impact of TQM and innovation, a few have focused on consulting engineering firms using the two constructs in this research study. It is considered relevant to conduct this research and to develop a conceptual framework for future research. The independent variables for the study will consist of the quality management principles as outlined in ISO 9001(SABS, 2015a). The dependent variables of the study will be business and technological innovation as a combined factor. Figure 7 below outlines both variables.

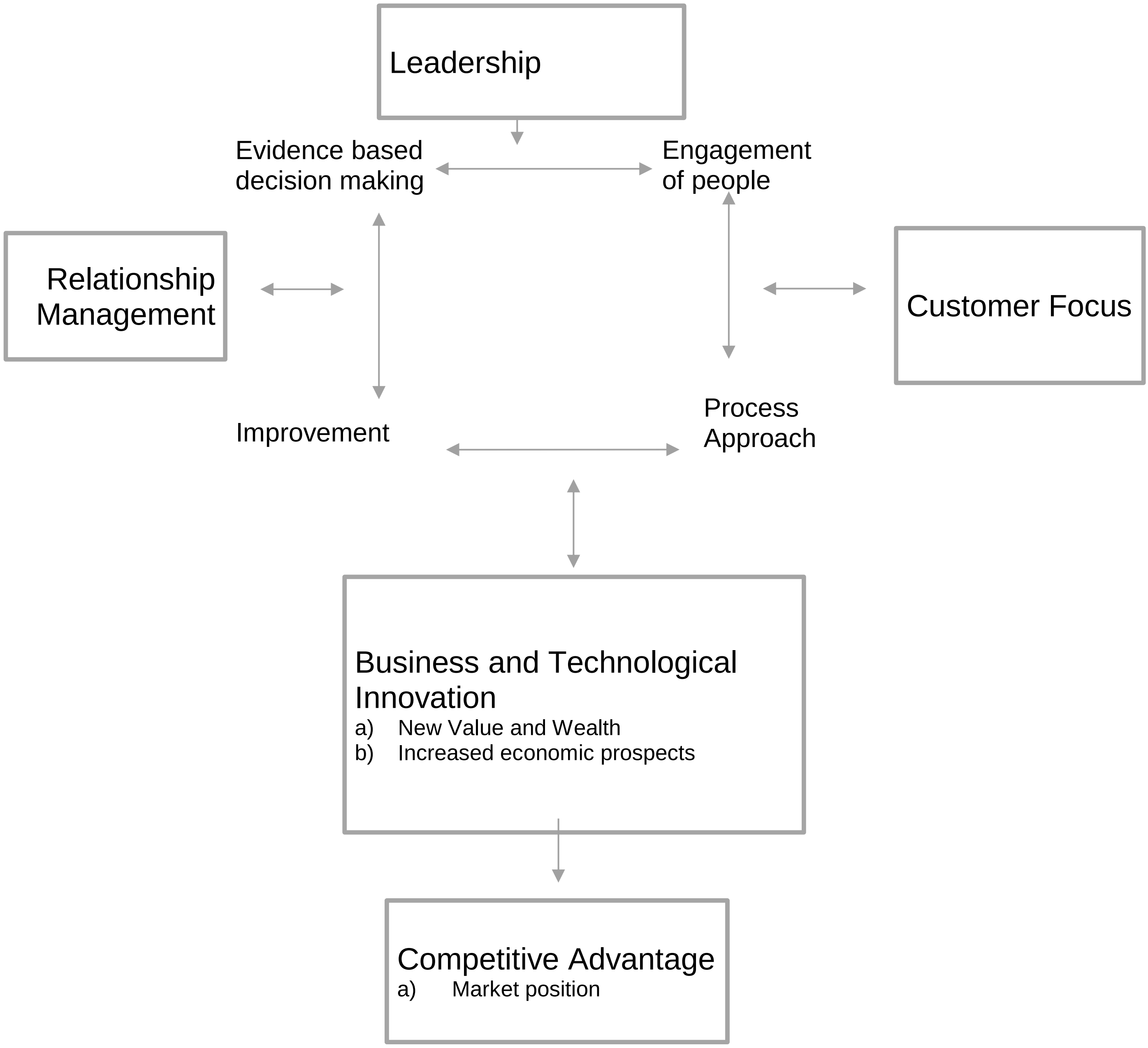


FIGURE 7: RESEARCHER'S CONCEPTUAL MODEL. (Source: Researcher)

2.10 STATEMENT OF HYPOTHESES

Research done over the past two decades on the relationship between TQM and innovation and/or impact of TQM on innovation has revealed conflicting outcomes, with some studies advocating that, specific TQM principles, have an impact on innovation (Demirbag *et al*., 2006; Hoang at al., 2006; Mustafa, 2015) whilst Smith *et al*. study (2004) resulted in insufficient statistical evidence that could suggest that TQM is related to innovation.

The principles of TQM should be managed holistically and not in isolation. Their application and adoption must be balanced in order to have an effective quality management programme (SABS, 2015a). In their research study, Manders *et al*. (2016) supports the statement and argues that product innovation is influenced by the extent ISO 9001 is adopted. Given the above and following the literature review and theoretical frameworks, the following hypotheses were developed:

The null hypothesis (Ho): All TQM principles have an impact on business and technological innovation combined

H1: Specific TQM principles have an impact on business and technological innovation
H1b: Customer focus has an impact on business and technological innovation
H1c: Leadership has an impact on business and technological innovation
H1d: Engagement of people has an impact on business and technological innovation
H1e: Evidence-based decision making has an impact on business and technological innovation
H1f: Process approach has an impact on business and technological innovation
H1g: Improvement has an impact on business and technological innovation
H1h: Relationship management has an impact on business and technological innovation

TQM principles give organisations the capacity to meet the challenges faced in the environment (SABS, 2015b). Shan *et al*. (2016) argue that both TQM and innovation are competitive key factors and are adapted to achieve higher business performance.

Galende *et al*. (2009) support this argument, stating that TQM and innovation are operational management elements that can increase a firms' competitive advantage.

Kafetzopoulos *et al*. (2015) only focused on certain TQM principles such as leadership, employee involvement, information and learning, process management and customer focus. In their study of Greek companies, the authors proved that quality management presented an opportunity for a firm to improve innovation and consequently its competitiveness. Given the above and following the literature review and in support of the significance of this study; the following hypotheses were developed:

H2: TQM and innovation positively influence the firms' competitive advantage

CHAPTER 3: RESEARCH STRATEGY AND METHODOLOGY

3.1 INTRODUCTION

The paradigm adopted for the study is post-positivist often called the scientific method. The paradigm is a suited choice for the study based on the nature of the research problem. According to Creswell (2014, p. 36), this worldview holds a deterministic philosophy in which causes (probably) determine effects or outcomes. It is the intention of this study to determine the impact of TQM on business and technological innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market. Therefore the use of statistical techniques for this investigation will enable the researcher to look at a sample drawn from the population of interest and make statistical inferences about the population.

Singh and Smith (2004) urge that there may be a more complex relation between TQM and innovation and the authors (Prajogo & Sohal, 2003) further suggest that researchers should take note not to quickly claim that TQM in its own right is sufficient for achieving innovation performance. In this study, inferential statistics are used through the application of probabilities to ensure that the researcher can reach a conclusion and attempt to answer the research questions.

3.2 RESEARCH STRATEGY AND DESIGN

This study follows a quantitative approach based on a non-experimental design and it used a survey questionnaire for data collection. Survey research studies provide a numeric description of trends, attitudes or opinion of a population by studying a sample of that population Creswell (2014, p. 41). The study sampled consulting engineering firms in South Africa with a CESA membership.

The author further describes a non-experimental survey design as a type of design used by researchers to describe and measure the degree of association (or relationship) between two or more variables or sets of scores through statistical correlation (Creswell, 2014, p. 41). From the perspective of this research, consulting engineering firms serves as the unit of analysis to study the impact of TQM on business and technological innovation and the data collected from the sampled firms was analysed with the aim to generalise from the sample to the population.

3.3 SELECTION OF PARTICIPANTS

3.3.1. The Population

The study's target population is consulting engineering firms located in South Africa with CESA membership.

The following criterion was applied:

- Firms must have implemented a quality management system or are ISO 9001 certified;
- Surveys to be distributed to middle-senior managers and technical staff;
- Firms must be operational for 5 years or more; and,
- Employee headcount should not be less than seven.

3.3.2. The Sample and Sampling Method

The study used a sampling frame taken from the CESA database. All firms including regional offices are either ISO 9001 certified or have implemented a quality management system. Thus a single-stage sampling was applied and samples were randomly selected.

CESA had a total of 701 member firms at the time of sampling and when the sample frame was extracted. The majority of consulting engineering firms including regional offices per firm are based in Gauteng (226), KwaZulu-Natal (138) and Western Cape (108) respectively (CESA, 2017).

The procedure followed for sample selection is as follows;

- A list of member firms from the sampling frame was computed on an excel programme in no particular order.
- The RAND-function was used to allocate random sample numbers (codes).

- The codes were sorted from smallest to largest.
- The first 200 firms matching the criteria set was then used as a sample for this study.
- All 200 firms were checked to determine whether the criteria set was met and firms that did not meet the criteria were excluded.
- The second set of random firms were then selected, checked and added into the total sample.
- 10 self-selected firms were used for a pilot study. The objective of a pilot study was to reestablish the validity and reliability of the instrument used. A nonprobability sampling method was used for the pilot method because it was convenient given the timeframe to complete this study. The process followed was:

    - Once the final 200 firms for the study was finalized, the researcher self-selected the first 10 firms from the sample frame that did not form part of the final 200 firms.

The possible implication for the nonprobability sampling method includes:

- Selection bias
- Results that cannot be generalised

3.4 RESEARCH METHODOLOGY

The overall approach to this study followed a quantitative research method using a non-experimental approach through the use of a survey. This method was chosen based on the nature of this study. Chapter 2 of this study outlined previous studies on similar topics and it has been found that the relationship between TQM principles, business innovation and competitive performance needed to be explored further (Kafetzopoulos *et al*., 2015). Only a few studies have been conducted specifically for this particular sample and the selected variables. Moreover, the impact of TQM on innovation as a contributor to a firms' competitive advantage is one factor worth exploring. Therefore this study aims to contribute the body of knowledge which can assist engineering firms or managers to better understand the impact TQM can have on innovation and to further understand the benefits of innovation at a macro-level.

3.4.1. Data Collection and Instrument

The study used a modified survey questionnaire for data collection. The survey questionnaire was based on an ordinal scale and administered to participants by email from 8-22 January 2018. The research instrument was compiled using four existing instruments from scholar articles.

The purpose of Kim *et al*. (2012) study was to examine the association among various TQM practices and investigate quality management practices that relate to innovation and the study focused on ISO 9001 certified manufacturing and service organisation. This study selected the following measurement items from the questionnaire outlined in Kim *et al* (2012):

- Management commitment
- Process management
- Customer relations
- Supplier quality management
- Administrative innovation

The following elements were selected from Vasiliki's (2014) proposed questionnaire:

- Leadership
- Customer focus and competitive advantage
- Peoples management
- Process approach (management)
- Financial performance
- Competitive advantage

The author's (Vasiliki, 2014) aim was to create an integrated framework that describes a relationship between quality management practices and innovation and determine how the relationship contributes to firms' performance.

The third extraction was taken from a thesis by Feng (2004), aimed at exploring the relationship between TQM programs and innovation in organisational practices for manufacturing and non-manufacturing firms. This study selected the following from the survey questionnaire:

- Leadership and strategy planning
- Customer focus
- People management
- Supplier relationships
- Financial performance

The last extraction was taken from a thesis by Hilmy (2016), investigating the effect of total quality management on competitive advantage in transport and logistics firms. This study selected the following from the survey questionnaire:

- Top management commitment
- Customer focus
- Innovation, information analysis
- Long-term supplier relationship
- Competitive advantage

The following steps were followed to collect data from participants:

- A modified survey (See Appendix B) together with a cover letter containing information about the research, its objective and confidentiality clause was compiled.
- Email addresses of managers and professional staff were obtained through a desktop research. The sample frame was also used to compile some of the email addresses.
- A pilot survey was first sent out and with a response rate of 1%, the instrument was not modified any further.

- A survey was distributed to 200 consulting engineering firms via email, targeting at least 2-3 managers and professional staff in each firm to minimise non-response rate. The email contained a cover letter with a link (https://docs.google.com/forms/d/e/1FAIpQLScan9uO3J2DONPcBC-aW7cNCLuQ2QPiVzMCCXRFLZpTVDb7sA/viewform?usp=sf_link) to access the complete survey.

The survey questionnaire is sub-divided into sections that will collect data to answer research questions as outlined in table 3 below.

TABLE 3: THE APPROACH APPLIED FOR DATA COLLECTION

<table>
<tr><th>Research Questions</th><th>Data Collection (Items on Survey)</th><th>Source</th><th>Analysis Method</th></tr>
<tr><td rowspan="2">What is the impact of TQM on business and technological innovation?</td><td>Q 22-30</td><td>Kim et al (2012)
ISO 9004</td><td>Multi-linear Regression</td></tr>
<tr><td>Q 1-21</td><td>ISO 9004
Vasiliki (2014)
Kim et al (2012)
Feng (2004)</td><td>Multi-linear Regression</td></tr>
<tr><td>How do these relate to the firms' competitive advantage?</td><td>Q 28-30</td><td>Hilmy (2016)
Vasiliki (2014)</td><td>Analysis of variance (ANOVA)</td></tr>
</table>

3.5 DATA ANALYSIS

Dowdy *et al*. (2009) state that researchers interested in quantitative method apply the same scientific methods in order to reach conclusion. The scientific method for this study followed these steps:

1. State the problem
2. Formulate the hypothesis
3. Design the experiment or survey
4. Make observations

5. Interpret the data
6. Draw conclusions

Hypotheses were formulated for this study and tested through multi-linear regression analysis. The chosen method of analysis is based on the paradigm used and on the nature of the study. Multi-linear regression applies when there is more than one independent variable used to predict the value of a dependent variable (Levine *et al*., 2008). Fernandes *et al*., (2012) further urge that when using multiple linear regression, it is assumed that there is a linear relationship between a variable Y (the dependent variable) and at least one of k-1 independent variable. The authors (Fernandes *et al*., 2012; 1995; Zhang *et al*., 2016) applied regression analysis in the study on the impact of TQM practices on innovation. The purpose of this research study is to investigate the impact of total quality management principles on business and technological innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market. Business and technological innovation represents the dependent variable and the seven TQM principles represent the independent variable. The linear regression model for the impact investigation is presented by the equation below:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon \qquad (1)$$

Where

Y = is Business and Technological Innovation
α = the Y intercept
$\beta_{1\text{-}7}$ = Slope
X_1 = Customer Focus
X_2 = Leadership
X_3 = Engagement with People
X_4 = Evidence based decision making
X_5 = Process Approach
X_6 = Improvement
X_7 = Relationship Management
ε = Random Error Term

The relationship between TQM, innovation and competitive advantage was explored through ANOVA by assessing the F-distribution.

The study interpreted the data collected through a survey questionnaire in order to draw conclusions about the population. The interpretation of results was used to answer the research questions and to outline any implications of the outcome/s. To test the null hypothesis, the value p of the statistic is used. If $p < \alpha$, then the null hypothesis is rejected. The F-test is used to test whether there is a significant relationship between the variable X and Y (the overall model).

The data analysis process applied was taken from Creswell (2014, p. 209-210) and it is as follows:

- Listing all sampled firms and firms that did not meet the sample criteria and were excluded as a result (Appendix A)
- Profiling firms that responded to the survey
- Responses received within one week were analysed and interpreted
- A second reminder was sent out two weeks after the first survey
- Responses received after the first group of respondents were analysed (late respondents) and compared with the first respondents
- A descriptive analysis (mean, standard deviation, etc.) of data conducted for all independent and dependent variables in the study
- Multilinear regression analysis and correlation analysis applied to attempt to answer the research questions
- Data were analysed using StatPlus (StatPlus: mac, Version v6) software to test the major inferential research questions or hypotheses
- Data analysis presented the results in tables and/or figures and the results interpreted were from the statistical test

3.6 LIMITATIONS OF THE STUDY

Quantitative research methods in this study will have its own limitations, such limitations will be based on the instrumentations used in the study and these may include:

- The study does not take into account consulting engineering firms without CESA membership or consulting engineering firms that do not participate in infrastructure projects, therefore, statistical inferences made on the sample to population may not be sufficient to suggest that it applies to all consulting engineering firms in South Africa,
- The use of survey questionnaire may result in low response rate and this will affect the inference that can be made. The author (Dowdy *et al*., 2009) has also argued that larger samples yield more information on which to base decisions.

3.7 ETHICAL CONSIDERATIONS

The research study abides by the rules and regulations of the University of the Witwatersrand (Wits) Business School. The guideline for Human Research Ethics for non-medical research (Wits Guidelines) outlines the important measures to be taken by researchers and mandates researchers to apply ethical standards in their research. This study used an online survey questionnaire that was sent to participants containing the following information/disclosures:

- Participates were given full disclosure about the topic and the purpose of the study.
- Participants were informed that participation is voluntary and that participation constituted an agreement to participate.
- A promise of anonymity (not identifying the person) and confidentiality of responses.
- Data analysed would not be manipulated.

3.8 RELIABILITY AND VALIDITY

The use of instruments by various authors (Feng, 2004; Kim *et al*., 2012; Hilmy, 2016; Vasiliki, 2014) has proven to be reliable. Several tests were carried out to confirm reliability (Table 4), Kim *et al*. (2012) measured random measurement errors, Vasiliki

(2014) and Feng (2004) used an existing survey related to innovation and measured how it is related to quality, performance and competitive advantage. Hilmy (2016) adopted the test-retest technique and concluded that items were reliable and measures what was intended.

This study combined a number of existing survey instruments which were modified to suit the research topic, therefore reliability and validity were reestablished during data analysis. To establish the content validity of scores on the modified survey instrument, a Cronbach test was carried out. Content validity measures the extent to which the items in a scale all measure the same contrast (Ghiselli *et al*., 1981 as cited by Flynn *et al*., 1995; Woon, 2000 as cited by Zhang *et al*., 2016). The overall Cronbach value on the instrument was 0.93 and this demonstrates reliability. A Cronbach alpha between 0.6-0.7 or higher is considered acceptable (Bon & Mustafa, 2014; Flynn *et al*., 1995; Zhang *et al*., 2016).

