DOCTOR OF PHILOSOPHY (PhD)
RESEARCH THESIS

HIERARCHICAL STRUCTURING AND EVALUATION OF RISKS, UNCERTAINTIES AND TECHNICAL CHALLENGES FACED BY BUILDING REFURBISHMENT CONTRACTORS

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THESIS SUBMISSION

This Thesis is submitted to the School of Engineering, Sports and Sciences, the University of Bolton in partial fulfilment of the requirements for the degree of Doctor of Philosophy (PhD) in Built Asset Renewal Management.

DECLARATION

I declare that the research contained herein is entirely carried-out by me as my own work except where otherwise stated. Absolute care has been taken to ensure that any sources of information used in this document have been appropriately cited and acknowledged. No part of this document or the entire document has been previously submitted in support of an application for the award of a degree or any other qualification, to this institution or any other institution of learning.

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DEDICATION

This work is dedicated to my wife and my son for their patience, understanding and invaluable support throughout the years.

ABSTRACT

The UK is believed to have some of the oldest buildings in Europe and these aged buildings are constantly growing in number while there is a concomitant growing pressure to maintain their utilitarian values in the face of changing technology, legislation and sustainability issues. Wholesale demolition of these buildings is believed to be unhealthy from an environmental protection perspective as it causes heavy pollution as well as placing more demand upon depleting resources. The need for alternatives to demolition and new-build is therefore imperative. Refurbishment is one such and a well-established alternative to demolition and new-build as the schemes are adjudged to be a cost-effective way of extending the lifespan of properties as it allows the provision of modern facilities.

However, dealing with an existing building is faced with various unknowns, unexpected, unpredictable and often undesirable situations which will require further attention and a mechanism to identify any source of uncertainty because when risks are unidentified and not properly managed, they consequently affect project objectives. The study investigates the factors which contribute to risks, uncertainties and technical challenges associated with building refurbishment schemes and the impact they may have in achieving project desired outcomes. The overall objective is to develop a framework that provides helpful information to refurbishment practitioners to assist in minimising level of uncertainty. Developing a framework that provides support for decision makers in pinpointing the vital elements that define the characteristics of the refurbishment projects in terms of achieving high quality standards as well as those factors which may act as barriers was chosen for this study as there is no widely used, understood and accepted refurbishment focused framework.

The research methodology adopted is a mixed method data collection strategy. The data were collected through industry practitioners working for building refurbishment contractors using semi-structured interviews and a questionnaire. A total of 133 fully completed questionnaires were received and analysed using nonparametric statistical techniques. In examining the typical characteristics of refurbishment schemes, eight factors believed to reflect typical refurbishment schemes were identified. Ranked high among the factors was the need to understand risks and how to manage them. At aggregate level, the study deduced that refurbishment risks are not permanent but will change relative to conditions on site and the rate at which they will change and the direction they will take as a result of the change must be known in order to be managed or their effect mitigated. This was identified as the transmutation of risk management attribute every refurbishment practitioner ought to possess. When practitioners were investigated relative to their industry experience, it merged that increased reliability of the diagnosis and prognosis of building defects was the most persistent barrier to quality refurbishment schemes. The study referred to this as another essential attribute itself defined as the 'plasmolysis of structural defects'; implying the need to have increased adroitness towards knowledge of incipient building defects.

This outcome is critical to the overall findings in that within the refurbishment sector there appears to be a widely acceptable dictum that tolerates the need to uncover defects as the work progresses. As a result of this, the refurbishment process is shrouded in increased uncertainty about scope, cost and duration and for a sector that is exceedingly fragmented and complicated it will require highly experienced and specialised practitioners to plan and coordinate projects effectively. In the light of this, the study offers a framework that helps to identify sources of uncertainty in the refurbishment process. The framework focuses on measures that improve certainty of information through CPD training and information flow among project partners prior to the implementation stages of any refurbishment project.

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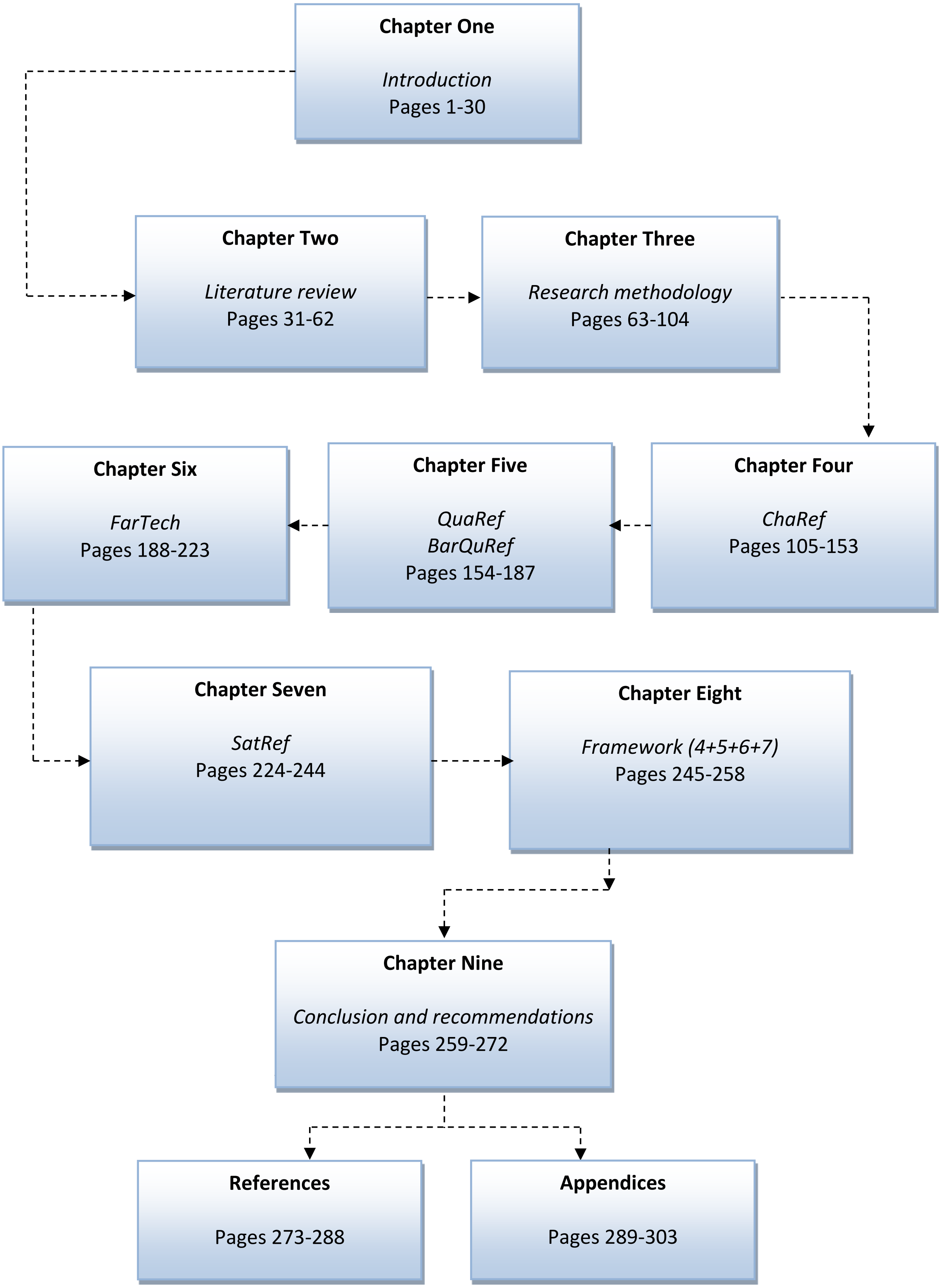

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KEY TO ABBREVIATIONS

ANOVA	Analysis of Variance
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BARQUREF	Barriers to Achieving Quality of Refurbishment Works
BREEAM	Building Research Establishment Environmental Assessment Method
BIM	Building information modelling
CDM	Construction Design and Management Regulation
CCC	Committee on Climate Change
CHAREF	Characteristics of Refurbishment Works
CIOB	Chartered Institute of Building
CIRIA	Construction Industry Research and Information Association
CPD	Continuous Professional Development
DV	Dependent Variables
FARTECH	Factors which Contribute to Risks and Technical Challenges
FMECA	Failure, Mode, Effect and Criticality Analysis
FMEA	Failure, Mode and Effect Analysis
GDP	Gross Domestic Product
H_0	Null Hypothesis
H_1	Alternative Hypothesis
H&S	Health and Safety
HSE	Health and Safety Executive
IV	Independent Variables
NFB	National Federation of Builders
NRC	National Refurbishment Council
ODPM	Office of the Deputy Prime Minister
ONS	Office of National Statistics
ORUP	Offsite related uncertainty parameters
QUAREF	Quality of Refurbishment Works
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
R&M	Repair and Maintenance

SATREF	Satisfaction with the Implementation of Refurbishment Works
SRUP	Site related uncertainty-parameters
UK	United Kingdom
UKCG	United Kingdom Contractors Group
UKGBC	United Kingdom Green Buildings Council
URI	Uncertainty in refurbishment Information

CHAPTER ONE

Introduction

1.1 Introduction

This study explores the types of risks associated with building refurbishment schemes. The study evaluates the risks in hierarchical order in relation to their impact on refurbishment schemes within the UK construction industry. The hierarchy of the risks is determined by the impact and difficulty in managing a particular risk factor in relation to the achievement of quality and/or desired outcomes. The broad context of this research is mainly concerned with risks associated with refurbishment schemes from inception up till completion and hand over.

The purpose of this chapter therefore, is to provide an overview of the study and to also present the statement of the problem leading to the need for research, an overview of the research scope and boundaries, the research aim and objectives, research hypothesis, the research questions for the study as well as the thesis outline.

1.2 Background

In every development project be it refurbishment, rehabilitation or new works, there exists a risk or collection of risks which may jeopardise the achievement of desired outcomes or project objectives. Indeed, it is often claimed that contracting in the construction industry is very competitive and highly risky. Generally, the construction industry is perceived as a complex environment and its activities are inevitably full of risks. These risks can be predictable or completely unforeseeable and might be caused by physical elements while some could originate from politics, commercial, economic, technical as well as operational activities (Lock, 2007). More so, construction projects are typically organised by hierarchically linked parties who possess differentiated skills and knowledge. As a consequence, complex relationships exist within project teams that, if not managed effectively, can adversely affect a project's performance (Walker, 1995). In many instances the perception of conflicting objectives among the parties involved in a construction project leads to adversarial relationships. In his report of the UK construction industry, Latham (1994) suggests that no construction project is risk free. Risk can be managed, minimised, shared, transferred, or accepted, but cannot be ignored.

This view is shared by Frank (1998) who suggests that it is impossible to eliminate all project risks in construction. Indeed, Mansfield (2009) suggests that risk and uncertainty exist in all projects, irrespective of type, size or location thus, the management of risks must be optimised rather than ignored (Cost Engineer, 1993) because risk has become a commercial product that is identified, priced and responsibility legally attributed (Centre for Public Services, 2004).

Many examples exist of projects finishing well over budget by enormous amounts, finishing late while other projects are being abandoned even before completion (Lock, 2007). This is due in part to the presence of risk and uncertainties in construction (Odeyinka, 2000) as well as the inability of project participants to identify and manage the risks and uncertainties effectively. Notwithstanding, such failures are often claimed to be common phenomenon. Similarly, the presence of risk and uncertainty elements in projects means that the events and tasks leading to the completion of such projects cannot be predicted with complete accuracy (Lock, 2007), thus, risk can be considered to be the possibility of a forecast variable (for example, refurbishment cost) being different from that at completion (Mansfield, 2009).

Reyers and Mansfield (2000), Rawlinson and Wilkes (2008) and GVAGrimley (2010) claimed that dealing with existing buildings introduces many sources of risks and uncertainties which can affect the scope of work, the total cost and the time or schedules. Much more than new construction project operation, the delivery process of building refurbishment projects is often assumed to be full of risk and may be guided by four primary objectives. These are cost, time, quality and safety. It is worth taking note that, each of these project objectives are usually associated with risk and uncertainty. Similarly, Burtonshaw-Gunn (2009) is of the opinion that failure to deal effectively with risk can lead to significant cost overruns, schedule delays and the inability to achieve the desired project outcomes. As a consequence, the subject of risk seems to increasingly attract attention from both researchers and practitioners across the globe. Hence, it is the intention of the study to investigate in greater depth the issue of risk in the arguably most volatile sub-sector of construction, namely; refurbishment.

1.3 Statement of the problem

The global economic meltdown in the last seven years has resulted in, the worst downturn experienced by the UK commercial property market since the second world war (GVAGrimley, 2010 p. 4; CIC, 2009; UKCG, 2009) resulting in lack of development finance which consequently led to significant reduction in the number of construction projects (CIC, 2009). Furthermore, the National Refurbishment Council-NRC (2010) reported that the UK has some of the oldest building stock in Europe, with almost a quarter of buildings in England built before 1919. This view was a reiteration by the Office of the Deputy Prime Minister - ODPM (2004) who reported that half of the commercial and industrial properties in England and Wales were built before 1940, with only 2% of the total stock built between 2001 and 2003 as shown in Figures 1.1 and 1.2. This clearly suggests that a majority of the commercial and industrial buildings have the potential to be classified as outdated and obsolete.

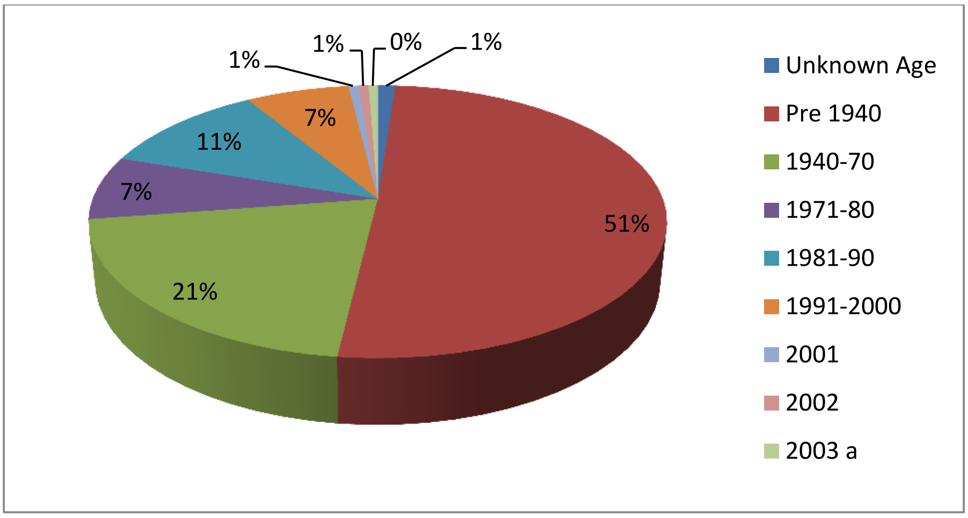


Figure 1.1: Age distribution of hereditaments in England and Wales (ODPM, 2005)

Similarly, Figure 1.2 shows the quantity of buildings within England and Wales among the four (4) bulk classes from pre-1940 to 2003.

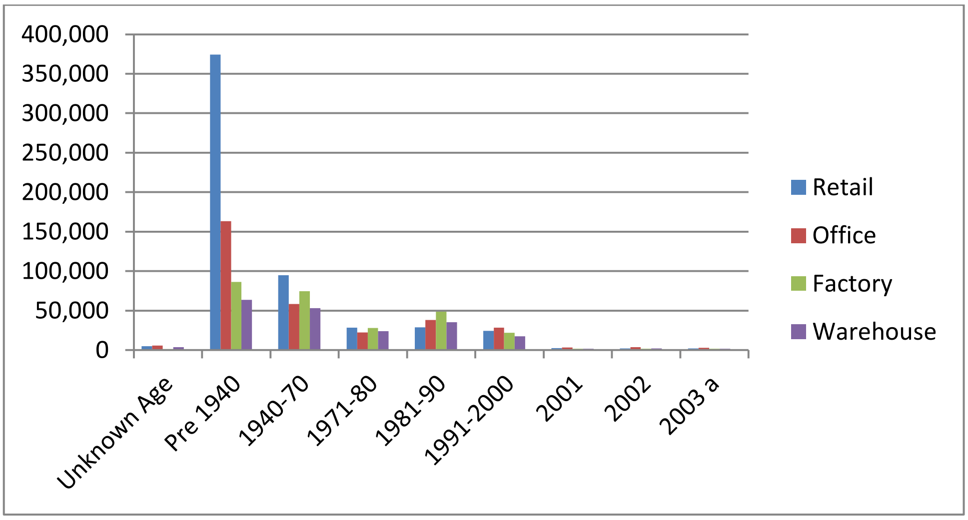


Figure 1.2: Quantity of hereditaments within England and Wales (ODPM, 2005)

From Figures 1.1 and 1.2, it can be concluded that:

- The retail stock is older with two thirds of all retail buildings built before 1940;
- Roughly two per cent of buildings were built in 2001-03;

- Offices have a relatively high proportion of older buildings with half of properties built before 1940. However, the proportion of offices built after 1990 is the highest out of the four use together;

- Factories and warehouses have very similar age profiles in terms of the number of hereditaments. About a third were built before 1940.

From the foregoing, it would appear that the majority of buildings within England and Wales as shown in the Figures above pre-date the emergence of modern concepts of sustainable development. There is significant growing global demand for improved interior comfort for existing buildings in recent years. In the UK, there is increasing demand for sustainable energy efficient offices from both regulators and occupiers (GVAGrimley, 2010; Gorse and Highfield, 2009). Indeed, from the public sector perspective, there is a concomitant growing pressure to meet current targets for zero carbon buildings by maintaining aged buildings to current standards. The situation is one of continuing national debate about improving the indoor quality of existing buildings for the comfort of the users. As a consequence, the existing building stock is classified as outdated, obsolete and inefficient thus, indicating clear opportunity for refurbishing a large amount of buildings to current standards (Gorse and Highfield, 2009).

Similarly, the absence of open sites available for new development, particularly in the prime commercial and residential areas of most towns and cities in the UK, means that developers seeking to provide modern commercial and residential buildings have no choice but to focus on existing buildings since there are significant numbers of redundant buildings in need of upgrade.

While building refurbishment has been a well-established alternative to demolition and new-build for many years, it is now more widely recognised that it makes far greater sense to retain and refurbish buildings in preference to demolition and new-build (Gorse and Highfield, 2009; Rawlinson, 2008), since demolition and new-build places increasing pressure on existing landfills (Dong *et al*, 2002). Indeed, Corus (2010) reported that refurbishment presents a means of improving the value and performance of existing buildings without the economic and environmental costs associated with new-build construction. Thus, it is widely accepted (Corus, 2010 p. 21; GVAGrimley, 2010; Mansfield, 2009; Gorse and Highfield, 2009) that a refurbished building can be as functionally efficient and can attain the same environmental sustainability as new-build. Notwithstanding, Marsh (1983) suggests that tearing down every building that became older than 30 years is a sheer waste of economic resources. Even from an environmental protection perspective, wholesale demolition of buildings can be quite unhealthy as it causes heavy pollution as well as placing more demand upon depleting resources (Zavadskas *et al*. 1998; Power, 2008). More importantly, through reuse of old and aged buildings, less construction waste is generated and less material resources are required (Edward and Turret, 2000).

Accordingly, Burton (2001) highlighted some important points as the main goals of refurbishing a building. This includes:

- To maximise the income or asset value of an existing building;
- To adapt the building to comply with new requirements or new use;
- To improve the indoor environment, mainly relates to the occupants; and finally
- To decrease the energy consumption.

However, while the last two objectives may at times seem conflicting, it is undeniably true that a well-integrated refurbishment strategy should achieve all these goals at the same time.

To ensure the goals of refurbishment outlined above are achieved, there is a need for an integrated strategy that aims to provide a building which is comfortable with minimised energy requirements. These aims are often achieved by reducing the energy needed for heating, cooling, airflow and artificial lighting, and their associated emissions of CO2, through a well-designed building.

Although refurbishment involves numerous cost saving opportunities, there is a widespread view among researchers which suggests that refurbishment projects are complex to design, implement and/or manage. Similarly, Mansfield (2009) reported that refurbishment projects contain more technical and economic risks than an equivalent new-build. Indeed, Babangida *et al.* (2012b) have been quick to warn that refurbishment projects contain more risks than an equivalent new-build project where individual risk or a combination of the risks may jeopardise the achievement of desired outcomes, hence, the management of risks is an essential strategy to ensure successful implementation of the schemes. It therefore comes as little surprise that there has been significant interest in the management of refurbishment schemes due to the risk and uncertainties they present.

Despite the increasing awareness of the uncertainties surrounding refurbishment schemes, a review of international literature suggests that risk management frameworks that do exist are directed more toward new-built projects. It therefore, comes as a surprise to note that there is no refurbishment focused framework for risk identification and analysis in existence. This view was echoed when Reyers and Mansfield (2000) argued that there is no formal approach to risk identification and analysis in refurbishment. Hence, Babangida *et al*, (2012) emphasised the need for a refurbishment focused approach to risk management to enable proper identification, management and implementation of refurbishment schemes effectively.

The UK will require a clearly understood refurbishment focused risk management framework which will enable both policy makers and senior management to get a thorough appreciation of available and missing knowledge in the course of promoting effective refurbishment schemes. Both government and a number of organisations have urged a more concerted approach towards refurbishment for many years, but as yet a clear way forward remains elusive (NRC, 2010).

It is therefore, the purpose of this research to document and subsequently develop a framework for use by both practitioners and collaborators within the sector with a view to ameliorating the psychological burden of the risks in the cause of promoting effective refurbishment schemes. This introductory chapter will therefore,

- Provide an overview of and the significance of the UK refurbishment sector;
- Review the need for research in risks associated with refurbishment; and
- Provide the research aim and objectives, scope and, the structure of the research.

1.4 The need for research

Generally, refurbishment is adjudged to be a complex task and has been the subject of much research across the globe. The complexity is said to be the result of a number of factors some of which are predetermined at the design stage, whilst others are determined during the life cycle period of the building (McGeorge and Betts, 1990). Anumba *et al.* (2004) and the Health and Safety Executive (HSE, 2008) have highlighted the dangers inherent within the refurbishment sector of the construction industry. More so, many authors consider building refurbishment to be the most notorious and hazardous sub-sector of the construction industry (Gorse and Highfield, 2009; Douglas, 2006).

Indeed, refurbishment projects have some unique problems in dealing with people, the environment and the project itself (Lam *et al.*, 2010). Literature suggests that refurbishment work is complicated and less predictable than new-build projects. A review of literature also suggests that refurbishment projects are generally adjudged to contain higher elements of risk and uncertainty than new-build (for example, Babangida *et al*. 2012b; Lam *et al*. 2010; Rahmat and Ali, 2010; Mansfield, 2009; Reyers and Mansfield, 2001; Brandon *et al.* 1999; CIRIA, 1994; Flanagan and Norman, 1993). This is due in part to the extent of deterioration which is sometimes obvious at the outset of the project.

Other researchers have claimed that refurbishment processes are more difficult to manage than new-build projects (Rahmat and Ali, 2010; Zavadskas *et al.* 1998; CIRIA, 1994) and that they require experience and capability to implement and/or manage (Corus, 2010 p.5; Zavadskas *et al.*, 1998), because they contain more technical and economic uncertainties (Ali *et al.*, 2010; Mansfield, 2009; Reyers and Mansfield, 2001; CIRIA, 1994), in addition to being fragmented and uncoordinated (Lam *et al.*, 2010). Thus, the complications experienced on new building projects doubles in refurbishment (Babangida *et al.* 2012; Marsh, 1983). As a consequence, refurbishment projects require collaboration (Babangida *et al*. 2012; CIRIA, 1994 p.15), and they also require effective management approaches and skills which are different from new build (Dixon, 1990; BRIE, 1990).

In terms of health and safety (H and S), Hughes and Ferret (2007 p.51) opined that 'safety is without doubt, the most crucial investment that can be made by construction organisations'. The term 'H and S' is commonly used to refer to the health, physical and mental well-being of people in and around workplaces (HSE, 2009 and Hughes and Ferret, 2007). Although, HSE (2006) perceived health and safety as preventing people from being harmed or killed at work; other authors including Phillip (2007) and Hughes and Ferret (2007), argue that health and safety should include economic motives rather than prevention from harm. This makes the definition of H&S difficult due in part to the difficulty in understanding what constitute inputs and outputs of safety practices.

According to accident statistics published by HSE (2004), the UK does not differentiate between new construction and refurbishment. However, the report suggests that refurbishment, in its different interpretations, accounts for a substantial proportion of injuries and fatal accidents with almost 41% of construction fatalities, thus an average of four fatal injuries a year to adult members of the public over five years was recorded.

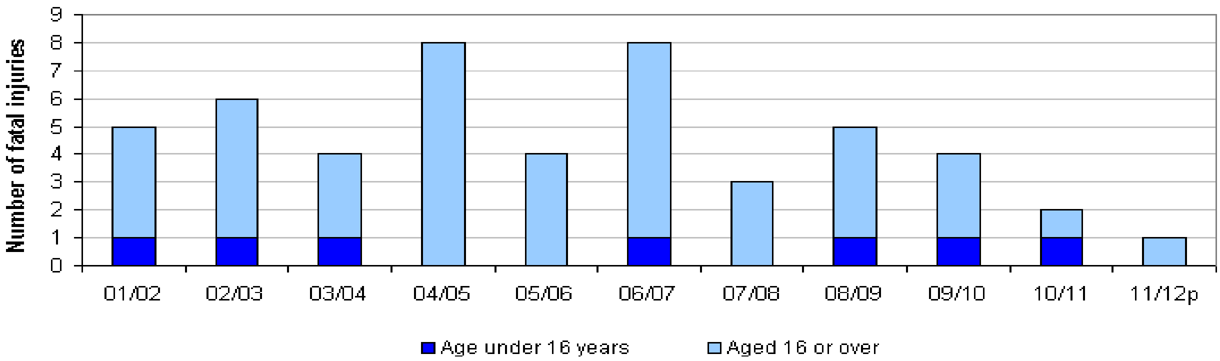


Figure 1.3: Fatal injuries to members of the public in construction (HSE, 2004)

In another study of H&S in refurbishment involving demolition and structural instability, HSE (2004) reported that refurbishment works involving demolition and structural instability can be considered among the most dangerous activities to be undertaken on site and therefore in need of a rigorous health and safety management strategy. As a consequence, the absence of a formal refurbishment focused decision-making framework was considered as a contributing factor to the challenges imposed by the project (Egbu, 1996). It therefore comes as little surprise to note that there has been significant interest in the management of refurbishment works with a plethora of literature advancing the importance of risk management in construction projects.

The review of literature also suggests that utilisation of an effective risk management (RM) strategy or technique may help to minimise risks and uncertainties associated with refurbishment projects. Hillson (2003) has argued that Risk Management (RM) is recognised as an essential tool to tackle the inevitable uncertainty and psychological burden of risk associated with projects, leading to an acceptable and manageable level of risk.

Researchers across the globe have developed sophisticated decision support tools or models in relation to refurbishment to enable stakeholders to choose the most appropriate strategy for a particular case (Alanne, 2004; Caccavelli and Gugerli, 2002; Rosenfiels and Sholet, 1999). All the decision support tools or models have considered a wide range of topics relating to refurbishment which include sustainable practices and the use of renewable energies as well as maintenance support tools (for example, Zavadskas *et al.*, 2006; Kangwa and Olubodun, 2004; Dascali and Balaras, 2004). However, models or decision support tools relating to risks and their impact on refurbishment will be an important step to achieving successful refurbishment schemes.

Some studies such as Egbu *et al.* (2003) and Robinson *et al.* (2001) have also highlighted the need to effectively manage knowledge as construction firms often move from one project to another working with different partners and supply chains. The role of knowledge management tools and systems as a source of potential advantage to improve the construction industry efficiency is now widely accepted. Indeed, knowledge management may also be considered as an essential and efficient tool to manage the risks and uncertainties associated with quality of refurbishment schemes. The study further posits that if the refurbishment sector is to improve, the issues relating to management of risks and uncertainties must be confronted by developing a refurbishment focused framework aimed at minimising the level of uncertainties with a view to delivering projects effectively. The line of development thoughts in relation to the study hypothesis is illustrated in Figure 1.4 and furthermore the perceived factors are summarized into a framework of interactions as illustrated in Figure 1.5.

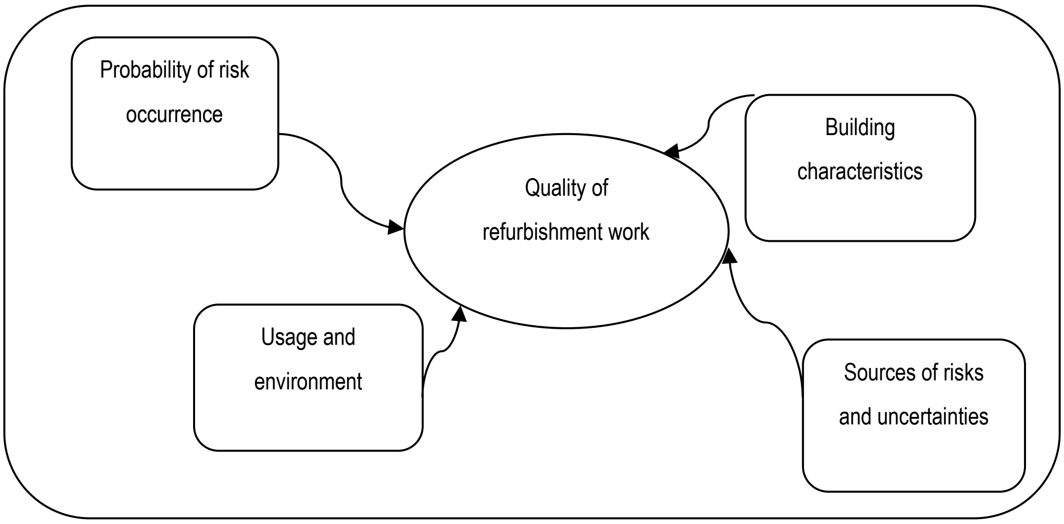


Figure1.4: Forces impacting on quality of refurbishment works

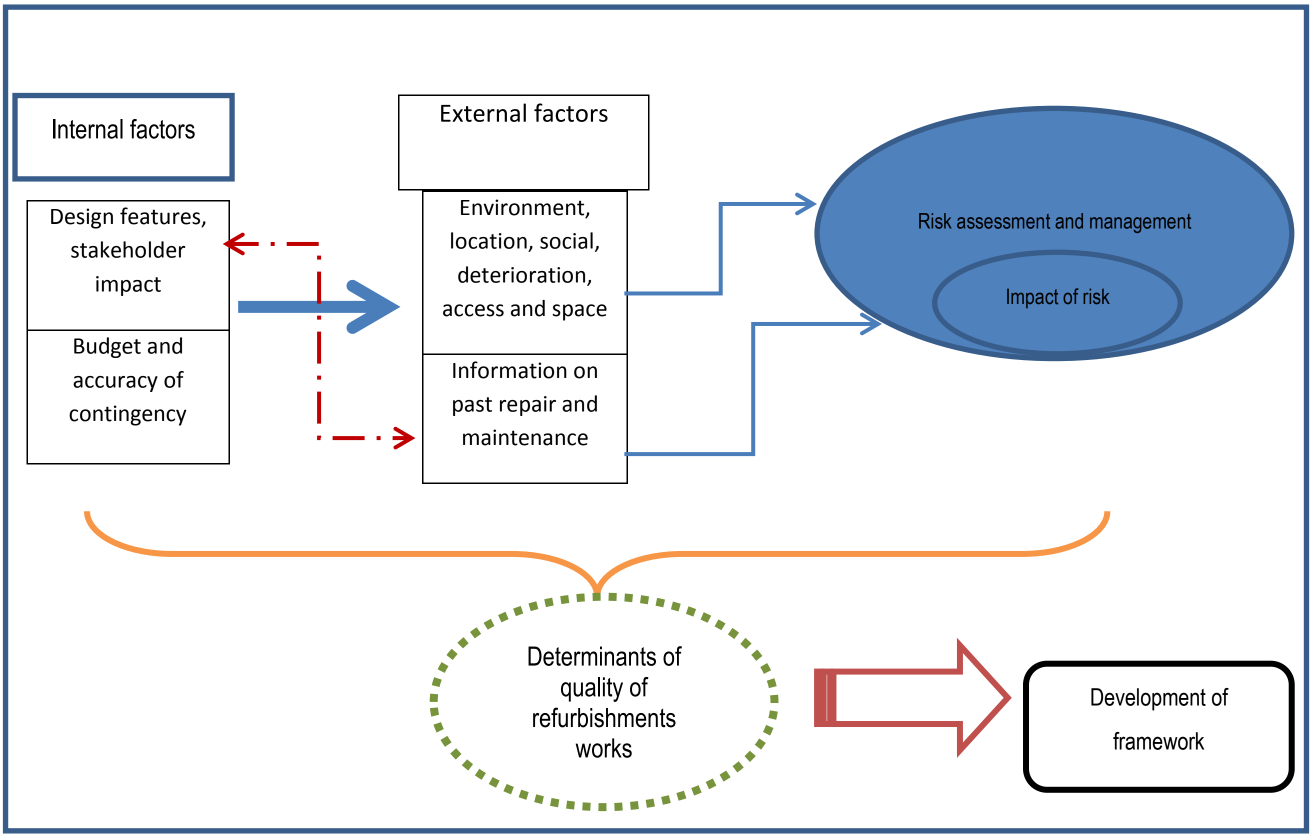


Figure 1.5: Interaction of factors associated with achieving quality of refurbishment works

1.5 Previous relevant studies

Holton (2004) in his paper 'defining risk' suggests that the most famous definition of risk is one by Knight (1921) who wrote during a period of active research into the foundation of probability. He goes on to suggest that the main debate that originated from that period relates to subjective versus objective interpretations of probabilities. In his opinion, the objective interpretations refer to probabilities as real, which can be discovered by logic or estimated through statistical analyses. In the subjective interpretations, probabilities are considered to be human beliefs because individuals specify them to characterise their uncertainty. However, a more recent study Winch (2010) opined that four different ways of thinking should be considered when defining risk and its correlation with probabilities. This involves:

- The objectivist school where the probability of a future event can be deduced from a number of observations of previous events arrived at by means of a known situation. The approach aims to predict the future based on available data on risk sources;
- The logical school where the data set is not consistent and large enough to be used for statistical representation hence, conclusions about possible risks are made based on assumptions by experts taking into account a number of factors;
- The subjectivist school where a prescriptive approach is utilised to give advice on how future decisions should be made largely dependent on the experts' degree of belief in relation to the probability of a particular event; and
- The behavioural school where it focuses on decision-making processes largely under uncertainty.

