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Degree of Doctor of Philosophy (PHD)

TITLE

Quality Exploitation and Quality Exploration: A model for selecting best QM practices mix for minerals testing laboratories operating in different environmental uncertainty contexts

A thesis submitted to Selinus University of Science and Literature in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Business Administration in the Faculty of Business and Media

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DECLARATION

"I do hereby attest that I am the sole author of this project/thesis and that its contents are only the result of the readings and research I have done"

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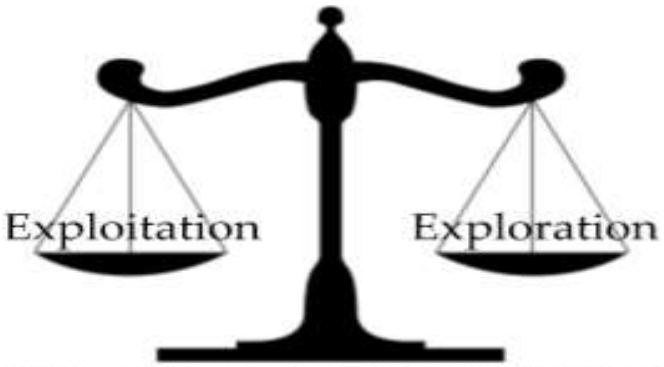

A good balance between exploration and exploitation contributes to high quality.

Two reasons why companies fail: They only do more of the same, or they only do what is new.

Knut Haanaes TED@BCG London

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The completion of this thesis is a result of great support and sacrifice given by members of organisations that participated in the research. I would like to express my gratitude to the support given by these organisations. My heartfelt gratitude goes to the academic and support staff at Selinus University of Science and Literature in particular Dr. Salvatore Fava and Elvira Di Mauro. My gratitude goes to my family–my sisters, my nephew, my wife Colleen and my children O'Brien and Carol, who have witnessed and accepted the absence of a father for this cause. My wife's unparalleled support and encouragement leading to the successful completion of this thesis is greatly appreciated.

DEDICATION

This work is dedicated to my late parents, my late brother and sister who could have witnessed my graduation with joy and to my wife and children with great love.

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ABSTRACT

Quality Management (QM) practices have been proposed as instruments for improving the quality performance of organisations and have often been advocated as universally applicable to all organisations and activities. However, the implementation of these practices has been characterised by mixed findings of success and high profile failures. Simultaneously, the field of QM is still faced with numerous challenges of integrating QM in business operations. Various studies have shown that the mixed results are due to the fact that QM practices are context dependent and that QM practices should take a contingency approach arguing that failures are a result of a great mismatch between context and the form of QM practices being implemented. Despite the importance of matching QM practices content to organisational context, limited empirical research has been devoted to providing models and guidelines on how to select best QM practices as a function of the organisation's environmental uncertainty context. Furthermore, studies that investigated the effect of organisational context on QM practices viewed QM practices as a set of interdependent practices, measuring QM practices with the assumption that all organisations implement the same type of QM. This has limited the understanding of the performance implications of QM. Drawing from Management literature, this study differentiates two forms of QM practices, Quality Exploitation (QEI) and Quality Exploration (QER) and empirically investigates using a case-study method the effect of environmental uncertainty context on the pattern of use of the two forms of QM practices for Customer Focus, Process Management, Teamwork and Training practices to develop a model for selecting best QM practices mix for a given level of environmental uncertainty context. The study also establishes the mechanism by which environmental uncertainty context influences the pattern of use of the various QM practices. The study strongly suggests that the pattern of use of Customer Focus for Quality Exploitation, Customer Focus for Quality Exploration and Process Management for Quality Exploration practices are contingent on the organisation's environmental uncertainty context and explains how environmental uncertainty context influences the patterns of their use. The study findings strongly suggest that when environmental uncertainty context is high, organisations should adopt an ambidextrous stature in the selection of their QEI and QER practices mix. The study develops a model for guiding the selection of best QM practices mix and contributes to contingency theory of QM effectiveness, empirically validating environmental uncertainty context as a contingent factor in QM. The study informs Quality Management implementation.

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Quality Management (QM) philosophy has found its way into every organisation seeking to gain competitive advantage and survival in a competitive and rapidly changing business world (Shafiq, Lasrado and Hafeez, 2019; Isa and Waziri, 2019). Associated with this philosophy is a set of practices and techniques through which QM is implemented to realise organisational improvement (Evans and Lindsay, 2016). Mineral Testing laboratories have equally adopted and implemented QM practices in order to improve the consistency, reliability and quality of service delivery to their customers (Ratseou and Ramphal, 2014) and to prevent or reduce undesired impacts and potential failures in their activities (ISO17025:2017).

The relationship among QM practices and the various aspects of an organisation's performance have been extensively studied (Shafiq, et al., 2019; Anil and Satish, 2019; Jimoh, Gomez et al., 2019). These studies have produced mixed results. Some studies have reported positive impact of QM practices on organisational performance (Yeng, Jusoh and Ishak, 2018; Shafiq et al., 2019; Gomez et al., 2019) whilst other studies have reported a pattern of failure (Zu, 2009; Foster, 2007) and yet other studies could not find a relationship between QM practices and performance (Yeung et al., 2006; Choi and Eboch, 1998). Astrini (2018) reported mixed findings on a review of research papers linking ISO 9001 and performance. Ratseou and Ramphal (2014) reported no difference in the operational performance of laboratories with or without formal quality standards.

Sousa and Voss (2008) and Fundin et al. (2018) have suggested that the mixed results in QM practices research are a result of QM practices being context dependent and suggested that QM research should take a contingent approach. Several studies e.g. Jayaram et al. (2010) have supported the contingency perspective of QM and there has been more support for contingency research in QM (McAdam et al., 2016; Fundin, et al., 2018).

Although research findings support the contingency theory perspective of QM, the set of QM practices were viewed by most researchers as one universal set of practices that cannot be easily customized (Zhang et al., 2014). Sitkin et al., (1994) theorized that QM consists of two distinct sets of practices serving two different goals of control and learning, and classified them as Total Quality Control (TQC) and Total Quality Learning (TQL). The two sets are more or less effective under different contextual settings. TQC practices are based on principles of cybernetic control systems. A cybernetic control process is a process in which a feedback loop is represented by using standards of performance, measuring the performance of the system and comparing that performance with the standards, feeding back information about the unwanted variances in the system and modifying the system (Green and Welsh, 1988, p289). These practices are more suitable to contextual settings where uncertainty is low (Sitkin et al. 1994). TQL practices are oriented towards uncovering of new problems and developing solutions independent of the current problems. These practices emphasise creativity and are considered more suitable to contextual settings characterised by high uncertainty and tasks being poorly understood.

March (1991), proposed two types of organisational learning goals relevant for organisational success-exploitation of old certainties and exploration of new possibilities. Exploitation learning focuses on the need for efficiency and customer responsiveness and reliability of processes. Exploration focuses on anticipation for changing requirements and innovation. Exploitation makes reference to activities such as refinement, choice, production, efficiency and execution whereas exploration refers to activities such as search, discovery, experimentation, variation and innovation (March, 1991). March's (1991) notion of exploitation and exploration is what Sitkin et al (1994) called Total Quality Control and Total Quality Learning. Quality Management often involves both types of organisational learning (Su et al., 2014, Zhang et al., 2014).

Empirical studies have identified a number of factors that may affect QM practices implementation. These factors include environmental uncertainty (Zhang et al., 2014), organisational strategy (McAdam, et al., 2016), internal variety and environmental dynamism (Kim and Rhee, 2009).

Environmental uncertainty has been a central construct in research initiatives related to the studies of an organisation and its relationship with its surroundings (Zhang et al., 2012). It has been defined as the lack of information regarding environmental factors associated with a given decision making process. Ettlie and Reza (1992) view environmental uncertainty as unexpected changes in customer, suppliers, competitors and technology. In generally, literature has identified three major sources of environmental uncertainty as change in demand for products and services by the customers of the organisation change in products or processes and competitive intensity. Researchers e.g. Foster (2010) and Sitkin et al (1994) advocated for a contingency perspective of QM and that environmental factors should be considered. Zhang et al (2012) noted that the effectiveness of QM practices is influenced by environmental uncertainty context and that exploitative oriented practices are more effective when uncertainty is low and explorative oriented practices are more suitable when uncertainty is high.

Based on Sitkin, et al. (1994) view of organisational learning as consisting of TQC and TQL, and March (1991)'s notion of organisational learning, exploitation and exploration, Zhang et al., (2014) used the same conceptual lens to view QM as consisting of two sets of QM practices with one focusing on exploitation and the other on exploration and called them Quality Exploitation (QEI) and Quality Exploration (QER) respectively. Each of these set of practices serve a different purpose in the learning of an organisation. Quality exploitation (QEI) practices aim to control, yet also improve existing processes. Quality exploration (QER) practices refer to variation, discovery and innovation activities. Adaptive systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of experimentation without gaining many of its benefits. They exhibit too many undeveloped new ideas and too little distinctive competences. Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibrium. As a result, maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity (March, 1991:71).

The potential benefit of balancing QEI and QER practices has been discussed but the challenge of getting it right remains. Zhang et al., (2014) notes that although scholars have recognised the need to customize QM practices to organisational context, little empirical

research has demonstrated how QM practices vary with different contextual settings. Zhang et al., (2014)'s study provided an insight into how QM practices could be customised using data from High Performance Manufacturing Projects (HPMP). HPMP data comes from traditional and world class reputation plants from Austria, German, Finland, Italy, Japan, Korea, Sweden and the USA. The context-dependency nature of the findings from the survey based HPMP data may not reflect the same relationship in developing countries and more so in the laboratory environment. No research has focused on tools to guide the selection of best QM Practices mix suitable for organisations operating in different environmental uncertainty contexts in a developing country. Fundin et al., (2018) identifies contextualisation and adapting QM practices to changing environmental conditions as a challenge and agenda for future QM research.

Recently, Eriksson et al., (2016) identified important quality related challenges facing organisations and investigated how current Quality models have incorporated these challenges. The study identified three areas of further research, first, how QM can evolve in different contexts that have varying needs in terms of adaptive and explorative capabilities. Secondly, the interfaces of QM and sustainability, and ways to understand how customers and stakeholders can be active contributors to improvements and finally, the roles of the owners and board of directors regarding QM and how to organise and distribute responsiveness of QM work. The study indicated that the excellence models were still relevant, since their content matched many of the identified challenges. The MBNQA and the SIQ models were found to have the most comprehensive coverage, whilst the ISO model had limited coverage. ISO 9001 is the most widely adopted Quality model. The study identified three important challenges that future revisions of the excellence models could address as follows: 1-making QM a strategic issue for company owners, 2-involving customers in improvement activities of an organisation and 3-developing processes that are robust yet still easily adaptable. As such, this study seeks to develop a model for guiding the selection of best QM practices mix across organisations representative of different levels of environmental uncertainty context and to develop a QEI and QER practices mix appropriate for laboratories operating in stable and highly uncertain environments in the mining industry of Zimbabwe and South Africa. In so doing the study seeks to contribute to addressing how QM can evolve in different contexts that have varying needs in terms of

adaptive and explorative capabilities and therefore addressing challenge number 3 which could be incorporated into future excellence models revision.

Given the increased reliance of organisations on QM in gaining competitive advantage, the findings of this study will assist practitioners in selecting best QM practices mix fit for their environmental uncertainty contexts. Selection of appropriate practices will ensure better performance benefits from QM. The study will also contribute to addressing current QM challenges and contribute to the revision of current excellence models e.g. ISO 9001. The findings will assist practitioners in appropriately allocating resources for the two sets of practices and increasing practitioner confidence in implementing QM practices. Understanding how environmental uncertainty context affect effectiveness of QM practices and the provision of a guideline on selecting best QM practices provides a strategic choice to management in QM.

The main theoretical contribution of this study lies in identifying the change in the most appropriate combination of quality exploitation and quality exploration practices across the environmental uncertainty context spectrum in order to develop a model for selecting the best mix of QEI and QER practices for a given level of environmental uncertainty. Taking QM as a universal set of practices not easily customizable and disregarding the dual roles of exploitation and exploration of QM limits the researchers' understanding of the relationship between QM practices and performance and there is a great concern among researchers that QM can lose its great potential if it's theoretical underpinnings are not adequately evaluated (Zhang et al., 2014).

The data comes from case study of four laboratories in the mining industry of Zimbabwe and South Africa, selected to provide different operational environments in terms of environmental uncertainty. The four laboratories provide a good setting for studying QEI and QER practices since the two laboratory environments provide different environmental uncertainty contexts. This study selected the laboratories in the mining industry as an area to perform the research. Two of the laboratories are mine site non-commercial and two are commercial laboratories. Commercial laboratories provide services to multiple customers and companies whilst mine site non-commercial laboratories provide services to only internal customers (Ratseou and Ramphal, 2014). There could be a slight variation to this

where the mine site laboratories have external customers for the product of the mine as customers as well for the laboratory.

The study builds on Sitkin et al., (1994) models of Total Quality Control(TQC) and Total Quality Learning (TQL) and March's (1991) notion of exploitation and exploration and proposes a model fig 1.1 for guiding the selection of best QEI and QER practices mix across the laboratory organizations.

The rest of the thesis is arranged as follows: Chapter 2, details the literature reviewed for this study. Chapter 3 addresses the methodological issues of the study. Chapter 4 provides the data analysis and results. Chapter 5 provides a detailed discussion of the research findings and chapter 6 details the recommendations for further study.

1.1 BACKGROUND TO THE RESEARCH

Many organisations have adopted QM practices (quality exploitation and quality exploration) with the aim of gaining competitive advantage (Shafiq et al., 2017) and specifically in laboratories to address credibility gaps that appeared in resource estimation partly following the Bre-X scandal (Scogings, 2014). However, not all organisations that embarked on this journey managed to realise the intended benefits (Astrini, 2018; Zu, 2009; Zhang, et al., 2014) despite successful implementation in other organisations. On the other hand the field of QM is still faced with numerous challenges of integrating QM in business operations (Fundin et al., 2018, Eriksson et al., 2016). Eriksson et al., (2016) identifies QM challenges and areas of future research to be incorporated in future revisions of the excellence models e.g. developing processes that are robust yet still easily adaptable i.e. how QM can evolve in different contexts that have varying needs in terms of adaptive and explorative capabilities.

Sousa and Voss (2008) have noted that the problems that QM practices have faced are due to them being context dependent and that contingency theory provides one way of understanding QM practices challenges (Foster, 2010, Maletic et al., 2017; Aquino et al., 2017, Panuwatwanich and Nguyen, 2017). Researchers have argued that QM practices implementation difficulties are a result of a great mismatch between the content of QM being implemented and the organisational context in which the organisations operate

(Maletic, et al., 2017; Sousa and Voss, 2008) arguing that there may be no one way of implementing QM practices across organisational contexts (Zhang et al., 2014). Some organisations may benefit more from implementing some practices than others (Wu, et al., 2011, Wu, 2020).

However, studies on QM practices and performance have viewed QM practices as a set of interdependent practices (Kaynak, 2003; Zhang et al., 2014), measuring QM practices with the assumption that all organisations implement the same type of QM. This has limited understanding of the performance implication of QM practices. At the same time, some studies have shown that not all QM practices lead to superior performance (Elshaer and Augustyn, 2016; Sabella et al., 2014) and that the effect of some QM practices on organisational performance is more pronounced than the effect of other practices (Talib et al., 2013).

Despite the importance of context on QM practices and the need to tailor QM practices to organisational context (McAdam, et al., 2016; ISO 9001:2015; Zhang et al., 2014), there has been limited empirical research conducted on how to select the best quality exploitation and quality exploration practices mix to fit context. Only a few studies e.g. Zhang et al., 2014 provides an insight into how organisations could customize their QM practices to context by distinguishing between the two conceptually different sets of QM practices. However, the data for this study came from a survey study of High Performance Manufacturing Project (HPMP) and the generalization of the findings to other settings e.g. services being limited. Furthermore the data for all HPMP comes from developed countries. No study has been conducted in developing countries and in particular laboratories in the mining industry. The questions that arise are: Does the QEI/QER context dependency perspective hold in the laboratory industry in a developing country? Are the QM challenges and mixed findings in QM research a result of a great mismatch between the content of QM being implemented and the context of the organisation? How can laboratory organisations go about selecting best QEI and QER practices to fit their context?

This study seeks to address the QM practices related challenges from a contingency theory perspective by developing a model for selecting best QM practices mix.

1.2 *PROBLEM STATEMENT*

Quality Management (QM) practices are known to result in competitive advantage in organisations and their effects on organisational performance have been well studied (Yeng, et al., 2018; Biswarkarma, 2017; Shafiq et al., 2019).

However these studies have produced mixed results including high profile failures (Zu, 2009; Astrini, 2018; Wright and Taylor, 2003). Sousa and Voss, (2008) have shown that the mixed findings are due to QM practices being context dependent. Zhang et al., (2012) identified environmental uncertainty context as one factor that can affect quality exploitation and quality exploration practices arguing that their effectiveness may differ when implemented in different environmental uncertainty contexts and therefore QM practices should be matched to their context (Arieftiara, et al., 2017; Maletic, et al., 2017; Fundin, et al., 2017). Similarly, Eriksson et al., (2016) and Fundin et al., (2018) have identified QM challenges relating to contextualising QM practices as an area of future QM research.

Despite the importance of environmental uncertainty context on QM practices, and the importance of customizing QM practices to their environmental uncertainty context, there is little empirical research on how organisations can go about tailoring their QEI and QER practices to fit their specific contexts. Little empirical research has been conducted in the context of a developing country and in particular laboratories in the mining industry to provide a model for selecting best QM practices suitable for a particular context.

Therefore, the purpose of this study is to develop a model to guide the selection of best QEI and QER Practices mix suitable for different environmental uncertainty contexts and further developing appropriate mix for these practices. The study further develops causal networks to explain how environmental uncertainty context influences the various QEI and QER practices mix.

1.3 RESEARCH QUESTIONS

Specifically, this study addresses the following research questions:

- What is the pattern of use of QEI and QER practices across the environmental uncertainty context spectrum represented by the commercial and non-commercial mine site laboratories?
- How does environmental uncertainty context influence the best QEI and QER practices mix in these laboratories?
- What is the model for guiding the selection of best Quality Exploitation (QEI) and Quality Exploration (QER) practices mix across the laboratory organizations?

1.4 AIM OF THE STUDY

The aim of the study is to develop a model for guiding the selection of best quality exploitation and quality exploration practices mix suitable for Laboratories operating in different environmental uncertainty contexts.

1.5 RESEARCH OBJECTIVES

To address the purpose of this research and addressing the above research questions, the following specific objectives have been defined:

- Establish the pattern of use of the various QEI and QER practices across the laboratory organisations.
- Develop causal networks for the relationship between use of the various QEI and QER practices and environmental uncertainty context variables.
- Explain the mechanism by which environmental uncertainty context affect the implementation and performance effects of the various QEI and QER practices.
- Develop a model for guiding the selection of best QEI and QER practices mix based on the contingent determined patterns.

1.6 BRIEF LITERATURE REVIEW

Many organisations have adopted Quality Management with the aim of gaining competitive advantage (Shafiq et al., 2017). However, not all organisations that embarked on this journey managed to realise the intended benefits (Zu, 2009; Astrini, 2018; Wright and Taylor, 2003; Yeung et al., 2006) whilst other studies reported that not all QM practices lead to superior performance (Sabella, et al., 2014; Dow, et al., 1999; Augustyn, 2016). On the

other hand there are still numerous challenges of integrating QM in business operations (Fundin et al., 2018, Eriksson et al., 2016).

For a mature field of study such as QM, mixed performance results and high profile failures are a cause for concern for both scholars and practitioners, raising some suspicions on the universal applicability of the quality management concepts and practices (Sousa and Voss, 2008). Researchers have noted that the problems that QM has faced are due to it being context dependent (Fundin, et al., 2018) and that contingency theory provides one way of understanding QM challenges (Sousa and Voss, 2008; Foster, 2010). Maletic et al. (2017) on sustainability practices and organisational performance supported the contingent view of quality management rather than the universal view. A need to adopt the contingency model appears promising where a particular form of QM practice or different quality management practices mix are emphasized depending on organisational context (Zhang et al., 2014).

Backstrom (2017) suggests balancing exploitation and exploration practices and internal efficiency and external effectiveness in a new QM, an emergent QM. Although some studies suggested a combination of QEI and QER practices depending on the organisation's environmental uncertainty context, some contingent studies have not distinguished the two orientations, viewing QM practices to serve as a package under the interdependence assumption of QM practices (Kaynak, 2003), whereas some studies have shown that some QM practices are more effective than others (Talib, et al., 2013). Similarly, Elshaer and Augustyn (2016) found that not all QM practices contribute to superior performance. Empirically, the two orientations of QM practices as suggested by Sitkin, et al. (1994) have not been taken into consideration in many QM performance studies.

Although earlier contingent studies viewed QM as a single bundle of practices (Sitkin et al, 1994, Zhang et al., 2012), recent studies have started recognising the dual role of QM practices (Asif et al., 2015; Fundin et al., 2019) and that organisations can benefit from pursuing both roles, based on March (1991) notion of exploitation and exploration and Sitkin et al., (1994) categories of TQC and TQL. Disregarding the existence of the two QM practices orientations in research and implementation has the potential of adopting and implementing practices that do not fit context, which will result in lack of effectiveness of the QM programs (Sousa and Voss, 2008).

Although scholars have recognised the importance of contingency theory in Quality Management research (Sousa and Voss, 2008; Foster 2006; Zhang et al., 2014, Aquino, et al., 2017) and the need to tailor quality management practices to organisational context (McAdam, Miller, and McSorley, 2016; ISO 9001:2015), there has been limited focus on how organisations can select the best QM practices mix to fit their environmental uncertainty context. McAdam et al., (2016) concludes that quality management must move beyond solely best practices and rule based approaches which are limited to stable environment and recommends further contingency research in different service sectors as further testing of the robustness of their findings. The need to tailor Quality Management practices to organisational context provides a promising avenue to resolving the mixed results and high profile failures in QM. Fundin et al., (2018) notes that combining QM practices geared to impact efficiency, stability and standardization and those geared towards effectiveness, development and innovation is difficult to implement and contextualizing QM practices remain a challenge and agenda for future research. Wu, et al., 2020; and Wu, 2011 argue that focusing on some QM practices may work better for some organisations than others and organisations may need to tailor their QM practices to their organisational contexts. Despite the importance of context on QM practices and the need to tailor it to organisational context, limited empirical research has been conducted on how to select the most appropriate QM practices mix to fit context. There is limited understanding of how environmental uncertainty context influences the most profitable QEI and QER practices mix and how QM practices should be implemented in the context of high environmental uncertainty versus low environmental uncertainty. Eriksson et al., (2016) identified, how QM can evolve in different contexts that have varying needs regarding adaptive and explorative capabilities as an area requiring further research? From a practical point of view they identified three important challenges that future revisions of excellence models could address: (1) Making QM a strategic issue for company owners; (2) involving customers in the improvement activities and (3) developing processes that are robust yet still easily adaptable. This makes it important for both theory and practice that a better understanding of the relationship between QEI and QER practices and performance in the context of environmental uncertainty be developed. There is great concern among researchers that the potential contribution of QM practices could be lost if their theoretical underpinnings are not adequately evaluated (Zhang et al., 2012).

This study seeks to close this gap by developing a model for selecting best QEI and QER practices mix to fit different environmental uncertainty contexts and contribute to research addressing challenge (3) which is related to developing processes that are robust yet easily adaptable thereby contributing to future revisions of current excellence models. Furthermore, the study seeks to establish the mechanism by which environmental uncertainty context influences best QEI and QER practices mix. The study also develops best QEI and QER practices mix suitable for commercial and mine site laboratories. The commercial laboratories operate in highly uncertain environments relative to mine site laboratories. This makes their operating environment different from the stable environment which has received much attention (Jansen et al., 2006).

1.7 *RESEARCH DESIGN AND METHODOLOGY*

This section deals with the research paradigm, research design and methodology followed in the study.

1.7.1 Research Paradigm

The study is positioned in the interpretive research paradigm.

1.7.2 Research Methodology

Based on the philosophical assumptions for the paradigm in which the research was positioned, the researcher adopted a qualitative research approach for the following reasons:

- The topic under study is a complex one requiring explanations to patterns.
- To uncover the meanings that people give to their experience in the implementation of the QM practices.
- To provide depth, detail and context to the research issue. The approach was found best in order to address the 'why' and 'how' questions in the research.

1.7.3 RESEARCH MODEL

This study is based on contingent research, which views implementation of QM practices to vary across organisational context. The research draws on Sitkin, et al. (1994) theoretical

model for TQC and TQL and March (1991) notion of exploitation and exploration and adopts Zhang et al., (2014) approach of classifying QM practices into exploitation and exploration QM practices and proposes the below research model.

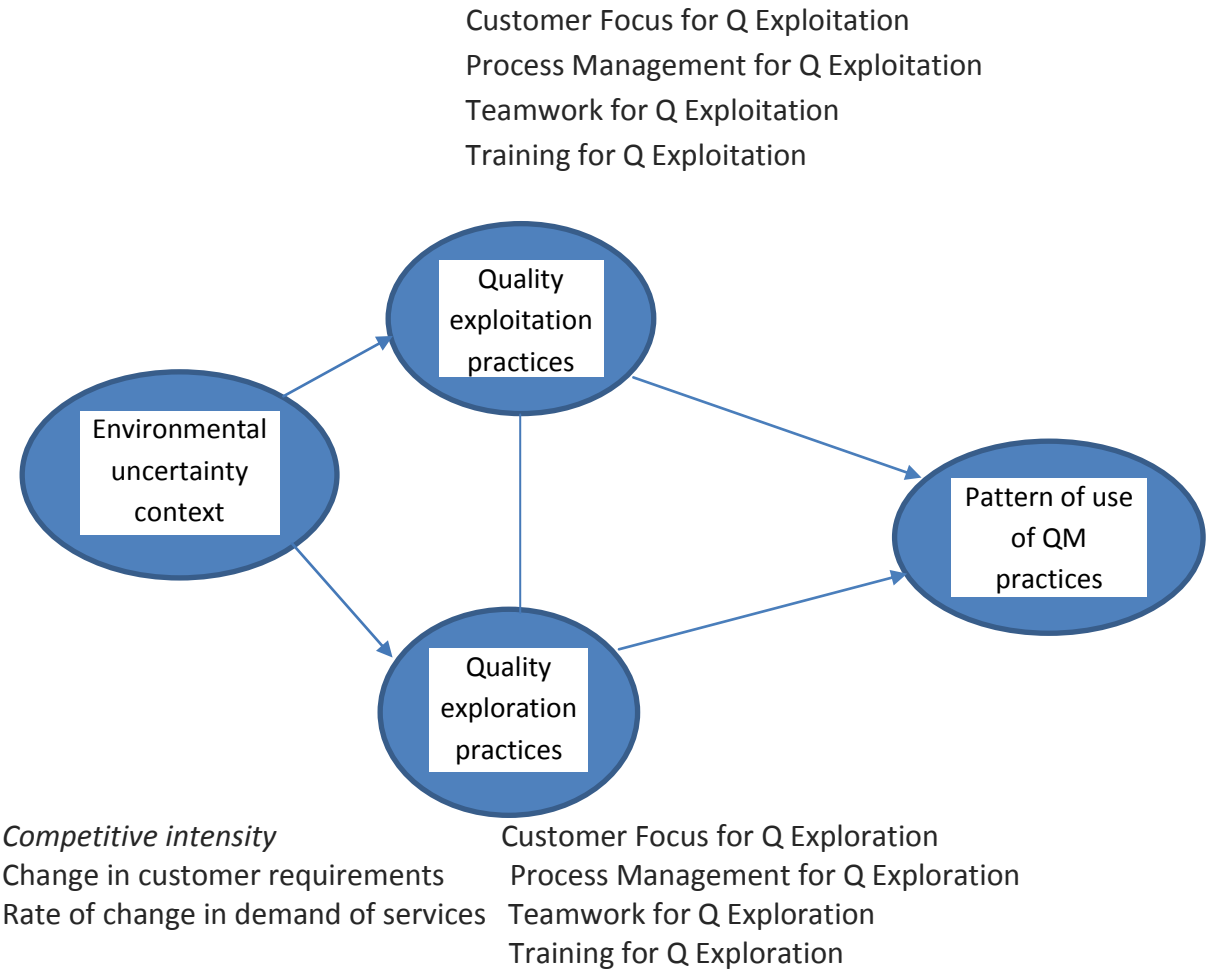


Fig 1.1 Proposed Research Model

1.7.4 RESEARCH DESIGN

The research follows a multiple case study design. Cases were selected from a target population of mine site non-commercial laboratories and commercial laboratories in the mining industry of Zimbabwe and South Africa.

Cases were chosen to represent different environmental uncertainty contexts. The extent of implementation of QEI and QER practices was investigated across the organisations. Environmental uncertainty context was based on an assessment of the degree of competition, change in customer needs and rate of change in product or service demand.

The case study method was chosen for two main reasons. First, the study is theory building in nature and requires explanations of how environmental uncertainty context affects the use of QEI and QER practices across different contexts. Qualitative data is useful in explaining causal relationships. Secondly, contingent research models require a number of research variables and controls. Sousa (2003) states that this requirement renders the use of distant methods e.g. survey methods ineffective.

The design can be best represented as in fig 1.2 below. Two cases were chose for each of the level of environmental uncertainty context for literal and theoretical replication reasons.

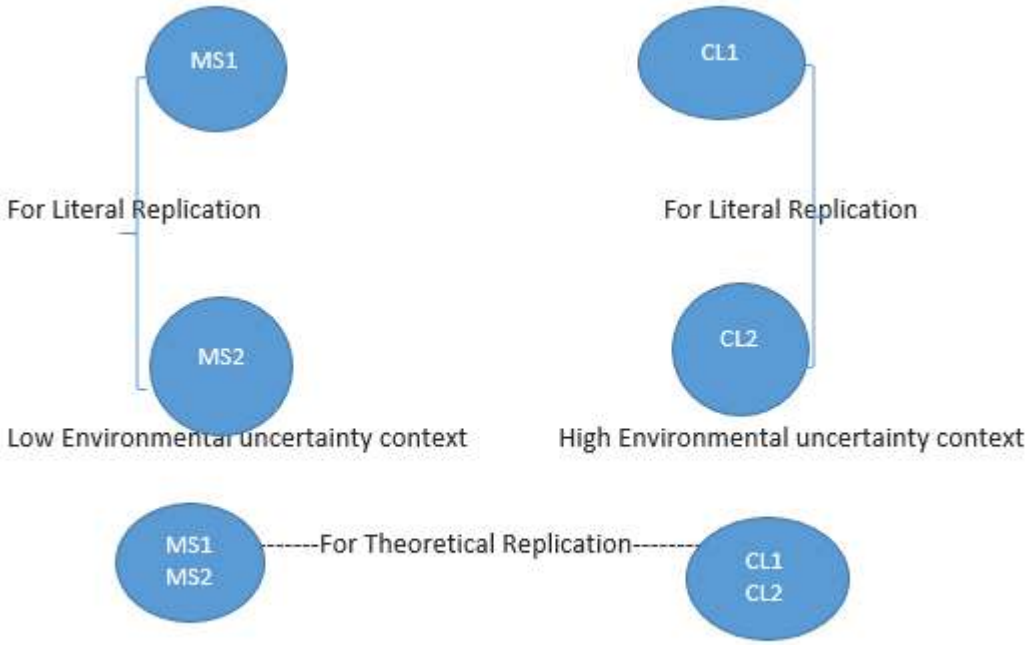


Fig 1.2 Pictorial representation of the research design

1.7.5 CONTROLS IN SELECTION OF CASE SAMPLES

Only laboratory organisations regarded as mature in QM were selected for participation in the study. These are organisations that have generally implemented QM systems for at least three years. A three year period is accepted as a cut-off point between mature and young organisations (Sousa and Voss, 2008; Ahire, 1996).

Secondly, all organisations were from one industry sector (laboratories in the mining industry) to avoid experiencing differences in the use of practices that may be due to industry effects rather than environmental uncertainty context.

1.7.6 METHODOLOGY

1.7.6.1 Sample selection

Case samples were selected from mine site non-commercial laboratories and commercial laboratories. All case study organisations provide laboratory services to mining organisations. The two groups represent a spectrum of environmental uncertainty context from low to high. This selection is in line with Baskarada (2014) where cases are chosen that either predict similar results or contrary results. The cases were chosen for theoretical reasons (Barratt, et al., 2011).

Four case studies were selected in total. Two organisations per each level of environmental uncertainty context allows for both literal and theoretical replication.

The choice of four cases is in line with Eisenhardt (1989) recommendation. Eisenhardt, (1989) suggests that a number of cases between four and ten work well, arguing that less than four cases will make it difficult to capture complexity and that more than ten cases makes it difficult to process the data gathered.

1.7.6.2 Data collection

Data was collected using in-depth interviews and review of documents where objective evidence of implementation of practices was sought. A research protocol was used. Findings from multiple sources of data were used for the purpose of triangulation.

Each case study company was visited at least once. Participants in the research included the Laboratory Manager, the Laboratory Superintendent, the Quality Manager/Quality Assurance Chemist and the Shift Chemists. Interviews per informant were typically 45 minutes but ranged from 30 minutes to 3 hours across cases. More time was spent with the QA Manager/Chemist or Laboratory Manager/Director.

1.7.6.3 Data Reduction

1.7.6.3.1 General data reduction process

Data was handled through two main stages that included first a data reduction step and secondly the data analysis.

Two main variables were considered in this study, the environmental uncertainty context of the organisations and the extent to which the QM practices were utilized.

1.7.6.4 Classification into Environmental uncertainty context

The final case organisations were classified into two categories representing low and high environmental uncertainty contexts using well defined rules.

1.7.6.5 Degree of use of quality exploitation and quality exploration practices

For each QM practice a detailed description is given regarding the use of the practice with the objective evidence of use. A rating of the level of implementation of the practice as high, medium or low was used and arrived at using well defined rules.

1.7.6.6 Data analysis

A pattern for the level of implementation of the various QM practices was displayed across the organisations.

Limited statistical methods (spearman's correlation coefficient) were used to establish whether the use of QM practices is contingent on environmental uncertainty context. Secondly, visual correlation graphs were established between context and level of use of practice where they existed.

Causal networks were developed to predict the mechanism by which environmental uncertainty context interacts with QM practices.

Thirdly, organisational performance was inferred to the extent to which practices are used across context. Using results from the pattern of use of the practices and explanatory models, data was used to develop the best QM practices mix for each given context.

1.8 Reliability and validity

To enhance the quality of qualitative case study, five tests that measure the rigour of the study were implemented.

1.8.1 Confirmability (objectivity)

Three tactics were adopted for enhancing confirmability, first by use of a research protocol. Secondly, a chain of evidence was established through the use of a well-defined data reduction process. Thirdly, key informants were given an opportunity to review the draft case reports and to confirm that the researcher's summary was a true reflection of the given information. Furthermore, the ontological and epistemological disposition of the researcher was clearly stated.

1.8.2 Credibility (Internal Validity)

Credibility was achieved through pattern matching for both similar and dissimilar cases (literal and theoretical replication respectively) as per research design and secondly by the adoption and use of well-established methods that have been successfully employed. Furthermore triangulation through the use of different data collection methods-interviews, observations and review of quality control records was employed to enhance credibility. A technique of iterative questioning was also employed.

1.8.3 External validity (Transferability)

This was achieved by the use of theoretical sampling logic that was employed at the research design stage of the study. Cases were chosen that differed significantly regarding the contextual variable of interest and therefore filling theoretical niches. This replication logic allows for analytical generalization. This is generalization from each case to a broader theory and not samples to populations (Stuart, et al., 2002; Yin 2003). Generalization from the Laboratory industry to other industries is therefore inferred.

1.8.4 Dependability (Reliability)

This was achieved through two main approaches. First, a case study protocol was employed. Second, a case study database was maintained. This stored database allows a different researcher to expose the same data collected, through the same reduction and analysis process to establish whether the same results (summary) could be arrived at. This process is in line with Eisenhardt (1989) guidelines for achieving reliability in qualitative research.

1.8.5 Authenticity

Authenticity was achieved at both design stage and data collection and analysis by purposeful sampling and having a number of groups or categories of employees to participate in the research as interviewees respectively.

1.9 ETHICAL ISSUES

In conducting the research, plans were made to address anticipated ethical issues. Some of these issues are generally easy to predict but others are not clear. As a result the researcher developed own sense of how to conduct the research in an ethical manner. As a minimum, the following were addressed: Seeking permission and informed consent, voluntary participation, minimization of harm, anonymity and confidentiality and cultural sensitivity.

The ethical issues in the study were guided by Belmont Report (Hennink et al., 2011) which identified three core principles for ethical conduct.

•That participants welfare should take precedence over science and society and that participants should voluntarily enter the research and with adequate information.

•Researchers should strive to maximize the benefits of the research for wider society and minimize risks to research participants.

•Researchers should ensure that research procedures are administered in a fair, non-exploitative and well-considered manner.

These principles were achieved through the following:

•Seeking permission and providing information-Permission was sought from the targeted organisations to conduct research in their organisations.

•Minimization of harm

•Informed consent-Informed consent was sought from each participant.

•Anonymity and confidentiality-It was clearly indicated that there were limitations to achieve full confidentiality of the information gathered during the study as reports were to

be generated and possibly published. However, anonymity was assured. No reference would be made to names of participants. All identifiable information was removed from the interview transcript or quotations noted.

•Justice-Every effort was made to avoid sensationalising the findings of the research and reporting the findings of the research and reporting incidents that do not reflect the real situation (Hennink, et al., 2011).

1.10 EXPECTED OUTCOME AND RESULTS

The research is based on a qualitative case study and a lot of data was generated. This data was treated through a number of reduction processes to generate patterns. It is expected that the same pattern of use of QEI and QER practices will be observed for those organisations categorised under the same contextual level of the organisational uncertainty (literal replication) for the practices which are contingent upon the organisational context. A change in the use of these same practices is expected across the organisational uncertainty context (lateral replication). A visual pattern of correlation graphs is expected to show this. Limited statistical methods are used to support the visual pattern. On the other hand, a complex pattern is expected as organisations strive to balance the use of these practices in meeting the needs of the current customers and those of new customers.

1.11 LIMITATIONS, SCOPE AND DELIMITATIONS

The purpose of this study is not to develop a measurement instrument for QM practices, but to develop a model for guiding the selection of best QEI and QER practices suitable for different environmental uncertainty contexts and focuses only on four QM practices of Customer Focus, Process Management, Teamwork and Training Practices. These practices provide a good balance between internally oriented QM practices (Process Management, Training and Teamwork Practices) and externally oriented practices of Customer Focus (Wu, 2020, Elshaer and Augustyn, 2016) at the same time providing a good balance between soft and hard QM practices.

The results of the study could provide reasonable justification for generalisation in the Laboratories in the mining industry. The single industry design utilized to control for industry effects is likely to reduce generalizability. However, it is still possible to make

theoretical inferences about other industries based on the existence of contextual variables that covered a spectrum of environmental uncertainty contexts. Yin (2003) states that generalisation of results from case studies stems on theory and not on populations. Use of the replication logic adopted in the study enhances the external validity of this case study.

The limitations were addressed by:

1. Use of multiple sources of evidence and also having key informants review draft case report to increase construct validity.
2. Use replication logic in multiple cases to allow for theoretical generalisation, thus increasing the external validity.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter provides a review of the literature related to QM practices and their relationship with organisational performance and the contingency effects of organisational context and in particular that of environmental uncertainty context on the relationship between QM practices and organisational performance. In particular, the review focuses on the different QM practices of exploitation (QEI) and exploration (QER) and the contingency effects of environmental uncertainty context on their use and effectiveness. First, the study reviews the literature on the theories that underpins the study.

2.1 Theoretical Framework

This study hinges on the contingency effect of environmental uncertainty context on the pattern of use of the various QEI and QER practices. The study takes the Contingency (CT) as the main theoretical lens through which the study is viewed. The CT is a major theoretical lens through which organisations are viewed. In its rudimentary form, the CT holds that organisations adapt their structures in order to maintain fit with changing contextual factors, so as to attain performance (Donaldson, 2001; Masud, Md; Ali, Julfikar and Saha, Akasha, 2016). Secondly, the study embraces the Organisational Learning Theory (OLT), based on the view that QM is ideally a continuous learning process with two main learning goals of exploitation and exploration (Zhang et al., 2012; Zhang et al., 2014). Based on March's (1991) framework of organisational learning QM practices can be viewed from this perspective into QEI and QER practices. Thirdly, the study incorporates the Organisation Information Processing Theory (OIPT). The main variable of environmental uncertainty, relates to lack of information in decision making and interaction with the external environment requires the organisation to have both the capability and capacity to collect and process information. Viewing the organisation as the internal environment and the customers as external environment, the internal processes of production, process management, control and design which contribute to control and improvement depends on the input and collaboration with customers. According to OIPT, external integration that

collects accurate demand and supply information is essential for coordinating the tasks (Thompson, 1967).

2.1.1 The Contingency Theory

In its rudimentary form, the CT holds that organisations adapt their structures in order to maintain fit with changing contextual factors so as to attain performance (Donaldson, 2001). Theoretical and practical contributions of the CT are accomplished by first identifying the most important contingency variables that distinguish between contexts (Sousa and Voss, 2008). Secondly, the different contexts are grouped according to contextual variables and finally establishing the organisational response variables, which in this study are Quality Exploitation and Quality Exploration practices. Four main ideas characterise the CT as follows:

First, there is no universal way or one best way to manage. Secondly, the design of an organisation and its subsystems must fit with the environment. Thirdly, Effective organisations, do not only have a proper fit with the environment but also within its subsystems and lastly, the needs of the organisation are better satisfied when its properly designed and the management style is appropriate both to the tasks undertaken and the nature of the work groups.

Within the field of CT, contingency studies are characterised by three variables. First are the contextual variables which represent the situational characteristics. These variables are not easily controllable e.g. environmental uncertainty context. The second set of variables are the response variables e.g. the various quality exploitation and quality exploration practices and finally the performance variables which are the dependent measures representing specific aspects of effectiveness appropriate to evaluate the fit between context and response variables (Sousa and Voss, 2008). Contingency studies in particular this one, examines the effect of contextual variables on the use and effectiveness of the QEI and QER practices by determining the extent to which these practices are implemented.