TABLE 4: INTERNAL CONSISTENCY ANALYSIS USING ANOVA TWO-FACTOR WITHOUT REPLICATION. (Source: Researcher)

Variables	Number of questions	Cronbach alpha
TQM	21	0.92
Innovation	6	0.91
Competitive Advantage	3	0.60

A copy of the research instrument is attached (Appendix B) and the same survey questionnaire was used for a pilot study. Ten firms were selected to participate in the pilot study (Appendix A) in order to improve formats, scales and questions.

3.9 SUMMARY

The chapter described the research strategy adopted for the study to answer the research questions. The topics covered included the research method applied and how data was collected and analysed, research scope and limitations, ethical considerations and instrument reliability and validity.

CHAPTER 4: STATISTICAL ANALYSIS AND RESULTS

4.1 OVERVIEW

4.1.2. Brief introduction

The purpose of the study is to investigate the impact of total quality management principles on innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market. This chapter outlines the findings and results from the research survey, carried out in the attempt to answer research questions. The chapter covers the following:

- Raw data analysis;
- Non-response analysis;
- Respondent profile;
- Descriptive data analysis; and
- Testing the conceptual model.

4.2 RESEARCH FINDINGS

4.2.1. Raw data analysis

The data generated from the survey questionnaire was analysed using StatPlus (StatPlus: mac, Version v6) software. Data screening was carried out in order to identify and handle outliers and/or missing values. The variable, competitive advantage had a few extreme outliers (figure 8) and identified outliers were winzorised and analysed. Winsorization brings the tail observation in towards the centre of the data (Pearson, 1990, p. 34).

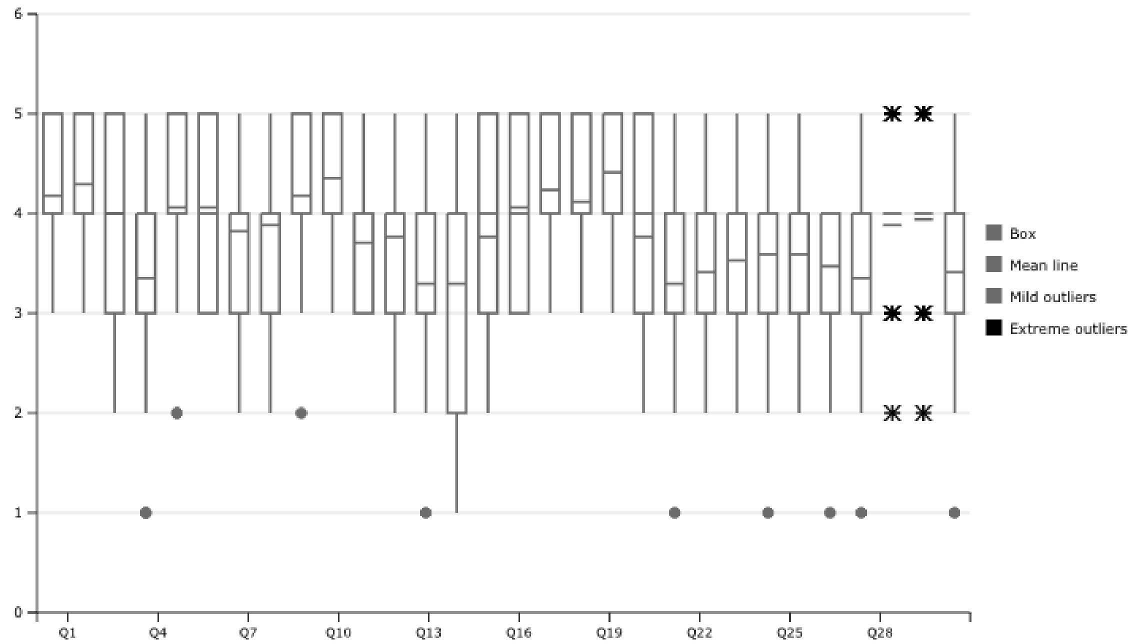


FIGURE 8: RAW DATA ANALYSIS - OUTLIER IDENTIFICATION [Source: Researcher]

Of the 200 sampled firms, 520 surveys were sent out to managers and professional staff and the researcher anticipated at least one response per firm. A total of 34 surveys were returned from different firms for final analysis (response rate of 17%). According to Hung *et al*. (2011) similar studies conducted had a response rates between 9% and 28% (Drew, 1996; Lawler, Mohrman, and Ledford, 1998; Lok, Hung, Walsh, Wang, and Crawford, 2005; O'Neill and Sohal, 1998; Zairi and Sinclair, 1995., as cited in Hung *et al*., 2011).

There are two types of errors that can occur given the responses received. Type I error occurs if the null hypothesis is rejected when it is actually true and should not be rejected and Type II error occurs if the null hypothesis is not rejected when it is actually false and should be rejected. The acceptable risk level for this study is at 0.05 alpha, as a means to control type I error and a sample size controls type II error.

4.2.2. Non-response analysis

A follow-up on non-responses was carried by telephonic communication and via email and it was confirmed that some individuals did not respond due to:

- time constraints;
- being out of office for their December and January break and could not complete the survey;
- refusal to participate; or
- the survey questionnaire may not have reached all members, emails went into spam folders or rejected by company domain.

To determine whether the non-response error is significant between respondents and non-respondents and between early and late respondents, a chi-square test and a t-test were performed. The t-test assesses whether the groups are statistically different from each other and the chi-squared value indicates whether the difference is substantially significant or not. This was done to get a sense that the respondents are typical of the population.

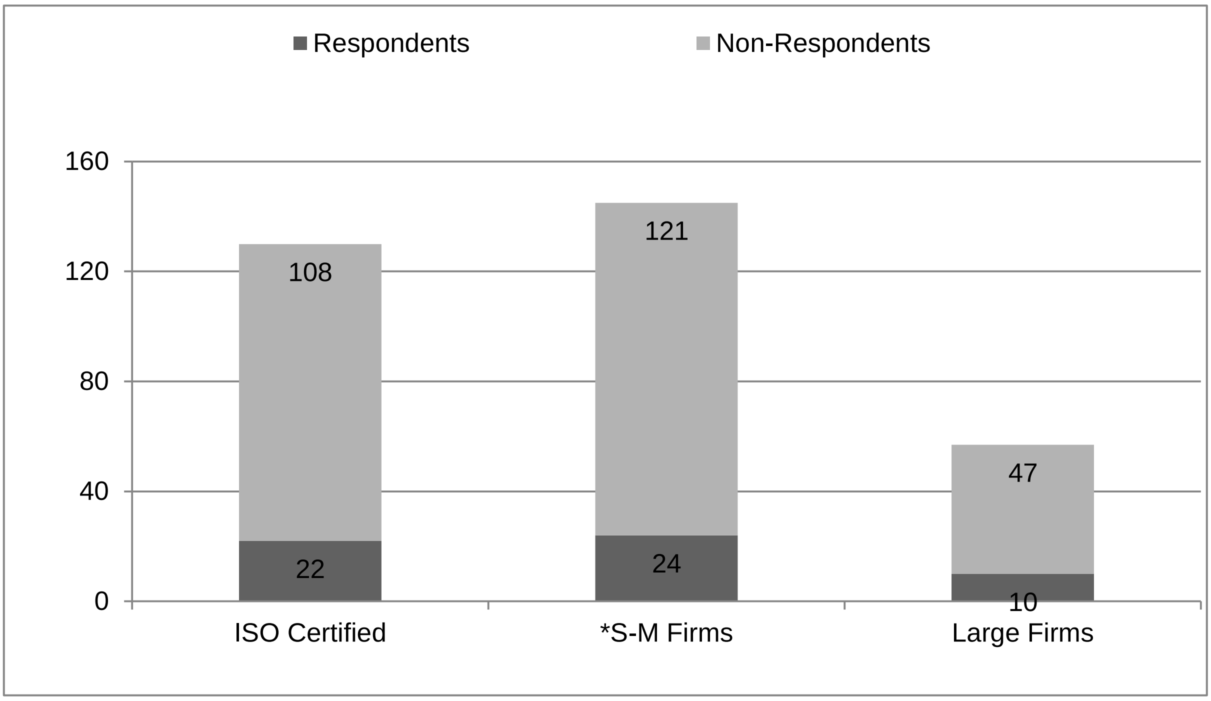
Firms were categorised as follows:

- Number of employees and
- Whether the firm was ISO certified or had only implemented a quality management system.

Table 5 and figure 9 below summarises the outcome for respondents and non-respondents. Table 6 and figure 10 summarises the outcome for early and late respondents.

TABLE 5: ANALYSIS OF DIFFERENCE BETWEEN RESPONDENTS AND NON-RESPONDENTS (Source: Researcher)

Firm Profile	Respondents	Non-respondents	Chi-Squared	p-value	t-test
ISO Certified	22 (11%)	108 (54%)	0.99	0.97	0.04
Small-Medium Sized (=<100 employees)	24 (12%)	121 (60.5%)	0.92	0.38	0.86
Large Sized (>100 employees)	10 (5%)	47 (23.5%)	0.89		

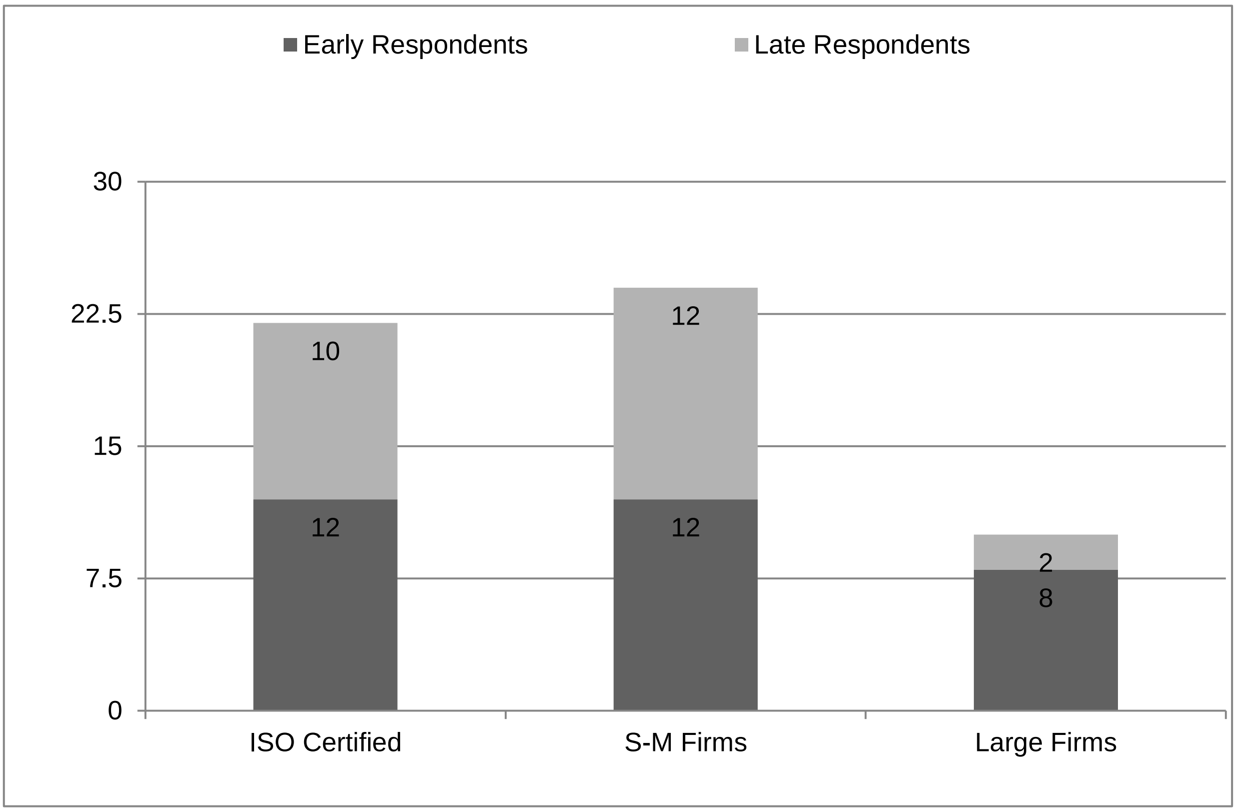


*S-M: Small-Medium

FIGURE 9: COMPARISON BETWEEN RESPONDENTS AND NON-RESPONDENTS. (Source: Researcher)

TABLE 6: ANALYSIS OF DIFFERENCE BETWEEN EARLY RESPONDENTS AND LATE RESPONDENTS. (Source; Researcher)

Firm Profile	Early Respondents	Late Respondents	Chi-Squared	p-value	t-test
ISO Certified	12 (6%)	10 (5%)	0.81	0.51	0.67
Small-Medium Sized (=<100 employees)	12 (6%)	12 (6%)	0.48	0.14	1.53
Large Sized (>100 employees)	8 (4%)	2 (1%)	0.14		



*S-M: Small-Medium

FIGURE 10: COMPARISON BETWEEN EARLY AND LATE RESPONDENTS. (Source: Researcher)

The results of the comparison between respondents and non-respondents sample indicate a high percentage of small-medium consulting engineering firms in the non-respondents sample compared to large sized consulting engineering firms, with 60.5% and 23.5% respectively, and 54% of the non-respondents are ISO 9001 certified. However, these differences are not significant enough to confirm the major differences between the two groups. The null hypothesis states that there is no difference between the respondents and the non-respondents. The t-test was carried out to assess whether the means for respondents and non-respondents were statistically different from each other. A t-test assuming equal variance in a two-tailed distribution resulted in a p-value that is greater than 0.05 and it was concluded that the mean for the two groups is not significantly different.

The computed chi-squared value between the observed distribution and the actual distribution was greater than 0.05, thus the null hypothesis is not rejected. It was therefore concluded that there are no statistically significant differences between respondents and non-respondents. The same conclusion was reached for the comparison between early respondents and late respondents. This is indicative that the sample is a good representative for the target population and thus statistical inference can be made on the sample for the population

4.2.3. Respondents Profile

Table 7 below summarises the firm profiles following the criteria set.

TABLE 7: RESPONDENTS PROFILE. (Source: Researcher)

Firms characteristics	Number	Percentage
ISO Certified	22	11%
Small-Medium Sized (=<100 employees)	24	12%
Large Sized (>100 employees)	10	5%
Experience (between 5-10 years in operation)	2	1%
Experience (between 11-100years in operation)	30	15%
Experience (>100 years in operation)	2	1%
Geographic Location (Northern Region)	14	7%
Geographic Location (Central Region)	92	46%
Geographic Location (Coastal Regions)	94	47%

**Northern region; Limpopo and North West **Coastal region: Kwa-Zulu Natal, Eastern Cape, Western Cape and Northern Cape **Central Region: Gauteng, Free State and Mpumalanga

The survey questionnaire was sent out to consulting engineering firms registered with CESA across South Africa. Below (figure 11) is the geographical representation of the participants.

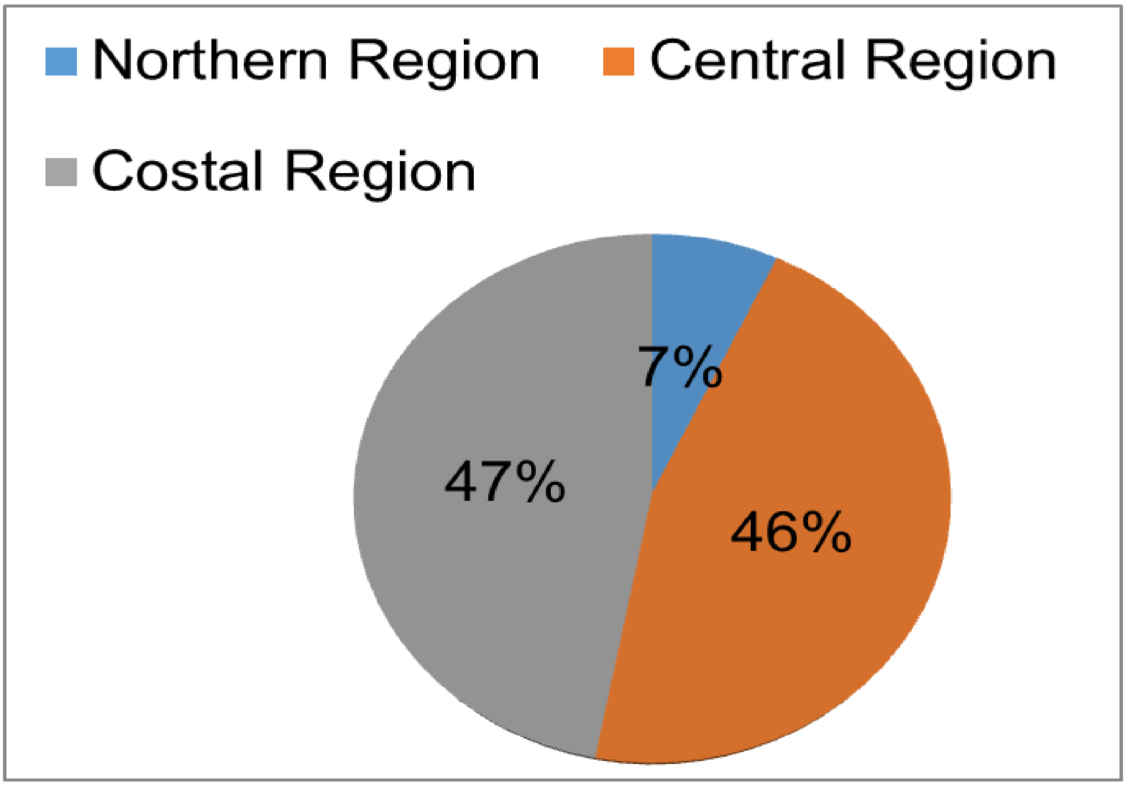


FIGURE 11: PARTICIPANTS GEOGRAPHICAL LOCATION WITHIN SOUTH AFRICA. (Source: Researcher)

4.2.4. Descriptive Data Analysis

The section provides a summary of descriptive statistics used to describe the basic features of each variable under study.