It therefore, appears that Winch (2010) added two classes of interpretation of probabilities which include the logical and behavioural school of thoughts. Winch (2010) developed the cognitive model of risk which involves all the four approaches he suggested. His approach to risk is where the occurrence of the risk in any event is either certain, impossible or somewhere in between the two. The basis of this theory is that risk depends on individual perceptions largely dependent upon the amount of information available to the decision-maker at the time of the decision and not an external factor. The cognitive approach diagram is divided into four different categories namely:

- The known 'knowns' where a risk source is identified and a probability can be assigned to the occurrence of a risk event;
- The known 'unknowns' where a risk source has been identified but a probability cannot be assigned to the occurrence of a risk event;
- The unknown 'knowns' where someone knows about the risk source and the associated probabilities but is keeping the information private; and
- The unknown 'unknowns' where a risk source has not been identified and therefore the risk event cannot be known.

This information is represented in Figure 1.6. The approach accepts a subjective probability which suggests that an event occurs in the future because of a decision-maker acting in the present, and not only because of the external factors. It shows the distinctions where a probability distribution can be assigned to the occurrence of a risk event and the condition where it is not possible to assign a probability distribution.

William (1996) however, perceived risk in a different way. His was a two dimensional approach. He opined that risk can be measured by the probability of its occurrence and the impact of the occurrence. Although, the view held by William (1996) is widely accepted by researchers in the field of project management, Winch (2010) is of the opinion that it has not differentiated the various risk categories identified by the cognitive theory of risk. As a consequence, Winch (2010) identified three aspects of risks as follows: the probability of risk occurrence, the impact of the risk in case of occurrence and the extent of risk occurrence. Although this may appear to be an important way of looking at the risk, in most cases the impact of the risk occurrence and the extent of risk occurrence may mean the same thing.

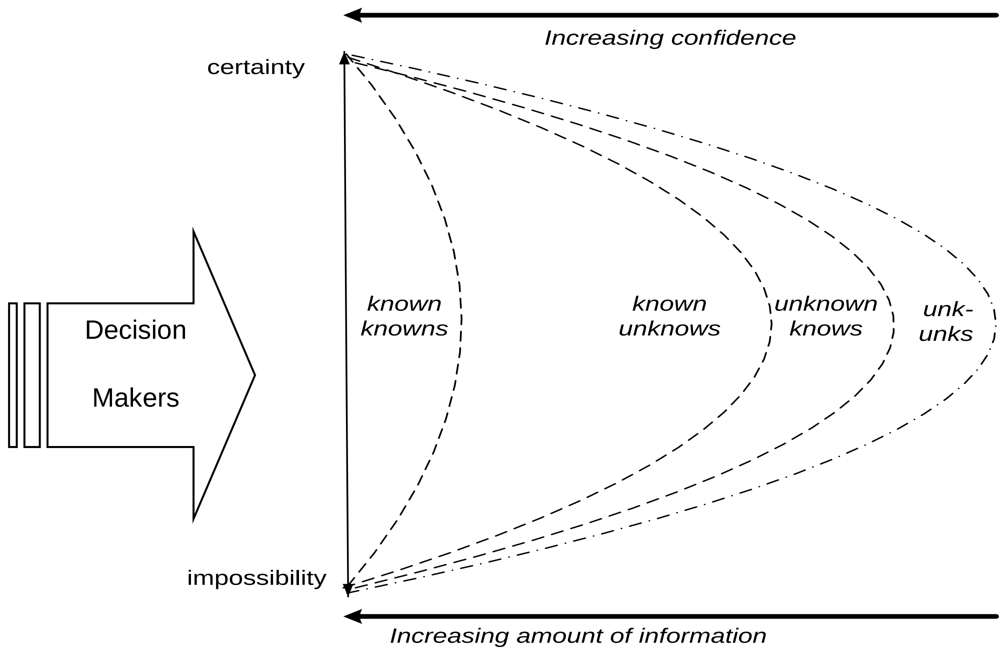


Figure 1.6: The Cognitive Model of Risk (Source: Winch, 2010)

Smith (2006) opined that combining the probability of risk occurrence with the impact of occurrence will help to determine the degree of risk. There are some merits of such an approach, which in part suggests why this approach is widely adopted in dealing with risk for proposed projects; Winch (2010) considers this approach as subjective. Smith (2006) also opined that combining the extent of risk occurrence with the impact of occurrence requires prior knowledge. This belongs to the objective school of thought who attempt to predict future events from known data about risk sources by comparing available data of past similar projects. However, what Smith (2006) ignored is the mere fact that there are instances where the past data may not be available. Where a proposed project is similar to a previous project with available data to be compared, special attention may not be required to handle the risks.

Lock (2007) indicated that for complex and large projects, an effective risk management strategy must be developed to enable the identification of potential risks and how to deal with them. Lock (2007) opined that the Failure, Mode and Effect Analysis (FMEA) commonly used in reliability engineering, may also be used as a project management method for dealing with risk. The FMEA considers possible risk events known as failure modes and then predicts their possible effects. FMEA is simply "a systematic process for identifying potential design and process failures before they occur, with the intent to eliminate them or minimise the risk associated with them". The same underlying principle is applied in the Failure, Mode, Effect and Criticality Analysis (FMECA) which appears to be more advanced than the FMEA method. Lock (2007) opined that FMECA contains some ranking assessments to enable the extent of the impact of the risk to be determined. The FMECA allocates a scale of 1 to 5 in the columns headed chance, severity and detection or prediction difficulty. The number 5 is assumed to be at the highest end of the perceived impact whereby the numbers are multiplied to give the ranking number for the risk as shown in Table 1.1.

The FMECA differs from the approach suggested by Williams (1996) and Winch (2010) in that this approach has a wider coverage or spectrum aimed at understanding the risk itself, its possible cause, the effect should it occur, the chance or possibility of the risk occurring, the severity of the risk in the event where it occurs as well as the detection or prediction difficulty of the risk occurring. The benefit of this approach is that a possible ranking can be done in order to understand the risks with the highest ranking that requires attention. Thus, a risk management approach is an important tool to effectively manage risks and uncertainties in projects. Lock (2007) suggests that project risk management attempts to identify all foreseeable risks, where the chance and severity of those risks can be assessed and then choosing an alternative cause of action to reduce the possible impact of the risk or avoid them completely.

Table 1.1: Failure, Mode, Effect and Criticality analysis - FMECA (Source: Lock, 2007)

Item		Failure Mode	Cause of Failure	Effect	Chance	Severity	Detection Difficulty	Rank
1	Main Building	Fall from height during roof installation	Incorrect positioning of ladder	Personal injuries, project delays, additional cost to project sum	2	5	3	30
2	Crane	Engine refuses to start	Poor maintenance	Project stalls, project delays, additional cost to project sum	2	1	3	6

There are different versions of risk management models which attempt to manage the occurrence of risk events in construction projects. The benefit of risk management is that risk can be assessed against the likelihood of its occurrence and the negative effects once they occur, and can also be weighed against the benefits. It would appear that a common similarity between most of the existing risk management models is that they all have common underlying principles summarised into the following three stages:

- Risk identification as the name implies, this is the stage where potential risks are identified and/or determined;
- Risk assessment which is the stage where the risks identified are analysed and/or evaluated in terms of its impact enabling ranking to take place; and
- Risk response which is the stage where a plan of action is implemented to enable control and management of the risk.

The same underlying principle is also applied in the basic project risk model outlined by Ward and Chapman (1991) where at inception of the project, a risk assessment and analysis is carried out. This assessment may lead the decision-maker to decide whether or not to go on with the project and/or explore a number of alternatives at their disposal which may include the modifications of the project to suit prevailing trends in terms of risk management. This process requires continuous monitoring as the project progress from one stage to the other in order to minimise or even avoid the level of uncertainties as far as possible. While the literature suggests a consensus that risk management pays off, the monetary benefit of risk management is hard to quantify (European Commission, 2010).

However, a review of literature also suggests that effective risk management increases the likelihood of success in construction projects. In some recent research such as Keizer *et al.* (2005) on new product development and that of Bannerman (2007) on software development projects, have determined that a development project can become a success if only the risks involved are identified at inception and subsequently managed effectively. Similarly, Lock (2007) determined that a risk event that occurs late in a project can be more costly in terms of time and money than a similar event nearer the start of the event. Therefore, this study will attempt to the take forward the suggestion of both William (1996) two dimensional nature of risk and Winch (2010) three aspects of risks. The study will attempt to develop a framework that will expose the risks associated with building refurbishment schemes and the impact they may have on projects' outcome. It is believed that this will allow the decision maker to either carry on with the project with the knowledge of likely impact or modify to suit the project needs.

Using the suggestion by William (1996) and Winch (2010), the three aspects of risk can be measured in two different groups and by adding the source of a particular risk factor. For example: the source of risk and the impact of occurrence (subjective) as well as the probability of risk occurrence and the impact of occurrence (objective). This will be utilised to determine how individual risk impacts on quality of refurbishment works as shown in Figure 1.7.

Figure 1.7: Research focus and matters under consideration

1.6 Research scope and boundaries

The review of literature suggests that building refurbishment is complex and difficult to implement and manage. Both Egbu (1994) and Ali *et al.* (2008) have provided evidence of complexity of these types of schemes. Lam *et al.* (2010) reported that refurbishment projects have some unique problems in dealing with people, the environment and the project itself. They further posited that, the tendency to go over budget in refurbishment projects is more likely than in new-build projects due to unforeseen problems. To minimise this however, Corus (2010, p. 5) stressed that experience is required in handling refurbishment projects to enable the selection of the most appropriate solution for a particular case where the contractors will be expected to consider a wide range of factors which can assist in planning and managing the schemes. The aspect of risk and uncertainty associated with refurbishment may include the following:

- The availability of information: there is need for the building’s original design and construction, including the existence of unrecorded alterations;
- The condition of the existing building: such as the quality of original construction and the effects of wear and tear;
- The effects of demolition, alteration and temporary works on the progress of works and on the retained fabric and the removal and disposal of old materials;
- Contingency requirement: The need for a higher level of contingency may be required for the increased risk of unforeseen costs associated with the schemes to deal with any unexpected difficulties;
- Health and Safety issues: Consideration should be given to the protection of workforce and surrounding buildings, unexpected occurrence of hazardous materials such as asbestos and possibility of complex planning sequencing of construction programme, which may require expert risk assessment and management;
- Expertise and Procurement: the elevated risks and technical challenges of refurbishment mean that contractors with specialist expertise may be required.

In order to minimise the occurrence of these risks, an appropriate risk response plan must be formulated through which the risks can be identified, and then subsequently an assessment made of their likely impact. Indeed, Lyer and Sagheer (2009) among others have observed the multiplicity of risks and the problem of bringing individual risks together to observe interactions and interdependencies thus making it extremely cumbersome if not impossible for decision makers to trace the actual sources of these risks. However, previous research which includes Bryde and Volm (2009) and Aiken and Cairn (2008) have claimed that project risk relating to construction is under-researched, which appears to be the case for refurbishment schemes. Whilst, it can be concluded that the inclination to refurbish rather than demolish and new-build is growing, Reyers and Mansfield (2000) opined that 'there is no formal approach to risk identification and analysis in refurbishment projects that is geared towards the management of risk and uncertainty of refurbishment projects.

This lack of a formal approach to risk identification and analysis in refurbishment triggers a need for research. The matters under consideration for this research relate to risks, uncertainties and technical challenges associated with building refurbishment which originates from commercial, operational, technical, economic and environmental activities. This will consequently lead to the development of a framework of risk and uncertainty.

Furthermore, the study will target building refurbishment practitioners within the contractor organisations while the views of professionals working for the client and public sectors are not part of the study scope. The focus of the study will be on mostly non-domestic buildings. However, the findings of the study may be applicable to other refurbishment projects hence it will be recommended that a further study be conducted to take the findings further to include other types of refurbishment projects in future research. Due to finance and time constraints, the study will target contractors within three regions in England and the criteria for selecting and choosing the population is based on stratified random sampling technique. This is explained fully in the methodology chapter.

1.7 Research Aim and Objectives

1.7.1 Aim of the study: The aim of the study is to develop a framework for risk hierarchy and structure in building refurbishment schemes.

1.7.2 Objectives of the study

- To critically evaluate the characteristics of building refurbishment schemes;
- To analyse key factors that contribute to achieving quality of refurbishment schemes and barriers to achieving quality of refurbishment schemes;
- To evaluate and analyse the factors that contribute to risks and technical challenges in refurbishment schemes;
- To develop a conceptual framework for risks and uncertainties associated with building refurbishment schemes.

1.7.3 Research Hypothesis

The anticipated variables in this research are expected to generate some data in numerical forms (quantitative data derived from questionnaires) as well as non-numerical data (qualitative data derived from interviews). The hypotheses likely to emerge for this research are as follows:

1. The source of risk has an impact on the overall quality of refurbishment work;
2. The impact of risk may jeopardises the achievement of the quality of refurbishment work; and
3. The probability of risk occurrence has an impact on the achievement of the quality of the refurbishment work.

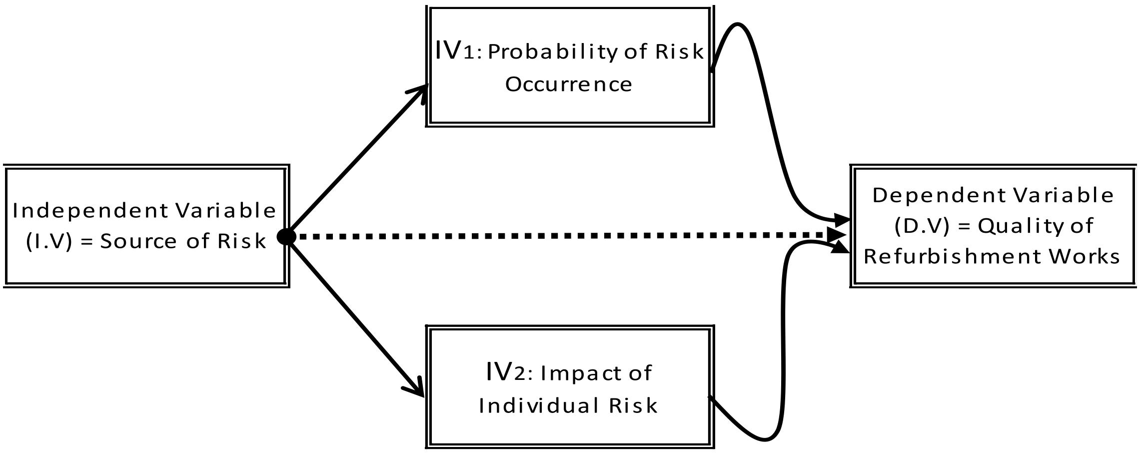


Figure 1.8: Proposed Research Hypotheses

To determine the types of risks, uncertainties and technical challenges associated with building refurbishment schemes, the focus should be on what constitutes a risk, what is the probability of its occurrence as well as the likely impact it may have on the quality of refurbishment works. Therefore, it is appropriate to say that the achievement of quality in refurbishment works is dependent upon proper management of the risk and uncertainties associated with the processes. This process is further shown in Figure 1.9.

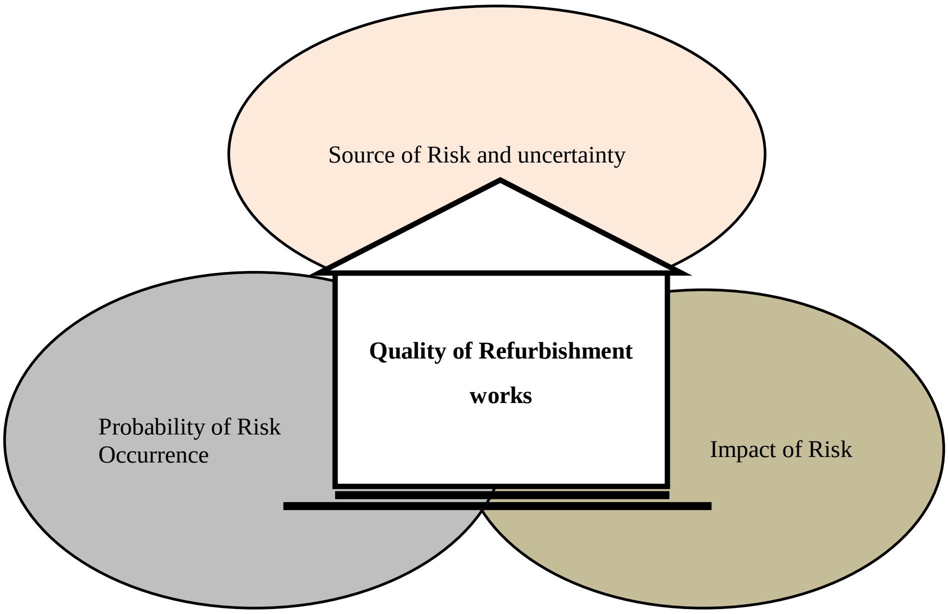


Figure 1.9: Detailed Research Focus and Hypothesis

Hence, the research scope has been determined with this in mind and has been broadly categorised into three possible areas for the purpose of this investigation as shown in Figure 1.9. These possible areas are meant to complement one another towards the development of a framework for the set of parameters in refurbishment schemes and the study will set out to determine the risk factors that exist in refurbishment and if they actually have an impact on quality of the works.

1.7.4 Research Questions

The research will attempt to answer the following questions:

- What are the major risks, areas of uncertainties and technical challenges associated with building refurbishment schemes?
- What are the likely impacts of the risks on refurbishment project desired outcomes?
- Which are the most difficult risks in terms of management in refurbishment schemes?

1.8 Benefits of the research

The refurbishment sector is an important sector within the UK construction industry with the sector contributing almost half of the UK construction industry output. The sector is said to be growing in comparison to new-build construction. As a consequence, a clear way forward in terms of a refurbishment focused formal approach to risk is imperative.

To be able to manage risk in refurbishment schemes, there is need to identify and understand clearly the types of risks that are associated with the schemes as well as their likely impact. This is an important step towards modelling the risk factors to enable both practitioners and policy makers to appreciate both available and missing knowledge with a view to managing the schemes effectively. The main benefit of the research is that it will investigate the types of risks and uncertainties and subsequently develop a refurbishment focused conceptual framework of risk and uncertainty.

The four reasons that justify the need to focus on risks and uncertainties associated with building refurbishment schemes are:

1. The office of the Deputy Prime Minister (ODPM, 2005) and National Refurbishment Council (NRC, 2010) reported that the UK has some of the oldest building stock in Europe, with almost a quarter of buildings in England built before 1919. The fact that these buildings pre-date the emergence of modern concepts of sustainable development is a challenge as to whether to consider them for demolition and new-build or refurbishing this large stock of

buildings, since there are increasing demands for sustainable energy efficient offices from both regulators and occupiers (GVAGrimley, 2010; Gorse and Highfield, 2009). Thus, refurbishment will continue to be an important sector within the economy;

2. If the set targets for sustainable developments are to be achieved efficiently, refurbishment of existing building stock must be a priority rather than demolition and new-build (RUDI, 2009), therefore the research will assist refurbishment practitioners in making an informed decisions as to the management of risks and uncertainties;

3. Dealing with an existing building introduces many sources of uncertainty, substantial risks and technical challenges which can affect the scope of work, the total cost and the time or schedules, thus, understanding the characteristics and difficulties of refurbishment processes will assist both clients and practitioners in identifying a solution to achieving desired outcomes;

4. Most existing risk management tools and techniques or frameworks tend to focus more on new-build projects rather than the repair and maintenance sector. These existing frameworks are not necessarily applicable to the repair and maintenance sector due to high level of uncertainties associated with refurbishment schemes. Therefore, to develop a framework that is geared towards achievement of refurbishment projects desired outcomes will be an added benefit to the UK construction industry which could help both clients and practitioners alike.

1.9 Expected research outcome

The focus of the research is to develop a framework for formal risk response planning in refurbishment schemes. The proposed framework is expected to have significance within the building refurbishment sector as it appears from literature, that there is an absence of a formal risk assessment model. Thus, there is a need for an appropriate risk response plan for refurbishment schemes. The research outcome will therefore, include an enhanced understanding of risks and uncertainties in the refurbishment sector and will contribute towards education and training of refurbishment managers which will also influence and focus the thinking of both collaborators and practitioners in both the public and the private sectors. The framework will be developed to support and assist refurbishment practitioners' in decision making processes.

1.10 Structure of the research

The structure of the thesis has been organised in a logical manner in order to enable the reader to appreciate the thought processes of the author in achieving the research aim and objectives.

The sequence of activities for the research is summarised as follows:

a. An in-depth review of relevant international literature will be conducted throughout the research to enable the author to capture a wide range of information, which is believed to enable a better understanding of the research problem. It is hoped that this will form the basis for formulating a working hypothesis leading to successful completion of the research;
b. During the literature review, relevant empirical investigations carried-out by other researchers will also form the basis for comparisons with similar work to be carried-out in this research;
c. Prior to the main data collection, a case study will be conducted through the use of semi-structured interviews. The interviews will be conducted to test both the validity and reliability of the main data collection technique. Farrell (2011) suggests that validity relates to 'how well a questionnaire really measures what it purports to measure'. This will also lead to testing the efficacy of the research outcome. It is also

hoped that at the case study stage, relevant information will be uncovered which will enable corrections to be made to the final data collection instrument;

d. The final data collection will be achieved through questionnaire in the form of quantitative data and this data will provide a major source of examining and testing the hypothesis variables.

The research thesis is structured into nine chapters. Each of the chapters will provide an introduction of what the chapter entails and a summary to recap what the chapter achieved.

Chapter two present an overview of the refurbishment sector. Definitions of refurbishment will be presented according to different researchers across the globe which will lead to an acceptable definition of refurbishment for the purpose of the present study. The relevance of the sector and its contribution to the Gross Domestic Product (GDP) of the UK economy is also presented.

In Chapter three, the main research methodology is presented. This chapter presents an in-depth method of data collection and tools for measuring the dependent and independent variables for the present study, the justification of the research approach, the population sample frame adopted and various research instruments used in mitigating the difficulties encountered. The chapter also presents part of the data collected (demographic data) and the statistical methods and techniques used in formulating the research findings.

In Chapter four, the analysis of the characteristics of refurbishment projects will be presented together with a discussion using relevant theory and literature relating to building refurbishment schemes.

Chapter five presents the analysis of factors which contribute to high quality refurbishment projects as well as those factors which act as barriers to achieving high quality refurbishment works.

In Chapter six, the relationship of individual risk factors to other groups of risks will be determined in other to consider the most significant risks of refurbishment schemes. The findings of the research will also be integrated with existing literature to determine the items for action that will lead to improvement and how they can be achieved. An in-depth overview of the risks, technical challenges and complexities associated with refurbishment schemes will be conducted based on literature review evidence.

Chapter seven will present the analysis of satisfaction factors for refurbishment schemes within the UK building refurbishment sector. This will also be supported by relevant theory and literature.

Chapter eight will provide the discussion of the research findings and the development of a conceptual framework and its contribution to the development of knowledge in the refurbishment sector. The limitations of the research findings will also be highlighted.

Chapter nine will provide the conclusion of the research. The chapter will present a summary of the research findings indicating the most important things that that need to change. The conclusion will also provide recommendations for future research in this topic area.

1.11 Summary

The main purpose of this chapter is to provide an insight into the research area. The chapter discussed the extent to which a conceptual framework for risks and technical challenges in the building refurbishment sector is needed. A number of reports from both government and researchers have highlighted the importance and the contribution of the refurbishment sector to the economy. Other researchers have also warned of the risks and technical challenges associated with refurbishment processes. To highlight the importance of risk assessment in managing refurbishment schemes, the HSE (2009) suggests that firms involved in refurbishment or maintenance should ensure that the work is planned properly and that sensible measures are taken to ensure that both workers and the public are not exposed to risk.

At present, there is no widely used, understood and accepted framework or formal approach to risk directed at understanding the impact of the most important risks and a way to minimise their impacts on the schemes. There is evidence which suggests that the existing risk management frameworks or models tend to focus more on new-build projects rather than the repair and maintenance sector which contributes almost equal amount of projects in comparison to new-build projects. Finally, the need to develop and implement a formal approach to risk will be an important step in considering the importance of the sector and the amount of uncertainty surrounding the refurbishment process.

The next chapter will present an overview of the building refurbishment sector in the UK as well as the definition of refurbishment chosen for the present study.

CHAPTER TWO

Relevance of the UK building refurbishment sector and nature of refurbishment schemes

2.1 Introduction

In this chapter, a review of literature relating to building refurbishment as well as the definition of refurbishment will be presented. This review will lead to an acceptable definition of refurbishment for the purpose of the present study. The chapter will also provide background on the importance, relevance and growth of the refurbishment sector of the UK construction industry as well as the factors that have influenced the growth of the sector.

The chapter will also review the importance and economic benefits of the sector. From time immemorial, building refurbishment has been in existence and the sector is claimed to have grown rapidly and is recently claimed to have been expanding in comparison to new development which makes it one of the most important sectors of the national construction programme in the UK. However, it would appear that the growth in the refurbishment of existing building has not been matched by research especially in the area of risk and uncertainties.

2.2 Definitions of refurbishment

Literature suggests that refurbishment is an important sector of the construction industry in every developed economy. Notwithstanding its importance, it remains complex to define as there are different terms employed to describe the improvements from deteriorated state of a building to acceptable standards. For instance, Quah (1988) and Mansfield (2002) would appear to demonstrate this point by arguing that many of the terms are used as if they are interchangeable. Hence, it is possible that due to the widespread and indiscriminate use of different terms, refurbishment has become a generic term as suggested by Quah (1988).

Literature also suggests that refurbishment is mainly undertaken to enable the beneficial use of an existing building to be extended by providing a cost-effective alternative to redevelopment (Markus, 1979). However, it may be argued, that this definition simply ignores some important points. The definition is also suspect because it implies that refurbishment will still be a cost-effective alternative even when the economic life of a building is almost over; although, this may be true it is not always the case. Moreover, refurbishment can only be regarded as a substitute for new-build if the building remains functionally satisfactory (Wordsworth, 2001).

Marsh (1983) offered an elaborate definition of refurbishment stating that refurbishment is the hard-headed business of making use of what is usable in the ageing building stock; the skilful adaptation of a building shell (to a new, or an updated version of its existing use). Although straight forward and simple, such a definition would appear to be limited in scope in juxtapose to what Mansfield (2002) described as having over twenty various terms currently associated with existing buildings.

CIOB (1987) described refurbishment as a process which allows the alteration of an existing building to improve the facilities and rearrange internal space and/or the structural life span without changing the original function. Unlike the definition by Marsh (1983), this definition includes alteration and the original function of the building is maintained. Lee (1987) considers the broader refurbishment process to be described by a number of names such as adaptation, conversion, retrofitting, renovation and modernisation. Exhaustive as Lee is, no mention is made of alteration therefore limiting its scope to updating to modern standards.

Aikivouri (1996) has suggested that refurbishment may either be as a result of profound damage that has occurred to physical structure or planned in advance in relation to the rate of deterioration. This means that the extent of deterioration of a building will, in some cases influence the extent of refurbishment work to be undertaken, not necessarily at the end of a buildings' lifespan. However, CIRIA (1994) who reported that refurbishment is not restricted to buildings whose physical condition has deteriorated to the detriment of their original purpose or earning capacity. Mansfield (2002) and Riley and Cotgrave (2011) opined that due to a number of factors, there is no fixed time by which buildings are ready for refurbishment and the extent of refurbishment required will also vary from situation to situation (Riley and Cotgrave, 2011).

In a more elaborate definition, Egbu (1996) considers refurbishment to encompass renovation, rehabilitation, extension, improvement, conversion, modernisation, fitting out and repair which is undertaken on an existing building to permit its reuse for various specified purposes. Egbu's definition would appear to have provided a wider and holistic perspective to refurbishment. However, Mansfield (2002) is of the opinion that Egbu's definition is far too inclusive in the work parcels and does not enable sufficient distinction to be made clear between them. In addition, Egbu's definition excludes routine maintenance such as daily cleaning activities. Hence, in an attempt to distinguish building maintenance from the refurbishment, Dixon (1990) argued that building maintenance is a process mainly concerned with restoring any defective or non-functioning part of a building to an acceptable standard while refurbishment is concerned with alteration and improvement of both small and large scale building components. Literature also suggests that refurbishment is entirely different from maintenance. Nevertheless, it is possible that in the process of adapting a building for new functional use, maintenance may be carried out on the existing structure, although this process may be regarded as a secondary component of refurbishment.

Therefore, the term refurbishment can no longer be considered to have a simple meaning, but has become multi-faceted and contextually fluid (Mansfield, 2002). Indeed, refurbishment may be viewed from the different perspectives of economic, legislative, functional, technical, social, and more recently, the sustainability concept. Douglas (2006) noted that refurbishment is widely used in the UK as the most popular term to describe a wide range of adaption work. It would appear that what all of the foregoing definitions share in common is that; the building exists, and requires some form of upgrading for more effective use.

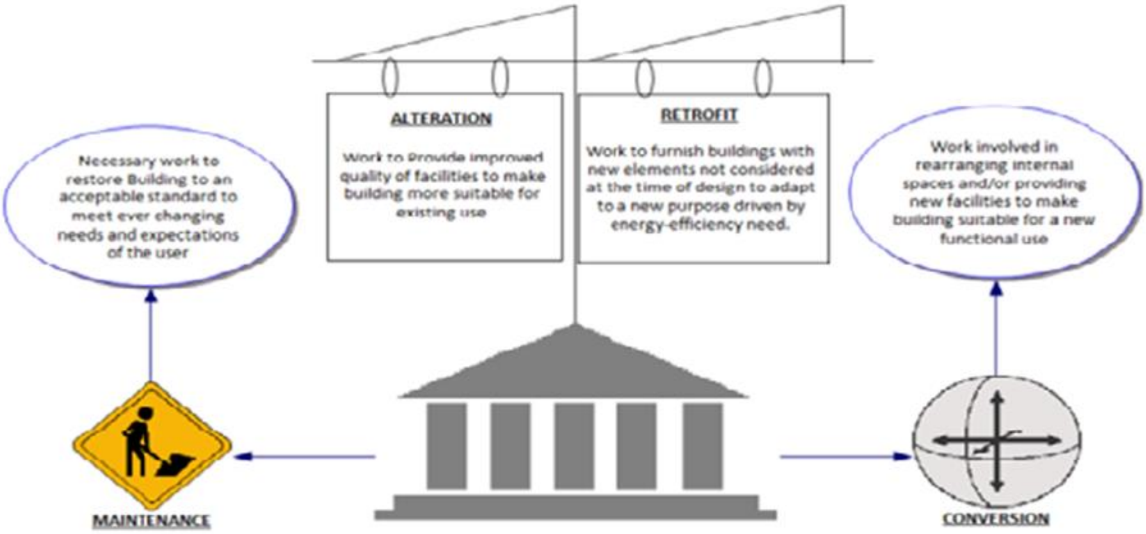


Figure 2.1: Construction activities relating to existing building refurbishment (Source: Babangida et al, 2012a)

However defined, the term refurbishment implies that an existing building is no longer fit for purpose in its present form (Riley and Cotgrave, 2011). Thus, for the purpose of the present study, refurbishment is considered to be an umbrella term which encompasses all the activities associated with repair and maintenance such as renovation, conversion, alteration, rehabilitation, adaptation, retrofitting, improvement and modernisation carried-out on an existing building to provide a more functional use with the sole aim of extending its beneficial life. Some construction activities relating to existing building refurbishment are summarised in Figure 2.1.

2.3 The Significance of the UK building refurbishment sector

The UK Construction Industry remains an important part of the economy with 17% of all jobs created in the economy (RICS, 2008). The Office for National Statistics (ONS) categorises construction output as ‘new work’ or ‘repair and maintenance’. Indeed, refurbishment as an umbrella term is broadly categorised as repair and maintenance (R&M) by the UK government mainly for statistical purposes (Gorse and Highfield, 2009) as there are no official statistics specific to refurbishment in the UK (Rahmat and Ali, 2010; Egbu, 1994). As a consequence, the actual value of refurbishment works is difficult to determine due to lack of specific data. The actual size of refurbishment work may well be much larger than anticipated or envisaged due to this unreported data.

However, it appears that this lack of specific data has prompted the use of the ONS statistics on R&M by researchers, practitioners as well as government establishments to represent the trends in the refurbishment sector. According to Egbu (1994) the R&M sector has traditionally been regarded as the "poor cousin" of the new build sector and the "Cinderella" of the construction industry. However, on the contrary, R&M has been in existence from time immemorial. A review of literature suggests that refurbishment has been an ever-present element of construction workload, and one that becomes more important in an economic downturn. This would appear to corroborate CIRIA (1994) who claimed that refurbishment is one of the most important sectors of the national construction programme in the UK, thus, the sector is claimed to have grown rapidly. For example, by value 50% of the construction activities undertaken in the UK are mainly repair and maintenance (Doran et al, 2009; Gorse and Highfield, 2009; Ali and Rahmat, 2009; CCCIS, 2005; Kherun et al, 2002). According to Doran et al (2009, pp. 1) the total value of construction is put at £80bn per annum, hence they concluded that the value of refurbishment must be put at £40bn.

Even in central Europe, refurbishment is claimed to account for 40% of construction activities and this is predicted to grow (Schttich, 2003). The prediction may be due in part to the abundance of redundant building stock as well as the historical heritage in the region. The increase in number of these aged buildings, coupled with the rapid changes in technology as well as the emergence of the sustainable development concept requires buildings to be upgraded to meet current regulations and standards. In the UK, it is claimed that a significant number of buildings have either inadequate conditions or historical value; hence there is so much to benefit from refurbishing the buildings to modern standards which will beneficially serve their owners, since by definition, an upgraded building will be more energy efficient. Moreover, new buildings only add 1% a year while the remaining 99% of the buildings are already built (Office of Climate Change, 2007).

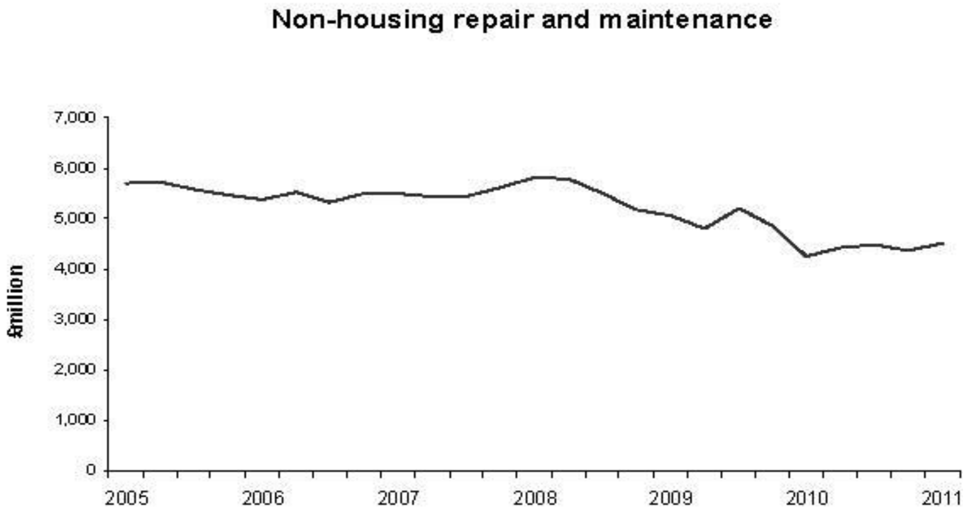


Figure 2.2: Non-Housing Repair and Maintenance Output (ONS, 2011)

Similarly, UKGBC (2008) emphasised that nearly eighty per cent of the buildings that will be inhabited in 2050 are those already standing. This clearly indicates the importance of the refurbishment sector, which invariably means that refurbishment, will continue to be a significant part of building activity for the foreseeable future. However, it has been argued that the relationship between investment in new construction and R&M of old buildings usually depends on the buoyancy of the national economy (Zavadskas *et al.*, 1998). The Office for National Statistics (2011) published data of construction output in the UK. The breakdown of this information is presented in Table 2.1. The Table shows the components of the non-housing R&M output with the greatest proportional increase in comparison to other works carried out in the first quarter of 2011 as against the fourth quarter of the previous year.