Underlying the CT framework is the concept of fit which is based on an economic rationality and design oriented mind-set (Ketokivi and Schroeder, 2004). According to the CT theory, organisations should use practices which are effective in their context i.e. with adequate fit

to a high degree. The rationality for use of practices is efficiency and restrictive role of context (Sousa and Voss, 2008).

2.1.2 The Organisational Learning Theory (OLT)

The Organisational Learning Theory (OLT) states that in order to be competitive in a changing environment, organisations must change their goals and actions to reach those goals. Organisational learning is defined as the change in organisational knowledge that occurs as a firm acquires experience (Asif et al., 2019) and can be measured in different ways e.g. measuring organisational learning through changes in practices or performance (Argote and Micro-Spekfor,2011). For organisational learning to occur, the organisation must make a conscious decision to change actions in response to a change in the environment and link action to outcome. Organisational learning starts at the individual level, shared among the members of the organisation to become organisational knowledge. There are various ways of acquiring the action outcome links e.g. experimental but the actions must be a conscious effort to discover, confirm, or utilize a cause and effect. Organisational actions must be changed as the environment changes.

The second part of learning is interpretations which consists of continually comparing actual and expected results or add to the memory. The third stage is adaptation. Learning is a process of continual adaptation to environmental conditions and is affected to a large extent by the complexity and dynamism the firm experiences.

QM is essentially a continuous improvement program with learning as the core (Zhang et al., 2014) and can be viewed from the lens of the OLT. Organisations deal with two tasks of controlling stable processes and improving their efficiencies and the search for new insights for innovation. The central concern of adaptive processes is to develop capabilities for efficiency and responsiveness to new insights in the environment (Asif, 2019). Based on March (1991) framework of organisational learning, Sitkin, et al., (1994) theorised that QM can be viewed from its two goals of exploitation and explorations. Zhang, et al., (2014) has viewed QM practices from this perspective and classified the practices into QEI and QER practices whereas QEI practices are needed to control the known processes whilst QER practices are needed to explore the unknown and search for novel solutions (Zhang et al., 2014). Each set of practices has its own unique advantages, which justifies the need for a

balance between the need to meet short term production and efficiency objectives as well as objectives related to long term growth and development (Palm and Lilja, 2017).

2.1.3 Organisation Information Processing Theory (OIPT)

The OIPT identifies three important concepts of information processing, information processing capability and the fit between the two to obtain optimal performance (Premkumar, G., Ramamurthy, K., and Saunders, C.S., 2005). At the same time, the CT posits that a firm's performance is attributable to the match between its structure and processes with environmental conditions, suggesting that firms often shape their business environment through a series of externally oriented strategies when facing uncertainty in the environment. The CT suggests that external integration is expected to fit with high environmental uncertainty context. This calls for a need to acquire rich information when uncertainty is high (Wong, et al., 2011) requiring external integration mechanisms to collect information, coordinate and monitor activities of partner firms and facilitate response (Sitkin et al., 1994). In order to be able to explain the contingency effects of environmental uncertainty, the study integrates the OIPT with the CT theory. Environmental uncertainty deals with lack of information for decision makers, and organisational learning deals with knowledge, which is correlated to information. Including the OIPT in evaluating the contingency effects of environmental uncertainty context on QEI and QER practices is noted as useful (Wong, et al., 2011). To cope with high environmental uncertainty, organisations need to improve their information processing capability.

The study is therefore positioned within a framework of three complementary theories of (a) the Contingency Theory that links QEI and QER practices to environmental uncertainty context, stating that the adaptation and effectiveness of QEI and QER practices is contingent upon the environmental uncertainty context of the organisation, (b) the Organisational learning theory-allowing classification of QM practices into two fundamentally different but distinct set of practices of exploitation and exploration. The effectiveness of QEI and QER practices being different in different contexts and (c) the Organisational Information Processing Theory-that would assist in explaining the contingency effects of environmental uncertainty context on the use of the different quality QEI and QER practices. The study

integrates the CT and OIPT to explain the contingency effects of Environmental uncertainty context.

2.2 The conceptual Framework

The central premise of this study is that there are two forms of quality management practices, QEI and QER. Each of these practices serves a different purpose and their effectiveness is influenced by the environmental uncertainty context in which an organisational operates. The study aims to develop a model for selecting best QM practices mix for different environmental uncertainty contexts and to answer the following research questions:

What is the pattern of use of QEI and QER practices across the environmental uncertainty context spectrum represented by commercial and non-commercial mine site laboratories? To address this question the study, investigated the degree of use of the various QEI and QER practices across the environmental uncertainty context. First, the study establishes the environmental uncertainty context of the various laboratories, which represents the contextual or contingency variables in the study. Secondly the study establishes the degree of use of the various QEI and QER practices across the environmental uncertainty context spectrum. The degree of use of QEI and QER practices represents the response variables in the research. It is assumed that under conditions of fit, the pattern of use of the practices would represent the pattern that leads to high performance (Sousa and Voss, 2008).

The second research question, "How does environmental uncertainty context influence the use of best QEI and QER practices mix in these laboratories?

The second research question is addressed by creating causal networks to determine the mechanism by which environmental uncertainty context variables influence the pattern of use of the various QEI and QER practices and finally the third research question:

What is the model for guiding the selection of best QEI and QER practices mix across the laboratory organizations? This is addressed by combining the information from research questions 1 and 2.

The researcher therefore presents the conceptual framework below for this study with the following key concepts: QEI practices, QER practices, environmental uncertainty context and organisational performance represented by the pattern of use of QEI and QER practices.

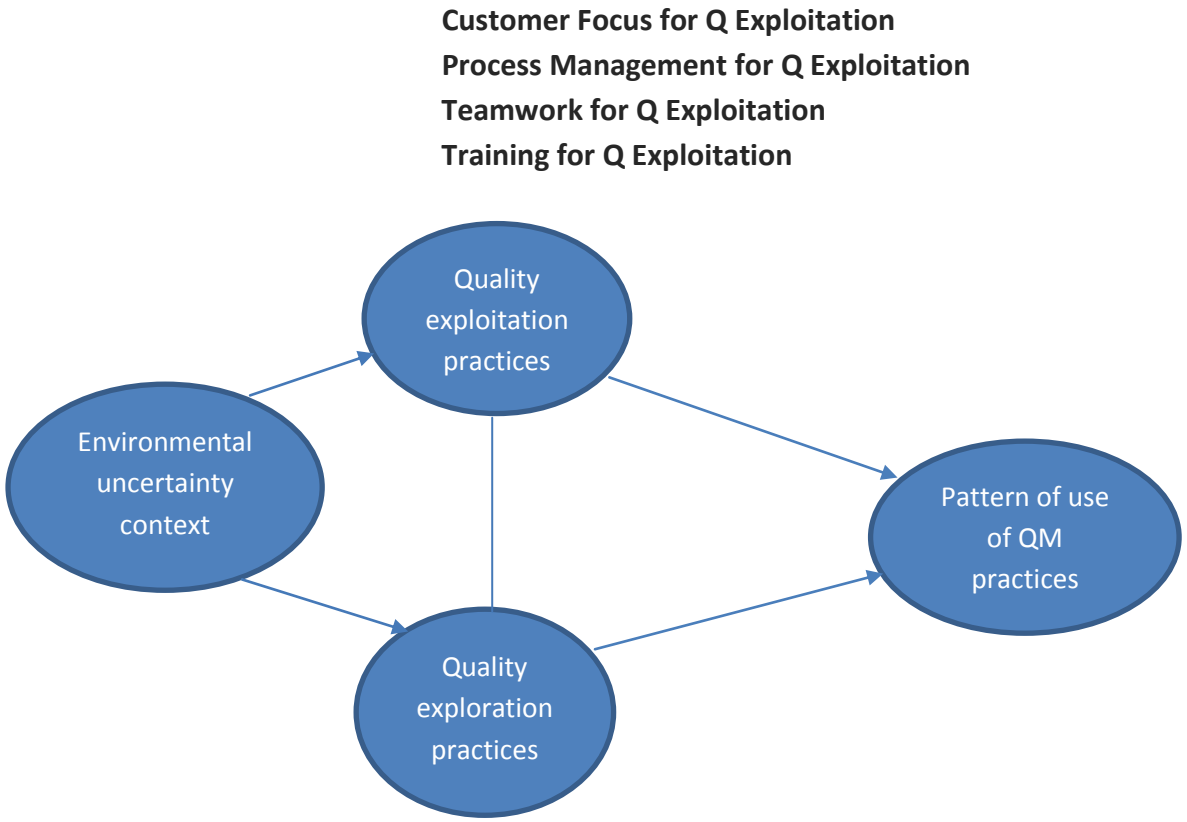


Fig 2.1 Conceptual Framework

2.3 Quality Management Practices

QM practices are the observable facets of Quality Management (QM) through which Managers work to realise performance. Sousa and Voss (2002) states that for empirical research principles are too general and techniques are too detailed to obtain reliable results e.g. the principles of continuous improvement can be implemented through process management practices which are supported by such techniques as statistical process control. Continuous improvement is a principle and too general for empirical research.

Early stages of research in QM have been exclusively devoted to the development of instruments that are capable of measuring quality practices (Saraph, et al., 1989; Flynn, et al., 1994). Subsequent to these, many researchers identified the practices that constitute QM (Powell, 1995; Samson and Terziovski, 1999; Kaynak, 2003). The study by Saraph, et al. (1989) identified eight QM practices which can be used to measure QM implementation. These practices were identified as the critical components of QM. The practices include top management leadership, role of the quality department, training, product design, supplier quality management, process management, quality data reporting and employee relations. The instrument by Saraph, et al. (1989) provides a model of QM practices with reliable and valid measures for the eight practices.

This instrument measures the extent to which a particular QM practice is utilized and is distinctly different from the performance measurements. Flynn, et al. (1994) developed a similar instrument for measuring the extent to which the QM practices are used. The instrument by Flynn, et al. (1994) identified seven QM practices of top management support, quality information, process management, product design, workforce management, supplier involvement and customer involvement. This instrument is in line with the one development by Saraph, et al. (1989). These practices were clearly defined and their components described. In addition to determining the extent to which QM practices were implemented the instrument also examined the relationship among the practices

A number of other related studies have established other QM practices or dimensions. Powell (1995) identified twelve factors. Kaynak (2003) adopted eight QM practices from an extensive review of literature. These practices included management leadership, training, employee relations, customer focus, quality data and reporting, supplier quality management, product design and process management.

Although different numbers of dimensions have been identified most of these practices are common and well linked to the original work of the QM gurus. There is now a common thread among these practices and those in the Baldridge Award criteria and the European Quality Award.

Sousa and Voss (2002) call this convergent validity of QM as substantial agreement among the movement's founders about the principles and practices now exists, furthermore

attributing discriminate validity to QM, arguing that the QM philosophy and practice can be reliably distinguished from other strategies for organisational improvement. The descriptive words, although have not been standardized, they can be interchangeably used for factor, dimension and practice. Saraph, et al. (1989) and Powell (1995) have used the word factor whereas the practices have been called constructs in Anderson, et al. (1995) studies. Recently most studies use the word factor e.g. Zhang et al., 2014. Apraiz et al., (2020) and Gomes et al., (2020) use the word practices for QEI and QER. This study uses the word practices for all purposes with regards to the factors or constructs of QM. The validity of the QM instruments allow for the use of instruments with minimal modifications. We summarize in table 1 below, the eight commonly used QM practices as noted in literature from which the practices used in this study were derived. Generally, earlier studies in QM viewed QM practices as a bundle of practices not easy to customize (Sitkin et al., 1994; Zhang et al., 2014).

TABLE 2.1: QUALITY MANAGEMENT PRACTICES IDENTIFIED IN LITERATURE

Quality Management Practice	**Description**
Management Leadership	Acceptance of quality responsibility by top management on quality. Evaluation of top management on quality. Participation by top management in quality improvement efforts. Specifying of quality goals. Importance attached to quality in relation to costs and schedule. Comprehensive quality planning (Saraph, et al., 1989:818)
Training	Provision of statistical training, trade training and quality related training for all employees (Saraph, et al., 1989:818)
Employee Relations	Implementation of employee involvement and quality circles. Open employee participation in quality decisions. Responsibility of employee for quality. Employee recognition for superior quality performance. Effectiveness of supervision in handling quality issues. Ongoing quality awareness of all employees (Saraph, et al., 1989:818)
Customer Focus	Customers' involvement in product or service design. Use of customer satisfaction surveys. Focus on achieving greater customer satisfaction (Powell, 1995, Ahire, et al., 1996, Kaynak, 2003)
Quality Data and Reporting	Use of quality cost data. Feedback of quality data to employees and managers for problem solving. Timely quality measurement. Evaluation of managers and employees based on quality performance. Availability of quality data (Saraph, et al., 1989:818)
Supplier Quality	Fewer dependable suppliers. Reliance on supplier process control. Strong

Management	interdependence of supplier and customer. Purchasing policy emphasizing quality rather than price. Supplier quality control. Supplier assistance in product development (Saraph, et al., 1989:818)
Product/Service Decision	Thorough scrub-down process. Involvement of all affected departments in design reviews. Emphasis on producibility clarity of specifications. Emphasis on quality and not roll out schedule. Avoid frequent redesigns (Saraph, et al., 1989:818)
Process Management	Clarity of process ownership, boundaries, and steps. Less reliance on inspection. Use of statistical process control. Selective automation. Fool proof process design. Preventative maintenance. Employee self-inspection. Automated testing (Saraph, et al., 1989:818)

Studies investigating the impact of quality management practices on organisational performance have treated QM practices as a set of practices which do not allow for customization. This has limited understanding of the performance implication of QM practices. Sitkin, et al. (1994) and March (1991) have theorized QM practices as having both a control and learning orientation and that different QM practices are more suitable to different organizational contexts.

This study focuses on four commonly used QM practices (Customer focus, process management, teamwork, and training) due to limitation on time to investigate deeply on all QM practices with the chosen interview based methodology. Secondly, some practices are most unlikely to respond to differentiation into QEI and QER practices e.g. top management support (Wu et al., 2011). Thirdly, the four sets of practices provide a good balance between internally oriented QM practices (Process Management, Training and Teamwork Practices) and externally oriented practices of Customer Focus (Wu, 2020, Elshaer and Augustyn, 2016) at the same time providing a good balance between soft and hard QM practices.

2.4 Quality Exploitation (QEI) and Quality Exploration (QER) Practices

To survive in today's competitive and rapidly changing environment, organisations require both reliable performance and adaptability (March, 1991, Aquino et al, 2017) and an organisation's effectiveness depends on its capacity to balance managing stability and reliability and those of exploration and innovation. Effectiveness then, depends on management's ability to balance between control and learning. Based on the OLT and

March's (1991) notion of exploitation and exploration, Sitkin et al., (1994) theorised that QM practices consists of two distinct but related set of practices that address the organisation's learning goals of control and learning. March (1991) calls these exploitation and exploration for the exploitation of old certainties and exploration of new possibilities. Exploitation learning goals emphasize the need for efficiency, customer responsiveness and reliable processes whereas exploration learning goals anticipate changing requirements and innovation. Exploitation is consistent with terms such as refinement, choice, production, efficiency and execution whilst exploration is associated with activities characterised by search, discovery, experimentation, variation and risk taking and anticipate changing requirements and innovation (March, 1991; Luo et al., 2016; He and Wong, 2004). Zhang et al., (2014) states that QM practices could be viewed from the QEI and QER point of view where QEI practices focus on process control and variance reduction. These practices focus on how to better utilize the knowledge that the organisation already has and include current market information, supply chain networks, technologies (Shi, Su and Cui, 2020). QEI practices enable companies to update existing products and exploit current markets, refining existing business processes (Badeira-de- mello et al, 2017, Song et al., 2018) and can lead to incremental innovation (Hughes, 2018). These practices meet the requirements for cybernetic control system, a process in which feedback loop is represented by using standards of performance, measuring system performance and comparing that performance with standards, feeding back instruction about unwanted variances in the system and modifying the system (Green and Welsh, 1995:259).

QER practices focus on search for new methods, new solutions, and new approaches and these practices can lead to development of radical innovation (Hughes, 2018). Both practices are guided by the same fundamental precepts of QM which can be conceptually classified into focusing on customer satisfaction, stressing continual improvement and treating an organisation as a total system (Sitkin et al., 1994; Zhang et al., 2014). QM practices are therefore based on identifying the needs of the customer, continuously improving its processes and products and operating as a total system. On one hand, organisations need to control and improve efficiency of existing processes while on the other hand to develop new processes and explore the unknown. Both practices are required in any organisation but they compete for resources and hence the balance between these

two is a critical component of a manager's job. Sitkin, et al., (1994) therefore proposed the contingent approach to QM, balancing the two QM orientations as a function of the organisation's environmental uncertainty context. Recent studies characterise QM practices as QEI and QER (Asif et al., 2020; Fundin et al., 2018; Apraiz et al., 2020; Gomes et al., 2020; Zhang et al., 2014, Wu and Zhang, 2013). Viewing QM practices as conceptually separate sets of practices assists with understanding of QM theory. The ability to balance practices appropriately will depend on a deep understanding of the degree to which practices associate with control or learning.

Luo et al., (2016) outline specific descriptive words for QEI and QER. These descriptive words are helpful in Qualitative research and guide the themes in exploitation and exploration activities and practices.

Table 2.2 Specific descriptive words for Exploitation and explorations (adopted from Luo et al., 2016)

Practice	Word	synonym
Exploration	Search	Explore, probe, pursue
	Variation	Change, transform
	Risk taking	Adventure, take charge
	Experimentation	Trial, Initiate
	Flexibility	Adapt, accommodate
	Discovery	Expand, extend
	Innovation	Invention, R&D, new technology/product/customer/market service
	Future	Long term, opportunity, turning point
Exploitation	Refinement	Optimize, polish up, improve, solidify
	Production	Manufacturing, making
	Efficiency	Cost, cost control, reduce expenditure, quality, productivity
	Implementation (execution)	Carry out, strengthen, technology reformation, complete
	Choice	Fully utilize, make use of
	Present	Short term, contemporary, current, existing technology/ product/customer/market/service

The classification of QM practices into QEI and QER finds support from theories of organisational learning. Studies of adaptive processes are concerned with the relationship between exploitation and exploration. In organisational learning theories, choice between exploitation and exploration is shown in distinction made between refining of existing

technology and intervention of new ones. Organisations are faced with tasks to control existing processes and improve their efficiency and to search for new insights for innovation (Zhang et al., 2014). Therefore QEI practices aim to control and improve existing processes and QER practices aim to explore the unknown and identify novel solutions (Appraiz et al., 2020). QER practices depart from existing knowledge and meet the needs of emerging customers or markets through the offering of new designs, creating new markets and developing new distribution channels (Luo et al., 2016; Appraiz et al., 2020). The search, variation and experimentation (March, 1991) associated with QER practices requires organisations to make risky investments during the early stages of the investments which may result in losses in the short term. Benefits of the practices could only be in the long term. QEI practices build on existing knowledge and reinforce existing skills and processes to meet the needs of existing customers and bring in stable income to organisation in the short term (Song et al., 2018). These practices focus on standardisation, stabilisation and focus on reliability (Apraiz et al., 2020).

Each of these set of practices are more or less suitable to different environmental uncertainty contexts and organisations can select the practices in different mixes to fit their contexts. Current research stresses the need for understanding which form of QM practices is effective under which condition (Zhang et al., 2014). The appropriate mix of these practices will depend on the environmental uncertainty context of the organisation (Zhang et al., 2012). This study focuses on four QM practices of Customer Focus, Process Management, Teamwork and Training practices. Each of these set of four practices are then classified into their two learning goals giving rise to Customer Focus for Quality Exploitation (CFQEI) and Customer Focus for Quality Exploration (CFQER) for the Customer focus practices, Process Management Practices for Quality Exploitation (PMQEI) and Process Management for Quality Exploration (PMQER) for the Process Management practices, Teamwork for Quality Exploitation (TWQEI) and Teamwork for Quality Exploration for the Teamwork Quality practices, and Training for Quality Exploitation (TRQEI) and Training for Quality Exploration(TRQER) for Training Quality practices.

TABLE 2.3: Description of the Quality Exploitation and Quality Exploration practices

QM factor	Quality exploitation	Quality Exploration
Customer Focus	Customer focus for quality exploitation (CFQEI)	Customer focus for quality exploration (CFQER)
Process Management	Process management for quality exploitation (PMQEI)	Process management for quality exploration (PMQER)
Teamwork	Teamwork for quality exploitation (TMQEI)	Teamwork for quality exploration (TMQER)
Training	Training for Quality Exploitation (TRQEI)	Training for Quality Exploration (TRQER)

TABLE 2.4: DESCRIPTION OF THE CONSTRUCTS OF QUALITY EXPLOITATION AND QUALITY EXPLORATION (Quoted from Zhang, et al., 2012)

Quality Management Practice	**Quality Exploitation**	**Quality Exploration**
Customer Focus	-Identify existing customer. -Assess customers' needs. -Better understand customer. -Respond to customer needs and expectations	-Explore new needs for customers. -Involve customers in the early stage of product development
Process Management	-Increase process control. -Increase process reliability	-Explore improvements of new products and processes. -Dynamic change of the organisation.
Teamwork	-Focus on within functional problem solving	-Focus on cross functional cooperation
Training	-Conduct training on existing skills	-Conduct training on multiple skills and new skills.

2.4.1 Customer Focus Practices

Customer Focus principle might be the most important principle of QM with the customer being the ultimate judge of the quality of goods and services and without the customer there is no business to talk about (Evans and Lindsay, 2016). An organisation that is closer to its customer knows what the customer needs, how the customer uses its products and anticipates needs that the customer may not even be able to express (Evans and Lindsay, 2016; Gomez, et al.,2020). To create satisfied customers, organisations need to identify the

needs of the customer and design the production and several systems to meet those needs and measure the results as the basis for improvement.

In line with the learning goals of organisations, QM related to Customer Focus practices have different goals and objectives. Some customer focus practices focus on satisfying customer requirements whilst some practices focus on identifying new customer requirements. Although both practices are called Customer Focus practices they serve different purposes and their effectiveness may differ depending on the context in which the organisation finds itself in. QEI practices focus on customer's current needs and wants. QER practices focus on identification of new customer needs.

2.4.2 Process Management Practices

A process is a sequence of linked activities that is intended to achieve the same results such as producing a good or service for customer within or outside the organisation (Evans and Lindsay, 2016). Organisations can be viewed as a set of interlinked processes or a system and QM focuses on controlling and improving these processes (Kaynak, 3003; Zhang et al., 2014). Process Management practices involve activities necessary to achieve consistent performance on key processes as well as help organisations to identify opportunities for improvement. Therefore, Process Management practices have different objectives which could be differentiated by exploitation and exploration where QEI practices focus on increasing control and consistency of existing processes, QER practices focus on increasing changing and improving processes (Sitkin et al., 1994; Zhang et al., 2014). Saunders et al., (2008) define Process Management as the design, control and improvement of a system of organised work activities that result in a product or service. Saunders et al., (2008) further defines process design as developing a new system of organised work activities with the aim of meeting customer requirements and or enhancing them, process control as the monitoring of conditions of a system of organised work activities to maintain stability and consistent performance. The third component of Process Management is Process improvement which Saunders et al.,(2008) have defined as the changes of an existing system of organised work activities with the aim of meeting customer requirements and or enhancing performance. The three components of Process Management, design, control and improvement can also be viewed from an exploitative and explorative view point.

2.4.3 Teamwork QM practices

Teamwork approaches are essential for achieving Quality and performance excellence (Evans and Lindsay, 2016). Teams provide opportunities to individuals to solve problems that they may not be able to solve on their own and help organisations to capitalize on diverse ideas, cultures and thinking of employees and therefore provide organisations the ingredient for organisational learning and performance improvement. Teams can be functional or cross-functional. Functional teams can best resolve problems related to their immediate processes whilst cross-functional teams work more broadly to break barriers among individuals, departments and line and staff-functions. Cross-functional teams can work better in creating more diverse ideas and creative thoughts (Evans and Lindsay, 2016). From an exploitation-explorative perspective, exploitative team work practices encourage employees within a function to work closely as a team to address local problems and enhance consistency of outcomes. Explorative Teamwork practices focus and emphasise cross-functional interactions and cooperation and these teams have more expertise about trade-offs between functions and cross system and can better create new processes and problems.

2.4.4 Training QM practices

Research has shown that organisations that spent more on training their workers outperform companies that spend considerably less (Evans and Lindsay, 2016). A strong workforce development system is therefore vital for high performance and training and education have been found to play a critical role in QM (Kaynak, 2003, Zhang et al., 2014). Training assist employees to better understand their job requirements and enhance their skills on the job and improve their work efficiency. Some training efforts focus on reinforcement of knowledge used in the employee's current job position in order to improve employee effectiveness and efficiency. On the other hand some training practices focus on multi-skilling the employee and both training efforts help to improve employee performance. From a QEI and QER perspective, QEI practices focus on enhancing skills for the current job position. This makes the employee more proficient in the work. QER practices emphasise multi-skilling and employees tend to learn from each other. These

types of practices help employees to think creatively and search for novel solutions (Zhang et al., 2014).

2.5 Impact of QM practices on organisational performance (Practices as a bundle of practices)

Organizations have implemented QM to achieve competitive advantage (Jimoh et al., 2019; Shafiq et al., 2019; Priede, 2012). Various studies have reported on the effect of various QM practices on organisational performance (Shafiq et al., 2019; Anil and Satish et al., 2019, Jimoh et al., 2019; Powell ,1995; Samson and Terziovski ,1999; Kaynak, 2003; Kaynak and Hartley, 2008; Wu and Zhangi, 2013; Wang, et al., 2012; Corredor and Goni, 2011; Nair, 2006; Choi and Eboch, 1998; Hendricks and Singhal , 1996, 1997,2001; Uyah, 2008; Agus, et al., 2009; Talib, et al., 2013; Nguyeni and Panutwanich, 2018; Mohrman, et al., 1995 and Jaafresh and Al-abedallat, 2013; Tari, et al., 2007; Javier, et al., 2014; Fening, et al., 2008; and Wahjudi, et al., 2011; Yamanda, et al., 2013; Al-Demen,2017). Other studies have reported on how to achieve and sustain high quality performance (Su, Linderman, Schroeder and Van de Ven, 2014; Su and Linderman, 2016).

These studies have shown mixed results with some e.g. (Gomez et al.,2019; Anil and Satish 2019; Biswarkin, 2017, Yeng et al., 2018; Al-Demen, 2017; Samawi et al., 2018; Shafiq et al., 2018; Samson and Terziovski, 1999; Nair, 2006; Choi and Eboch, 1998; Cua, et al., 2001; Kaynak, 2003, Yeng et al., 2018; Lakmal et al., 2018; Al-Demen, 2017) reporting positive effects of QM practices on organisational performance. Although reporting positive impact of QM practices on organisational performance, Shafiq et al., (2018) concluded that only hard QM practices like process and partnership and resources had highest positive relationship with both financial and non-financial results. In studies where QM was taken as a multi- dimensional practice, results indicated that some of the practices had positive effect on some performance measures and yet some practices had no effect on performance (Dow, et al., 1999; Elshaer and Augustyn, 2016; Sabella et al., 2014) e.g. Dow et al (1999) showed that employee commitment, shared vision and customer focus are positively related to performance, whilst the hard practices of benchmarking, cellular teams, supplier relations and advanced manufacturing technologies did not contribute to improved performance. Other studies have shown that the effects of some practices on organisational

performance are more pronounced whereas they are minimal for other practices (Talib et al., 2013). Samson and Terziovski (1999) reported that the relationship between QM practices and organisational performance was significant. However, not all practices were significant predictors of performance. In their study the influence of QM on organisational performance, Nguyen and Ninh (2017) concluded that strategic planning, Human Resources and Customer satisfaction had a positive contribution to organisational performance. The other two dimensions of Leadership and process management were noted to have no impact on organisational performance in that specific context. In a similar study on contribution of QM practices to sustainability performance, Matsui, Phan and Nguyen (2018) noted that the QM practices have mixed impacts on economic performance and environmental performance while showing positive impact on sustainability performance. Furthermore, the study revealed some moderating effects of some contextual factors on the relationship between QM and sustainability performance. Zhang and Kia (2013) reported that firms' award winning organisations performed better than their control groups in a number of operating performance measures. Furthermore, it was observed that these award winning organisations had superior performance records before the awards.

Despite these positive results some studies failed to find significant link between QM and organisational performance. Dooyoung (1998) reported a total quality management failure rate of 60-67%. Harari (1993) reported that at least two in every three TQM initiatives in America fail citing the reasons for the failure. Other studies could not find relationship between some QM practices and performance (Powell, 1995; Alshaer and Augustyn, 2016). In his landmark study Powell (1995) concludes that it is not the features associated with TQM e.g. quality training, process management that produce competitive advantage, but the soft aspects of behaviour, culture and employee empowerment. Some studies have shown that not all QM practices lead to superior quality performance (Dow, et al., 1999; Alshaer and Augustyn, 2016). Astrini (2018) reported mixed findings on a review of research papers linking ISO 9001 and performance. On the other hand some have reported a pattern of failure (Zu, 2009). Ratseou and Ramphal (2014) reported no difference in the operational performance of laboratories with or without standards. Similarly, once high performing organisations have failed to maintain quality performance (Su and Lindeman, 2016; Su et al.,

2014) due to contextualisation related reasons. Psomas and Jaca (2016) concluded that the extent to which QM is linked to improvement performance in literature is subject to debate.

Although results of QM practices on organisational performance have been mixed, the general consensus is that QM practices lead to organisational performance but their effect is context dependent and that QM research should take a contingent approach (Sousa and Voss, 2008, Zhang et al., 2014, Wu, 2020). Sila (2007) suggests that a possible reason for some of the unsuccessful quality initiatives is the possibility that QM is context dependent. Fundin et al (2018) outlines the current challenges in QM and calls for more contingency research in QM, highlighting contextualisation of QM practices as one key challenge facing QM that forms an agenda for future research. Several researchers have called for more contingency research (McAdam et al., 2018; Foster, 2006; Sousa and Voss, 2008, Fundin et al., 2018). Wu (2020) states that focusing on QM practices may work better for some organisations than others and organisations may need to customize their QM practices to their internal and external factors.

The results of many QM performance studies support the contingency theory perspective of quality management although QM practices have been treated as a single set of practices (Zhang et al., 2012). Sitkin, et al. (1994), notes that scholars overlooked the need for potential customization of QM practices and have theorized QM practices as having both a control and learning orientation which are invariably suitable for different organisational settings. They envisage that this set of practices can be unbundled into their different orientations of total quality control and total quality learning called exploitation and exploration practices respectively.

2.6 The Contingency Theory, Contingency Research and Quality Management Practices

In its rudimentary form, Contingency theory holds that organisations adapt their structures in order to maintain fit with changing contextual factors, so as to attain high performance (Sousa and Voss, 2008). A review of literature on QM practices research shows that studies investigating the impact of QM practices on organisational performance have produced mixed findings. However, the general consensus is that QM practices have a positive impact on organisational performance but the mixed findings are due to the fact that the performance effects of QM practices are context dependent (Zhang et al., 2012; Sousa and

Voss, 2008; Fundin et al., 2018). In their study on challenges and propositions for future research in QM, Fundin et al., (2018) identified contextualizing QM practices and ambidexterity as key challenges requiring future research. Their suggestion is that mixed findings and challenges in QM practices are due to them being context dependent. Sousa and Voss (2008) and Zhang et al.,(2014) argue that the difficulties in QM practices implementation are due to a great mismatch between the proposed form of best QM practices mix and the particular organisational context and there has been more support for contingency research (McAdam et al.,2016; Fundin et al.,2018; Sousa and Voss, 2008).

Empirical research has identified a number of contextual factors that may affect QM practices effectiveness e.g. organisational uncertainty and organizational structure (Zhang, et al., 2012), organisational culture (Wu and Zhang, 2011); environmental complexity (Bocanet and Ponsiglione, 2012), environmental dynamism and competitiveness (Yang and Li, 2011), organisational strategy (McAdam et al., 2016; Apraiz, 2020), Internal variety and environmental dynamism (Kim and Rhee, 2009), competitive strategy (Apraiz, 2020); competitive intensity (Shi, Su and Cui, 2019); environmental dynamism (Asif et al., 2020). These studies support the contingency theory of QM practices. However, among these studies some did not view QM practices through the lens of exploitation and exploration e.g. Ahire and Golhar (1996) and Sila (2007). Although the contingency nature of QM practices is shown in most of the studies, studies lack details on how to guide the selection of best QM practices mix for a given organisational context (Zhang et al., 2014).

Sitkin, et al. (1994) provided a conceptual framework culminating into viewing quality management as made up of two different orientations of total quality control and total quality learning. March (1991) calls these exploitation and exploration practices for the exploitation of old certainties and exploration of new possibilities. Both practices are required in an organisation but they compete for resources and hence the balance between these two is a critical component of a manager's job. Sitkin, et al. (1994) therefore proposed the contingent approach to quality management, balancing the two quality management orientations of exploitation and exploration as a function of the organisation's environmental uncertainty context.

In their study on customizing quality management practices (Zhang et al., 2014) developed a reliable and valid set of measures for QEI and QER practices. The study concludes that an appropriate mix of QEI and practices depends on the learning needs of the organisation. The effective use of these practices depends on organizational context. The study empirically provided support for the theory of two different yet related aspects of QM, QEI and QER, providing a plausible challenge to the universal view. The study also provides insight into the different challenges organisations may face in managing quality under different environmental uncertainty contexts and hence the need to customize.

2.7 Environmental uncertainty context

Environmental uncertainty has been a central construct in research initiatives related to the studies of an organisation and its relationship with its surroundings (Zhang et al., 2012). It is defined as the lack of information regarding environmental factors associated with a given decision making process. It is the inability to know the outcome of a specific action, and the inability to assign probabilities with a degree of confidence as to how environmental factors will affect success or failure, Duncan (1972). Ettlie and Reza (1992) view environmental uncertainty as unexpected changes in customer, suppliers, competitors and technology.

According to Daft (2004), environmental uncertainty means decision makers have limited information about environmental factors making it difficult for them to predict external changes. Environmental uncertainty has two dimensions namely the simple-complex and the stable-unstable dimension (Zhang et al., 2012). The simple-complex dimension refers to heterogeneity or the number of dissimilarity of external elements relevant to an organisation's operations (Zhang et al., 2012). The stable-unstable dimension refers to how abruptly environmental elements shift. Operations Management research has generally focused on the stable-unstable dimension of environmental uncertainty e.g. Bozarth et al., (2009). Benson, et al. (1991) identified environmental uncertainty as degree of competition, change of customer needs and rate of product/process change as the three major components of environmental uncertainty. In generally, literature has identified three major sources of environmental uncertainty as: demand change i.e. change in demand for products and services by the customers of the organisation, change in products or processes

and competitive intensity. Zhang et al (2012) used the last three in establishing environmental uncertainty.

The factors of demand change (change in demand for product/services), and change in product/process and customer requirements relate to environmental dynamism. Environmental dynamism is a concept that can be used to describe the rate of change and unpredictability in the environment (Saunders, Schroeder and Lindeman, 2008). Various studies have acknowledged environmental dynamism as a central dimension in characterizing the environment (Hanbrick and Cannella, 2004). Environmental dynamism refers to the change in the organisation's environment and captures the same extent the underlying theme of unpredictable change. Some studies have actually referred it as uncertainty (Wagner and Tishler, 2012). Another dimension of environmental uncertainty is competitive intensity (Benson et al., 1991, Zhang et al., 2012, Apraiz et al., 2020). Competitive intensity is influenced and is greater when there are many competitors and the competitors are roughly of the same size and growth in the industry is slow, characterised by high exit barriers, committed rivals (Porter, 2008). These factors are known to affect QM practices. The best QEI-QER practices mix will depend on these factors. The question is, how do these factors affect the best QEI and QER practices mix for a given environmental uncertainty context and what is the model for guiding the selection of these practices mix?

This study is centred on competitive intensity, change in demand of product and services and change in customer requirements, product and processes as the sources of environmental uncertainty.

2.8 Quality exploitation, quality exploration and organisational performance

The influence of quality exploitation practices on organisational performance has produced mixed results (Lavie et al., 2010; Abebe and Angriawan, 2014). Studies by Lin et al., (2007) found that a focus on either exploration or exploitation leads to better performance but studies by Hjelmgren and Dubois (2013) found that focusing on either exploration or exploitation leads to lower organisational performance. In their meta-analytical study of exploitation and exploration, Shi et al., (2019) found that exploration and exploitation practices positively influence organisational performance and the two sets of practices are positively related to each other. Overall, the study showed that QEI and QER practices

positively influence each other suggesting that firms could benefit from simultaneous implementation of both QEI and QER practices. Other studies have produced conflicting findings suggesting that QEI and QER practices may impede each other (Ozsomer and Gencturk, 2003) and of difficult nature to coordinate.

In a separate study, Asif et al., (2020) found that QEI and QER practices are pivotal in achieving the exploitation and exploration goals of the organisation. Furthermore, their study found that whilst other studies suggest that QEI and QER practices may impede each other (Ozsomer and Gencturk, 2003), QEI practices do not hinder but rather create, the basis for QER, which take place not sub-sequentially but also in parallel. QM practices can support punctuated equilibrium which alternates QEI and QER but in dynamic environment, simultaneous implementation of the two sets of practices becomes the best way (Asif et al., 2020).

Wu at al., (2011) study on customizing quality practices findings indicated that QEI practices are highly correlated to organisational performance when quality culture has not become a prevailing organisational culture. In contrast, QER practices are significantly associated with organisational performance when the quality culture has become a critical component of the organisational culture. The study findings further suggests selective adaptation of certain QM practices based on the prevalent culture in the organisation. These studies indicate that there still exist mixed findings in the implementation of quality exploitation practices. Furthermore, these studies have not addressed the aspect of how to select best quality management practices to match an organisation's context.

2.9 Quality Exploitation, quality exploration and environmental uncertainty context

Research has shown that environmental uncertainty influences the relationship between QM practices and performance (Zhang et al., 2012, Nair, 2006; Zhang et al., 2014). Shi and Cu (2019) studies show that some components of environmental uncertainty e.g. competitive intensity affect QM practices. External environmental factors change rapidly, are uncertain and complex and create problems for organisations (Wang et al., 2012). Organisations ignoring environmental factors or fail to respond to such factors place themselves at a competitive disadvantage and serious business problems (Gomez et al., 2020). Different organisations face different environmental factors and respond differently

in managing their competitiveness. Research has generally shown that when market, technological turbulence and competitive intensity are low, organisations focus on customer satisfaction (Wang et al., 2012). However, when market turbulence, competitive intensity and technological turbulence increase firms shift their attention from existing customer needs to satisfy latent needs in order to maintain a competitive advantage. From the view point of QEI and QER practices, firms focus on QEI practices when competitive intensity, technological turbulence and market turbulence are low. On the other hand when these variables are high, firms shift to QER (Wang et al., 2012).

In a study to establish the moderating role of organisational context on QM practices, Zhang et al., (2012) found that in an environment with low uncertainty, quality exploitation that emphasise refining existing competencies lead to higher performance i.e. when environmental uncertainty is low, customer needs, products and processes and competition do not change significantly and organisations focus on existing customer needs. Operations operating in low environmental uncertainty context benefit more from QEI practices. However, an organisation facing high environmental uncertainty benefit more from QER practices but the relationship is much more complex, with organisational structure playing a moderating role.

In a meta-analytical study on exploitation and exploration practices, Shi et al., (2019) found that market turbulence, a key component of environmental uncertainty is not significantly related to exploration practices whilst competitive intensity is positively related to exploration practices but negatively related to quality exploitation practices. These results indicate that exploration quality management practices mediate the influence of competitive intensity on organisational performance and furthermore that quality exploitation and quality exploration practices positively influence each other. In Shi et al., (2019) study, market turbulence refers to the situation where market demand is hard to predict accurately because of factors such as customers changing needs and competitive intensity is defined as a situation where competition is fierce due to the number of competitors in the market and lack of potential growth. These findings on competitive intensity (Shi et al., 2019) agree with the findings of Zhang et al., (2014) where quality exploration practices contribute more to quality performance than quality exploitation when competitive intensity high.

Wagner and Tishler (2012) found that focusing on QEI practices seems productive in the short term only, and may prove disruptive to the firm's future ability to adapt to changing and unpredictable environments. Conversely, exploitative practices may be more profitable in a stable environment in the short term than QER practices (Burgelman, 2002). Wagner et al., (2012) further argues that excessive efforts in either QER or QEI in high or low dynamic environments may reduce firm performance i.e. higher exploration is not the most preferred option in environments of higher environmental dynamism and at the same time exploitation does not exist as the optimal approach in a stable environment. When uncertainty is high (high environmental dynamism), organisations are required to engage in adequate exploitation to ensure short term performance, and they require adequate exploration practices in a stable environment to ensure future organisational performance but the optimal level of exploration practices are predicted to be higher when environmental dynamism is high. On the other hand the optimal level of exploitation practices is lower in highly dynamic environment than stable environment (Wagner and Tishler, 2012). Overall, Wagner and Tishler (2012) findings suggest an optimal balance between exploitation and exploration practices contingent on environmental conditions and that firms must invest in more exploitation than exploration practices under both high and low levels of environmental dynamism and competiveness to maximise performance for both the short term and long term market values.

Asif et al.,(2020) in their study on exploitation and exploration in strategic leadership, concludes that QM practices can support punctuated equilibrium which alternates between exploitation and exploration but in a highly dynamic environment ambidexterity is the only feasible option which can be enabled by implementing simultaneously quality exploitation and quality exploration practices.

In general, these contingency studies indicate that QM practices are contingent on an organisation's environmental uncertainty context and suggest that QM practices be matched to their context. However, studies have not focused on how to select the best mix of quality exploitation and quality exploration practices. Environmental uncertainty context affects quality exploitation and quality exploration practices differently, and separating them provides a useful way of understanding that influence and how to select the best mix.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.0 INTRODUCTION

This chapter deals with the research paradigm, research design and methodology followed in addressing the research questions: What is the pattern of use of quality exploitation and quality exploration practices across the environmental uncertainty context spectrum and secondly how does environmental uncertainty context influence the best quality exploitation and quality exploration practices mix? Finally, what is the model for selecting best quality exploitation and quality exploration practices mix across the laboratory organizations in the mining industry? First, the Research paradigm that was followed is discussed, followed by selected methodology and research design.