When TQM principles are effectively implemented in any organisation, it allows every aspect of the organisation to operate at peak level (Steenkamp, 2012, p. 15). Organisations tend to achieve such performance over a certain maturity level. The study assessed TQM using seven principles to measure the extent of adoption and maturity of TQM in consulting engineering firms in South Africa.

TABLE 8: VARIABLE # 1 - CUSTOMER FOCUS (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.58131
Mean	3.82353	Second Moment	0.49827
Mean LCL	3.57353	Third Moment	0.09281
Mean UCL	4.07353	Fourth Moment	0.50086
Variance	0.51337		
Standard Deviation	0.71650	Sum	130
Mean Standard Error	0.12288	Sum Standard Error	4.17786
Coefficient of Variation	0.18739	Total Sum Squares	514
		Adjusted Sum Squares	16.94118
Minimum	3		
Maximum	5	Geometric Mean	3.75894
Range	2	Harmonic Mean	3.69565
		Mode	4
Median	4		
Median Error	0.02641	Skewness	0.26389
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.01736
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0.5	Skewness (Fisher's)	0.27623
Coefficient of Dispersion (COD)	0.13235	Kurtosis (Fisher's)	-0.94450

The pattern of distribution of data values for the variable is left-skewed; as a result, the median is used as a measure of central tendency. The study found that customer focus had an overall median of 4, which indicates full implementation and maturity of this variable within a TQM program. The peakness of distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 9: VARIABLE # 2 - LEADERSHIP (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.72664
Mean	3.52941	Second Moment	0.71972
Mean LCL	3.22895	Third Moment	-0.40912
Mean UCL	3.82987	Fourth Moment	1.28337
Variance	0.74153		
Standard Deviation	0.86112	Sum	120
Mean Standard Error	0.14768	Sum Standard Error	5.02117
Coefficient of Variation	0.24398	Total Sum Squares	448
		Adjusted Sum Squares	24.47059
Minimum	2		
Maximum	5	Geometric Mean	3.40871
Range	3	Harmonic Mean	3.26923
		Mode	4
Median	4		
Median Error	0.03174	Skewness	-0.67004
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.47753
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0	Skewness (Fisher's)	-0.70137
Coefficient of Dispersion (COD)	0.14706	Kurtosis (Fisher's)	-0.40872

The pattern of distribution of data values for the variable is left-skewed; as a result, the median is used as a measure of central tendency. The study found that leadership had an overall median of 4, which indicates full implementation and maturity of this variable within a TQM program. The peakness of distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 10: VARIABLE # 3 - ENGAGEMENT OF PEOPLE (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.53287
Mean	3.70588	Second Moment	0.44291
Mean LCL	3.47018	Third Moment	-0.23082
Mean UCL	3.94158	Fourth Moment	0.72638
Variance	0.45633		
Standard Deviation	0.67552	Sum	126
Mean Standard Error	0.11585	Sum Standard Error	3.93893
Coefficient of Variation	0.18228	Total Sum Squares	482
		Adjusted Sum Squares	15.05882
Minimum	2		
Maximum	5	Geometric Mean	3.63627
Range	3	Harmonic Mean	3.55401
		Mode	4
Median	4		
Median Error	0.02490	Skewness	-0.78307
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	3.70288
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0	Skewness (Fisher's)	-0.81968
Coefficient of Dispersion (COD)	0.10294	Kurtosis (Fisher's)	1.01797

The pattern of distribution of data values for the variable is left-skewed; as a result, the median is used as a measure of central tendency. The study found that engagement of people had an overall median of 4, which indicates full implementation and maturity of this variable within a TQM program. The peakness of the distribution is leptokurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 11: VARIABLE # 4 - EVIDENCE-BASED DECISION MAKING (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.67820
Mean	3.47059	Second Moment	0.60208
Mean LCL	3.19578	Third Moment	-0.13067
Mean UCL	3.74540	Fourth Moment	0.92635
Variance	0.62032		
Standard Deviation	0.78760	Sum	118
Mean Standard Error	0.13507	Sum Standard Error	4.59248
Coefficient of Variation	0.22694	Total Sum Squares	430
		Adjusted Sum Squares	20.47059
Minimum	2		
Maximum	5	Geometric Mean	3.37481
Range	3	Harmonic Mean	3.26923
		Mode	4
Median	4		
Median Error	0.02903	Skewness	-0.27971
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.55549
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0	Skewness (Fisher's)	-0.29279
Coefficient of Dispersion (COD)	0.16176	Kurtosis (Fisher's)	-0.31795

The pattern of distribution of data values for the variable is left-skewed; as a result, the median is used as a measure of central tendency. The study found that evidence-based decision making had an overall median of 4, which indicates full implementation and maturity of this variable within a TQM program. The peakness of the distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 12: VARIABLE # 5 - PROCESS APPROACH (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.78893
Mean	3.47059	Second Moment	0.83737
Mean LCL	3.14650	Third Moment	0.24303
Mean UCL	3.79468	Fourth Moment	1.55733
Variance	0.86275		
Standard Deviation	0.92884	Sum	118
Mean Standard Error	0.15929	Sum Standard Error	5.41603
Coefficient of Variation	0.26763	Total Sum Squares	438
		Adjusted Sum Squares	28.47059
Minimum	2		
Maximum	5	Geometric Mean	3.34928
Range	3	Harmonic Mean	3.22785
		Mode	3
Median	3		
Median Error	0.03424	Skewness	0.31716
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.22099
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	1	Skewness (Fisher's)	0.33199
Coefficient of Dispersion (COD)	0.23529	Kurtosis (Fisher's)	-0.70742

The pattern of distribution of data values for the variable is right-skewed; as a result, the median is used as a measure of central tendency. The study found that the process approach had an overall median of 3, which indicates moderate implementation and maturity of this variable within a TQM program. The peakness of the distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 13: VARIABLE # 6 - IMPROVEMENT (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.44291
Mean	4.05882	Second Moment	0.40830
Mean LCL	3.83252	Third Moment	-0.01343
Mean UCL	4.28513	Fourth Moment	0.40644
Variance	0.42068		
Standard Deviation	0.64860	Sum	138
Mean Standard Error	0.11123	Sum Standard Error	3.78193
Coefficient of Variation	0.15980	Total Sum Squares	574
		Adjusted Sum Squares	13.88235
Minimum	3		
Maximum	5	Geometric Mean	4.00695
Range	2	Harmonic Mean	3.95349
		Mode	4
Median	4		
Median Error	0.02391	Skewness	-0.05149
Percentile 25% (Q1)	4	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.43795
IQR	0	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0	Skewness (Fisher's)	-0.05390
Coefficient of Dispersion (COD)	0.10294	Kurtosis (Fisher's)	-0.45481

The pattern of distribution of data values for the variable is symmetric and a mean is used as a measure of central tendency. The study found that improvement had an overall mean of 4, which indicates full implementation and maturity of this variable within a TQM program. The peakness of the distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

TABLE 14: VARIABLE # 7 - RELATIONSHIP MANAGEMENT (Source: Researcher)

Item	Result	Item	Result
Count	34	Mean Deviation	0.85121
Mean	3.47059	Second Moment	0.95502
Mean LCL	3.12448	Third Moment	0.07694
Mean UCL	3.81669	Fourth Moment	1.83130
Variance	0.98396		
Standard Deviation	0.99195	Sum	118
Mean Standard Error	0.17012	Sum Standard Error	5.78399
Coefficient of Variation	0.28582	Total Sum Squares	442
		Adjusted Sum Squares	32.47059
Minimum	2		
Maximum	5	Geometric Mean	3.32616
Range	3	Harmonic Mean	3.17757
		Mode	3
Median	3		
Median Error	0.03657	Skewness	0.08244
Percentile 25% (Q1)	3	Skewness Standard Error	0.39102
Percentile 75% (Q3)	4	Kurtosis	2.00788
IQR	1	Kurtosis Standard Error	0.71772
MAD (Median Absolute Deviation)	0.5	Skewness (Fisher's)	0.08629
Coefficient of Dispersion (COD)	0.27451	Kurtosis (Fisher's)	-0.95555

The pattern of distribution of data values for the variable is right-skewed; as a result, the median is used as a measure of central tendency. The study found that relationship management had an overall median of 3, which indicates moderate implementation and maturity of this variable within a TQM program. The peakness of the distribution is platykurtic. The dataset values are less than 1 standard deviation away from the mean value, meaning the datasets are slightly dispersed and resulted in a flat shape.

4.2.5. Testing the conceptual model

This section provides a summary of descriptive statistics used to describe the basic features of the variables under study. The second part outlines the outcome of testing the theory.

The purpose of this research proposal is to investigate the impact of total quality management principles on innovation. A survey questionnaire was sent to consulting engineering firms in order to collect data, analyse and enable the researcher to make statistical inferences about the population. In the ordinal scale instrument with a rating of 1-5, the respondents were required to demonstrate the degree to which consulting engineering firms are innovative as a result of adopting TQM.

<u>Descriptive Analysis</u>

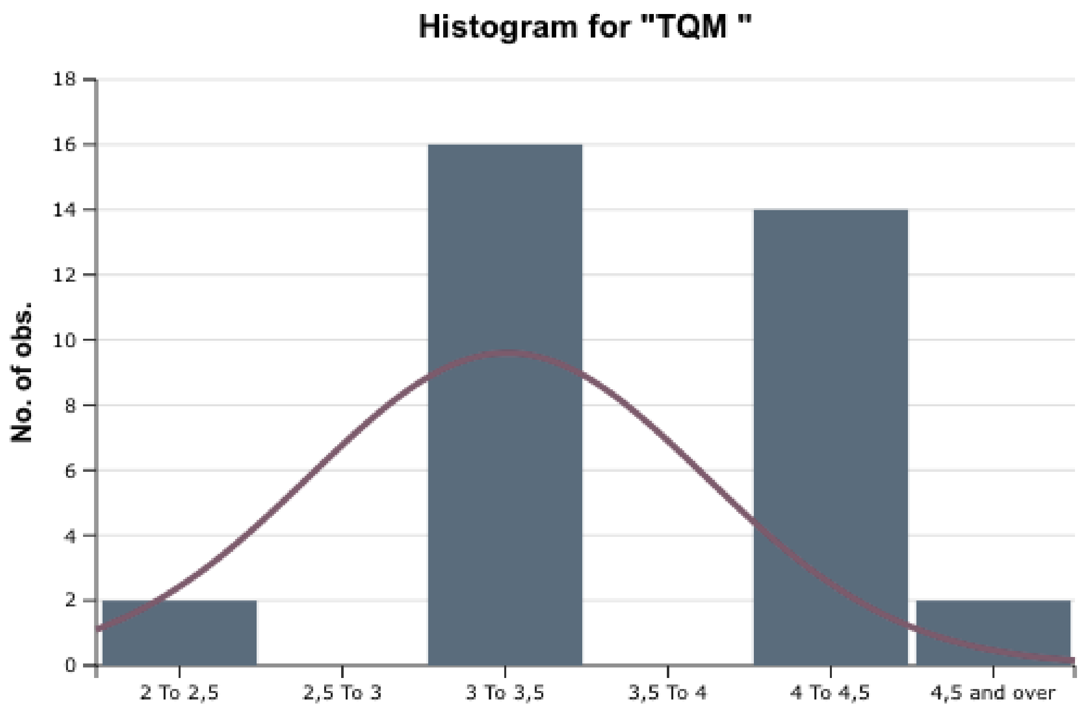


FIGURE 12: TQM DATA VARIATION AND SHAPE. (Source: Researcher)

The pattern of distribution of data values for the variable is right-skewed; as a result, the median is used as a measure of central tendency. The study found that TQM had an overall median of 3, which indicates an overall moderate implementation and maturity of a TQM program. The peakness of the distribution is platykurtic.

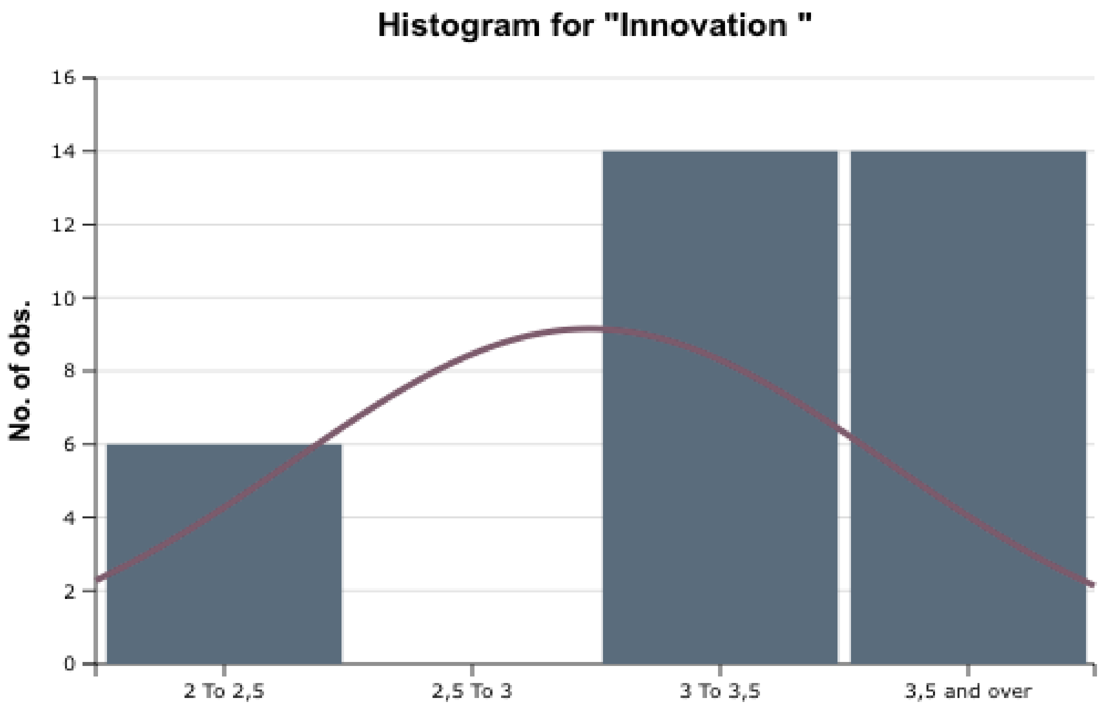


FIGURE 13: INNOVATION DATA VARIATION AND SHAPE (Source: Researcher)

The pattern of distribution of data values for the variable is right-skewed; as a result, the median is used as a measure of central tendency. The study found that innovation had an overall median of 3, which indicates moderate innovation taking place in a firm. The peakness of the distribution is platykurtic.

Conceptual Model Testing

Null Hypothesis: The hypothesis to be tested states that all TQM principles have an impact on business and technological innovation combined. The model is expressed below:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon$$

The model assumes a linear relationship between the variables and in order to test the model, a multiple linear regression analysis was carried out. However before a regression analysis can be done, it is necessary to verify the fulfilment of the assumptions made.

Table 15: Regression Statistics and ANOVA Analysis (Source: Researcher)

Regression Statistics	
R	0.73064
R-Squared	0.53384
Adjusted R-Squared	0.40833
S	0.56995
MSE	0.32484
Predicted R-Squared	0.20457
N	34

ANOVA					
	d.f.	SS	MS	F	p-value
Regression	7	9.67187	1.38170	4.25350	0.00300
Residual	26	8.44577	0.32484		
Total	33	18.11765			

Model	Coefficient	Std. Error	t Stat	p-value
Intercept	1.68451	0.77438	2.17531	0.03889
Customer Focus (X1)	-0.46902	0.21161	-2.21642	0.03562
Leadership (X2)	-0.24993	0.29453	-0.84857	0.40387
Engagement of People (X3)	0.96223	0.39584	2.43085	0.02227
Evidence-Based Decision Making (X4)	0.6204	0.23633	2.62511	0.01432
Process Approach (X5)	-0.33976	0.18001	-1.88753	0.0703
Improvement (X6)	0.07083	0.28061	0.25242	0.8027
Relationship Management (X7)	-0.17322	0.1593	-1.08742	0.28683

Linearity: Testing the significance of the linear relationship, i.e. goodness of fit (F-test), the p-value of 0.003 at 95% confidence level (alpha at 0.05) rejects the null hypothesis, which implies that TQM principles jointly significantly explain business and technological innovation.

Normality: To assess whether the errors are normally distributed at each value of X, a probability plot of residuals was constructed. In the figure below the data does not appear to depart substantially from a normal distribution.