Table 2.1: Construction Output in the UK (ONS, 2011)

Construction output (constant (2005) prices, seasonally adjusted)						
Great Britain						£ million
		Housing new work	Non-housing new work	Housing repair and maintenance	Non-housing repair and maintenance	Total output
2007		20,920	48,418	16,914	21,981	108,233
2008		17,273	50,049	17,455	22,256	107,033
2009		13,751	45,215	15,882	19,908	94,756
2010		16,478	51,002	16,547	17,550	101,577
2008	Q2	4,442	12,507	4,435	5,797	27,181
	Q3	4,162	12,605	4,326	5,483	26,577
	Q4	3,805	11,868	4,390	5,175	25,237
2009	Q1	3,542	11,401	4,027	5,052	24,022
	Q2	3,464	11,254	3,919	4,796	23,432
	Q3	3,288	11,007	4,196	5,203	23,694
	Q4 R	3,457	11,553	3,741	4,858	23,608
2010	Q1 R	3,563	12,061	3,978	4,251	23,852
	Q2 R	4,188	12,824	4,095	4,432	25,539
	Q3 R	4,381	13,288	4,291	4,485	26,445
	Q4 R	4,347	12,829	4,184	4,382	25,741
2011	Q1	3,991	12,306	3,904	4,512	24,713

Furthermore, as shown in Figure 2.2 and 2.3, it can be concluded that despite the recession, the output of the R&M sector is steady over 2011 and 2012 as against the new-work. UKCG (2009) predicted more decline in new work to continue with marginal growth forecast due to the construction industry facing its worst economic downturn since the Second World War although there is more recent sign of significant improvement.

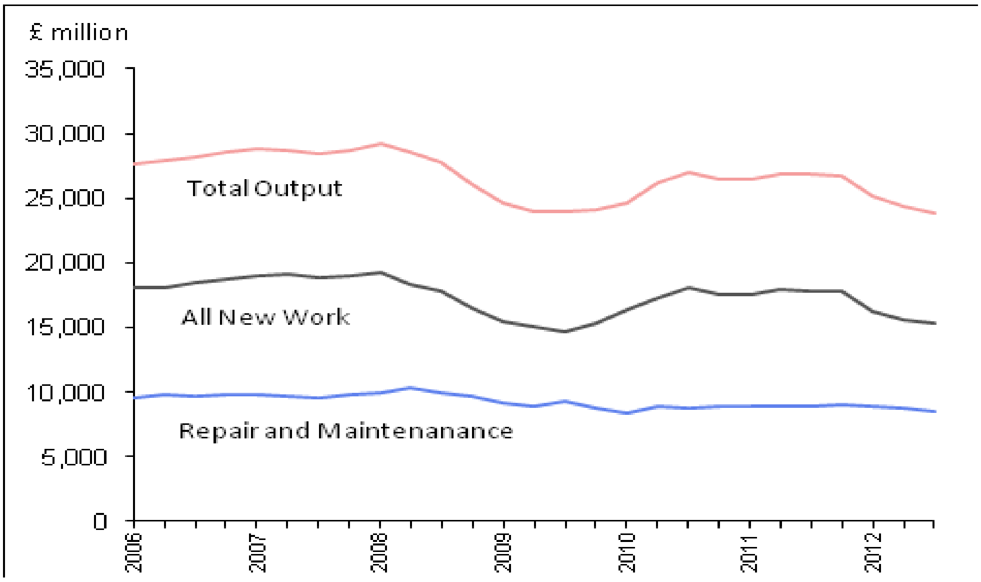


Figure 2.3: Construction Output in the UK (ONS, 2012)

2.4 Why refurbish?

The decision to refurbish a building is made when a building is not deemed to be 'fit for purpose'. Buildings physically deteriorate over time, while becoming subject to various other forms of obsolescence. Due to obsolescence, at some stage it will become necessary to consider whether to refurbish or completely redevelop (Kangwa and Olubodun, 2004). To decide whether a building is obsolete will require an assessment of its physical form and condition (Riley and Cotgrave, 2011), as well as the building's ability to accommodate modern technology and the potential to be upgraded to meet the increasing demands for carbon reduction. Similarly, any building that is in good condition but is in the wrong location may be considered as obsolete and deteriorated. It is also possible that a building may fail due to faulty design, construction, use, maintenance or materials (Riley and Cotgrave, 2011).

The Royal Institution of Chartered Surveyors (RICS) identifies factors which could lead to building obsolescence as follows:

a. Aesthetics: It is a well-known fact that some buildings appear to be too old, ugly or even too out of date;
b. Technological Factors: The emergence of modern technology and the increasing use of technology for business and the ability of a building to accommodate the supporting infrastructure;
c. Economic Factors: Building are generally financial assets, once their income generation potential reduces, they will cease to be viable assets;
d. Physical/Legal Factors: The ability for older buildings to meet requirements for energy conservation, accessibility and the control and removal of deleterious materials may simply be uneconomical;
e. Functional/Social Factors: The changing nature of society, business and building use means that some building types are simply no longer needed in their present form. For example large numbers of churches have been converted to other uses such as retail and residential units.

According to Wordsworth (2001) quality of life is no doubt affected by unhealthy buildings in a decaying environment which also contributes to anti-social behaviour. A review of literature also suggests that making comparisons between refurbishment and redevelopment is problematic because the term refurbishment is often used to imply a wide spectrum of building activities, ranging from minor cosmetic improvement, to extensive upgrade and/or reconstruction. In direct comparison, refurbishment is no doubt perceived as a quicker and cheaper means of restoring an existing and obsolescence building to an acceptable standard and/or to comply with regulation.

Conversely, CIRIA (1994) reported that refurbishment is not restricted to building whose physical condition has deteriorated to the detriment of its original purpose or earning capacity. Hence, many refurbishment projects are concerned with a building still in good working condition but whose owners wish to accommodate new technology or to change its role in their business operations.

There are numerous examples of newly-completed buildings being refurbished (converted) to suit a different purpose from that for which they were designed. More so, due to the economic climate, clients who would rather go down the new-build route are being forced by circumstances to make do with the buildings that they have (Rawlinson, 2010).

To carry-out a successful refurbishment project, developers must balance the twin challenges of delivering a building that meets the expectations of current standards and regulations while responding to the opportunities presented by the building. Demolition of buildings over 50 cubic meters requires the owner to apply to the local authority for approval, while difficulties in obtaining planning approval for new-build projects can make refurbishment more attractive (Caleb, 2009). The HM Treasury Operational Efficiency Review has also identified property as an area for savings through increased efficiency and the disposal of excess space.

It is claimed that the value of a building declines in relation to age and usage. Refurbishment therefore, becomes an option due to changing ways of working. Furthermore, when completed, refurbishment should either substantially improve performance levels for the original use or provide the new performance level required to suit the changed use of the asset.

It is also often claimed that refurbishment is prompted once there are signs of leakage and/or damage to an existing building structure. However, this trend is perceived as a planned repair and maintenance activity as there are instances where refurbishment is carried-out when there is change of use or when a building changes ownership. Recently, buildings are refurbished in order to minimise the energy consumption by improving insulation as part of meeting the current regulation and standards. Research also suggests that refurbishment tends to be employed for technical upgrades, more often than it is used to overcome problems with the building envelope (Corus, 2010). Additionally, there are a number of reasons why a property owner may choose to refurbish a property rather than to demolish and new-build as highlighted by Corus (2010). This may include the following:

- To increase the asset value of a property;
- To improve the occupants' working space and/or configuration;
- To increase the rental income;
- To improve the aesthetics of the property;
- To minimise energy consumption and costs and also improve thermal efficiency;
- To replace a damaged building envelope that may be costly to repair.

However, the challenge for the developer's team is to overcome the effects of building related constraint while making the most of a building's qualities both internally and externally (Rawlinson and Wilkes, 2008). Depending on the condition and age of the building, the scope of works may include a number of things ranging from the construction of new framed structure to replace load-bearing masonry which may increase floor areas. However, Rawlinson and Wilkes (2008) opined that this type of works is more complex to design and manage and involves a degree of uncertainty.

2.5 Factors influencing the growth of refurbishment

Douglas (2006) opined that buildings are usually affected by some form of obsolescence or inefficiency to a greater or lesser rate. Due to the inefficiency of the building fabric, they sooner or later are unable to satisfy the needs of occupants and also fail which also means that they do not meet the current regulation and standard. The control of disrepair and obsolescence in a building is therefore, largely dependent upon understanding the mechanism causing building deficiency.

The average life expectancy period of a building is 60 years, thus, it has been suggested that once a building is erected, the level of maintenance required in keeping it physically and functionally satisfactory through this period is more or less influenced by several factors associated with the use and environmental conditions. Some of the factors that influence the growth of the UK refurbishment sector may include social factors, global economic climate, technology factors, political factors, legislation, planning constraints, large stocks of redundant and ageing buildings or sustainability concepts, as well as the health and safety requirements. These factors are considered and discussed below:

2.5.1 Planning constraints

As a general rule, work of minor internal alterations to a building does not require planning consent. For example, the Town and Country Planning (General Permitted Development) (Amendment No. 2) (England) Order 2008 allows the enlargement, improvement or other alteration of a dwelling house and construction of porches. Therefore, minor external alterations are covered by permitted development rights, so that a planning application is not required, while major alterations require planning consent (Collings, 2002). However, when dealing with buildings of particular or special Architectural and Heritage interest or importance, these controls are not considered sufficient. These types of buildings are particularly known as 'listed buildings'. Being of historical importance, Collings (2002) and Doran et al (2009) claimed that listed buildings generally require an approval usually referred to as 'listed building consent' as further controls apply to this type of buildings. In addition, permitted development rights are also reduced on this type of buildings while major alterations may require both listed building consent and planning permission (Collings, 2002).

Where a building is 'listed', it is an offence under the provisions of the Act to carryout works of complete or partial demolition, alteration or extension without obtaining listed building consent. As obvious as it may seem, demolition is often not an option, either because of the need to continue operations on site or because the existing building has heritage aspects which the client desires, or is required to preserve. Therefore, planning constraints can be said to have contributed to the growth of building refurbishment as many buildings of architectural and historical value are protected and as a consequence, these buildings are only permitted to be refurbished and/or upgraded to a certain extent but cannot be redeveloped.

Moreover, in accordance with section 55 of the Town and Country Planning Act 1990, "development" refers to the carrying out of building, mining or other operations in, on, over or under land, or the making of any material change in the use of any buildings or other land. Subject to certain exemptions as set out in the Act, all development requires planning permission. Indeed, in most cases, the sheer difficulty in obtaining planning permission and/or consent especially for new development means that developers may opt for refurbishment rather than redevelopment. Although, this possible improvement, extension and/or alteration activities associated with refurbishment may combine both refurbishment with new-build activities, the constraints in redevelopment has no doubt contributed to the growth of refurbishment sector.

2.5.2 Stock of redundant and obsolete buildings

ASHRAE Handbook (2009) reported that reuse of existing buildings is imperative if only, the environmental impact can be minimised effectively. The environmental impact of new-build is comparatively minimal (OECD, 2004) whereas the existing stock has a potential to make a larger more significant contribution (Mansfield, 2009) partly, because it promotes and preserves heritage which gives a community its unique character. The office of the Deputy Prime Minister-ODPM (2005) and National Refurbishment Council (NRC, 2010) reported that the UK has some of the oldest building stock in Europe, with almost a quarter of buildings in England built before 1919. These buildings pre-date the emergence of modern concepts of sustainable development. As a consequence, many urban areas are poorly maintained and rundown, occupied by generally disadvantaged populations (ODPM, 2003) and are considered obsolete and inefficient.

However, there is concomitant growing pressure for sustainable energy efficient buildings from both regulators and occupiers (NRC, 2010; GVAGrimley, 2010; Gorse and Highfield, 2009). There are also current government target for carbon reduction in buildings. This means that the refurbishment sector has an important role to play as every refurbishment offers an opportunity to reduce carbon emissions beyond the standard set by building regulations (The Carbon Trust, 2008). Whilst some exponents contend that removing or demolishing a building is the easiest and quickest way of reducing energy use, it must be said that demolition is claimed to be slow, costly and unpopular as it can provoke community opposition. There has been revulsion against demolition as a tool for area renewal and it is not considered practicable to attempt anything like the average scale of demolition of the post-war clearances (Power, 2008).

In an attempt to minimise carbon emissions from buildings, The Committee on Climate Change (CCC, 2010) sent a clarion message to all sectors of the UK construction industry stating that in the UK, energy consumption in buildings is responsible for 45% of carbon dioxide emissions. Of this, 27% comes from domestic buildings and the rest (18%) from non-domestic buildings. For instance, in the domestic sector alone, seventy-three per cent of emissions come directly from space and water heating, and yet 80% of these - heating systems - are fuelled by gas, the biggest source of emissions (DCLG, 2006).

Therefore, by improving energy efficiency in buildings, the amount of carbon emissions can be significantly reduced. However, there also exists a general apprehension about spiralling levels of disrepair such that most of the existing building stock is outdated and inefficient with poor energy performance (Roberts, 2008), thus, unable to deliver the best returns on investment. While there might be some merit in such concerns, what Roberts (2008) failed to observe is the fact articulated by the UK Green Building Council-UKGBC (2008) that existing buildings have an important role to play. No doubt the refurbishment sector will help in achieving the carbon emission targets and raising the standard of existing obsolete buildings. Indeed, evidence to date suggests that it is feasible to raise the energy performance of existing buildings to a standard as high as a new-build, thereby reducing the energy usage by 60% or more (Sustainable Development Commission – SDC, 2007).

It follows therefore, that the scale of this challenge and the magnitude of the increase in number of aged buildings coupled with the decline in development finance have incontrovertibly led to the search for cost-effective alternatives to demolition and new-build and this clearly emphasises the significance of the refurbishment sector of the UK construction industry. Hence, building refurbishment may be perceived as a well-established alternative to demolition and new-build and it is now more widely recognised that it makes far greater sense to retain and refurbish buildings in preference to demolishing and new-build (Corus, 2010; Gorse and Highfield, 2009; Marsh, 1983).

In terms of domestic buildings alone, there are over 24 million homes in the UK (Power, 2008). While the building stock may continue to increase over the years, it will need very different solutions to incorporate evolving sustainable criteria, as it is patently unsustainable for large-scale new build to replace existing buildings (Mansfield, 2009). Therefore, this large stock of redundant and ageing buildings can be said to have contributed to the growth of refurbishment sector as the declining conditions of residential buildings, industrial buildings as well as other commercial buildings have exerted pressure on both government and private home owners alike to carry out refurbishment and rehabilitation work.

2.5.3 Technological factors

According to Douglas (2006), advances in technology and growing demands by building users for a more comfortable internal environment have prompted the need for modernization of buildings. Especially in the last two decades, building users are increasingly becoming more conscious of the need for 21st century standards of environmental comfort.

Similarly, in comparison to modern buildings, some aged and obsolete buildings do not have suspended ceilings to enable the installation of modern electronic equipment and air conditioning systems. This suggests that such buildings will need to be upgraded to an acceptable level to meet current regulations and standard as well as to meet the needs of the users. For example, there are several varieties of modern communication systems as well as sophisticated security and fire systems on the market and they are continuously upgraded to meet the growing demand for higher standards of services for the comfort of the building users. Therefore, the demand for modern technology in buildings can be seen as a factor which influences the growth of the building refurbishment sector.

2.5.4 Political factors

The growth in the refurbishment market has been influenced by changes in the political climate of the UK. Within the last decades, the economy has seen drastic restructuring. This is particularly evident in the decline of new-build projects due to the recession which has led to lack of development finance. It also seems that the volume of vacant space is set to increase as the impacts of the global recession are more keenly felt (Mansfield, 2009). More so, across the UK, there is large quantity of redundant commercial buildings in need of being upgraded which will be suitable for an extended economic life.

This large stock of redundant commercial and industrial buildings which are under-utilised will continue to require upgrading, modernisation or converting for residential and/or retail use to meet current standards and regulation. Mansfield (2009) claimed that government can have both direct and indirect influences on refurbishment activity and can act as an example for the private sector to emulate. The government also has a multiplicity of roles as it acts as a client for refurbishment works, as a legislator and also as a regulator. Being a major client of construction activities, government is leading the way to ensure that refurbishment projects achieve the Building Research Establishment Environmental Assessment Method (BREEAM) rating of 'excellent' (Doran et al, 2009; NAO, 2008).

In an attempt to increase revenue from the commercial property sector, the UK government introduced the Rating Act 2007 (for empty properties). The Act took effect from April 2008 and provided for the removal of relief for unoccupied commercial property for more than six months. The government's aim was to encourage owners to bring empty stock back into beneficial use. This move means that refurbishment will continue to be a significant part of the entire building and construction activity. According to UK Government website (Gov.UK, 2014) Energy Performance Certificate (EPC) is needed whenever a property is:

- Built
- Sold; and/or
- Rented

An EPC contains:

- Information about a property's energy use and typical energy costs; and
- Recommendations about how to reduce energy use and save money.

Additionally, an EPC gives a property an energy efficiency rating from A (most efficient) to G (least efficient) and is valid for 10 years. It is also required by law that the person selling a house, the landlord or the letting agent must show the potential buyer the EPC and this also applies to renting out the property.

2.5.5 Global economic climate

The global economic meltdown in the last few years is claimed to be the worst downturn experienced by the UK commercial property market since the Second World War (GVAGrimley, 2010; Construction Industry Council (CIC, 2009). It resulted in lack of development finance which has consequently led to significant reduction in the number of construction projects (CIC, 2009). Accordingly, CIC (2009) reported that the total construction output in the current economic climate has fared poorly, with the fall in new work output steeper than that of repair and maintenance.

Unsurprisingly, a survey-generated data by the Royal Institute of British Architect-RIBA in CIC (2009) shows that the downturn has impacted on industrial and commercial sectors, where lower revenues and unemployment will continue to limit spending growth. In 2010, the impact of the recession was predicted by a professor of economics Nouriel Roubini as being at the second stage. Roubini (2010) referred to the financial crisis as a second leg of the credit crunch because as he claimed, 'the recession will move from a private to a public debt problem'. He further claimed that the Greek Debt crisis is a tip of the iceberg of rising sovereign debt problems in the Eurozone, the UK, the USA and Japan. This is however, evident in the slowdown of growth showed in the first half of 2011, if not outright contraction in most advanced economies and especially in the Eurozone.

As a consequence of the recession, the refurbishment of existing buildings may be perceived as a strategic avenue through which property owners could secure value for money. Hence, Rawlinson (2010) opined that when budgets are tight, refurbishment seems to be the ideal solution. The impact of the recession would therefore appear to make refurbishment a more commercially viable alternative to new-build; as a decline in development finance due to the recession contributes to the growth of refurbishment.

2.5.6 Sustainable development concepts

In the UK, the built environment in general is said to account for half of all carbon emissions. As a consequence, sustainability is now a well-established area at the core of UK urban policy. This requires all development projects, be they rehabilitation, conversion, refurbishment or new-build, across all sectors to deliver to the various targets set. To emphasise the importance of sustainable development, Planning Policy Statement 1: Delivering Sustainable Development (ODPM, 2005) states that sustainable development is a core principle underpinning planning, and also suggests that planning policies should promote high quality inclusive design in terms of function and impact.

The issue of whether to opt for a wholesale demolition or refurbishing existing buildings has been a subject of debate in the last 10 years. For instance, Government Sustainable Communities Plan, 2003 proposed a large – scale clearance and rebuilding. More so, the Oxford University Institute of Environmental Change argued that to achieve the energy reduction targets, around three million demolitions are necessary by 2050 (Boardman et al 2005). Conversely, there are also environmental arguments for refurbishing existing buildings in which people sought to defend their communities from demolition (Power, 2008). This is especially because wholesale demolition of buildings is claimed to be quite unhealthy from an environmental protection perspective as it causes heavy pollution as well as placing more demand upon depleting resources. This view is a reverberation of the views of the Sustainable Development Commission – SDC (2006) and the UK Green Building Council – UKGBC (2008) who both argues that existing buildings still have an important role to play; hence there is urgent need to upgrade the existing stock.

Evidence on whether demolition would help to minimise the amount of greenhouse gases emitted by building occupants is unconvincing and largely unsubstantiated. Power (2008) argued that upgrading the stock of buildings to high environmental standards could be achieved more cheaply with significant carbon reduction than actually demolishing them. This clearly emphasises the significance of refurbishing and retrofitting existing buildings up to standard not only to meet carbon emission targets, but also to improve the general living conditions for occupants and therefore tomorrow's generation (Babangida et al, 2012a). Adopting policies that aid the retention and upgrading of the existing stock will invariably enhance the development of refurbishment skills and technologies, and will subsequently save materials and land and also facilitate the integration of existing communities in need of regeneration (Power, 2008). If the energy and emission problems associated with the entire built environment are to be confronted and addressed in a more meaningful way, sustainable refurbishment programmes must be optimised and considered fully (Mansfield, 2009).

2.5.7 Social factors

It has been widely acknowledged that buildings are structures which are used for different purposes, and which from time to time, have changes of use. As a result, they require maintenance in order to prevent them from falling into disrepair due in part to the ravages of time and use. Although, dilapidated and unhealthy buildings in a decaying environment depress the quality of life and contribute in some measure to antisocial behaviour (Wordsworth, 2001), old buildings offer psychological reassurance because of their distinguishing characteristics. No doubt, retaining the character of a street is best achieved through the adaptation of its buildings.

There were also concerns about the demolition of historic buildings which arose in institutions such as the pressure group, the Society for the Preservation of Historic Buildings which appealed against demolition and neglect on a case by case basis. There are many other registered Building Conservation Organisations in the UK whose vision and mission is geared towards protecting existing historic buildings. Conservation is an endeavour which seeks to preserve, conserve and protect buildings of historic significance. These organisations include English Heritage, The National Trust, SAVE Britain's Heritage, Maintain Our Heritage, Churches Conservation Trust, and The Architectural Heritage and so on. Sustained pressure from social and preservationist groups such as these, in favour of keeping and maintaining communities together as opposed to slum clearance sometimes advocated by Governments, has contributed to the significant growth of the refurbishment sector. Indeed, Catt (1992) opined that the movement towards conservation and preservation of building assets rather than demolition and new-build as spearheaded by English Heritage has positively influenced the growth in refurbishment.

Furthermore, shortages of land for development especially in most city centre locations as well as increased prices for land to be developed in other parts of the cities and country suggests the need for refurbishing rather than redevelopment. For example, the lack of land in most city centre locations means that property owners within these premises have no option but to upgrade and modernise their buildings in order to stimulate demand, and enable the opportunity for generating steady income. By definition, an upgraded building will be more energy efficient than it used to be and could be compared to the performance of a new-build property. The upgrade may require actions such as insulation, window replacement, and optimised heating systems that lead to significant reduction in energy consumption.

2.5.8 Environmental factors

The last two decades saw the international community deliberating on the issue of global environmental problems. While the problems are diverse in nature, the depletion of key natural resources and increasing air and water pollution as well as growing levels of solid waste are perceived as a problem for generations to come with emphasis on global warming. Babangida et al (2012a) have further opined that the emergence of modern concepts of sustainable development has gained international recognition in recent years due in part to the growing concerns for global warming as a result of the depletion of natural resources, climate change as well as environmental pollution. Typical example of such concerns were deliberated at the United Nations conference on Environment and Development, Rio de Janeiro (1992) and 10 years later at the World summit on sustainable development, Johannesburg (2002).

To minimise the implications of global warming problems, sustainability and sustainable development concepts were introduced and discussed at various conferences including the two stated above. These growing concerns have forced governments worldwide to enact and promulgate laws in order to minimise the effects of higher carbon emissions by buildings (Babangida et al, 2012a). The 'Green Leases' and environmental memorandums-of-understanding are also increasingly gaining popularity. There are standard agreements which include additional obligations for monitoring and achieving standards of energy performance, water consumption, and levels of waste. Moreover, the adoption of Corporate Social

Responsibility (CSR) policies will also have direct implications for commercial property development. The CSR policies usually place environmental sustainability as a core value. One effect of this already felt in the market is that buildings with high environmental performance ratings are increasingly demanded by occupiers.

The need to meet the demands of both regulators and occupiers will mean that owners of property will need to reassess the environmental and social sustainability of the property. This means that existing buildings that do not meet the standards required, in terms of energy and space efficiency, will need to be refurbished or redeveloped if they are to remain attractive to both occupiers and investors.

2.5.9 Health and Safety requirements

Literature suggests that construction has always been a dangerous industry. With refurbishment now considered one of the most important sectors of the national construction programme in the UK, safety in this sector is an important issue which requires careful attention. The issue of safety is dealt with by legislation. For example, the Health and Safety at Work Act 1974 is an umbrella which provides the legislative framework to promote, stimulate and encourage high standards of health and safety at work (Riley and Cotgrave, 2011). Similarly, the Construction (Design and Management) Regulations 2007 is a set of management regulations dealing with the responsibilities of the construction professionals (client, designers, CDM coordinator, principal contractor and subcontractors) and with the documentation necessary to enable safe operation of construction activities on site (Riley and Cotgrave, 2011). The CDM regulations encompass general construction activities including refurbishment. For example, they contain requirements aimed at controlling certain types of risks arising from demolition, excavation, vehicles and traffic movement and so on.

The responsibilities of safety in refurbishment will also be more complicated than on a new-build site due to the nature of refurbishment projects. Reyers and Mansfield (2001) claimed that there is an increased use of temporary works such as scaffolding, shoring systems and safety issues than would be expected in new-build schemes. As a consequence, the client, contractor and other professional consultants have legal responsibilities for safety to their respective personnel and operations. This suggests that as a requirement of the law, the establishment of a safety regime at pre-tender stage is imperative to enable the identification of primary responsibilities for safety and also to serve as a basis for identifying hazards. The details of the safety regime must be included in the enquiry documents while the CDM coordinator or the project manager will have to ensure that the different responsibilities of safety are effectively coordinated throughout the project.

There is also a safety requirement for unexpected occurrence of hazardous materials such as asbestos which is a constant occurrence in older buildings and hence in refurbishment projects. Also, building regulations concerning means of escape and other fire safety regulations, access, ventilation, energy conservation and, the use of acceptable building materials have resulted in many buildings failing to meet the minimum standards. This means that those buildings which pre-date the modern concepts of sustainable development or current regulations and standards have to be refurbished and upgraded to meet the requirements of the present day regulations. The regulations imposed by the government to ensure the health and safety of occupants and building workers, which are usually stringent, have influenced the growth of refurbishment work.

2.6 Types of refurbishment

Refurbishment is an umbrella term that covers a wide range of activities from simple decoration to complete conversion of an existing building. Refurbishment work can therefore, be classified by the extent of work required to make the building ‘fit for purpose’. Rawlinson (2010) suggests that despite the enormous project challenges associated with refurbishment projects, there are few procurement options which do not particularly cater for a specific refurbishment project characteristic, hence the options are not much wider than that of a new-build project.

More so, in order to determine the best alternative strategy for a particular case, it is imperative to consider the complexity of the project as well as the scope of the project. By so doing, it is possible to understand whether or not the project falls under the following scales:

- Simple or Minor refurbishment: A refurbishment of this nature is simply undertaken as a short-term tactical investment to enable the economic life of the property to be extended, by up to five years depending on the type and quality of work. In most cases, this type of refurbishment is mainly carried-out to repair common areas and it also involves redecoration and furniture update of fittings and equipment (Rawlinson, 2010). For example, it may involve replacement or upgrading of plant and services, redecoration and new floor coverings (Riley and Cotgrave (2011). More so, this type of refurbishment is often claimed to present few complexities. However, despite such claims, literature suggests that clients will need to determine whether it is cost-effective to transfer the risk to contractors in this process;
- Medium Refurbishment: The main characteristic of this type of refurbishment project is that it has an investment time frame of between 15 to 25 years (Rawlinson and Wilkes, 2008). This type of project mainly involves upgrade of existing building services and finishes but not major structural alterations. Medium refurbishment projects are often claimed to involve a greater level of risk and uncertainties which is either related to the reuse of some systems or remodelling of windows and doors.

More so, risk transfer is considered imperative and must be done carefully as the condition of existing fabric and systems can have great impact on the completion of work (Rawlinson, 2010), especially in occupied buildings which may have great impact on building users;

- Major Refurbishment: This type of project is mainly carried-out to reposition a building as well as improving its performance in the long-term. Major refurbishment projects are carried-out to deliver top quality projects which are expected to equal new-build projects. This may include replacement of major plant and services, suspended ceilings, floor finishes, raised floors and internal walls (Riley and Cotgrave, 2011); and
- Redevelopment: The redevelopment option is considered mostly where the only element to remain is the existing façade and foundations.

However, Riley and Cotgrave (2011) are of the view that the extent of refurbishment that will be required would be very different on projects and would depend on the following:

1. The condition of the existing building/structure;
2. The shape and size of the existing structure;
3. The location of the structure;
4. Amount of work required to enable compliance with current Building Regulations;
5. Adequate funding available; and
6. Whether the work can be carried-out safely.

Furthermore, to establish real facts about the structure will require an appraisal of the existing building to be carried-out. This means that an appraisal of an existing building is essential when deciding whether a refurbishment scheme is feasible and viable. Hence, the initial appraisal should reveal the following issues:

- Whether the building is in a state of serious deterioration or possible collapse;
- Whether the building is suffering from significant deterioration, which may indicate that major remedial works are necessary, for example, works to the structure;
- Whether or not there are any defects evident with the original design and/or construction that have caused or are causing damage;
- Whether or not there has been any accidental damage to the building;
- Whether it is feasible or viable that the building could be used for an intended change of use;
- Whether a further and more detailed structural survey is required.

2.7 Sustainable refurbishment

Building refurbishment towards' zero carbon standard is believed to be facing tremendous technical challenges (Xing et al, 2011). This is especially because there is still lack of specific and rigorous process for zero carbon building refurbishment. From the public sector perspective, there is a concomitant growing pressure to meet current government's targets for carbon reduction in buildings, otherwise known as sustainable retrofit. However, Wilkinson (2012) defined sustainability in terms of a triple bottom line framework where economic, environmental and social sustainability are professed as equally important and the definition of retrofitting is derived from a definition of adaptation as any work to a building over and above maintenance to change its capacity, function or performance. On the other hand, Douglas (2006) opined that retrofitting is any intervention to adjust, reuse, or upgrade a building to suit new conditions or requirements. This would suggest that retrofit can occur to whole buildings or to parts of a building.

Indeed, in order to meet the zero carbon targets in the UK, in 2008, the Government passed the Climate Change Act to help combat rising carbon dioxide levels. This Act implemented a carbon emission reduction target of eighty per cent, with at least twenty-six per cent by 2020 set against the 1990 baseline. According to the Committee on Climate Change-CCC (2010), the UK was the first country in the world to implement such legally binding framework. The Department of Energy and Climate Change –DECC (2006) spearheaded the Climate Change Act which covers all aspects of carbon emitting sources such as energy consumption, transport, agriculture and domestic and non-domestic buildings.

However, there also exists a general apprehension about spiralling levels of disrepair such that most of the existing building stock is considered outdated and inefficient with poor energy performance (Roberts, 2008), and is thus, unable to deliver the best returns on investment. While there might be some merits of such concerns, existing buildings still have an important role to play as it is believed that nearly eighty per cent of the buildings that will be inhabited in 2050 are those already standing. This clearly emphasises the significance of refurbishing and retrofitting existing buildings up to standard not only to meet carbon emission targets, but also to improve the general living conditions fit for the occupants and therefore tomorrow's generation.

There is a wide spread view among researchers that all development projects be they refurbishment or new-works have an important role to play in achieving the current government targets for sustainable development; since the construction industry is better placed to implement sustainable practices than other industries (Rees, 1999). The Organisation of Economic Co-operation and Development-OECD (2004) suggests that the existing stock can be considered as an unexploited asset with great potential to improve the environment; hence, Rees (1999) opined that new construction must be limited in developed countries while concerted efforts should be directed towards refurbishing existing building stock. Indeed, Resource for Urban Design Innovation-RUDI (2009) claimed that refurbishing the existing building stock must be a priority if only to achieve the set targets for sustainable development, thus building refurbishment has become an important part of the entire building and construction process.

Furthermore, apart from the normal problems associated with refurbishment schemes, developers are currently faced with challenges to comply with current legislation to minimise carbon emissions in buildings. The emergence of modern concepts of sustainable development has gained international recognition in recent years. However, in the UK there is divergence of opinions which suggests that although this can be achieved, it will require concerted efforts to meet the current targets. Indeed, the Task Force on Sustainable Development (2007) indicates that in order to achieve the anticipated improvements needed to address the environmental impact of the built environment; the construction and property sectors must engage more meaningfully and become more pro-active with the sustainable development agenda within the next 15-20 years. This is due in part to the fact that the UK has some of the oldest building stock in Europe (Office of the Deputy Prime Minister-ODPM, 2005; National Refurbishment Council-NRC, 2010).

Notwithstanding, the UK Green Building Council-UKGBC (2008) articulated that existing buildings still have an important role to play as nearly eighty per cent of the buildings that will be inhabited in 2050 are those already standing. Nevertheless, the refurbishment of these buildings to current regulations and standards would be a huge step towards the sustainability agenda. Thus, this clearly emphasises the significance of refurbishing and retrofitting existing buildings to standard not only to meet carbon emission targets, but also to improve the general living conditions fit for the occupants.

2.8 Building obsolescence

The term obsolescence is taken to mean that an existing building or component is no longer suitable for current demands in its present form, in addition to being unavailable from manufacturers' (BSI, 2007). It is the period after which an existing building or its component discontinues further production or support expected of it (Baker, 2011). Where this happens, the impact of such occurrence will ultimately affect the ability to maintain or repair an existing building, which will potentially jeopardise the achievement of the intended design life without considerable investment.