3.1 Research Paradigm

The study seeks to develop a model for guiding the selection of best QEI and QER practices mix by first establishing the pattern of use of QEI and QER practices across an environmental uncertainty context spectrum and then establishing how environmental uncertainty context influences the pattern of use of these practices. Like any other research, it is based on some philosophical assumptions about the development of knowledge. These philosophical assumptions influence the development of appropriate research design and methodology. Each research method has philosophical underpinning as to how the world is viewed, the relationship between reality and the method of research. The study follows the interpretative research paradigm.

3.1.1 Interpretive/ Constructivist Paradigm

The central aim of the Interpretative paradigm is to understand the subjective world of human experience (Guba and Lincoln, 1989). This approach makes effort to see things from the eyes of the subjects being studied and to understand and interpret what the subject is thinking or the meaning the subject is making of the context. Based on this philosophy, this study follows an interpretative paradigm and a subjectivist epistemology, relativist ontology and naturalist methodology and a balanced axiology. The subjectivist epistemology implies

that the researcher will make meaning of the generated data through participants' own thinking. Data is generated through the researcher's interaction with the participants.

3.2 Research Methodology

The study follows a qualitative research methodology for the following reasons:

- The topic under study is a complex one requiring explanations to patterns relating to the extent of implementation of Quality Management Practices across different contexts and our need to have detailed understanding of the issue, which can only be established by talking directly with the people, in their space and allowing them to tell their stories.
- The participants are empowered to share their stories and minimizing the power relationships that often exist between the researcher and the participants, to understand the behaviours, beliefs, opinions and emotions from the perspective of the study participants themselves.
- Uncover the meanings that people give to their experience in the implementation of the QM practices-what causes them to implement this practice more than the other, what challenges do they face when they implement this practice.
- Provide depth, detail, and context to the research issue.

The approach was found best in order to address the 'why' questions in the research to explain and understand issues or how questions that describe the process.

3.3 Research Design

- The research adopted a multiple case study design. The nature of research questions and the conceptual framework, the research paradigm in which the research is positioned and chosen methodology greatly influenced the choice of the research design. The study investigated the use of QEI and QER practices across a spectrum of organisational uncertainty context. This provides the researcher with the constructs to be studied enabling the construction of a conceptual framework, in which the extent of implementation of some QEI and QER practices is determined across a spectrum of environmental uncertainty context.

The first research question seeks to establish whether the pattern of use of QEI and QER practices is contingent upon the organisation's environmental uncertainty context. This question is central to the adoption of the research design chosen. First, a practice is adequate for a given organisational context if its implementation contributes to improved performance for that context. Secondly, a practice is contingent upon an organisational context if the effectiveness of its implementation varies across organisational context. This definition of a practice being contingent to the environmental uncertainty context is crucial in determining the research design. Sousa (2003) defines a practice as being contingent on an organisation's context if its effectiveness varies significantly across the organisational context. Under conditions of fit, a practice is implemented if it contributes positively to an organisation's performance (Sousa and Voss, 2008).

Cases were selected from a target population of mine site analytical laboratories and commercial analytical laboratories in the mining industry of Zimbabwe and one laboratory from South Africa. The selected mine site laboratories were chosen to coincide with low environmental uncertainty context and the commercial laboratories to coincide with high environmental uncertainty context. In case research a sample of cases is built by selecting cases according to a given criteria e.g. selection using a replication logic so that each case is selected such that it either predicts similar results (literal replication) or produces contrary results but for predictable reasons i.e. theoretical replication, (Sousa and Voss,2002). Cases were selected for both literal and theoretical replication.

The environmental uncertainty contexts of the organisations were established from the assessment of the degree of competition, change in demand levels, change in customer needs and rate of product/process change faced by the different laboratory environments (Zhang, et al., 2012) resulting in low environmental uncertainty context for the mine site laboratories and high environmental uncertainty context for the commercial laboratories in comparative terms. An interview questionnaire was used for this purpose and the selection of the laboratories in Zimbabwe was mainly influenced by accessibility.

The study investigated the degree of use of QEI and QER practices across the organisations to establish if their use was contingent upon the environmental uncertainty context. The adequacy of a practice was inferred by the degree of its use across contexts.

A laboratory was considered mine site if its services were restricted to only one organisation (the internal clients of the parent organisation). Laboratories were considered commercial if their services were rendered to a number of clients for a fee. It could also be that a mine site laboratory belongs to another organisation (the mine having outsourced this function, but serving one organisation). However, all laboratories in the final sample were typical mine site and commercial laboratories as previously defined. Table 3.1 below shows the initial characteristics that made the laboratories good candidates for the research sample.

Table 3.1 Characteristics of the laboratory groups forming the case organisation

Laboratory characteristics	Mine site laboratories	Commercial laboratories
Customer heterogeneity	Homogeneous. Laboratories serve only one organisation, the parent organisation	Heterogeneous. The laboratories provide services to many organisations with different requirements although all within the mining sector
Competition	No competition noted. The laboratories only serve only one customer. At worst laboratory could be threatened to have its function outsourced to an external laboratory	Generally high. There are other commercial laboratories offering the same services, locally and abroad.
Product/ process matrix	Simple, relative to the product/process matrix for commercial laboratories.	Complex, relative to matrix for mine site laboratories
Product/process matrix changes	Low (generally low). Include only product/process samples from one mine e.g. base metals and platinum group metals. These samples would generally be consistent although ranging in grades e.g. feed, tails and concentrate samples.	High (generally high) relative to mine site laboratories. Include samples from a number of different customers. May include base metals and platinum group metals, other products with varying levels e.g. feed, tails and concentrate samples from different organisations.
Task uncertainty	Generally low task uncertainty	Relatively higher task uncertainty than the mine site laboratories

The researcher adopted the case study research design for two main reasons. First, the study is theory building in nature and requires explanations as to how environmental uncertainty context affects the use of QEI and QER practices. Qualitative data is useful in

explaining causal relationships. This data was pertinent in answering the second research question, "How does environmental uncertainty context influence the use and effectiveness of QEI and QER practices mix in these laboratories?"

The case study method allows the questions of why, what and how, to be answered with a relatively full understanding of the nature and complexity of the phenomenon (Meredith, 1998). The case study method is recommended when contextual issues are pertinent to the enquiry (Yin, 2014).

Secondly, the complexity of the research renders the use of distant methods e.g. survey methods ineffective. The researcher found it necessary to gather objective evidence regarding the use of QEI and QER practices.

The aspect of sample controls was considered important e.g. when selecting cases it is important to consider what factors affect the population and may need to be kept constant across cases (Voss, Tsikriktsis and Fohlich, 2002). In order to control for implementation effects, certain controls were established which all participant organisations had to meet.

3.3.1 Controls in the selection of case samples

As the study was aimed at investigating the contingent effect of environment uncertainty context on the pattern of use of QEI and QER practices, the effects of environmental uncertainty context were isolated from other potential contingent factors e.g. the number of years the organisation had implemented quality management practices. The number of years since adoption of QM may determine the proficiency by which a practice is implemented. Implementation of a QM practice can be influenced by both the maturity of the organisation with regards to quality implementation as well as organisational context. The control on maturity and other factors was to isolate the effect of organisational uncertainty context from those of other potentially confounding factors. To achieve this isolation process and to be able to infer adequacy of a particular practice to its context by observing the pattern of use of a practice across the different contexts, case organisations had to comply with the following controls.

3.3.1.1 The organisations had reached a stage of quality maturity. Characteristically, these organisations would have implemented a formal QM programme complying with the

requirements of ISO17025 or ISO9001. All case organisations were accredited to ISO 17025 international standard, a QM system that assesses the competence of a laboratory to carry out specific tests e.g. analysis of base metals in ore or concentrate samples by a particular method or were certified to ISO9001. All organisations had implemented formal QM for at least three years. After three years of implementing a QM system, an organisation is expected to have reached steady state conditions regarding implementation of the program. It is assumed after three years the benefits of implementing a program or lack of the benefits will have been established and hence continued use of a practice is likely to be a well-informed organisational decision associated with performance. A three year period is accepted as a cut-off point between mature and young organisations in QM (Ahire, 1996). Sousa and Voss (2008) assert that an important aspect in designing contingency studies is the choice of the point in time, relative to the initial adoption of a given set of best practices at which to empirically assess fit. The assessment for fit should concern the match between the best practice and context when steady state conditions have been reached. This is because it is generally accepted that there is a time lag between the implementation of practice and performance (Hendricks and Singhal, 1997). Generally, the adoption and implementation of best practice follows a cycle of introduction, experimentation and then maturity.

Effective QM systems would normally be demonstrative of a sound system to manage occurrence of nonconformities. This would normally include a procedure for the identification of nonconformities and the implementation of effective corrective actions, normally leading to continual improvement. Selected organisations had to demonstrate this aspect of effective QM as one indication of quality maturity.

3.3.1.2 All organisations were from the analytical services industry providing services to the mining industry. This was to control for industry and technology effects as similar analytical methods and instrumentation is used in general.

Laboratory organisations that complied with the above controls are most likely to have an implementation pattern of QEI and QER practices suitable to and adequate to their contexts, having made informed decisions after experimenting with the use of particular practices to arrive at a state of organisational fit between practice and context. The

assumption is that the organisations will use the practices because they have produced required results. Ineffective practices are assumed to have been dropped during the experimentation period. This assumption was utilized to exclude the measurement of performance resulting from the implementation of the practices. Hackman and Wagerman (1995) state that measuring and comparing performance with such a small sample is meaningless.

3.3.2 Environmental uncertainty context

Case organisations were selected to represent different levels of environmental uncertainty context. Three indicators were used to capture the aspects of environmental uncertainty. These factors included change in customer needs, unstable and unpredictable nature of the demand for products and competitive pressure respectively. This study focuses on the environmental aspects of dynamism and competitiveness (Jansen, Van den Bosch and Volberda, 2006). The average score of the three factors was used to indicate the environmental uncertainty context. A high score indicated a higher level of uncertainty context which could be high due to different contributions of the different factors. These factors are known to affect the environmental uncertainty context of an organisation.

Interview questions were used to establish the environmental uncertainty contexts of the organisations in the research samples.

3.3.3 Quality management practices (exploitation and exploration)

The research is designed to observe the use QEI and QER QM practices across organisations representing different organisational contexts. Four different QM practices were selected to describe the constructs of quality exploitation and quality exploration practices identified as QEI and QER respectively. This identification was further utilized in the coding of data generated during data collection. The four QM practices included customer focus, process management, teamwork and training. Each of the four QM practices has the exploitation and exploration component resulting in a total of eight QM practices identified as customer focus for quality exploitation and customer focus for quality exploration coded as CFQEI and CFQER respectively. Similarly process management practices were coded as process management for quality exploitation and process management for quality exploration

(PMQEI and PMQER), teamwork for quality exploitation and teamwork for quality exploration (TWQEI and TWQER) and training for quality exploitation and training for quality exploration (TRQEI and TRQER) respectively.

Table 3.2 describes these QM practices based on cited literature. The developed questions are designed to establish the degree to which each of these practices is implemented across the organisations and hence their pattern of use.

Table 3.2.1 Customer Focus for Quality Exploitation Practices

Table 3.2.1 Customer Focus for Quality Exploitation (CFQEI) practices
○ Identification of the organisation's customers and segmenting them-[existence of a mechanism within the organisation to segment customers either based on sample volume, revenue etc. in order to standardise or customise services to better meet different needs] ○ Assessing current needs and expectations of the customer by employing systematic processes for listening to the voice of the customer-[collecting information on the needs of the customer through various means e.g. direct customer contact, complaint analysis, collection of information on the importance placed by customers on various aspects of the business e.g. accuracy, precision, turnaround time of results, price of analytical services ○ Dissemination of customer information within the organisation and ability to respond to those needs-[Existence of processes or mechanisms within the organisation to disseminate information on customer needs and respond to the information on the needs e.g. daily toolbox talks, special meetings, procedures etc.] ○ Establishing customer relationships-[use of customer focused technologies which is designed to increase customer loyalty and stickiness, conducting face to face meetings with organisations executives, mutual technical assistance, honesty and integrity in all dealings with the customer] ○ Developing organisational members on key customer service practices, motivating them leading to better understanding of the needs of the customers and responding to those needs
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016),

Table 3.2.2 Customer Focus for Quality Exploration (CFQER) practices
○ Collection of information on new requirements, services or technologies needed by existing customers-[collecting information on new needs of the customer through various means e.g. surveys, direct customer contact, analysis of information on lost business] ○ Identification of new customers and their needs ○ Identification of the needs of potential customers and customers of competitors to obtain information on what the organisation can act on ○ Customer involvement in the development and validation of new methods or service offers
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016)

Table 3.2.3 Process Management for Quality Exploitation (PMQEI) practices
○ Extent to which Statistical Process Control charts are used to monitor state of control of the analytical process? ○ Internal Quality Control (IQC)-Degree of use of Internal Quality Control Processes (IQC) and procedures to ensure that errors in the analytical data are of a magnitude appropriate for the use to which data will be used?-Use of certified reference materials, internal quality control calibration check solutions, use of duplicate samples to check precision, use of blank samples. ○ Process Offline Feedback (Process Control) Analysis- [Extent to which quality control data is analysed offline] e.g. weekly, monthly. Information includes in-process control data, customer feedback data, internal quality audit results, performance in proficient testing schemes] ○ Zero Defects -Extent to which mistake proofing mechanisms are utilised to prevent errors from being made? [These are mechanisms to prevent errors from being made and include automation, self-checking mechanisms, and zero defects mechanisms] ○ Real Time In-Process Feedback. Extent to which Process Control mechanisms are utilized to provide real time feedback on state of control of the analytical process[Existence of a formal observation window on the state of control of the analytical process e.g. use of real-time SPC] ○ Process Improvement-Extent to which process improvements are made to meet changing needs of the clients?
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016), Flynn et al. (1995)

Table 3.2.4 Process Management for Quality Exploration (PMQER) practices
○ Formalized New Method Introduction Process. [The degree of formality and comprehensiveness in the development, validation and introduction of new analytical methods to ensure it meets requirements before being put into use. Thoroughness to which performance parameters are established and evaluated] ○ Process Improvement-Extent to which radical process improvements are done to meet new customer needs
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016),

Table 3.2.5 Teamwork for Quality Exploitation (TWQEI) practices
○ Extent to which employees are supported by supervisors to work as a team? ○ Extent to which employees are supported by supervisors to share ideas and opinions? ○ Extent to which meetings are held to discuss issues together?
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016),

Table 3.2.6 Teamwork for Quality Exploration (TWQER) practices
○ Extent to which cross-functional teams are supported in the organisation? ○ Extent to which teams from different functions cooperate to resolve conflicts between them, when they arise? ○ Extent to which teams from different functions interactively work with others?
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2016),

Table 3.2.7 Training for Quality Exploitation (TRQEI) practices
○ Extent to which employees are trained and developed in workplace skills? ○ Extent to which managers believe and support the continual training and upgrading of employee skills? ○ Extent to which clear training and development objectives for employees are set and pursued?
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2011),

Table 3.2.8 Training for Quality Exploration (TRQER) practices
○ Extent to which employees are trained to perform a variety of tasks? ○ Extent to which the number of tasks an employee can perform a function of the number of years the employee has worked at the organisation?

○ Extent to which employees are trained to fill in for others if need arises? ○ Extent to which training programs are designed to cater for anticipated future needs of the organisation?
○ References Zhang et al. (2012), Zhang et al. (2014), Powel (1995), Dean and Bowen (1994), Sitkin et al. (1994), Sousa and Voss (2002), Evans and Lindsay (2011),

Table 3.3 Applicable codes used in the study

Variable	Codes
Customer Focus for Quality Exploitation	CFQEI
Process Management for Quality Exploitation	PMQEI
Teamwork for Quality Exploitation	TWQEI
Training for Quality Exploitation	TRQEI
Customer Focus for Quality Exploration	CFQER
Process Management for Quality Exploration	PMQER
Teamwork for Quality Exploration	TWQER
Training for Quality Exploration	TRQER
Context variable	CTX
Environmental uncertainty context variable	EUXV
Customer Relationships	CUST-REL
Customer Information	CUST-INFO
Customer Feedback	CUST-FEED
Information Dissemination	INFO-DISSEM
New Information	INFO-NEW
New Needs Information	INFO-NNEEDS
Customer Involvement	CUST-INV
Needs Definition altering	NEEDS-DEF-ALT
Improvement	IMPROV
Statistical Methods	STAT-MET
Internal Quality Control Processes	IQC-PROC
Zero Defect	ZERO-DEF
Overall Offline Process Feedback	OOF-FEED
Real-time Process Feedback	RTM-FEED
New method introduction	NMI

3.4 Methodology

3.4.1 Case selection

All case organisations were selected from laboratories in the mining industry. The selection of cases from one industry enabled the use of industry-specific measurements for relevant

research variables. These laboratories would generally offer services similar in terms of elements being analysed, the methods of analysis and the instrumentation used enabling the control for industry and technology effects. As an example, the analysis of gold is done by fire assay using lead collection followed by Atomic Absorption Spectrometry or Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES). Similarly, the determination of base metals is done by sodium peroxide fusion followed by ICP-OES or four acid digestion followed by ICP-OES or aqua-regia digestion followed by Atomic Absorption Spectrometer (AAS) or ICP-OES for acid soluble minerals.

The laboratories services industry was chosen for five main reasons. First, it is an industry where QM has been practiced for a long time, and has traditionally been the centre for quality control of most manufacturing industries. Second, the research design required distinguishing between environmental uncertainty contexts, for which the two laboratory groups were readily evident as possible candidates. Third, familiarity with the industry processes, methods and practices positively contributed to the decision. Fourth, it was most likely to find organisations that complied with the research controls that were defined. Fifth, feasibility within the individual laboratories was determined by the laboratory's willingness to participate in the study.

The selection of case organisations was based on a sample design where cases are selected to coincide with traits that are pertinent to the investigation e.g. different environmental uncertainty levels. Four cases were selected in total to coincide with both low and high environmental uncertainty contexts. The cases comprised of two mine site laboratories and two commercial laboratories. This is in line with Miles and Huberman (1994) suggestion on selecting cases with sharply contrasting characteristics (polar type cases) that will highlight the differences being studied. The four laboratories complied with the controls for candidate cases. All laboratories were accredited to ISO17025 for generally similar analytical methods, had implemented formal QM at least three years and had shown good awareness of the quality management practices. Two cases representing the low environmental uncertainty context allowed for literal replication that is to verify whether similar cases would exhibit the same pattern of use of the QM practices and the same for the high environmental uncertainty context (Yin, 2014). The two different categories of low and high environmental uncertainty contexts allowed for theoretical replication that is to verify

whether different contexts would exhibit different patterns of use of the quality management practices (Yin, 2014). Cases were chosen to predict similar results (literal replication) or produce contrary results but for predictable reasons (a theoretical replication). Selection of such polar cases with sharply contrasting characteristics would highlight differences being studied.

The four cases selected are in line with Eisenhardt (1989) guideline of between 4 and 10. The number of literal replication depends on the researcher's discretion. Eisenhardt (1989, p 545) states that while there is no ideal number of cases, a number between 4 and 10 cases usually works well, stating that it is difficult to generate theory with less than 4 cases and difficult to cope with the complexity and volume of data when dealing with more than 10 cases.

The selection of cases was based on an initial review of SANAS/SADCAS accredited laboratories as published on their websites and public knowledge of the laboratories known in the mining industry. All laboratories making the cases are involved in mineral testing.

After preliminary selection of the cases, the case organisations were grouped into the two categories of mine site and commercial laboratories. To ensure that the organisations met the required controls, consideration was given to those organisations where easy access could be obtained. Once access was obtained, data was collected to ensure all required controls were met. All the four case organisations that were approached first, met the required controls giving the final selection of four cases in total. Table 3.4 below is a description of each organisation that formed part of the final selection. The four case organisations were coded Mine Site Laboratory number one as MS1, Mine site Laboratory number 2 as MS2, and Commercial Laboratory number one as CL1 followed by Commercial Laboratory number 2 as CL2.

Table 3.4 Description of case organisations

Variable	MS1	MS2	CL1	CL2
Type	Mine site	Mine site	Commercial	Commercial
# of employees	3	22	19	23
Type of analysis and instrument used	Base metal analyses by sodium peroxide fusion followed by ICP-OES, Potentiometric analysis, Sulphur and carbon analysis by sulphur carbon analyser. Instrumental methods include XRF, ICP-OES, C and S Analyser.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES or AAS finish. Sulphur analysis by IR sulphur analyser. Platinum group metal analysis by lead fire assay followed by ICP-OES. Au determination by AAS following Lead Fire Assay collection.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES or AAS finish. Spectrometry (AAS). Sulphur analysis by IR sulphur analyser. Gold and Platinum group metal analysis by lead fire assay followed by ICP-OES or AAS.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES finish or AAS. Sulphur analysis by IR sulphur analyser. Gold and Platinum group metal analysis by lead fire assay followed by AAS or ICP-OES. Laboratory also performs food product analysis, water analysis and microbiological analysis.
Customer composition	Customer is the parent organisation only.	Customer is the parent organisation only	Wide array of customers. Customer includes artisanal miners and large exploration companies.	Wide array of customers. Customer base includes artisanal miners and large exploration and mining companies, farmers in the agricultural community, and food producers.
Main samples types	Metallurgical samples	Geological and metallurgical samples	Geological and metallurgical samples	Geological and metallurgical samples, water and soil samples

3.4.2 Unit of analysis

In all cases, the unit of analysis was the analytical laboratory as addressed in the laboratory's quality manual and the scope of work. The boundaries for the cases was the sampling and sample analysis processes, and included employees employed by the laboratory department, the instruments, methods and all laboratory processes (sampling and sample processing, sample treatment, instrument measurement, data processing and reporting of analytical results). The scope of the QM system defined the unit of analysis. The environmental uncertainty was measured for the analytical laboratory and not the whole mine in the case of the mine site laboratory. For the commercial laboratories, the unit of analysis was the whole laboratory, which amounted to the whole organisation including the marketing and sales. In mine site laboratories the function of marketing and sales is for the whole mine for the product it produces. Where marketing was involved in dealing with

clients in which the laboratory was a subject, marketing was taken as part of the laboratory. The environmental uncertainty context variables of the organisation were measured in relationship to the boundaries defining the laboratory activities i.e. competitive intensity facing the laboratory, change of demand for the laboratory services, and rate of change of customer requirements. The QM practices (QEI and QER were measured for the whole laboratory). Generally, all laboratories used the same methodologies and instrumentation, which facilitated good control for process technology.

3.4.3 Data collection

Different data collection methods were used with the aim of triangulating or establishing converging lines of evidence to increase the robustness of the research findings. A research protocol was developed to provide guidance in the data collection process. The protocol covered methods and questions designed to capture information on the extent of use of QEI and QER practices for the four selected quality management practices of customer focus, process management, teamwork and training. Following the case study protocol several data collection methods were employed which included the use of in-depth interviews (open ended questions with key informants) representing the main data collection method, observation of analysts and chemists doing the work, review of documents in most cases to confirm interview statements (Laboratory reports and procedures) pertaining to laboratory use of the quality practices. Implementation of each practice is associated with generation of QM system records which provided objective evidence for implementation. Reviewed quality control data included use of certified reference materials as shown by the use of Statistical Process Control (SPC) Charts and use of proficiency scheme data. Using the same interview approach, data was collected on the environmental uncertainty context variables to establish the environmental uncertainty context of each organisation.

A pilot study was conducted at one of the organisations in Mpumalanga, for the sole reason that the case organisation was close to the place of residence of the researcher. Secondly, access to the case organisation was easier. Results of the pilot study were used to refine the research protocol that was used in the final study.

Each laboratory was a subject of one visit. The visit included the use of all data collection methods where applicable. More time was spent with the Quality Manager (however

named), e.g. Quality Manager, Quality Assurance Manager and the Laboratory Manager who were the main informants for each laboratory and the Laboratory directors. Each case visit lasted about 8 hours. The idea was to fully utilize time for each visit. The 8 hours were spent with different informants including a combination of the different data collection methods. Interviews per informant were typically 45 minutes but ranged from 30 to 3 hours.

Only senior laboratory personnel who normally would be involved in reviewing new service level agreements, new contracts or assessing the laboratory's readiness and capability to accept any new contracts were questioned on the factors affecting environmental uncertainty context. In general, these employees included the laboratory managers, laboratory directors, laboratory supervisors, laboratory superintendents and quality managers.

During interviews, information was tap recorded and also hand written and typed later. Records were maintained for all interviews. On an ongoing basis, feedback was given to the interviewees who were asked to provide confirmation on the accuracy of the recordings. As these field notes were taken, both observation and analysis were simultaneously recorded but the two were kept separate as much as was possible. Eisenhardt (1989) recommends the separation of records of observation and analysis. The informal analysis process during data collection was useful in revealing pertinent information to the line of enquiry that could potentially be missed. This was addressed by providing for additional field trips or calls in the research protocol. Although, one investigator conducted the research, every effort to minimise observer bias was given.

Recording of collected data was made per site with all notes grouped per person who was interviewed or observed. A summary of the key points per interview was agreed with the informant and signed off. Recorded information was transcribed for analysis. A chain of custody was maintained for traceability. Every effort was made to ensure anonymity and confidentiality was maintained.

3.4.4 Data Reduction

3.4.4.1 General Data Reduction Process

Case research data was handled through a two-stage process of data reduction and data analysis. The data reduction process followed Miles and Huberman (1994) guideline for handling qualitative data. Data obtained from the interviewees was first transcribed, reduced and organised for coding, summarising and discarding of irrelevant data. The data reduction process consisted first of organization of raw data into the conceptual categories. Organisations were characterised across the environmental uncertainty context and the extent of use of QEI and QER practices. The interview protocol and questionnaire were designed to address specifically the use of the eight QM practices. The coding process was in line with Miles and Huberman (1994). Codes were mutually exclusive and exhaustive. All relevant data was fitted into a code. All statements that referred to the research question were identified. Meaning was derived from all the statements and notes taken in the field and assigned a code or category. Statements were then organised into their respective codes. Using the identified codes, all data was placed into their appropriate categories. Responses from every respondent was categorised under these different codes or themes and kept separately for each respondent and organisation.

This information was then first summarised from the interview field notes and confirmed with recordings that were made. The second part of the data reduction process was the consolidation of the information from the separate respondents. During this process, questions were asked whether there were any contradictions between responses given by the different respondents. In general, there were no contradictions noted for the responses given in all the organisations. What was noted were minor cases of omission from some respondents on some practices being implemented? Where such omissions were noted, calls were made to confirm the implementation of the practices. During the within case data reduction process respondent answers that indicated practices as CFQEI where it would best fit to be under CFQER based on literature review and developed guidelines was corrected and the information placed into the correct bins rather than being noted as not practiced. Following this stage, responses from all the respondents were consolidated into one. A chain of custody was maintained for the data reduction process. This process constituted the within case data reduction process.

Following the first part of data reduction, tabular displays were constructed to manage the Qualitative data. In coming up with tabular data displays, information was given some

ratings based on defined rules for coming up with ratings. By following these rules, variables were rated low, medium or high as follows:

First rule, for each variable e.g. the environmental uncertainty context or use of customer focus for quality exploitation (CFQEI), a decision was made, first whether there was a difference across laboratories. This difference had to be significant and notably identifiable. In the absence of this difference, all case organisations were then classified medium by default unless it was noted that though similar the implementation was significantly high or very low in all organisations in which case all organisations were rated equal and high or equal and low respectively. Where a difference was observed across cases and depending on the nature of variables being measured, further guidelines were followed as follows:

The laboratories were ranked from the lowest to the highest rank for a particular variable. The lowest ranking was assigned the rating of low and the highest, the rating of high for that particular variable. A rating in between the two polar ends was ranked medium and the remaining organisation is allocated a rating of low, medium or high depending on whether they were closest to low, medium or high rating. If no medium rating was present then remaining organisations are rated low or high depending on the organisations they represented most. The result of this process was that all variables had a rating of either low, medium or high.

In cases where the ultimate variable is an aggregate variable consisting of a number of other variables, the rules followed above were slightly modified to accommodate this process. The individual variables are initially rated low, medium or high as discussed above. Each of the dimensions making up the aggregate variable is then allocated a numerical figure of 1 (low), 2 (medium) and 3 (high). The individual scores from the different dimensions were then added to give a score for the composite aggregate. The score was then compared with the other laboratory scores to come up with a final low for the lowest, high for the highest and the rest classified relative to the low, and high as low (if closer to the lowest), or high (if closer to the highest), otherwise medium.

This approach was possible as it was based on a comparative approach of the laboratory cases. Furthermore, the fact that the laboratories are from one industry it was easier to compare variables isolated from confounding industry and technology effects. The overall

effect was that case organisations were classified according to their similarities as originally designed. This process was easily achieved for the contextual variables (mine site and commercial laboratories).

3.4.4.2 Environmental uncertainty context data

Following the procedures outlined above, data was reduced for the environmental uncertainty context first. This resulted into categories of low environmental uncertainty context (mine site laboratories) and high environmental uncertainty context for the commercial laboratories.

3.4.4.3 Data for the use of quality management practices

The procedures described in 3.4.4.1 above were followed to reduce the data for the four QM practices of customer focus, process management, teamwork and training. In total the data was reduced to eight practices, two of each of the practices (QEI and QER practices for customer focus, process management, teamwork and training). The final data was presented for each of the eight QM practices as a rating of low, medium or high with regards to the extent of use of that particular QM practice. The reduced data leading to the ratings was clearly displayed. Using the data reduction process, evidence of the link between raw data and summary was maintained to demonstrate the chain of custody.

3.4.5 Data Analysis

Following the data reduction process discussed above, patterns for the use of the eight QM practices were developed for each case. This process was then followed by a cross-case analysis in which similar patterns across cases were identified. First, similar patterns within organisations characterised by the same environmental uncertainty context were searched for. This initial within category analysis enabled the question, “were similar patterns for the use of QEI and QER practices observed in organisations falling in the same environmental uncertainty context”? The same pattern matching process was done for the organisation falling in the high environmental uncertainty context as for the low environmental uncertainty context in order to verify whether similar organisations would exhibit the same pattern of use of the QM practices.

The initial pattern matching process above was followed by investigating the pattern of use of QEI and QER practices across the polar groups, to establish whether patterns in the low environmental uncertainty context were different from the pattern in the high environmental uncertainty context (disconfirming cases). The matching of patterns was visually displayed for each of the QM practices (eight in total).

In addition to the use of visual display of patterns in the analysis of data, non-parametric methods were used to confirm whether the use of the different practices was contingent upon the environmental uncertainty context. The statistical methods were based on the ranking of data for the use of practices (1 for low, 2 for medium and 3 for high). The use of ranked data was in line with ranking of case organisations across the environmental uncertainty context relative to other laboratories.

The Spearman's rank correlation factor was calculated to establish whether a move across the environmental uncertainty context spectrum (low to high) for the four laboratories ranked as 1,2,3, and 4 for organisations MS1, MS2,CL1 and CL2 was associated with a change in the use of the eight practices individually.

The visual display patterns for the use of the eight QM practices across the environmental uncertainty context and the use of the non-parametric statistical method was adequate to answer the question "What is the pattern of use of QEI and QER practices across the environmental uncertainty context spectrum?"

The second research question, "How does environmental uncertainty context influence the selection and use of best QEI and QER practices mix in these laboratories?" was addressed by building causal networks as described by Miles and Huberman (1994). The causal networks were drawn for each case organisation. The four sets of causal networks were compared to each other, a process that resulted in the identification of similarities and differences across cases. Further analysis was searched to establish whether common causal networks could be developed for the two polar groups, one representing the low uncertainty context group and one representing the high uncertainty context group.

Results from the first and second research questions were adequate to address the third research question, "What is the model for selecting best QEI and QER practices mix across the laboratory organizations?"

Summary of methodology

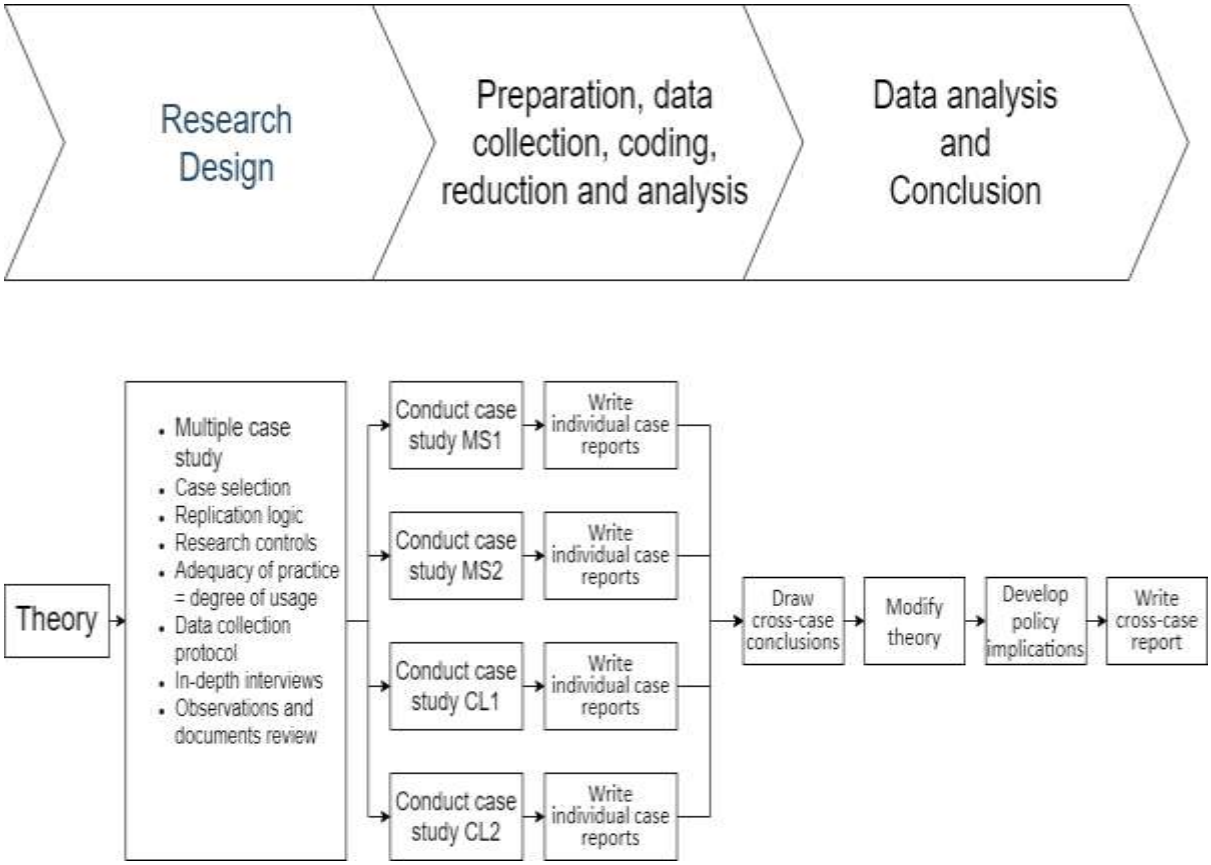


Fig 3.1 Summary of methodology

3.4.6 Reliability and validity of the study

To enhance the quality of qualitative case study research the reliability and validity of the research summarised by words such as reliability, validity, dependability, confirm ability, credibility, trustworthy, compelling, usefulness, the following five tests that measure the rigour of the study were implemented.

3.4.6.1 Confirmability

Confirmability makes reference to a study's freedom from unacknowledged researcher bias. The concept of confirm ability is the Researcher's comparable concern for objectivity. Steps are taken to ensure that the study's findings are a result of the experience and ideas of the informants, rather than the characteristics and preference of the researcher. Three tactics were adopted for enhancing confirmability. First, confirmability was achieved by use of a research protocol detailing how data were collected via the interview, observations or records where applicable. The research protocol contained procedures and rules that were used in using the research instrument and provided information on who and where sources of data were to be found. The protocol outlined the sets of questions to be covered during the interviews, and the data to be captured and is detailed enough to be audited by an outsider. Second, a chain of evidence was established through the use of a well-defined data reduction process. The guideline described for the data reduction process and analysis was adequate and reliable for a different person to arrive at the same summary and conclusion starting with the same raw data. In light of this, a database of the raw data was maintained. Thirdly, key informants were given an opportunity to review the draft case reports and to confirm that the researcher's summary was a true reflection of the given information.

3.4.6.2 Credibility

Credibility (the extent to which we can establish a causal relationship, whereby certain conditions lead to other conditions as distinguished from spurious relationships) was established by the use of pattern matching. Within case patterns were matched with proposed pattern as per literal replication research design. Disconfirming patterns for dissimilar cases was used for theoretical replication. In summary credibility was achieved through pattern matching for both similar and dissimilar cases (literal and theoretical replication respectively) as per research design. Credibility was established at the data analysis stage, although provided for at the design stage. Explanation building was employed to enhance credibility.

Credibility was also enhanced by the adoption and use of well-established methods that have been successfully employed. Furthermore triangulation through the use of different data collection methods-interviews, observation and review of quality control records was

employed to enhance credibility. All participants had voluntarily accepted to participate and hence data was collected from willing participants.

A technique of iterative questioning was also employed. This involved returning to previously asked questions for consistency in response. Different responses could be indicative of data that was not credible and could be discarded.

3.4.6.3 External validity

This makes reference to whether the research's findings can be generalised beyond the immediate case study to other contexts. This was achieved by the use of theoretical sampling logic that was employed at the research design stage of the study. Cases were chosen that differed significantly regarding the contextual variable of interest and therefore filling theoretical niches. This replication logic allows for analytical generalization. This is generalization from each case to a broader theory and not samples to populations (Stuart, et al., 2002; Yin 2014). Generalization from the analytical services industry to other industries is therefore inferred.

3.4.6.4 Dependability

Dependability refers to the consistency and reliability of research findings and the degree to which research procedures are documented allowing someone else outside the research to follow and audit the research process. It makes reference to the extent to which a study's operations can be repeated with the same results (Moon, Brewer, Januchowski-Hartley, Adams and Blackman, 2016). This was achieved through two main approaches. First, a case study protocol was employed. Second, a case study database was maintained. This stored database allows a different researcher to expose the same data collected, through the same reduction and analysis process to establish whether the same results (summary) could be arrived at. This process is in line with Eisenhardt (1989) guidelines for achieving reliability in qualitative research.

3.4.6.4 Authenticity

Authenticity was achieved at both design and data collection and analysis stages. Purposeful sampling at design stage and having a number of groups or categories of employees to participate in the research as interviewees were the strategies used to achieve authenticity.

3.4.7 Ethical Considerations

In conducting the research, plans were made to address anticipated ethical issues. Some of these issues are generally easy to predict but others are not clear. As a result I developed my own sense of how to conduct the research in an ethical manner. As a minimum, the following were addressed: Seeking permission and informed consent, voluntary participation, minimization of harm, anonymity and confidentiality and cultural sensitivity.

The ethical issues in the study were guided by Belmont Report (Hennink et al., 2011) which identified three core principles for ethical conduct.

- That participants welfare should take precedence over science and society and that participants should voluntarily enter the research and with adequate information.
- Researchers should strive to maximize the benefits of the research for wider society and minimize risks to research participants.
- Researchers should ensure that research procedures are administered in a fair, non-exploitative and well-considered manner.

These principles were achieved through the following:

- Seeking permission and providing information-Permission was sought from the targeted organisations to conduct research in their organisations. The permission awarded was part of the submission for ethical clearance. When permission was sought information was given concerning the research objectives, information on how the data was going to be collected, and how the data was going to be used. Furthermore information was provided to give the participants assurance of anonymity. No names would appear on any documents for the research. Participant information was given to all participants.

- Minimization of harm- Every effort was made to ensure there was no harm rendered to the participants. Although little harm was anticipated, but every effort was made to avoid harm. This was achieved by ensuring participation was voluntary and with total knowledge of what the participants were going for.
- Informed consent-Although the list of potential participants was identified by the researcher and the Laboratory Manager as gatekeeper, informed consent was sought from each participant. Where an individual refused to participate, this was kept confidential from the gatekeeper. All participants were provided with sufficient information about the research, in a format that is comprehensible to them and make voluntary decision to participate.
- Anonymity and confidentiality-It was clearly indicated that there were limitations to achieve full confidentiality of the information gathered during the study as reports were to be generated and possibly published. However, anonymity was assured. No reference would be made to names of participants. All identifiable information was removed from the interview transcript or quotations noted. No individual participant's names were identifiable on any documents. Where recordings were made, no one was given access to listening to the recordings except those working on the project. A list of names and codes was kept under lock as part of anonymizing the data.
- Justice-Every effort was made to avoid sensationalising the findings of the research and reporting the findings of the research and reporting incidents that do not reflect the real situation (Hennink, et al., 2011). Every effort was made to report both positive and negative aspects of the findings to ensure interpretation of data remained balanced.

CHAPTER 4

RESULTS

4.0 INTRODUCTION

Chapter 4.0 presents the results of the study, starting with a presentation of the descriptive data for the final research sample as indicated in table 4.0 below. Following the purposive sampling approach described in chapter 3, methodology the final research sample consisted of four organisations consisting of two mine site laboratories and two commercial laboratories respectively. These were coded MS1, MS2 for the two mine site laboratories and CL1 and CL2 for the two commercial laboratories respectively. Table 4.0 below provides a brief description of the four organisations. The four laboratories fulfilled the research controls defined in chapter 3, i.e. the laboratories were all mature in quality management practices having established formal quality management systems complying with the requirements of ISO17025 laboratory accreditation standard and had reached a stage of quality maturity. Characteristically, these organisations would have implemented a formal quality management programme complying with the requirements of ISO17025 or ISO9001. Secondly the organisations had demonstrated a high level of quality awareness. Quality awareness was related to customer focus practices, process management practices, teamwork related practices and training practices. Employees had generally demonstrated awareness of the overall quality objectives of the organisation and the related quality policy. Awareness of quality management practices ensures that a practice is not excluded from implementation because the organisation is not aware of that particular practice. Thirdly, all the organisations were from the analytical services industry providing services to the mining industry. This was to control for industry and technology effects as similar analytical methods and instrumentation is used in general. Services to the mining industry were the main line of business even though the commercial laboratory had additional services like agriculture and food.