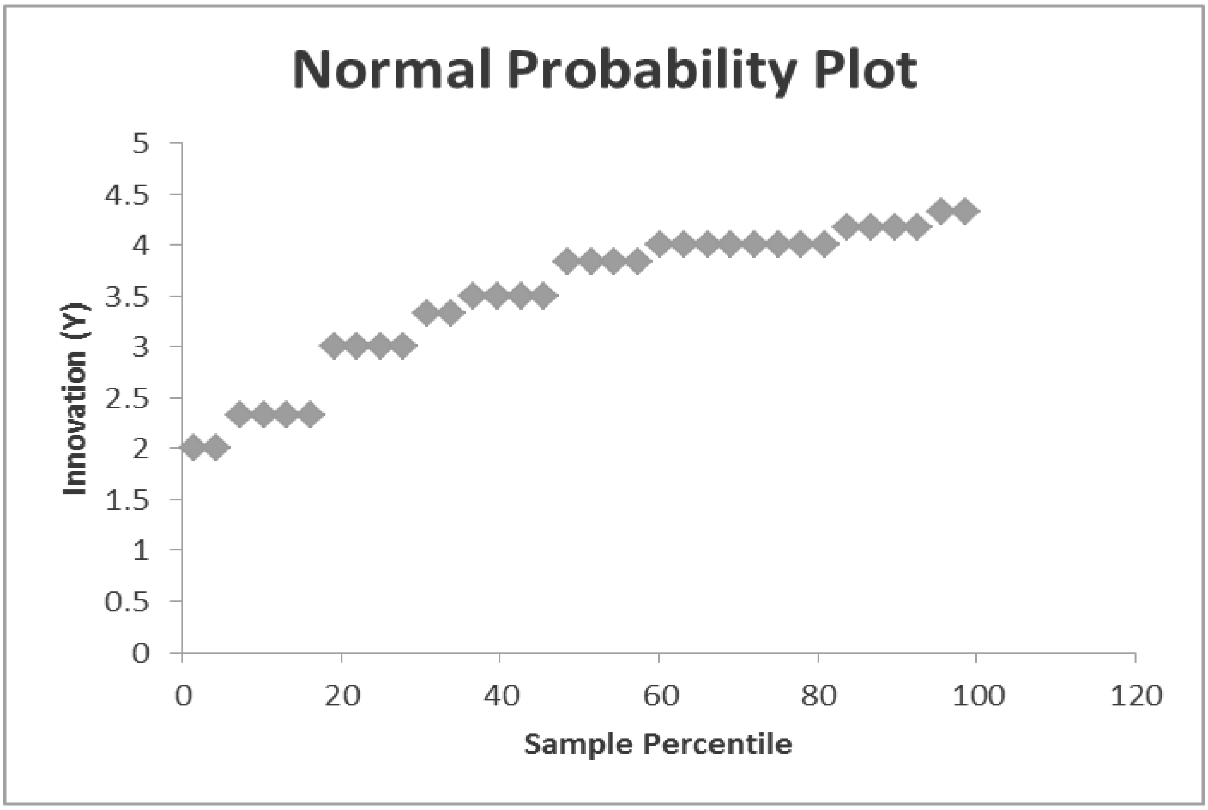
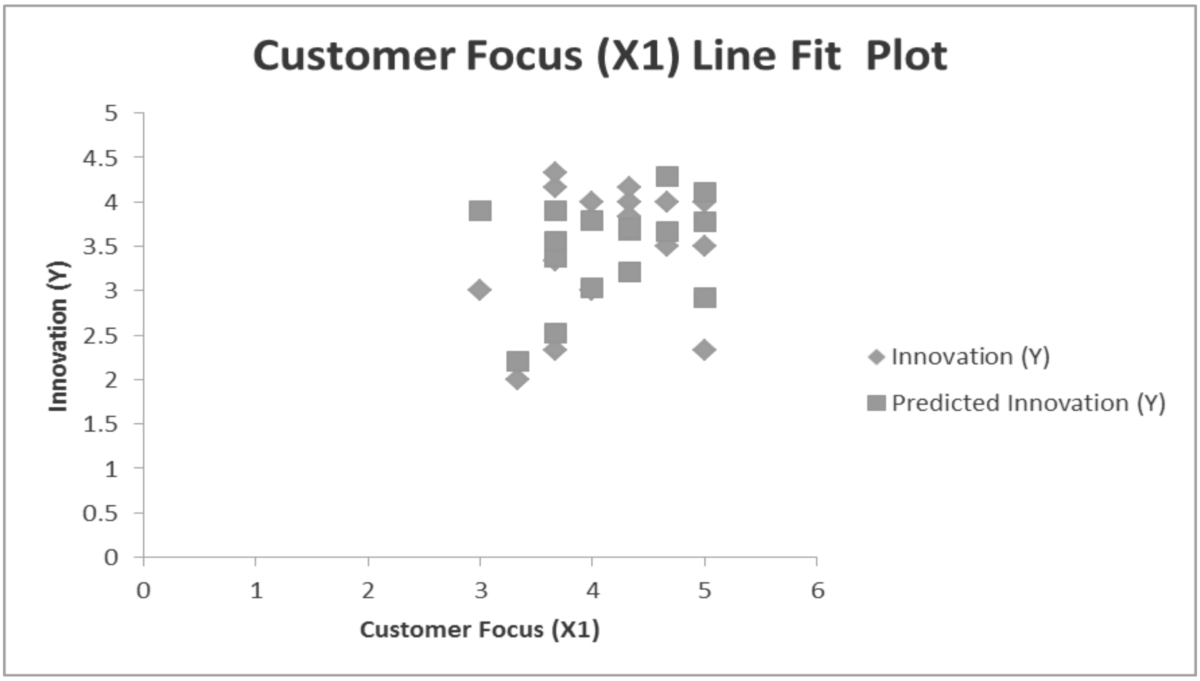
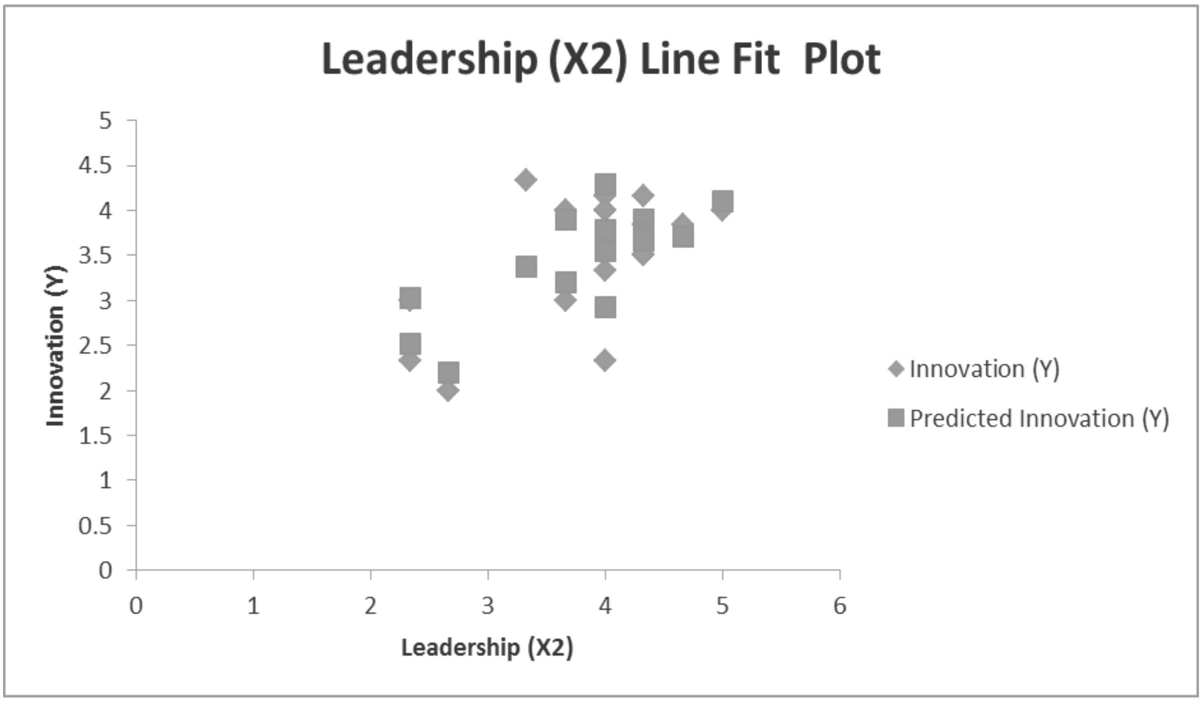
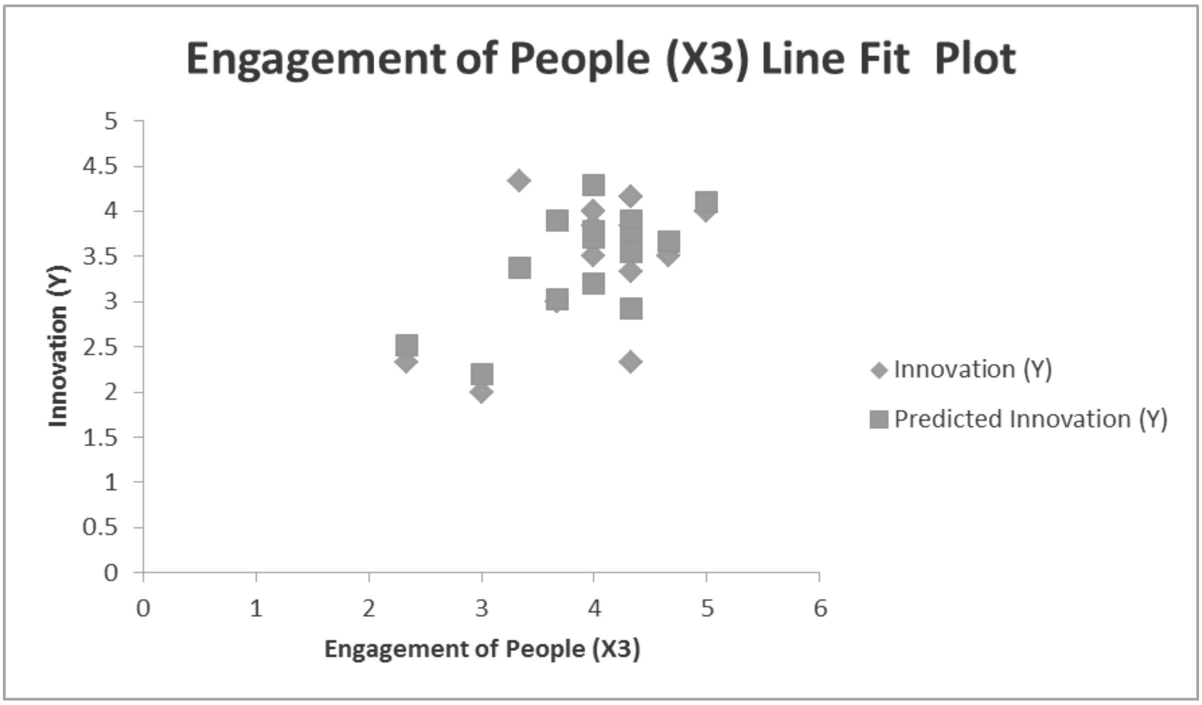


FIGURE 14: NORMAL PROBABILITY PLOT OF RESIDUALS. (Source: Researcher)

Homoscedasticity: A residual analysis was used to evaluate the assumptions about the model and to determine whether the regression model is an appropriate model. This is demonstrated in figure 15 below.






Engagement of People (X3) Line Fit Plot
Innovation (Y)
Engagement of People (X3)
Innovation (Y)
Predicted Innovation (Y)
0
0.5
1
1.5
2
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3
3.5
4
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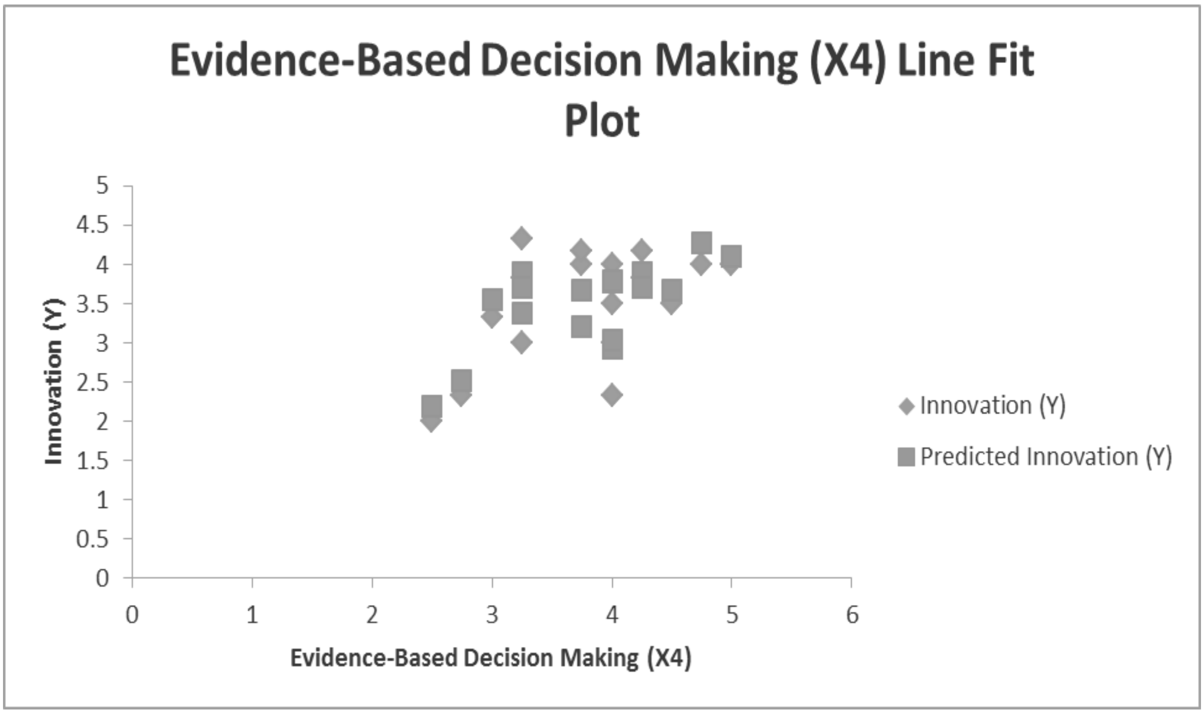
0
1
2
3
4
5
6


Evidence-Based Decision Making (X4) Line Fit Plot
Innovation (Y)
Evidence-Based Decision Making (X4)
Innovation (Y)
Predicted Innovation (Y)
0
0.5
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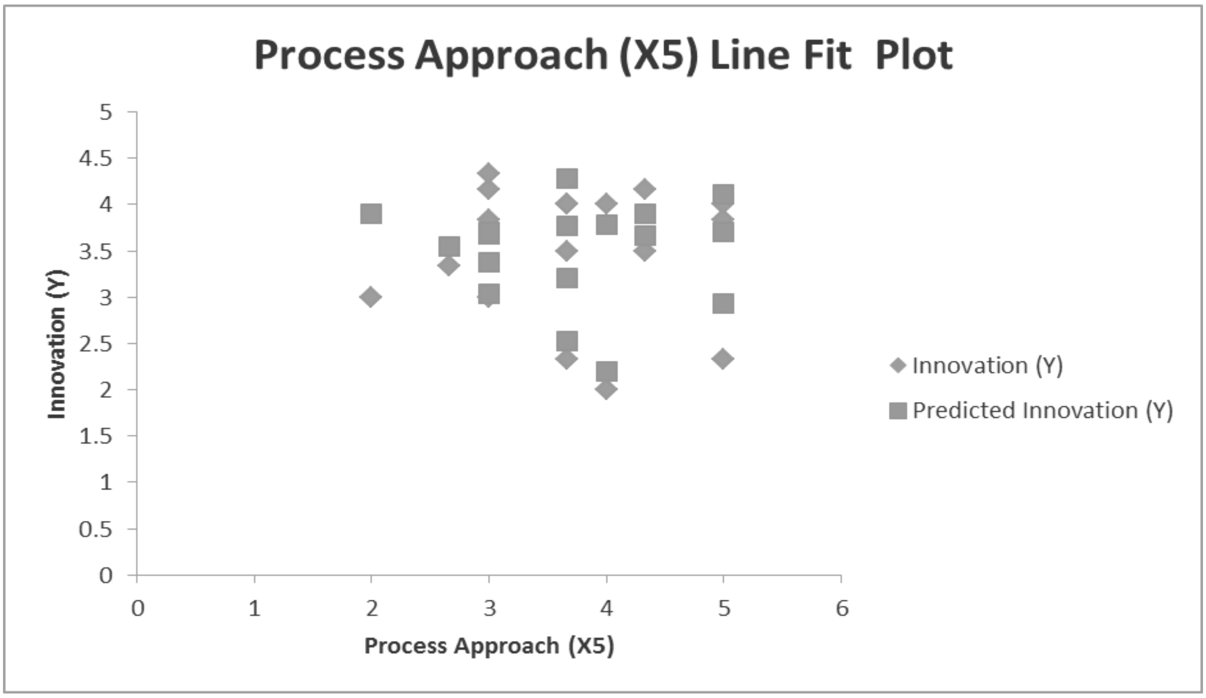
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
5
6


Process Approach (X5) Line Fit Plot
Innovation (Y)
Process Approach (X5)
Innovation (Y)
Predicted Innovation (Y)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
5
6


Improvement (X6) Line Fit Plot
Innovation (Y)
Improvement (X6)
Innovation (Y)
Predicted Innovation (Y)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
5
6