Addressing obsolescence in existing buildings may be achieved through reactive or proactive strategy (MacCormac, 2003). While the reactive strategy responds to obsolescence only when a component or equipment may not be replaced, a proactive strategy responds to obsolescence early before it occurs (BSI, 2007). This is referred to as obsolescence management which is concerned with reliability mostly because obsolescence does not count except when a building component fails.

2.9 Summary

The chapter has provided a variety of definitions of building refurbishment which led to a working definition for the purpose of the present study and also an overview of the building refurbishment sector within the UK construction industry. The factors which influence the growth of refurbishment were considered and discussed namely: large stock of redundant and obsolete buildings, global economic climate, sustainable development concepts, social factors, environmental factors, political factors, economic factors, technology factors, and health and safety requirements and planning constraints.

The chapter also presented the main reasons why a building should be refurbished, a general overview of a refurbishment project which includes the nature, type and scale of refurbishment works undertaken; the benefits associated with such refurbishment as well as the concept of sustainable development in building refurbishment schemes.

It is believed that refurbishment of existing building stock may help towards achieving the zero carbon targets. However, zero carbon refurbishment is also believed to be a complicated task involving a range of advanced technologies. It is also facing challenges in promoting awareness and increasing relevant skills sets among relevant stakeholders.

In a nutshell, evidence gathered from literature suggests that the building refurbishment sector will no longer be considered as a Cinderella activity due to its significant contribution to the UK economy.

CHAPTER THREE

Research Methodology

3.1 Introduction

This chapter presents the research methodology adopted for the research. It explains how the research problem was investigated. It also explains the research instrument for the research. In carrying out research, it is important to identify a research approach to investigate a problem. The study's main instrument was through surveys (defined as the collection of information in a standardised way from selected groups of people) using mixed methods.

This was achieved through pilot interviews with experienced professionals in refurbishment. The literature review and the pilot interviews helped in confirming the relevance of the research area, the gaps within the topic and thus assisted in understanding the most important issues relating to the research.

The Oxford English Dictionary defines research as a diligent and systematic inquiry, study or investigation into a subject in order to discover or revise facts, theories and applications. Leedy (1989) defines research as a procedure by which we attempt to find systematically, and with the support of demonstrable fact, the answer to a question or the resolution of a problem. In other words, research is a process of collecting, analysing and interpreting information to answer certain questions. However, to qualify as research, the process must have certain characteristics: it must, as far as possible, be controlled, rigorous, systematic, valid and verifiable, empirical and critical. Hence, in defining research, the following must be considered to be important in its definition:

- Methodology; which refers to the use of approaches such as qualitative or quantitative;
- Validity; which refers to the application of correct procedures to find answers to a question;

- Reliability; which refers to the quality of a measurement procedure that provides repeatability and accuracy; and

- Unbiased and objective; which means that each step is taken in an unbiased manner (without deliberate attempt to either conceal or highlight something) and the conclusion is drawn to the best of one's ability without introducing vested interest.

It appears that these preceding points informed the definition of Oppenheim (1996) who opined that the goal of the research process is to produce new knowledge. However, Bryman (2001) suggests that in practice much research is driven by pragmatic assumptions or 'technical' issues as much as it is driven by philosophical assumptions. Hence, the framing of research questions may be underpinned by philosophical and pragmatic issues. More so, there is an argument that sound methodological practice is to choose a method appropriate to the research question (Cresswell, 2003; Mason, 2002; de Vaus, 2001; Blaikie, 2000). This would appear to mean that in order to address a research problem or set of research questions, a researcher must devise a strategy (Brannen, 2005; Bryman, 2001 p. 20). A researcher must undertake an investigation of a research problem by using a structured and systematic strategy.

Therefore, this chapter highlights the technique adopted for the study and the reasons underlying the choice of the technique are also discussed in detail. The methodological procedure that had to be adopted for the study needed to be one that is capable of providing in-depth, relevant, up-to-date, reliable as well as unbiased information relating to the indexation of risks and their impact on building refurbishment schemes. The methodology took account of the need to identify day to day refurbishment problems by looking at the most frequent refurbishment challenges, how these challenges impact on the outcome of the schemes and how they can be managed to achieve successful refurbishment schemes.

The population for the study is also described and the method of selecting the sample is outlined. The chapter will also highlight the statistical techniques adopted for data analysis.

3.2 Identification of target population and selection of sample frame

In a study of this nature, it is imperative to identify a population which has the potential of providing answers to the problem, one that is comprehensive, with a sample that is truly representative of the entire population. This is essential if the outcome of the research is to be considered towards improving the refurbishment standards. Indeed, if the right population is not identified, with a reasonable sample size, it may be difficult to achieve the aim and objectives of the research. The process of selecting part of the population as a sample, from which the characteristics of the larger population are inferred, has long been accepted as a legitimate and expeditious method of research (Egbu, 1994).

It has been argued that, in the appraisal of skills, the skilled activity should be discussed almost *ad nauseam* with the individuals who practice it, (in this case, the refurbishment contractors), as well as those for whom they are responsible (Fortune and Skitmore, 1994; Olubodun, 1996). In considering the sampling of a population, due regard must be paid to the purpose of the research. This research involves seeking the opinions of practitioners in refurbishment projects within the UK construction industry. Sampling theory distinguishes between `probability' and `non-probability' sampling (Olubodun, 1996; Kidder and Judd, 1981). In the former, every subject in the population has a known, non-zero probability of being included in the sample. In the latter, the probability of inclusion of each subject is not known and many of the elements may have zero probability (Olubodun, 1996).

In view of this, it was considered appropriate to gather views from experts at different levels of contractors (principal contractors, specialist contractors and sub-contractors). A large number of contractors are thought to be important and were selected randomly. There are two reasons for choosing refurbishment contractors for this study namely:

- It remains a fact that every construction and refurbishment activity is carried-out by experts otherwise known as contractors. Bearing this in mind, it was thought that information sought on risk and uncertainties associated with refurbishment schemes, are best obtained from those who are actively involved. The rationale was that the contractors were better informed by virtue of their professional training and experience;

- More so, refurbishment contractors were deemed to be in a position to comment on the types of risks and uncertainties that affect the achievement of quality especially in terms of health and safety. HSE (2004) suggest that refurbishment, in its different interpretations, accounts for a substantial proportion of injuries and fatal accidents with almost 41% of construction fatalities. It was therefore, recognised that refurbishment contractors are better informed to comment on this.

At the outset of this study, several efforts were made to obtain a suitable list of contractors in the UK who carry out refurbishment work. This proved difficult as it was considered uneconomical to telephone each individual organisation to ascertain whether they carry out refurbishment work or not, due to the large number of contractors in UK.

However, another attempt to obtain a suitable population sample frame meant that a list of national contactors from the National Federation of Builders (NFB) directory, the UK contractors Group, (UKCG) and other similar organisations across England had to be consulted. This attempt proved successful. The UKCG comprises the largest construction companies in the UK as members. The directories have the characteristics of a good sample frame, in that it is comprehensive. It was important and necessary that the selection of contracting organisations was made from a reliable source so as to be a homogenous sample frame. From the directories, a large number of contracting organisations were identified as carrying out refurbishment work which includes commercial, industrial, housing and historic building refurbishment.

The author also adopted a procedure in selecting refurbishment organisations, to participate in the study, by contacting the personnel departments of the contractor organisation by telephone in order to ascertain whether or not, the organisation is still in business and carrying out refurbishment work. This technique proved expensive and discouraging in terms of response and politeness as well as being time consuming, however, it was a successful initiative in the end.

Having arrived at a desired population sample frame, the next challenge was deciding whether the contacts established are those involved in actual refurbishment work or those who make decisions in the office, as one of the objectives of the study is to evaluate and model the factors that contribute to risks in building refurbishment schemes, it became pertinent that those involved in actual refurbishment work were to be targeted.

Four hundred and fifty (450) questionnaires were distributed among the three (3) groups of respondents as identified. This means that one hundred and fifty (150) questionnaires were distributed across each of the three (3) regions selected randomly. In each region, 50 questionnaires were distributed to each of the three (3) groups of contractor respondents. A pictorial representation of which the contractors were selected is shown in Figure 3.1.

3.3 Stratification of target sample

The author adopted stratification of the population sample. Stratification refers to the classification of a mass of data (obtained from research) into categories and sub-categories on the basis of one or more chosen criteria. It means the division of the population into subgroups or strata. Fink (2006) suggests that in stratified random sampling, the population is subdivided into subgroups or strata and then a given number or proportion of respondents is selected from each sample or stratum. The research therefore adopted the use of stratified random sampling to select the respondents for the study.

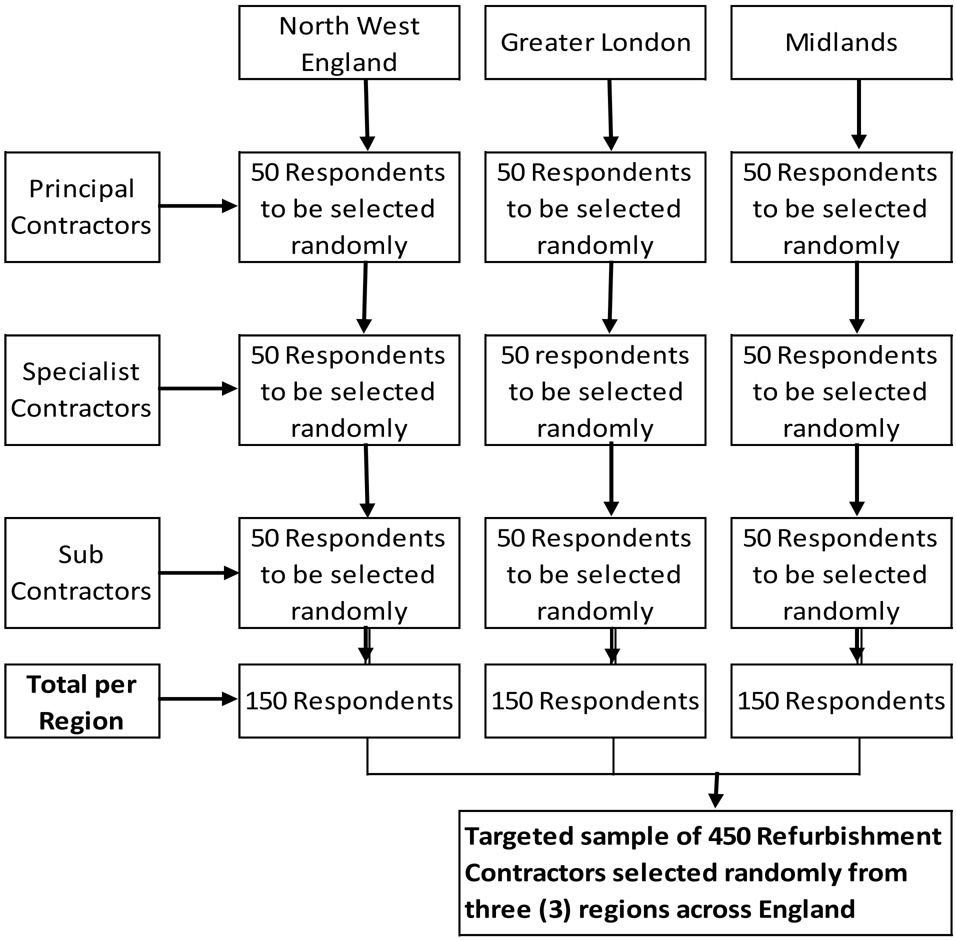


Figure 3.1: Stratified Random Selection of Respondents across England

The respondents for the study were chosen from what could be described as a subset of contractors in three regions in England (The North West, the Midlands and Greater London).

The random selection followed initial stratification of contractors into Principal contractors, specialist contractors and sub-contractors. Moreover, random sampling initiated after applying stratification technique is accepted (Kangwa, 2004). This method of categorising contractors into different levels is to enable the researcher to collect as much information from those involved in the refurbishment processes as possible.

As earlier explained, respondents were selected from three classes of contractors obtained from the UK Contractors Group (UKCG) and National Federation of Builders (NFB) directories. As shown in Table 2.1, the target of 50 research participants per class of respondents more than doubled the 20 person requirement set by Fink and Koesecoff (1995), (see section 3.3.1).

3.3.1 Benefits of stratified sampling

Fink and Kosecofff (1995) have highlighted the benefits and disadvantages to a researcher and the survey results in having to choose a stratified random sampling technique as opposed to a simple random technique. The benefits are as follows:

- It can be more precise than a random sampling, it permits the researcher to choose a sample that represents the various groups which characterise the targeted sample;
- It homogenises the groups within a stratum without which, results or findings may be unrepresentative.

However, they further outlined the disadvantages of stratified sampling as follows:

- The method requires more effort than simple random sampling;
- It often needs a larger sample size than a simple random to produce statistically meaningful results;

- The size of each subgroup must exceed twenty (20) in order to make statistical comparisons meaningful (p. 56).

More so, the benefit of handling stratification with utmost care is highlighted by Kvanli *et al.* (1992). In their opinion, adequate sampling holds the key to accuracy in descriptive statistics arising from the collected data. They further cautioned that from time to time, researchers have to wrestle with the temptation of having to analyse and interpret data and therefore, form opinions and new lines of thinking, using what may not necessarily qualify to be inferential statistics.

In agreement with Kvanli *et al.* (1992), Litwin (1995) has also cautioned that an author who intends to go beyond descriptive statistics should ensure that the data is drawn from a well representative sample. Oppenhiem (1998) also opined that transparency in the method of selecting respondents is paramount to the credibility of a study's findings; hence the present study has taken all of the above into consideration.

3.4 Data collection strategy

In this study, the collection of primary data for the study was considered imperative as there is no other data available from any other source. The preliminary survey was conducted during the early stage of the study following an extensive literature search on the subject. The final data collection was conducted to establish the observations and to justify or refute the hypothesis developed from the theoretical background work and preliminary questionnaire.

There are several methods available to a researcher for collection of data. Kangwa (2004) reiterated that there are various techniques of data collection available to the social researcher. These techniques may include structured and semi-structured interviews, case study, the postal questionnaire, experiment and survey (Naoum, 2008; Oppenheim, 1996;

Jobber, 1991). Similarly, Bell (2005) is reported by Farrell (2011) to have suggested seven approaches to research. This includes action research, case studies, surveys, experiments, ethnography, grounded theory and narrative enquiries. In appreciation of this view, Farrell (2011) further noted that the definitions vary between authors. However, they may be called approaches to collecting data, and are applicable if the data to be collected are qualitative or quantitative. Pertinent to this study, Naoum (2008) suggests that it is possible for a researcher to combine and conduct a postal questionnaire and a case study, or to conduct interviews in addition to postal questionnaires.

Farrell (2011) suggests that a researcher may collect some data that is both quantitative and qualitative. This observation was a reverberation of Jobber (1991) who was of the view that it is impossible to say which method is superior in abstract terms, and that each method has its own strength and limitations.

Nevertheless, Jobber (1991) further noted that a researcher is expected to assess each of the methods and its limitations against the research objectives, the information required and the available resources. Similarly, Naoum (2008) further claimed that a researcher's decision on the type of data to use depends on the purpose of the study. Therefore, in the present study, the use of a combination of methods otherwise known as mixed methods research was considered imperative to enable the author to capture a wide range of information needed to develop the conceptual framework.

To achieve the research objectives, the researcher anticipates using mainly primary data. Indeed, researchers seeking associations between primarily qualitative and primarily quantitative data can look to mixed method research designs for structured and tested integrative processes (Driscoll *et al.*, 2007). More so, to define mixed methods research as a "method of data collection" is accepted by many researchers (Elliot, 2005). Mixed methods research refers to adopting a research strategy by employing more than one type of research method (Brannen, 2005); and is often referred to as multi-strategy research (Bryman, 2001; Creswell and Clark, 2007). It means working with different types of data by collecting, analysing, and mixing both quantitative and qualitative data in a single study (Driscoll *et al.*, 2007; Creswell, 2007; Brannen, 2005; Tashakkori and Teddlie, 2003). Thus, the use of a combination of research procedures is often more useful than a single one, since the different methods yield different kinds of data, which if combined together facilitate more comprehensive analysis of the phenomenon studied. Its central premise is that the use of quantitative and qualitative approaches can provide a better understanding of research problems than either approach alone (Creswell, 2007).

It is therefore, hoped that the objectives of the research will be achieved through literature review, semi-structured interviews and questionnaires. Initially, the researcher conducted some interviews with selected contractors as a pilot study to capture a wide range of relevant information. This information was used to design the questionnaires for further investigation in order to obtain a larger sample. The validity of the questionnaire was piloted first, with the research supervisors because of their experience with refurbishment work and; secondly a targeted number of the respondents who provided initial interviews selected randomly, before the final version was sent-out to the sample. The questionnaires were distributed to practicing professionals across the industry, specifically contractors namely: principal contractors, sub-contractors as well as specialist contractors. The structure of this method of data collection is presented in Figure 2.1. The semi-structured interviews, the postal questionnaire and the piloting phases of the study are also considered and explained in this chapter.

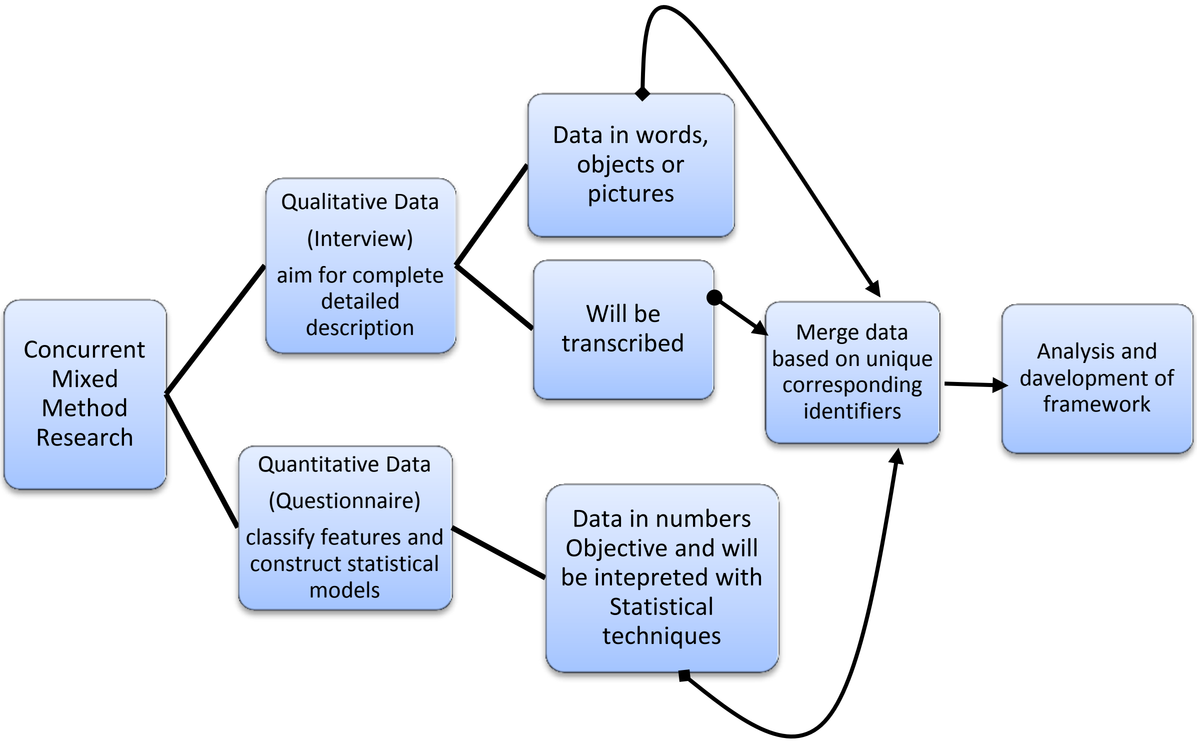


Figure 3.2: Mixed Methods Research Strategy

(Adapted from Brannen, 2005; Creswell, 2007; Driscoll *et al.*, 2007)

3.5 Rationale for the choice of mixed methods research

The complex nature of refurbishment schemes coupled with the ever present risks and technical challenges associated with the schemes mean that an unbiased method of data collection will be required to achieve the objectives of the research, hence the rationale behind the use of mixed method research strategy. The justification is that the use of both quantitative and qualitative approaches can provide a better understanding of research problems than either approach alone (Creswell, 2007). Literature also suggests that a combination of research strategy has its advantages, since the different methods yield different kinds of data, which when combined facilitate a comprehensive analysis of the problem.

Table 3.1: Features of Qualitative and Quantitative research strategy
(Source: Neil, 2007; Miles and Huberman, 1994)

Qualitative	**Quantitative**
"All research ultimately has a qualitative grounding" - Donald Campbell	"There's no such thing as qualitative data. Everything is either 1 or 0" - Fred Kerlinger
The aim is a complete, detailed Description	The aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed
Researcher may only know roughly in advance what he/she is looking for	Researcher knows clearly in advance what he/she is looking for
The design emerges as the study unfolds	All aspects of the study are carefully designed before data is collected
Researcher is the data gathering Instrument	Researcher uses tools, such as questionnaires or equipment to collect numerical data
Data is in the form of words, pictures or Objects	Data is in the form of numbers and Statistics
Subjective - individuals interpretation of events is important ,e.g., uses participant observation, in-depth interviews etc.	Objective - seeks precise measurement and analysis of target concepts, e.g., uses surveys, questionnaires and so on
Qualitative data is more 'rich', time consuming, and less able to be generalized	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail
Researcher tends to become subjectively immersed in the subject matter	Researcher tends to remain objectively separated from the subject matter

The use of mixed methods can help to ameliorate any problem with either method. More so, questions left unanswered by one method can be answered by the other method. Notwithstanding, both methods are perceived to have some limitations since every empirical research approach has its advantages and disadvantages. For example, Brannen (2005) stressed that quantitative researchers perceive qualitative researchers as too context specific, with unrepresentative samples, unwarranted work claim, which is usually judged from the vantage point of statistical generalisation. He further stated that qualitative researchers view quantitative research as overly simplistic, decontextualized, reductionist in terms of its generalisations, and failing to capture the meaning that actors attach to their lives. However, to use both methods in a single research project is acceptable (Brannen, 2005) as the limitations of one can be balanced by the other to achieve the desired outcome.

3.6 Measurement validity and reliability

Measurement has been defined as a way of sorting numerals to aspects of objects or events according to rules (Oppenheim, 1992). Similarly, Wiersma (1991) argued that it is a process through which the kind and intensity of phenomenon is determined, and as an assignment of points for responses, or the summing of numerals assigned to responses to two or more items. This was reiterated by Leedy (1989) who described measurement as the quantifying of a phenomenon which results in a mathematical value.

In research, one good starting point is the measurement of the variables. Hence, a measurement has to be developed to measure the response of the participants in order to analyse it. Thus, measurement of variables is an integral part of any empirical research (Nassif, 2003). Once the level of measurement has been established, appropriate statistical tools can then be applied to produce the final Figures useful to draw the conclusions. Then, the accuracy of measures will show whether the measurement instrument is appropriate or not (Aaker *et al.,* 1995). A discussion of two aspects of measures which contribute to accuracy is provided below namely: reliability and validity.

3.6.1 Reliability

It is believed that the process of data collection can be complex and the collected data is also believed to yield some errors in the process. This means that there are some errors involved in any type of measurement. This error can be in the form of either a systematic bias or random error (Nassif, 2003). However, a researcher is expected to acquire a wide range of skills and techniques to assist them in minimising such errors so as to enable accurate reflection of the real results. If the measurement error is slight, reliability refers to the degree of accuracy of the estimate of the true score in a population of objects to be measured.

Relative to other measures of reliability, such as split-half or the odd-even, coefficient data is considered the most popular and superior technique for estimating internal consistency (Norusis, 1992). Internal consistency is a measure, which assesses the degree to which the item used is internally consistent with other items comprising the scale. Edgett (1991) argued that the items with a corrected item-total correlation score lower than 0.35 should be removed while items with score of 0.35 and higher could be retained.

Similarly, in recognising measurement errors, Litwin (1995) has identified two main types of errors namely:

- Random errors; and
- Measurement errors.

The random error is perceived to be unpredictable error which occurs in all research regardless of type. This type of error can be caused by different factors mainly affected by sampling techniques. However, in order to minimise the chances of occurrence of the random error, a researcher should select larger and more representative samples. Whilst larger samples have a direct implication on resources, the author opted for a larger sample on the strength of getting more reliable statistical results as larger samples allow a researcher to minimise the probability of a particular result falling below 5 per cent due to random error. As a result of this, the author accepts that errors can occur with any type of technique employed in social research since no instrument is perfect (Oppenheim, 1998), hence different statistical techniques will be used to test the same data in other to arrive at a conclusion.

3.6.2 Validity

Validity refers to the ability to accurately measure what it is supposed to be measured. There are several types of validity mainly categorised according to the purpose of the assessment and the kind of evidence on which the validity is to be judged. The most popular types of validity are content and construct validity (Nassif, 2003).

However, based on the knowledge that every statistical technique has its benefits based on how it is used, in this study, different statistical analysis was used to analyse the research data in order to validate the findings.

3.7 Literature review

The research commenced with an in-depth literature review to enable the author to capture a wide range of information needed for successful completion of the research. To enable in-depth understanding of the research area, the researcher decided to carry-out a thorough review of literature on previous work relating to risks associated with refurbishment schemes. The researcher will review relevant literature relating to the construction industry as well as refurbishment schemes. This process involves relevant source which have been identified as journals, conference papers from relevant proceedings, reports, text books, websites and many more relevant sources. Participation at conferences and workshops also provided essential source of knowledge relating to the research.

3.8 Semi-structured interviews

The semi-structured interviews were conducted with professionals with knowledge of refurbishment works (contractors and academics) to enable the author to uncover a wide range and relevant information which helped in designing the main study data collection instrument.

The author identified and selected randomly a sample of respondents from a list sourced through the UK contractors Group (UKCG) directory. Having established a target sample of respondents with the required expertise to comment on the research problem, the next step was to solicit the cooperation of the respondents for a face-to-face semi-structured interview. However, some of the respondents preferred a telephone interview due to their tight schedules while some due to their location, meant that the financial constraints did not permit a face-to-face interview.

Out of fifteen (15) refurbishment contractors contacted, six (6) declined participating in the study due to company policy while two (2) declined a week before the interview date, due to heavy work load. However, the cooperation of seven refurbishment experts was gained and the semi-structured interviews were conducted and it took place as scheduled and lasted for a minimum of 56 minutes and a maximum of one hour 18 minutes. All the interviews were conducted during August and September 2012. The author has chosen turnover as a measure of size because of the ease in getting this data. However, the use of turnover as a measure of size is not entirely satisfactory, as it suffers from the problem of possible imbalance of yearly distribution of the assets. Notwithstanding, the author recognises the view of Newbould and Wilson (1977) in Egbu (1994) who concluded that, the choice of size measure can be flexible and it is not very much considered in practice, which measure is opted for, as most measures are highly correlated with each other.

The participating refurbishment organisations for this research span across different contractor organisations with offices spread across the UK and abroad. However, the offices of the companies visited for interviews were within the Northwest of England due to time and financial constraints.

3.9 Rationale for the choice of semi-structured interview approach

There are three main types of interview techniques namely: structured, semi structured and un-structured interviews. However, in the present research, the author used the semi-structured interviews. Indeed, the choice of this technique is largely dictated by the research objectives, the nature of the information required as well as finance and time constraints. The reasons for semi-structured interviews are stated below:

- Semi-structured interviews allow for in-depth discussions of areas of concern. In so doing, new areas not already thought of, could emerge. It gives the researcher opportunity to obtain more relevant information without deviating from the topic;

- Semi-structured interviews allow the researcher to ask further questions to clarify ambiguity in the response immediately, an opportunity which is not available when using the questionnaire approach.

A refurbishment expert in the context of this study is a person employed by a person and/or an organisation to carry-out or manage a certain task to enable the achievement of desired outcomes on a particular refurbishment project.

3.10 Questionnaire design

As a method of data collection, a plethora of literature abounds (Farrell, 2011; Naoum, 2008; Oppenheim, 1996) with many sources of advice on questionnaire design. Fink (1995) and Litwin (1995) provide comprehensive advice on the whole process of questionnaire design and layout. Information gleaned from these authors was found to be useful. In addition, some guidelines on questionnaire design from Bryman and Cramer (1999) and Fink (1995) was taken into consideration by way of looking at the following issues they highlighted:

1. Defining the study objectives eloquently;
2. Identifying the suitability of the population relative to main objectives;
3. Knowledge of the most appropriate sampling methods for the study;
4. Probability of non-response; and
5. Wording of the questionnaire.

Therefore, the questionnaire was designed in line with the aim and objectives of the research and took into account important issues unveiled at the case study stage. The questionnaire attempted to translate the research objectives into specific questions and also to cover all the information relevant to refurbishment practices as well as the proposed framework. The questionnaire technique is claimed by different researchers to provide an opportunity to reach a large proportion of a population and also attain a statistically significant data hence, the adoption of stratification sampling in this study. The questionnaire was designed into different sections with each section covering a specific heading. In this study, the questions were developed following the initial semi-structured interviews with practitioners involved in refurbishment, and a thorough review of literature in the areas relating to risk and refurbishment. The summary of the questions is presented below. The questionnaire format is supplied in the appendix section of this document as appendix B.

3.10.1 Section one: General information

This section contains some multiple choice questions and is aimed at understanding some important information related to the participants such as job title, gender, professional discipline, level of industry experience, the type of organisation he/she works for, size of organisation, the scale of refurbishment work the organisation carried out, as well as the participant's understanding of the research area.

3.10.2 Section two: Refurbishment specific questions

This section is aimed at understanding the general characteristics of refurbishment schemes which include the factors which contribute to quality of refurbishment works, the barriers to achieving quality, the participant's level of satisfaction with projects undertaken, characteristics of refurbishment schemes, the risks, uncertainties and technical challenges associated with the schemes as well as the degree of difficulty of refurbishment works.

3.10.3 Section three: Additional comments

The last part of the questionnaire also allows for further comments from respondents in relation to any topic that has not been covered by the questionnaire and which may help in achieving the research objectives.

3.11 Justification for the choice of questionnaire

In meeting the objectives of the study, the questionnaires technique for data collection was adopted for two main reasons namely:

1. With the technique, it is possible capture a wide range of samples such as those of this study which were identified as principal contractors, specialist contractors and sub-contractors in the building refurbishment sector. Nauom (2008) endorsed the questionnaires technique as one which offers relatively high validity of results because of their wide geographic coverage and it is more suited to assembling a mass of information at minimum expense. This view is also shared by Farrell (2011) who claimed that a questionnaire is a convenient way of getting data and also quick to administer. He further argued that questionnaires are used to measure something within a defined population and a careful selection of the population must take place. In addition, Heywood (1994) claimed that questionnaire provides the opportunity to analyse data using various statistical techniques;

2. As a method of data collection in social research, the questionnaire is relatively cheap, simple and easy to administer. Both Heywood (1994) and Egbu (1994) endorsed the questionnaire as one that is capable of providing the opportunity to analyse data through a variety of statistical techniques.

However, the questionnaire as a method of data collection has received criticisms from a number of quarters (Kangwa, 2004). The technique is widely acclaimed to suffer from poor response rates, response bias, misrepresentation of meaning due to wording of questions, as well as the inability of the investigator to verify the information provided by the respondents. Hence, Naoum (2008) suggests that it is only suitable for simple and straightforward questions which can be answered with the aid of easy instruction and definitions.

Other authors have also suggested that the shortcomings of the questionnaire techniques can be overcome by utilising a variety of technique (Bryman and Cramer, 1999; Fink, 1995). In the light of this, Bryman and Cramer (1999) have argued that the most important factor in ensuring high response rates is whether the respondents perceived the survey as important or current to them. This view is in keeping with Fink (1995) who suggests that a high response rate can be attained if the respondent is knowledgeable about the issues covered by the survey. The study will ensure that the questionnaires reach refurbishment practitioners' who have relevant refurbishment experience capable of achieving the objectives of the study. Another way is to ensure that the content of the questionnaire is understandable to all the research participants.

3.12 Piloting the questionnaire

Prior to sending out the questionnaire to research participants, a pilot study was conducted. The piloting is an important part of the process in order to ascertain whether the questions provided the much needed data. In other words, it was conducted to test both the validity and reliability of the main research instrument. According to Farrell (2011) validity is defined as 'how well does a questionnaire really measure what it purports to measure'. This is required to test the efficacy of the research outcome. It was anticipated that through the pilot study, more relevant information could be gathered which eventually proved useful and assisted the author to make necessary corrections in designing the final research questionnaires. More so, the piloting was important so that important issues relevant to meeting the objectives of the study were not omitted. The research participants were asked to critically evaluate the questionnaire to enable the achievement of the followings objectives:

- Examine the adequacy of the questions provided;
- Highlight areas of ambiguity and suggest possible remedies;

- Highlight questions that may not be relevant to the research objectives;
- Suggest additional questions that may be relevant;
- Evaluate the length of the questionnaire; and
- Determine the time taken to complete the questionnaire.

Literature suggests that piloting a questionnaire for improvement should be carried-out among different groups of people which may include one's colleagues as well as potential users of the anticipated data and information. The pilot process helped in understanding areas of ambiguities in the questionnaire as some participants believed that the content captured the objectives of the study while others believed that it could be improved to cover further specific areas.

Therefore, participants who perceived the questionnaire as needing improvement were asked whether it could be possible to contact them again after making correction to further discuss the issues and areas of ambiguities that they had raised and/or whether the correction was in order. Perhaps as expected, all the participants who highlighted areas of improvement agreed to provide follow-up meetings in that regard. As highlighted by participants, some questions were believed to be double barrelled questions which needed to be separated into single questions while other questions were not perceived as being relevant to the research objectives hence, should be deleted. Another question needing correction was in section two: Factors which contribute to risks and technical challenges as some participants perceived the content in this section as too many.

In the final analysis, this initiative proved beneficial as the research participants' comments were given much thought and considered fully. The comments and suggestions assisted in incorporating some of the concerns raised thus corrections were made to the final questionnaire. Interestingly, during the follow-up meetings with those participants who highlighted areas of ambiguity it appears that the final version of the questionnaires was endorsed as the participants believed that it was more organised, structured, unambiguous and straight forward.

After the refinement of the questionnaire, the next step was to send it to research participants who were earlier identified as presented in Figure 3.1. This was anticipated to allow time for respondents to complete the questionnaires at their convenience. The process involved using the online platform such as the Google document system of collecting data, as well as direct message through email to respondents with the questionnaire attached as a word file and also personal construction site visits.

3.13 Questionnaire administration

The questionnaire distribution was accompanied by a covering letter which contained a brief description of the objectives of the research, the sponsoring institution, an introductory statement and basic definitions of terms and the benefits of the study to the industry. The covering letter was written on the University of Bolton letter head. These methods were duly recognised, and to reiterate the name of the institution as a sponsor to the research, with the effect of increasing response rate (Fink, 1995). The returned questionnaires were 161 in total, although the valid copies used (fully filled-in questionnaires) were 133 in total.