Table 4.0 Final Research sample description

Variable	MS1	MS2	CL1	CL2
Type	Mine site	Mine site	Commercial	Commercial
# of employees	3	22	19	23
Type of analysis and instrumentation used	Base metal analyses by sodium peroxide fusion followed by ICP-OES, Potentiometric analysis, Sulphur and carbon analysis by sulphur carbon analyser. Instrumental methods include XRF, ICP-OES, C and S Analyser.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES finish. Base metal analysis by Atomic Absorption Spectrometry (AAS). Sulphur analysis by IR sulphur analyser. Platinum group metal analysis by lead fire assay followed by ICP-OES. Au determination by AAS following Lead Fire Assay collection.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES finish. Base metal analysis by Atomic Absorption Spectrometry (AAS). Sulphur analysis by IR sulphur analyser. Platinum group metal analysis by lead fire assay followed by ICP-OES. Au determination by AAS following Lead Fire Assay collection.	Base metal analyses by four acid digestion and sodium peroxide fusion followed by ICP-OES finish or AAS. Sulphur analysis by IR sulphur analyser. Platinum group metal analysis by lead fire assay followed by AAS or ICP-OES.. Laboratory also performs food product analysis, water analysis and microbiological analysis.
Customer composition	Customer is the parent organisation only.	Customer is the parent organisation only	Wide array of customers. Customer includes artisanal miners and large exploration companies.	Wide array of customers. Customer base includes artisanal miners and large exploration and mining companies, farmers in the agricultural community, and food producers.
Main samples types	Metallurgical samples	Geological and metallurgical samples	Geological and metallurgical samples	Geological and metallurgical samples, water and soil samples

A total of two employees were interviewed in organisation MS1, eight in organisation MS2, six in CL1 and five in CL2.

Table 4.0.1 Summary of interviews carried out

	Organizations			
Laboratory identity	**MS1**	**MS2**	**CL1**	**CL2**
# of employees	**3**	**22**	**19**	**23**
Total interviewed	**2**	**8**	**6**	**5**
Top Management (Senior Managers and Directors)	**1**	**2**	**2**	**2**
Quality Managers, Section Heads	**1**	**6**	**4**	**3**
Interview Questions	**All**	**All**	**All**	**All**

4.1 General Data reduction process

This section provides a detailed data handling process, mainly consisting of a data reduction process and data analysis as described in chapter 3.0 methodology. The data that was collected in the field was typed for each informant and organisation. For each of the organisation, the tap recorded information was transcribed using independent transcribers and hand notes for each respondent generated in the field was summarised and consolidated into one set of data for each interview question. The overall response for each question and organisation was an additive summary of the responses from all respondents. There were no notable contradictions in responses given. This could be a result of the fact that responses were based on actually practices being implemented e.g. How is quality control achieved during the whole analytical process? The information from the different respondents generally agreed and was confirmatory. Some differences noted were cases of omission of some practices and where needed confirmation was made through telephone calls as follow-up on the interviews. This data consolidation from the individual responses to arrive at a summary of the extent to which a practice was implemented in an organisation formed the basis of data reduction process within each case. During this process

information from other responses that reflected implementation of a practice under a different question was selected and included in that practice i.e. was placed into the theme that reflected the correct theme or information bin. Following this first data reduction process, the summarised responses were then written against the other summarised responses for the other organisations. Each interview question was reviewed and all summarised responses from the four organisations documented against each other. For each interview question, a question was asked whether there was any significant difference in the extent to which a practice was implemented or whether a difference existed in an environmental uncertainty context variable. Where there was no significant difference noted across the organisations, all practices were rated medium (M) unless the no difference was evidently shown to be "No difference but at very high level of implementation" in which case a rating of High (H) was given to all the organisations. On the other hand, a "No difference "was also rated Low (L) if the implementation was noted to be very low. This approach is clearly described in section 3.4 of chapter 3, Methodology. Variables for environmental uncertainty context were treated in the same manner, but details are given below for all research variables as explained in chapter 3, Methodology.

4.2 Classification of organisations along the environmental uncertainty context spectrum

Following the interview protocol, information on laboratory identity, context variables, e.g. competitive intensity, rate of change of customer requirements, rate of change of service demand and complexity of services was obtained through the interview process for each organisation and from the various respondents. Following the generally methodology to data reduction process, information from the individual respondents was summarised to come up with one response for the organisation as in 4.1 above. This data was presented in four columns with column one showing the identity of the laboratory, column two contained information on the context variable being measured, third column contained information on the details of implementation of a practice or a detailed description of an environmental variable being measured and the last column containing the rating of the practice or context variable relative to other organisations. As described under general data treatment above and section 3.4.4.1 in chapter 3, methodology, a decision was made whether there was any significant difference among the context variables. Where significant differences existed, the variables were rated High (H) for an organisation exhibiting the

highest of that variable and Low (L) for the organisation that was rated lowest for that variable. The other organisations were rated as to the organisation they most represented. An organisation in between the L and H ratings was rated M for medium. In all variables, the organisations were rated H and L and the remaining organisation rated similar to the organisations that had already been rated H or L resulting in all the mine site labs (MS1 and MS2) rating L and commercial labs (CL1 and CL2) rating H in most variables with an overall rating of L and H environmental uncertainty context for the two sets of organisations. Because all context variables for each laboratory rated same, the overall rating of the environmental uncertainty context of the laboratory was same as the ratings for the individual variables. Table 4.1 provides the final summary of classification for organisations into the different environmental uncertainty context.

Table 4.1: Classification of the organisations into different environmental uncertainty context categories

Summary of the responses received on environmental uncertainty context variables across organisations rated as (H=High, M=Medium and L=low in comparative terms)

Lab	Context variable	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Context variable rating as (L,M,H)
MS1	Rate of change of customer requirements	The needs and wants of the customers for this company do not change significantly. Both the needs and wants of the external and internal customers are stable. Internal customers in the context of MS1 refer to the process departments and the external customers are the company customers who purchase the product produced by the company. The ferrochrome and ferromanganese products do not significantly change in terms of composition and quality. Changing the product entails changing furnace design and the cost implications are so high. Hence customer requirements are generally determined by furnace design and hence do not change much. The customers are ferrochrome and ferromanganese producers. Customers are defined by what they deal with. To change from one product to another involves a lot of capital. The customer needs therefore do not change significantly. The changes could be only in terms of demand for the product i.e. more or less of the product. This is demand change.	L
MS2	Rate of change of customer requirements	"Customer needs and expectations do not change fast if at all", said the laboratory Manager. The laboratory is a mine site laboratory and provides analytical services to the mine site customers. Work is very routine and requirements generally the same. Very little changes might be experienced if there is a change in exploration focuses but very rare.	L
CL1	Rate of change of customer requirements	The needs of customers are changing with clients now going for mine dumps that were left in the 1950s when companies were targeting high grade resources and dumping waste that has now become a resource. This change on one hand requires change in methodologies for sample analysis and services required by the clients. The artisanal miners are seeking assistance on methods to recover the once low gold grades. The mining industry in Zimbabwe has a significant number of new players (the artisanal miners) who have some ethical issues in business dealings e.g. submitting a different ore sample for analysis and selling a different batch with the assays for a different material. This puts the laboratory in a different position and requiring different practices to protect its integrity e.g. sample retention periods requiring change to fit these challenges. The focus has also changed from gold and chrome only to significant lithium metal exploration. The heterogeneous customer base also implies that submissions from different companies come with different requirements e.g. every client has different requirements for different projects e.g. different sample preparation protocols, storage requirements, detection limits, reporting requirements, quality control protocols for example inclusion rate of certified reference materials in a batch of samples, duplicate generation instructions etc. Being a competitive environment, when competition introduces a capability, this new capability becomes a new standard and a new requirement for customers.	H
CL2	Rate of change of customer requirements	Customer requirements change but not that fast. They change to a certain extent. The new customer needs may still be the same as for the old customers e.g. when the trend is to follow chrome mining by artisanal miners everyone goes for chrome, When its gold everyone goes for gold. The change comes in the form of specific requirements e.g. special sample treatment protocols, inclusion rate for certified reference materials, sample storage instructions after analysis, reporting requirements and format,	H

		invoicing preferences and requirements e.g. weekly, per batch or monthly. The change is in the permutations of requirements from different clients.	
MS1	Instability in the demand for product and services	In the last three years the changes have happened once. And the laboratory was well informed of the changes ahead of time i.e. about 14 months before the changes were made. This is well planned. During the normal cycle there is not much change in samples volumes. The change that happened three years ago resulting in significant volume and number of employees was well planned and communicated 14 months ahead of time.	L
MS2	Instability in the demand for product and services	The demand for laboratory services is very stable. There is a scope of work which is followed. Occasionally, new projects or test work can put some strain on the laboratory but overall demand is stable. The scope of work is produced at the beginning of the year and details the sample volumes to be submitted to the laboratory including the frequency of sample submission e.g. hourly, weekly or daily, required turnaround time.	L
CL1	Instability in the demand for product and services	The demand for services is very variable (not stable). The 51% shareholding requirement in Zimbabwe significantly reduced the number of companies undertaking exploration activities. Exclusive Prospective Orders (EPO) which allows exploration companies to do large scale exploration has been suspended resulting in reduction in the number of samples submitted. Sample volumes are generally low and very difficult to predict sample flows. Furthermore the miningg exploration business is cyclical in nature. During rainy season most small scale miners seize operations and sample volumes are reduced. Combining this with high competition predicting sample volume submissions become a problem. Uncertainty in sample volumes becomes very high. The macroeconomic environment of the country has seen the laboratory experiencing very low sample volumes and suddenly high sample volumes but difficult to predict changes.	H
CL2	Instability in the demand for product and services	" This is the greatest challenge that we face as a commercial labortaory and any other commercial laboratory, you need to rely on someone else to bring samples" said one of the directors at CL2. Whilst mine site laboratories have a clear schedule of sample submissions e.g. hourly, two hourly, daily composites etc, commercial laboratories do generally not have solid submission plans from all clients except in those cases where contracts have been won. Even though, other clients will adhocly submit samples. Overall sample flows are therefore unpredictable. This makes planning difficult for commercial laboratories, creating challenges in estimating turn around times. Crossing industries has helped this laboratory to at least have steady sample flows by smoothening the ups and downs in the different industries but the overall market conditions determines demand. Business is cyclical.	H
MS1	Degree of competition faced by the laboratories	The company is in competition with other producers of the same products but when it comes to the laboratory there is no competition. The labs are not in competition with each other.	L
MS2	Degree of competition faced by the laboratories	No competition with other laboratories.	L
CL1	Degree of competition faced by the laboratories	The laboratory competes with both small to medium enterprise laboratories as well as large mineral laboratories in and out of Zimbabwe. The laboratory therefore faces both national and international competition. Similar sized laboratories and international laboratories compete on quality of service and cost whilst competing more on cost with the small to medium enterprise laboratories. These small labs compete strongly for artisanal miners whose focus on quality is not as strong as other companies. These small laboratories have less focus on quality enhancing their performance on turnaround time and becoming competitive with artisanal miners who may settle for low quality, good turnaround time and low cost. Competition with regional and global companies is on both quality of service and cost and compete for a limited number of customers. The laboratory provides its quotations in US$ or RTGS with different rates when payment is cash or transfer. This multiple quotation system weakens the laboratory competitive position in comparison with the regional or global companies most clients would prefer stable quotatations. Some clients may leave because you insist on solid currency which might be required to source consumables. Competition is therefore very tough.	H
CL2	Degree of competition faced by the laboratories	Competition is quite high from both local and international laboratories. The laboratory has lost a number of clients to international laboratories especial those based in South Africa. Foreign companies have recommended laboratories they prefer using globally, and there is need to demonstrate higher service quality to compete or to break the normal preference that exists. The Zimbabwean situation makes it much more difficult as the international community has reservation in using Zimbabwean laboratories. Prices quoted by Zimbabwean laboratories are not stable as a result of swinging between currency, the US dollar and the Zimbabwean RTGS currency with multiplicity of payment options-cash, transfer, eco-cash etc all giving different quotes. This affects the competitive position of the laboratory. In Zimbabwe itself, there are a number of laboratories offering the same services including Govt laboratories who charge lower prices than the private companies. These laboratories form part of the pool of competing laboratories. This has forced the laboratory to try and provide wider service scope e.g. minerals, agriculture, food and water analysis. " There are about seven laboratories around this area" said one of the directors at the company. If the lab loses a customer, that customer communicates the poor service to other customer or potential customers. There is therefore need to ensure high qualitity service to remain competitive". Competition is tough.	H
MS1	Complexity of processes	Process complexity is low	L
MS2	Complexity of processes	Much of the work is routine and therefore simple processes. Routineness of the processes reduces complexity.	L
CL1	Complexity of processes	The laboratory receives sample from a heterogeneous source of customers which causes downstream complexity. Each customer has its own specific requirements regarding sample preparation, duplicate	H

		requirements, composting requirements, storage instructions, reporting formats, invoicing preferances. Samples are of different matrices and may require different treatment for succeful analysis e.g. fire assay fusion process and fluxes are not universal. Different sample matrices may require different treatment regimes for successful analysis. Concentration ranges are wider and variable as compared to mine site laboratories and the laboratory may not have any historical information to use for quality control.	
CL2	Complexity of processes	The work performed is much more complex than the analysis performed by mine laboratories. Whilst it might be the annalysis of the same element gold by Fire Assay, the mine site receives samples of uniform matrices and hence would require same treatment for all batches. In the case of commercial labs, different customers bring different samples with different matrices and requiring different ways of treatment. Complexity comes form the heterogeneous nature of matrices making universal treatment by fluxes not possible. The samples are not known and there is no knowledge regarding what could be expected and hence use of product knowledge to control quality is limited e.g. in mine site laboratorories one would know that a tail for this plant would average this amonut. Anything out of the ordinary calls for investigation before reporting. Every client has different reporting requitrements, sample treatment requirements and every submission should be scrutinized to ensure that any changes are captured.	H
		Additional information on challenges and differences between the two environmental contexts. This information is not for rating environmental uncertainty context but ic useful in explaining some practices during data analysis.	
MS1	Challenges faced by the laboratory	No notable challenges regarding quality management relative to commercial laboratories.	
MS2	Challenges faced by the laboratory	No significant challenges noted	
CL1	Challenges faced by the laboratory	Pricing is a challenge as a result of the multiple currency usage. Furthermore, the heterogeneous nature of the laboratory customers implies samples are of different matrices and may need to be handled differently eg. when Fire Asssay analysis is being used. Sample treament may need to be customized.	
CL2	Challenges faced by the laboratory	Pricing is a serious challenge in the Zimbabwean economy as a result of the mulitiple current system being used. The exchange rate is unstable.	
	Other issues in comparing the two environments	Other issues regarding the differences between commercial and mine site laboratories: included that the mine site labs have higher employee retention than the commercial laboratories. The mine site labs tend to retain their employees longer than the commercial labs. There is high turnover in commercial labs. There is higher pressure in commercial labs than mine site labs. Samples vary significantly in commercial labs than in mine site labs on a monthly basis i.e. demand varies significantly over a very short period of time. Even when capacity is not there samples may be received and sometimes there is excess capacity. Employees are retained only when samples are there but retrenched accordingly and engaged when samples have increased. Work is not very routine in commercial laboratories as is for mine site laboratories. There is a wide range of sample types and matrices received by commercial labs than for the mine site labs. So, "We have different matrices, different sample types, and complex environment in commercial labs than mine site laboratories" said one commercil laboratory Manage at CL1. A person working in a mine site laboratory is much more inclined to identify problems with samples as he actually know these are concentrates, tails, head grades etc.	

Table 4.2 Summary of the classification of the organisations into the different environmental uncertainty context categories

Environmental uncertainty context variable	**Laboratory code** **MS1**	**Laboratory code** **MS2**	**Laboratory code** **CL1**	**Laboratory code** **CL2**
Competitive intensity (CI)	**Low(L=1)**	**Low(L=1)**	**High (H=3)**	**High (H=3)**
Rate of change of demand of product and services (RTD)	**Low(L=1)**	**Low(L=1)**	**High (H=3)**	**High (H=3)**
Rate of change of customer Requirements (RTCR)	**Low(L=1)**	**Low(L=1)**	**High (H=3)**	**High (H=3)**
Complexity (CTY)	**Low(L=1)**	**M(M=2)**	**High (H=3)**	**High (H=3)**

Total score	**4**	**5**	**12**	**12**
Overall Environmental Uncertainty Context classification (EUXT)	**Low (L)**	**Low (L)**	**High (H)**	**High (H)**

A rating of L was given a numerical value of 1 and a rating of H, a numerical value of 3 as described in chapter 3. The individual variable scores were added to arrive at an aggregate score, which was then rated using guidelines in section 3.4 to arrive at MS1 (L), MS2 (L), CL1 (H), CL2 (H),

4.3 Rating the degree of use of Quality Management practices-Data reduction process

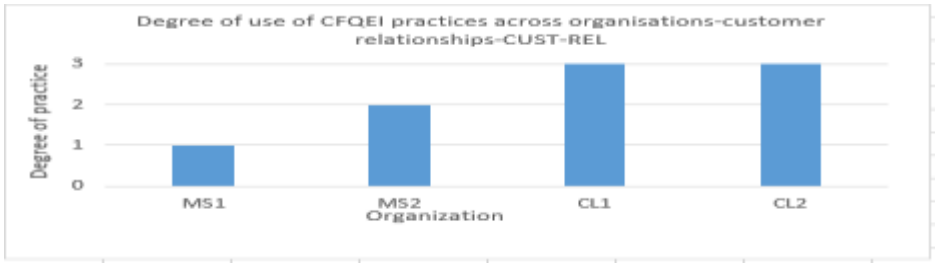
4.3.1 Rating the degree of use of Customer Focus for Quality Exploitation (CFQEI) Practices

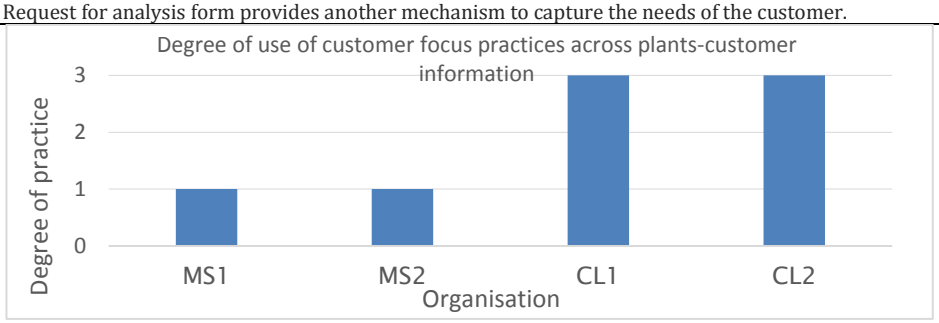
Using the general methodology described in chapter 3 and section 4.1 above, interview data was first written per individual respondent and organisation (section A3.7.1 customer focus for Quality Exploitation). This data was then consolidated per question for all the respondents ensuring that no information noted as important was left out. No notable contradictions were noted from the information given by the different respondents except that omissions were noted which were confirmed by telephone calls. The information for each organisation was then displayed in tabular form against the data from the other organisations, table 4.3 which compared the extent to which the different customer focus practices are implemented. Comparing the different summarised data, a question was asked whether there were any significant differences among the organisations. Where differences were notable, the organisation exhibiting the highest level of implementation for a particular practice was given a rating of High (H), and the one exhibiting the lowest (L) was given a rating of Low (L). The remaining organisations were rated Medium, if practice was in between the two extreme ends and either H or L depending on which organisation it reflected most. Where data did not indicate a level in between the two extreme performance levels, then remaining organisations were rated either L or H depending on which organisation they resembled most. This data was summarised in a table consisting of a column for practice, details of implementation and rating of the practices. Table 4.3 gives a summary of the degree of use of the Customer Focus for Quality Exploitation practices (CFQEI) across the organisations.

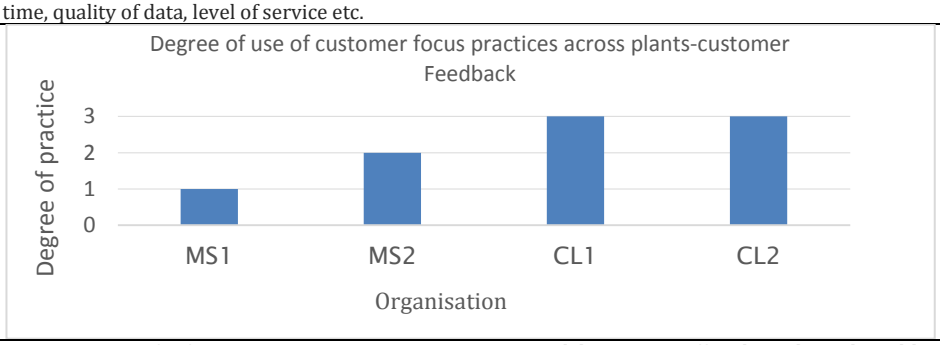
Cross–case comparisons of the use of customer focus for quality exploitation practices

Table 4.3 (a)
Summary of the use of customer focus for quality exploitation (CFQEI) practices across the case organisations (H=High, M=Medium and L=low use of practices in comparative terms)

Lab	(CFQEI)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Customer Relations	Communication with clients is through face to face meetings. There is a monthly meeting with internal clients to review the performance of the laboratory against the Service Level Agreements (SLA) in place. Two other additional meetings are conducted weekly to discuss (1) lab performance regarding turnaround time, complaints, quality of data etc., with all HODs including Head of the laboratory to discuss performance of all sections and (2) Laboratory meeting with GM to specifically discuss lab performance regarding productivity and any other issues. In between these meetings communication with clients is through emails (reporting of results, follow-up on assays, any concerns) and telephone calls. The clients make routine visits to the laboratory to discuss any issues coming up and requiring the attention of the laboratory. The marketing department communicates shipment requirements through emails.	L
MS2	Customer Relations	Communication with three of its internal customers (Technical services, marketing and production) is through formal meetings. There is a monthly production meeting attended by laboratory. Once every week the Laboratory team visits its clients. Issues required to be addressed by the laboratory are addressed during these visits and meetings. There is a weekly operations meeting attended by the strategic team of the operation and laboratory takes note of all client concerns and implements appropriate corrective actions. Laboratory carries out a quarterly client satisfaction survey and responds to concerns raised. Surveys seek feedback on laboratory performance in key performance areas e.g. turnaround time, data quality, ability to address concerns, etc. Communication with clients at Analyst level is mainly through emails when reporting results or telephone calls when communicating delays in reporting data or when client is following up on assays. Lab has made effort to invite clients to the laboratory for them to familiarise with lab operations, to observe how work is done, laboratory capacity etc. Clients have appreciated this and this has assisted to build better relationship with the client. Lab is honesty and encourages this culture in its analysis and reporting of work. Laboratory strives to meet its targets and this helps to build better relationships. Relationships are built by adhering to agreements and meeting deadlines. Marketing has face to face meetings with external clients and then has face to face meetings with laboratory, communicates daily with clients or whenever required by email or telephone. Laboratory is involved in technical investigations of concerns raised by clients for clients. This is a value adding practice which helps to build relationships between lab and its clients.	M
CL1	Customer Relations	Communication with clients is on daily basis as clients (both Artisanal miners and large Exploration companies) submit samples to the laboratory and have face to face meetings with clients. Laboratory communicates daily with all clients by email and telephone calls e.g. whatsApp calls. Laboratory makes courtesy calls to clients capturing information (feedback) on laboratory performance through these discussions enabling the laboratory to serve the clients better and build relationships. Laboratory takes client concerns seriously and is very responsive to concerns, queries or complaints. Laboratory carries customer satisfaction surveys once a year and is very responsive to feedback requirements e.g. positive response to client requirements to build satellite laboratory closer to customer site to reduce sample transportation costs-a form of partnership arrangement. Laboratory responded positively with the results of constructing two satellite laboratories around key clients. This development was in part supported by client commitment to use the facility and hence sharing the business risk. Both parties had to work to ensure success of the development. There is a formalised procedure for dealing with customer complaints and carrying out customer satisfaction surveys. Addressing concerns and queries builds client trust of the laboratory and hence better relationships. Laboratory offers client assistance whenever possible e.g. completion of sample submittal forms when samples are being submitted to the laboratory. Laboratory has scheduled client visits to discuss its performance and areas of potential improvement and any future businesses and shares its successes and challenges to build trust and relationship. Honesty portrayed assists in building better and stronger relationships with the client. Laboratory management trains Artisanal miners on relevant aspects of their businesses to do with data handling e.g. confidentiality issues. Laboratory is easy to contact i.e. has created a system to ensure its easily contacted when required e.g. whatsApp messages, calls, normal telephone calls, emails, visits and website. Laboratory gives access to clients to visit and tour the laboratory. The completion of the feedback forms provide a platform for capturing client needs and knowing the needs better enabling the lab to serve the client better, and developing stronger relationships.	H
CL2	Customer Relations	Laboratory has several methods for communicating with clients which include face to face meetings when clients visit the laboratory. Laboratory Business Development makes scheduled visits to clients to discuss laboratory performance and areas requiring improvement, potential new business and makes regular courtesy calls to clients to find out how the laboratory is performing and where improvements could be made. The laboratory has a formalised mechanism in place for getting client feedback on its	H

		performance and is responsive to the concerns raised. There is a formalised procedure for dealing with customer complaints and laboratory is very responsive to complaints, which are taken seriously. Laboratory Management has social meetings and events with clients which help to assist in building relationships. The interaction allows business relationships to become personal and strong leading to strong business relationship. The laboratory has a strong culture of honesty and integrity. It is honesty about its capability and turnaround time. The honesty about capability results in consistently fulfilling commitments to clients and this assists in building strong relationships. Lab cultivates relationships by being honesty and meeting expectations of the clients through commitment to client needs. Other interactions with clients are through emails. Marketing function of the laboratory is also achieved through the company website, local paper adverts. When client visits the laboratory, the management makes effort to establish what other services the laboratory can provide to ensure a one stop laboratory service to the clients. This attracts and helps to build stronger relationship with the clients. Laboratory attends mine expos and participates in Agricultural shows, meeting individual clients, producing articles in the local papers, internet publications and lab website making it easier for the laboratory to be contacted. Laboratory invites customers to the laboratory and during these visits seeks feedback on its performance. Client feedback includes complaints, and the laboratory is honesty in dealing with complaints e.g. honesty about its failures improves relationship with its customers. During client visits the laboratory gives clients access to tour the laboratory and have face to face meetings with them. Business Development has scheduled client visits and on these visits seeks client feedback and encourages them to give this feedback. Communication with clients is also daily when reporting results, when client is following up on results, when laboratory is communicating potential delay in reporting results e.g. by email or telephone calls. Client communicates with laboratory for elaboration of results. The lab offers free services to some clients during development and validation of methods and service offers. Laboratory offers technical advice to clients e.g. farmers. Laboratory is committed to client service. Degree of use of customer focus practices-Relationships across organisations	
			
MS1	Customer information	Shipment requests from marketing to laboratory define client requirements (the ultimate external client). Internal client requirements are defined through the Service Level Agreements. (SLA). Laboratory performance is discussed in weekly scorecard meetings against SLA. Customer requirements are also defined in the sample submittal forms that are submitted with all samples during submission of samples. This ensures that any change in SLA is captured and responded to. Accuracy, turnaround time and precision are defined as critical and of high significance. Laboratory has a formalised customer satisfaction survey process which is done once a year. The survey captures client needs and laboratory responds to those requirements. Customer complaints which the laboratory captures also define client needs. Timely reporting of analytical results for stock piling, lab technical ability to investigate and resolve client complaints are some of the needs of the clients.	L
MS2	Customer information	Work done by the laboratory is to support the internal customers and is generally routine in nature. Laboratory and clients develop a scope of work once a year. This covers the needs of the customers e.g. frequency of submission of samples, sample volumes, submission times, and expected reporting times, mode of reporting of results, expected accuracy and precision, acceptance criteria for reported data. Customer needs are also captured from completion of request of analysis form, which is completed and submitted with every sample batch. Needs captured include Turnaround time requirements, partial reporting of results e.g. the quick to complete assays, before finalising the entire report, sample storage requirements, e.g. one year for some samples and one month for others. Laboratory conducts a customer satisfaction survey every quarter and customer needs and expectations are captured from the survey. Laboratory has a formalised customer complaint system and also captures needs from the analysis of the customer complaints. The laboratory identifies what the needs are and their respective priorities. Other client needs are captured during day to day interaction with the clients. Client place high importance on turnaround time and accuracy of data. External client places high importance on accurate billing which is also based on accuracy of data. Through information gathering, turnaround time for process control samples was changed from one day to eight hours.	L
CL1	Customer information	Client needs are captured through sample submittal forms (SSF) and include the following: turnaround time, price of analysis, invoicing preferences, e.g., weekly, monthly or per batch, accuracy, turnaround time estimation, technical details e.g. preparation procedure, QC requirements, sample disposal options, laboratory ability to pay VAT (15%) to Government within transactional period. Price of analysis is of high importance to most clients in Zimbabwe. Every submission is accompanied by a sample submission form. Requirements for long term clients are captured through signed contracts and reviewed at contract renewal but requirements for every submission can be modified through the submitted SSF. There is a formalised procedure on request for assays and review of contract. Clients provide feedback as they bring samples through completion of a feedback form designed to capture client feedback. The completion of the feedback forms provide a platform for capturing client needs	H

		and knowing the needs better enabling the lab to serve the client better, and developing stronger relationships. Every interaction with the client creates an opportunity to capture client needs. Laboratory is responsive to these needs and requests and takes them seriously. Once a year laboratory carries out a customer satisfaction survey to establish its performance with respect to lab key performance indicators and relative to its competitors. The questionnaire covers the importance of the different quality performance parameters to the client e.g. turnaround time, price of analysis etc. Business Development team captures client needs during routine client visits and subsequent face to face meeting with the clients. Importance placed by clients on turnaround time, price, data quality and report format is captured during these visits. The needs are also captured through the complaint management system. There is a formalised procedure on customer complaints. Laboratory captures information on lost tenders and identifies client needs through the gathered and analysed information.	
CL2	Customer information	Needs of the customer are established through communication with clients by email, telephone calls and face to face meetings when clients visit and tour the laboratory. Laboratory anticipates needs of the customer through discussions with them. Needs are further identified through field intelligence by the business development team. This entails getting knowledge of exploration companies and their pursuance from the Geological Survey department. The laboratory then contacts the specific companies for the identified potential needs e.g. Lithium determination. Similarly, Esteria determination was unearthed in a similar manner. The process involves anticipation of potential needs through field intelligence followed by confirmation during visits, face to face meetings or telephone calls. Customer needs are also captured from the analysis of customer complaints and addressed as part of the corrective action process. There is a formalised process for receiving and responding to customer complaints and laboratory has a system in place to make it easy for customer to complain e.g. easy to contact telephones and email facility on the company website. Feedback forms are provided to clients during visits by the business development team or when clients visit the laboratory. The laboratory conducts a yearly customer satisfaction survey from which client needs are identified. There is a formalised procedure for this process and questionnaires cover information on laboratory performance indicators e.g. turnaround time, value for money, general customer service, data accuracy and their respective importance to the client and how the laboratory compares with competition. Complaints provide a valuable means of identifying customer needs which are also identified during routine communication with clients and deep understanding of the analytical service industry in the mining sector which enables laboratory management to decode the needs. Some of the needs include turnaround time, price of analytical services, accuracy etc., Price is currently a very critical requirement which also forces laboratories to operate efficiently to keep costs low. Other requirements include preparation specifications, sample disposal options and invoicing requirements. The completion of the Request for analysis form provides another mechanism to capture the needs of the customer.	H
	Customer information		
MS1	Customer Feedback	Laboratory carries out a customer satisfaction survey once a year. This is a formalised process with detailed procedure on how the process is carried out and what is captured e.g. performance on turnaround time, data quality, level of service, value adding role, availability of laboratory personnel to assist when need arises. Additional surveys are carried out when complaints are received. The laboratory uses the customer complaint as part of feedback process and this is a formalised process with a well detailed procedure. The Laboratory information management system (LIMS) is configured to capture turnaround time performance as results are reported, providing a feedback system in itself.	L
MS2	Customer Feedback	Laboratory has set up a system focusing on identified client needs to monitor its performance with respect to turnaround time. Turnaround time performance is captured as results are released. The technical services function provides performance feedback in the function's quarterly report or as results are being reported (from performance of certified reference materials that the department inserts in every batch submitted), with the marketing function providing feedback as and when assay exchange between the laboratory and external client is completed. Compliments and complaints are captured as part of customer feedback. Laboratory has a customer satisfaction survey process which is conducted every quarter. The customer satisfaction survey covers the following areas: turnaround time, accuracy, any future needs, overall laboratory performance etc. Laboratory staff also captures customer feedback from meetings it hols with the customer.	M
CL1	Customer Feedback	Laboratory carries out a client satisfaction survey once a year. Results of the survey are analysed and responded to accordingly. There is a formalised customer satisfaction measurement process in place. The questionnaire seeks feedback from clients on both the performance of the laboratory on a particular quality aspect and the importance of that aspect to the client e.g. performance with regards to turnaround time, data quality, housekeeping etc. and how important these are to the client. The analysis of feedback results are linked to the laboratory processes which may have to be changed in addressing poor customer feedback results. In addition to the formal survey, Client feedback is captured on an ongoing basis as the laboratory makes contact with the client and any need to evaluate and respond to the feedback is carried out as soon as possible. In addition customer feedback is also	H

		captured during face to face meetings with clients either when clients visit the laboratory or when the business development team visits the customer. Any feedback received by laboratory is captured into the laboratory management system and acted upon. Example of feedback that was acted upon includes the establishment of two satellite laboratories following client requests to have such in order to minimise sample transportation costs. Customer feedback is taken seriously and is acted upon wherever possible. To ensure feedback is adequately captured, the laboratory has client feedback forms that are given to its clients when they visit the laboratory or when the business development team visits the customers. The laboratory has a formalised customer complaints handling process which provides a valuable feedback system.	
CL2	Customer Feedback	Laboratory has customer feedback forms that are given to clients upon visiting the laboratory or when the laboratory business development team visits the clients. Feedback received applies to both negative and positive feedback but negative feedback is given high priority in terms of analysis and responding to the feedback information i.e. negative feedback is reviewed and investigated immediately upon receipt, and feedback on investigation given to clients without delay. Feedback is also captured during routine communication with clients that is when lab makes courtesy calls to clients or emails clients or when the client calls the laboratory or during any interaction with the clients' e.g. face to face meetings. Any such feedback is immediately captured in the management system of the laboratory and followed up. Laboratory has a customer satisfaction survey process in place which is carried out once a year. Customer feedback is captured through this process. Information in the survey is related to key laboratory performance indicators which are linked to customer needs and how the lab compares with competition in regards to the measured metrics. The importance of the different performance measures to the client is covered in the survey. Responses are analysed and appropriate actions taken to address any shortfalls and facilitate improvement. Other performance measures sought indicate turnaround time, quality of data, level of service etc.	H
			
MS1	Information dissemination and Responsiveness	Dissemination of information on customer requirements to laboratory staff is done through tool box talks meetings. These meetings are held every morning and information passed could be information on urgent work that has come up, specific client concern etc.	L
MS2	Information dissemination and Responsiveness	Client needs are communicated to laboratory staff during laboratory liaison meetings. (However, new needs are rare). Liaison meetings are held once a month. There is a weekly meeting for laboratory management and staff and one for supervisory team and client needs are disseminated through these meetings as well. Information may include change in volume of work due to project samples or test work. There is a laboratory group email address which is used for such communications. Communicated needs are implemented as much as possible.	M
CL1	Information dissemination and Responsiveness	There is a documented procedure on dissemination of customer information. Information is disseminated during weekly meetings. There is a weekly review meeting with lab workers and a monthly worker's council meeting. Employees are briefed on existing lab challenges and client requests or feedback. Dissemination of information is also through a daily safety meeting. Any client needs are discussed. Negative feedback results in urgent meetings to address concerns. Laboratory takes client concerns seriously and is very responsive to concerns, queries or complaints. Laboratory carries customer satisfaction surveys once a year and is very responsive to feedback requirements e.g. positive response to client requirements to build satellite laboratory closer to customer site to reduce sample transportation costs-a form of partnership arrangement. Laboratory responded positively with the results of constructing two satellite laboratories around key clients. This development was in part supported by client commitment to use the facility and hence sharing the business risk. Both parties had to work to ensure success of the development.	H
CL2	Information dissemination and Responsiveness	Information from clients is disseminated during staff meetings. Laboratory holds weekly meetings every Monday morning before any task is undertaken. Information captured by management and discussed in management meetings is rolled down to all personnel during this meeting. Agenda include information on changes in client needs or any specific needs defined by the client e.g. samples requiring fast tracking for urgent reporting. The meeting provides platform for dissemination of the needs. The laboratory has a formalised mechanism in place for getting client feedback on its performance which is communicated to all employees during the weekly meeting and is responsive to the concerns raised. There is a formalised procedure for dealing with customer complaints and laboratory is very responsive to complaints, which are taken seriously. Action plans to address complaints are assigned to specific employees and progress in addressing customer concerns or needs is monitored during meeting.	H

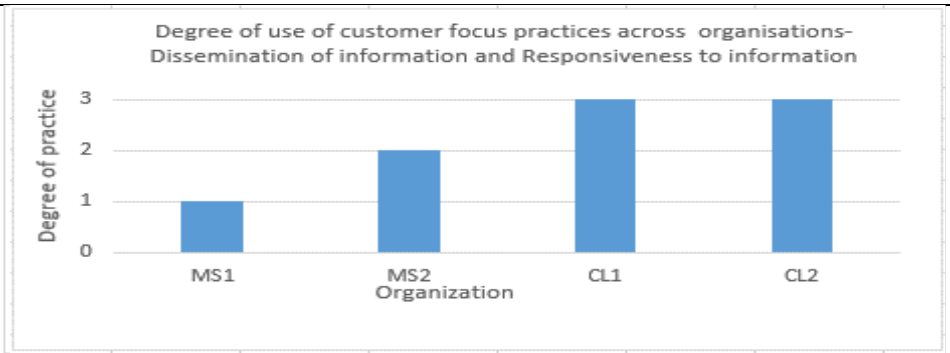
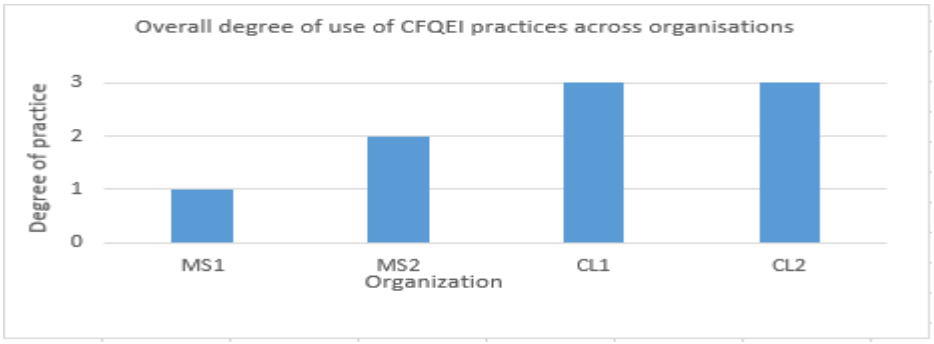
	Information dissemination and Responsiveness		

Table 4.3 (b) Overall summary of the degree of use of customer focus for quality exploitation practices (CFQEI) across the organisations

CFQEI	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Customer Relationship	L (1)	M (2)	H (3)	H (3)	0.95
Customer Information	L (1)	L (1)	H (3)	H (3)	0.89
Customer Feedback	L (1)	M (2)	H (3)	H (3)	0.95
Information dissemination and Responsiveness	L(1)	M (2)	H(3)	H(3)	0.95
Total score	4	7	12	12	
Overall Rating CFQER	L	M	H	H	0.95
Overall degree of use of CFQEI practices					

The overall degree of use of the CFQEI practices was determined by calculating the total score for the individual practices and following the rule in section 3 of chapter 3. In a similar

manner, by establishing whether there was a significant difference between the practices across the laboratories and ranking them if differences existed, the laboratories were given their rankings.