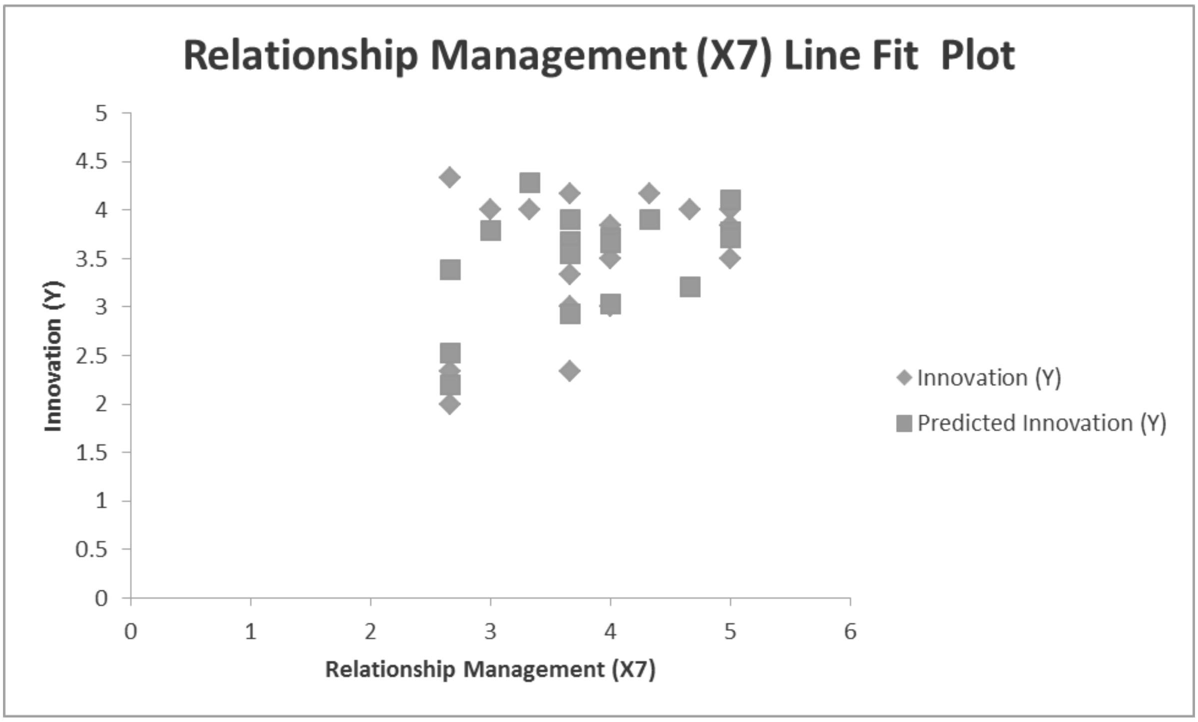
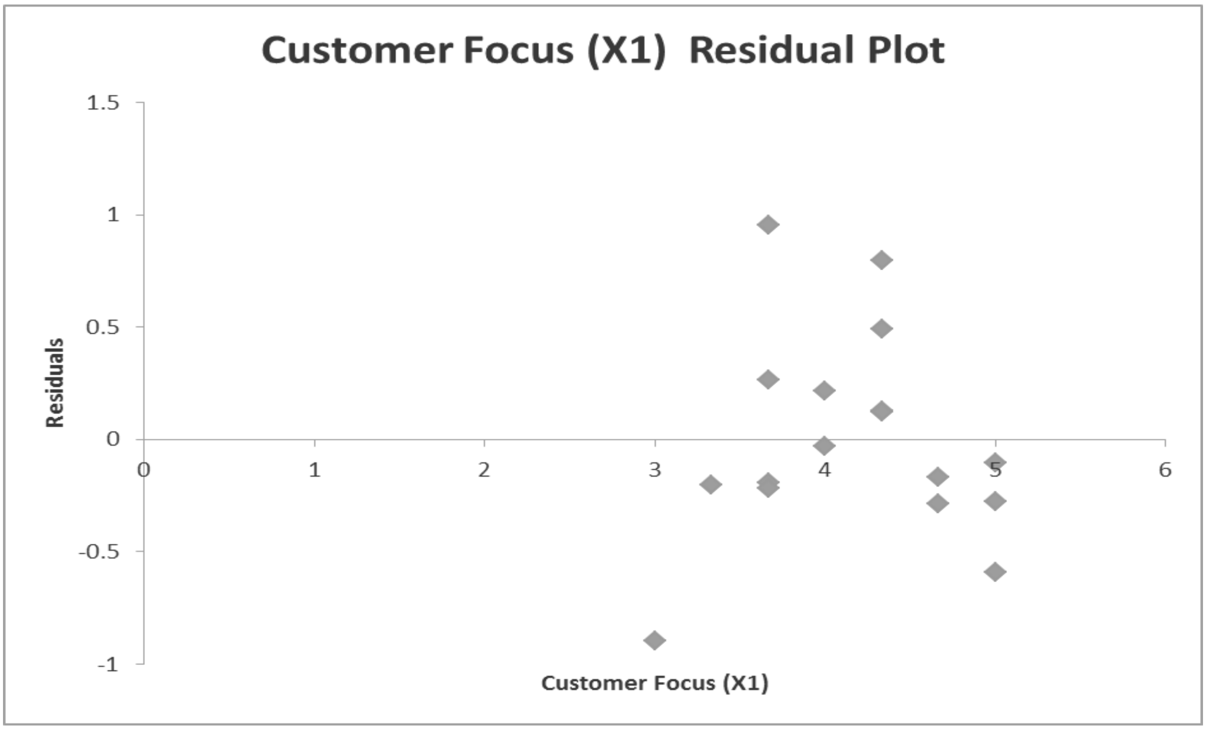
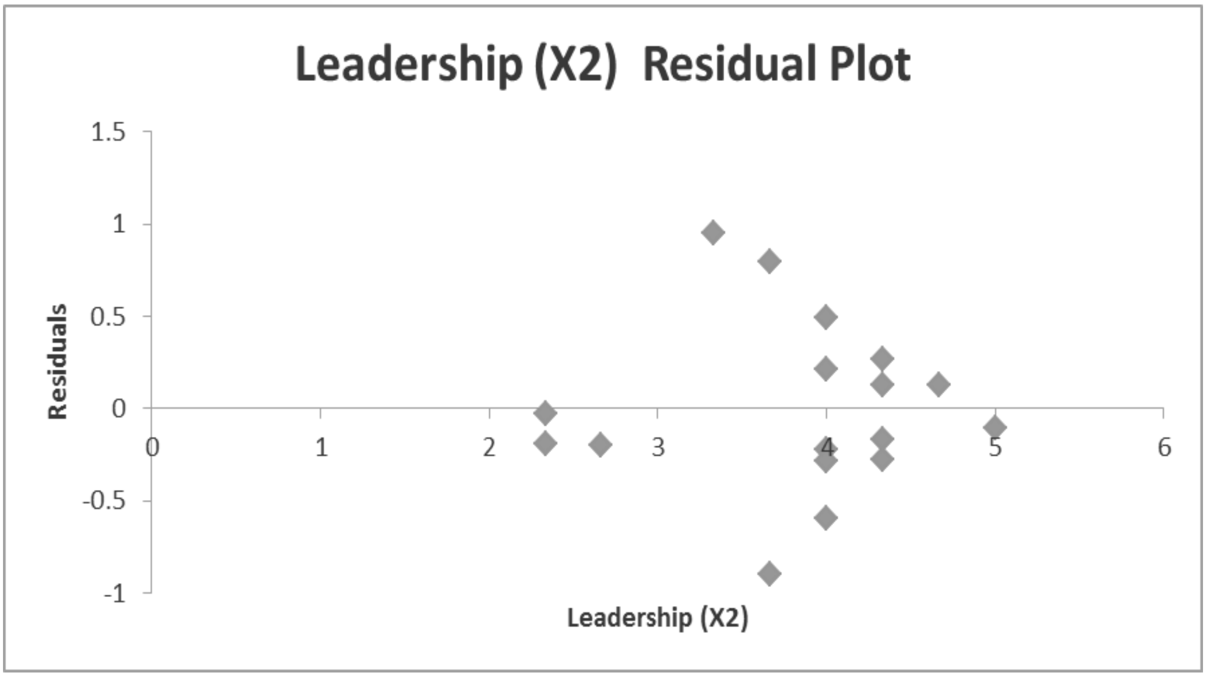
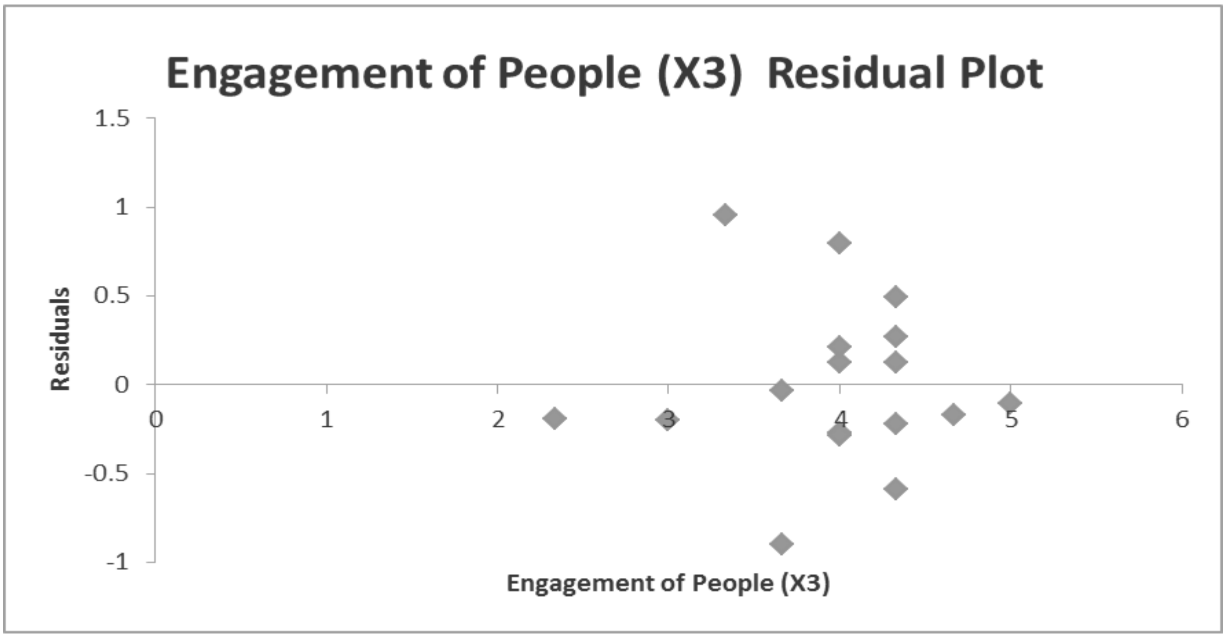


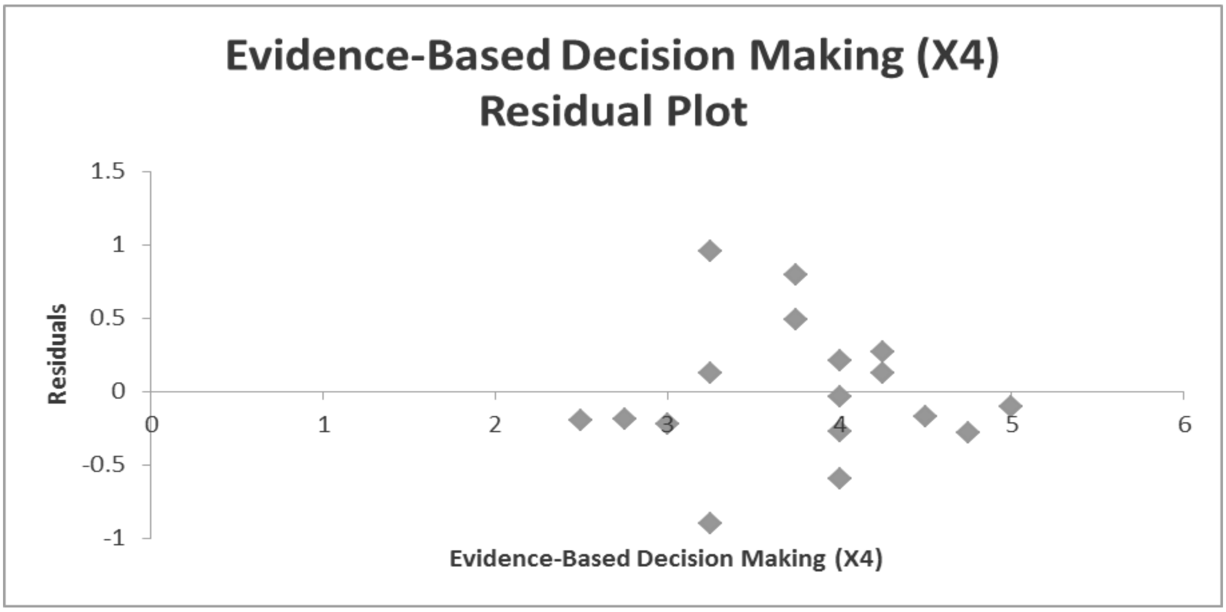
FIGURE 15: PATTERN OF RESIDUALS VERSUS THE PREDICTED VALUES OF Y. (Source: Researcher)

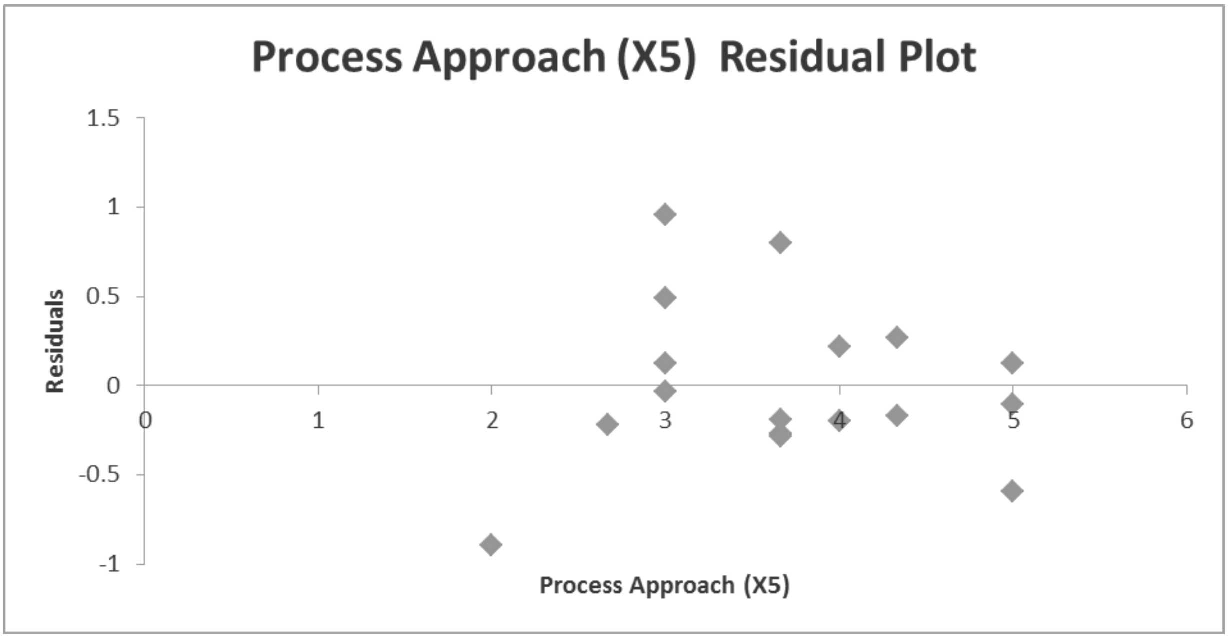
There is a very little pattern for different predicted values of Y, thus no evidence of a possible violation of equal variance assumption. Residuals against the independent variables are used to assess any possible quadratic effect demonstrated on the figures below and the figures demonstrate that a multiple regression model is appropriate.

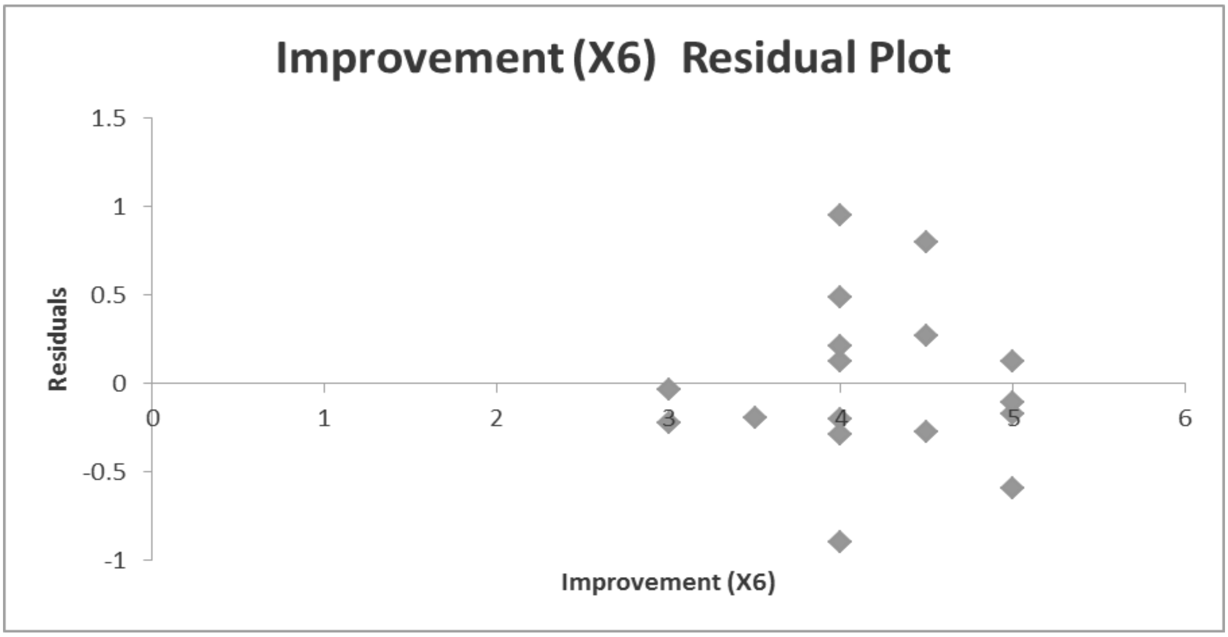

Customer Focus (X1) Residual Plot
Residuals
Customer Focus (X1)
1.5
1
0.5
0
-0.5
-1
0
1
2
3
4
5
6


Leadership (X2) Residual Plot
Residuals
Leadership (X2)
1.5
1
0.5
0
-0.5
-1
0
1
2
3
4
5
6


Engagement of People (X3) Residual Plot
1.5
1
0.5
0
-0.5
-1
Residuals
0
1
2
3
4
5
6
Engagement of People (X3)


Evidence-Based Decision Making (X4) Residual Plot
1.5
1
0.5
0
-0.5
-1
Residuals
0
1
2
3
4
5
6
Evidence-Based Decision Making (X4)


Process Approach (X5) Residual Plot
1.5
1
0.5
0
-0.5
-1
Residuals
0
1
2
3
4
5
6
Process Approach (X5)


Improvement (X6) Residual Plot
1.5
1
0.5
0
-0.5
-1
Residuals
0
1
2
3
4
5
6
Improvement (X6)

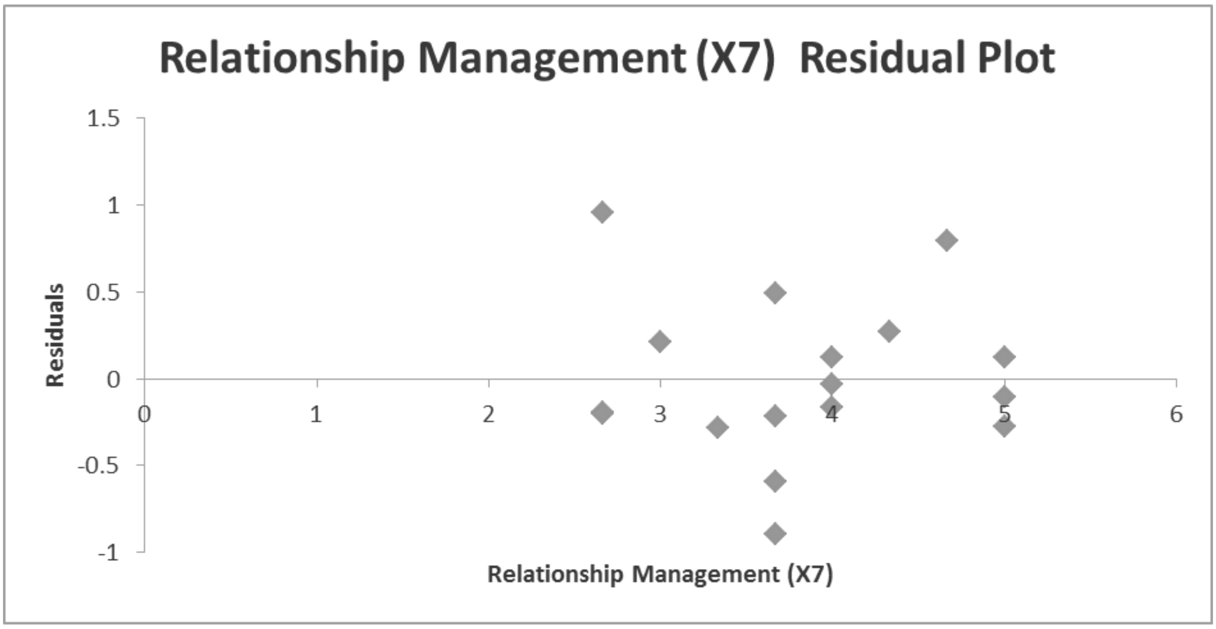


FIGURE 16 RESIDUAL AGAINST TQM PRINCIPLES. (Source: Researcher)

Independence: Data was collected in the same period; therefore there is no need to evaluate the independence assumption.