3.14 Data analysis and presentation techniques

The methods to be adopted for analysis of the questionnaire depends on the nature and complexity of the research questions adapted to achieve the objectives of the study. However, in analysing and presenting the collected data, several methods are suitable.

For the present study, the use of Microsoft excel was utilised to enable statistical analysis to be carried-out using various statistical tests to consider the issues the research attempts to investigate. These are: The sources of risk and uncertainty associated with refurbishment processes, the probability of the risk occurrence as well as the impact of the risk and/or uncertainty on refurbishment works.

Furthermore, some statistical tests will be employed in the testing of hypotheses. These include: the Kruskal-Wallis test and Spearman's ($r_{s)}$ rank correlation coefficient (Tabachnick and Fidell, 1989) and Mann-Whitney test of independence (Kangwa, 2004). The statistical tests employed for testing the study hypotheses were set at a ninety five per cent level of significance confidence level.

The rationale for selecting the tests was based on the principle that given the data generated is being non-parametric; the associated statistical tests do not require the assumption of homogeneity of variance. Both Fink, (1995) and Bryman and Cramer (1999) data advised that this kind of data is best manipulated by comparing medians rather than means. Furthermore, where the data sets have one or more outliers, their influence is negated by adoption of the 'mode' value implying the most typical or recurring value in any given sets of results..

Throughout this study, Microsoft Excel is adopted for data manipulation and tools such as scatterplots and radar graphs will help in establishing the hierarchical clustering of factors. Furthermore, Excel proffers a friendlier data handling environment and reliability of its output will enable the study to generate inferences and tests of hypotheses adding to the validity of the study outcomes. With these benefits in mind, the use of SPSS and Factor analysis technique and outputs were discounted in order to minimise the volume of work.

3.15 Data coding process

At the data collection stage, returned questionnaires were checked to determine the number returned and those that are suitable for analysis. Coding was carried-out at the same time as data collection. Coding is a system of writing in which numbers or letters are used to condense data. Each response was marked with its questionnaire code number, to make it easy to retrieve, whenever information about a respondent was needed which enabled the data entry process to be achieved.

In analysing the data, declarative statements and a list of response categories of up to five-point scales were used after Likert (1932), which are both nominal and ordinal data in character. This includes using terms as such as ‘Male’ or ‘Female’ which being categorical or nominal data would then be represented during manipulation as 1 for ‘Male’ and 2 for ‘Female’. The Nominal scales are thus used for labelling variables to aid with description without attributing any quantitative value. Furthermore, where ordinal data had to collected such as on a Likert scale where respondents are prompted to indicate their position on a continuum such as: 4 = strongly agree; 3 = agree; 2 = undecided; 1 = disagree and 0 = strongly disagree, this approach enabled the study to gather opinions on important study objectives were it would be impossible to understand how different variables differ from each other without the use of a 0 to 4 scale. Past the questionnaire administration stage, the Likert scale was used to extrapolate and make comparison between various parameters of the population sample. In all the analysis chapters, it formed the basis for evaluating different hypothetical variables and any extreme preferences among the respondents to a given issue being investigated.

Strict interpretation of the rules of measurement requires that these types of data generated by such scales be treated as ordinal data (Hoxley, 2008). However, the best way to determine *central tendency* on a set of ordinal data is to use the mode or median (Noum, 2008). However, Purplemaths (2013) have provided a cautionary approach in stating that 'if the data is set perfectly normal, the mean median, and mode are equally to each other to handle normally distributed data'. With this in mind, the study opted to use the mean value. According to BBC (2014) the mean is the total of the numbers divided by how many numbers there are. The mode is the value that appears the most while the median is the middle value in any group of numbers.

Given the nature of questionnaire data, there is always bound to be missing data; however, from the onset, a strict criterion was set-up to aid the interpretation of the rules of measurement: where 5% or less of data is missing the missing values would be represented by the calculated mode. Any questionnaires with more than 5% data missing were discarded.

However, Weisberg *et al*., (1996) in Hoxley (2008) argue that provided the intervals between the various possible responses are approximately equal, such data can be regarded as interval data, which of course enables more sophisticated statistical techniques to be undertaken. Interval scales are numeric scales in which we know not only the order, but also the exact differences between the values. This is an important issue that needs to be explicitly addressed by any researcher who treats attitude scale data as interval data (Hoxley, 2008). This study did not collect any data which falls under this criterion and therefore any meaningful manipulations are based on non-parametric techniques.

3.16 The variables data collection

The data collection took into account the following factors:

- Physical factors such as designs;

- Organisational and social factors relating to job variation and cooperation between project team members;
- Cultural climate relating to method of dealing with risks and uncertainty;
- Safety aspects relating to training and knowledge of health and safety; and
- The dimension of risk such as fire and weather conditions etc.

3.17 Research design and study sample characteristics

The category of refurbishment contractors who participated in the research includes principal contractors, specialist contractors as well as sub-contractors. The scale of refurbishment work undertaken by the participants organisations are: minor refurbishment, medium refurbishment and major refurbishment works. The procedure for identifying the participants and how the questionnaires were distributed is described and depicted in section 3.3. However, the method of distribution of the questionnaires was through emails and personal site visit.

Table 3.2 category of refurbishment contractors and valid questionnaires

Category of refurbishment contractors	**Number of questionnaires distributed in three regions**	**Total number of questionnaires received**	**Number of valid questionnaires**
Principal contractors	150	88	80
Specialist contractors	150	29	19
Sub-contractors	150	44	34
	450	**161**	**133**

It can be noted that there was a slight disappointing low response of the research questionnaires. Perhaps, as expected 50% response rate may be difficult to achieve as Fellows and Liu (1997) argued that the expected response rate of questionnaires is 30%. This may be connected to the nature of the industry and also the sensitivity of certain information to some organisations. However, despite the response to distribution ratio being lower than expected, the total response (as shown in Figure 3.3) was numerically greater than the originally desired 30%, and as such was considered more than sufficient to ensure a detailed analysis.

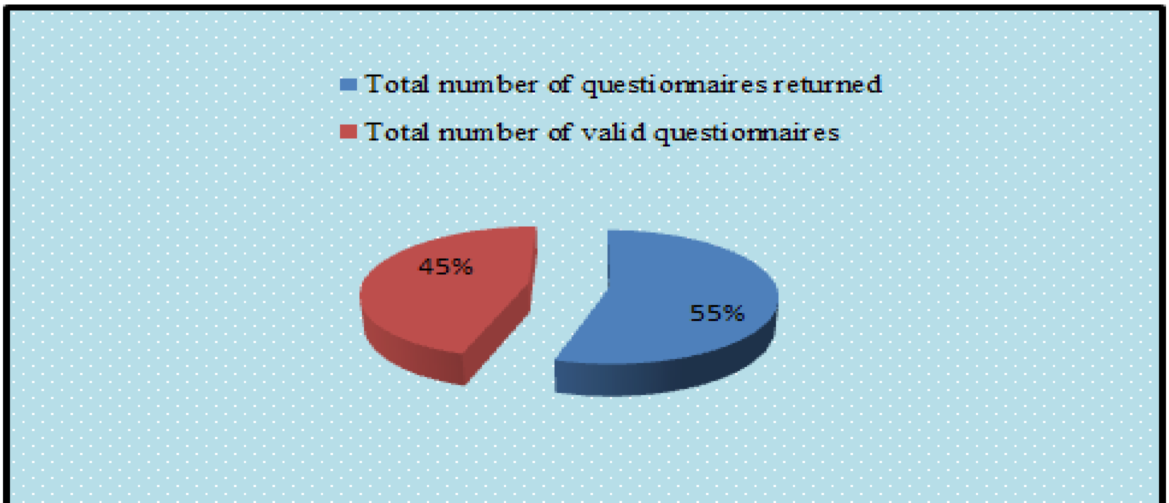


Figure 3.3: Percentage ratio of returned questionnaires against valid copies

Further, the variables measured by the questionnaire are divided into different sections. Section one contains eight questions aimed at understanding personal and organisational level information. Section two contains refurbishment specific questions aimed at investigating the participants' views and/or opinions on the research problem. For example, questions 9 to 14 focused on investigating typical characteristics of refurbishment works, factors which contribute to high quality refurbishment works, barriers to achieving high quality refurbishment works, factors which contribute to risks and technical challenges, satisfaction with implementation of refurbishment works and opportunity for refurbishment schemes.

Finally, section three focused on additional comments from research participants. This is aimed at getting further information on issues which the questionnaire did not cover and which may help in achieving the objectives of the research. Although the majority of the research participants did not respond to this section by not completing the section, a few of the comments were considered not essential or relevant to the analysis.

3.18 Section one: General information

This section of the questionnaire consists of eight questions; the first question was about the participant's job title being optional while the remaining seven are multiple choice questions. This section of the questionnaire is also considered to be an important part of the questionnaire as it provides some vital information about the research participants. Table 3.3 shows a cross tabulation of some demographic details of the research participants which includes the gender, area of specialism as well as their respective organisations and/or scale of refurbishment works of participants' organisations. The data collected were analysed statistically and summarized by calculating percentages, means, standard deviations and ranks.

Table: 3.3: Cross tabulation of percentage of Area of specialism (AOS) by organisation designation and gender

	Principal contractor		Sub Contractor		Specialist contractor		
Specialization	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Total*
AOS1	8	2	1	3	1	1	16
AOS2	17	6	8	2	4	1	38
AOS3	7	1	6	1	2	0	17
AOS4	16	1	4	0	2	2	25
AOS5	15	7	8	1	5	1	37
Total	**63**	**17**	**27**	**7**	**14**	**5**	133

Percentages

	Principal contractor		Sub Contractor		Specialist contractor		
Specialization	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Total*
AOS1	6.0	1.5	0.8	2.3	0.8	0.8	12.0
AOS2	12.8	4.5	6.0	1.5	3.0	0.8	28.6
AOS3	5.3	0.8	4.5	0.8	1.5	0.0	12.8
AOS4	12.0	0.8	3.0	0.0	1.5	1.5	18.8
AOS5	11.3	5.3	6.0	0.8	3.8	0.8	27.8
Total	47.4	12.8	20.3	5.3	10.5	3.8	100.0

KEY:	
AOS1	Architects
AOS2	QS
AOS3	Building Surveyors
AOS4	P/managers
AOS5	C/managers

3.18.1 Job title

Under this heading, the research participants were asked to provide title of their job within the organisation they work for. However, this question was optional. Perhaps, contrary to expectations the majority of the research participants completed this section. The research response indicates that almost all of the participants (129 out of 133) provided their job roles.

3.18.2 Research participant's gender

This question provides the research with the gender of the research participants, the research results suggests that 78% of the participants were male while 22% of the participants were female as shown in Table 3.4 and depicted in Figure 3.4 respectively. This confirms that there are more male professionals in the industry.

Table 3.4 Research participant’s gender

Description	Frequency (No of response)	Percentage (%)
Research participants who are male	104	78.1
Research participants who are female	29	21.9
	N = 133	

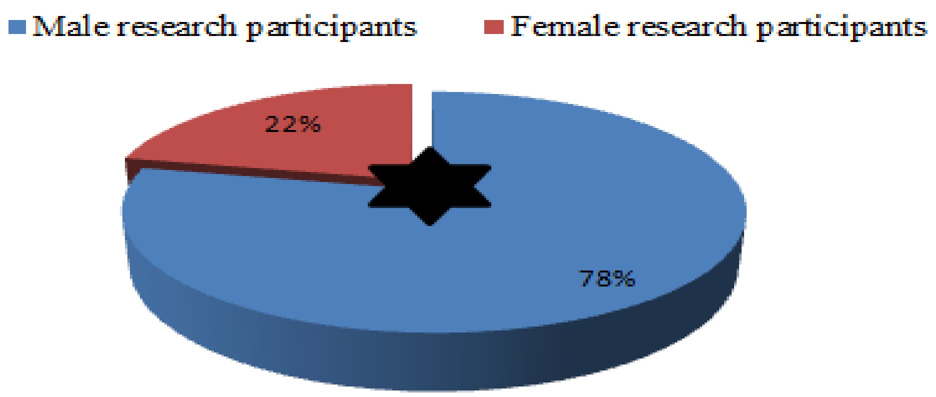


Figure 3.4: Research participants gender

3.18.3 Research participant’s professional disciplines

Within each contractor organisations contacted for the research, there were responses received from various professionals which include Architects, Quantity Surveyors, Building Surveyors, Project Managers as well as Construction Managers.

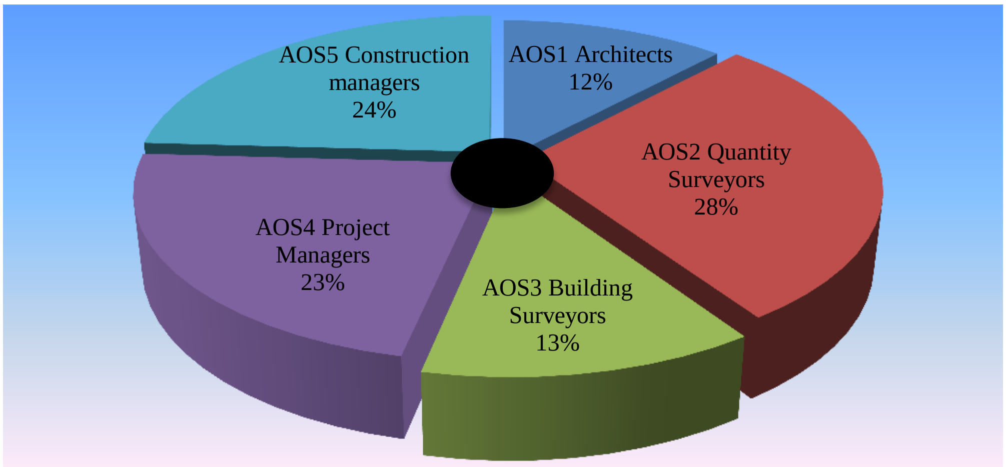


Figure 3.5: Research participants' sample by professional discipline

From the research findings based on the analysis of all valid questionnaires, research participants provided their professional disciplines. The research results indicate that 12% of the research participants were architects, 28% quantity surveyors, 13% building surveyors, 23% project managers while 24% were construction managers. Detailed information of the number of responses received from the research participants in terms of professional discipline is shown in Table 3.3 and Table 3.5 respectively and depicted in Figure 3.5.

3.18.4 Research participant's professional experience

Further filtering of the results suggests that about 86% of the participants have undertaken works of different types ranging from minor refurbishment, medium refurbishment and major refurbishment works as shown in figure 3.6. In terms of work experience, perhaps as expected, the results suggests that majority of the research participants have adequate experience required to provide information which could help in achieving the research objectives.

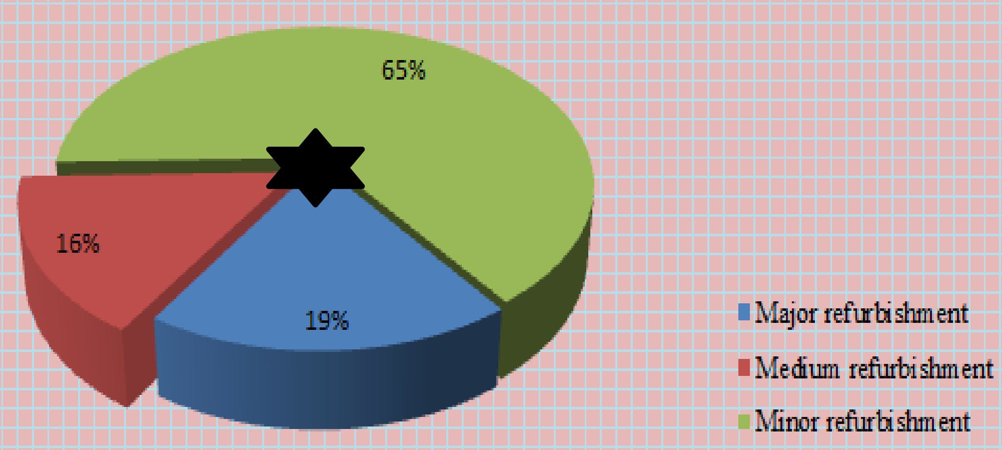


Figure 3.6: Percentage of scale of refurbishment projects undertaken by participants organisations

Table 3.5: Cross tabulation of ratio of scale of Refurbishment projects by refurbishment experience, organisation and professional designations																			
Professional	Major Refurbishment Projects						Medium Refurbishment Projects						Minor Refurbishment Projects						
	0 - 15yrs Experience			16yrs+ Experience			0 - 15yrs Experience			16yrs+ Experience			0 - 15yrs Experience			16yrs+ Expereince			
Discipline	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	Total
AOS1	0	2	0	0	0	1	2	0	0	0	1	0	7	1	1	1	0	0	16
AOS2	3	2	4	0	0	0	2	1	1	0	1	0	12	5	0	6	1	0	38
AOS3	0	4	1	0	0	0	1	0	0	0	0	0	5	1	0	4	1	0	17
AOS4	1	0	2	1	0	0	0	3	0	0	0	0	8	3	0	5	1	1	25
AOS5	0	1	3	0	0	0	1	2	1	2	2	1	6	1	2	13	1	1	37
Total	4	9	10	1	0	1	6	6	2	2	4	1	38	11	3	29	4	2	133
Percentages																			
Professional	Major Refurbishment Projects						Medium Refurbishment Projects						Minor Refurbishment Projects						
	0 - 15yrs Expereince			16yrs+ Expereince			0 - 15yrs Expereince			16yrs+ Expereince			0 - 15yrs Expereince			16yrs+ Expereince			
Displine	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	PC	SubC	SP	Total
AOS1	0.0	1.5	0.0	0.0	0.0	0.75	1.5	0.0	0.0	0.0	0.8	0	5.26	0.8	0.8	0.8	0.0	0	12.03
AOS2	2.3	1.5	3.0	0.0	0.0	0	1.5	0.8	0.8	0.0	0.8	0	9.02	3.8	0.0	4.5	0.8	0	28.57
AOS3	0.0	3.0	0.8	0.0	0.0	0	0.8	0.0	0.0	0.0	0.0	0	3.76	0.8	0.0	3.0	0.8	0	12.78
AOS4	0.8	0.0	1.5	0.8	0.0	0	0.0	2.3	0.0	0.0	0.0	0	6.02	2.3	0.0	3.8	0.8	0.75	18.80
AOS5	0.0	0.8	2.3	0.0	0.0	0	0.8	1.5	0.8	1.5	1.5	0.75	4.51	0.8	1.5	9.8	0.8	0.75	27.82
Total	3.01	6.77	7.52	0.75	0.00	0.75	4.51	4.51	1.50	1.50	3.01	0.75	28.57	8.27	2.26	21.80	3.01	1.50	
% Total						18.80						15.79						65.41	100

AOS1 = Architects; AOS2 = Quantity Surveyors; AOS3 = Building Surveyors; AOS4 = Project Managers; AOS5 = Construction Managers

The years of participants' experience were classified into five categories as follows: 0 – 5 years, 6 – 11 years, 11 to 15 years, 16 to 20 years as well as over 21 years. Although for easy understanding of this category, the years of experience was grouped into two categories. The first three groups (0 – 5 years, 6 – 11 years and 11 to 15 years) were grouped under 0 – 15years experience while the last two groups (16 to 20 years and those with experience over 21 years) were grouped under 16 years and above experience.

In general, it appears that 66.92% of the research participants have building refurbishment experience between 0 – 15 years while about 33.08% of the research participants have refurbishment experience of over 16 years. The research finding also suggests that out of those participants with experience ranging from 0 – 15 years, 35% have experience between 11 to 15 years. The results suggest that quite a number of the research participants (68%) have refurbishment experience of over ten years and this has contributed very positively to the reliability of the gathered data.

3.18.5 Research participant's type of organisation

This question was introduced to identify the types of contractor organisation the participants work for as there are different categories of refurbishment contractors and each have differing projects. In order to achieve the research aim and objectives, questionnaires were distributed to professionals within the UK construction industry as research participants. An understanding of the research population was deemed to be vital to achieving the main research aim and objectives, as it was understood that the analysis of the results and ultimately the success of the entire study as a whole, are intrinsically linked to the profile of the research participants.

For example, if the research data was gathered from non-refurbishment contractors with minimal understanding and/or less experience in refurbishment projects, the research findings may then portray views which could be baseless and not reporting the true nature of the research problems.

3.18.6 Number of employees within participant's organisations

This question was introduced to enable the research to identify the size of the contractor organisation. This is in order to ensure that the research objectives are achieved; the size of organisation in terms of number of employees and scale of work undertaken must be identified and matched with the appropriate refurbishment projects.

The research finding indicates that the research participants belong to different types of organisations in terms of size. A majority of the participants belong to organisations with employees ranging from fifty to hundreds. In actual Figures, 45% of research participant's work for organisation with employees ranging from 11 to 50, 21% of participants work for organisations with employees ranging from 51 and 100, 23% of the research participants work for organisations with employees over hundred. However, only 11% of the participants belong to organisations with fewer than 10 employees. On the basis of the above results, the research participant organisations are reasonably in the range of medium to large size organisations which greatly benefits the study due to the range of experience of the participants.

The size of organisation may be defined either by using turn over or number of employees within an organisation. However, this study chose number of employees as a measure of organisational size. A range of criteria have been used by different authors to define size of organisations, for example: Atkins and Lowe (1996) found that in the UK and Australia, number of employees was used in 34 out of 50 studies as a measure of defining organisational size. However, variation exists in different countries relating to the threshold figures. For example, in the United States, the definition for small business ranges from 100 – 500 employees. The definition of small businesses by the Australian Bureau of Statistics (1999) is fewer than 100 employees in the manufacturing sector while in the construction and retail sector, requires fewer than 20 employees. Therefore, this study defines small organisation as having fewer than 20 employees, medium size organisation as having over 50 employees while large organisations are those having over 100 employees.

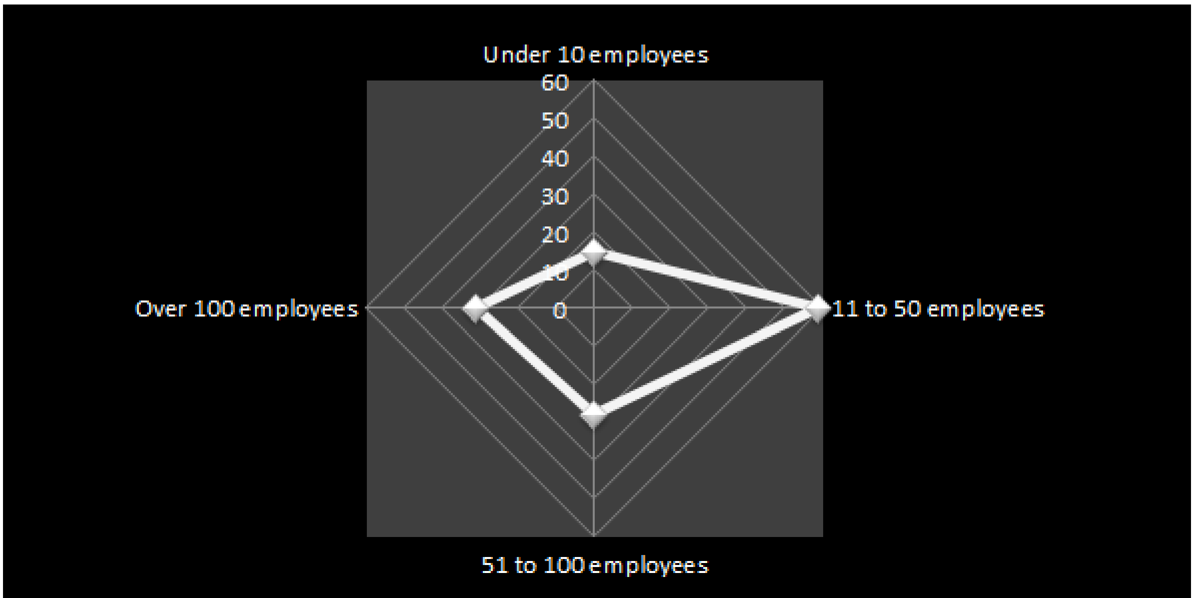


Figure 3.7: Size of participants organisations

3.18.7 Scale of refurbishment projects

It was important to understand the scale of works undertaken by participants organisations within the refurbishment sector. The research results indicates that 35% of the research participants regarded their projects as minor with respect to project complexity, also 35% of the research participants regarded their projects as medium with respect to project complexity, whereas 30% of the research participants considered their projects as major refurbishment projects with respect to project complexity.

3.18.8 Participants knowledge of the concept of risk in refurbishment

This question was introduced to investigate whether the research participants have knowledge and understanding of the concept of risk and uncertainty in refurbishment schemes. The research findings suggest that upto 89% of the participants appears to be very confident with the research area as shown in Table 3.6. As a result, understanding of the risk and uncertainty therefore, ensured that more probing questions in the research could proceed with a reasonable degree of confidence.

Table 3.6: Cross tabulation of Area of specialism (AOS) by refurbishment experience

	Predisposition to Risk-Aversion				
	VC	**C**	**Pc**	**unC**	
Specialization	***PRA1***	***PRA2***	***PRA3***	***PRA4***	***Total***
AOS1	5	2	8	1	16
AOS2	10	8	15	5	38
AOS3	6	2	6	3	17
AOS4	9	6	13	2	30
AOS5	15	6	8	3	32
Total	**45**	**24**	**50**	**14**	133

Percentages

	Predisposition to Risk-Aversion				
	VC	C	Pc	unC	
Specialization	***PRA1***	***PRA2***	***PRA3***	***PRA4***	***Total***
AOS1	3.8	1.5	6.0	0.8	12.0
AOS2	7.5	6.0	11.3	3.8	28.6
AOS3	4.5	1.5	4.5	2.3	12.8
AOS4	6.8	4.5	9.8	1.5	22.6
AOS5	11.3	4.5	6.0	2.3	24.1
Total	33.8	18.0	37.6	10.5	100.0

Abbreviation	**Description**
AOS1	Architects
AOS2	QS
AOS3	Building Surveyors
AOS4	Project Managers
AOS5	C/managers

3.19 Descriptive statistical analysis

This section examines the statistical analysis of quantitative data generated from section two of the questionnaire which investigated variables related to risks and uncertainties in refurbishment projects. The analysis of the quantitative data in this section is segregated into five headings aimed at understanding what may be considered as:

- Characteristics of refurbishment work;
- Factors which contribute to quality of refurbishment work;
- Barriers to achieving high quality refurbishment work;
- Factors which contribute to risk and technical challenges;
- Satisfaction with the implementation of refurbishment work.

However, the different headings of the questionnaire as outlined above were directed towards understanding the most important issues under each heading as they relate to refurbishment works. For example, question 9 refers to the typical characteristics of building refurbishment schemes. Research participants were asked to indicate the extent to which they agree or disagree with the statements provided as they relate to the characteristics of refurbishment projects. For example, whether they agree or disagree that a refurbishment project contains more risks, uncertainties and technical challenges than an equivalent new-build project, whether refurbishment requires more expertise to manage than an equivalent new-build project, whether it is more complex to design and coordinate, whether it poses more challenges in programming site activities, whether it contains more economic uncertainties, whether it is prone to more accidents on site than an equivalent new-build project, whether it requires more collaboration between project partners, whether there are more challenges in occupied buildings than unoccupied buildings, and finally, whether there are more site discoveries as the project progresses.

A Likert scale ranging from 0 – 4 and Strongly agree to Strongly disagree was provided to guide the participants to indicate which option best fits their answer to the questions as shown in Table 3.7:

Table 3.7: Likert Scale Coding

Response	**Code**
Strongly agree	4
Agree	3
Undecided	2
Disagree	1
Strongly disagree	0

The foregoing procedure was used in the other 4 headings as highlighted above. The Likert scale was also used in all the other sections of the analysis (see questionnaire in appendices section).

3.20 Summary

This chapter presented a detailed methodology adopted for the collection of data for this study. The methodology was informed by comparing approaches of other studies and more so literature relating to refurbishment risk and uncertainty. The main responses reported herewith are derived from a structured questionnaire completed by industry practitioners working for contracting organisations. These were organisations whose main activity is in the refurbishment sector. In total 133 refurbishment practitioners were captured using a stratified random method and of which 80 (60%) of practitioners worked under Principal Contractors, whereas 19 (14%) were employed directly by Specialist Subcontractors while the remaining 34 (26%) were employed by General Subcontractors. A cross-tabulation analysis on gender a wide divide in that of the 133 respondents captured, 29 (22%) were female practitioners and 104 (78%) were male practitioners. The study also managed to capture a fairly spread type of professions relative to trade background, namely: 16 (12%) came from a Design/Architectural background; 38 (29%) were Quantity Surveyors; 17 (13%) were Building Surveyors and 25 (19%) were Project Managers while the remaining 37 (28%) came from a Construction Management background. The characteristic of the practitioners and scope of refurbishment works they undertake were s also defined under five areas, namely:

- Characteristics of refurbishment work
- Factors which contribute to quality of refurbishment work
- Barriers to achieving high quality refurbishment work
- Factors which contribute to risk and technical challenges
- Satisfaction with the implementation of refurbishment work.

All the questions relating to the five areas were presented to the respondents on a Likert scale based on continuum where 4 is the highest score recorded and 0 as the lowest score. Similarly, the analysis chapters that follow comply with the same order, and so is the reporting of the key findings from each respective area.

Chapter Four

Characteristics of refurbishment schemes (ChaRef)

4.1 Introduction

The aim of this chapter is to present the quantitative data analysis based on information provided by the research participants in response to the question to define the factors that best describe the Characteristics of Refurbishment Schemes, hereafter abbreviated as – ChaRef.

The study intends to establish what defines refurbishment projects by asking practitioners to identify them in order of their relevance. This information is relevant to understanding the typical issues associated with refurbishment projects. This would be of value to architects, contractors, clients and professionals associated with the refurbishment sector. The terms by which refurbishment projects can be defined will determine the parameters for design, scheduling of activities, cost evaluations and management of health and safety. These areas sometimes need to be redefined to inform project managers how they go about managing various aspects of refurbishment and more importantly that adequate resource can be put in place to mitigate their effects. It is this hierarchical nature of risks associated with refurbishment projects that is the core objective of this study. In order to establish what they are or what their effects are, practitioners within the refurbishment sector were targeted and it is believed that establishing the hierarchical nature of risks would benefit practitioners within the refurbishment sector and the construction industry as a whole.

The natural starting point should be to define the characteristics of refurbishment projects and then to establish which factors are perceived to contribute to achieving high quality refurbishment works and with such knowledge to understand what prevents maintaining such high quality standard.

The chapter will therefore present the findings on refurbishment characteristics, in order to explore those important areas that might help in defining the attributes, quality determining factors and barriers to refurbishment. Statistical techniques are employed to help with the analysis. The format of presentation of the data follows the order of formulating the hypothesis, independent variables and dependent variables. This approach illuminates the data handling, analysis and interpretation of the follow-on findings. The significance of the findings and how they add to the overarching objective of establishing the hierarchical nature of refurbishment risks will be underscored by the logical conclusions and summary to each chapter.

The key independent variables utilised in this study are:

- Experience of practitioners: number of years they have worked in the refurbishment sector;
- Professional designation: Identifies area of specialism as: Architects; Quantity Surveyors, Building Surveyors, Project Managers and Construction Managers;
- Type of Contractor designation, namely: Principal Contractor (PC); Subcontractor-(SubC); Specialist Contractor (SpC);
- Scale of refurbishment work;
- Predisposition to Risk (Priskaver);
- Size of firm; and
- Gender.

Some of the above independent variables (e.g. workload designation) are used mainly to provide descriptive statistics to define the practitioners while others are used as exploration variables, eg. level of experience both at aggregate level and when respondents are split on the basis of years worked in the refurbishment sector < or > 15years.

In the UK, the agenda for refurbishment is driven by many factors most important of which is the desire for improved quality of thermal comfort especially in very old buildings. Indeed, from the public sector perspective, there is growing pressure to meet current targets for zero carbon buildings by improving aged buildings to current standards. The situation is one of continuing national debate about improving the indoor quality of existing buildings for the comfort of the users. As a consequence, the existing building stock is classified as outdated, obsolete and inefficient thus, clearly indicating an opportunity for refurbishing large amounts of building stock to current standards (Gorse and Highfield, 2009).

The cost of heating buildings is an on-going concern for society as expressed in the Climate Change Act (2008). Thus, Gorse and Highfield (2009) and GVAGrimley (2010) have emphasised the need to understand the various aspects of refurbishment, including finding cheaper retrofitting ways of reducing the energy use of buildings as well as identifying the skills for the future managers.

4.2 Nature and characteristics of refurbishment schemes

Many authors across the globe have noted the increasing recognition of the importance of refurbishment. For example, refurbishment is generally characterised to be of higher risk, more complex and needs greater coordination than new-build projects (Lee and Egbu, 2005). Another distinguishing characteristic of refurbishment projects that is completely different from new-build projects, and apart from the usual complexity, is the existence of the building asset (CIRIA, 1994). This means that the building already exists as against new-build projects which require the building to be constructed. Although, in the process of refurbishment, the existing building may require redesign, conversion and/or complete remodelling to serve a new purpose that is completely different from the previous function.

Additionally, refurbishment projects also allow or permit occupancy and/or the use of a building during the project because the building already exists and was most likely in use before the initiation of the refurbishment project. In many instances, disruption to production or the workplace during refurbishment works is considered a major issue as very often refurbishment involves working on confined sites with restricted access (especially in inner city centres), sometimes with abutting building. However, Corus (2009) opined that in many cases the business operation may continue within the building while the refurbishment works are undertaken, although a certain level of disruption will occur during any construction work. However, when refurbishment works are performed within property that has continuing occupation, the effect on overall costs, work programme and safety issues increases disproportionately as against those that would normally be envisaged in an empty property (Reyers and Mansfield, 2001).

Another major problem with refurbishment work is the difficulty in determining the cost of works before construction work starts. This difficulty of producing bills of quantities is a challenge. As a consequence, the majority of refurbishment works have to be priced using drawings and specification. This means that each tendering contractor will interpret the documents in a different way, which can also lead to large differences in tender bids and can affect competition whereas in new-build work competitive prices be more easily achieved.

There is also a need to set aside a significant amount of money for any contingencies that may arise during the works as it is clear that there is far greater tendency for refurbishment projects to be completed over the tender price than new-build projects. Furthermore, due to the nature of refurbishment, different management processes may be required to be implemented in order to deal with problems which are peculiar to dealing with an existing building. CIRIA (1994) highlighted some differences in construction processes peculiar to refurbishment works as follows:

- The approach to design must focus on detection and analysis;
- Discovery of unforeseen conditions is possible for almost all the construction period;
- Data on the asset may be difficult to locate and may require several different types of investigation;
- Interaction between the old building, temporary works, existing services, and new construction will affect construction methods, planning, and programming throughout most of the construction period, as will interaction with neighbouring assets, processes, activities or people;
- The existing asset will in many cases be occupied, and if occupancy continues during refurbishment this will almost certainly constrain options of planning and programming, increase the costs and lengthen the time required;
- Statutory restraints such as planning legislation, building regulations and fire regulations often have special application to old buildings and materials and existing assets;
- Hazardous materials and conditions, eg asbestos, infestation, are liable to be encountered requiring special measures and making the project an unattractive one for operatives;
- Temporary weather protection may be required, sometimes involving the construction of a temporary roof structure;
- Some designers and contractors appear to give a low status to refurbishment work compared with new build. This can be reflected in the quality of staff and in the attitude of organisations to refurbishment projects.