Table 4.3 (c)
Thematic summary of the use of customer focus for quality exploitation (CFQEI) practices across the case organisations (H=High, M=Medium and L=low use of practices in comparative terms)

Practice	Description of level of implementation of practices within theme	Lev
CUST-REL	Lab MS1 Client segmentation Client visits communication Technical assistance	L
	Lab MS2 Clients segmentation for customization Honest and Integrity Frequent communication Commitment to promises and targets Client visits Technical assistance Performance-meeting targets High responsiveness to queries Sticking to agreement terms	M
	Lab CL1 Client segmentation Customer Technical assistance Communication through various ways Customer visits by senior staff Courtesy and friendly calls to customers- Sharing successes and challenges Commitment to address customer concerns Honesty and integrity High responsiveness to client queries Training and empowering clients Partnership in projects Laboratory easily contactable Initiates and encourages feedback	H
	Lab CL2 Visits to customers by Business executives Various contact platforms Frequent communication through various ways Clients access to laboratory Courtesy calls to clients on business performance Free technical advice to clients High level responsiveness to queries Encouraging client feedback Facilitates method development Social meetings and events to know clients better Meeting expectations Building trust client segmentation Client support to capacitate lab Supply of test material by client which is also tested for free during development	H

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Level
Customer Focus (CFQEI)	CUST-INFO	Lab MS1 Use of multiple listening methods to understand customer requirements: e.g. shipment request forms, Service level agreements (SLA), Sample Submittal forms (SSF), Customer complaints, formal laboratory meetings, Formalised customer satisfaction surveys –once per year covering Importance placed on various performance measures e.g. accuracy, turnaround time, price and data precision etc.	L
	CUST-INFO	Lab MS2 Use of various methods to obtain information on customer requirements e.g. Laboratory scope of work, weekly scorecard meetings, request of analysis form (RAF), customer complaints, day to day interaction, field intelligence, plant visits Quarterly customer satisfaction surveys covering performance and Importance placed on some aspects of performance e.g. Turnaround time (TAT)	L
	CUST-INFO	Lab CL1 Use of various listening posts to understand customer requirements e.g. Sample Submittal Form (SSF), contracts, feedback forms, every interaction with client (Field intelligence), meetings, customer surveys, client visits by senior laboratory staff, customer complaint system, visits. Surveys gather information on performance and importance placed on various performance parameters e.g. price, TAT, Accuracy, etc. Collects information on multiple groups-e.g. current customers, former customers and potential customers Collects information on needs of competitor customers Collects information on how laboratory performs in comparison with its competitors Learn about customers and important customer trends	H
	CUST-INFO	Lab CL2 Use of multiple listening posts e.g. face to face meetings, field intelligence e.g. from Geological Society of Zimbabwe, every interaction with clients is opportunity to tap client information, use of customer complaint system, yearly satisfaction surveys, feedback systems, Identifies needs of the customers and the respective importance of the needs, Collects information on how lab is performing in comparison with competitors Collect of information on multiple customer groups (current customers, former customers and potential customers). Collects information on the needs of competitor customers Learn about customer and important customer trends through loyal participation in industry trend groups	H

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Customer Focus (CFQEI)	CUST-FEED	Lab MS1 Use of multiple avenues for getting client feedback e.g. yearly customer satisfaction surveys, use of customer complaint system, LIMS configured to some performance feedback on real-time e.g. TAT Feedback is on lab performance with respect to various performance parameters	L
	CUST-FEED	Lab MS2 Multiple avenues used to get customer feedback-Automatic system in LIMS to capture feedback on real-time performance e.g. TAT, Quarterly reports from clients, Use of complaint management system, Formalised yearly customer satisfaction survey, meetings Feedback is on performance with respect to laboratory key performance indicators	L
	CUST-FEED	Lab CL1 Multiple methods used to get feedback from the customer-customer satisfaction, Feedback captured on an ongoing basis as laboratory interacts with customers, face to face meetings, use of customer feedback forms, use of customer complaint system Feedback is with respect to performance of laboratory in meeting customer needs and the importance of the needs Feedback is with respect to performance of laboratory in meeting customer needs relative to competitors Feedback is also from previous customers Captures customer feedback from every interaction opportunity Emphasis to all employees on importance of capturing customer feedback at every opportunity	H
	CUST-FEED	Lab CL2 Multiple avenues for getting feedback from customer e.g. completion of customer feedback forms from customer, captured through routine communication with customer e.g. calls, e-mails, meetings, use of customer satisfaction surveys, use of complaint management system. Feedback is on lab performance with respect to customer needs and their importance Feedback is with regards to performance of lab in meeting customer needs relative to competitors Feedback is sought from customers who were customers for the laboratory Every interaction with customer is opportunity to capture customer feedback Employees are trained to capture feedback based on their interaction with customers	H

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Customer Focus (CFQEI)	INFO-DISS-RES	Lab MS1 Information dissemination is through tool box talks meetings	L
	INFO-DISS-RES	Lab MS2 Information dissemination is through laboratory liaison meetings-monthly, weekly Use of laboratory group e-mail Communicated needs are promptly responded to. There is a target for response time to concerns especially complaints.	M
	INFO-DISS-RES	Lab CL1 Procedure on dissemination of customer feedback-dissemination during daily, weekly, monthly meetings, technical bulletin Negative feedback responded to urgently-may call for urgent meeting to address High responsiveness to feedback, queries, concerns, complaints e.g. there is target to respond to complaints e.g. acknowledge within 24 hours and then work on resolution. Evidence of high responsiveness in development of satellite laboratories close to clients to reduce sample transportation costs Complaints taken as potential for customer lose and hence taken seriously leading to high responsiveness	H
	INFO-DISS-RES	Lab CL2 Dissemination through meetings-rolling down information to all employees, technical bulletin, notice boards High responsiveness to queries, complaints and concerns Responsibility to address concerns is normally assigned to senior lab personnel and progress in addressing them monitored weekly Target to acknowledge receipt of complaint is 24 hours and then resolve as soon as possible Once a laboratory establishes complaint was due to laboratory error and needs re-assaying samples, laboratory will quickly performs re-assaying and rapid replacement of erroneous results Complaints taken as opportunity for improvement and are taken seriously by every employee leading to high responsiveness	H

4.3.2 Rating the degree of use of Customer Focus for Quality Exploration (CFQER) Practices

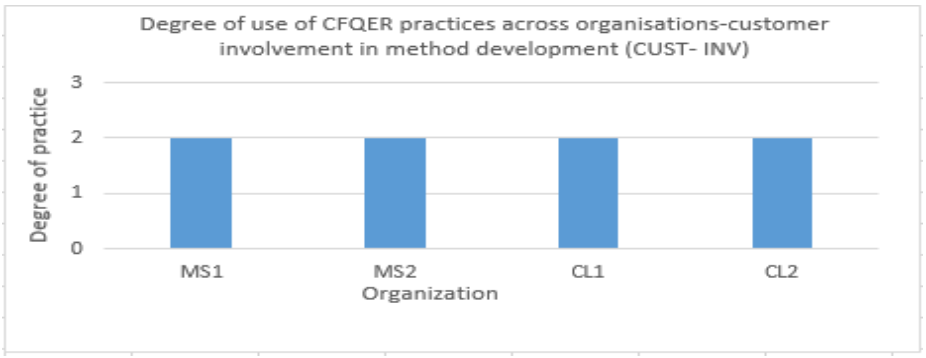
Using the same data reduction approach as for CFQEI practices, the final implementation pattern for customer focus for Quality Exploration Practices is shown in table 4.4 below.

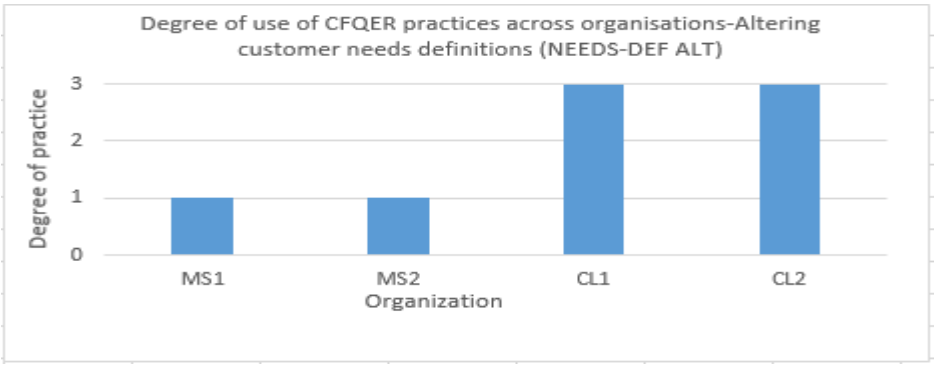
Table 4.4 (a)
Summary of the use of customer focus for quality exploration (CFQER) practices across the case organisations (H=High, M=Medium and L=low use of practices in comparative terms)

Lab	CFQER	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Exploration of new customer needs-Customer Information	The laboratory has not actively gone ahead of clients to identify potential client needs. The laboratory does what they are requested to do. In not many cases, when the laboratory goes to lab shows e.g. Lab Africa where it might identify better ways of doing assays that it may consider adopting that e.g. reducing errors by adopting microwave digestion instead of fusion digestions.	L
MS2	Exploration of new customer needs-Customer Information	New needs come from the strategy of the company. Should needs come from the customer then they are fulfilled as well. Customer needs from the customer have included the analysis for arsenic in concentrate samples. New needs are therefore defined by business strategy and customer requirements. As a result of the customer requirements on Arsenic in concentrates, Arsenic is now done in all materials analysed at the laboratory. Initially, it was done in concentrates but it is now done from ores to concentrates. Currently the company sales the concentrate material through a trading arm of metal trader company, who then sells to a variety of buyers. Most of the material goes to Canada and China. Final user needs come through the metal trading company. Most issues from client concerned product quality and not assays. Although the laboratory has had its own analytical issues, these have been addressed. New needs are also captured from the customer satisfaction surveys that are conducted.	L
CL1	Exploration of new customer needs-Customer Information	The laboratory ensures that knowledge concerning the new needs of the customer is obtained through direct communication with the clients during face to face meetings when clients visit the laboratory. The information is obtained from direct questions to clients on what additional needs the client has or where could the lab improve to support the client business strategies better. The clients then state their new requirements during these visits and the laboratory follows up on the defined needs. In some cases it could be the client requesting the laboratory to carry out additional tests on previously completed work which on further follow up it becomes a new need. Similarly the same approach is used when business development team visits the clients. The laboratory management makes routine visits to the Geological Survey department where it gets information on exploration activities in the country including that being conducted by the laboratory's existing clients. This information provides the laboratory with a lead on potential new needs of its existing clients which it follows up on with the clients. The laboratory management utilises every interaction with the client to identify needs that may have not been even clearly articulated but are known to exist from the discussion. Laboratory management always give its clients the floor to highlight their needs during every interaction process. The laboratory uses industry knowledge to suggest to clients other elements that can be analysed for by methods already being used for the client samples but client having not requested for that e.g. Laboratory suggested adding Arsenic analysis when lithium was asked for. Through the analysis of customer feedback information and customer satisfaction survey data, the laboratory identifies potential new needs of its clients e.g. need for establishing sister laboratory in a location closer to some of the clients resulting in reduced sample transportation costs. The laboratory captures	H (M)

		information on lost tenders and establishes reasons for the loss in which case new client needs could be identified.	
CL2	Exploration of new customer needs-Customer Information	The laboratory management reviews trends in the mining industry and follows the direction in which the economy is moving. An example is the lithium exploration in Zimbabwe which was noted as a key event in the economy but no laboratory in Zimbabwe was providing the analytical service for this development. This was identified as a new need in the mining sector and the laboratory developed a method for the analysis of lithium. Laboratory CL2 became the first laboratory to develop and have the lithium analytical method offered and accredited in Zimbabwe. Currently there is a trend towards rare earth elements in the mining industry and no one is offering this service in Zimbabwe and hence the laboratory is working on the rare earth methods. The laboratory anticipates that this will be a new need and is working on the equipment and additional resources for developing the capability. Additional needs of the customer are established through discussion with the customers either through telephone calls; when client visits the laboratory or when business development team visits the customers. Clients can specify their new needs during these interactions. The laboratory anticipates some new customer needs through discussions with the customer. A typical example is the determination of lithium stated above. "First, exploration companies visited the laboratory not knowing that anyone could do the analysis of lithium. We also knew which companies were doing lithium exploration and we made contacts with them and offered the service. As a laboratory, you need to invite customers to visit the laboratory, ask them to send a few samples for analysis even for free for them to gain confidence in your capability. For the listeria bacteria issue in South Africa, the laboratory went ahead and developed a method to analyse for listeria. When customers finally came seeking the service of the laboratory, the laboratory was already prepared to provide the service. When this happens, the customers will always approach you first when they have a new need and can offer your organisation assistance to build capacity." Stated one of the directors at organisation CL2. (A form of partnership arrangement). The laboratory also follows the various strategic groups in the country e.g. the Agricultural groups, Mining Engineers groups, Metallurgists platforms to know what is happening in the areas of interest where the laboratory can provide its services. Management of the laboratory also attends conferences and follows leads from these conferences. Other new needs are identified through the feedback received from clients during customer satisfaction surveys and the analysis of customer complaints data.	H
			
MS1	Collection of information on new customers-[Customer Information]	The company does not easily get new customers. Generally, all products are committed to existing clients and there is no effort put to get new customers. This implies that the laboratory remains with its few external customers and the internal customers.	L
MS2	Collection of information on new customers-[Customer Information]	The laboratory has one main external customer and several internal customers. The laboratory has had other potential customers for the product and who would be for the analytical services, but the current trading company has always made better offers. Commercialising the laboratory services has been discussed but it has been noted that there are so many players in the business.	L

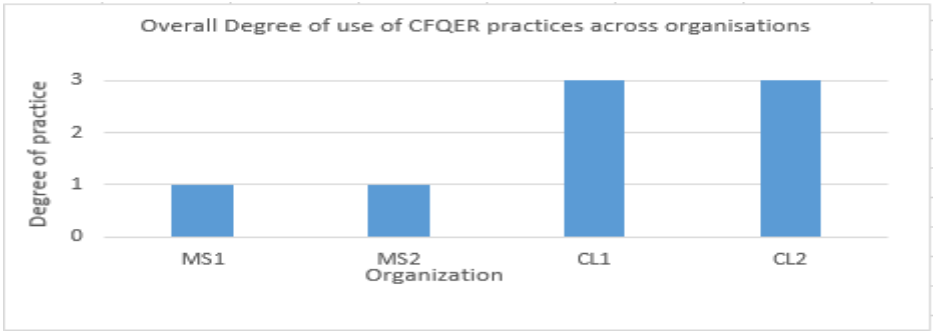
CL1	Collection of information on new customers-[Customer Information]	The laboratory attends Mine Entrap (Zimbabwe International Trade Fair) where it spends a week advertising the analytical services offered by the laboratory. In addition the laboratory produces Flyers, T-shirts, and pens as part of marketing efforts. This is where the laboratory gets details of potential new customers for follow up. The laboratory Management visits clients and potential clients as part of business development. In addition laboratory Management visits the Provincial offices and the Geological Survey offices. This is where the laboratory identifies activities in the survey department and mining industry including who is focusing on what and makes the basis for identifying new customers. The laboratory has developed a website from which all its adverts, contact details, capabilities, offers etc. are documented. The website contains the laboratory's accreditation details e.g. methods offered; scope of accreditation, contact details etc. and customers can contact the laboratory through the details on the website. During follow-up with the potential clients, the laboratory tries to establish why the potential client is not using the laboratory for its analytical services. From, this the laboratory identifies the needs of these potential customers.	H
CL2	Collection of information on new customers-[Customer Information]	Information on new customers and their requirements is obtained through the marketing effort of the organisation. If something comes up in the papers, then we follow it up" indicated one senior executive at organisation number CL2. The company seeks for information on who is doing what in exploration from the Geological Survey department and follows up with the potential clients." The laboratory advertises its services in a number of ways e.g. local papers, mining Expositions, radio, website etc. The marketing and business Development sections mainly handle this function. Business Development team has routine visits to known mining companies who are not yet customers of the organisation and markets the laboratory's analytical services. The needs of these potential clients are identified during these visits and discussions. The laboratory follows the various strategic groups in the country e.g. the Agricultural groups, Mining Engineers groups, Metallurgists platforms to know what is happening in the areas of interest where the laboratory can provide its services. Requirements of potential clients are identified through these strategic groups. Management of the laboratory attends conferences and follows leads from these conferences. Adverts on website and papers enable potential clients to contact the laboratory with their full details and requirements.	H
			
MS1	[Customer involvement-CUST-INV in method development	This is very low. If a new product has to be developed, the laboratory will look at cost and efficiency other than anything else. Customer involvement is only the definition of its needs that defines the need for the method. Development only restricted to efficiency and cost reduction e.g. microwave digestion can cut down digestion time by 30 minutes.	M
MS2	[Customer involvement-CUST-INV in method development	The involvement of client in method development and validation is mainly the request for the method i.e. when client requests for the introduction of a particular method.	M
CL1	[Customer involvement-CUST-INV in	Clients are involved in the development of new methods through their submitted requests. Clients can request for the development of a particular method or capability in analysing samples for some elements to specified detection limits e.g. clients for the laboratory requested for analysis of gold by	M

	method development	Aqua-regia digestion method with solvent extraction to achieve lower detection limits. Clients submit own samples for testing during the development and validation of method.	
CL2	[Customer involvement-CUST-INV in method development	Customers influence the development of new methods.	M
			
MS1	Altering customer needs definitions-NEEDSDEF-ALT	Not significant	L
MS2	Altering customer needs definitions-NEEDSDEF-ALT	Not implemented to a significant level	L
CL1	Altering customer needs definitions-NEEDSDEF-ALT	The cases discussed above apply. Most customers e.g. the artisanal miners are layman in the field. They would just come and ask for gold or chrome analysis. Few guys would know what methods are to be used. In the case of Artisanal miners the laboratory may lead in identifying the needs of the clients. Some other customers would know exactly what they would want assayed for e.g. develop a method for this but in some cases it's only a few samples. For laboratory number CL1, when the need for Lithium determination came and a method was developed the laboratory offered analysis for Antimony, a capability the laboratory had developed to be analysed alongside Lithium analysis. After the development of the Aqua regia digestion with solvent extraction method for gold determination and obtaining lower detection limits, the lower detection limits became the new detection limit requirement for most clients. Laboratory now makes this a sell point convincing clients that this is the ideal detection limit.	H
CL2	Altering customer needs definitions-NEEDSDEF-ALT	"The laboratory is not really strong on research and development because of budget constraints" said one director at company CL2. However, the laboratory communicates the benefits of analysing for other elements in submitted samples even if these elements did not form the original requests e.g. Other bacteria and not only E-coli to provide a complete and valuable offer. Customers then put additional parameters for analysis constituting additional client requirements coming from the laboratory. Tracer elements are a good example in exploration samples. Where clients have wanted the laboratory to use their own methods the laboratory has always tried to give the customer the various method options that the laboratory already has, shaping the client needs towards the capability of the laboratory and not necessarily developing new methods always. The laboratory influences needs to analyse for additional elements as part of analytical suite where it would be of benefit to the client.	H

			
MS1	Complaint analysis for improvement-IMPROVEMENT	Not significant Laboratory has a customer complaint management system in place. The laboratory at the time of the interviews had an active customer complaint from the internal customers. The issue was about product consistency in the stockpile versus precision in data analysis and had something to do with the sampling process. The conclusion from the investigation was that the laboratory had to take over sampling. There is significant knowledge of sampling at the laboratory. ISO standards for sampling chrome products are very comprehensive and well defined but this puts a lot of pressure on production personnel and hence potential for not performing sampling correctly. ISO 17025 has sampling as a requirement. Sometimes the results reported to the customer are lower because of sampling errors. The Laboratory Manager stated,"80% of the places I have worked at, sampling is taken as simple and straight forward as possible. Sampling is a science on its own. In an environment where we work, people look at the laboratory as a black box. Bad sample will just give bad results. One can perform all laboratory processes perfectly, but as long as I get a wrong sample, it does not help"	L
MS2	Complaint analysis for improvement-IMPROVEMENT	"This process is not used to a very high extent, since the number of complaints is not many but the laboratory has used the complaint system to make some improvements. Our procedure on customer complaints involving investigation, root cause analysis and corrective action implementation has forced the laboratory to review in detail the laboratory management system. Current complaints are on turnaround time e.g. this implies that the laboratory needs to relook at the laboratory arrangement or set up of the laboratory to meet business needs of turnaround time", stated the Laboratory Manager of organisation number 4. When the complaints are received the laboratory carries out an investigation to establish the root cause of the complaint. In some cases the laboratory finds out that it was on the wrong and hence implements the required corrective actions but some cases it's not. This comes after thorough investigation of the problem. On another hand, it sometimes occurs that the laboratory was not wrong and appropriate communication is made to the client. Where the problem points to the laboratory's system, appropriate corrective action and improvement is made to the laboratory system.	L
CL1	Complaint analysis for improvement-IMPROVEMENT	When the laboratory receives any customer complaint, it immediately addresses the complaint. There is a formalised procedure to handle customer complaints. Once a complaint is received, it is investigated and corrections and or corrective actions are implemented. Improvements are implemented from addressing the complaint. These improvements may be in the form of modifying a method, improving turnaround time etc. Most complaints are related to turnaround time; especial the artisanal customers who bring say one sample and do not understand why one sample cannot be reported on time. The laboratory has made an improvement by creating two different routes for single sample clients and those that bring many samples. Some complaints are related to poor Quality and improvement is focused on improving the poor quality. Why poor turnaround time? As a typical example, laboratory CL1 established that the root cause of poor turnaround time complaints was poor communication. Complaints were due to poor communication with the client on instrument	H

		breakdown and power outage. Poor communication was noted to be internally as well, especial during shift handover and with the client when breakdowns or when power cuts were experienced. In most cases it was noted that the customer was not informed of the challenges that will lead the laboratory to fail to achieve the promised turnaround time. If the foreseen delays are communicated, then the complaints may not be raised. Improving communication helps and hence becomes an area of targeted improvement. Laboratory has made improvements in this area as a result of customer complaints. Complaints are an indication of the potential to lose clients and the laboratory highly values the importance of thorough investigations and commitment to addressing the complaints. The complaints analysis is linked to customer feedback during satisfaction surveys and the importance given to parameters that are the subject of the complaint, enabling the laboratory to prioritise the improvement process.	
CL2	Complaint analysis for improvement-IMPROVEMENT	The laboratory has a system for handling customer complaints. The procedures outlines the receiving, and recording of the incident, investigating the incident, establishment of the root cause and implementation of the appropriate corrective action, and communicating the corrective actions to the client. Every employee has been trained to understand the customer complaint handling procedure. The laboratory takes customer complaints seriously and looks at how the laboratory can improve following a customer complaint. Every complaint is regarded as an opportunity for improvement. The employees are encouraged to take complaints seriously and never to put complaints under the carpet. "It is better to work on the complaints than to hide them." Said one of the directors at the laboratory. Complaints are separated from other forms of feedback received by the laboratory. This is to ensure that the complaints receive the uttermost attention that they deserve and are responded to as soon as is practically possible. "The most important part of the laboratory management system is to improve, hence the need to capture feedback from the clients" stated one senior manager at organisation CL2. Upon arriving at the laboratory, customers are given a customer feedback form to complete. The customers can give either positive or negative comments. When negative comments are given, the laboratory quickly discusses them and responds accordingly. Client feedback can be received through email. Feedback received by telephone is immediately registered for implementation of corrective action or responding to the client. Once a year the laboratory also submits a customer satisfaction survey questionnaire. Response to the questionnaires is analysed and actionable items implemented. Poor feedback or negative feedback is treated like a complaint. All complaints are recorded as non-conformances and there is a procedure for handling non-conformances.	H
			

Table 4.4 (b) Overall summary of the degree of use of customer focus for quality exploration (CFQER) practices across the case organisations

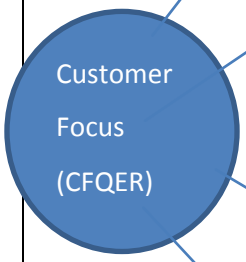
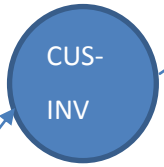
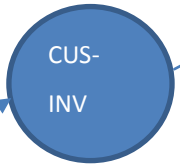
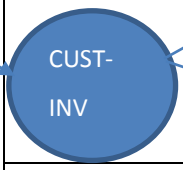
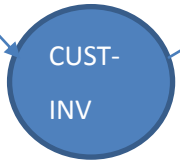
CFQER	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Exploration for new customer needs	L (1)	L (1)	H (3)	H (3)	0.89
Customer involvement	M (2)	M (2)	M (2)	M (2)	-
Altering customer needs definition	L (1)	L (1)	H (3)	H (3)	0.89
Improvement from analysis of complaints	L (1)	L (1)	H (3)	H (3)	0.89
Total score	5	5	11	11	
Overall Rating CFQER	L	L	H	H	0.89
Overall degree of use of CFQER practices					

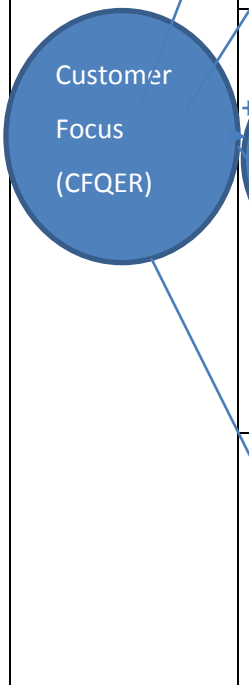
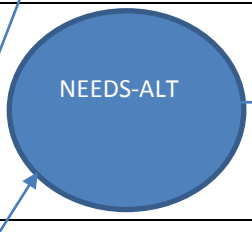
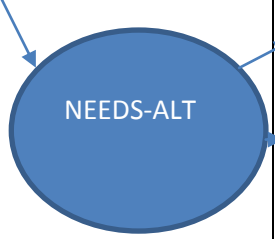
The overall degree of use of CFQER practices was determined by calculating the total score for the individual practices and following the rule in section 3 of chapter 3, i.e. by establishing whether there was a significant difference between the practices across the laboratories and ranking them if differences existed as per procedure used for CFQEI practices to arrive at the pattern above.

Table 4.4 (c)

Thematic summary of the use of customer focus for quality exploration (CFQER) practices across the case organisations (H=High, M=Medium and L=low use of practices in comparative terms.

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Customer Focus (CFQER)	INFO-NEW-NEEDS	Lab MS1 Focus is on defined needs-No active search for new customer needs-Process is inbound	L
	INFO-NEW-NEEDS	Lab MS2 Focus is on customer defined needs. No active search for new needs. Process is inbound	L
	INFO-NEW-NEEDS	Lab CL1 Active search for new customer needs (face to face meetings) Follows up on new needs to meet them Obtain leads on new customer needs from Geological Survey Department and follows up on them Extraction of new needs from interaction with customers (Every interaction opportunity) Use of industry knowledge to suggest to customers the needs that they may not be able to express Analysis of customer feedback information actively searching for new needs Captures information on lost tenders to identify reasons and potential needs Carries out surveys on non-customers to identify potential customer needs(which could be new) and not currently met e.g. why not using the lab Identified from needs of competitor customers	H
	INFO-NEW-NEEDS	Lab CL2 Active follow up on industry trends in the mining industry e.g. lithium, rare earth elements identified as new needs Direct communication with customers and seek for new needs Following various strategic groups in the country e.g. mining engineers Attend conferences and follow up leads from there Analysis of feedback information from customers Active search from the Geological survey department of Zimbabwe Follow up to meet new needs e.g. develop new methods New customer needs also identified from needs of competitor customers	H

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
		Lab MS1 Restricted to defined needs and clarification of needs	M
		Lab MS2 Restricted to request for new methods	M
		Lab CL1 Restricted to customer request for new methods Development of new lab site to ensure customer samples are preliminary prepared to reduce transport cost	M
		Lab CL2 Restricted to customer requested methods	M

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
		Lab MS1 Not implemented	L
		Lab MS2 Not implemented	L
		Lab CL1 Lab effort to identify needs of the Artisanal miners-Artisanal miners may not really know their needs Influence customer where analysis could be technically useful but customer unaware and lab has capability e.g. antimony analysis for lab CL1 Influence customer requirements by developing a capability that finally become a requirement e.g. low detection limits for gold analysis (shaping customer needs towards lab capability) Influence analysis of elements as part of analytical suite for client benefit	H
		Lab CL2 Influence customers to analyse for other elements to provide complete and valuable offer and requirements become standard Give customer options that meet their requirements but lab having the capability already e.g. With tracer elements in exploration	M

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Customer Focus (CFQER)	IMPROV-FCOMP	Lab MS1 Formal procedures for handling complaints that initiates improvement Corrective actions result in improvement e.g. transfer responsibility for sampling from plant to lab.	L
	IMPROV-FCOMP	Lab MS2 Formal procedure is followed to address complaints Complaints may result in review of all processes in detail All complaints investigated and formally reported-corrective action leads to improvement	L
	IMPROV-FCOMP	Lab CL1 Formal system in place for handling complaints Corrective actions to complaints leads to improvement Developed new system as part of improvement emanating from addressing customer complaints on turnaround time e.g. dual reporting system. Improvement on communication with customers as part of addressing customer complaint on turnaround time Laboratory sees complaints as a potential to lose customers and addresses them effectively (Lab takes complaints seriously). Complaints linked to customer feedback and the importance given to parameters subject of complaint-enabling lab to prioritize improvement High responsiveness to complaints Lab makes it easy for clients to complain e.g. whatsApp call availability, e-mail, website, face to face etc.	H
	IMPROV-FCOMP	Lab CL2 Formal procedure followed in handling complaints Lab takes complaints as opportunity for improvement and every employee is encouraged to take complaints seriously Complaints clearly separated from other forms of feedback to ensure utmost attention in addressing them High responsiveness in addressing complaints Encourages customers to complain when required and making it easy for them to do so e.g. multiple communication channels available and made known to customers Corrective action leads to improvement High level of responsiveness to complaints	H

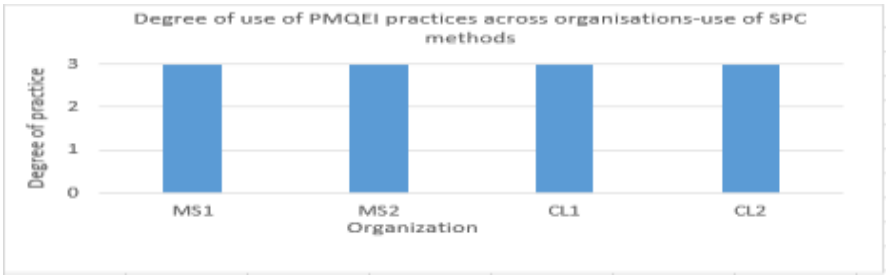
4.3.3 Rating the degree of use of Process Management for Quality Exploitation (PMQEI) Practices

Using the same data reduction approach as for CFQEI and CFQER practices and further guidelines in measuring each variable, Appendix A, the final implementation pattern for Process Management for Quality Exploitation Practices (PMQEI) is shown in table 4.5 below.

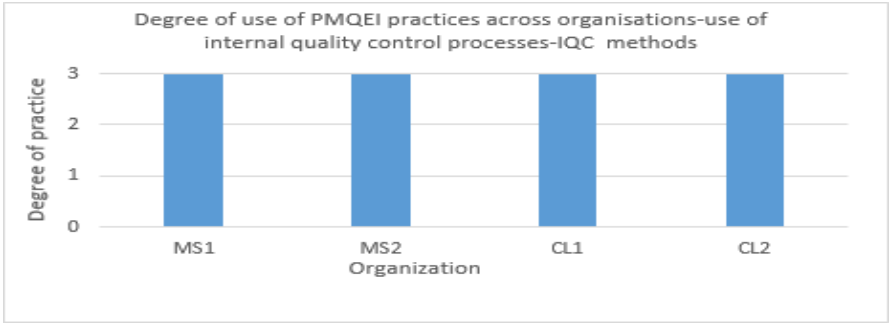
Table 4.5 (a)

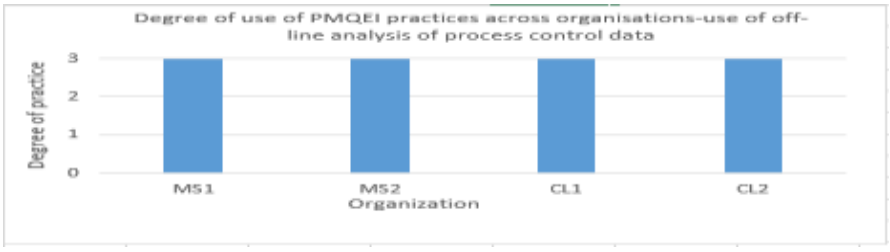
Summary of the use of Process Management for quality exploitation (PMQEI) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

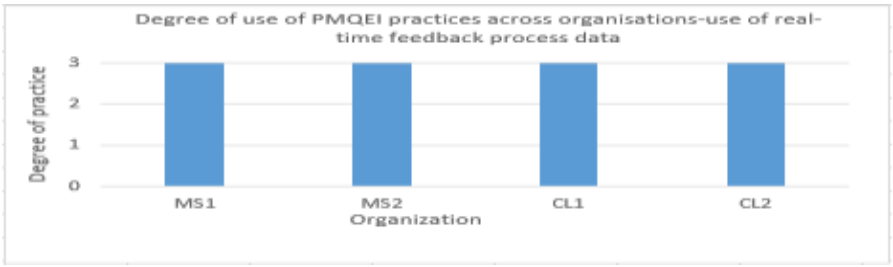
Lab	(PMQEI)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Use of statistical methods of analysis	The laboratory uses most statistical methods of analysis for significance testing during the method validation process e.g. T-test, F-test etc. Thereafter methods performance data for all certified reference materials in use and elements analysed is reviewed and control charts are used significantly to monitor state of control of the methods during routine use. Action is taken for all results trending badly e.g. bias, negative or upward trending for a time outside expected tolerances, or unexpected scattering etc. Z-scores statistics are used to evaluate laboratory performance in round robin and proficiency testing analysis and targets are set for acceptable performance. Action is taken when out of specified tolerances is realised. Evidence of reviews and action taken were noted. Data is reviewed weekly, monthly and on an ongoing basis internal quality control and as results are made available for external quality control.	H
MS2	Use of statistical methods of analysis	Statistical methods are used significantly during method validation e.g. T-test, F-Test, etc for significance testing of validation parameters to establish whether performance of new method is significantly different from established methods or whether means obtained for certified reference materials are different significantly from declared values. QC Charts, HARD plots, scatter plots are all used for controlling quality of work and monitoring trends. QC charts for every element and certified reference material used are reviewed weekly and monthly and on an ongoing basis as results are approved. Z-score statistics are used for evaluating proficiency testing data and actions are taken for data trending badly. Evidence of data reviews using these methods was noted.	H
CL1	Use of statistical methods of analysis	Statistical methods are used during the validation process to establish fitness of purpose for any particular method. These tests include but not limited to T-test, F-test, mean, standard deviation etc. Control charts are significantly used to routinely monitor state of analytical control of the methods and trends. Charts are reviewed weekly and monthly when monthly reports are generated and also on an ongoing basis as data are being approved. Action on poor trending data is acted upon. Data is generated for all certified reference materials used and elements being analysed. Z-scores statistics are used in evaluating laboratory performance in inter-laboratory participation. Evidence of review and auctioning of unwanted trends was noted.	H
CL2	Use of statistical methods of analysis	Statistical methods of analysis are used especial during method validation stage. These include basic statistical methods e.g. mean, standard deviation significance testing statistics e.g. F-test, T-test. QC charts are used for monitoring statistical control of methods during routine use. Charts	H

		are reviewed weekly, monthly and on an ongoing basis and poor trending is acted upon. Charts are reviewed for every certified reference material used and every element analysed. Z-score statistics are used to evaluate laboratory performance on proficiency testing. Poor trends are addressed. Evidence of data review and auctioning of poor trends was noted.	
	Use of statistical methods of analysis		
MS1	Use of Internal Quality Control (IQC) processes and procedures	Every batch of samples analysed includes one blank sample, one duplicate and two certified reference materials. The laboratory has an intra-laboratory programme in place where samples are analysed by different analysts and results compared. Commercial samples area done in triplicates and analysed by two different analysts. Results are only reported if the results of the two analysts agree within defined acceptable limits. There is a set of certified reference materials that are rotated to ensure analysts do not get used to one set of certified reference materials. The knowledge of the process resulting in reasonable expectation of results provides an additional quality control aspect. QC charts are generated for all certified reference materials that are used and all elements that are analysed. The charts are reviewed weekly and monthly and on an ongoing basis and displayed in the laboratory. At the instrument stage, calibration process has to achieve a targeted correlation coefficient in order for analysts to proceed with sample analysis and a QC solution is read before samples are read. Corrective actions are implemented where targets are not met. Sample preparation QC involves performing pulverising or milling efficiency QC test at a rate of one sample per batch. Milling equipment is cleaned with barren material which is previously tested to ensure its meet quality for a clean blank. There is a defined QC procedure in place and process follows a documented work instruction. Only equipment that has been tested is used for analysis. Authorised and competent personnel perform the analysis.	H
MS2	Use of Internal Quality Control (IQC) processes and procedures	The analytical processes follow clearly documented work instructions. QC control begins with the sample preparation stage where crushing QC and milling quality control is performed to ensure samples have been prepared correctly. The analytical batch size is twenty samples and consists of three quality control samples (one certified reference material, one blank and one duplicate sample). This gives a quality control to sample ratio of about 15%. There is an additional coarse duplicate sample once in a while. A blank sample is analysed between every sample and a blind sample is often include in the batch. This sample is a certified reference material known to the supervisors but not known to the analyst. So QC to sample could go up to 20%. For commercial samples each sample is run in triplicate and done by two analysts. Results are only reported when there is good agreement between the two analysts. The calibration process has defined tolerances to be met for linearity of the instrument response to standard concentrations. Reading of samples has to meet defined standard deviations as three readings are taken per sample. A QC solution is read after calibration to check the quality of calibration. There are defined tolerances for the QC solution. QC Charts are generated and reviewed weekly, monthly and daily as results are reported. QC charts are displayed around the laboratory. Corrective actions are taken when QC charts are trending poorly. The laboratory rotates about six certified reference materials to ensure analysts do not get used to use of same standard. The laboratory participates in proficiency testing scheme. Only authorised and competent employees perform the laboratory tasks. Suppliers are	H

		selected based on competence to supply consumables that are fit for purpose and some reagents are tested for suitability before being put into use. Equipment is maintained and records of maintenance are kept.	
CL1	Use of Internal Quality Control (IQC) processes and procedures	There is a detailed internal Quality Control procedure that is followed to control quality of work, from preparation, weighing, digestion, analysis and reporting of data. Furthermore, every process is clearly defined in a documented procedure which is followed during implementation. There are several quality control stages and materials used in the analytical process. Incoming reagents are analysed for suitability before being put in use. Where not possible supplier selection ensures that reagents purchased are produced by a competent supplier. Equipment is tested before its place into uses e.g. grinding vessels for sample preparation. Only competent employees are used to carry the analytical tasks. All samples analysed are analysed with a batch of control samples which are treated in a similar manner with the client samples. The control samples include blank sample which are used to monitor level of analytical contamination, certified reference materials to monitor method accuracy and duplicate standards to monitor precision. Sample preparation is cleaned with barren material after every five samples unless the operator identifies a need to increase the frequency of equipment wash. Quality control for the crushing and milling stage is performed by analysing the amount of sample passing a defined mesh size. Targets are set for % passing defined mesh for both crushing and milling. Procedure clearly defines action to be taken when failures are encountered. Evidence of adherence to procedures was noted. Crushing QC is performed at the rate of one in every 20 samples and milling QC at a rate of one in 20 samples. Corrective actions are taken when crushing or milling targets are not achieved. Quality of barren material is checked before use. The laboratory works with a sample batch size of 20 samples. In each batch there is one blank sample, one certified reference material and one duplicate sample giving a control sample inclusion rate of 15%. Quality control at the instrument stage includes the uses of set limits for calibration linearity. A Quality Control (QC) solution, mid-range standard is used to check quality of calibration before samples are analysed. This sample is continuously read after every twenty samples. QC charts are generated for all certified reference materials used and elements analysed. These are monitored daily during data approval, reviewed weekly and monthly. QC charts are printed and displayed in the laboratory. The laboratory has a program of sample analysis by different analysts as part of inter-laboratory analysis. Laboratory participates in external quality control program (proficiency testing scheme). There exists an additional internal quality control process where a re-scale solution is used. Corrective actions on poor or unwanted trends are taken.	H
CL2	Use of Internal Quality Control (IQC) processes and procedures	There is a detailed quality control procedure defining controls to be taken across the analytical process. There are set tolerance limits for calibration curve linearity which should be achieved before samples could be read. There are set limits for expected instrument response per given concentration of element being analysed. Once these are achieved a QC solution is analysed to check quality of achieved calibration. This solution has to give results within clearly defined limits for acceptability of the calibration stage. A QC blank is included as part of checking the calibration quality. Sample analysis is per batch of 23 samples. For every batch there are a blank sample, one certified reference material and one duplicate sample giving a quality control to sample ration of 13%. Additionally, a blind sample is added (not always). This samples is a certified reference material but not known by the analyst. On average the QC to normal sample ration averages 15%. An independent QC sample used to check the quality of calibration is read after every twenty samples. QC charts are generated for all processes and every certified reference material used and for every element analysed. The charts are displayed around the laboratory. Corrective actions are taken for poor trending data. Work follows clearly defined work instructions. Sample preparation equipment is cleaned using barren material. The quality of the barren material is established before use to ensure it meets required standards. Sample preparation QC control is performed to	H

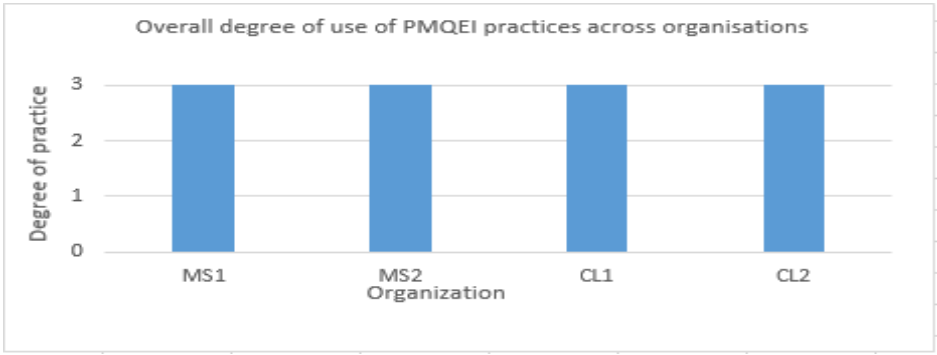
		ensure sample crushing and milling has achieved the required particle size. One crushing quality control sample and one milling quality control sample is performed per batch of samples being analysed. Corrective actions are taken when targets are not met, and these are clearly defined in the work instructions. Every process is clearly defined in a documented procedure and all tasks are carried out by competent personnel authorised to carry out the tasks. Reagents are tested before use and every equipment is also tested before commissioning. Proper maintenance schedules are defined for all critical equipment.	
	Use of Internal Quality Control (IQC) processes and procedures		
MS1	Use of mistake proofing mechanisms (zero defects mechanisms)	Only correlation coefficient of the calibration graph is employed, otherwise reliance to act is on the analyst intervention	M
MS2	Use of mistake proofing mechanisms (zero defects mechanisms)	Relies on the correlation coefficient of the calibration graph. The instrument stops if the target linearity is not achieved. No, other aspect is utilised.	M
CL1	Use of mistake proofing mechanisms (zero defects mechanisms)	Instrument calibration quality to meet specified pass criteria e.g. linearity, calibration process stops if linearity is not achieved. The mid-range standard to be within set limits, otherwise instrument is set to flag and stop the analytical process if the required limits are not achieved. The mid-range standard is not one of the calibration standards being used.	M
CL2	Use of mistake proofing mechanisms (zero defects mechanisms)	The instrument is set to flag and stop if the QC solution reads outside acceptable limits. Calibration of the instrument has to meet some quality requirements for linearity and the process stops if the linearity is not achieved. The calibration graph does not plot if set linearity limits are not achieved. The QC solution is not one of the calibration solutions.	M
	Use of mistake proofing mechanisms (zero defects mechanisms)		
MS1	Off-line analysis of Process Quality Control data. Performed off-line. [Extent to which	QC charts are reviewed daily as results are approved and once every month. Proficiency Testing scheme data is reviewed as it is received and for management review. Management review done once a year and reviews all other laboratory key performance indicators, covering complaints, audit results, results of proficiency testing and inter-laboratory participation, performance of certified reference materials, blind samples, duplicates and blank samples. Complaints and	H

	quality control data is analysed offline]	customer feedback are analysed as they are received and monthly. Client survey data is analysed once a year. Results of inter-laboratory performance and proficiency testing data reviewed as data is made available and once every month. Performance of duplicate samples is done daily and monthly. Evidence of implementation was noted.	
MS2	Off-line analysis of Process Quality Control data. Performed off-line. [Extent to which quality control data is analysed offline]	A weekly report on laboratory performance covering the key performance indicators is generated for top management review. The report covers turnaround time performance, data quality, result of proficiency testing etc. Monthly QC report on similar KPI above is generated. Customer complaints and feedback are reviewed as they are received, analysed weekly and monthly. Proficiency testing data is reviewed as it is received weekly and monthly. Qc charts are reviewed every week and monthly. Client survey data is reviewed every quarter. QC charts are reviewed daily, weekly and monthly. A management review is conducted once every year and reviews all other laboratory key performance indicators (results of audits, complaints, feedback from customer, training requirements, proficiency testing data, etc.). Evidence of implementation was noted.	H
CL1	Off-line analysis of Process Quality Control data. Performed off-line. [Extent to which quality control data is analysed offline]	QC charts data trends are monitored daily, visually and analysed weekly and monthly. The plotting of QC charts is done weekly, although data is collected daily. Customer complaints are analysed as they are received and formally once a month. Customer feedback is analysed as the information is received and formally report generated once a month. Every element QC data is audited at least once a year and results of the audit reviewed and analysed. Client survey data is generated and reviewed once a year. Results of proficiency testing reviewed as they are received and action taken. Results of inter-laboratory participation reviewed as they are received. Customer complaints, audit results, customer feedback, results of proficiency testing, certified reference material performance data, etc. are all reviewed additional once a year as part of the management review process. Corrective actions are implemented where need is identified. Evidence of implementation was reviewed.	H
CL2	Off-line analysis of Process Quality Control data. Performed off-line. [Extent to which quality control data is analysed offline]	Results of control samples (blind samples, QC standards, duplicates) are reviewed daily and analysed weekly. QC charts are reviewed weekly and at the end of the month. Formal review of QC charts by section supervisors are done weekly. Every month a QC report with all key Quality indicators is generated by managers and discussed at management meeting every two month. Customer complaints and customer feedback are reviewed as they are received and every month. Customer enquiries are reviewed as they are received and every month. Proficiency testing data is analysed and reviewed as it is made available. Internal audit results, external audit results, customer complaints, customer feedback, results of proficiency testing, certified reference material performance data, etc. are all reviewed additional once a year as part of the management review process. Actions to address areas of concern are implemented. Records of implementation were reviewed.	H
	Off-line analysis of Process Quality Control data. Performed off-line. [Extent to which quality control data is analysed offline]		
MS1	Use of real time feedback to control the analytical process?	The laboratory uses QC solutions known to the analysts and the results of these samples are a source of real time feedback data. The analysts take appropriate timely action as the results are produced. The analysts uses information on expected correlation coefficient of calibration graph as timeous information on whether analysis is out of control or not. Each calibration standard is associated with an expected absorbance (instrument response) and this information is real time	H

		feedback to the analyst. Similarly analysts use certified reference materials known to them as source of real time feedback data.	
MS2	Use of real time feedback to control the analytical process?	There is a target for the reading of a blank sample on the instrument and as analysts reads the samples, the value obtained for the blank immediately provides information on state of performance of the analytical process. The results of certified reference materials known to the analysts provide some form of real-time feedback data on state of process control. The analyst can therefore control his own work with this real time feedback data. QC solution e.g. initial calibration verification solution and continuous calibration verification solution provide real time data for quality control. Results of expected instrument response signal strength is a source of real time feedback data and similarly the expected correlation coefficient data on calibration graphs.	H
CL1	Use of real time feedback to control the analytical process?	Real-time data is obtained from results of the mid-range standards. These results are reviewed as they are generated and define whether analyst can continue with the analysis or not. Results provide real-time feedback on state of analytical control. Immediate action is taken if results are out of control limits. Expected instrument response data provides real time feedback data and analyst response accordingly on time. Reagent blank QC data also provide real time information on state of analytical control. Similarly, information from re-scale control standard provides similar information.	H
CL2	Use of real time feedback to control the analytical process?	The use of calibration standards information data on expected linearity (Correlation coefficient) provides real time performance quality control data. Similarly calibration standards are expected to give signal responses within a certain range and any deviation is data that is used to control quality of the analytical process. Instrument is set to flag out of limits data on QC solution standards e.g. initial calibration verification standards and blanks and continuous calibration verification standards. Standard deviation on each reading provides good data to act on. Each sample or standard reading is an average of three readings and hence information on reproducibility is real time data used to control quality of work.	H
			
	OVERALL USE OF PMQEI PRACTICES		

		ORGANISATION			
Question	PRACTICE	MS1	MS2	CL1	CL2
1	Use of statistical methods of analysis	H	H	H	H
2	Use of IQC	H	H	H	H
3	Use of zero defects mechanisms	M	M	M	M
4	Use of Offline data analysis	H	H	H	H
5	Use of Real-time feedback mechanism	H	H	H	H
OVERAL SCORE	OVERALL PMQEI	H	H	H	H

Table 4.5 (b) Overall summary of the degree of use of Process Management Practices for Quality Exploitation (PMQEI) across the case organisations

PMQEI	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Use of statistical methods of analysis	H (3)	H (3)	H (3)	H (3)	-
Use of IQC (Degree of use of QC samples)	H (3)	H (3)	H (3)	H (3)	-
Use of zero defects mechanisms	M(2)	M(2)	M(2)	M(2)	-
Use of Offline data analysis	H (3)	H (3)	H (3)	H (3)	-
Use of Real-time feedback mechanism	H (3)	H (3)	H (3)	H (3)	-
Total score	14	14	14	14	-
Overall Rating PMQEI	H	H	H	H	-
Overall degree of use of PMQEI practices					

The overall degree of use of PMQEI practices was determined by calculating the total score for the individual practices and following the rule in section 3 of chapter 3, i.e. by establishing whether there was a significant difference between the practices across the laboratories and ranking them if differences existed as per procedure used for CFQEI practices to arrive at the pattern above. The difference in overall implementation was not significant with only use of zero defect practices causing the minor difference in score. All other practice variables were rated the same across all organisations.