Multi-collinearity occurs when some of the TQM principles are highly correlated. The table below indicates that the independent variables are not highly correlated (below r≥0.80).

TABLE 16: CORRELATION COEFFICIENT MATRIX. (Source: Researcher)

	(X1)	*(X2)*	*(X3)*	*(X4)*	*(X5)*	*(X6)*	*(X7)*	*(Y)*
(X1)	1							
(X2)	0.561339648	1						
(X3)	0.59968861	0.859304193	1					
(X4)	0.70964702	0.637177967	0.747876441	1				
(X5)	0.573907451	0.399457001	0.3705424	0.543474056	1			
(X6)	0.575929971	0.667694844	0.535501364	0.570588663	0.744024762	1		
(X7)	0.550850623	0.649334237	0.684193458	0.599559078	0.341619616	0.515281323	1	
(Y)	0.251843049	0.595328538	0.524184073	0.520498351	-0.021630366	0.208646414	0.364168817	1

Note: Y=Innovation; X1= Customer Focus; X2=Leadership; X3= Engagement of People; X4= Evidence-based Decision Making; X5= Process Approach; X6=Improvement; X7=Relationship Management

A multilinear model is deemed reasonable for this study. The following regression equation was derived from the regression model:

Innovation (Y) = 1,68451 - 0,46902 * Customer Focus (X1) - 0,24993 * Leadership (X2) + 0,96223 * Engagement of People (X3) + 0,6204 * Evidence-Based Decision Making (X4) - 0,33976 * Process Approach (X5) + 0,07083 * Improvement (X6) - 0,17322 * Relationship Management (X7)

The constant of 1,68 shows that when TQM principles are equal to zero, then business and technological innovation changes by 1.68. The sample slope was then tested to determine the existence of a significant linear relationship. The null hypothesis Ho: β1 = 0, was also rejected at 95% confidence level for the model above and this confirms that there is a linear relationship between the dependent variable and, at least, one of the independent variables. The scatter plot below represents the linear relationship between the two variables.

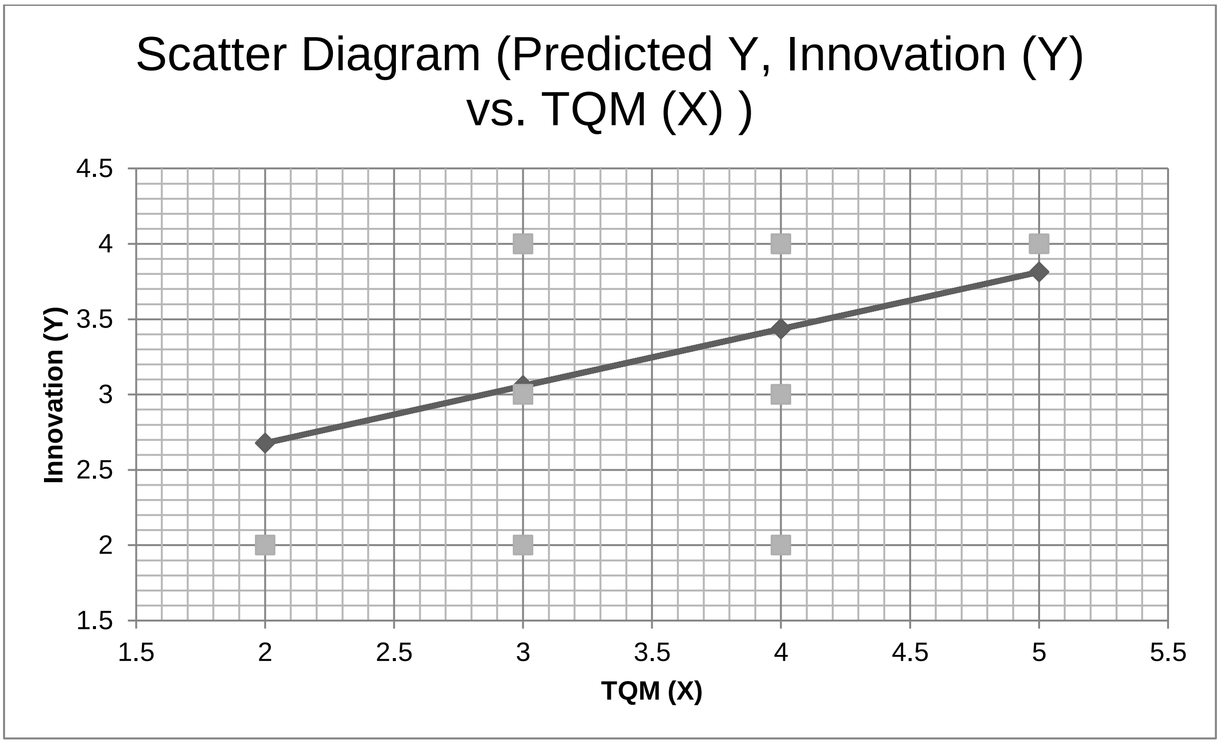


FIGURE 17 SCATTER DIAGRAM FOR TQM AND INNOVATION. (Source: Researcher)

To test the study's null hypothesis, the significance of the overall multiple regression model was assessed using an F-test (Ho: β1=β2=β3=β4=β5=β6=β7=0). The results

(Table 15) indicated that at a 95% confidence interval, TQM principles jointly explain business and technological innovation. Therefore, the null hypothesis, which states that all TQM principles have an impact on business and technological innovation could not be rejected. That is, there is insufficient evidence to warrant its (Ho) rejection. This is supported by Martinez-Lorente *et al*. (1999) and Kim *et al*. (2012).

A regression coefficient R squared is 0.53 which shows that almost 53% change in business and technological innovation is due to TQM principles. However, for multiple regressions, adjusted R square is a better estimate. The adjusted R square indicates that TQM principles explain only 41% of the variation in business and technological innovation based on the number of independent variables and sample size. This means that there is 59% of the variation in business and technological innovation that is not accounted for.

The equation that was derived from the regression model shows that the only TQM principles which significantly explains business and technological innovation include the engagement of people, evidence-based decision making and improvement. However, to measure the strength and direction of this linear relationship, the coefficient of correlation was determined and the results (table 16) indicate that the TQM principle of leadership has a moderate but positive correlation whilst process approach has a weak but negative correlation. The other TQM principles have a weak but positive correlation. However, given the above, the existence of a correlation does not imply a causal effect.

Hypotheses 2: To review how TQM and business and technological innovation relates to consulting engineering firms' competitive advantage in the South African market, a theory that TQM and business and technological innovation positively influence the firms' competitive advantage was tested following an ANOVA analysis (table 17). The null hypothesis is that TQM and business and technological innovation has no influence on the firms' competitive advantage.

TABLE 17: ANOVA (Source: Researcher)

	d.f.	SS	MS	F	p-value
Regression	2	9.38361	4.69180	12.06262	0.00013
Residual	31	12.05757	0.38895		
Total	33	21.44118			

Using a 0.05 level of significance, the critical value of the F distribution with 2 and 31 degrees of freedom found in the F-distribution table is approximately 3.32. The F statistic given in the ANOVA summary table is 12.06262 and because 12.06262 > 3.32, or because the p-value = 0.000 < 0.05, the null hypothesis was rejected. It was therefore concluded that TQM and business and technological innovation influence the firms' competitive advantage. The slope for TQM and innovation is positive, meaning that the influence is positive.

A revised framework is presented below.

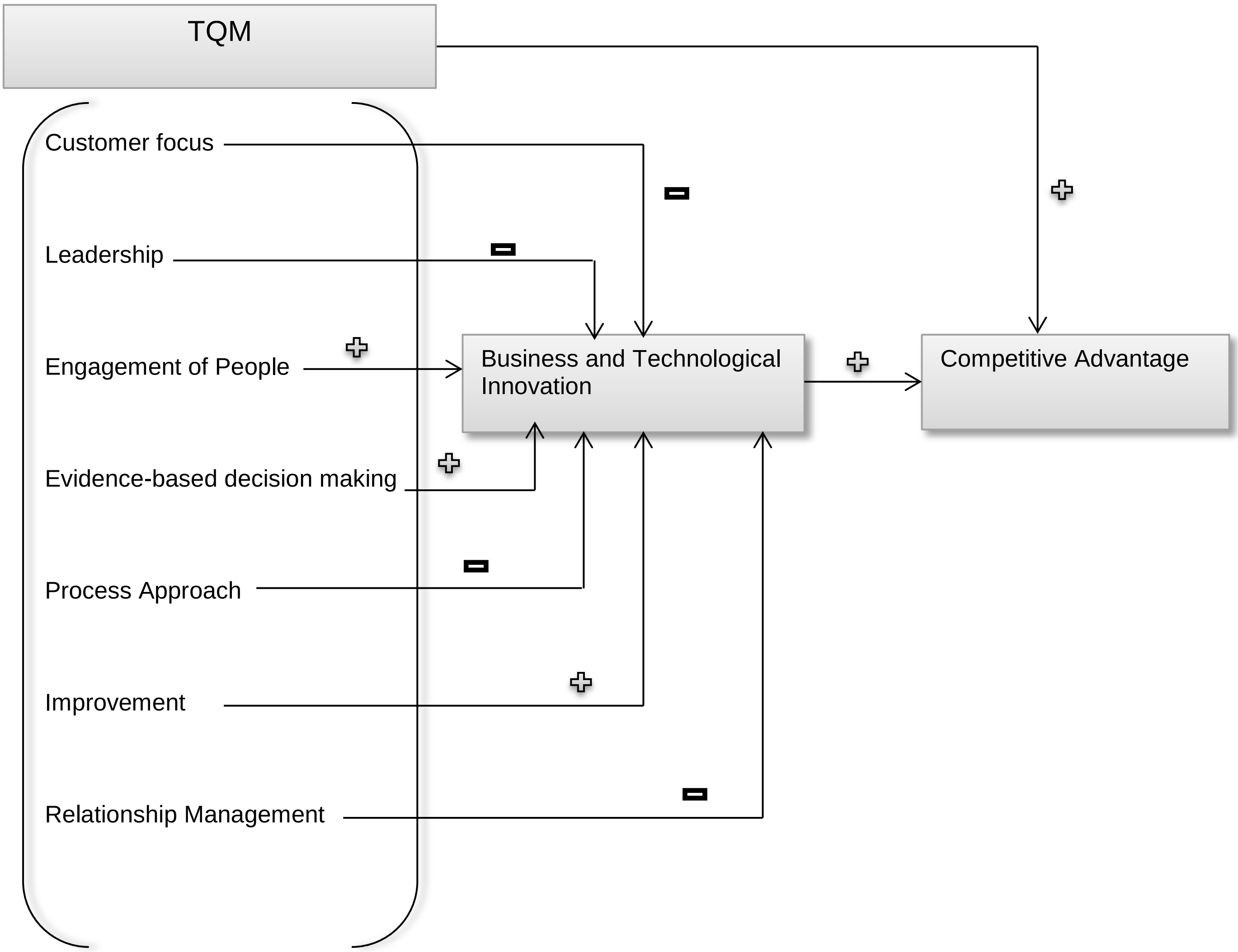


FIGURE 18: FINAL MODEL FOR THE IMPACT OF TQM PRINCIPLES ON BUSINESS AND TECHNOLOGICAL INNOVATION. (Source: Researcher)

CHAPTER 5: ANALYSIS AND DISCUSSION OF THE RESEARCH FINDINGS

5.1 INTRODUCTION

The proposed conceptual model that explains the impact of TQM principles on innovation was developed based on the literature review conducted. The model was tested with consulting engineering firms within South Africa and the data were reported and analysed. The chapter covers the analysis of data based on the results of the previous chapter.

5.2 BACKGROUND

The purpose of this research study is to investigate the impact of total quality management principles on business and technological innovation and to review how this relates to consulting engineering firms' competitive advantage in the South African market. This research topic was selected as a means to contribute to the body of knowledge in the field of operational management and innovation management. The key driver is to expand on the contribution of TQM to innovation within the South African context. The contribution can then later be used by firms for the strategic management of innovation aimed at addressing the challenges faced in the industry.

This study collected data from CESA member companies within the various provinces in South Africa that were either ISO 9001 certified or had a quality management system in place. Data collected (table 5) revealed that only 11% of the respondents were ISO certified and 5% were large-sized firms (employee headcount greater than 100). Therefore the majority of the sample used for data analyses came from what's classified as small-medium sized companies, which also account for more than 60% of non-respondents. However, the differences between respondents and non-respondents were not significant enough to confirm the major differences between the two groups. This outcome was indicative that the sample was a good representative for the target population and thus statistical inference could be made on the sample for the population.

To assess the level of adoption or implementation of all TQM principles for sampled companies, the researcher assessed the level of maturity of the quality system. Descriptive data for each TQM principle had a central tendency of 4, with the exception of the process approach and relationship management. Meaning, the variables were not fully implemented by the respondents.

5.2.1 The impact of TQM principles on business and technological innovation

The TQM principles were used to predict the value of innovation using multilinear regression analyses. The study found that both TQM and innovation had an overall median of 3 (figure 12 and figure 13), which indicates an overall moderate implementation (TQM and innovation) and maturity of a TQM program.

The conceptual model resulted in a constant of 1,68 meaning that when TQM principles are equal to zero, then business and technological innovation changes by 1.68. A linear relationship between the dependent variable and, at least, one of the independent variables was then confirmed and the results (Table 15) indicated that at 95% confidence interval, TQM principles jointly explain business and technological innovation.

The regression model further indicates the coefficient estimates for leadership, customer focus, and process approach and relationship management are statistically not different from zero. The outcome as compared to literature revealed various research done over the last decade aimed at establishing the relationship between TQM and innovation including the impact of one on the other. The outcomes varied from one research study to another. However, no studies were carried out investigating the impact of TQM on innovation using this particular sample along with the type of innovation under study.

Based on the overall outcome of results, this study has established that all TQM principles (jointly) have an impact on business and technological innovation. These results are consistent with the results obtained by Zhang *et al*. (2016), Prajogo and

Sohal (2003), Bon and Mustafa (2014) and Maistry *et al*. (2017) but inconsistent with Martinez-Lorente *et al*. (1999), Hoang *et al*. (2006), Kim *et al* (2012) and Mustafa (2015) who argue that only specific TQM principles influence innovation. Feng (2004) further argues that since many aspects of the EFQM are in line with creativity and innovation, a positive relationship between TQM and innovation is expected. However, the adjusted R square (table 15) indicated that TQM principles only explains 41% of the variation in business and technological innovation based on the number of independent variables and sample size, meaning there is 59% of the variation in business and technological innovation that is not accounted for.

Singh and Smith (2004) argue that there is insufficient statistical evidence to suggest that TQM is related to innovation. An assessment of which of the TQM principles are strongly correlated to innovation was made.

In addition, the results revealed that of the seven TQM principles, five demonstrated a weak but positive correlation and these are customer focus, engagement of people, evidence-based decision making, improvement and relationship management. The TQM principle for process approach demonstrated a weak but negative correlation and leadership demonstrated a moderate but positive correlation (table 16). This means that the above TQM principles would move in the same direction as business and technological innovation with the exception of process approach. This outcome is supported by Satish and Srinivasan (2009) who argue that there's a positive correlation between TQM and innovation. However, the existence of a correlation does not imply a causal effect.

The equation that was derived from the regression model shows that the only TQM principles which significantly and positively impacts business and technological innovation include the engagement of people, evidence-based decision making and improvement. Descriptive statistics for TQM principles implemented by the firms (table 8-14); show that customer focus, leadership, engagement of people, evidence-based decision making and improvement in consulting engineering firms that participated in the survey generally expressed a high contribution to their quality management programmes, whilst process approach and relationship management are not fully implemented. Given the outcome, consulting engineering firms need to put more emphasis on the engagement of people, evidence-based decision making and improvement in order to influence business and technological innovation.

5.2.1.1 The value of engagement of people towards business and technological innovation

The significance of these outcomes puts emphasis on the importance of innovation for consulting engineering firms. Business innovation has been described as a means of adopting new business practices that may include; the establishment of best practices, finding ways to improve worker retention, etc. A lot can go into employee retention and in order for firms to drive innovation; employees need to be empowered and skilled. Of importance, is the establishment of a culture of innovation (Goffin & Mitchell, 2017, p. 298-297). The authors argue that such a culture of innovation benefits employees by promoting entrepreneurial thinking, challenging people to take risks, fostering learning and encouraging independent thinking. Flynn *et al*. (1995) support the importance of organisational culture as an enabler to employee's contribution to the attainment of organisational objectives. The author further argues that employees that are loyal, with a positive work attitude and are proud of their work and the organisation they work for are more likely to take risks that will improve the organisation. Engagement of people fosters business innovation by empowering employees to realise the firms' innovation initiatives.