Other characteristics which (CIRIA, 1994) highlighted, while not absent from new-build projects, may take on a different form or severity in refurbishment work include:

- Uncertainty, which is likely to be greater;

- The likelihood that some of the primary objectives of cost, time and functional performance may need to be flexible and allowed to evolve during the project;
- Secondary objectives such as aesthetic compatibility with the existing environment, safety and continuing operation by the client may be more dominant;
- A possible greater interaction between client roles such as owner/user and between different levels of clients such as development agency/project owner;
- The involvement of a larger number of parties, which coupled with flexibility of objectives, may cloud the perception of the purpose of the project in the minds of key staff;
- Financial control rules which may be based on revenue expenditure rather than capital expenditure;
- Funding which may be more dependent on grants;
- Contract strategies which work satisfactorily on new- build but may be unsuitable to cope with increased uncertainty and with the greater need for flexibility and collaborative working;
- Construction which will involve greater interaction of temporary works design with permanent works design, so affecting plans and contract strategies;
- Access to and within the site which will often be restricted and cause problems to arise from shared access with other contractors, organisations, the public, the occupants and neighbours;
- Safety issues intensified by the greater uncertainty and involvement of building users who may include the public. Other safety issues include the effect of temporary works design and responsibility for it, congestion and restricted access;
- Fire hazards tending to be greater, and means of escape need to be adequate for the larger variety of occupants present in the building;

- Unusually onerous constraints on storage;
- Specialist skills which are in short supply, so that staff and labour may have to work unsociable hours, and the work is more likely to be characterised by stops and starts.

All these features of refurbishment affect the management of the project in many ways and make different demands on managers and the professional team than would be expected on new-build. A thorough and open-minded professional approach to contract strategy is therefore needed, with a willingness to modify traditional strategies and sometime to experiment with some of the less conventional strategies. Overall, these features of refurbishment projects have consequences for the selection and control of project resources of all kinds such as contractual, human, technical, managerial, material, construction methods as well as equipment.

4.3 Perceived characteristics of refurbishment projects (ChaRef)

The acronym ChaRef refers to perceived characteristics of refurbishment projects and the acronym will be used throughout the thesis. The research participants were asked to respond to the question by stating the extent of their agreement on each refurbishment characteristics as to whether the notion of each statement provided exist in refurbishment schemes, by using the Likert scale from 0 – 4.

Table 4.1 presents the eight ChaRef factors initially identified from literature. They are listed in work order in Table 4.2 to a conclusion based on the analysis and subsequently compare the results against sub-groups of the research participants based on either, level of experience or organisational.

Table 4.1: Description of characteristics of typical refurbishment schemes

Factors	Factor description	Mean
ChaRef1	Higher risk than an equivalent new-build	3.29
ChaRef2	Requires more expertise	3.06
ChaRef3	More complex to design and coordinate	2.18
ChaRef4	More economic uncertainty	3.20
ChaRef5	Prone to more accidents	3.33
ChaRef6	Requires more collaboration between project partners	2.86
ChaRef7	More challenges in occupied buildings	2.60
ChaRef8	More site discoveries as project progresses	2.94

4.3.1 Evaluation of consensus ranking of ChaRef factors at aggregate level

This section aims to look at the ranking order of the factors in order to develop an understanding of the observations of the industry practitioners in ranking of the identified factors perceived to represent characteristics of refurbishment projects.

Table 4.2 presents the aggregate ranking of perceived characteristics of refurbishment. The Table shows the total number of research participants (N = 133), the aggregate mean values and ranking of each factor. This section therefore, focuses on a consensus ranking of the ChaRef factors and also to validate an inventory of factors that define the characteristics of a refurbishment projects.

Table 4.2: Ranking of characteristics of typical refurbishment schemes

Factors	Factor description	Sample Mean	Rank	
ChaRef5	Prone to more accidents	3.33	1	
ChaRef1	Higher risk than an equivalent new-build	3.29	2	Transmutational risks
ChaRef4	More economic uncertainty	3.20	3	uncertainty
ChaRef2	Requires more expertise	3.06	4	Adroitness towards
ChaRef8	More site discoveries as project progresses	2.94	5	incipient plasmolysis
ChaRef6	Requires more collaboration between project partners	2.86	7	Design
ChaRef7	More challenges in occupied buildings	2.60	8	human factor
ChaRef3	More complex to design and coordinate	2.18	9	egornomics (HF&E)

Based on the research findings shown in Table 4.2, there are three major themes to emerge. The sub-headings below outline each one in turn and in greater detail.

4.3.1.1 Managing the Transmutation of risks

Based on the foregoing result in Table 4.2 three factors (ChaRef5; 1 and 4) were grouped under one implied meaning referred to as the 'Transmutation of Risks Management'-Trisma'. This can be defined to imply that as the scope of the work changes, so does the level of risks projected (ChaRef5). This is more synonymous with refurbishment projects and perhaps as the high ranking of ChaRef1 suggests, they are projected to be more dangerous compared to say new build (BBC, 2012). According to accident statistics published by HSE (2004) refurbishment in its different interpretations, accounts for a substantial proportion of injuries and fatal accidents, thus an average of four fatal injuries a year to adult members of the public over five years was recorded. This outcome does not come as a surprise, in that in 2012, after the UK's HSE carried out a surprise crack down on construction sites they stated:

> *"we are concerned about smaller refurbishment projects because more than half of all deaths take place on that type of site………Construction is seen as a high-risk industry and within construction, refurbishment sites are shown to have a higher rate of accidents" (BBC 2012).*

The above evidence suggests that refurbishment projects are more dangerous than new build. In terms of ChaRef5, it is also not surprising to find this factor ranked at the top of the Table. Literature suggests that managing refurbishment projects is often faced with some unique problems in dealing with people, the environment and the project itself (Lam et al, 2010). This view is further supported by different authors (for example, Rahmat and Ali, 2010; Lam et al, 2010; Mansfield, 2009; Reyers and Mansfield, 2001; CIRIA, 1994) who argued that refurbishment is generally characterised to be of higher risk than an equivalent new-build project. This is mostly due to the extent of deterioration which is hardly obvious at the outset of the project (Babangida et al, 2012b). As a consequence, it is believed that the complications experienced on new-build projects doubles in refurbishment (Abd Karim et al, 2007; Marsh, 1983).

In terms of ChaRef4 which relates to refurbishment projects being more economically uncertain as the third highest ranked factor, this ranking is also not surprising as available evidence from literature supported the view that refurbishment has more technical and economic uncertainties (for example, Ali et al, 2010; Mansfield, 2009, Reyers and Mansfield, 2001; CIRIA, 1994).

Unlike new build where new works or layers are scheduled or introduced progressively, with refurbishment the whole process is iterative and sometimes illogical. Thus as long as the effects of risks are known and identified and the project team is able to put in place mitigating or control measures, effectively this is what allows for a safe working environment. Effective risk management implies the potential a manager has in being able to manage the transmutation of refurbishment risks. This level of skill is not commonplace if the reports by the HSE (2012) and BBC (2012) are anything to go by.

4.3.1.2 Adroitness of incipient building defects

Given the previous definitions, it is established that the interchangeability of risks ought to be managed or controlled as the project progresses. ‘TRISMA’ is the resulting response to managing the severity projected by any refurbishment hazards. It typifies the notion that any risk is susceptible to change. In short risks are not permanent; they will change relative to conditions on site and the rate at which they will change and the direction they will take as a result of the change must be known in order to be managed or their effect mitigated.

A further inspection of Table 4.2 suggest that the management of the refurbishment process requires not only experience and relevant knowledge of structural building defects (ChaRef2 and ChaRef8) but that the diagnosis and prognosis must be accurate. This implies that even before a defect begins to manifest such defect ought to be known and therefore nipped in the bud (Kangwa, 2004). This finding would seem to echo the TRAP analysis thesis as promulgated by Kangwa (2004). Kangwa (ibid) put emphasis on knowledge of the manner in which defects are formed within the material, component or group of components. The TRAP analysis thesis suggests that once this is done correctly, the iterative stages inform the remedial strategy (R_s) and therefore the eventual outcome.

In building materials, decay or change in characteristics is also a function of the presence and effect of moisture. Moisture is key and profound in defining the performance of most building materials and structural elements, (Timber, mortar, concrete and most quarried materials such as bricks, ceramic and pozzolanic or cement based materials including plaster and paint).

Similarly, ChaRef8 which relates to the possibility of more site discoveries as a refurbishment project progresses may relate to the fact that there are difficulties in determining the extent of deterioration at the inception of refurbishment projects (Babangida et al. 2012b). From a review of literature, Lam et al (2010) identified refurbishment works as being fragmented and uncoordinated and thus needing experienced managers with the requisite skills and/or knowledge to handle the challenges of the schemes. Wilson and Kishk (2011) also highlighted this challenge as the source of large numbers of variation orders to the project mainly due to the 'unknown' nature of the building. This shows that due to the uncertainty of works and/or the unknown nature of the existing building, understanding the extent of deterioration from inception of the project is vital in order to avoid or minimise the possibility of variation orders which could also lead to cost and time overruns where there are new site discoveries, hence this ranking also suggests that more site discoveries are part of any refurbishment project.

Given this level of difficulty associated with refurbishment projects, it is appropriate to suggest that decay of parts of a building is always a common theme in old buildings. The fact that all building materials are heavily laden with moisture which is either expelled during manufacturing (cement, mortar-based materials, clay bricks, timber and or ceramic materials) they all have endure a process of change mainly due to reduction in the amount of moisture contained within the inner cell or matter. Therefore by definition one has to acknowledge that all building materials share one weakness in that they suffer from plasmolysis.

4.3.1.3 Design and human factor ergonomics

The final analysis of Table 4.2 relates to a factor that defines building refurbishment schemes as projects that more often than not involve higher interaction with owners or existing users. Thus the management of refurbishment projects goes beyond that of a typical new built project; they often involve ongoing use of the building while the refurbishment is in progress. This is another characteristic that makes refurbishment projects almost unique, difficult and sometimes unmanageable and would explain why they project more risks than new build. Thus, managing the human factor and ergonomic interface (HF&E) with refurbishment activities is an additional skill and a characteristics peculiar with refurbishment projects. The role of design in ensuring this is kept to the minimum is acknowledged by Charef6, 7 and 3.

Additionally, a further inspection of Table 4.2 shows the following factors ranked at the bottom of the Table:

- ChaRef6, Requires more collaboration between project partners;

- ChaRef7, More challenges in occupied buildings; and
- ChaRef3, More complex to design and coordinate.

These factors were grouped under the implied meaning of 'Design and human factor ergonomics (HF&E)'. However, in terms of the ranking of these factors, ChaRef6 was ranked 6th by research participants with the sample mean of 2.86. Hence, based on the Likert Scale, it would appear that majority of the research participants agree with in ranking this factor. Based on this information, it is appropriate to suggest that majority of the research participants share the view that ChaRef6 relates to the requirement of more collaboration between refurbishment project partners. This ranking is not surprising as there is evidence in literature which supports the view that refurbishment projects require more collaboration between refurbishment project partners, for example, the CIRIA Report (1994).

In terms of ChaRef7, which suggest that there are more challenges in occupied buildings than there are in empty refurbishment sites, the ranking of this factor is also not surprising as the CIRIA Report (1994) identified building occupancy as a risk factor in terms of management of occupied refurbishment buildings.

Under the 'Design and Human Factor Ergonomics' (HF&E)' in Table 4.2, ChaRef3 which relates to refurbishment projects being more complex to design and coordinate than an equivalent new-build project was ranked eight by research participants with sample mean of 2.18, hence being more than just mere refurbishment. It expounded the theory that for refurbishment to be entirely satisfying to the end user, the functionality of the building and its suitability to the user always takes centre stage in the design phase. Therefore the extent to which an existing building is made to interact with human or users' needs can be more complex to design and coordinate than an equivalent new-build project (BIM, 2011). Based on the Likert Scale, it would appear that a majority of the research participants ranking was neutral in relation to refurbishment projects being more complex to design and coordinate than an equivalent new-build project. However, the NRM3 (2012) identified ineffective design co-ordination as a refurbishment risk factor. Similarly, Lam et al. (2010) opined that refurbishment projects are usually fragmented and uncoordinated. Based on this information, it is appropriate to therefore, suggest that refurbishment projects could be more complex to design and coordinate than an equivalent new-build project, hence it is unclear why the aggregate ranking of this factor is ninth in Table 4.2.

4.4 The paradox of risk-control measures

Clearly, as noted by the HSE above, smaller refurbishment projects are riskier than new build. This implies there is a reason for concern and one has to wonder as to what the solution ought to be? The study pays cognisance to the fact that one of the many solutions lies in a manager’s ability to identify the risks projected within a refurbishment, well before the works begin. This requires putting in place control measures. However, once control measures are in place, one must cast their attention to the sufficiency of the control measures to manage the projected risks. It is strongly believed that once control measures are in place, this act alone should not be the end but the commencement of the process of managing the tasks ahead. Suffice to note that this still requires that the manager has to be alerted to the fact that risks will generally mutate, that is evolve or change from their original state or level. Through the use of control measures, risks are by their very nature said to change in their level of severity. Thus the effect of a control measure is that a risk will shift from being at a high level to a say a ‘moderate’ and or subsequently to a ‘low’ level where the resulting harm is negligible. The study assumes this is one of the sole objectives of putting in place control measures. They either eliminate completely, or reduce the risks of injury or harm likely to take place.

4.5 Evaluation of ChaRef factors relative to Predisposition to risk (Priskaver)

As the study has established the rank order of the Characteristics that define refurbishment projects as perceived by all the 133 research participants, the follow-on sections will explore any variations in the perceptions of ChaRef as held by industry practitioners and, if any, what factors would help to explain such variations.

The HSE (2013) reported that 4 out of 5 projects that had to be closed down involved small refurbishment projects other than new build. This therefore pre-supposes that refurbishment projects are more likely to subject project personnel to more risks.

High and low predisposition to risk: On account of the above definition, it is logical for the study to take a position that those factors which undermine the viability or smooth running of a refurbishment project ought to be known to the project manager. Conversely, those factors that would 'precipitate' or provoke the risk elements of a project would need to be avoided, prevented or minimized through well thought through and well planned control measures. However, the extent to which the control measures impact on the positive outcomes or success of the refurbishment project is directly proportional to the amount of knowledge the project manager has about risks. There are three expectations: firstly that a manager plans the project well or secondly that they are very poor at it or thirdly a neutral position where they are neither very good nor very poor.

High predisposition to risk: Mainly relates to managers capable of planning and managing the risks well. These will not only understand safety legislation but human factors and limitations of construction machinery. They will allow for enough resources to ensure the success of a project. Managers who achieve such levels of management are defined as taking a 'high' predisposition to risk or *high-Priskaver'*; they have in them, management traits and attributes that enable them to achieve efficient planning and management of safety control measures.

Low predisposition to risk: This relates to those project managers who work things out as the project evolves. Such managers are more likely to note the hazards and react to the risks as they about to happen. Such managers are said to have low predisposition to risk aversion. They will take chances, and gamble their way through and thus be susceptible to preside over a refurbishment project processes. In this study such managers are generally referred to as *low-Priskaver*; they don't have in them management traits and attributes that would enable them to achieve efficient planning and management of safety control measures. Often times *low 'Priskaver'* managers will take a gamble. Figure 4.1 is a pictorial depiction of the thesis of how human beings take a predisposing position when for instance making an assessment of risks and putting in place appropriately suitable control measures to effect the successful management of refurbishment projects. Although this equally applies to many fields in the Built Environment little is known about the effectiveness of managers that take a more or less predisposing to being risk averse. Figure 4.2 therefore presents what can be seen as attributes of a highly predisposed manager to risk aversion (a high Prisk). This prompted a need for the study to establish the position managers take in their approach to understanding refurbishment risks as well as the position as reflected in the effectiveness of the control measures to mitigate the perceived threats or risks.

There are two extremes to decision making, herein taken as a dichotomy disposition: one definition relates to managers that are highly 'Priskaver'. These are said to be more fearful of any looming danger from whatever perceived hazard and the resulting risk. Such managers will not take chances but will investigate in full, leave no stone unturned until all the practicable risks and the associated severity, as directly linked to the hazards are either eliminated, reduced and if this is not possible that their impact in terms of the resulting harm is minimised, controlled and therefore managed. Managers who succeed to the point of being in control of the risks are highly predisposed to risk.

Throughout this study such managers are referred to as being ‘highly Priskaver’. With this in mind, it is important for this study to outline the significance that this area brings to the field of building refurbishment. In one part it is the expectation that where a manager understands the diagnosis of a defect very well and can project the likely outcome of the project, if they are faced with two scenarios: a defect has to be remedied but demands the use of an expensive tool and or a period of delay. If the alternative is a cheaper option but is likely to leave a building with a latent or residue defect, then given the training the manager has and if they are ‘pre-disposition’ to risk, then the logical thing to do is not to consider the cost to the remedy but the benefits ensuing from getting rid of a defect completely however long it takes.

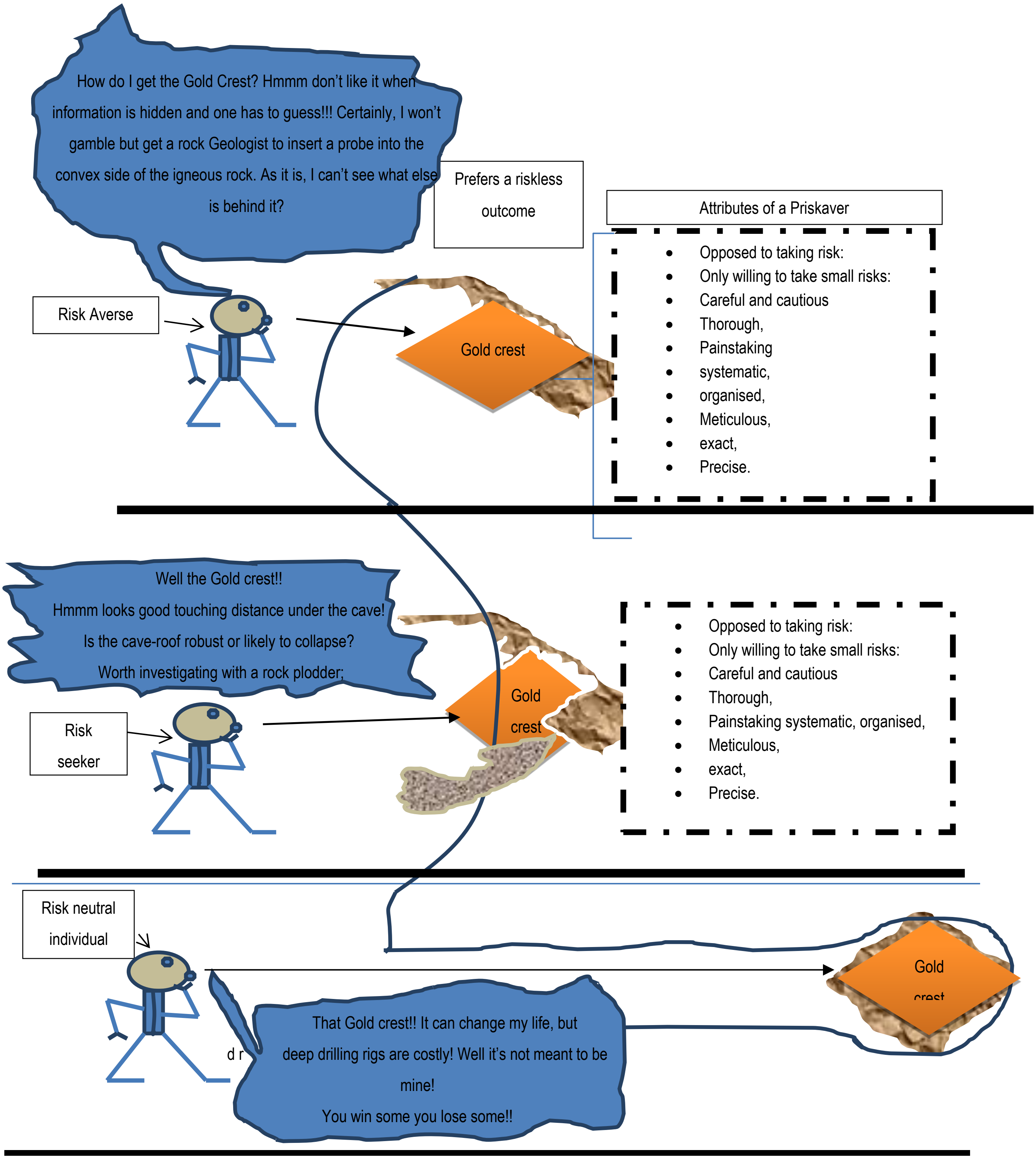


Figure 4.1: Depiction of typical attributes of a Prisk

4.6 Exploring the effect of (Priskaver) on CHAREF using four independent groups

Based on the foregoing analysis, the research has determined the views and/or rank order of the eight ChaRef factors at the aggregate level. Using this as a basis for further analysis, industry practitioners experience was grouped into the four different *k levels* (groups) of confidence levels (or Priskaver levels). As shown in Figure 4.3 practitioners were asked to indicate how confident they were in understanding the concept of risk. The options to which they were prompted to rank were 1 as 'very confident'; 2 as confident; 3 as 'partially confident' and 4 as 'not confident'.

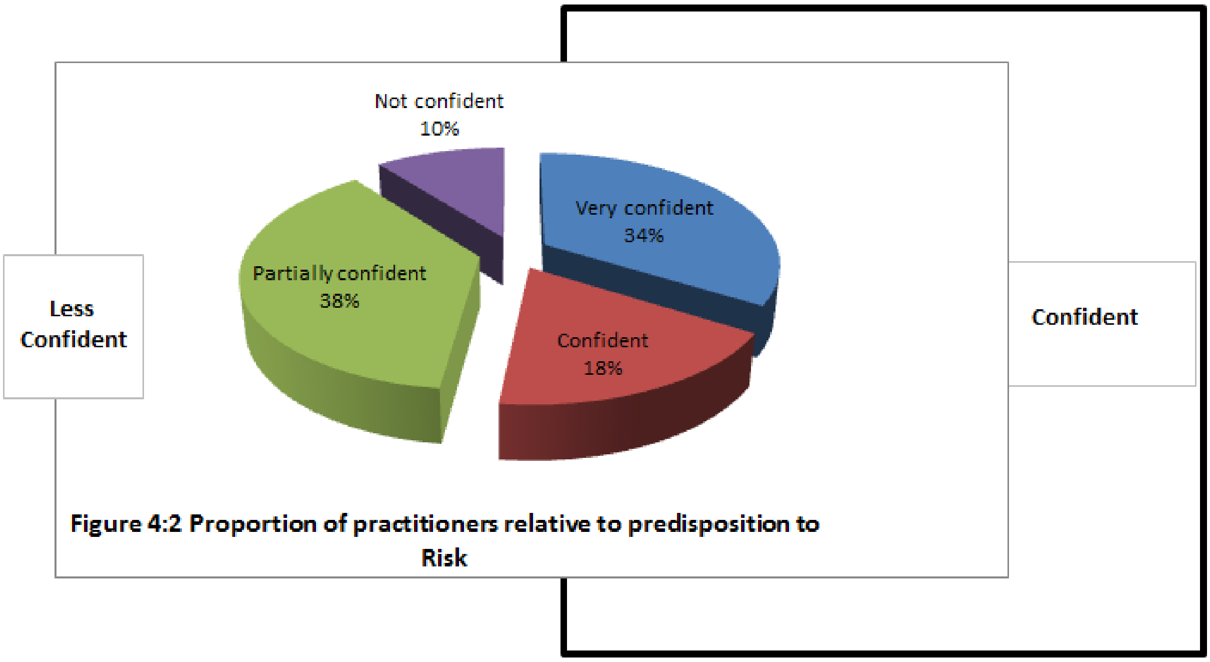


Figure 4:2 Proportion of practitioners relative to predisposition to Risk

Accordingly it is expected that practitioners that have a predisposition to risk are likely to engage with the elements of a project likely to present some more risk and to focus their planning and attention to ensuring that information is generated to inform other duty holders about the presence of such risks and what control measures needs to be in place. At the same time mangers that responded as 'unsure' are not so confident due to lack of knowledge and experience and thus are likely to 'take a fair gamble' would be considered doubtful in being able to handle refurbishment risks efficiently. These would be described as having a lower predisposition to risk thus defined hereafter as ‘less-Priskaver’. Given this delineation to risk approach, the study investigated the sample to understand if there were differences in the ranking of the ‘characteristics that define building refurbishment’ projects when compared to new-build.

As there are four different groups of Priskaver, a non-parametric equivalent to analysis of variance methods (ANOVA) had to be adopted in the form of Kruskal–Wallis (KW). In order to deploy Kruskal–Wallis to detect any variance in the rank order of ChaRef the procedure should allow the study to establish whether any variance in the rank order across the four groups can be narrowed down to lack of confidence about the safety management of refurbishment projects or is merely due to lack of knowledge of risks and uncertainties within the refurbishment sector. Having to establish the effect of certainty and uncertainty on practitioners’ ability to manage refurbishment works will inform the understanding of what is perceived as typical characteristics of refurbishment projects among practitioners with varying levels of confidence in risk management of refurbishment projects.

The Kruskal-Wallis *(KW)* analysis test is given by the formula:

$$KW = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{T_i^2}{n_1} - 3(n+1)$$

Procedure: *KW* requires that the independent samples are not related and their values are generated from a measurement scale that is at least ordinal (that is each respective sample can n_1, n_2……n_k from each of the *k* populations. be ranked from smallest to largest). The total sample size is $n = n_1 + n_2 \ldots\ldots + n_k$. The next step is to pool the samples and arrange them in order, assigning a rank to each respective factor. Where there are ties, the study assigns the average rank of the sample to the tied positions.

The test begins with a set of one tail hypotheses:

Null Hypothesis:

H_0 The *refurbishment practitioners* have identical ranks on ChaRef

Alternative Hypothesis:

H_1 At least two of the 4 levels of *refurbishment practitioners* differ in their ranks of ChaRef.

Let $T_1 =$ the total of the ranks from the *i*th sample. The KW statistic approximately follows a chi-square distribution with *k -1*df. As the four groups or *k* levels are split into 4 *K* groups, therefore, *df = 4 -1 = 3.*

The Test Statistic for *KW* is to reject the H_0 if KW is >$\chi^2_{a.df}$ [the critical value of chi-square curve α = 0.05 significance level or 95% confidence level and 3 degrees of freedom].

The respective samples for n_1, n_2…….n_k are shown in Table 4.3 which presents the various mean values within the levels of predisposition to risk (very confident; confident; partially confident; various levels and not all confident). As earlier stated the matter of interest is to establish whether there is notable variation in the ranks on ChaRef given the different levels which define practitioners' predisposition to risk-aversion. The pooled values are further presented in Table 4.4 and the total n_k = 32 derived from the 4 *k* levels with each level defined by the eight ChaRef factors.

Table 4.3: Pooled mean sores for 'Characteristics of refurbishment projects' by predisposition to risk-averse

1	**ChaRef5**	**3.56**	
2	**ChaRef1**	**3.47**	
3	**ChaRef4**	**3.33**	
4	**ChaRef2**	**3.29**	Very Confident
5	**ChaRef3**	**3.24**	
6	**ChaRef7**	**3.22**	
7	**ChaRef8**	**3.18**	
8	**ChaRef6**	**3.13**	
9	**ChaRef1**	**3.46**	
10	**ChaRef8**	**3.42**	
11	**ChaRef5**	**3.38**	
12	**ChaRef4**	**3.25**	Confident
13	**ChaRef2**	**3.17**	
14	**ChaRef6**	**2.96**	
15	**ChaRef3**	**2.33**	
16	**ChaRef7**	**2.00**	
17	**ChaRef1**	**3.36**	
18	**ChaRef5**	**2.52**	
19	**ChaRef4**	**2.26**	
20	**ChaRef2**	**2.24**	Partially Confident
21	**ChaRef8**	**2.04**	
22	**ChaRef6**	**1.94**	
23	**ChaRef7**	**1.86**	
24	**ChaRef3**	**1.76**	
25	**ChaRef5**	**2.50**	
26	**ChaRef3**	**2.36**	
27	**ChaRef4**	**2.00**	
28	**ChaRef2**	**1.71**	
29	**ChaRef6**	**1.64**	Not at all Confident
30	**ChaRef8**	**1.57**	
31	**ChaRef7**	**1.43**	
32	**ChaRef1**	**1.36**	

From Table 4.4 which shows the relative position of factors against each mean score, where there are ties, for instance for the 23rd and 24th position, it is the average of the two that is allocated (hence 23+24/2) = 23.5.

Table 4.4: Pooled ranks of Characteristics of refurbishment projects (ChaRef)		
ChaRef5	**3.56**	**1**
ChaRef1	**3.47**	**2**
ChaRef1	**3.46**	**3**
ChaRef8	**3.42**	**4**
ChaRef5	**3.38**	**5**
ChaRef1	**3.36**	**6**
ChaRef4	**3.33**	**7**
ChaRef2	**3.29**	**8**
ChaRef4	**3.25**	**9**
ChaRef3	**3.24**	**10**
ChaRef7	**3.22**	**11**
ChaRef8	**3.18**	**12**
ChaRef2	**3.17**	**13**
ChaRef6	**3.13**	**14**
ChaRef6	**2.96**	**15**
ChaRef5	**2.52**	**16**
ChaRef5	**2.50**	**17**
ChaRef3	**2.36**	**18**
ChaRef3	**2.33**	**19**
ChaRef4	**2.26**	**20**
ChaRef2	**2.24**	**21**
ChaRef8	**2.04**	**22**
ChaRef7	**2.00**	**23.5**
ChaRef4	**2.00**	**23.5**
ChaRef6	**1.94**	**25**
ChaRef7	**1.86**	**26**
ChaRef3	**1.76**	**27**
ChaRef2	**1.71**	**28**
ChaRef6	**1.64**	**29**
ChaRef8	**1.57**	**30**
ChaRef7	**1.43**	**31**
ChaRef1	**1.36**	**32**

The rank positions are then used in Table 4.5 in to establish the total of the sum of ranks per T_1 = the total of the ranks from the '*i*' sample and the values of *T1*, T_2, T_3, and T_4 taken from Table 4.5.

Table 4.5: Perception of ChaRef rank order relative to Predisposition to Risk

	Mean	VC	Rank	C	Rank	PC	Rank	NC	Rank
ChaRef5	3.34	**3.56**	**1**	**3.38**	**5**	**2.52**	**16**	**2.50**	**17**
ChaRef1	3.17	**3.47**	**2**	**3.46**	**3**	**3.36**	**6**	**1.36**	**32**
ChaRef4	3.01	**3.33**	**7**	**3.25**	**9**	**2.26**	**20**	**2.00**	**23.5**
ChaRef2	3.00	**3.29**	**8**	**3.17**	**13**	**2.24**	**21**	**1.71**	**28**
ChaRef8	2.89	**3.18**	**12**	**3.42**	**4**	**2.04**	**22**	**1.57**	**30**
ChaRef6	2.80	**3.13**	**14**	**2.96**	**15**	**1.94**	**25**	**1.64**	**29**
ChaRef7	2.50	**3.22**	**11**	**2.00**	**2.3.5**	**1.86**	**26**	**1.43**	**31**
ChaRef3	2.20	**3.24**	**10**	**2.33**	**19**	**1.76**	**27**	**2.36**	**18**
			65		**68**		**163**		**208.5**
			T1		*T2*		*T3*		*T4*

Using the sum of the ranks for T_s from the Table 4.5 the study is able to compute the value of KW statistic using the ranks of the observations in the pooled sample:

$$KW = \frac{12}{n(n+1)}\sum_{i=1}^{k}\frac{T_i^2}{n_1} - 3(n+1)$$

$$\frac{12}{32(32+1)}\left[\frac{65^2}{8}+\frac{68^2}{8}+\frac{163^2}{8}+\frac{208^2}{8}\right] - 3(32+1)$$

$$\frac{12}{32(33)}\left[\frac{65^2}{8}+\frac{68^2}{8}+\frac{163^2}{8}+\frac{208^2}{8}\right] - 3(33)$$

$$\frac{12}{1056}\left[\frac{4225}{8}+\frac{4624}{8}+\frac{26569}{8}+\frac{43472.25}{8}\right] - 99$$

$$\frac{12}{1056}[528.13+578+3321.13+5424.03] - 99$$

$$\frac{12}{1056}[9861.29] - 99$$

$$112.06 - 99$$

$$\underline{\boldsymbol{KW = 13.06}}$$

Based on the above computed value, the testing procedure is to reject H_0 if KW is $>\chi^2_{\alpha.df} = 7.82$, [derived from Appendix E-2]. As the computed value of *KW* 13.06 exceeds the chi-square Table value of 7.82 at α = 0.05 and 3 degrees of freedom the study therefore, rejects the Null hypothesis in favour of the alternative and concludes that there is sufficient evidence to project differences in the perception of factors which are perceived to be typical characteristics of refurbishment projects. Indeed a further inspection of the Table values shows a very small p – value which is < 0.01 indicating a very strong conclusion. In other words, these means ranks indicate a clear difference in the effect of predisposition to risk in the ranking of factors that define the characteristics of Refurbishment projects (ChaRef).

Indeed a further inspection of Table 4.5 shows that the sum of the ranks across the four groups is: $T_{1\,=\,65}$; $T_{2\,=\,68,}T_{3\,=\,163}$; $T_{4\,=\,208}$ respectively. While it can be concluded that the groups which show closely related ranks are $\mathrm{T}_{1=65}$ and $\mathrm{T}_{2=68}$, these are also distinct to the sum of the ranks for $T_{3\,=\,163}$; $T_{4\,=\,208}$ and thus statistically significant.

This result has wider implications in the study's conclusions: it appears that regardless of the acceptance that practitioners will have differing experiences and subsequently differing confidence levels in their ability to handle risks associated with refurbishment projects, it appears that confidence is nonetheless everything and it inspire practitioners. Therefore, practitioners defined as 'not so confident' are less likely to define the factors that characterise refurbishment projects in the same manner as those that are confident. Indeed, a further inspection of Table 4.4 shows that at the bottom of the table, it is practitioners who disagreed in the rank values 0 = strongly disagreed; and 1 = disagree) and the two groups of practitioners colour-coded in red and purple ('not so confident' and 'partially confident').