Table 4.5 (c)

Thematic summary of the use of Process Management for quality exploitation (PMQEI) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

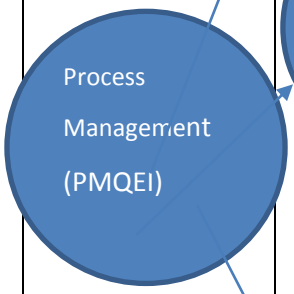
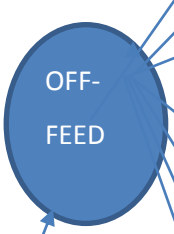
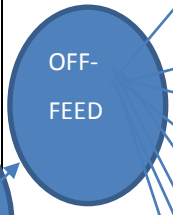
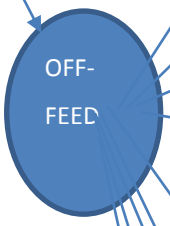
Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Process Management (PMQEI)	STAT-MET	Lab MS1 Use of statistical methods for significance testing during method development QC Charts during production to ensure process stability and control Action taken on badly trending data Z-score used for monitoring proficiency testing performance, action taken to address out of tolerance performance Data reviewed weekly for , monthly for internal quality control and when received for external quality control All data reviewed for management review	H
	STAT-MET	Lab MS2 Use of various methods during method development and validation e.g. T-test Use of QC charts for all elements, methods during routine operations for all CRMs Z-Score for round robins and proficiency testing Data reviewed daily, weekly, monthly Actions taken on out of specification data or poorly trending data All data reviewed for management review Action taken on out of control processes	H
	STAT-MET	Lab CL1 Used during validation to evaluate significance e.g. F-test, T-test Use of QC charts during routine analysis Use of Z-score for Proficiency testing results and round robin participation Data analysed daily, weekly, and monthly Action taken on out of control processes and poorly trending results All reviewed for Management Review Data captured for all methods, elements and Certified Reference Materials (CRMs)	H
	STAT-MET	Lab CL2 Widely used during development and validation of methods for significance testing QC charts used for routine work QC charts for all methods, elements and certified reference materials Use of z-scores for Proficiency testing data and round robins Data reviewed daily, weekly and monthly Action taken for bad trending data All data reviewed for Management review	H

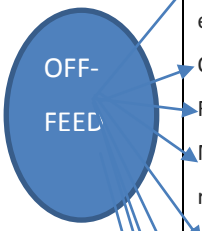
Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Process Management (PMQEI)	IQC-OCCCC	Lab MS1 Every batch of sample included Quality Control samples (blanks, duplicates, CRMs) Use of intra-laboratory testing and results reported upon agreement of analysts data Rotation of CRMS to reduce Analyst familiarity Use of process knowledge provides additional control point where obtained results are compared with expected results QC charts for all methods, CRMs and elements QC Charts reviewed daily , weekly, and monthly and displayed in the laboratory Calibration coefficient to be within targeted figures-at instrument stage QC solutions read after calibration and at defined frequency during sample runs Corrective actions implemented where targets for control samples are not met Sample preparation quality control includes CRU-QC and PUL-QC Milling equipment cleaned with previously tested barren material at defined frequency Authorised and competent staff used for tests Only previously tested reagents are used for analyses Use of clearly defined procedures	H
	IQC-PROC	Lab MS2 QC follows clearly documented procedures Both CRU-QC and PUL-QC performed at sample preparation stage at rate of one sample per batch Three QC samples per batch of sample-blank, duplicate and 1 CRM Additional coarse duplicate at defined frequency A blind sample unknown to Analyst introduced in addition to known CRMs (QC sample rate approximately-20%) Each sample analysed in triplicate by two Analysts for commercial commodity samples Linearity tolerances defined for calibration solutions-not less than 99.95 Standard deviation for calibration standards defined at not greater than 3% Defined tolerances to be met for QC solutions which is read after calibration QC charts generated for all elements, CRMs, and methods QC Charts reviewed daily, weekly and monthly and yearly for management review QC charts displayed in the lab Corrective action taken for all out of tolerance results and poor trending results Laboratory rotates CRMs to avoid Analyst familiarity and potential falsification of results Only authorises and competent Operators perform analysis Reagents tested and qualified before use Only previously tested and qualified equipment used for analysis	H

	IQC-PROC	Lab CL1 Detailed QC procedure followed throughout the analytical process-preparation to reporting Incoming material (reagents) tested for suitability and qualified Use of competent supplier of reagents and consumables Equipment tested and qualified before putting into use Use of only competent and authorised personnel Use of quality control samples in every batch of samples consisting of CRMs, blank, duplicates -1 blank, 1 CRM and 1 duplicate per batch Sample Preparation –Crushing QC (CRU-QC) for every 20 samples Sample preparation –Pulverising QC (PUL-QC) for every 20 samples QC solution (mid-range standard) used to qualify calibration graph Reading of QC solution during analysis (Continuous Calibration Verification) solution after every 20 samples QC charts for every method, CRM, and element QC charts monitored daily, during approval, weekly and monthly Use of inter-laboratory analysis programme Use of re-scale solution Defined standard deviation limits for calibration solution QC charts displayed around the laboratory for easy monitoring and control Corrective action taken for all out of specification standards and poorly trending CRMs. Rotation of CRMs to avoid Analyst familiarity and potential falsification of results Use of blind samples	H
	IQC-PROC	Lab CL2 Detailed QC procedure for quality control Set tolerances for linearity of calibration graphs Set targets for instrument response-absorbance Check QC solution used to check quality of calibration before analysis Use of QC blank to confirm quality of calibration and absence of contamination Use of quality control samples in every batch of samples consisting of CRMs, blank, duplicates -1 blank, 1 CRM and 1 duplicate per batch Use of blind sample Use of independent QC solution read after 20 samples QC charts generated for all methods, CRMs and elements QC Charts displayed around the laboratory QC charts reviewed daily , weekly and monthly and yearly for management review Corrective actions taken for all out of tolerance and poorly trending QC data Lab follows clearly defined procedures Previously tested and qualified barren material used to clean sample preparation equipment Sample Preparation–Crushing QC (CRU-QC) for every 20 samples	H

		Sample preparation –Pulverising QC (PUL-QC) for every 20 samples Corrective actions taken for all CRMs results out of specified limits and poorly trending results Use of previously tested and qualified reagents Equipment tested and qualified before putting into use Tasks carried out only by competent and authorised personnel	

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
Process Management (PMQEI)	ZERO-DEF	Lab MS1 Correlation coefficient of calibration standards during calibration. Instrument set not to calibrate if correlation coefficient is out of limits Use of QC solution-defined limits to be achieved	M
	ZERO-DEF	Lab MS1 Use of correlation coefficient of calibration standards during calibration. Instrument set not to calibrate if correlation coefficient is out of specification Use of QC solution-defined limits to be achieved	M
	ZERO-DEF	Lab CL1 Use of correlation coefficient of calibration standards during calibration. Instrument set not to calibrate if correlation coefficient is out of specification Use of mid-range QC solution-defined limits to be achieved	M
	ZER-DEF	Lab CL2 Use of correlation coefficient of calibration standards during calibration. Instrument set not to calibrate if correlation coefficient is out of specification Use of QC solution-defined limits to be achieved	M

Main Theme	Sub Theme	Description of level of implementation of practices within theme	Lev
		Lab MS1 QC charts reviewed daily and every month Proficiency Testing Scheme(PTS) data reviewed and analysed as it is received Management Review once a year and all key performance indicators reviewed- covering customer complaints, audit results, PTS data, QC performance of CRMs, etc. Review of customer satisfaction measurement data once a year Review of customer complaints as they are reviewed and monthly Performance of duplicates, blind samples, blanks data on monthly basis Corrective actions implemented	M
		Lab MS1 Weekly and monthly review of lab KPIs covering turnaround times, PTS data, Round Robin data, CRMs performance Review of customer complaints and customer feedback data as its received PTS and Round Robin data reviewed as its received QC charts reviewed daily, weekly and monthly Customer satisfaction survey data reviewed every quarter Management Review once every year and reviews all KPIs of the lab covering PTS and Round Robin data, CRM performance data, customer complaints and feedback, results of internal audits Corrective actions implemented on all aspects of performance not meeting requirements	M
		Lab CL1 QC charts data trends monitored daily, visually and analysed weekly and monthly Customer complaints analysed as they are received and formally once a month Every QC data is audited at least once a year Customer feedback is analysed as information is received and formally reported once a month Every Element QC data is audited at least once a year and results of audit reviewed and analysed Customer satisfaction survey data is generated and reviewed once a year Results of PTS and round robin data is analysed as its received and corrective actions implemented where required Management review conducted once a year addressing all key performance indicators of the laboratory Corrective action implemented where necessary	M

		Lab CL2 Results of quality control samples which includes CRMs, blank samples, duplicates etc. reviewed daily and analysed weekly. QC charts monitored daily and reviewed weekly and at the end of the month Formal QC charts review by section supervisors conducted weekly Monthly QC reports with all key performance indicators are generated and reviewed at management meetings once in two months Customer complaints and customer feedback data reviewed as they are received and monthly Customer enquiries are reviewed every month PTS data analysed and reviewed as received Internal Quality Audit results, external audit results, customer complaints, customer feedback data, etc. reviewed yearly at management review Actions to address areas of concern implemented and effectiveness of actions evaluated	M

4.3.4 Rating the degree of use of Process Management for Quality Exploration (PMQER) Practices

Using the same data reduction approach as for CFQEI and CFQER practices and further guidelines in measuring each variable, Appendix A, the final implementation pattern for Process Management for Quality Exploration Practices (PMQER) is shown in table 4.6 below.

Cross –case comparisons of the use of Process Management for quality exploration practices

Table 4.6 (a)
Summary of the use of Process Management for quality exploration (PMQER) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

Lab	(PMQER)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Degree of formalisation of New Method Introduction (NMI)	All methods are validated to a certain extent but original methods were based on well-established standard methods and validation process was not well documented. Currently laboratory validates for key performance parameters to establish fitness for purpose of the method. These include accuracy, selectivity and precision and if the performance on these parameters is satisfactory, the method is offered to the client. The laboratory does not wait to complete all the method validation parameters before offering the method to the clients. The other parameters e.g. limit of detection, uncertainty of measurement, limit of quantification, range, linearity are then	M

		completed as method is being used. The validation of methods is an ongoing process e.g. detection limit values have been changed for one method because of changes in the method of detection. There exists a formalised procedure for the validation of methods and validations are done in accordance with this procedure. A validation report is produced for all completed validations.	
MS2	Degree of formalisation of New Method Introduction (NMI)	The laboratory has been in existence for many years and during that time methods were validated without proper documentation but once certified reference materials were coming right the method was deemed fit for use. The process of ensuring proper validation has been completed before use strictly now applies to new methods which are not many in the operational context of the mine site laboratory. However, once a method is validated for accuracy, detection limit and precision, the method is deemed fit for purpose and is offered to the clients. The validation for other parameters (e.g. sensitivity, ruggedness, range, linearity, measurement uncertainty, etc.) is done whilst the method is being offered to the client. The validation process is ongoing and methods are validated after a defined period. There is a procedure for the validation of analytical methods and methods are validated as per that procedure. A validation reported is produced and records maintained.	M
CL1	Degree of formalisation of New Method Introduction (NMI)	There is an established method for the development and validation of analytical methods. The laboratory has identified key operational performance indicators that are initially validated to allow the processing of client samples. These key method performance parameters are accuracy established by the analysis of certified reference materials, the analysis of some client samples submitted for testing process and proficiency testing data if available. Once these pass criteria, the laboratory continues with the analysis of client samples. The completion of other validation parameters is done whilst the method is being offered to the client. The use of client samples provides really field test of the method performance. Full validation for other parameters done to meet the requirements of ISO 17025 (uncertainty of measurement, sensitivity, repeatability, robustness, ruggedness, linearity, range, detection limit, quantification limit, etc.). Method is then validated for a range of other parameters whilst in use including optimisation of fusion time for samples, whether samples would require re-fusion of the slag etc. Method is re-validated after some time and especial if complaints are being received. A validation report is available for all completed validations.	M
CL2	Degree of formalisation of New Method Introduction (NMI)	There is an established method for the development and validation of analytical methods. The laboratory has established key method validation parameters which it targets to complete before putting the method into use. These are accuracy, which is established by the use of certified reference materials, precision established by analysing same samples a multiple times and detection limit. Once these three are validated, the method is put into use and results are reported to the clients. Full validation to meet accreditation requirements is continued whilst method is being offered to the clients. Clients are informed of methods that have not been fully validated and that are not yet accredited. The methods are finally validated for other parameters to meet the requirements of accreditation (sensitivity, robustness, measurement uncertainty, linearity, ruggedness etc.). The validation process is an ongoing activity as methods continue to be validated when changes are made or at defined period. A validation report is produced for every completed validation.	M

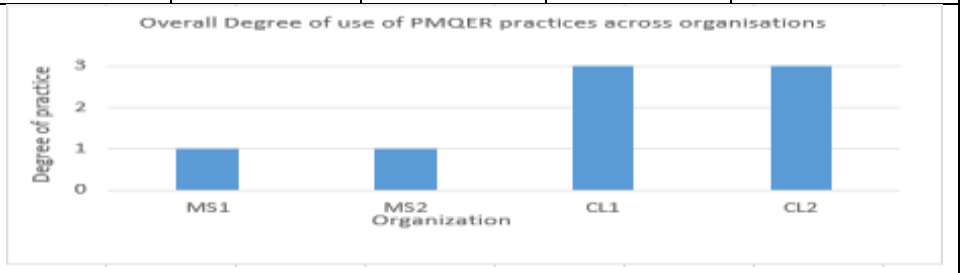
	Degree of formalisation of New Method Introduction (NMI)		
MS1	Process improvements to meet changing needs of the clients?	Very few changes in the needs of the customers occur. The product itself does not change and the customers are not changing as well. One major change was the change from a ferrochrome to a ferromanganese furnace. These changes do not really affect the lab processes much. Therefore few changes are received from the clients. The request to analyse for arsenic in final product is one such change that came from client as results of environmental concerns. The laboratory improvement was to introduce the analysis of this new element. In the case of furnace changes, benchmarking visits were made to prepare laboratory for new additional analysis.	L
MS2	Process improvements to meet changing needs of the clients?	Process improvements made are based on feedback received from clients, complaints, analysis of data, internal audits etc. Generally, the laboratory has met most client requirements and is focusing on improving turnaround time. One improvement that that came as a changing need from clients is the analysis of Arsenic in concentrates. The issue came as a client requirement following safety and environmental concerns. Following a laboratory audit analysis of concentrate samples changed to using fusion as the primary method and not four acid digestion. The laboratory does not make significant effort to identify the emergent needs and respond to them but responds to requests.	L
CL1	Process improvements to meet changing needs of the clients?	Improvements come from the analysis of customer complaints and subsequent corrective actions implemented to address the complaints, customer feedback, and analysis of the results of internal quality audits, the analysis internal non-conformities, review meetings and external audits. The laboratory undertakes benchmarking visits from which improvements are undertaken. The laboratory also makes improvement by responding to emergent client requirements e.g. the determination of lithium in geochemistry samples in the recent years was a result of a need from clients that had to be met. Suggestions for improvements are open to all employees. Every improvement suggestion is reviewed and if there is merit, the improvement is undertaken unless resources do not allow the implementation of the process at that particular time. There is a clearly defined process for forwarding and reviewing of suggestions from employees which includes a thorough review process for reviewing the value of the suggestion before implementation. There is a system to assist with the identification of new client needs or potential needs from the customers e.g. the market intelligence system, client visits or invitations to the laboratory and to tap the needs during discussions with the clients.	H
CL2	Process improvements to meet changing needs of the clients?	Most of the laboratory services are customer driven and the laboratory reacts to those needs, therefore the laboratory tries to meet the changing needs of the customer. There is a procedure on managing improvement in the laboratory. The laboratory follows on emergent client needs and changes in client needs and act to meet the new needs e.g. New detection limit requirements. Examples of such new needs were given e.g. new detection limit requirements for the analysis of molybdenum. There is a system to detect the changing needs of the customers e.g. through the market intelligence system of the laboratory for example by visiting the Geological survey department to get information on companies pursuing different exploration activities. The laboratory then follows up on these and improves its system to meet the new needs. Meeting the new needs might entail developing of new service offers (radical improvements or continual improvement). New needs are also identified from an analysis of customer complaints and feedback, analysis of internal and external audit results, analysis client satisfaction survey results,	H

		etc. Some of the improvements required could be simply to communicate better as might be indicated by the analysis of complaints. Currently, there is a market trend towards rare earth elements in the mining industry and the laboratory is already working on methods to ensure the service is offered to meet anticipated new client needs. The laboratory's change in scope of methods offered is a typical example of improvements made to meet the changing needs of the customers influenced by market changes. The laboratory follows various strategic groups in the country e.g. Agricultural group, Mining Engineers group, Metallurgical groups as a way to identify new needs and respond to them. The needs are also identified from calling customer, visiting or inviting them to the laboratory and whatever needs are identified will dictate improvements the laboratory can embark on. Esteria breakdown is a typical example of improvements that were made to meet changing client needs. Price is a critical requirement of the clients and the lab is forced to lower cost of analysis by increasing efficiencies in all processes e.g. reduce rate of re-analysis of samples.	
	Process improvements to meet changing needs of the clients?		
MS1	To what extent does the laboratory apply itself to better serve its customers?	Any improvement to better serve the customer is based on customer needs.	L
MS2	To what extent does the laboratory apply itself to better serve its customers?	Laboratory aims to improve its performance regarding turnaround time which has often been the subject of some complaints.	L
CL1	To what extent does the laboratory apply itself to better serve its customers?	Improvement come from client demands or requests e.g. Lithium determination which came as a client requirement resulting in the laboratory developing a method to meet this need. The effort to identify client requirements or potential requirements and responding to those requirements is a way to better serve the laboratory's customers. Data analysis on customer feedback, complaints and information obtained from client during client laboratory interactions provides a way of knowing the need and then to respond to those needs. The laboratory management believes that improvement in the level of service offered to clients comes from better understanding of the requirements of the clients. This is why market intelligence obtained by collaborating with the survey department and other strategic groups in the industry is strategic in better serving clients. The laboratory undertakes benchmarking visits and these provides a platform of setting improvement targets to better serve clients. Laboratory aims to improve efficiency of the processes in order to reduce analytical costs. This enables the laboratory to offer competitive prices to the clients. The laboratory has a suggestion scheme in place and every employee is encouraged to give improvement suggestions. The management believes there are no suggestions which should not be evaluated.	H
CL2	To what extent does the laboratory apply itself to better serve its customers?	Improvements come from the analysis of customer feedback data, customer complaints, results of internal and external audits findings, management review action plans. The analysis of this data enables the laboratory to better understand the requirements of the client. The laboratory taps more client requirements through its market intelligence system and responds to the findings. Responding to these requirements creates a way of serving the client better. The laboratory aims	H

		to have at least one new method every year. The laboratory aims to provide complete service to clients and make the laboratory a one stop show rather than clients splitting samples to different labs because of capability limitations e.g. rare earth elements analysis go to lab A and platinum group metals are done at laboratory B. Customer survey data provides information on how the laboratory compares with competition and the lab sets improvement targets on the basis of being better than what competition is achieving. Laboratory targets reduction of analysis cost by reducing unnecessary repeats which enables the lab to offer competitive prices to its customers. The laboratory encourages improvement suggestions from its employees and funding is supported as much as possible if the suggestion is sound. Employees are trained in Quality Management principles which facilitate understanding of improvement processes. ISO 17025 has a dedicated section on improvement.	
	To what extent does the laboratory apply itself to better serve its customers?		
MS1	Belief in improvement processes	Laboratory believes that there is always room for improvement in every process.	L
MS2	Belief in improvement processes	The laboratory believes that there is always a room to improve the performance of a process e.g. the laboratory aims to improve on its ability to meet customer requirements.	L
CL1	Belief in improvement processes	The laboratory aims to register at least one improvement every month. There is a suggestion scheme in place and every employee is encouraged to contribute to the suggestion process. It is open to all employees. It is the practice of the laboratory that the flow is open for contributions to the suggestion scheme at every works council meeting which is held every month. The organisation aims to improve efficiencies to lower cost and offer this vale to the client. Competition drives need for improvement. "You always want to be better than your competition" said the laboratory manager at organisation CL1. There exists a formalised procedure for managing improvement in the laboratory Quality Managers.	H
CL2	Belief in improvement processes	The laboratory believes that improvement is an ongoing process. The laboratory is quick to adapt and has a supporting structure for adapting quickly to changes in the market place e.g. when there is a need to make improvements these are quickly implemented. There is no need to seek board approval for implementing the changes. Continuous process improvement is one permanent objective of the laboratory. The laboratory operates in a competitive environment and competition drives improvement e.g. the laboratory needs to be better than competition. The improvements can be incremental or breakthrough. Incremental improvements may include simple improvements like communicating better with the clients, serving the clients better, improvements in turnaround times by improving process efficiencies. The laboratory believes efficiencies can be continuously improved and all processes can be implemented better. By operating efficiently the laboratory can offer clients better value for money. The laboratory CL2 has a target of at least introducing one new method in a year.	H
	Belief in improvement processes		

Table 4.6 (b) Overall summary of the degree of use of Process Management for Quality Exploration (PMQER) practices across the case organisations

PMQER	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Degree of formalisation and comprehensiveness in use of New Method Introduction process (NMI)	M (2)	M (2)	M (2)	M (2)	-
Process Improvement to meet changing needs	L(1)	L (1)	H (3)	H (3)	0.89
Process Improvement to better serve customers	L (1)	L (1)	H(3)	H (3)	0.89
Belief in Improvement	L (1)	L (1)	H (3)	H (3)	0.89
Overall Rating PMQER	L	L	H	H	0.89
Overall degree of use of PMQER practices					

4.3.5 Rating the degree of use of Teamwork for Quality Exploitation (TWQEI) Practices

Using the same data reduction approach as for above practices the final implementation pattern for Teamwork for Quality Exploitation Practices (TWQEI) is shown in table 4.7 below.

Cross –case comparisons of the use of Teamwork for quality exploitation practices

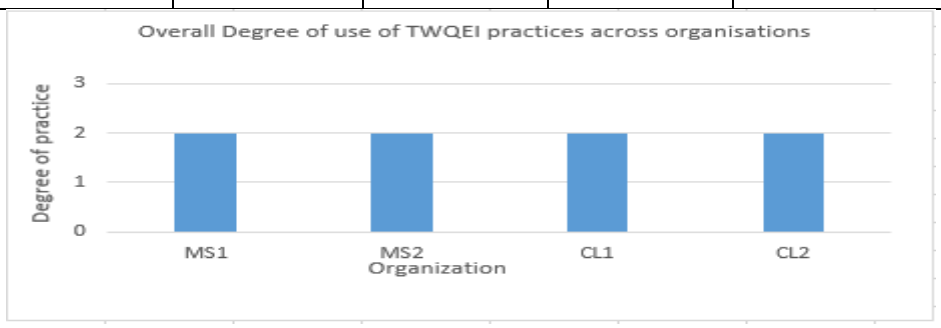
Table 4:7 (a)
Summary of the use of Teamwork for quality exploitation quality exploitation (TWQEI) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

Lab	PRACTICE TWQEI	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Encouragement of teamwork by supervisors.	The laboratory manager stated that whilst teamwork was important, at the end of the day he measures the performance of an individual person. The employees understand their key performance indicators (KPIs). In the past he stated that it was some form of competition between the operators but when they failed to achieve the required level, performance actually suffered. An individual person's action does affect the performance of the other team members and the overall performance of the laboratory e.g. handover specifying issues faced in the previous shift and other issues in the laboratory. Team performance without competition has been a problem. One may not like the targeted numbers, but because there is a measure of performance one has to work as accurately as possible. The laboratory manager stated," I have a different view of teamwork. At the end of the day, I like competition but not to affect performance of the laboratory in a negative way. Then I have a problem". When an employee is faced with a problem he is encouraged to seek assistance from other team members. An analyst in the laboratory indicated that teamwork was supported and the current set up showed same.	L
MS2	Encouragement of teamwork by supervisors.	The laboratory concurred that there was no way the laboratory could produce quality results without teamwork and indicated his unreserved support for teamwork. The lab manager stated that Team participation was highly implemented at the laboratory. Short interval control meetings allowed engaging members as teams. Commitment to teamwork was noted and evident among all employees who were interviewed in this laboratory. Work design supported teamwork approach. Samples analysed in the laboratory are received and prepared at sample preparation and therefore there should be trust between sample preparation and the analytical side of the laboratory. No one person is responsible for the total analytical process. Samples are handed from one process area to the other and the final approval of results is done by the Analyst, area supervisor or by the Laboratory Manager. Performance rewards are often given to teams and not individuals. This highlights the importance of teamwork. There was an in-depth understanding of the consequences of poor team spirit to quality of data.	H
CL1	Encouragement of teamwork by supervisors.	Employees are encouraged to work as a team. The laboratory manager indicated that this was something that is always discussed in every meeting and added "I believe a team can achieve more than what can be achieved by people working as individuals". The Laboratory Manager retrieved one of the speeches that he made during a one million hours Injury Free shifts celebrations. Hard work and Teamwork were emphasised during that celebration. Work in the analytical laboratory is a relay. There are different sections starting from sample receiving and preparation, Fire Assay section, Wet Chemistry section, Bottle Rolling section etc. This relay requires great quality consciousness at every stage to ensure that the whole process ultimately produces high quality work; hence the need to work as teams. The workflow design and the worksheets completed during the analytical process facilitate the teamwork approach. Work is coordinated among the teams. Quality is discussed among the teams. The employees interviewed clearly stated that this was their work and this is where their future would come from. He further stated that he could not say teamwork was encouraged but they work as a team. Sample processing is passed from section to another and to get it right every stage should be performed well, from sample receiving and preparation to reporting of results. There was significant evidence of teamwork within the laboratory employees.	H

CL2	Encouragement of teamwork by supervisors.	"At this laboratory, we are a family. This is what we encourage on a daily basis", said one of the directors at lab CL2. An employee works at a particular station and passes on the work to another station. This is the process and hence need to work as a team. "When one person is not a good team player, the team suffers and it's difficult for any such person to work at this lab", continued the director. "The laboratory is a small team. It has a few numbers of employees. It has been shown that if sample preparation does not do its work properly, all downstream processes come to nothing and the laboratory loses clients. New employees are trained into this culture. No one person's idea is bad. All ideas are welcome. Employees in this organisation are encouraged to communicate well. The analytical function is a customer of the sample preparation process. This should be understood by everyone. Sample preparation needs to understand that as well. Analysts should share their challenges and resolve problems across teams", indicated one of the laboratory executives. The laboratory production process is a chain where samples are handled in one section and passed on to the other section, signed off as received in the other section creating a production process. The process starts from sample receiving, preparation until a result is reported. Employees are therefore encouraged to work as a team to ensure process success. Yes, the laboratory encourages teamwork. "I have always told my guys that teamwork is cement for all the building blocks of an organisation. There is a team in spot, in politics, etc. This only shows that without teamwork we cannot achieve much. This organisation is a system-two or more components working together to achieve a common goal. Together, every person achieves more." Said the senior laboratory supervisor. There was evidence of understanding of the importance and support for teamwork among all employees and the negative consequences of poor teamwork e.g. poor work and loss of customers.	H
	Encouragement of teamwork by supervisors.		
MS1	Encouragement of employees to exchange ideas and opinions.	In a large organisation it is difficult to filter information from say the General Manager through all the organisational layers to the shop floor employees. Information is passed on but may not reach the employees with the same message that was intended to be passed. It is easy to pass the information in a small group. In a unionised environment, people tend not to express their opinions and would just like to do what they are told to do. The less the information one gives the better. People tend to be reserved in a unionised environment. Currently, the laboratory is running 12 hour shifts, 4 days in and 4 days out. Handover is when they complete their 4th day. In this environment, the laboratory has employees with over 25 years of experience. Some of these employees are getting into their sixties. This age distribution is not most likely found in commercial laboratories. These employees are very good at what they do but difficult to change their practices. The issue is ferrochrome is ferrochrome. An Analyst interviewed indicated supervisor support for exchange of ideas was high.	M
MS2	Encouragement of employees to exchange ideas and opinions.	The supervisors encourage employees to exchange opinions and ideas. The level of employee engagement and participation is very high. Every time there are improvements to be made, the team sits together to evaluate and assess the intended changes. Everyone is free to contribute and bring any idea that can bring in some improvement to the process. Discussions and exchange of ideas by team members has resulted in some changes where some sample streams are now done in duplicates and some in triplicates. This is based on contribution from different employees, of which some have had the experience to perform the analyses and realise this need from experience in performing the analysis.	M
CL1	Encouragement of employees to exchange ideas and opinions.	This concept is always emphasised. "We need to accept advice from other employees and even Management should be able to listen and take employee recommendations." This is both a top down and bottom approach. So Supervisors encourage the exchange of ideas and opinions. "This is same as for improvement in the company. An employee states an opinion, which is	M

		evaluated and if it adds value and can be implemented, it gets implemented. It doesn't matter who the source of the opinion is", said one operator.	
CL2	Encouragement of employees to exchange ideas and opinions.	This is much encouraged. "This is an innovative organisation and anyone is free to contribute. During the laboratory's Monday morning meetings, employees are encouraged to come up with innovative ideas and some brilliant ideas have come out of these meetings and from employees on the shop floor". Stated the director at this company. "The management here are a free people and we encourage people to share their ideas and opinions. We have developed the skill to listen and this allows people to exchange their opinions. The most difficult skill in communication is listening, and by listening we have managed to allow free sharing of opinions." Said the same supervisor above. When performance appraisals are performed, employees are encouraged to express their opinions.	M
	Encouragement of employees to exchange ideas and opinions.		

Table 4.7 (b) Overall summary of the degree of use of Teamwork for Quality Exploitation Practices across the case organisations

TWQEI	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Encouragement of Teamwork by Supervisors	H (3)	H(3)	H (3)	H (3)	
Encouragement to exchange ideas	M(2)	M(2)	M(2)	M(2)	-
Overall Rating TWQEI	M(2)	M(2)	M(2)	M(2)	-
Overall degree of use of TWQEI practices					

4.3.6 Rating the degree of use of Teamwork for Quality Exploration (TWQER) Practices

Using the same data reduction approaches as for above practices the final implementation pattern for Teamwork for Quality Exploration (TWQER) Practices is shown in table 4.8 below.

Cross –case comparisons of the use of Teamwork for quality exploration practices

Table 4:8 (a)

Summary of the use of Teamwork for quality exploration (TWQER) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

Lab	Teamwork For Quality Exploration Practices (TWQER)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Use of cross functional teams within the organisation	The laboratory promotes cross functional teams in its operation. One of the driving forces for the use of cross functional teams has been the need for independency in carrying out laboratory Quality Management System audits. These audits are carried out by the Safety, Health and Environment Management System team (SHE team). SHEQ helps with ISO17025 audits and the laboratory performs SHEQ audits. The operation is ISO 9001 certified. Employees are generally trained to perform several tasks in the laboratory and can work from sample preparation to analysis on the instrument. At the same time an employee can carry out the whole analytical process from weighing to reporting and bringing some form one person working alone.	M
MS2	Use of cross functional teams within the organisation	The laboratory Manager indicated that he would rate the implementation of this process as medium. Although some form of superiority among functions has been evident at some time, training into the benefits of team work has helped to improve on this aspect. The analytical system follows a process approach where sample are prepared by the sample preparation team and passed to the analytical section. In the analytical section, an analyst weighs samples and can process the samples until reporting which also brings some individual work into the process.	M
CL1	Use of cross functional teams within the organisation	Every employee is trained to perform a number of tasks e.g. sample preparation and Bottle roll. There is generally good communication between workers and across teams. This gives the laboratory a fall-back position especial after the downsizing that has taken place. A person has to be in a position to work in at least three different departments. Working as teams is encouraged. "It is the system", said one of the interviewees and employees have been trained into the teamwork culture. The laboratory process follows a typical process approach where the work of sample preparation team feeds into the next process, which feeds into the next process team until results are reported. Resolution of complaints requires the cooperation of employees from different sections in the investigation process in order to establish where things could have gone wrong. This process requires cooperation and contribution of different teams to address the problem. There is a need to be honest on what could have transpired during the initial analysis of the work.	M
CL2	Use of cross functional teams within the organisation	"Employees in this laboratory are jack of all trades. Everyone has to be a jack of all trades", said one of the laboratory Directors. Most employees are trained to work in almost all work stations in the laboratory. The reason for this is because, the organization is small and if one goes on leave the other employees need to cover up for the person who will be away and in a typical process approach, failure at sample preparation implies failure of the whole process. All new employees are trained in the team approach as part of the induction process. Employees share their challenges and resolve the problems together.	M

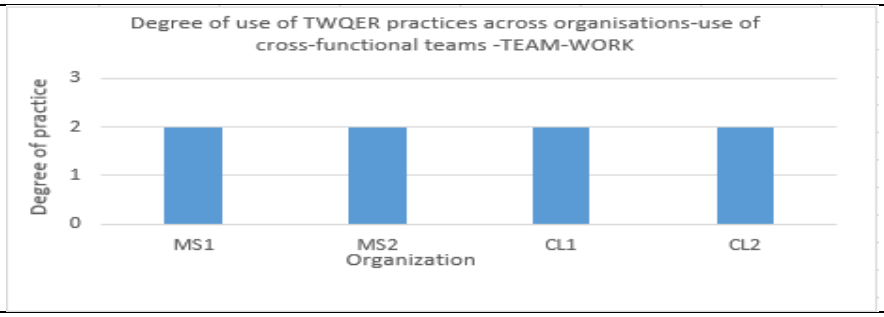
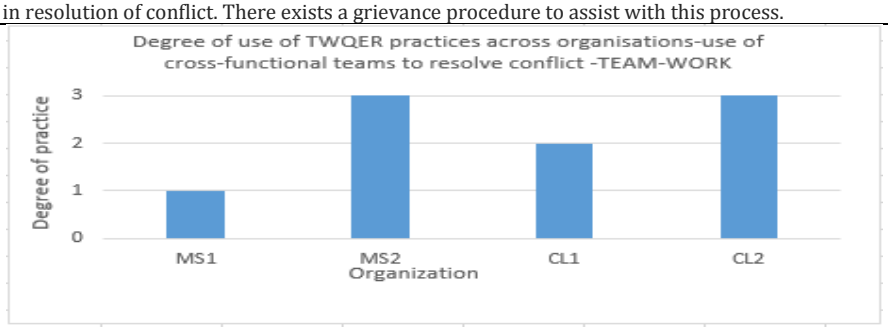
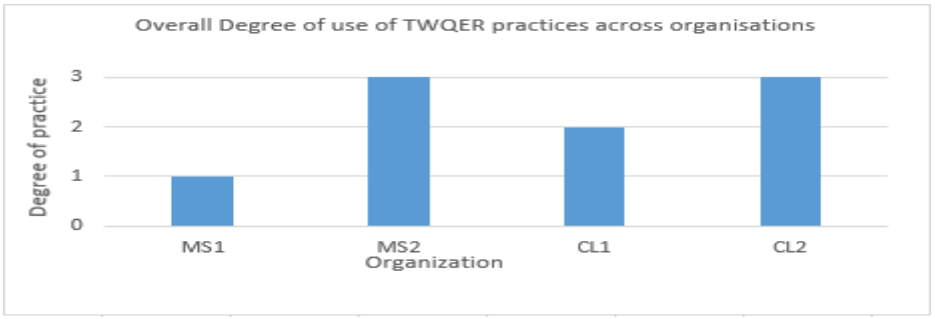
	Use of cross functional teams within the organisation		
MS1	Cooperation of cross functional teams to resolve conflicts between them	The laboratory manager indicated that much of the conflict experienced in the laboratory was to do with non-conformances. "Basically, the conflict we have is about Non-conformances. Interpersonal conflicts are difficult to resolve. A NC is factual and easy to address but interpersonal conflicts are always difficult to resolve", he stated.	L
MS2	Cooperation of cross functional teams to resolve conflicts between them	Employees have cooperated in the resolution of conflict in the laboratory, e.g. between employees and management. Laboratory management has listened to the concerns raised by employees and understood the concerns and similarly employees have understood management concerns. A typical example has been the shift system preference by the employees which was not as required by management, but there has been cooperation to address the concerns amicably. There is a formalised approach to deal with conflict e.g. between teams.	H
CL1	Cooperation of cross functional teams to resolve conflicts between them	This is not well documented but when conflict arises every effort is made to resolve it. The Laboratory does not have a standalone HR Department and hence the Laboratory Manager assumes the role of the HR function. The HR function is based at Head Office. Most HR negotiations are done and agreed at the laboratory and submitted to Head Office. E.g. salary negotiations are done at the lab.	M
CL2	Cooperation of cross functional teams to resolve conflicts between them	Everyone's aim when conflict arises is to get to the root cause of the conflict and resolve it. The aim of management is not to penalise the employees but to resolve the conflict. "When employees know that the aim of management is not to punish people, they cooperate", stated one director at company CL2. The low turnover at the laboratory implies that everyone at the laboratory is aware of how things are done there. One supervisor stated that understanding employees' social lives and challenges in resolving conflict is very critical in Zimbabwe more now than ever before. "People have become very sensitive". He said. A deep understanding of the fact that the resolution of conflict should result in meeting customer needs better assist in the cooperation of employees in resolution of conflict. There exists a grievance procedure to assist with this process.	H
	Cooperation of cross functional teams to resolve conflicts between them		

Table 4.8 (b) Overall summary of the degree of use of Teamwork for Quality Exploration Practices across the case organisations

TWQER	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Use of cross-functional teams	M(2)	M(2)	M(2)	M(2)	-
Cooperation of cross-functional teams to resolve conflict	L(1)	H(3)	M(2)	H(3)	
Aggregate rating	3	5	4	5	
Overall Rating TWQER	L(1)	H(3)	M(2)	H(3)	
Overall degree of use of TWQER practices					

4.3.7 Rating the degree of use of Training for Quality Exploitation (TRQEI) Practices

Using the same data reduction approaches as for above practices the final implementation pattern for Training for Quality Exploitation (TRQEI) Practices is shown in table 4.9 below.