Technological innovation looks into new technology adoption into management processes and products. The adoption of new technologies brings about capacity building and learning, which is the essence of innovation. Without the knowledge and creative ideas of employees most innovation would have never been introduced (Perdomo-Ortiz *et al*. , 2009 as cited by Kafetzopoulos *et al*. 2015). Therefore, firms can benefit more from adopting new technology and investing in the knowledge build-up and not just absorbing and using new technologies developed elsewhere. This is supported by Galande *et al*. (2009) who argue that only human resource principle has an impact on technological innovation. This approach will contribute to employee skill development, which in turn will be good for the firms' performance.

5.2.1.2 The value of evidence-based decision making towards business and technological innovation

The process of innovation begins with ideation and this stage, also referred to as the fuzzy front end (FFE), is described as a dynamic phase where quality ideas are generated, evaluated and refined into workable concepts for implementation (Goffin & Mitchell, 2017, p. 153). The phases of managing innovation cannot succeed without the use of reliable and accurate information that will enable a firm to make decisions related to its innovation objectives. This relates to the importance of evidence-based decision making principle which consulting engineering firms should adopt to ensure that their decision-making process throughout the innovation phases becomes effective. During the early phase of innovation management, customer‘s problems are identified and defined, ideas on how to solve them are sought, usually, by engaging people in the organisation and decisions about the concept to be applied are made. The solutions sought could address business or technology gap, which can be bridged in the future and bring competitive advantages to firms (Feng, 2004). Such decisions, however, can never be made without making use of the facts or evidence presented. This is supported by Bon and Mustafa (2013) who argue that information and analysis are gathered and observed, then used effectively in positive benchmarking which gives positive outcomes on innovation.

5.2.1.3 The value of improvement towards business and technological innovation

Improvement covers all facets of the organisation; people, processes, products, services and the environments. Therefore, it is not surprising that improvement is one of the TQM principles that significantly explain business and technological innovation. On the other hand, Zandhesami and Jalili (2013) argue that improvement or rather a continuous improvement lies with the organisation’s ability to search for never-ending improvements and developing processes that find better methods in the process of converting inputs to outputs. This is supported by McAdam (1998), who argue that organisations which have a history of continuous improvement are more likely to build a successful innovative culture whilst Prajogo and Sohal suggest that continuous improvement provides a solid foundation on which radical innovations can be successfully implemented (Jha *et al*. 1996 as cited by Prajogo & Sohal, 2003).

Moreover, in his contribution to the TQM frameworks, W. Edwards Deming's philosophy was operationalised through what is now known as the Deming fourteen points. Under the fourteen points, it is said that barriers that rob employees of their pride to workmanship should be eliminated and firms need to improve continuously in order to reduce costs (Steenkamp, 2012, p. 18). The bottom line is, both TQM and innovation are needed for firms' performance and it is important for managers of consulting engineering firms to recognise the vital role that TQM plays in innovation and to do this, managers also need to understand and be able to distinguish the type of environment needed to enable an effective TQM programme and a culture of innovation (table 18).

TABLE 18: COMPARISON OF MANAGERS IN A TQM AND AN INNOVATION ENVIRONMENT
(Source: Samaha, 1997 and Luthans & Kessler, 1993, as cited by McAdam *et al*. 1998)

Managers who foster an environment conducive to innovation, do most if not all the following	**Managers who foster an environment conducive to TQM, do most if not all the following**
Encourage a learning organisation	Self-image themselves as a team leader, sponsor or internal consultant
Create long-term goals	Cut across functional lines dealing with anyone necessary to attain quality goals
Manage innovation proactively	Change the composition of teams in response to customer needs and needed innovation
Make innovation part of the strategy	Act and make decisions as part of a team
Create a consistent recognition system	Share and supplement information with the team or anyone else
Create opportunities for cross-functional collaboration	Becomes an expert and has significant assignments in many different functions
Teach teamwork	Demand quality results and loyalty not only to the organisation and one's boss but also to subordinates, team-mates in other departments and especially customers
Encourage the use of problem-solving skills	
Teach people to assess their creative potential	
Stop treating TQM as the only solution	
Take a step to overcome barriers to innovation	

Even with the efforts put in place to ensure that TQM and innovation exist in a firm, the results of this study have indicated that over 50% of the variation in business and technological innovation is not explained by all TQM principles; that there could be additional factors at play. Singh and Smith (2004) have already alluded to a complex relationship between TQM and innovation. The authors further suggest that researchers should take note not to quickly claim that TQM in its own right is sufficient for achieving innovation performance. In this study; leadership, customer focus, process approach and relationship management were found not to have a significant and positive impact on business and technological innovation in consulting engineering firms.

5.2.1.4 The contribution of Leadership in business and technological innovation

Leadership in this research has no significant impact on business and technological innovation. However, the literature review conducted emphasised on management's way of doing things or rather their practices and the management of supplier relations as the basis of business innovation to increase economic prospects while technological innovation looks into new technology adoption into these management processes and products.

In the research study conducted by Haong *et al*. (2006) investigating the impact of TQM on innovation in a developing country contradicts what is found in this study and concluded that only leadership and people management, process and strategic management, and open organisation showed a positive impact on the firms' innovation performance. It is said that the purpose of leadership should be to help people and technology work better (Steenkamp, 2012, p. 18). Therefore, even though leadership is deemed not to have a significant impact in this study, it should not be ignored given that the impact on business and technological innovation is based on all TQM principles combined.

5.2.1.5 The contribution of customer focus in business and technological innovation

Customer focus principle was fully implemented (table 8) according to the outcomes of this study. This demonstrates an understanding of the importance of this principle by the consulting engineering firms that participated in this study. Customer focus has been and continues to be an important element of total quality management. This is due to the fact that customers in a quality setting define quality (Steenkamp, 2012, p. 85) and this approach allows for a greater customer satisfaction. Ramadani and Gerguri (2011) argue that the importance of innovation from the customer's perspective means innovation represents products with better quality and better service, which together mean a better way of life. Contrary to what this study found, Bon and Mustafa (2014) investigated the impact of customer focus on innovation in the service organisation and found a positive impact on both processes and administrative innovations. The authors further argue that the positive impact may be due to the categories of customers an organisation focuses on, which could be; mainstream or emerging customers. That is, the type of innovation is influenced by whether the firm wants to focus their innovation programmes for retaining or attracting customers. This is the approach to be undertaken by consulting engineering firms in order to fully utilise this TQM principle to drive innovation.

5.2.1.6 The contribution of the process approach to business and technological innovation

Process approach was one of the principles not fully implemented (table 12) by consulting engineering firms that participated in this study. This signifies a possible weakness in the firms' quality management system. Stable and consistent processes are beneficial for firms in a highly competitive marketplace. The potential key benefit to the process approach principle in any TQM programme is the enhanced ability to focus efforts on key processes and opportunities for improvement. (SABS, 2015b). Kafetzopoulos *et al*. (2015) argue that process management optimises the business processes design to ensure productivity, quality and innovativeness through the adoption of relevant technologies. This research study failed to prove a significant impact of the process approach to business and technological innovation. Manders *et al*. (2016) supports these findings and argue that process approach hinders radical innovation and this is supported by Flynn *et al*. (2005), who argue that organisations that focus their strategy on making frequent and fast innovation would not have the time to learn about the process in order to statistically control them to achieve a high level of conformance.

5.2.1.7 The contribution of relationship management to business and technological innovation

Relationship management was one of the principles not fully implemented (table 14) by consulting engineering firms that participated in this study. The nature of any infrastructure project requires collaboration from all the stakeholders in the value chain, this relationship management is key to continual improvement, a variable that was found to be significant in business and technological innovation in this study.

Relationship management may also be a good platform for open innovation. Manders *et al* (2016) argue that it promotes sharing expectations, resources and information thereby increasing product innovation performance. Hilmy (2016) argues that relationship management positively impacts customer satisfaction due to the enhanced relationship a firm has with its suppliers. However, managing this type of relationship was found not to be significant enough to influence business and technological innovation in this research study.

5.2.2 How TQM and Innovation related to Competitive Advantage

In this study, the two variables (TQM and innovation) were combined to assess whether the combination can bring about firms' competitive advantage. The analysis was made with the assumption that all TQM principles have an impact on innovation; thus, based on the outcome of the data results in chapter 4, the assumption is valid. The sample slope was tested to determine the existence of a significant linear relationship and the outcome confirmed that there is a linear relationship between the dependent variable and, at least, one of the independent variables.

This study aimed at extracting value out of TQM and innovation combined and to establish how the two variables relate to consulting engineering firms' competitive advantage in South Africa. It was concluded that TQM and innovation influence the firms' competitive advantage. The slope for TQM and innovation is positive, meaning that the variables are positively related. Galende *et al*. (2009) support this outcome, stating that TQM and innovation are operational management elements that can increase a firms' competitive advantage.

The topic on TQM or innovation and competitive advantage has been covered in a number of studies (Kafetzopoulos *et al*., 2015; Hilmy, 2016; Ramadani & Gerguri, 2011) and it is believed that both variables bring about competitive advantage to firms. TQM mainly focuses on meeting or exceeding customer expectations. Kafetzopoulos *et al*. (2015) argue that competitive advantage is a result of customers that are deeply satisfied. Whilst Steenkamp (2012) argue that when TQM is effectively applied, the end results can include global competitiveness. However, Hilmy (2016) found a moderate impact of TQM on competitive advantage and later argued that competitive advantage provides firms with a relatively higher position in the market that leads to them to surpass their competitors in terms of revenue generation.

On the other hand, the authors (Ramadani & Gerguri, 2011) argue that innovation is the best way to achieve competitive advantage and firms try to achieve competitive advantage in order to help obtain a better and a stable position in a marketplace. This is supported by Nguyen and Chau (2017) who argue that firms who have benefited from innovation increased their market share.

The rationale behind competitive advantage is that firms operate in a marketplace that is unstable, with customer needs and expectations constantly changing. As a result, firms need to put together all the resources at their disposal to stay ahead of the game. For consulting engineering firms in South Africa, the dynamics are not different. Consulting engineering firms compete for the same infrastructure projects and are required to deliver these on time, on budget and of superior quality. Firms that successfully achieve these attain customer satisfaction and gain market advantage.

5.3 SUMMARY OF THE DISCUSSION

The research question for this study was to investigate the impact TQM principles has on business and technological innovation. The literature reveals that TQM principles have a positive impact on innovation. This study has demonstrated that there is no sufficient evidence to conclude that not all TQM principles have an impact on business and technological innovation. However, the study also revealed that TQM principles that significantly and positively impact business and technological innovation include the engagement of people, evidence-based decision making and improvement. Therefore, consulting engineering firms should ensure that they recruit skilled workers and ensure that a culture of innovation is enabled and embraced.

The decision-making process that is based on facts enables firms to make an informed decision regarding quality and innovation programmes. Factual information enables decisions to be made about the improvement a firm needs to make with regards to; people, processes, products, services and the environments.

That said, the design phase in any consulting engineering firms is a core function. Hence, Mezher *et al*. (2005) argue that for consulting engineering firms to survive tomorrow's consulting work, they need to enhance technical skills in order to increase productivity, that is, produce projects with high quality in less time. Arditi and Gunaydin (1997) further argue that a quality project is described by terms such as ease of understanding drawings, level of conflict in drawings and specifications, the economics of construction, ease of operation, ease of maintenance and energy efficiency.

To enable the above, it becomes necessary for manager and professional staff in this industry to focus on the TQM principle of engagement of people, improvement and the use of the evidence-based approach to decision making as the main driver of business and technological innovation.

The study later demonstrated how TQM and innovation relate to consulting engineering firms' competitive advantage. It was concluded that TQM and innovation positively influence the firms' competitive advantage.

Therefore, consulting engineering firms should implement or adopt TQM not based on industry pressures or bid requirements but should base their TQM programmes on the desire to be the leader in the market they operate in. The spillover effect of this approach is in the positive impact TQM has on business and technological innovation and subsequently, the positive influence on the firms' competitive advantage.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter summarises the major findings of the study and conclusions drawn from the statistical analysis carried out and from the reviewed literature. The chapter also includes recommendations to senior managers in consulting engineering firms, based on the outcome of the research. Identified areas for future research are to be used to make suggestions for future research.

6.2 MAJOR FINDINGS

The study investigated the impact of TQM principles on business and technological innovation. The theory was tested on consulting engineering firms and it was assumed that all TQM principles had an impact on business and technological innovation combined. It was found that there is insufficient evidence to warrant the rejection of the null hypothesis, that is, all TQM principles have an impact on business and technological innovation. The regression model indicated that the engagement of people, evidence-based decision making and improvement positively and significantly impact business and technological innovation in consulting engineering firms.

The second part of the research question aimed at reviewing how TQM and innovation relate to consulting engineering firms' competitive advantage in the South African market. It was concluded that TQM and innovation positively influence the firms' competitive advantage.

When collecting data, the researcher confirmed the two key delimitations outlined in chapter 1 of this study for all sampled firms and, with the review of the responses received from participants, there was no indication that the respondents could have provided inaccurate information. In addition to this, the researcher's assumption of skills and knowledge of the participants was verified by the findings which were consistent with the literature.

The findings offer clear implications for firms undergoing structural changes, providing that they give emphasis on TQM and innovation in order to prioritise their technological capabilities and create new value and wealth for stakeholders.

6.3 KEY CONCLUSIONS OF THE STUDY

Infrastructure development fuels the economy by creating employment, developing skills and contributing towards economic growth. It requires the support and skills from consulting engineers in order to realise its objectives. The services rendered by these firms range from pre-feasibility studies to facility management services. It is important for any firm involved in such initiatives to have resources and capabilities to realise projects effectively. Participants in this study have either implemented or have a certified quality management system that provides the confidence that products and services produced will consistently meet customer’s expectation and/or exceed them. The system, however, does not give guidance to firms on how to exceed customer’s expectation, therefore a firm may need to look beyond the current management practices. The objective of this study was to investigate the impact that TQM has on innovation, in particular, business and technological innovation. The significance was derived from the perspective that TQM may not be fully sufficient to exceed customer’s expectations at the firm level and to identify a way in which firms can utilise existing TQM programme to drive firm performance through new wealth and increased economic prospects. To achieve this, the study investigated the impact that TQM may have on business and technological innovation and found that all TQM principles impacted business and technological innovation. Consulting engineering firms, however, need to focus more on improvement, evidence-based decision making and engagement of people in order to experience a significant and positive impact on business and technological innovation. Therefore, looking at the outputs of business and technological innovation, TQM can influence a successful drive for innovation resulting in financial benefit.

The South African landscape has indicated a decrease in investment in infrastructure projects and this inversely creates room for stiff competition amongst consulting engineering firms. Therefore the second part of the research question aimed at reviewing how TQM and innovation relate to consulting engineering firms’ competitive advantage. The significance stems from the ability of the consulting engineering firm to gain a competitive advantage in spite of the tough economic challenges faced by the industry. The outcomes confirmed that both TQM and innovation positively influence the firms’ competitive advantage. Therefore, there should be a higher emphasis on TQM and innovation, and for consulting engineering firms to integrate the two variables in order to achieve competitive advantage.

6.3 RECOMMENDATIONS FOR MANAGERS

Based on the findings of this study, these are the recommendations for managers in consulting engineering firms:

- TQM and innovation require strong and committed leadership to ensure its success. Consulting engineering firms need to ensure that there’s management commitment to the cause. Ways of demonstrating this can include defined strategy, availability of resources and active participation from top to bottom.
- To realise the full potential of a TQM programme, ensure that all TQM principles are adopted and implemented effectively. For the purpose of this study, however, emphases can be placed on the engagement of people, improvement and evidence-based decision-making principles.
- Managers need to look beyond the principles of TQM and manage innovation in a systematic way. Like TQM, innovation requires policy, objectives, measures, resources and monitoring.
- To drive innovation, management needs to establish an innovation policy for their firms, with clear and objectives. The policy should be cascaded down to employees in the firm to ensure effective implementation.
- Innovation can be a platform that firms use to drive a growth strategy and managers should apply the learnings from TQM as a holistic approach to managing innovation.

6.4 SUGGESTIONS FOR FUTURE RESEARCH

The following are suggestions for future research:

- This study has focused on a specific industry, firms participating in infrastructure projects and the sample was taken from the CESA database. Therefore it might be more useful to carry out a similar study which covers the engineering firms with no ties to CESA and/or firms in the manufacturing sector given that a sample size increases,

- Secondly, this study adopted a cross-sectional data for examination, but this approach may not necessarily be sufficient to identify the causal relationship between the variables. A longitudinal research in future studies might produce more reliable results and may support causal inferences,
- The findings of this research study revealed that TQM principles only explains 41% of the variation in business and technological innovation based on the number of independent variables and sample size, future research should then look at other factors, either intervening or mediating that may account for the 59% variation for a similar study,
- EFQM is a representative theory widely recognised to improve traditional quality management (TQM) by expanding the narrow concept into a holistic concept (Kim *et al*., 2010). Dahlgaard *et al*. (2013) argue that firms continuously search for effective new approaches to enhancing their management capabilities and EFQM is adopted as a result. Even though there is extensive research about TQM and innovation, a few studies have tackled EFQM and innovation. Therefore, future research needs to explore this topic further.