Consequently, the notable differences in the rank order of the factors as established through Kruskal-Wallis have been established relative to practitioners' predisposition to risk, Priskaver, the concern of this study is that these may also affect the confidence levels and therefore the performance of refurbishment practitioners. In order words, it can be concluded that confidence helps practitioners to be positive managers. Table 4.4 also suggest that the 'very confident' practitioners, colour-coded 'black' and 'confident' coded 'blue' are responsible for the mean ranks with higher scores of 3 for 'agree' and 4 'strongly agree' respectively. These are generally defined as practitioners who take a positive outlook to the definition of refurbishment projects. This observation is consistent with the depiction of the differences in the Priskaver line graph of Figure 4.4 and radar plot in Figure 4.5.

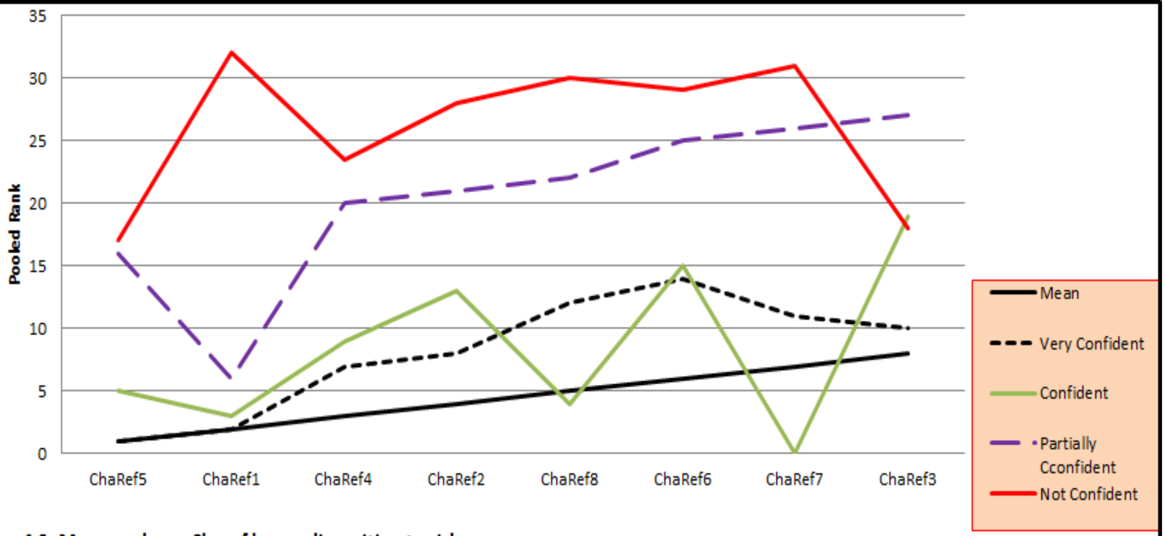


Figure 4.3: Mean ranks on Charef by predisposition to risk

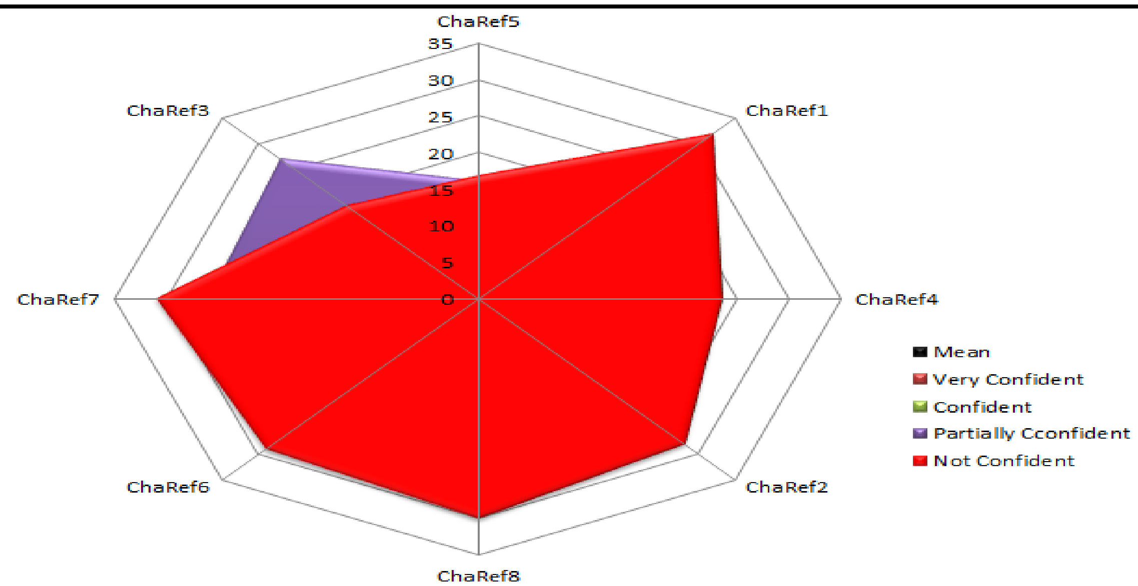


Figure 4.4: Radar graph of predisposition to risk

4.7 Exploring the differences between two independent Priskaver on ChaRef

This section of the study proceeds to establish if there would be notable variations in the characteristics of refurbishment projects (ChaRef) if the four groups defined above were collapsed into two definitive samples as illustrated in Figure 4.6.

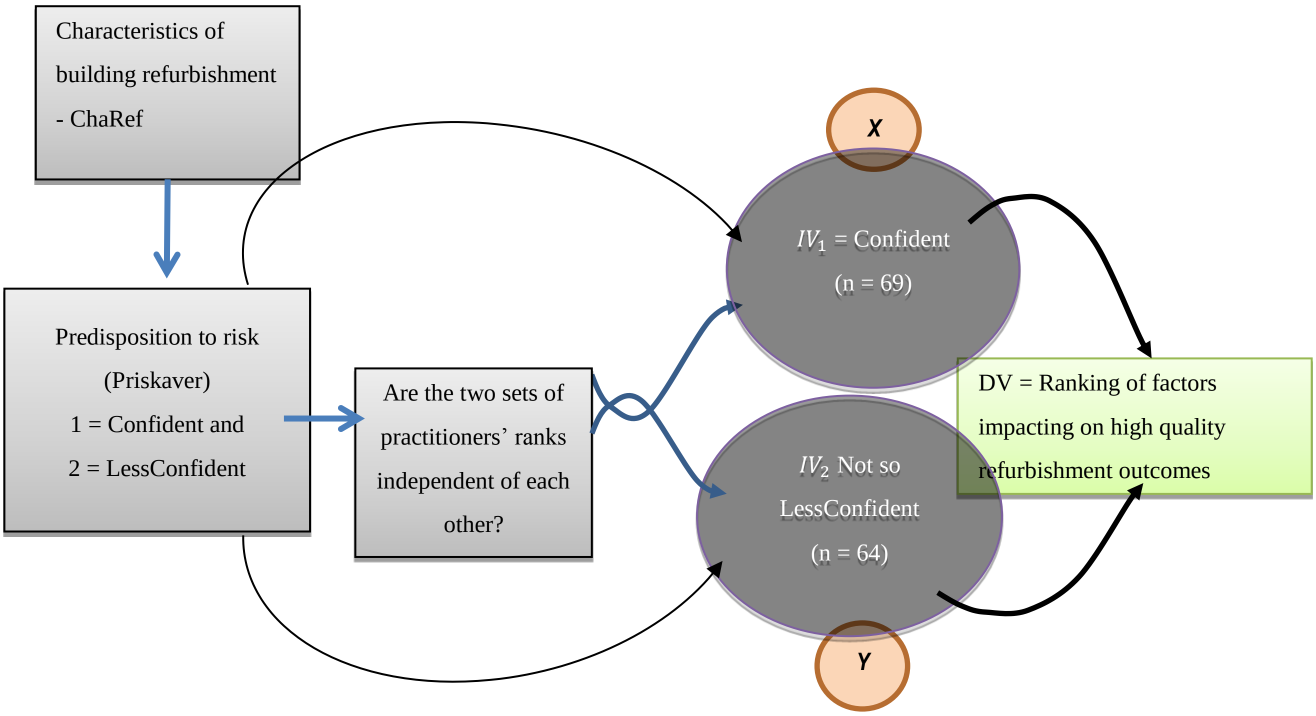


Figure 4.5: Two–tail hypothesis on ChaRef relative to Predisposition to risk

The research logic for collapsing these two groups aims to establish the difference between 'Confident' and 'LessConfident' practitioners, as illustrated in Figure 4.6. The question to be asked is: are the two groups of practitioners' independent in the ranking of ChaRef factors relative to whether they are 'Confident'or 'LessConfident' to predisposition to risk? In order to answer this question, the Mann-Whitney statistic will be used to test the mean ranks of the two independent samples.

4.8 Mann-Whitney (U) statistic test on 'Priskaver' relative to ChaRef factors

It is assumed that project managers on refurbishment projects often gain the experience and confidence to run a refurbishment project with risk management utmost on their list of priorities. For the very experienced, this demands that before the works commence they identify any unforeseen or hidden risks so as to establish beforehand what mitigating measures should be put in place. At some stage decisions have to be made by the project team as to what hierarchy of control measures need to be established and allowed, namely:

- at a higher level, thus practicable – due to projected risks; or
- at a moderate level thus foreseeable and
- at a low level and thus defined as 'so far as reasonably foreseeable'.

Therefore, the study posed the following question: does the data collected in this research support such a thesis? Is there any credence in taking such a measure?

4.8.1 Test of Independence 'Confident' and 'LessConfident on ChaRef

Mann-Whitney Test of Independence establishes how distinct two independent variables are in so far as investigating the ranking to the ChaRef factors is concerned. According Weiers (2011) the use of Mann Whitney Test for small samples requires that should the number of items to be rated be less than ten, the procedure for smaller sample should be adopted (meaning $n_1 \leq 10$ and $n_2 \leq 10$). Where the factors are more than ten then accordingly, the Mann-Whitney for large samples should be adopted. As the number of factors presented to the practitioners was eight, (see Table 4.6) it is the Mann-Whitney (U) test for small samples that is adopted. The objective is to explore how distinct the two sets of practitioners are in their definition of the characteristics of refurbishment projects.

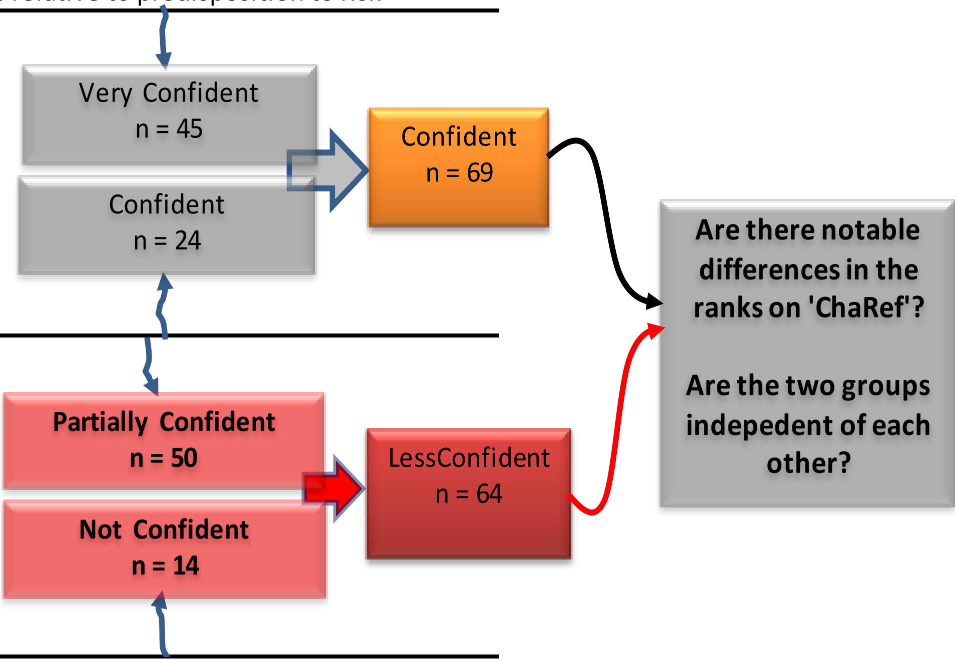
In order to test how independent the two groups of practitioners are the study generated the hypotheses to guide the test as follows:

- H_0: The 'Confident' and 'LessConfident' practitioners have identical ranks on ChaRef;
- H_1 The 'Confident' and 'LessConfident' practitioners differ in ranks on ChaRef.

As noted in Table 4.6 below the initial four groups were collapsed to generate two sets of practitioners of interest. The 'very confident' and 'confident' formed 'confident' group (= 69); the partially confident and not confident were put into the 'LessConfident' group (n = 64) as shown in Figure 4.6.

Table 4.6: Mean ranks relative to predisposition to risk

Charef1	**3.41**
Charef2	**3.23**
Charef3	**3.20**
Charef4	**3.42**
Charef5	**3.57**
Charef6	**3.06**
Charef7	**3.14**
Charef8	**3.17**
Charef1	**1.73**
Charef2	**2.23**
Charef3	**3.06**
Charef4	**3.02**
Charef5	**3.13**
Charef6	**2.06**
Charef7	**1.89**
Charef8	**1.92**



Of interest to the study is the need to define how distinct the two camps of practitioners are in their definition of the characteristics of building refurbishments are. The Mann-Whitney equation is given as follows:

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - T_1 \qquad \text{(i)}$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - T_2 \qquad \text{(ii)}$$

As shown in Table 4.7, the procedure begins by finding the sum of the pooled ranks in each group (T_1 for the pooled ranks in 'Confident' *X*- and T_2 for the 'LessConfident' or *Y*', ensuring that *n* (number of ranked items is not over 10) and then substituting the items in the Mann-Whitney equations (i) and (ii). The individual mean ranks from each group are then pooled and their relative position established.

Table 4.7: Pooled ranks on 'ChaRef' relative to predisposition to risk

	X n = 69		Y n = 64	
Factors	Confident	Rank X	LessConfident	Rank Y
ChaRef5	3.57	1	3.13	8
ChaRef1	3.41	3	1.73	16
ChaRef4	3.42	2	3.02	11
ChaRef2	3.23	4	2.23	12
ChaRef8	3.17	6	1.92	14
ChaRef6	3.06	9	2.06	13
ChaRef7	3.14	7	1.89	15
ChaRef3	3.20	5	3.06	10
		$T_{1=37}$		$T_{2=99}$

The test procedure is to determine U_1 and U_2 letting *U* be the minimum between U_1 and U_2. Using the table value from Appendix E-3 the computed value is derived by using the table and looking down and across at $n_{1=}8$; $n_{2=}8$ picking the value based on the minimum of the two equations. Thus for T_1 the computation of *U* is:

$$U_1 = n_1 n_2 + \frac{n_{1(n_1 +1)}}{2} - T_1$$

$$U_1 = (8)\,(8) + \frac{(8)(9)}{2} - 37$$

$$\underline{\mathbf{U_1 = 63}}$$

For T_2 the computation of *U* is:

$$U_2 = n_1 n_2 + \frac{n_{2(n_2 +1)}}{2} - T_2$$

$$U_2 = (8)\,(8) + \frac{(8)(9)}{2} - 99$$

$$\underline{\mathbf{U_2 = 1}}$$

As the study set a two-tailed hypothesis, (after Weiers; 2011; Kvanli *et al.* 1992) the study adopts U as the minimum of U_1 *and* U_2. Since the computed value of U2 = 1 and less than U_2 = 63, it is U = 1 which is adopted and taken forward in the testing of the hypotheses.

Therefore using Table in Appendix E-3 where $n_1 = 8$; $n_2 = 8$ and $U = 1$, the value in the Table is 0.0002. Since the hypothesis was set out as a two-tailed approach, Kvanli et al (1996) have further advised dividing the significant value $\alpha = 0.05$ by two (i.e. $\alpha/2$), giving a test value of 0.025. Thus as the Table value (0.0002) is less than half the $\alpha/2$ given as 0.0002, the study can reject the Null hypothesis (H_0) in favour of the alternative.

This outcome would imply that the two groups of practitioners based on ‘Confident’ and ‘LessConfident’ differ in ranks on ChaRef. The Scatter plot in Figure 4.7 and correlation chart in Figure 4.8 as well as Figure 4.9 help to illustrate this outcome. Based on this outcome there is sufficient evidence to indicate a difference between the ‘very confident’ and the ‘LessConfident’ practitioners in the ranking of the characteristics of building refurbishment. This implies that practitioners’ perception of what defines refurbishment is affected by their own ‘predisposition to risk’.

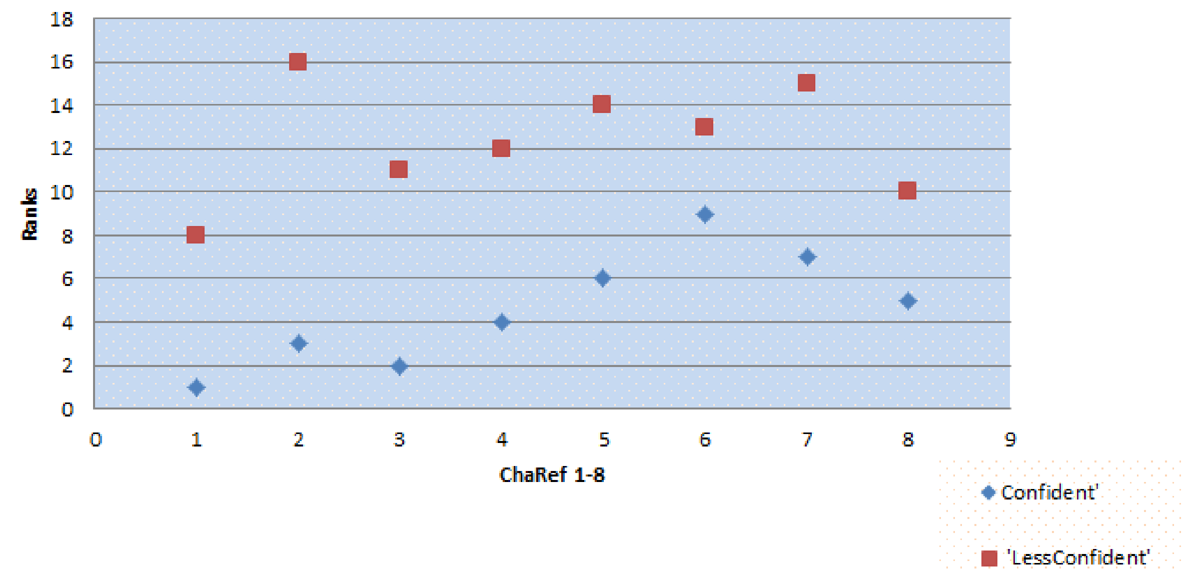


Figure 4.6: Correlation ranks on ChaRef by 'Confident' and 'LessConfident'

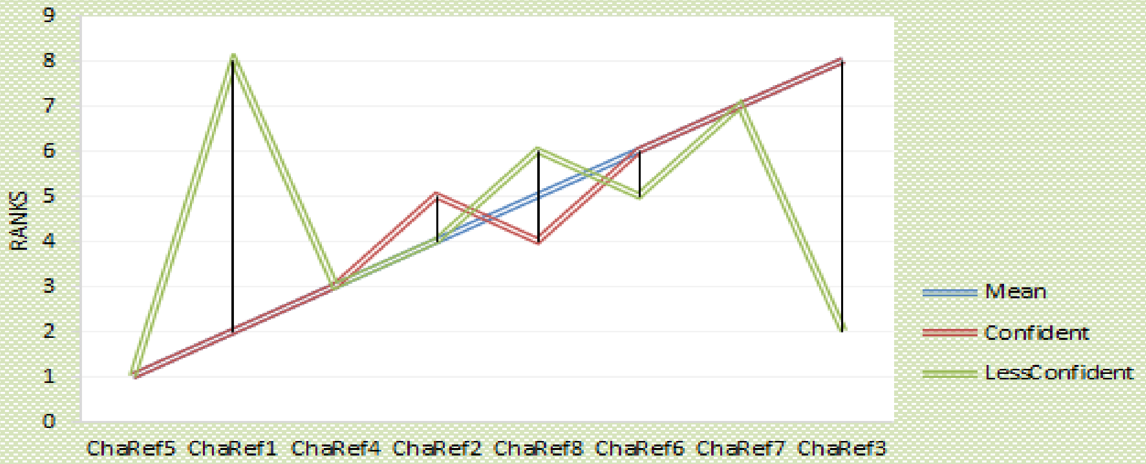


FIGURE 4.7: CORRELATION CHART OF CHAREF RELATIVE TO PREDISPOSITION TO RISK

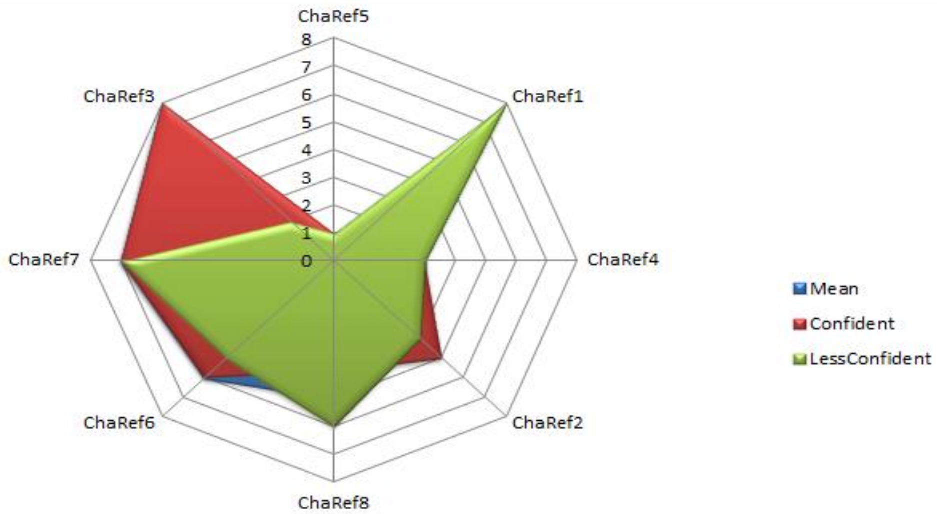


Figure 4.8: Radar graph-plot of rank correlation on ChaRef (μ: Confident/LessConfident)

The fact that the study is able to observe differences based on level of how predisposed to risk the practitioners are nonetheless unsurprising. As one might expect, the LessConfident' practitioners are less forthcoming in their ranks. Indeed on closer inspection, these recorded lower mean scores and from the pooled sample these were predominantly at the bottom of the pool, thus generally less confident about their ability to manage refurbishment projects safely. As a result of this, it is noted that there are differences in the ranks provided by practitioners who indicate more confidence in their ability to manage refurbishment risks.

4.9 Influence of industry experience in ranking of ChaRef factors

This section will explore the extent of agreement among research participants in ranking the initial eight characteristics of refurbishment (ChaRef). In an attempt to ensure the ranking is achieved accordingly, as well as to uncover any variation and/or relationship in ranking, the research participants were grouped into two based on level of refurbishment experience within the industry. This is in order to effectively achieve the desired research goal set out as in Figure 4.9.

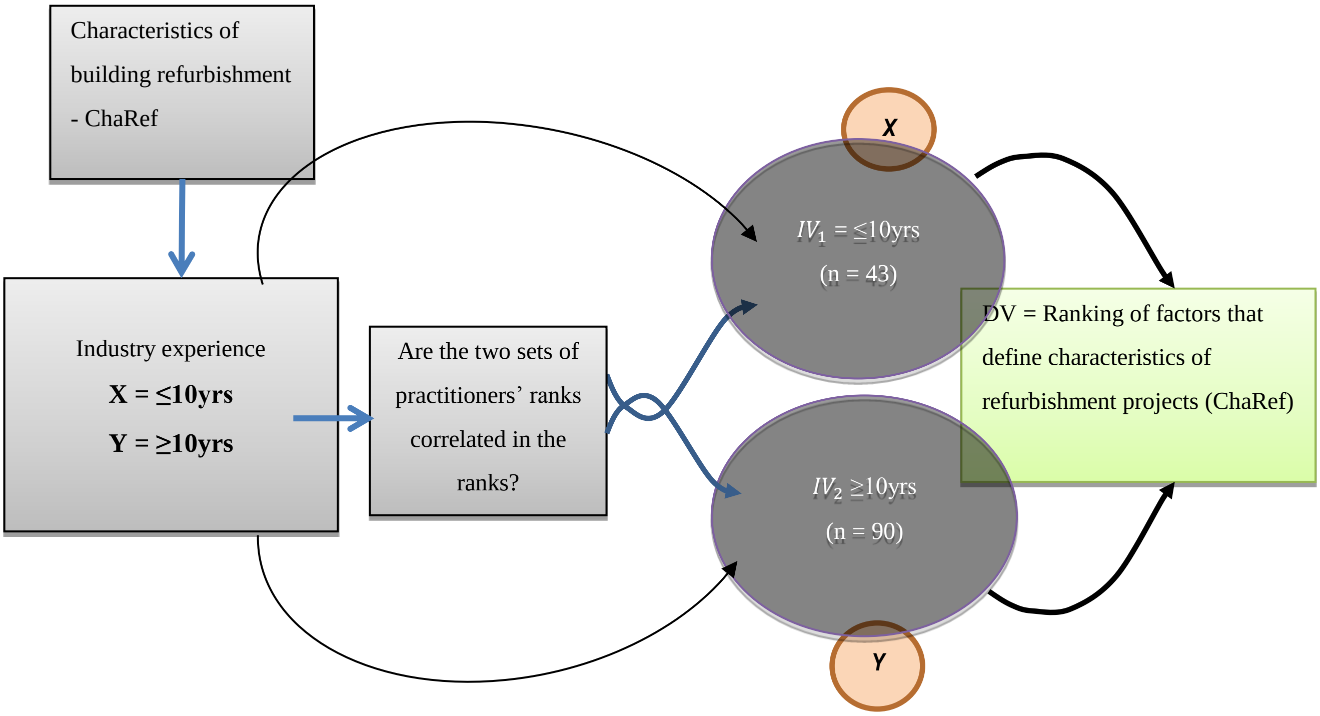


Figure 4.9: Two–tail hypothesis on ChaRef relative to refurbishment experience

The first test attempts to explore the impact that refurbishment experience has on practitioners in how they perceive the factors that define the refurbishment process. It is assumed that as an independent factor experience will expose any level of variation or relationships in the ranking of ChaRef factors. Whether any notable positive effects on ChaRef are associated with the most experienced or less experienced is unknown until the subjects in each group are exposed to the non-parametric testing. It is also important to state therefore that as a two tail hypothesis suggests, the first indication should come from establishing the presence of a relationship and the strength of that relationship. This approach needs to benefit from the use of Spearman rank correlation coefficient r_s which is given by the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where:

- *N* is the aggregate mean; *n* is the total number of ranking for each group;
- *d* is the difference between X and Y ranks given as: R(*X)*-R*(Y)*
- r_s is the Spearman's rank correlation which measures the extent of linear agreement between X and Y variables.

Consequently, the following research hypotheses were set:

Null Hypothesis:

H_0: There is no relationship between the two sets of practitioners in the ranking of ChaRef factors relative to refurbishment experience

Alternative Hypothesis:

H_1*:* There is a relationship between the two sets of practitioners in the ranking of ChaRef factors relative to refurbishment experience.

Since the objective is to determine whether there is any relationship between the two groups of refurbishment practitioners and also to understand whether experience is an important factor in terms of differentiating the ranking of the ChaRef factors, Spearman should establish the strength of the coefficient value. As the prima facie, Spearman Rank (Rho) correlation is set to establish whether large values of ranks within the sample are associated with practitioners of up to 10 years or those with 10 years and above of refurbishment experience (positive association). The other possible outcome would be to establish if smaller rank values are notable with practitioners with less than 10 years while larger values are associated with those with more than 10 years (negative association). The other option would be that there is association.

Table 4.8: Mean values relative to refurbishment experience		
	up to 10yrs	
Factors	Mean	Rank within
ChaRef6	**3.02**	**1**
ChaRef2	**2.91**	2
ChaRef8	**2.81**	3
ChaRef5	**2.67**	4
ChaRef1	**2.40**	5
ChaRef3	**2.37**	6
ChaRef4	**2.00**	7
ChaRef7	**1.88**	8
	10yrs +	
Factors	Mean	Rank within
ChaRef5	**3.58**	**1**
ChaRef1	**3.34**	**2**
ChaRef6	**3.26**	**3**
ChaRef8	**3.10**	**4**
ChaRef2	**3.08**	**5**
ChaRef7	**3.04**	**6**
ChaRef4	**3.01**	**7**
ChaRef3	**2.52**	**8**

Nonetheless, should experience be perceived as an important factor this would imply it has some influence as to the standards and accuracy of the day-to-day decisions made by project managers. Table 4.8 therefore, presents the results of the analysis of ranks within the respective groups. Table 4.8 is thus a first attempt at noticing the differences in the ranks relative to refurbishment experience. Since Table 4.8 gives a representation of the perceptions of ChaRef factors within the independent variables but does not present a full picture of the strength of the relation, it is necessary to arrange the factors relative to the mean value obtained at the aggregate level.

An inspection of Table 4.9 therefore shows ChaRef factors splits between the two independent variables. Spearman rank correlation (r_s) is appropriate for testing the hypothesis of the presence and strength of correlation, after Howitt and Cramer (2011). As a measure of how well practitioners agree, the larger the r_s value is closer to 1, the more agreement there is between two sets of practitioners. Therefore a computation of $r_s = 1$ would imply a perfect agreement; where as a perfect disagreement would result in a value of$r_s = -1$.

Table 4.9: Comparision of rank order based on refurbishment experience

N = 133 Factors	Sample Mean	*Y Up to 10 yrs* *n = 43*	R(X)	*Y 10 yrs+* *n = 90*	R(Y)	*(d)*	d^2
ChaRef5	3.33	2.67	*4*	3.58	*1*	3	9
ChaRef1	3.29	2.40	*5*	3.34	*2*	3	9
ChaRef4	3.20	2.00	*7*	3.01	*7*	0	0
ChaRef2	3.06	2.91	*2*	3.08	*5*	-3	9
ChaRef8	2.94	2.81	*3*	3.10	*4*	-1	1
ChaRef6	2.86	3.02	*1*	3.26	*3*	-2	4
ChaRef7	2.60	1.88	*8*	3.04	*6*	2	4
ChaRef3	2.18	2.37	*6*	2.52	*8*	-2	4

$\sum d^2 = 40$

In Table 4.9 the calculated differences *(d)* and sum of d^2 are shown and from these, the rank correlation of r_s is computed as follows:

Hence from the equation $r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$, the computation of r_s is set out as follows:

$$r_s = 1 - \frac{6(40)}{8(8^2-1)}$$

$$r_s = 1 - \frac{240}{504}$$

$$\boldsymbol{r_s = 0.523}$$

Given that throughout this study the significance level (α) is set at 0.05 where n = 8, the test procedure is to reject the null hypothesis (H_0) if $\boldsymbol{r_s}$ >**0.738**; where 0.738 is obtained from

Spearman rank correlation table in Appendix D - 1 which contains the critical values of Spearman's rank correlation coefficient. The computed value of $\boldsymbol{r_s} = 0.523$ does not exceed the Table value of 0.738. As a consequence, the study fails to reject (H_0) implying that there is insufficient evidence to suggest there is association between the two sets of refurbishment practitioners based on refurbishment experience. As endorsed by scatterplot in Figure 4.10 and the line graph in Figure 4.11 the study can conclude that the two groups are distinct in their perceptions and ranking of ChaRef factors. The above conclusion is based on the strength of the correlation coefficient which is below 0.05. Although this is a positive relationship nonetheless it is very weak relationship as confirmed by the rank correlation value.

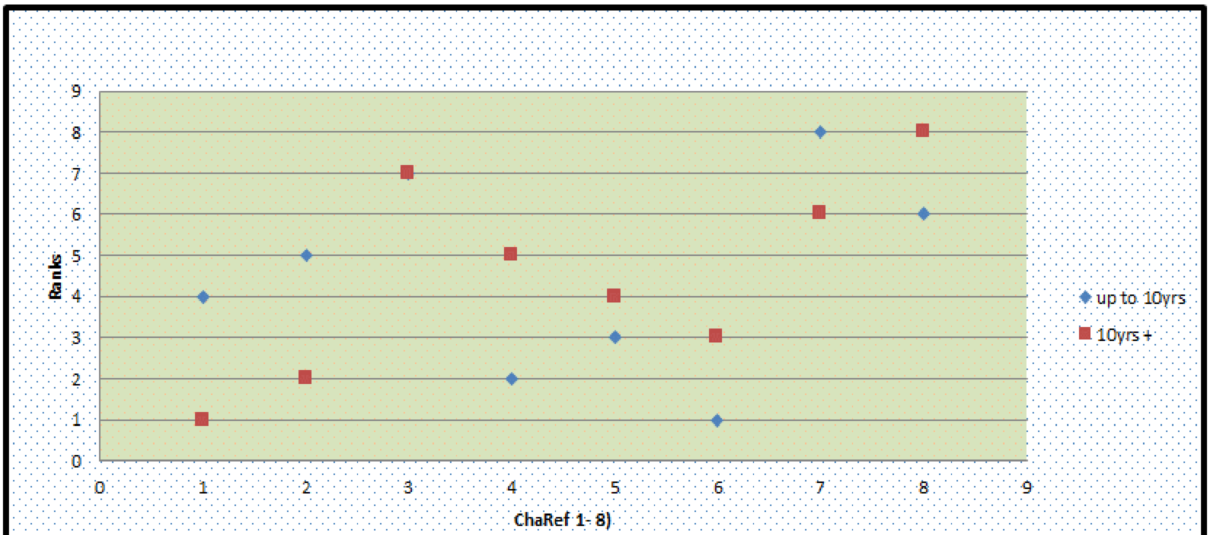


Figure 4.10: Scatterplot of ranks on ChaRef relative to refurbishment experience (<10: >10years)

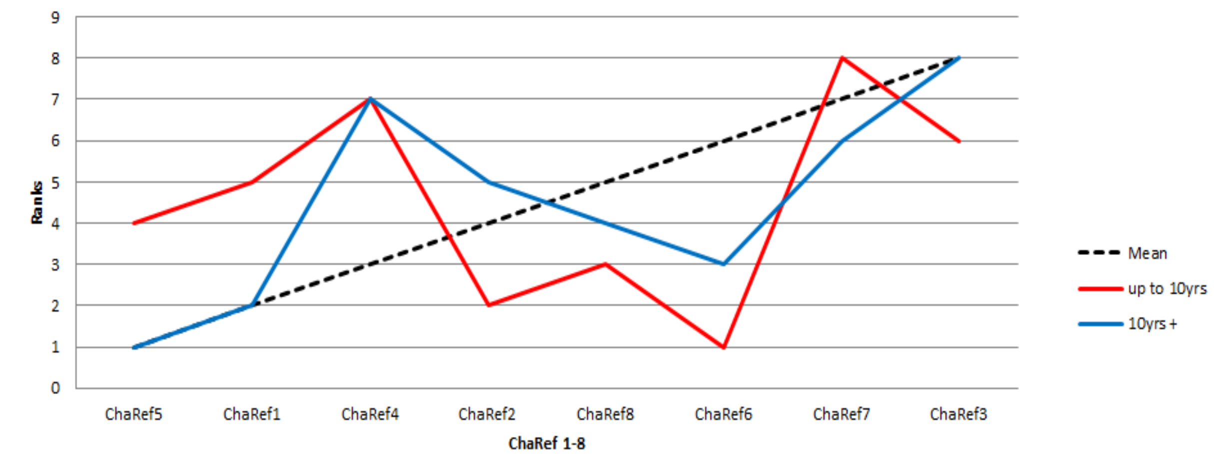


Figure 4.11: Scatter plot on ChaRef relative to refurbishment experience

It follows therefore from the foregoing analysis that the ranking of factors which typify the characteristics of refurbishment is distinguishable on the basis of experience; implying practitioners with more experience recorded different scores to those with less experience. The distinction becomes more pronounced in Table 4.12 when the two groups are compared relative to the sample mean ranks; thus the dissimilarity between the two groups cannot any more stark. Indeed the difference between the two is further pronounced as depicted by the radar plot in Figure 4.12 where the total area under the union of the two groups (in brown) is far less than the total surface area outside the union (denoted by light brown and purple).