Cross–case comparisons of the use of Training for quality exploitation practices

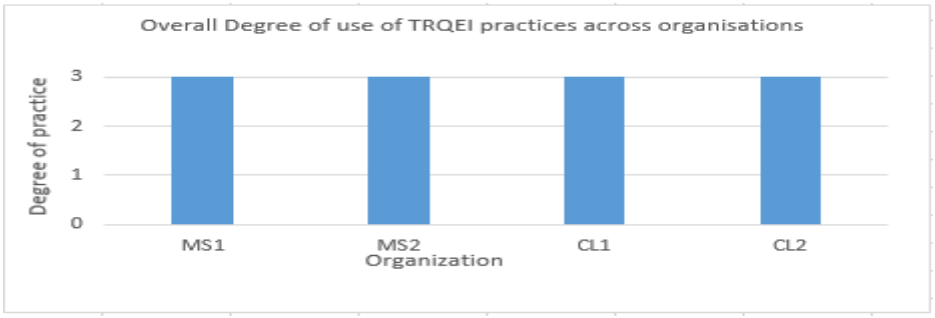
Table 4:9 (a)

Summary of the use of Training for quality exploitation (TRQEI) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

	Training For Quality Exploitation Practices (TRQEI)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Training and developed in the workplace skills?	There exists a formalised process for training employees on operational procedures. Employees upon recruitment undergo training and work under supervision of competent personnel. Upon completion of training in particular area, employee is tested for competence in those procedures and is declared competent once he passes a competence test. Re-testing for competence occurs after five years to ensure continued competence. In between re-testing, employees' competence is based on quality of work as indicated by results of quality control samples and planned task observations. Training needs are assessed annually and this is a formalised auditable process. Training in management courses is mainly on system standards e.g. ISO 17025. Management supports employee development to acquire tertiary qualifications and special leave or advances to pay for courses is supported by the organisation.	H
MS2	Training and developed in the workplace skills?	Training in operational procedures is based on job profile and there is a formalised training program for each job profile. Upon recruitment, a new employee undergoes through training of the operational procedures for the particular profile. Upon completion of training employee is tested to ensure the required competence level has been achieved. Before the competence sign off the employee works under the supervision of a competent person and works independently upon successful completion of the training and passing the competence test. Training on management system courses is done externally. Employees are re-assessed for continued competence after every two years. Laboratory supports individual development by allowing employees to attend tertiary training that results in diploma for the relevant subject. An employee on this supported training was on attachment at the time of the interviews with a second person attending college. The organisation has a graduate learner-ship program in place.	H
CL1	Training and developed in the workplace skills?	There is a formalised training process and needs assessment procedure. Needs assessment is conducted annually and followed up with the relevant training. New employees undergo an initial induction process which is a run through of the main processes at the laboratory followed by detailed training on the relevant procedures for that role. Before the employee is declared competent, he works under the supervision of a competent person until he is declared competent by passing a competence examination. Once employee is declared competent, he works under minimal supervision and is retested for continued competence after five years. Before the end of the five years a performance assessment using quality of work data is used to ensure continued competence. The laboratory supports development of its personnel to attain higher tertiary qualifications and support is offered in terms of time for examinations and study. Laboratory also supports managerial training e.g. ISO 17025 Quality Management training and benchmarking visits to enhance the technical knowledge of its personnel.	H
CL2	Training and developed in the workplace skills?	The laboratory has a formalised training needs assessment process and training procedure in place. Upon recruitment, an employee goes through a training process based on the operational procedures for that role. The process takes up to three months to complete the first round of training. Training on safety, health, environment and quality is covered during this period. After the initial training on procedures, the employee is tested for competence in those areas covered and is declared competent upon successful completion of the competence assessment. The assessment is based on analysis of certified reference materials or previously analysed samples. Before competence sign off, employee works under supervision of competent personnel. External training is conducted for supervisory and system courses e.g. ISO 17025 training. Management supports individual training to attain tertiary education e.g. diploma or degree in relevant courses. A number of employees who joined the organisation with only high school leaving certificates have graduated with degrees. Support for the development is offered in the form of time to attend the courses or any other appropriate ways.	H
	Training and developed in the workplace skills?		

MS1	Support for the continual training and upgrading of employee skills	Supervisors and management support training of employees. There is a formalised performance management system in place which is linked to a training needs assessment process. Training needs assessment is carried out once a year and there is training budget that is then determined by the identified training needs. Training is implemented to adapt to changes in technology, procedure or process changes, change in software for equipment manufactures if any. Employees are trained in multiple tasks and procedures as part of continual training.	H
MS2	Support for the continual training and upgrading of employee skills	Continual training and upgrading of employee skills is well supported by managers and supervisors. The organisation sponsors employees to attain higher qualifications in their operational field. Some employees were on attachment at the laboratory as part of the curriculum for the diploma course they were undertaking whilst some were at the college. The laboratory has a formalised two years graduate learner-ship program which trains university graduates after their university education. Employees attend management system training courses provided by external organisations e.g. ISO17025. Employees are trained in a number of methods and procedures as part of widening their skills base and as part of encouraging learning. Training needs assessments are conducted yearly and followed up during yearly employee performance assessments.	H
CL1	Support for the continual training and upgrading of employee skills	There is an educational policy in place to encourage continual training and employee development e.g. employees are given period to study for and write examinations. Employees are also supported financially as part of the educational policy. Managers and supervisors support continual training and allow employees to have familiarisation tours to other operations as part of benchmarking process. Employees are trained in multiple tasks to ensure continual learning process and are trained to adapt to changes e.g. change in technology, procedures or processes and management system standards e.g. ISO17025.	H
CL2	Support for the continual training and upgrading of employee skills	Continual training of employees is well supported by supervisors and managers. There is an educational policy that facilitates the support system allowing employees to register for tertiary education e.g. given time for classes and examinations. Employees are trained in a number of methods and are encouraged to learn more methods and multiskilling wherever possible. Assessment of training needs is a formalised process which is conducted yearly and has resulted in employees undergoing training on the new ISO17025 standard. Some supervisory and management courses are offered based on needs assessment e.g. preparing for employee promotion into supervisory roles. There is evidence of a support system with employees attaining degree qualifications when they joined the company with high school leaving qualifications.	H
Overall degree of use of TRQEI practices	Support for the continual training and upgrading of employee skills		

Table 4.9 (b) Overall summary of the degree of use of Training for Quality Exploitation (TRQEI) Practices across the case organisations

TRQEI	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Extent of training and development of employees	H(3)	H(3)	H(3)	H(3)	-
Extent of continual Training and upgrade of employee skills	H(3)	H(3)	H(3)	H(3)	-
Overall Rating of TRQEI	H(3)	H(3)	H(3)	H(3)	-
Overall degree of use of TRQEI practices					

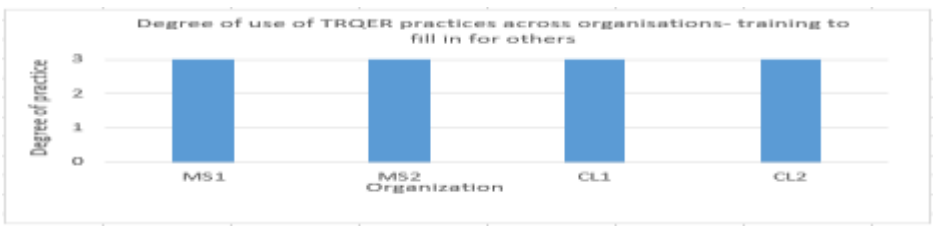
4.3.8 Rating the degree of use of Training for Quality Exploration (TRQER) Practices

Using the same data reduction approaches as for above practices the final implementation pattern for Training for Quality Exploration (TRQER) Practices is shown in table 4.10 below.

Cross–case comparisons of the use of Training for quality exploitation practices

Table 4:10 (a)

Summary of the use of Training for quality exploration (TRQER) practices across the case organisations. (H=High, M=Medium and L=low use of practices in comparative terms).

Lab	Training For Quality Exploration Practices (TRQER)	Detailed description of the practices observed as identified in the interviews and other methods specified, observation, participation in meetings	Degree of use of practices as (H,M,L)
MS1	Training to perform a variety of tasks	Most employees are trained in a number of tasks e.g. employees can perform sample preparation tasks to instrumental methods. They are multi-skilled and the longer an employee has stayed with the organisation the more tasks the employee can perform.	H
MS2	Training to perform a variety of tasks	Most employees have been trained to work in different areas of the laboratory e.g. laboratory technicians can perform most of the Laboratory Analyst functions. The more years an employee has been with the organisation the more tasks the employee is capable to perform.	H
CL1	Training to perform a variety of tasks	Employees are trained in a number of tasks. Most Fire Assay employees are well trained to work in the sample preparation area. The target is that every employee has to be able to work in at least three different areas. The selection and recruitment process is designed to engage employees with the educational level that will enable to achieve a certain level of multi-skilling. Four employees have been trained up to instrumental analysis and can perform Atomic Absorption Spectroscopy analysis. This gives the laboratory a fall-back position especial after the downsizing that has taken place. One Operator stated, "I can work in any section from sample preparation to instrumental analysis. Training is encouraged and well supported".	H
CL2	Training to perform a variety of tasks	Every employee has been trained to multi-skill with employees having been declared competent to perform various lab tasks. More years spent with the company means more tasks the employee has gone through. The laboratory has dealt with a few challenges to deal with less cooperation of some employees regarding assisting with training of employees in their areas of speciality.	H
	Training to perform a variety of tasks		
MS1	Training to fill in for others	This is high. Generally employees are able to fill in for others in all areas they have been declared competent to work. Competence records indicating areas of competence of some employees were reviewed.	H
MS2	Training to fill in for others	Most employees can stand in for all other employees who are working in areas to which they have been declared competent.	H
CL1	Training to fill in for others	As more employees are trained to multitask, the more people are available to stand in for others when there is need. Training program designed to ensure employee flexibility and competence to stand in for others.	H
CL2	Training to fill in for others	Resulting from the training of employees and their competence declaration in a number of areas, it is easy to have employees standing for each other when need arises. The laboratory operates with two teams and when sample volumes are low one team can operate at a time. This is easily possible because of the many tasks employees have been trained to perform.	H
	Training to fill in for others		

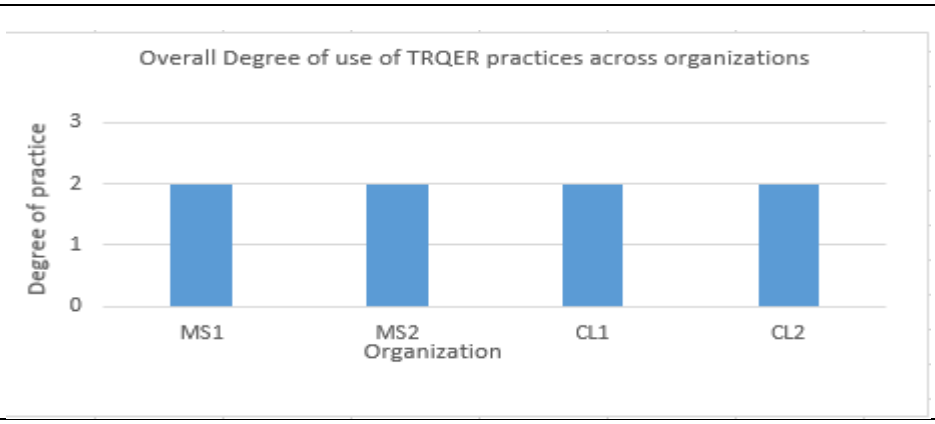
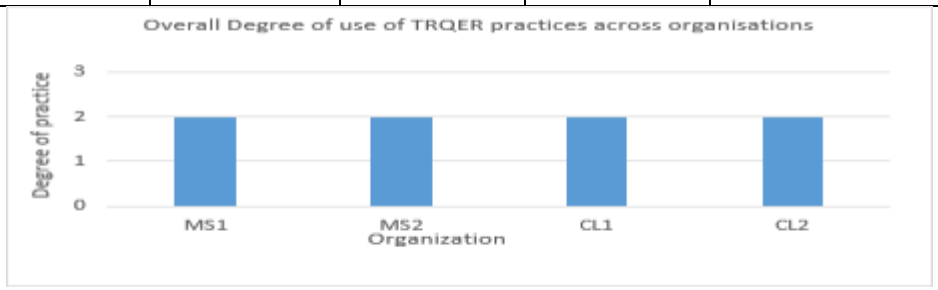
	Training to cater for anticipated future needs of the organisation		

Table 4.10 (b) Overall summary of the degree of implementation of Training for Quality Exploration Practices across organisations

TRQER	Laboratory				Spearman's correlation coefficient Rho (2)
	MS1	MS2	CL1	CL2	
Training to perform a variety of tasks	H(3)	H(3)	H(3)	H(3)	-
Training to fill in for other employees	H(3)	H(3)	H(3)	H(3)	-
Training for anticipated future needs	M(2)	M(2)	M(2)	M(2)	-
Overall Rating of TRQER	M(2)	M(2)	M(2)	M(2)	-
Overall degree of use of TRQEI practices					

Chapter 5

Data Analysis and discussion

5.0 Introduction

Chapter 5 provides an analysis and interpretation of the results presented in chapter 4, to address the research question, "What is the pattern of use of quality exploitation and quality exploration practices across the environmental uncertainty context spectrum represented by the commercial and non-commercial mine site laboratories"? Where contingency effects are noted in the pattern of use of these QM practices, causal networks were developed linking the trends and direction of the key environmental uncertainty context variables with the direction and trends in the pattern of use of the various QEI and QER practices to address the second research question, "How does environmental uncertainty context influence the use of best quality exploitation and quality exploration practices mix in these laboratories"? Finally, information from research question one and two is used to develop a model for selecting best QM practices to suit particular context and answering the third research question "what is the model for selecting best quality exploitation and quality exploration practices mix across the laboratory organizations?"

First data on the classification of the organisations along the environmental uncertainty spectrum is presented from the data reduction processes in chapter 4. This data confirmed the purposive sampling strategy used to select organisations operating as mine site laboratories and those operating as commercial laboratories to fit the different niches of low and high environmental uncertainty contexts in relative terms. Relative terms is important in this study as the same organisations may not fit perfectly high or low environmental uncertainty context profiles when compared to other industries. Table 1.0 shows the responses to questions on environmental uncertainty context captured during the interviews, reduced and summarised to arrive at low and high environmental uncertainty context which is then given in table 2.0 (Summary on classification of organisations into the environmental uncertainty spectrum).

5.1 Degree of use of CFQEI practices across the organisations

Table 4.3(b) provides an overall summary of the degree of use of customer focus for quality exploitation practices across the different laboratories. In addition to the overall degree of use of CFQEI, the data shows the different practices identified in the overall CFQEI bundle of practices e.g. collection of information on customer needs, developing and maintaining customer relationships, dissemination of customer information on customer needs and obtaining feedback from customers on organisational performance and their degree of use across the different laboratories. The visual pattern shown in table 4.3 (b) indicates that the degree of use of CFQEI practices is higher in the two commercial laboratories (Higher environmental uncertainty context) than the mine site laboratories (lower environmental uncertainty context). The results indicate that the degree of use of customer focus practices for quality exploitation (CFQEI) is influenced by the environmental uncertainty context in which the organisation operates. The visual pattern was further investigated by calculating the spearman's rank correlation coefficient (a non-parametric coefficient) between the ranked data of degree of use of quality exploitation practices (L=1 to H=3) and ranked data of the environmental uncertainty context from 1 to 4 across the environmental uncertainty context spectrum. The Spearman's rank coefficient for the different practices is shown in table 4.3 (b). The values indicate strong and positive correlation between context and degree of use of each practice except for the dissemination of information. The results suggest that the use of CFQEI practices is contingent upon the environmental uncertainty context of the organisation implying that a greater % of the variation in the degree of use of CFQEI practices across the organisations is influenced by the environmental uncertainty context of the organisation. Based on the economic efficiency embedded in the Contingency Theory, the results provide some empirical evidence that implementation of CFQEI practices is more beneficial when uncertainty is high.

5.2 Degree of use of CFQER practices across the organisations

Table 4.4 (b) provides an overall summary of the degree of use of customer focus for quality exploration practices across the different laboratories. The visual pattern shown in table 4.4 (b) indicates that the degree of use of CFQER practices is higher when environmental uncertainty is high and shows a trend across the organisations. This pattern is reflected in

the degree of use of collection of information on new customer needs for the organisations existing customers, practices for identification of new customers and their needs (information collection), altering customer needs definitions, and improvement processes from complaint data analysis except customer involvement in developing new service offers. The results suggest that the degree of use of customer focus practices for quality exploration (CFQER) is influenced by the environmental uncertainty context in which the organisation operates. The calculated Spearman's rank coefficient values between environmental uncertainty context and the different practices are shown table 4.4 (b). The values indicate strong and positive correlation between context and degree of use of each practice. The results indicate that the use of CFQER practices is contingent upon the environmental uncertainty context of the organisation. Based on the rationale behind the Contingency theory and concept of fit embedded in the theory the results would imply that the implementation of CFQER practices is more beneficial when uncertainty is high.

5.3 Pattern of use of CFQEI and CFQER practices across the organisations

The second research question, "How does environmental uncertainty context influence the use of best quality exploitation and quality exploration practices mix in these laboratories?" i.e. what is the mechanism by which environmental uncertainty context influences the degree of use of customer focus for quality exploitation (CFQEI) and exploration (CFQER) practices across the organisations?" The pattern shows that both CFQEI and CFQER practices are implemented at a higher level in the commercial laboratories (organisations CL1 and CL2) than the mine site laboratories (organisations MS1 and MS2) and that the two practices are highly correlated. Higher CFQER practices are associated with higher CFQEI practices.

5.3.1 Explaining the pattern of use of CFQEI across the organisations

To address the research question, "How does environmental uncertainty context influence the use of best quality exploitation and quality exploration practices mix in these laboratories?", the researcher developed causal networks to identify the mechanisms by which environmental uncertainty context influenced the use of quality management practices providing grounded explanations for the identified patterns of use of the QM practices. The use of causal networks is a recommended strategy for producing explanations in qualitative research (Miles and Huberman, 1994). By definition, a causal network is a

display of the most important independent and dependent variables in a field of study (shown in boxes) and of the relationships among them (shown by arrows). The plots of these relations are directional, and not only correlation relationship. It is assumed that some factors exert an influence on others e.g. X brings Y into being or makes Y larger or smaller (Miles and Huberman, 1994). First, all research variables; both the dependent and independent variables were identified and listed. Some of the variables were identified from the conceptual framework and the others from the research questions. These variables included the context variables of competitive intensity, rate of change of customer requirements, rate of change of product and service demand and complexity and all quality management practices as dependent variables. Based on the established patterns of use of the quality management practices and their relationship to the environmental uncertainty context variables, the researcher identified variables that always appeared together consistently, and have some form of relationships. This was feasible as all variables had already been rated both for the context and quality management practices. For each pair of variables that appeared to have some form of relationship, arrows were drawn between them, starting with the variables that appear to come first and those that the first variables appear to influence. Where two variables co-varied, but with seemingly oblique influences on each other, the researcher sought to identify intervening variables. In this whole process, context variables were represented by round or oval shapes whereas the practices variables were represented by squares and the direction of the influence by arrows. As the causal networks were developed, reviews were made to the original ones, confirming whether conclusions were plausible and revised where necessary. The networks were developed for each case organisation and patterns were observed among the networks. First, similar relationships were identified for the mine site laboratories (low environmental uncertainty) indicating the same general direction of influence of the independent variables on the dependent variables. A similar pattern of relationships was also observed for the commercial laboratories but the direction of influence being opposite to the ones for the mine site laboratories. Further reviews indicated that the causal networks patterns could be generalised for the low environmental uncertainty context organisations as well as for the organisations in the high environmental uncertain context level but with opposite direction on influences of the independent variables on the dependent variables. Figure 5.1 summarises the combined general causal networks for the two low environmental

uncertainty context organisations and the two organisations representative of the high environmental uncertainty context. The two organisational sets are distinguished by the ratings in the environmental uncertainty variables. Low environmental uncertainty context organisations (mine site laboratories) labels are in brackets.

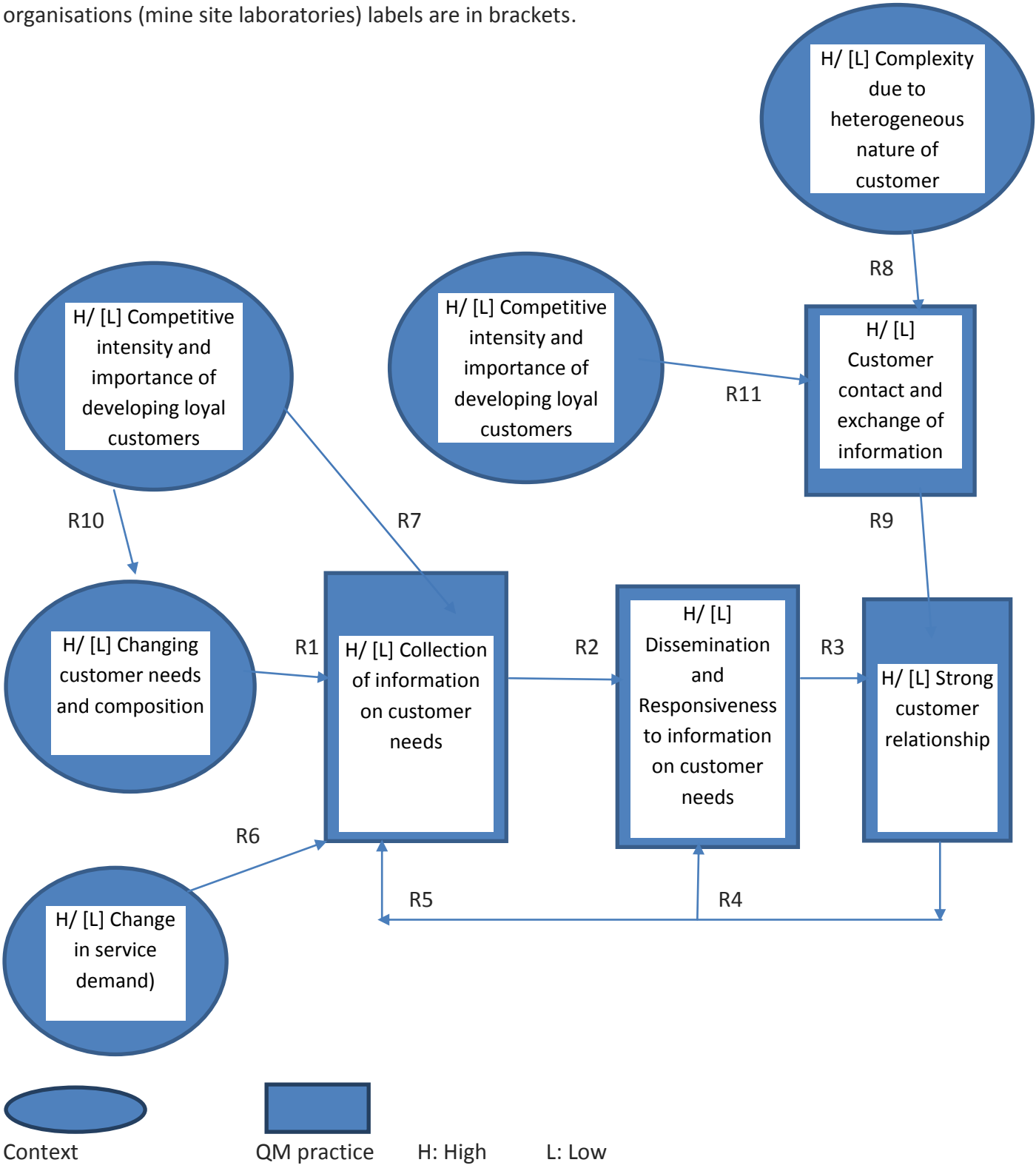


Figure 5.1 Causal networks for the use of customer focus for quality exploitation (CFQEI) practices in a high environmental uncertainty context organisation and low environmental uncertainty context organisation. Low environmental uncertainty context organisations (mine site laboratories) labels are in brackets.

- Changing customer needs and customer composition give rise to higher environmental uncertainty context which requires effective information acquisition processes (R1). Every submission from client could be different due to the heterogeneity nature of the customers and their needs which are also project dependent. Changing customer needs may include different requirements for sample preparation protocols, requirements for rate of inclusion of certified reference materials, billing requirements, etc. These changes are minimal in mine site laboratories and hence lower degree of use of information collection methods would be adequate for purpose under low environmental uncertainty context.
- The availability of information on customer needs dictates strong mechanisms for the dissemination of the same information within the organisation and mechanisms to respond to the information (R2). The opposite is true for stable customer requirements (context) which would give rise to low environmental uncertainty context and less application of information collection practices (practice). There is less need to develop mechanism to collect information on customer needs which are not changing much and also less need for developing mechanisms to disseminate and respond to this information when compared to the organisations operating in the high environmental uncertainty context. This would explain the higher degree of use of information collection practices in the two commercial labs than the mine site laboratories.
- The acquisition and dissemination of information (Practice) and responsiveness to customer requirements (R3) lead to closer customer relationship. This is evident for the acquisition of information and responsiveness to information but not reflected in the dissemination of information which rated equal in all organisations.
- Developing closer customer relationship requires understanding of customer needs which is achieved by high level collection of information on customer needs and responding to the information through (R2) and (R3). The opposite applies, when

less information is collected and known, the relationship becomes distant as evident in the degree of use of collection of customer information and customer relationship in the two mine site labs.

- Higher change in product and services demand (context) requires strong information gathering mechanisms (R6) for planning to ensure turnaround time is achieved i.e. collection of information from clients (practice) which is higher in the two commercial laboratories.
- Complexity in sample handling requirements which are client specific and customised requires high level scrutiny and attention to detail processes and requiring close communication with the customer (R8). The high level of attention to detail and constant interaction with the customer requires close relationship with the customer (R9).
- Higher competition (context) and the need to develop loyal customers requires that organisations know customer needs better than competition and hence requires high level systems and mechanisms of collecting information of customer needs (R7).
- Higher level competition results in competitor setting new standards which influence customer requirements and hence changing customer requirements (R10) i.e. competitor action influences change in customer requirements (context) forcing organisations to collect data on those requirements (R1).
- Strong customer relationship in turn facilitates the collection of information on customer needs (R5) and dissemination in order to respond to the information effectively (R4).
- Higher competitive intensity giving rise to higher uncertainty gives customers more options on who to use as suppliers resulting in need for the laboratories to develop loyal customers. This context results in high level contact and interaction with customers giving rise to stronger customer relationships (R11). The use of CFQEI practices in the low Environmental uncertainty context organisations corresponds to the L in the causal network and is explained by similar arguments reversed.
- To attain competitive advantage in quality requires performing better in quality than competition. From the “Red Queen” perspective, the action of competitors will influence an organization’s quality performance. In competitive environments,

competitors aim to provide better quality products and services to customers in order to attract them. This process influences the customers' expectations and organisations need to continuously adapt to their environmental context, hence evolving with customers' expectations (Su et al., 2014). Influencing customers' expectations by competitor changes the customers' requirements.

The above narrative statements provide explanations of the mechanism by which context affects the degree of use of the CFQEI practices. In general, the results between the two mine site laboratories representing the low environmental uncertainty agree and similarly the results for the two commercial laboratories representing high environmental uncertainty are in good agreement and in contrast to the results of the mine site labs. These results indicate both literal and theoretical replication.

5.3.2 Explaining the pattern of use of CFQER practices across the organisations

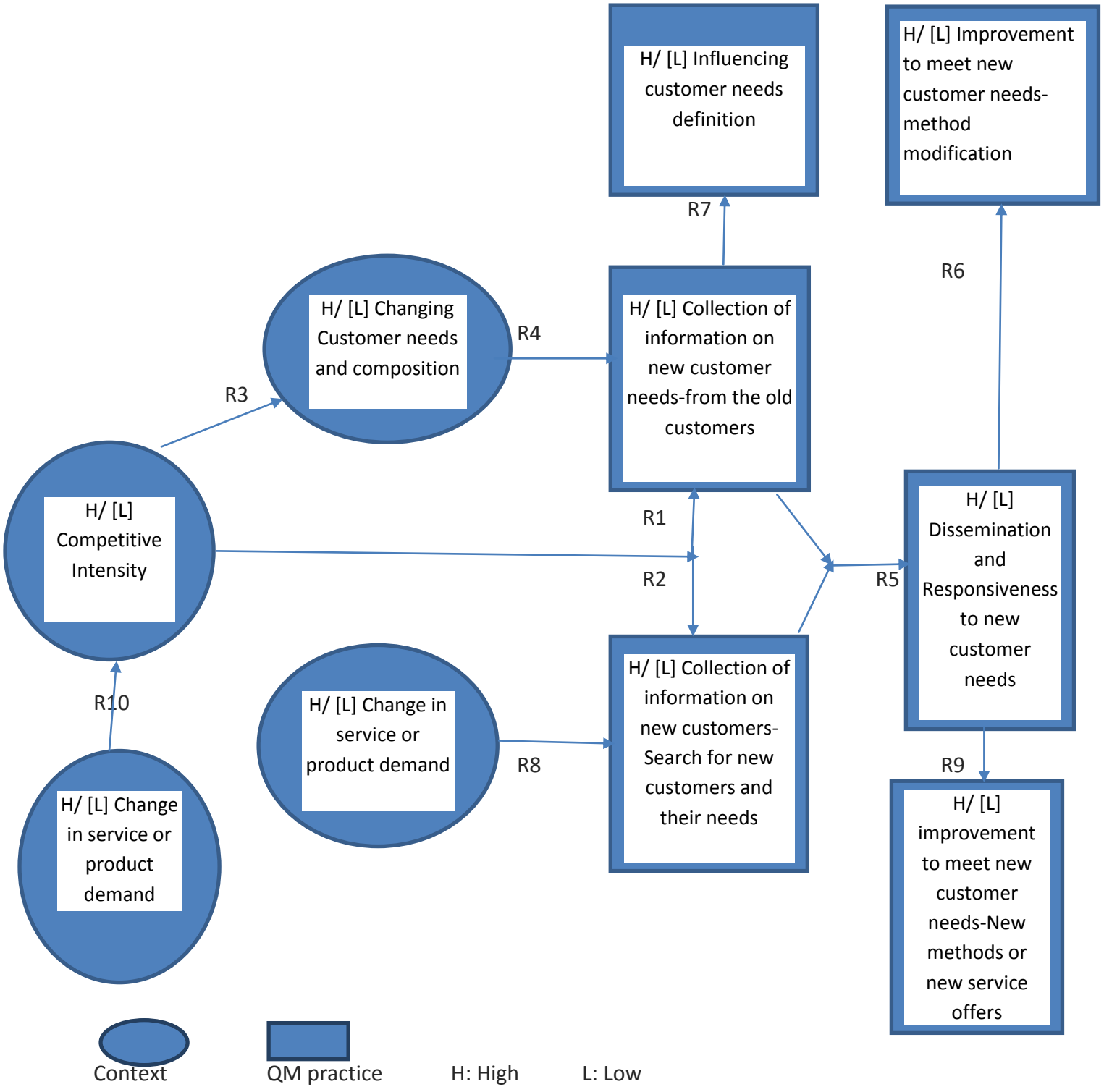


Figure 5.2 Causal networks for the use of customer focus for quality exploitation (CFQER) practices in high environmental uncertainty context organisation and low environmental uncertainty context organisation. Low environmental uncertainty context organisations (mine site laboratories) labels are in brackets.

- Higher competitive intensity requires organizations to develop strong mechanisms for collecting information on new customer needs (unfulfilled needs of the organisations' existing customers), (R1) and requires mechanisms for collecting information on potential customers and their needs (R2). In a less competitive and stable environment the benefits of developing a complex system for collecting information on the new needs of customers are less. Literally, there are very few new requirements and less new customers in non-commercial mine site stable laboratories.
- Resulting from the high competitive environment, the competitors influence the needs of the customers by changing standards of service through their improvement processes and influence customers to make the new performance standards as the standard of performance resulting in changing the customer needs (R3) which requires effective collection of information on the changing needs (R4). The reverse arguments explains the low use of this practice in stable non-commercial mine site laboratories.
- The collection of information on customers' new needs and the availability of this information call for strong mechanisms to disseminate and respond to the information (R5). The reverse argument explains the low use of practice in stable mine site laboratories.
- Responsiveness to the new needs of the customer leads to continuous improvement of the organisations' processes to meet the new needs (R6). The improvement processes could be exploitative or explorative. The reverse argument explains the low use of this practice in stable mine site laboratories.
- In a highly competitive environment organisations may not manage to keep up with the changing requirements of the customers which call for the organisations' ability to influence the definition of the needs of the customer to be in line with the organisations' capabilities (R7). Influencing the needs of the customers is an alternative to responding to and meeting the needs of the customers (R5). In a less competitive environment, and where there is low collection of information on new customer needs, the benefits of investing in mechanisms to alter the customers' needs definition is minimal, explaining the low use of this practice in less competitive environment.

- Higher change in demand for product and services forces organisations to develop mechanisms to collect information on these market changes (R8) to ensure effective planning processes are implemented. Laboratories operating in an environment where demand for services is not stable benefit more from strong information collection mechanisms which explains the high use of these practices.

  The above narrative statements provide an explanation of the mechanism by which context affects the degree of use of the CFQER practices in a high environmental uncertainty context. The reverse explains the mechanism by which environmental uncertainty context influences the use of CFQER practices when environmental uncertainty context factors are low.

5.3.3 Linking the use of CFQEI and CFQER practices across the organisations

The results above indicate that the degree of use of both CFQEI and CFQER are higher at higher environmental uncertainty context i.e. in the commercial laboratories than the mine site laboratories. This implies that at higher environmental uncertainty context organisations benefit more by implementing a higher degree of use of both CFQEI and CFQER practices. Organisations need to meet the needs of their current customers and the needs of potential customers. Commercial laboratories focus on the needs of their current customers simultaneously implementing practices to attract and meet the needs of the new customers. The results indicate that organisations operating in highly uncertain environments may benefit more from ambidexterity than organisations operating in stable environments. The results also show that the lower level implementation of customer relationship building practices in a stable environment becomes inadequate when organisations are operating in a highly uncertain environment where customers have more options due to the highly competitive nature of the environment. This also means that, the importance of developing loyal customers is higher in a highly uncertain environment as this would ensure consistent business and hence profitability. Low implementation of information collection practices evident in mine site laboratories (low environmental uncertainty) relative to commercial laboratories becomes inadequate at higher levels of uncertainty and hence organisations need to up their information collection and customer relationship building practices in highly uncertain environments. The strong and close

relationships are built through consistent communication with clients, being honest with clients, face to face meetings, visiting clients, and giving them reasonable access to the laboratory facilities, socialising with them where possible and being highly responsive to their needs and meeting their requirements. Honesty and integrity is key in building a loyal customer base in the laboratories industry. Good knowledge about customer needs is a requirement for building strong relationships with the customers.

5.4 Degree of use of PMQEI practices across the organisations

Table 4.5 (b) provides an overall summary of the degree of use of Process Management Practices for Quality Exploitation (PMQEI) across the different organisations. The table provides data for the overall use of the bundle of practices under the umbrella of PMQEI practices in addition to the individual practices that make the PMQEI set of practices. The visual patterns indicate that PMQEI practices are rated high across all organisations. This indicates that these practices are not influenced by the environmental uncertainty context of the organisation and therefore not contingent on the environmental uncertainty context.

Three distinct practices fall under the umbrella of Process Management i.e. Process Control, Process design and Process improvement (Evans and Lindsay, 2016). All process management practices under PMQEI virtually follow under the broad category of Process Control. Process control is the activity of ensuring conformance to requirements and taking corrective action when necessary to correct problems and maintain stable performance (Evans and Lindsay, 2016 page 221). The results suggests the fundamental importance of process control for all processes and organisations and that it is a prerequisite for any improvement an organisation may embark on. Process control is a necessary condition for achieving high quality results for all laboratories but may not be adequate to provide competitive advantage over other laboratories.

Since all practices are not influenced differently by the environmental uncertainty context no causal networks were developed for the PMQEI practices as these would be the same across contexts.

5.5 Degree of use of PMQER practices across the organisations

Table 4.6 (b) provides a summary of the degree of use of PMQER practices across organisations. The visual pattern indicates that the overall use of PMQER practices follows a distinct trend across the environmental uncertainty context spectrum except for the use of New Methods Introduction process which was rated medium and same across organisations. All other process improvement practices (improvement to meet changing customer needs, process improvement to better serve customers and belief in improvement) were rated higher for the commercial laboratories than the mine site laboratories. The rating for the degree of use of the practices for the mine site laboratories are in agreement and those for the two commercial laboratories exhibiting same high level agreement but in contrast to the rating for the mine site laboratories. These results give both literal and theoretical replication enhancing the validity of the results. Further investigation on the visual pattern was supported by calculating Spearman's rank correlation coefficient. All results for the practices except New Method Introduction practices gave positive and high correlation coefficient (0.89). Overall, the visual pattern and the Spearman's rank correlation coefficient suggest that PMQER practices are contingent on the environmental uncertainty context. The results indicate that organisations operating in highly uncertain environment may benefit more from implementation of process management for quality exploration practices (PMQER) than those organisations operating in a stable environment.

New Methods Introduction process was rated same across all organisations. All organisations reported conservative approach to application of thorough review for all validation parameters before offering the methods to clients. Laboratories ensure that the method to be introduced is fit for purpose considering three critical validation parameters of accuracy, precision and detection limit. All organisations reported that once accuracy and range (validated by use of certified reference materials), precision and detection limits are validated, methods are offered to clients. Laboratory CL1 further indicated that tests are done on client samples as part of validation process. This suggests that New Method Introduction (NMI) process is critical irrespective of the environmental uncertainty context. Other parameters are validated as methods are used.

5.6 Pattern of use of PMQEI and PMQER practices across the organisations

The pattern of use of the QM practices shows that both PMQEI and PMQER practices are implemented at a higher level in the commercial laboratories (organisations CL1 and CL2), with PMQEI implemented the same across all the organisations. The two sets of practices are highly correlated in commercial laboratories. At low environmental uncertainty context PMQEI practices are implemented at a higher degree than PMQER practices. The results show that the degree of implementation of PMQEI is higher than for PMQER at the mine site laboratories (low environmental uncertainty context). At the same time, the degree of use of both PMQEI and PMQER is high in commercial laboratories. At higher environmental uncertainty context, both practices, PMQEI and PMQER are equally important and organisations operating in a highly uncertain environment will need to develop capabilities to utilise both practices at higher degree of implementation. This suggests that the organisations should develop ambidexterity (the ability to implement QEI and QER simultaneously). The results also suggest that PMQEI is necessary for PMQER to be implemented as it is highly implemented in both mine site and commercial laboratories but PMQER is implemented at low degree of implementation in mine site laboratories.

5.6.1 Explaining the pattern of use of PMQEI across the organisations

The pattern of use of the various PMQEI practices is explained below but causal networks were not developed for PMQEI as most of the practices were not contingent on environmental uncertainty context.

- Process Management consists of three distinct practices of design, control and improvement (Evans and Lindsay, 2016). The PMQEI practices of use of statistical process control tools, use of zero defect practices, Real-time Feedback process control, use of Offline Feedback analysis, and use of control samples are all Process Control Practices. Process Control ensures conformance to requirements and taking corrective actions to correct problems and maintain stable performance. The control system consists of a standard or goal, a way of measuring achievement of the goal, comparison of the results with standard to provide feedback and the ability to make

corrections as appropriate. Process control to achieve stable processes is achieved through the use of standard operating procedures, statistical process control, etc. Process Feedback is a critical component of process control. The visual pattern for the use of Process Management for Quality Exploitation practices (PMQEI) shows that the degree of use of these practices is high and uniform across all organisations and that the use is not contingent upon the environmental uncertainty context. Process efficiency is critical either under low or high environmental uncertainty and helps to improve on turnaround time. In a stable environment organisations focus on process efficiency to meet the requirements of their current customers and hence implement process control to achieve this and to a high degree. In a highly uncertain environment characterised by high competitive intensity organisations need to increase efficiency to be able to compete effectively on dimensions of quality, cost and delivery and this is achieved by high implementation of process control practices (Real-Time Feedback processes, overall offline process feedback, use of control samples, statistical process control). This indicates that process control is a necessity for all operations and hence not contingent upon environmental uncertainty context.

- High competitive intensity forces organisations to improve their efficiency which is achieved by high implementation of process control but this may not lead to competitive advantage. No causal network diagrams were constructed for Process Management for Quality Exploitation Practices.