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APPENDIX

APPENDIX A: List of Consulting Engineering Companies

A. List of Participants_Random Sample

Thyme Engineering Services cc	Nelspruit	MP
S Zoko Consulting cc	Margate	KZN
Trans African Consulting Engineers (Pty) Ltd	Johannesburg	GP
SML Projects Pty Ltd	Nelspruit	MP
Ndodana Consulting Engineers (Pty) Ltd	East London	EC
UWP Consulting (Pty) Ltd	East London	EC
HHO Consulting Engineers (Pty) Ltd (trading as HHO Africa)	Sandton	GP
Mosomo Consulting Civil Engineers (Pty) Ltd	Tzaneen	LIMP
DPA Specialist Consulting Engineers (Pty) Ltd	Durban	KZN
Aurecon South Africa (Pty) Ltd	eThekwini	KZN
Aurecon South Africa (Pty) Ltd	Kimberley	NC
De Villiers & Moore (Pty) Ltd	Cape Town	WC
HBS Africa Consulting Engineers (Pty) Ltd	Randburg	GP
Envitech Solutions (Pty) Ltd	Durban	KZN
Hemingway & Associates cc	Mooi River	KZN
Hatch Africa (Pty) Ltd	Durban	KZN
Nyeleti Consulting (Pty) Ltd	Alberton	GP
Ekcon (Pty) Ltd	Cape Town	WC
Water & Wastewater Engineering (Pty) Ltd	Stellenbosch	WC
Makhaotse, Narasimulu & Associates (Pty) Ltd	Theunissen	FS
Knight Piesold (Pty) Ltd	Pretoria	GP
MBB Consulting Services (South) (Pty) Ltd	Stellenbosch	WC
MSW Project Managers & Consulting Engineers (Pty) Ltd	Nelspruit	MP

ISA & Partners (Pty) Ltd	Welkom	FS
SMEC South Africa (Pty) Ltd	Polokwane	LIMP
Sukuma Consulting Engineers (Pty) Ltd	Pietermaritzburg	KZN
Khandisa Consulting Engineers (Pty) Ltd	Ermelo	MP
Iliso Consulting (Pty) Ltd t/a NAKO ILISO	Bloemfontein	FS
CSE Consulting (Pty) Ltd	Kokstad	KZN
Asakheni Consulting Engineers (Pty) Ltd	Gallo Manor	GP
WSP l Parsons Brinckerhoff	Stellenbosch	WC
AECOM (SA)	Mthatha	EC
SMEC South Africa (Pty) Ltd	Bloemfontein	FS
EVN Africa Consulting Services (Pty) Ltd	Polokwane	LIMP
BVi Consulting Engineers Gauteng (Pty) Ltd (Member: BVi Group)	Pretoria	GP
R & H Rail (Pty) Ltd	Kathu	NC
EMZANSI ENGINEERS (PTY) LTD	PIETERMARITZBURG	KZN
ARQ (Pty) Ltd	Pretoria	GP
Element Consulting Engineers	Polokwane	LIMO
Element Consulting Engineers	Johannesburg	GP
Tsekema Consulting Engineers (Pty) Ltd	Randburg	GP
Consultmech Mechanical Engineers cc	Cape Town	WC
SMEC South Africa (Pty) Ltd	Randburg	GP
Thabile Engineering	Pinetown	KZN
NWE Business Trust t/a NWE Consulting Engineers	Cape Town	WC
Ilifa Africa Engineers (Pty) Ltd	Secunda	MP
SNA Civil & Structural Engineers (Pty) Ltd	Polokwane	LIMP
Dihlase Consulting Engineers (Pty) Ltd	Pretoria	GP
AECOM (SA)	Bloemfontein	FS
Neil Lyners & Associates (RF)(Pty) Ltd	George	WC
EVN Africa Consulting Services (Pty) Ltd	Pretoria	GP
C A du Toit Wes-Kaap (Edms) Bpk	Cape Town	WC

Carifro Consulting Engineers cc	East London	EC
LEO Consulting (Pty) Ltd	Pretoria	GP
SRK Consulting (South Africa) (Pty) Ltd	Pietermaritzburg	KZN
Arup (Pty) Ltd	Durban	KZN
Cort and Fred Consulting Engineers (Pty) Ltd	Midrand	GP
UWP Consulting (Pty) Ltd	Cape Town	WC
Virtual Consulting Engineers VCE (Pty) Ltd	Pretoria	GP
Africa Route Clearance Consultants (Pty) Ltd	Kempton Park	GP
CSM Consulting Services (Pty) Ltd	Worcester	WC
Ron Beard Associates	East London	EC
AECOM (SA)	Durban	KZN
Kantey & Templer (Pty) Ltd	Johannesburg	GP
WSM Leshika Consulting (Pty) Ltd	Pretoria	GP
Aurecon South Africa (Pty) Ltd	East London	EC
Calliper Consulting Engineers (Pty) Ltd	Randburg	GP
AECOM (SA)	Johannesburg	GP
Royal HaskoningDHV	Bloemfontein	MP
SNA Civil & Structural Engineers (Pty) Ltd	Cape Town	WC
AECOM (SA)	Bellville	WC
SADC Project Consulting	Akasia, Pretoria North	GP
Flagg Consulting Engineers (Pty) Ltd	Frankfort	FS
Shikwambana Sithole & Associates cc	Tzaneen	LIMP
Optimal Engineering Solutions	Pretoria	GP
Mott MacDonald Africa (Pty) Ltd	Cape Town	WC
Six Sense Consulting	Parktown North	GP
MSW Project Managers & Consulting Engineers (Pty) Ltd	Polokwane	LIMP
Uhambiso Consult (Pty) Ltd	Port Elizabeth	EC
Nkanyezi Consulting (Pty) Ltd	Durban	KZN
Thabile Engineering	Sandton	GP

SRK Consulting (South Africa) (Pty) Ltd	Durban	KZN
Aurecon South Africa (Pty) Ltd	Mbombela	MP
MBB Consulting Services (Nelspruit) (Pty) Ltd	Nelspruit/Mbombela	MP
Ibhongo Consulting cc	Ballito	KZN
Moroff & Kuhne Consulting Engineers	Cape Town	WC
Ndodana Consulting Engineers (Pty) Ltd	Johannesburg	GP
JG Afrika (Pty) Ltd	Pretoria	GP
Element Consulting Engineers	Durban	KZN
Hatch Africa (Pty) Ltd	East London	EC
UWP Consulting (Pty) Ltd	Centurion	GP
BVi Consulting Engineers Free State (Pty) Ltd (Member: BVi Group)	Bloemfontein	FS
Makone Consulting Engineers cc	Johannesburg	GP
Element Consulting Engineers	Bloemfontein	FS
UWP Consulting (Pty) Ltd	Bloemfontein	FS
Iliso Consulting (Pty) Ltd t/a NAKO ILISO	Durban	KZN
Kantey & Templer (Pty) Ltd	Durban	KZN
SKC Masakhizwe Engineers (Pty) Ltd	Aliwal North	EC
DNA Consulting Engineers & Project Managers	Durban	KZN
Sintec SA	UGIE	EC
Plantech (Pty) Ltd	Pretoria	GP
Tumber Fourie Consulting Engineers cc	Nelspruit/Mbombela	MP
Motla Consulting Engineers (Pty) Ltd	Robertson	WC
BMK Consulting Engineers	Port Elizabeth	EC
Dibetsi (Pty) Ltd	Bloemfontein	FS
Ilifa Africa Engineers (Pty) Ltd	Newcastle	KZN
L&S Consulting (Pty) Ltd	Sandton	GP
WSM Leshika Consulting (Pty) Ltd	Polokwane	LIMP
SiVEST SA (Pty) Ltd	Pietermaritzburg	KZN
Siroccon International (Pty) Ltd	Centurion	GP

Qonda Ekukanyeni Consulting Engineers & Project Managers	Boksburg	GP
Tshashu Consulting and Project Managers	Polokwane	LIMP
Ingerop South Africa (Pty) Ltd	Sandton	GP
Bigen Africa Group Holdings (Pty) Ltd	East London	EC
HHO Consulting Engineers (Pty) Ltd (trading as HHO Africa)	Cape Town	WC
High Voltage System Engineers	Midrand	GP
PRDW Africa (Pty) Ltd	Cape Town	WC
AB Projects	Umhlanga Ridge	KZN
WEC-Consult (Pty) Ltd	Stellenbosch	WC
HSC Consulting cc	East London	EC
Mtema Mashao Consulting Engineers (Pty) Ltd	Tzaneen	LIMP
Ceenex (Pty) Ltd	Erasmusrand	GP
C A du Toit (Pty) Ltd	Pretoria	GP
MADAN SINGH & ASSOCIATES CC	Ladysmith	KZN
SNA Civil & Structural Engineers (Pty) Ltd	Richards Bay	KZN
Mtema Mashao Consulting Engineers (Pty) Ltd	Pretoria	GP
SiVEST SA (Pty) Ltd	Durban	KZN
Tumber Fourie Consulting Engineers cc	Klerksdorp	GP
RPS Engineering cc	Durban	KZN
Mbona Saunders and Wium Pty Ltd t/a MSW Consulting	Pietermaritzburg	KZN
Thabile Engineering	Cape Town	WC
KBK Engineers (Pty) Ltd	Secunda	MP
LNW Consulting Engineers & Project Managers (Pty) Ltd	Northcliff	GP
Thusabatho Consulting Engineers CC	Bloemfontein	FS
SNA Civil & Structural Engineers (Pty) Ltd	Bloemfontein	FS
SKC Masakhizwe Engineers (Pty) Ltd	Paarl	WC
M Hurworth & Associates cc	Cape Town	WC
Bigen Africa Group Holdings (Pty) Ltd	Pretoria	GP
MADAN SINGH & ASSOCIATES CC	Melmoth	KZN

Ballenden & Robb South Africa (Pty) Ltd	East London	EC
Elukani Engineering Projects (Pty) Ltd	Randburg	GP
Element Consulting Engineers	Potchefstroom	NW
BVi Consulting Engineers Northern Cape (Pty) Ltd (Member: BVi Group)	Upington	NC
Royal HaskoningDHV	Pietermaritzburg	KZN
Nala Consulting Engineers (Pty) Ltd	Pretoria	GP
Izazi Consulting Engineers (Pty) Ltd	Randburg	GP
R & H Rail (Pty) Ltd	Randburg	GP
Sintec SA	Pretoria	GP
Ingerop South Africa (Pty) Ltd	Durban	KZN
UWP Consulting (Pty) Ltd	Mthatha	EC
Engineering Advice & Services (Pty) Ltd	Port Elizabeth	EC
BMK Consulting Engineers	Durban	KZN
ECA Consulting (Pty) Ltd	Vryheid	KZN
Aurecon South Africa (Pty) Ltd	Secunda	MP
NDA Consulting Engineers cc	Durban	KZN
Envitech Solutions (Pty) Ltd	Benoni	GP
Carifro Consulting Engineers cc	Port Elizabeth	EC
Tuiniqua (Edms) Bpk	George	WC
Pienaar & Erwee Engineers (Pty) Ltd	Nelspruit/Mbombela	MP
Anderson Vogt & Partners	Durban	KZN
PHB Engineers (Pty) Ltd	Roodepoort	GP
Sobek Engineering (Pty) Ltd	Durban	KZN
GKB Design Associates (Pty) Ltd	Pretoria	GP
Trans-Africa Projects (Pty) Ltd	Midrand	GP
SSA Consulting Engineers (Pty) Ltd	Pietermaritzburg	KZN
Spoormaker & Partners Incorporated	Durban	KZN
LMV Raadgewende Ingenieurs (Edms) Bpk	Kroonstad	FS
AOS Consulting Engineers (Pty) Ltd	Richards Bay	KZN

Lidwala Consulting Engineers (SA) (Pty) Ltd	Randburg	GP
V3 Consulting Engineers (Pty) Ltd	Tyger Valley Bellville	WC
UWP Consulting (Pty) Ltd	Polokwane	LIMP
Element Consulting Engineers	Durbanville	WC
Sobek Engineering (Pty) Ltd	Roodepoort	GP
Phatwe Consulting Engineers	Rustenburg	NW
ARQ (Pty) Ltd	Pretoria	GP
MAP Africa Consulting Engineers	Durban	KZN
Aurecon South Africa (Pty) Ltd	Kathu	NC
MADAN SINGH & ASSOCIATES CC	Durban	KZN
Africa Consulting (Pty) Ltd	Nelspruit	MP
Golder Associates Africa (Pty) Ltd	Midrand	GP
Royal HaskoningDHV	Cape Town	WC
COENG Consulting & Construction Engineers (Pty) Ltd	Centurion	GP
Ziyanda Consulting cc	Pietermaritzburg	KZN
Malani Padayachee & Associates (Pty) Ltd / MPA	La Mercy	KZN
EOH Roads & Highways (Division of EOH Industrial Technologies (Pty) Ltd)	Pretoria	GP
MBB Consulting Services (PMB) (Pty) Ltd	Pietermaritzburg	KZN
ISA & Partners (Pty) Ltd	Bloemfontein	FS
Lategan Bouwer Civil & Structural Engineers (Pty) Ltd trading as NAKO LBE	Centurion	GP
Vuka Africa Consulting Engineers (Pty) Ltd	Pretoria	GP
DJJC Consulting Engineers	Pretoria	GP
Delca Systems	Durban	KZN
SRK Consulting (South Africa) (Pty) Ltd	Rustenburg	NW
Theodor Hoffmann and Mouton Engineers (Pty) Ltd t/a THM Engineers	Bloemfontein	FS
Proper Consulting Engineers (Pty) Ltd	Bloemfontein	FS
VIP Consulting Engineers (Pty) Ltd	Benoni	GP
Jones & Wagener (Pty) Ltd	Johannesburg	GP

Shumba Engineering Services	Randburg	GP
SMEC South Africa (Pty) Ltd	Randburg	GP
ZAI Consultants CC	Empangeni	KZN
SSA Consulting Engineers (Pty) Ltd	Melmoth	KZN

Source: CESA Member List Database

NOTE: GP=Gauteng, KZN= Kwa-Zulu Natal, FS=Free State, NW=North West, WC=Western Cape, NC=Northern Cape, MP=Mpumalanga, LIMP=Limpopo, EC=Eastern Cape

B. List of Participants in Pilot Study

Motla Consulting Engineers (Pty) Ltd	Tzaneen
Denzhe Engineers (Pty) Ltd	Pretoria
Selatile Moloi Consulting Engineers	Bloemfontein
Clinkscales Maughan-Brown incorporating CM-B (Pty) Ltd & CM-B (South) (Pty) Ltd	Cape Town
Delta Built Environment Consultants (Pty) Ltd	Durban
WSP l Parsons Brinckerhoff	Durban
De Villiers & Moore (Pty) Ltd	Stellenbosch
Mahesh Khoosal & Associates CC	Umhlanga Ridge
Royal HaskoningDHV	Newcastle
AOS Consulting Engineers (Pty) Ltd	Midrand

Source: CESA Member List Database

APPENDIX B: Research Survey Questionnaire

Research Survey

The survey should take approximately 10 minutes

1. **Email address** *

Cover Letter

Dear Respondent

I am a student from the Wits Business School (WBS) and I'm conducting a research for my master's degree in a topic I hope you will find appealing. The purpose of this research is investigate the possible impact of total quality management principles on innovation and review how this relates to consulting engineering firms' competitive advantage in the South African market.

The aim is to contribute to the body of knowledge in the field of strategy, operation management and to assist firms to effectively manage innovation through a quality programme.

I have designed a questionnaire to assist me in gathering information for the said objective. I am inviting you to be part of the study and to spend a few minutes to answer all the questions in this survey.

Participants for this survey were randomly selected. However, please note that participation is voluntary and will remain confidential. The results of this study will be purely for academic purposes and access to the data will be restricted to me and my supervisor at WBS.

Thank you for your anticipated response.

The first 20 respondents qualify for a stage 1 equivalent ISO 9001:2015 readiness audit at no cost.

Feel free to contact me should you have any questions.

Name: Ntheng Sebesho (MM in Innovation Studies)
Email: ditebogos@icloud.com or 1780327@students.wits.ac.za

General Information_Part A

2. **Legal Name**

3. **Total Number of Employees**

4. **Years in Operation**

Organisational TQM_ Part B

5. **Customer needs and expectations are effectively disseminated and understood throughout the workforce**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. **Customers are involved in product and service design process**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. **Customer satisfaction is systematically measured and complaints used to improve product and service quality**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

8. **There an innovation strategy or policy in place and implemented throughout the firm**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. **Senior managers actively encourage change and implement a culture of improvement, learning, and innovation in moving towards ‘excellence’**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. **There is a high degree of unity of purpose throughout our company, and we have eliminated barriers between individuals and/or departments**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

11. **We have an organisation-wide training and development process, including career path planning, for all our employees There is a motivation and rewarding system in the organisation**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

12. **Employees are fully committed to the firm's goals**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

13. **Employees are encouraged to be creative , work as a team and to think outside the box**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

14. **Quality procedures are available to ensure the reliability and improvement of data gathering**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

15. **Data is analysed using technology for managers to make accurate decisions**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

16. **Our company has an effective performance measurement system that incorporates a number of measures and indicators to track overall organisational performance**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

17. **We are engaged in an active competitive benchmarking program to measure our performance**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

18. **Work processes, Inspection, review, or checking of work is automated**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

19. **The processes are continuously improved and variances minimised**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

20. **We have clear, standardised and documented process instructions which are well understood by our employees**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

21. **Leadership proactively pursue continuous improvement in people, processes, product/service and environment**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

22. **There is evidence of a strong relationship between improvement activities and the achievement of above average sector results for the organisation**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

23. **Our organisation maintains long-term relationships with suppliers**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

24. **Our suppliers are involved in our product/service development process**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

25. **We use a supplier rating system to select our suppliers and monitor their performance**
Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Skip to question 25.

Innovation_Part C

26. **Our firm obtained new financing sources and its profitability is...**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

27. **Preventive plans are developed to avoid or minimise the identified risks accompanying innovation activities**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

28. **Innovation is applied to products, processes, organisational structures, the operating model and the organisation's management system**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

29. **The updated-ness or novelty of the technology used in our processes is...**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

30. **We make an effort to anticipate the full potential of new practices and technologies**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

31. **We pursue long-range programmes in order to acquire technological capabilities in advance of our needs**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

32. **The firm provides more quality to the final product/services than its competitors**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

33. **The firm is more flexible and quick in adapting in the new market's demand than its competitors**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

34. **The firm uses better technology than its competitors**
Mark only one oval.

	1	2	3	4	5	
Worst in Industry	⬭	⬭	⬭	⬭	⬭	Best in Industry

A copy of your responses will be emailed to the address that you provided