5.6.2 Explaining the pattern of use of PMQER across the organisations

- The degree of use of Process Improvement Practices was rated high for both commercial laboratories and low for the mine site laboratories showing a distinct pattern across the environmental uncertainty context spectrum. Although the degree and extent of formalisation of New Methods Introduction was rated same across the organisations, overall rating of PMQER was higher for the commercial laboratories and contingent upon the environmental uncertainty context.
- At high environmental uncertainty context characterised by high competitive intensity, laboratories are forced to compete on efficiency factors of cost, quality and turnaround time and organisations are forced to improve their processes

incrementally (R1) or create new products and services (R2) to meet changing customer needs.

- When uncertainty is high, characterised by high change in product or service demand, low demand for laboratory services results in intense competition (R3). Intense competition, results in competitors of the organisations introducing new products and services or improving their service levels leading to change in customer requirements (R4) i.e. High competitive intensity introduces capabilities which become standard requirements thereby changing customer requirements and forcing organisations to improve.
- When competition introduces a new service offer or improved offer, it becomes standard and customer's needs change such that the new offer becomes a requirement. The change in requirements forces organisations to improve incrementally (R5) or radically (R6) in order to meet the new requirements.
- Changing customer needs forces organisations to improve or create new methods more frequently than in a stable environment. The reverse argument provides an explanation on the use of PMQER practices in low environmental uncertainty context organisations MS1 and MS2.
- In a stable environment where changes in customer requirements are not frequent there is no pressure to improve or change processes leading to low implementation of Improvement practices. There are no significant changes in method performances e.g. influenced by competition e.g. new detection limits, new different methods etc.

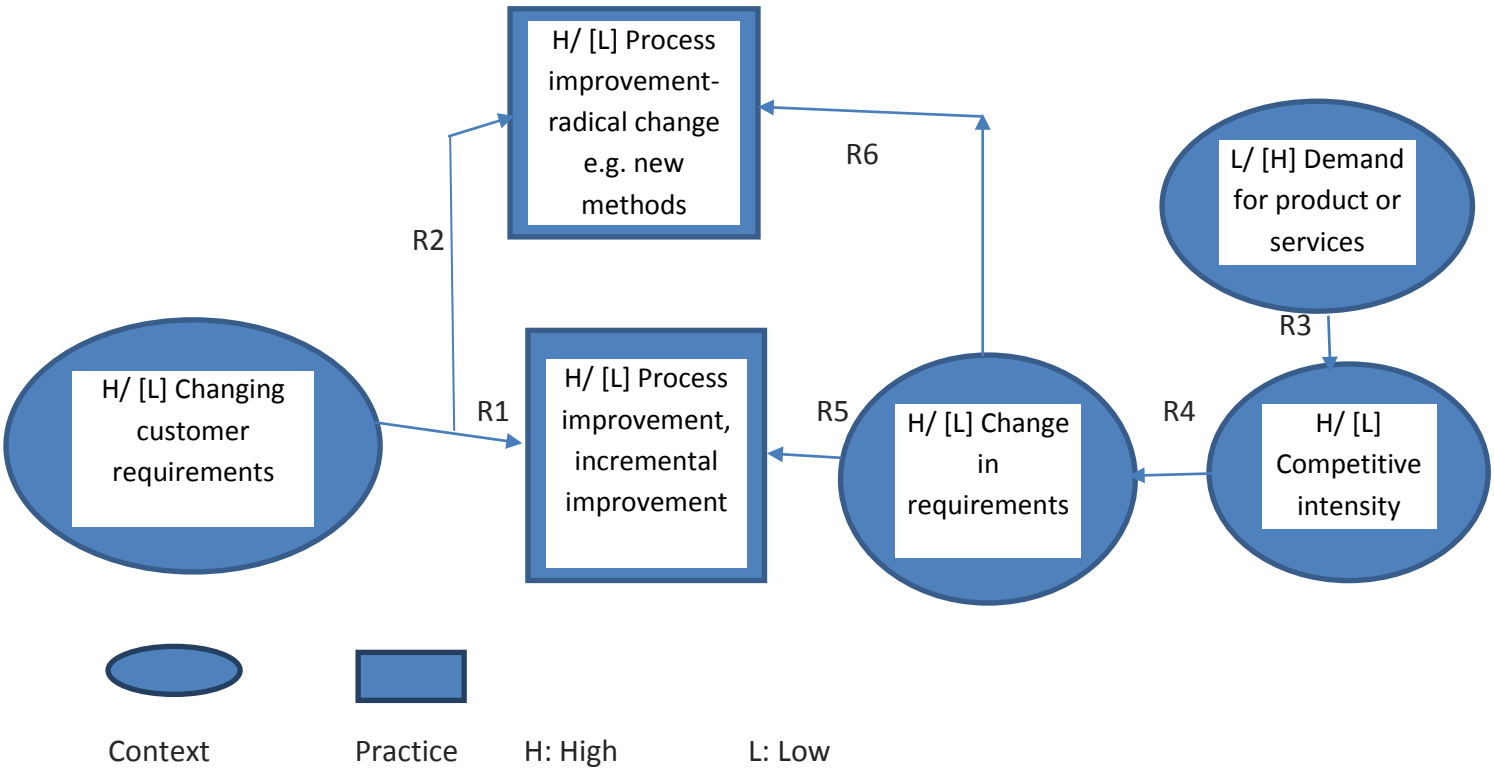


Fig 5.3 Causal networks for the Process Management Practices for Quality Exploration (PMQER) practices in high environmental uncertainty context organisation and low environmental uncertainty context organisation

Low environmental uncertainty context organisations (mine site laboratories) labels are in brackets.

5.6.3 Linking the use of PMQEI and PMQER practices across the organisations

- The results indicate that the degree of implementation of PMQEI is high at both low and high environmental uncertainty contexts whilst the degree of implementation of PMQER practices is low at low environmental uncertainty context and high at high environmental uncertainty context.
- This indicates that at high environmental uncertainty context, characterised by high competitive intensity, change in customer requirements, changing product and service demand levels, organisations need to meet the current requirements of their

customers through exploitative practices and those of new customers or the new needs of its current customers through explorative Practices.

- PMQEI ensures current customer needs are met and PMQER ensures the new requirements of its existing customers and those of new customers are met through the development of new processes and methods or improvement of the current methods.
- High competition may influence the needs of the laboratory's current customers e.g. new detection limits which a competitor has achieved and sets that as new standard influencing customer requirements. This forces organisations to improve their current practices. This pressure is less or not there in a non-competitive environment.
- Since the degree of use of PMQEI is high in both environments, it shows that there is no competitive edge that would come from PMQEI but a necessity; hence organisations are forced to compete on PMQER practices.

5.7 Degree of use of TWQEI practices across the organisations

Table 4.7(b) provides an overall summary of the degree of use of Teamwork for Quality Exploitation practices across the organisations. The overall degree of use was rated same across organisations. TWQEI practices are therefore not contingent on environmental uncertainty context. The design of the processes supports the use of teams as no one person works on samples from start to finish. In general, samples are weighed by a different operator and send for digestion which is done by a different employee and handed over to instrument operators to complete the analysis. The design of the process inherently supports strong teamwork approach. A high level understanding of the importance of teamwork to achieve customer satisfaction was evident during the interview process across all organisations.

5.8 Degree of use of TWQER practices across the organisations

Table 4.8(b) provides an overall summary of the degree of use of Teamwork for Quality Exploration practices across the organisations. The Spearman's correlation coefficient shows a week positive correlation between context and degree of use of the TWQER practices

across the environmental uncertainty context spectrum, RHO=0.63. Though the correlation is weak, there is an overall increase in degree of use of TWQER practices across the plants with organisations MS2 and CL2 rated H in the use of the practices whilst MS1 and CL1 rated low and M respectively. The pattern suggests existence of other influencing factors for the explorative practices across the plants.

5.9 Pattern of use of TWQEI and TWQER practices across the organisations

5.9.1 Explaining the pattern of use of TWQEI practices across the organisations

The results indicate that the degree of use of TQWEI practices is the same across the environmental uncertainty context spectrum. From the results of the interviews the analysis of samples follows a distinct process in which samples are passed from one operator in a particular area to another operator at a different stage in the process. This process approach requires that employees take a team approach to ensure quality results at the end of the different stages of the analytical process. It requires trust among the different members of the team and having one goal, to meet client requirements as a unifying aspect in the process. The different environmental uncertainty context variables do not seem to influence the degree of use of practices across the environmental uncertainty context spectrum.

5.9.2 Explaining the pattern of use of TWQER practices across the organisations

Table 4.8(b) provides an overall summary of the degree of use of Teamwork for Quality Exploration practices across the organisations. The Spearman's correlation coefficient shows a week positive correlation between context and degree of use of the TWQER practices across the environmental uncertainty context spectrum, RHO=0.63, p (2-tailed) =0.37. Though the correlation is weak, there is an overall increase in degree of use of TWQER practices across the plants with organisations MS2 and CL2 rated H in the use of the practices whilst MS1 and CL1 rated low and M respectively. The pattern suggests existence of other confounding factors for the explorative practices across the plants but

simultaneously indicating that organisations operating in highly uncertainty environment would benefit more from use of cross-functional teams.

5.9.3 Linking the use of TWQEI and TWQER practices across the organisations

The results indicate that the overall use of TWQEI practices is the same across all organisations and hence the use of these practices is not contingent upon the environmental uncertainty context spectrum. However, the overall use of TWQER is higher for the organisations operating in high environmental uncertainty context than those operating in a low environmental uncertainty context. Although, the correlation between context and use of TWQER practices is weak, the results suggest that organisations operating in a highly uncertain environment would benefit more from the use of explorative practices. Having noted that the use of TWQEI practices is same across all plants, results further suggest the tendency of employing both TWQEI and TWQER when environmental uncertainty is high. The weak correlation between context and degree of use of TWQER implies the existence of other confounding factors affecting the use of TWQER practices.

5.10 Degree of use of TRQEI practices across the organisations

Table 4.9 (b) provides an overall summary of the degree of use of Training for Quality Exploitation practices across the different laboratories. The visual pattern indicates that the degree of use of TRQEI practices is similar across the environmental uncertainty context spectrum. These results suggest that Training for Quality Exploitation practices are not contingent upon the environmental uncertainty context in which the organisations operate. The practices are highly used across the organisations irrespective of the environmental uncertainty context. These results show the criticality of training on requirements for one's current job competence needs.

5.11 Degree of use of TRQER practices across the organisations

Table 4.10 (b) provides an overall summary of the degree of use of Training for Quality Exploration practices across the different laboratories. The visual pattern shown for the overall degree of use of TRQER practices indicates that the degree of use of TRQER practices is similar across the environmental uncertainty context spectrum. These results indicate that

Training for Quality Exploration practices are not contingent upon the environmental uncertainty context in which the organisation operates. The practices are highly used across the organisations irrespective of the environmental uncertainty context.

5.12 Pattern of use of TRQEI and TRQER practices across the organisations

5.12.1 Explaining the pattern of use of TRQEI across the organisations

The visual pattern shown in Table 4.9 (b) indicates that the degree of use of TRQEI practices is similar across the environmental uncertainty context spectrum. These results suggest that Training for Quality Exploitation practices are not contingent upon the environmental uncertainty context in which the organisation operates. The practices are highly used across organisations irrespective of the environmental uncertainty context. Training in work related practices increases the proficiency of the operators which is required to ensure effective and efficiency of the organisation, a requirement in stable environment. In the same manner, at higher environmental uncertainty context characterised by high competition organisations start to compete on efficiency, cost and turnaround time which would require well trained and experienced operators. There is a strong training culture in all the organisations with employees taken through the procedures that govern the different processes. The training ensures deep understanding of the processes, and implementing the procedures enhances operator ability to identify potential process problems and addressing them. This reduces waste and increases process efficiency. Although the need for process efficiency becomes more critical as competitive pressure increases, it is still critical for those organisations operating in a stable environment.

5.12.2 Explaining the pattern of use of TRQER across the organisations

The results in Table 4.10 (b) indicate that training practices to ensure employees are trained in a variety of task are equally implemented across the environmental uncertainty context. When employees are trained in a variety of tasks, the employees are enabled to stand in for other employees who work in different sections or areas of the process. These practices were found not contingent on environmental uncertainty context. At low environmental uncertainty context, there isn’t much change in customer needs and organisations focus on training employees to meet current job requirements. This assists employees understanding

their procedures better thereby becoming more efficient in the operations of those procedures. At higher environmental uncertainty context, organisations also focus on training employees to meet their current job requirements. Training in a variety of tasks helps the employees to think creatively through learning from the different tasks and other employees. This helps employees to solve complex problems that are associated with processes at high environmental uncertainty context characterised by complexity. Other factors may explain the high implementation of multitasking in all organisations.

5.12.3 Linking the use of TRQEI and TRQER practices across the organisations

At low environmental uncertainty context organisations implement TRQEI practices to a high degree. This was also observed for the organisations operating in high environmental uncertainty context. In a similar manner, TRQER practices involving training of employees in a variety of tasks were implemented to the same level across the environmental uncertainty context and were all rated medium. The results suggest that TRQEI practices set a fertile ground for TRQER practices. There are potentially other factors that could be influencing the high use of training of employees in a variety of tasks e.g. the way the analytical processes are designed.

5.13 Contingency determined pattern of use of quality exploitation and quality exploration practices across organisations (best QEI and QER mix across organisations)

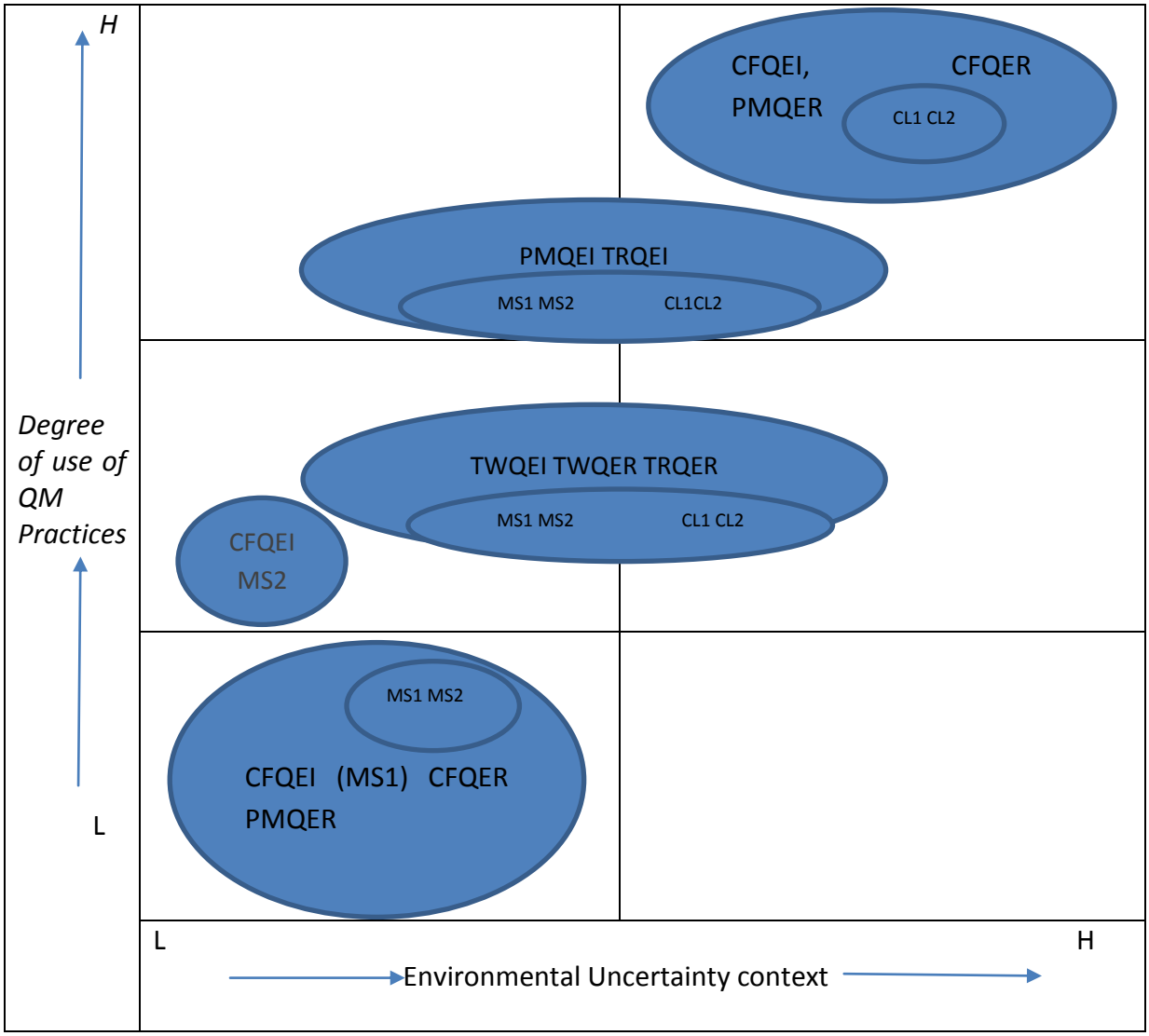


Figure 5.4 Contingency determined patterns of selecting best QEI and QER practices mix across case organisations indicating organisations grouped according to common patterns of use of practices

Chapter 6

Conclusions and recommendation for further research

6.0 Introduction

Chapter 6 provides a conclusion on the research findings, limitations and recommendations for further research in answering the study research questions.

6.1 Pattern of use of QEI and QER practices across the organisations (RQ1).

The visual patterns for the degree of use of quality exploitation and quality exploration practices indicate that the use of these practices in particular customer focus and process management practices are contingent on an organisation's environmental uncertainty context. The degree of use of these practices change across the environmental uncertainty context spectrum and in a predictable manner. The patterns indicate that customer focus for quality exploitation, customer focus for quality exploration and process management for quality exploration practices are contingent on an organisation's environmental uncertainty context providing support for the contingency theory of QM. The spearman's correlation coefficient calculated between the ranked data of the degrees of use of the various quality exploitation and quality exploration practices and environmental uncertainty context variables supported the contingency nature of the patterns of use of quality exploitation and quality exploration practices. In general, the patterns of use for the various quality management practices show good agreement for those organisations in the same environmental uncertainty context e.g. the two mine site non-commercial laboratories (MS1 and MS2) have the same patterns for the degree of use of CFQEI, CFQER and PMQER practices. Similarly, commercial laboratories, CL1 and CL2 have similar patterns for the degree of use of these practices but different from the patterns of the degree of use found in the mine site laboratories providing both literal and theoretical replication for the use of QEI and QER practices. Whilst the degree of use of some practices are influenced by environmental uncertainty context, some practices are employed to the same degree across the environmental uncertainty context spectrum e.g. PMQEI.

The causal networks provided detailed explanations of how the contextual variables of environmental uncertainty context influence the use of QEI and QER practices providing a

strong support for the contingent nature of CFQEI, CFQER and PMQER practices. Similar to the degree of use of the various QEI and QER practices which provided both literal and theoretical replication, the causal networks also found replication within the same context e.g. the mechanism of influence of the various contextual variables in MS1 and MS2 were similar (literal replication) as were for CL1 and CL2 (literal replication) which were opposite to those of MS1 and MS2 (theoretical replication) providing strong support for the contingency nature of the patterns of the degree of use of QEI and QER practices.

The results show that at high environmental uncertainty context, CFQEI, CFQER and PMQEI and PMQER are critical and employed to the same high degree of use. CFQER and PMQER including CFQEI are employed to a lower degree of use when environmental uncertainty is low. These results suggest that at high environmental uncertainty organisations need to adopt ambidexterity to meet both requirements of their current market and those of emerging and new markets. Previous research has shown contradictory results on the relationship between QEI and QER, with some findings suggesting that QEI and QER may impede each other (Ozsomer and Gencturk, 2003) and of difficult nature to coordinate whilst Asif et al., (2020) found that both quality exploitation and quality exploration practices are pivotal in achieving the exploitation and exploration goals of the organisation. Furthermore, their study found that quality exploitation practices do not hinder but rather create, the basis for quality exploration, which take place not sub-sequentially but also in parallel. Quality management practices can support punctuated equilibrium which alternates quality exploitation and quality exploration. The findings of this study suggest that QEI and QER can be implemented simultaneously to high levels and when uncertainty is high, organisations need to use CFQEI, CFQER, PMQEI and PMQER to a high degree.

The CT theory states that the firm performance is dependent on a fit between the structure and process of a firm and its external environment. Based on the CT, integration of the internal structures and processes is expected to fit a high environmental uncertainty context. The Organisational Information Processing Theory (OIPT) suggests the need to improve information quality and processing capability when environmental uncertainty is high (Wang et al., 2011). From the empirical results of this study, high environmental uncertainty context is associated with high degree of use of information collection and processing practices, providing a strong grounding on existing theory e.g. (H/L) change in

service demand is associated with (H/L) degree of use of information collection and processing practices. Similarly, (H/L) changes in customer needs, requirements and composition is associated with (H/L) collection of information on new customer requirements. These results are consistent with established Organisational Information Processing Theory (OIPT). Environmental uncertainty is related to lack of information required for decision making.

The study findings provide support to previous propositions (that the mixed findings on the relationship between quality practices and performance could be related to QM practices being context dependent (Sousa and Voss, 2008, Fundin et al, 2018) and research and quality programs designs should consider environmental uncertainty context. For research involving QEI and QER practices and organisational performance, consideration should be given to environmental uncertainty context, which can be taken as part of control. For QM practitioners, the findings inform implementation to adjust QEI and QER practices mix to match environmental uncertainty context. The use of contingent determined patterns can provide a good starting point.

6.2 Causal networks for the influence of environmental uncertainty context variables on degree of use of QEI and QER practices (RQ2).

Causal networks were developed to provide mechanisms by which the various contextual variables influenced the various QEI and QER practices. The causal networks provided a strong support for the contingency nature of the use of CFQEI, CFQER and PMQER practices. The mechanism of influence provide evidence that environmental uncertainty context variables provide some constraints or difficulties in the use of QEI and QER practices e.g. high level rate of change of demand for services will make it difficult to attain effectiveness of practices with low use of information collection, hence the need to use collection of information on customer requirements to a very high degree (high degree of use of information processes was always associated with high rate of change of product or demand for product and services but following the rate of change of demand for product and services). Similarly, once strong relationships are developed with customers it becomes difficult not to be responsive to their needs, hence need for high use of customer responsiveness practices. Therefore, causal networks provide insight into the nature of

problems related to QEI and QER practices as related to the right mix of practices which defines the content of QM practices. There are problems that are related to the content of QM practices mix and how it matches environmental uncertainty context, which are different from problems related to the process of implementing QM (Sousa, 2003). Problems related to matching of QEI and QER mix to environmental uncertainty context will require changing the mix of QEI and QER or changing the environmental uncertainty context to address them. The latter is not easy to change, but possible e.g. in this study organisation CL2 provides a way of reducing the effect of uncertainty due to change in product service demand by spreading their services across industries, mining being the main stream but agriculture and food analysis being added to their portfolio of services. This minimises overall rate of change in demand of product and services as demand peaks for the various industries are different. On the other hand, Laboratory CL1 provides metallurgical test work, which attracts customers that prefer a one stop shop for the services that they require. This strategy reduces demand variation to a certain extent at the same time attracting more customers since most customers would prefer one stop shop. Laboratories, CL1 and CL2 also provide effort to minimise effect of change on customer requirements by influencing (or altering customer requirements) to fit their capabilities. These approaches provide a means of matching context to practices mix. The ability to distinguish QM practices challenges of QEI and QER mix from process implementing challenges provides a great step in managing QM practices and enhancing their success.

The difficulties posed by environmental uncertainty context variables on the use of QEI and QER practices as revealed by the causal networks provide the causal networks with predictive power in determining possible pattern of use of QEI and QER practices for given environmental uncertainty context variables, hence their use in selecting best QEI and QER practices mix.

The application of causal networks to QEI and QER in QM research makes a theoretical contribution to QM practices literature as this is one of the first few applications of causal networks in QM distinguishing the effect of environmental uncertainty context variables on QEI and QER separately.

6.3 Model for guiding the selection of best QEI and QER practices mix across the environmental uncertainty context spectrum (RQ3).

The contingency determined patterns of use of QEI and QER mix provide the ideal quality management practices mix. Whilst it is understood that there are other factors that may affect the adoption of QEI and QER practices, the contingent determined patterns provide an ideal starting point in designing the content of QM practices mix. From the pattern of use of the various QEI and QER practices mix across the environmental uncertainty context, the study identifies the best QEI and QER practices mix for given environmental uncertainty context. Various studies have identified the effects of environmental uncertainty context on QM practices but there has been limited research on a working tool on selecting the best QEI/QER practices mix (Zhang et al., 2012). Zhang et al., (2012, 2014) provided the first attempt to empirically measure QEI and QER practices in an effort to customize the use of QM practices. However, the data used for this was derived from the HPMP and may not be applicable to laboratory industry. Furthermore, all participants in the HPMP project were from developing countries and the question remains whether the QEI/QER relationship obtained will apply to the laboratory industry and in particular in developing countries. ISO 9001:2015 QM frameworks acknowledge that QM practices are context dependent but do not provide a working tool to guide practitioners in selecting QM practices mix to implement. Using the contingent determined patterns and the causal networks practitioners can identify and establish the best QEI and QER practices mix by using as base contingency determined patterns in this study and predict the degree of use of other practices using causal networks upon determining the contextual variables of interest. Figure 6.1 below shows the model for guiding selection of best QM practices mix in laboratories serving the mining industry in Zimbabwe and SA.

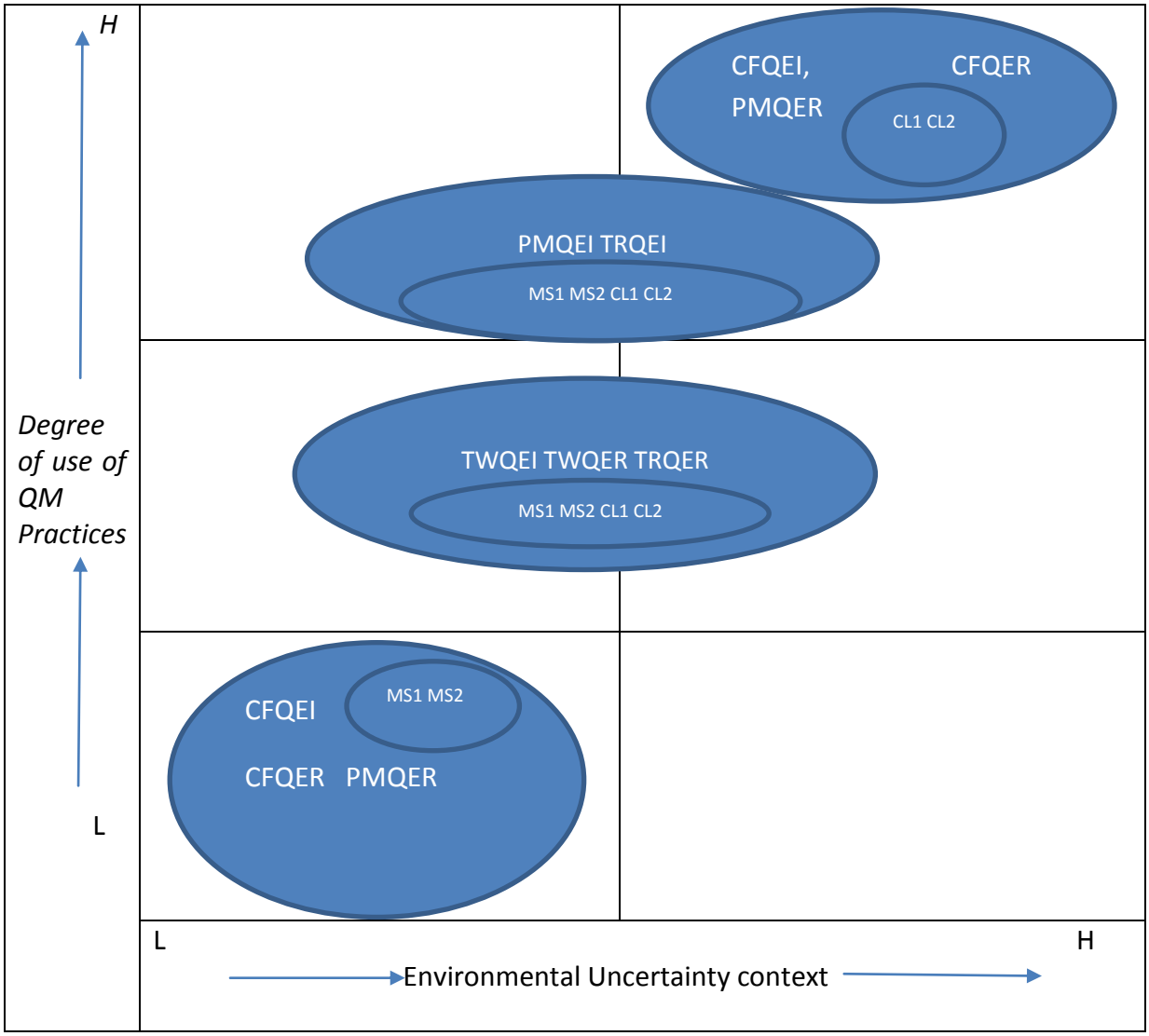


Figure 6.1 Model for guiding the selection of best QM practices mix

6.4 Contribution of the study

The study makes theoretical contribution to the understanding of the influence of environmental uncertainty context on QEI and QER practices separately in the context of mining laboratories in developing countries and identifies best QM practices mix for different environmental uncertainty contexts. In particular the study shows that at high environmental uncertainty context organisations need to implement CFQEI, CFQER, PMQEI and PMQER to high levels which imply organisations need to adapt ambidextrous stature in their choices of QEI/QER practices mix.

By separating QEI and QER, the study addresses the issue related to the effectiveness of QM practices contributing to resolution of mixed findings in QM research and implementation.

Furthermore, the study identifies how the influence of environmental uncertainty context variables takes place on the two forms of QM practices contributing to the application of causal networks to the two forms of QM i.e. QEI and QER in QM research and implementation.

The study concludes that the use of QEI and QER are contingent on the environmental uncertainty context of an organisation and supports the contingency theory of QM effectiveness but not all QEI and QER practices are contingent on environmental uncertainty context e.g. PMQEI, TRQEI practices were found to be implemented to the same high level across the environmental uncertainty context whilst PMQER are contingent on the environmental uncertainty context. This knowledge provides insight into the selection of best QEI and QER practices mix across contexts and addresses the effectiveness of QM practices. The study empirically validates environmental uncertainty context as a contingent factor for QEI and QER practices.

The study contributes to contingency theory in QM by developing a model for selecting best QEI and QER mix along an environmental uncertainty context spectrum highlighting the need to adjust QEI and QER practices to match environmental uncertainty context. This study provides practitioners a model to use in designing QM programs in organisations and enhances the success rate of QM programs. The contingency determined patterns for the degree of use of QEI and QER practices implies that when environmental uncertainty is high organisations need to consider use of CFQEI, CFQER, PMQEI and PMQER to the same high degree across the environmental uncertainty context.

Finally, the study findings inform implementation of QEI and QER practices. From the difficulties posed by environmental uncertainty context variables on the use of QEI and QER, practitioners can distinguish problems related to QM practices content from those related to implementation process and prescribes the correct remedy to QM practices related issues by either adjusting QEI and QER mix to fit context or modify environmental uncertainty context to enhance fit.

6.5 Limitations of the study

Due to the use of one industry in this study, the findings can be generalized to the laboratories in the mining industry. The replication logic utilized in the research design allows for analytical generalization. Analytical generalization implies that the results of this study can be generalized to a broader theory. Despite the use of one industry study, which limits generalization, the study results can be theoretically but not statistically inferred to other industries (Yin, 2009). It is expected that many organisations in other industries can be positioned along the same environmental uncertainty context and hence the effects of the environmental uncertainty context variables on the use of QEI and QER practices would be similar across industries. Furthermore, these findings are supported by literature e.g. Zhang et al., (2012) which should enhance generalization of the research findings.

Initially, the research was designed to study organisations in one country; however because of difficulties in getting access to some laboratories the final sample composition included one organisation in South Africa. Although controls were put in place, country differences could have introduced some errors. Furthermore, the study aimed to interview about eight employees per organisation, but this number was not reached as the organisations had significantly reduced their labour. However, saturation was reached with the numbers that were interviewed.

There are many other QM practices sited in literature but due to limited time, the study focused on only four practices and the findings of this study are only limited to these four practices, eight in total considering the two orientations for each.

6.6 Recommendation for further study

Further research is recommended to establish whether these findings replicate in other settings e.g. the health industry. Future research should consider evaluating performance of laboratories that exhibit contingency derived patterns of use of their QEI and QER mix by conducting large scale cross-sectional studies to establish whether these organisations outperform organisations exhibiting out of fit QEI and QER practices mix. Further insight into this study can be enhanced by extending the study to included customers of the organisations.

There are many other QM practices sited in literature but due to limited time, the study focused on only four practices and the findings of this study are only limited to these four practices, eight in total considering the two orientations for each. Future studies should look at other practices beyond these four practices.

Appendix A: Research questions:

Quality Exploitation and Quality Exploration: A guideline for the selection of best Quality Management Practices Mix-Questionnaire

A3.6 Questions on the use of quality management practices of exploitation and exploration for customer focus, process management, teamwork and training practices.

Interviews were held to gather information on the use of the eight quality management practices. Multiple respondents included the laboratory manager, laboratory supervisor, the Quality Manager, laboratory supervisors.

Objective evidence for the use of these practices was obtained through the review of QA/QC generated data and observations where applicable. Each case organization was visited at least once with each visit lasting up to six hours. Interviews with each respondent ranged from 20 minutes to 3 hours. More time was spent with the senior Laboratory personnel (QA, Laboratory Managers and Directors) in all cases.

A3.7 Measurement instrument for the extent to which each of the eight quality management practices is used. The practices include customer focus for quality exploitation, customer focus for customer exploration, process management for quality exploitation, process management for quality exploration, team work for quality exploitation, teamwork for quality exploration, training for quality exploitation and training for quality exploration. These have been coded as CFQEI, CFQER, PMQEI, PMQER, TWQEI, TWQER, TRQEI, and TRQER respectively.

The following questions provided an initial guideline that shaped the questioning. Response given shaped the subsequent questions but in general questions followed this guideline.

A3.7.1 Customer Focus for Quality Exploitation (CFQEI)

Q1: Who are your customers and how do you build relationship with them? How often are you in contact with your customers?]

Q2: How do you identify the needs and expectations of your organization's customers?

Q3: How does the laboratory seek feedback from its customers on quality and delivery performance of its work?

Q4: How does the laboratory disseminate information collected on customer needs within the organization and to what extent does the laboratory respond to that information?

A3.7.2 Customer focus for quality exploration (CFQER)

Q1: How does the laboratory explore the new needs of its existing customers?

Q2: How does the laboratory identify new customers and their requirements?

Q3: To what extent does, the laboratory test customer needs definitions and stimulates new customer need definitions and levels?

Q4: How does the laboratory use the complaints system to initiate improvement? [The existence of a process or mechanism to analyse customer complaints and develop improvement actions based on the complaints]

Q5: To what extent are customers involved in the development and introduction of new methods? [Customer involvement]

A3.7.3 Process management for quality Exploitation (PMQEI)

Q1: To what extent are statistical methods of analysis used to reduce variances in analytical process?

Q2: How and to what extent are Internal Quality Control Processes (IQC) and procedures utilized to ensure that errors in the analytical data are of a magnitude appropriate for the use to which data will be used?

Q3: To what extent is the analysis of Quality Control (Process Control) data performed off-line [Extent to which quality control data is analysed offline] e.g. weekly, monthly. Information includes in-process control data, customer feedback data, internal quality audit results, performance in proficient testing schemes].

Q4: To what extent is the use of mistake proofing mechanisms utilized to prevent errors from being made? [These are mechanisms to prevent errors from being made and include automation, self-checking mechanisms, and zero defects mechanisms]

Q5: How is Process Control mechanisms utilized to provide real time feedback on state of control of the analytical process?

A3.7.4 Process management for quality exploration (PMQER)

Q1: To what extent is the process of developing, validation and introduction of new methods of analysis formalized?

Q2: To what extent are process improvements made to meet changing needs of the clients?

A3.7.5 Teamwork for quality exploitation (TWQEI)

Q1: To what extent are employees encouraged by supervisors to work as a team?

Q2: How and to what extent are employees encouraged by supervisors to exchange opinions and ideas?

A3.7.6 Teamwork for quality exploration (TWQER)

Q1: To what extent is the use of cross-functional teams encouraged and supported in your organization?

Q2: To what extent do different functional teams cooperate to resolve conflicts between them, when they arise?

A3.7.7 Training for quality exploration (TRQEI)

Q1: How are employees trained and developed in workplace skills?

Q2: To what extent do managers believe and support the continual training and upgrading of employee skills?

A3.7.8 Training for quality exploration (TRQER)

Q1: To what extent are employees trained to perform a variety of tasks?

Q2: How are employees trained to fill in for others if need arises?

Q3: To what extent are training programs designed to cater for anticipated future needs of the organization?

A3.9 Questions on Environmental Uncertainty Context

How would you rate your organization and justify the rating of the extent to which you agree or disagree with each of the statements below concerning your laboratory?

Q1: The needs and wants of our customers change very fast

Q2: The demand for our laboratory's products is unstable and unpredictable

Q3: Our competitive pressures are extremely high

General

Q1: What challenges is your laboratory currently facing?

Q2: What major differences would you say exist between commercial laboratories and mine site non-commercial laboratories?

Appendix B. Guidelines for data reduction process resulting in the rating of degree of use of the Process Management Practices for Quality Exploitation and Exploration

Use of statistical Methods of analysis

A list of general analytical processes where statistical methods are expected to be used was developed. The actual detailed description of the use of the methods captured from the interviews and data review was compared with expected use rate e.g. use of QC Charts during normal control of

analysis, use of Z-score in assessing proficiency testing and round robin data, use of significance testing statistics during method development e.g. T-test, F test and Q Test. The results were then rated L, M or H using rule 1 defined in section 3.4.4.1 of the methodology section of this report-data reduction process.

Use of internal Quality Control (IQC)

A textual description of the analytical process was given for the major analytical methods in the laboratory (the most common methods) as sample preparation (crushing, pulverising), weighing, digestion, making up to volume (dilution process), instrument calibration, reading of samples on the instrument, data approval and reporting processes. Key quality control checks or controls were identified across the analytical process. The identified quality control checks across the analytical process included the following:

- Crushing quality control checks known as Crushing QC (CRU-QC) to check whether crushing has passed crushing criteria
- Pulverising quality control checks known as pulverising QC (PUL QC) to check whether pulverisation process has passed criteria
- Use of duplicate samples to monitor analytical precision
- Introduction and use of blank samples to monitor potential contamination
- Use of standard mass pieces to check balance accuracy
- Volumetric accuracy checks
- Calibration of instrument-checks on the calibration graph to ensure required correlation coefficient was achieved
- Reading of samples-checks to ensure calibration quality is satisfactory before reading of samples-initial calibration verification checks (ICV)
- Initial calibration blank verification(ICB)
- Continuous calibration verification checks (CCV)
- Continuous calibration blank verification(CCB)
- Reading of certified Reference Materials known by the Analyst for analyst to control own work
- Reading of blind certified reference materials unknown to the analysts
- Final comparison of the quality control samples results with known values and taking appropriate actions to ensure quality targets are achieved-blank values, CRMs, ICV, CCV

The detailed description of the use of these practices and controls was compared with the expected usages and then rating the usage by establishing whether any significant differences existed among the organisations and following rule 1, in section 3.4.4.1 of chapter 3 to arrive at L, M or H degree of usage of the practices.

Use of zero defects-practices (ZD)

A list of possible zero defect practices (or mechanisms) in the main method of analysis (most common method found across organisation was chosen) e.g. identified mechanisms in the described general method above included

- Instrument set to stop after calibration failing to meet pass criteria specifications

- Instrument stops or flags after ICV solution fails pass criteria
- Instrument stops or flags after ICB solution fails pass criteria
- Instrument flags after standard deviations on readings for same sample are out of defined limits.

The number of zero defect mechanisms in use for general similar processes were compared and a note taken whether there was a significant difference among organisations. Using rule 1, of section 3.4.4.1 a summary on the degree of use of zero defect practices across plants was arrived at.

Use of Real-Time In-Process Feedback mechanisms

A list of possible Real-Time In-Process Feedback mechanisms was identified for the common methods e.g. correlation coefficient after calibration, result of ICB and CCB, results of ICV and CCV, result of CRM known to Analyst. A list of Real-Time feedback mechanisms was identified in the responses given and compared to possible Real-Time feedback mechanisms in the methods. Further, the extent of analysis and corrective action taken was evaluated. Based on these two, the comparison among the different organisations was performed and rated using rule number 1 in section 3.4.4.1 of methodology section of the thesis to arrive at L, M or H degree of use of the practices.

Use of Process Off-line Feedback mechanisms across plants

A list of processes for which data concerning Process Performance was identified as following: Customer complaints, Results of Proficiency Testing data and Inter-laboratory Analysis data, client Feedback data, Repeat rates for test analysis, Performance of Certified Reference Materials indicated on the QC charts. A list of actual data analysis processes identified during interviews were noted and compared with possible data analyses to arrive at an intensity of implementation of the overall process feedback analysis process. A question was then asked whether there was a significant and apparent difference in the implementation of the practices to arrive at a rating of L, M or H among the plants.

New Method Introduction (NMI)

A list of validation parameters was made from those listed in ISO 17025 requirements and the parameters validated by the various laboratories from the interview questions. A note was made for the parameters that were validated before methods were put into use in terms of analysing client samples, including the degree of formality of the whole method validation and introduction process. Laboratories were then rated in comparative terms. The method validation parameters included the following: Detection limit, Limit of Quantification, Precision, Accuracy, Linearity, Selectivity, Sensitivity, Uncertainty of Measurement, robustness, Ruggedness, Range.

Process Improvement

Rating was based on existence of formalised approach to process improvement to meeting changing needs and included monitoring processes for change in customer needs and responses in a formalised manner.

In all cases the question on whether a formalised process or procedure is in place was considered in the rating process.

Appendix C. Guidelines for data reduction process resulting in the rating of degree of use of the Customer Focus Practices, Teamwork and Training Exploitation and Exploration Practices.

Lists of possible customer focus, teamwork and training practices as indicated in table 3.2.1 to table 3.2.8 respectively were identified. The actual detailed description of the use of the methods captured from the interviews and data review was compared with identified set of practices in the tables 3.2.1 to 3.2.8. A question was then asked whether there was a significant and apparent difference in the implementation of the practices to arrive at a rating of L, M or H among the plants.

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