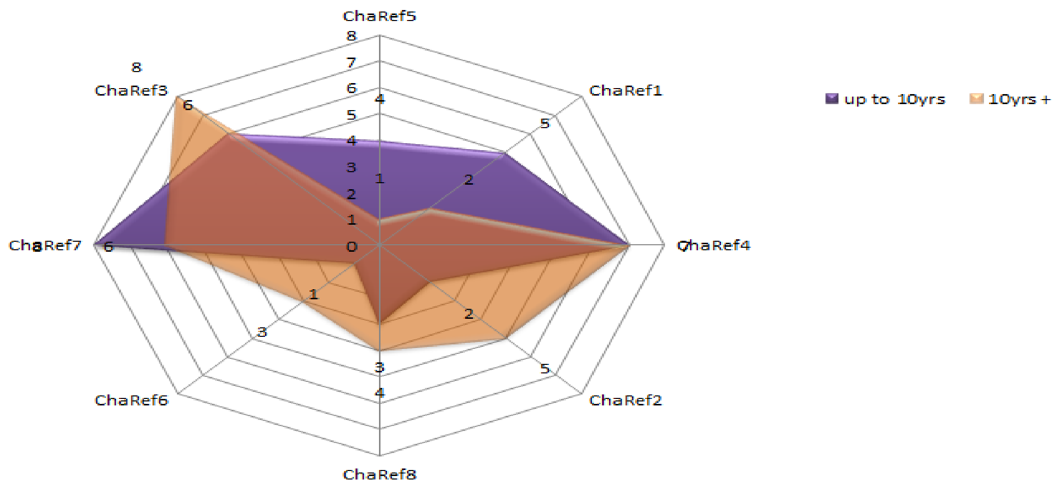


Figure 4.12: Radar graph plot on ChaRef relative to refurbishment experience

The significance of these comparisons is to move forward in providing an explanation of the effect of experience on the perceptions practitioners have about ChaRef. While correlation does not establish causation, there is nonetheless an indication that the least experienced practitioner disagree more in their rankings compared to the sample mean (with more contrast in surface area under the plot graph) compared to practitioners with more experience. This rather tentative and cautious observation is endorsed by Figures 4.13 and 4.14 respectively.

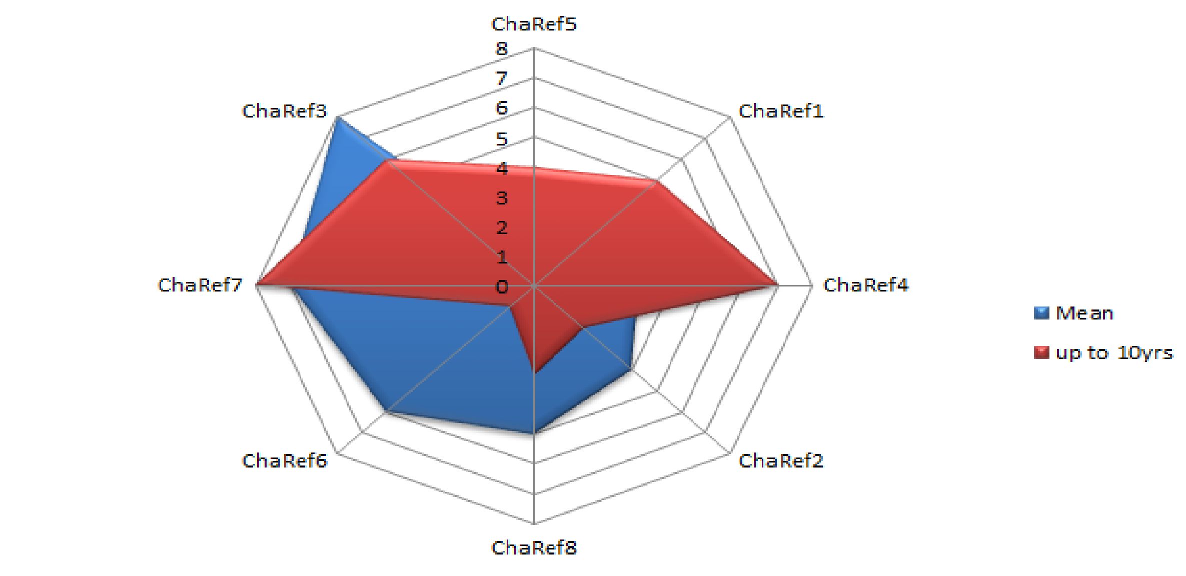


Figure 4.13: Radar graph plot of rank correlation (μ: ≤10yrs)

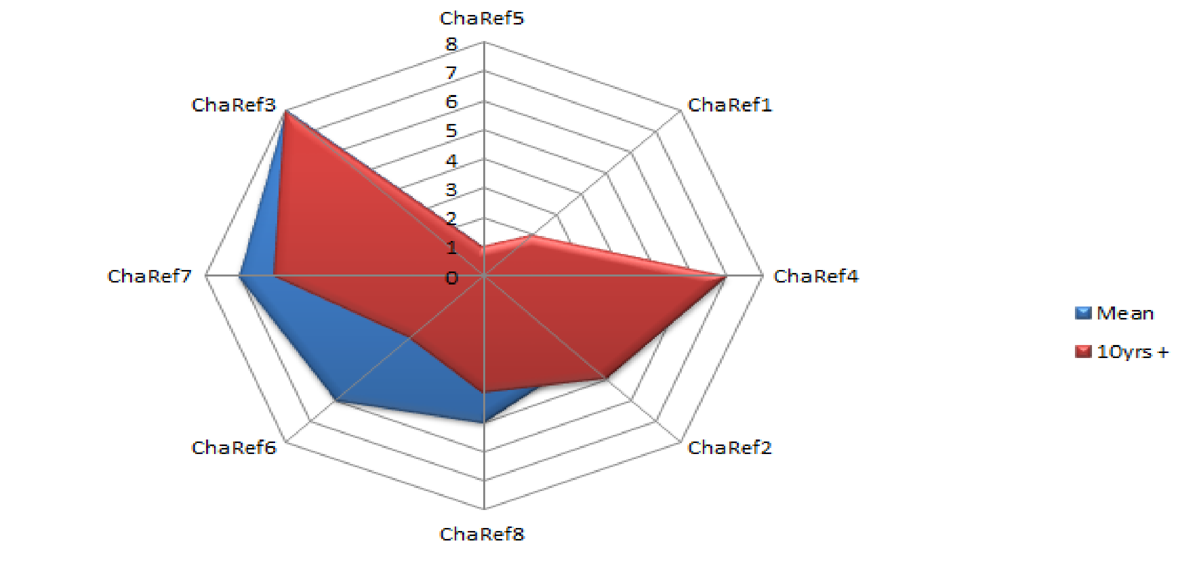


Figure 4.14: Radar graph plot of rank correlation (μ : ≥ 10yrs)

This outcome is rather interesting to the wider objective of this study. The variance between the group certainly warrants intuitive exploration if only to establish the order of the factors which are given more credence within each group. In other words which factors are more appealing to the practitioners with less than ten years refurbishment experience and conversely which factors are relevant to the practitioners with over 10 years of refurbishment experience.

This information is presented in Tables 4.10 and 4.11 with respective occurrence of the need to develop synergy in managing project partners in a refurbishment project a fascination for improved experience for the least experienced practitioners followed by the desire to manage the uncertainty associated with the regular mutation of risks on a refurbishment project. As noted in the two tables below, it would appear that 'risk-transmutation management' is also more pronounced on refurbishment projects than on new build; the corollary being there is need to promote awareness, of its relevance and aptitude to develop strategic tools to help in managing the effects the factor has on the refurbishment process; the potential within refurbishment sector could not be more immediate. Risk in refurbishment projects is the Achilles heel of unsuccessful management of refurbishment projects.

Table 4.10: Rank order of ChaRef by refurbishment experience (0 to 10 yrs)

Factors	Factor description	0 to 10yrs Mean		
ChaRef6	Requires more collaboration between project partners	3.02	1	Synergy in project partnership management
ChaRef2	Requires more expertise	2.91	2	
ChaRef8	More site discoveries as project progresses	2.81	3	Risk-transmutation uncertainty management
ChaRef5	Prone to more accidents	2.67	4	
ChaRef1	Higher risk than an equivalent new-build	2.40	5	
ChaRef3	More complex to design and coordinate	2.37	6	Strategic management of HF&E
ChaRef4	More economic uncertainty	2.00	7	
ChaRef7	More challenges in occupied buildings	1.88	8	

Table 4.11: Rank order of ChaRef by refurbishment experience (10 yrs+)

Factors	Factor description	10 yrs+ Mean		
ChaRef5	Prone to more accidents	3.58	1	Risk-transmutation uncertainty management
ChaRef1	Higher risk than an equivalent new-build	3.34	2	
ChaRef6	Requires more collaboration between project partners	3.26	3	Synergy in project partnership management
ChaRef8	More site discoveries as project progresses	3.10	4	
ChaRef2	Requires more expertise	3.08	5	
ChaRef7	More challenges in occupied buildings	3.04	6	Strategic management of HF&E
ChaRef4	More economic uncertainty	3.01	7	
ChaRef3	More complex to design and coordinate	2.52	8	

This outcome from the two comparative analyses again endorses the earlier observations made when the Health and Safety Executive carried out a surprise crack down on construction sites. They emphasised the fact that refurbishment projects are more dangerous than new build. The 'experience' factors clearly denote that experience counts for a lot in so far as efficient management of refurbishment projects is concerned. However, the two groups are also in agreement about the need for strategic management of the Design and Human Factor Ergonomics peculiar to refurbishment projects.

Ultimately, these observations also appear to corroborate Lam et al (2010) who identified six key performance indicators for building maintenance projects which are:

- Safety;
- Sustainability in terms of environmental friendliness of the project;
- Quality;
- Functionality of the refurbished project;
- Cost; and
- Time.

Unquestionably, safety - magnified by lack of competence on how to manage or control the mutation nature of risks as a project progresses - appears to be an important requirement in refurbishment projects. It must be optimised rather than ignored if refurbishment challenges are to be efficiently confronted with a view to achieving project desired outcomes.

4.10 Effect due to an increased gap in experience on ranking of ChaRef

There are several experiments in the field of psychology that have established the effect of prior experience on performance with Cox and Griggs (1982) emphasising the strength of deductive reasoning and rational choices under stressful conditions as widely varied but consistently rewarding among subjects with more content experience. Cox and Griggs (ibid) have found rational decision making to be heavily reliant on memory-cuing/reasoning-by analogy process and that the acuteness or strength of the derived solutions, whatever the conditions to be resolved - rely much on the prior experience of an individual. They further argue that subjects in general have a tendency to transfer problems in solving strategies from experience of specific or similar conditions. These findings suggest that experience does influence the quality and accuracy of the options taken in problem solving scenarios.

Given the foregoing conclusion: that experience accounts for the differences among refurbishment practitioners in their ranking of ChaRef, the full effects of this factor needed further exploration. A decision was made to stretch the experience-gap of 0 to 10years to 0 to 15 years; the objective being to establish if the study could still arrive at the same conclusion of a presence of a distinct difference in the ranking of ChaRef arising from two groups with differing refurbishment experiences.

In the light of this, does the same level of distinctiveness persist in as far as the ranking of ChaRef factors is concerned? It is anticipated that as the test is based on participants' experience, any variations in ranking of perceived factors must be notable. It is also important to state that a two tail hypothesis was identified aligning with the use of Spearman rank correlation coefficient r_s. As a consequence, the following research hypotheses were identified as follows:

- X refers to practitioners with up to 15 years' refurbishment experience (Independent variable, IV_1);
- Y refers to practitioners with over 15 year's refurbishment experience (Independent variable, IV_2).

Accordingly the hypotheses were identified as follows based on the Spearman ranks correlation formula below and the resulting mean values presented (procedurally as before) in Table 4.12.

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Null Hypothesis:

H_0: There is no relationship between the two sets of practitioners in the ranking of ChaRef factors relative to refurbishment experience;

Alternative Hypothesis:

H_1: There is a relationship between the two sets of practitioners in the ranking of ChaRef factors relative to refurbishment experience.

Table 4.12: Comparison of rank order on ChaRef based on refurbishment experience

N = 133 Factors	Mean	*R(x) up to 15 yrs* *n = 91*	Rank (X)	*R(Y) 15 yrs+* *n = 42*	Rank (Y)	*(d)*	d^2
ChaRef5	3.33	3.58	1	3.69	1	0	0
ChaRef1	3.29	3.44	2	3.62	2	0	0
ChaRef4	3.20	3.12	3	3.55	3	0	0
ChaRef2	3.06	2.93	5	3.28	5	0	0
ChaRef8	2.94	2.41	7	2.95	6	1	1
ChaRef6	2.86	2.73	6	2.55	7	-1	1
ChaRef7	2.60	2.40	8	2.40	8	0	0
ChaRef3	2.18	3.08	4	3.45	4	0	0
							$\sum d^2 = 2$

Table 4.12 therefore, presents the results of the analysis based on research participants' refurbishment experience. Using the computation value in the formula:

$$r_s = 1 - \frac{6(2)}{8(8^2-1)} = 0.976$$

At a significance level of α = .05 where n = 8. Procedure is to reject the null hypothesis (H_0) if $\boldsymbol{r_s} > \mathbf{0.738}$ as obtained from Appendix E-1 as before described. The value of $\boldsymbol{r_s} = 0.976$ exceeds the Table value of 0.738 leading to the rejection of the null (H_0) and conclusion that there is sufficient evidence of a positive and higher correlation coefficient. This outcome reinforces the prevailing knowledge that experience positively engages quality and improved performance of practitioners. Indeed the scatterplot in Figure 4.15 and 4.16 respectively suggest a very close positive association arising from the increase in the experience of practitioners in each group.

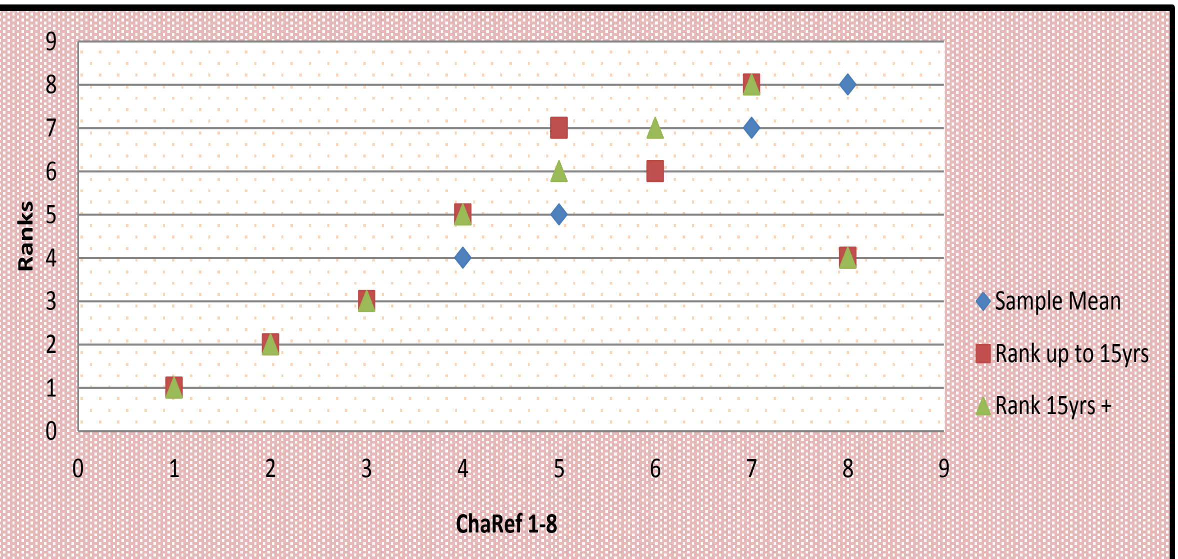


Figure 4.15: Scatterplot of ranks on ChaRef by experience (≤15:≥15years)

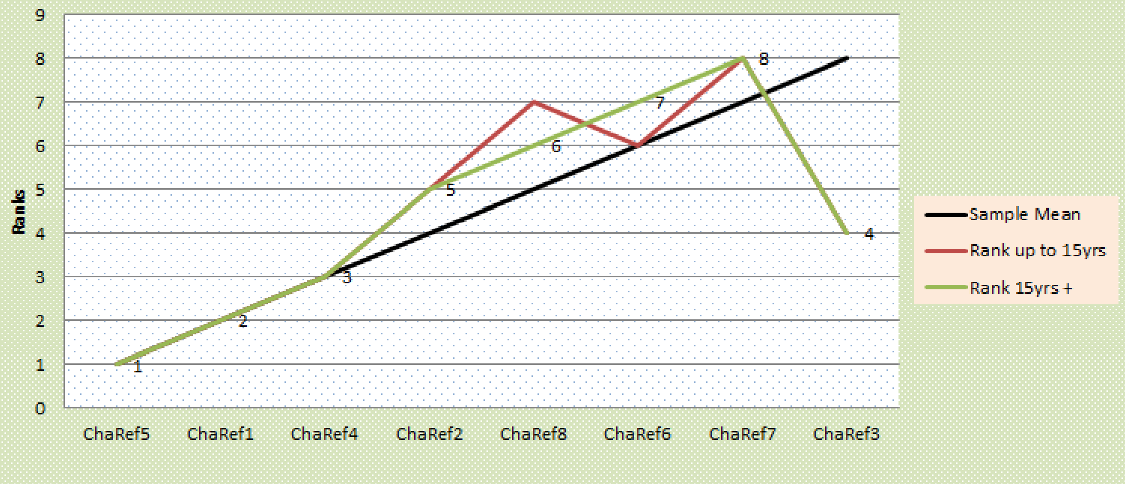


Figure 4.16: Rank correlation on ChaRef relative to mean by different levels of experience

The study has therefore been rewarded by the decision to widen the experience gap in that while the previous groups showed a weak relationship, the intuitive decision to allow for the widening of the experience gap has yielded a positive outcome: there is greater agreement between the experienced practitioners. Figure 4.17 magnified the close match in perceptions between the 'up to 15years experienced practitioners and those in the 15years and over group. The extent of correlation (closeness in the ranks) is vivid to see.

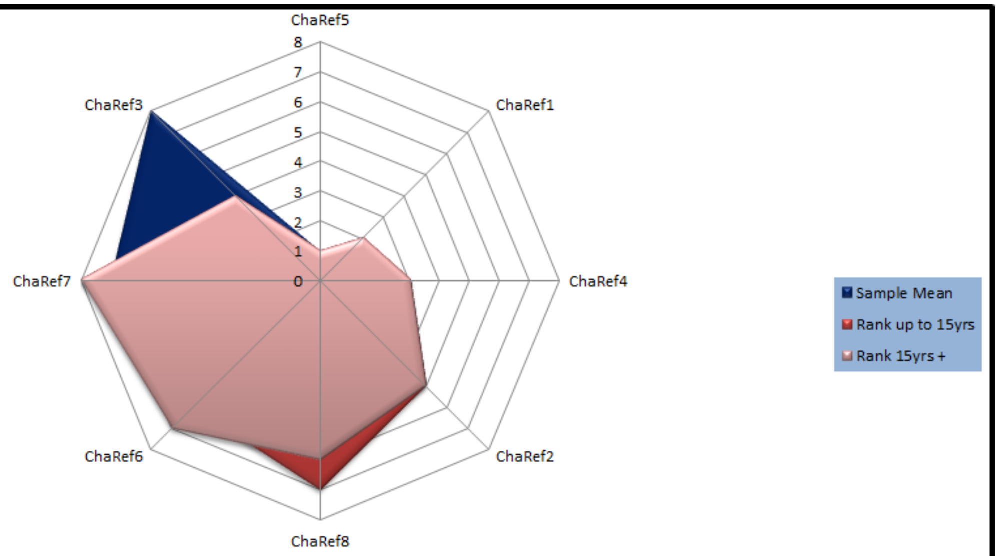


Figure 4.17: Radar graph of rank on ChaRef relative to sample mean and refurbishment experience

Therefore the proceeding conclusions, as summarised in Tables 4.13 and 4.14 with respect to the implied effect of experience on performance is that this factor brings out the peculiarity embedded within management related themes namely:

- The case for manager to be Priskaver: practitioners must be predisposed to risk;
- Strategic design management: that design has to interact and lead the refurbishment process;
- Synergy and experience in partnership management because many entities come together with interest in a project. This is often a recipe for confusion, mistakes and only experience can see a manager overcome such demands efficiently;
- Refurbishment projects are driven by the desire to renovate urban city-centres which after all, are the hubs for economic generation. However these spaces bring about challenges in running and managing site logistics.

Table 4.13: Description of characteristics of typical refurbishment schemes

Factors	Factor description	Up to 15yrs		Implied term
ChaRef5	Prone to more accidents	3.58	1	
ChaRef1	Higher risk than an equivalent new-build	3.44	2	Pro-Priskavers
ChaRef4	More economic uncertainty	3.12	3	Strategic design
ChaRef3	More complex to design and coordinate	3.08	4	management
ChaRef2	Requires more expertise	2.93	5	Synergy & experience of
ChaRef6	Requires more collaboration between project partners	2.73	6	Partnership Management
ChaRef8	More site discoveries as project progresses	2.41	7	Adoitness in site
ChaRef7	More challenges in occupied buildings	2.40	8	Logistic Management

Table 4.14: Description of characteristics of typical refurbishment schemes

Factors	Factor description	15yrs+	Rank	Implied term
ChaRef5	Prone to more accidents	3.69	1	
ChaRef1	Higher risk than an equivalent new-build	3.62	2	Pro-Priskavers
ChaRef4	More economic uncertainty	3.55	3	Strategic design
ChaRef3	More complex to design and coordinate	3.45	4	management
ChaRef2	Requires more expertise	3.28	5	Experience &
ChaRef8	More site discoveries as project progresses	2.95	6	Dexterity in PM
ChaRef6	Requires more collaboration between project partners	2.55	7	Synergy in project
ChaRef7	More challenges in occupied buildings	2.40	8	Partnership Management

It would seem logical, given the foregoing findings that refurbishment projects do require a different management approach compared to say new build. They generate more uncertainty, and are risky to manage. The risks mutate rapidly, and there are hidden dangers looming in the activities associated with piecemeal dismantling or wholesale demolition. In order to mitigate the secondary effects and unintended consequences of elements collapsing unexpectedly which are characteristics of old buildings. It is for these reasons that refurbishment projects demand increasing knowledge of building management. Taking a particular type of buildings into account: historical or heritage assets may be crumbling monuments, yet they may have to be handled without introducing further secondary failures. The skills - embedded in say façade retention schemes - are no match to the skills required in building or managing more straightforward new build projects.

4.11 Summary

This chapter set to explore the prominent factors which are perceived as typical characteristics of refurbishment projects. The chapter presented the ranking of eight factors perceived to be typical characteristics of refurbishment projects. The ranking order of these factors was considered fully and further grouped into three factors. The groups were also given an implied meaning based on members of each group as follows:

- Risk transmutation uncertainty;
- Adroitness towards incipient plasmolysis; and
- Design and human factor ergonomics (HF&E).

These groups of items were ranked from one to eight hence, their importance in refurbishment was discussed and supported by literature. Out of the eight ranked factors, the top three also reflected the most important issue of this research in terms of risk and uncertainties. Generally, what all refurbishment projects share in common is a greater risk profile than an equivalent new-build project. Perhaps as already identified, refurbishment projects are said to contain more risk than new-build and indeed individual risk or a combination of the risks may jeopardise the achievement of project desired outcomes.

The challenge imposed by uncertainty in terms of budget and estimate is also highlighted among the top three ranked characteristics of a refurbishment project. The occurrence of large variation orders to a project mainly due to the unknown nature of a building to be refurbished has been identified as a source of cost and time overruns hence, this usually requires a higher level of contingency for the purpose of the increased risk of unforeseen costs associated with the schemes and in order to deal with any unexpected difficulties. The fact that managing refurbishment undertaken is done under greater uncertainty mainly due to insufficient and incomplete information and also under changing conditions means that a flexible approach must be adopted.

The importance of tripartite cooperation and collaboration between project partners especially the designers, clients and contractors is also highlighted in the findings as a characteristic of typical refurbishment schemes.

The next chapter will further evaluate and analyse quantitative data generated from question 10 and 11 respectively in order to identify factors which contribute to quality of refurbishment works and factors which act as barriers to achieving quality of refurbishment works.

CHAPTER FIVE

Factors which contribute to quality of refurbishment works and barriers to achieving quality of refurbishment works

5.1 Introduction

This chapter examines the factors perceived to contribute to high quality refurbishment works (abbreviated throughout as QuaRef) as ranked by refurbishment practitioners captured within the study sample. It follows on from the previous chapter which examined the factors that define the characteristics of refurbishment projects. Thus having established the notable characteristics of refurbishment schemes, it is logical for the study to investigate which factors contribute to high quality refurbishment works. As project managers would normally be expected to focus on the critical aspects of a project that bring about quality outcomes, it is essential to generate an inventory of factors that contribute to the success of refurbishment projects.

The exploratory methods deployed are based on the application of non-parametric statistical techniques such as Spearman's rank correlation coefficient, analysis of variance in the form of Kruskal-Wallis as well as the test for independence using the Mann-Whitney test. These statistical techniques enable the study to uncover a wide range of factors that contribute to the success of refurbishment projects as well as those likely to hinder achieving high quality outcomes from refurbishment projects.

The information generated will inform clients as well as practitioners associated with the renovation and restoration of heritage assets. New project managers in the refurbishment sector should also benefit from the findings in that they can use the information herein to inform their management strategies. Perhaps, it should also be noted that understanding the benefits of consensual ranking will help to provide the study with some conclusions in relation to the research objectives. Based on the literature evidence thus far (Climate Change Act, 2008; GVAGrimley, 2010; Gorse and Highfield, 2009), it would appear that the majority of buildings within England pre-date the emergence of modern concepts of sustainable development. The increasing number of these obsolete buildings is as a result of the global demand for improved interior comfort within existing buildings. In the UK therefore, the case for indoor quality, comfort of existing buildings and functional performance are all driven by the desire to ensure buildings meet the demands of the users and the wider society. These themes have gained much recognition and attention leading to the implementation of the Climate Change Act (2008). With this in mind, Gorse and Highfield (2009) and GVAGrimley (2010) have been quick to remind those interested in the refurbishment sector about the increasing demand for sustainable energy efficient buildings from both regulators and occupiers perspectives.

Indeed, from the public sector perspective, there is growing pressure to meet current targets for zero carbon buildings by improving aged buildings to current standards. Therefore as regards refurbishment and retrofitting, the situation is one of continuing national debate about improving the indoor comfort and quality of existing buildings but for this to happen construction has to have managers that are predisposed attaining quality outcomes that maximise the comfort of the end users.

5.2 Significance of factors impacting on quality of refurbishment works QuaRef

The decision to refurbish a building is made when a building is deemed unfit for purpose in its present form. This often involves identifying the most deteriorated parts of the building. This process also uncovers the extent of works to be undertaken in terms of scope, specification, quality of materials and standard benchmarks agreed upon to guide the refurbishment process. Using the above criteria eight factors were identified (as shown in Table 5.1) from the pilot stages; the final list therefore comprises factors which may be significant in contributing to the quality-success of refurbishment works. The list helps to crystallise those factors that define refurbishment success: they relate to managing design, quality, safety, cost, structural defects, personnel, site logistics, plant machinery, planning and scheduling of work. These were therefore redefined using descriptors against which the respondents would provide a rank value based on a Likert scale of 0 to 4, where 0 = very insignificant 1 = insignificant; 2 = undecided; 3 = significant and 4 = very significant. It follows therefore that in Table 5.1, high mean values reflect greater impact on the quality of refurbishment success.

Table 5.1: Description of factors which contribute to high quality refurbishment works

Factors	Description	Mean
QuaRef1	Access and space	3.22
QuaRef2	Knowledge of structural defects	3.37
QuaRef3	Tripartite cooperation between clients, designers and contractors	3.44
QuaRef4	Avoidance of unrealistic time pressures	3.12
QuaRef5	Experience of type of work	3.28
QuaRef6	Appropriateness of designs	3.34
QuaRef7	Accuracy and reliability of estimates	2.94
QuaRef8	Effective quality control procedures	2.57

Table 5.1 shows the resulting rank order as discerned at the aggregate level. Perhaps as expected, in their own experience the factors at the top of Table 5.2 are discerned to be 'very significant' whereas any factors at the bottom of the table have less impact in achieving high quality refurbishment works but not necessarily insignificant. Table 5.2 depicts the implied definitions summarised under three headings. These are outlined in turn.

Table 5.2: Ranking of factors which contribute to high quality refurbishment works

Factors	Description	Mean	Rank	Implied term
QuaRef3	Tripartite cooperation between clients, designers and contractors	3.44	1	Cooperation and adeptness towards structural defects
QuaRef2	Knowledge of structural defects	3.37	2	
QuaRef6	Appropriateness of designs	3.34	3	Design, access and skills constraints
QuaRef5	Experience of type of work	3.28	4	
QuaRef1	Access and space	3.22	5	
QuaRef4	Avoidance of unrialistic time pressures	3.12	6	
QuaRef7	Accuracy and reliability of estimates	2.94	7	Cost and quality uncertainty
QuaRef8	Ineffective quality control procedures	2.57	8	

5.3 Outline of the rank order of QuaRef factors

5.3.1 Adeptness with diagnosis of structural defects: Since the primary objective is to identify the rank order and thus the influence of the factors which impact on the quality of refurbishment outcomes, it can be concluded from Table 5.2 that tripartite cooperation (QuaRef1) as well as adeptness in the diagnosis of structural defects (QuaRef2) are the most significant determinants of quality outcomes in refurbishment projects. This outcome appears to endorse the fact that in any refurbishment scheme, the collective input of duty holders on a project is critical to achieving the ultimate quality expected of any refurbishment project. This comes as no surprise as Zavadskas et al (1998) have placed high credence on the relevance of understanding building defects at the inception stages of the refurbishment brief. It is rare that the need to modernise or retrofit a building is required for cosmetic reasons other than that the building may be derelict to a point where the original structural performance is either lost or completely diminished or waned. As regards, cooperation between project partners Figure 5.1 depicts the fact that it is equally important to make reference to the legal position imposed on refurbishment managers. When this happens, understanding the defects responsible for structural deterioration of a building is an indispensable dimension to achieving quality refurbishment.

Similarly, both GVAGrimley (2010) and Rawlinson and Wilkes (2008) emphasised the importance of understanding the condition of an existing building by investigating the quality of original construction, wear and tear as well as the constraints arising from the condition of the building fabric. This view is a reverberation of Zavadskas *et al.* (1998) who opined that the extent of deterioration of a building proposed for refurbishment should be investigated properly before any informed decision can be made as to viability of the project and contract strategy.

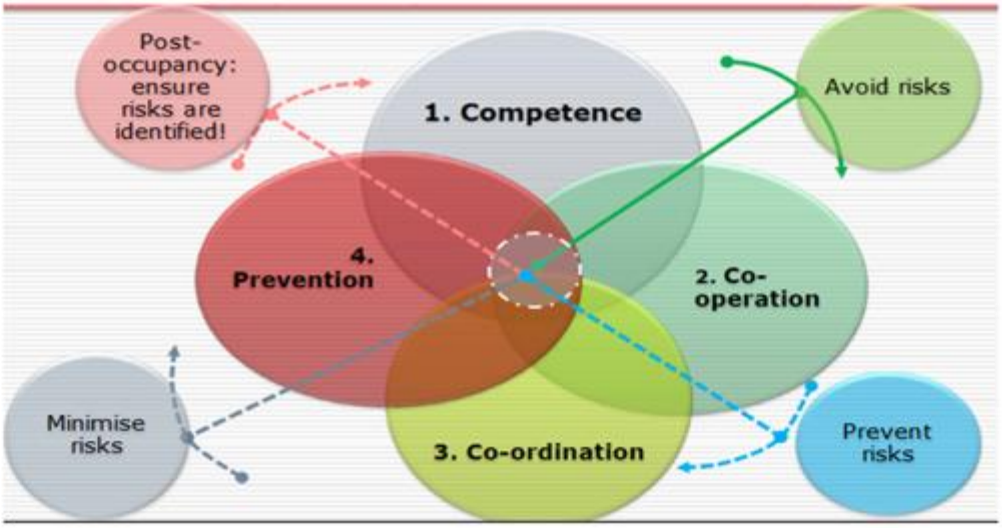


Figure 5.1: General management requirement of project managers under CDM 2007
(Source: Kangwa, 2014)

CDM 2007 regulations demand that there is close cooperation and coordination between the project partners in order to minimise disputes and enhance effective project delivery within cost and time constraints. For example, the CDM (2007) regulations 5 and 6 require co-operation and co-ordination between the project team members especially on projects which are exposed to high risks such as refurbishment involving partial or complete demolition. In this case a more demanding approach to competence is required. This should help clients in ensuring that those appointed are competent and well-resourced to plan, cooperate and coordinate projects effectively in order to manage the effects of any anticipated risks and associated refurbishment challenges presented by a building project.

5.3.2 Design access and skill constraint: The second most fundamental factor to achieving quality refurbishment is 'Design'. It is clear from Table 5.2 that based on refurbishment experience there is unanimity among practitioners of the role of design in achieving high quality refurbishment outcomes. It is certainly the case that if one follows the **ERIC Principle (HSE 2014)** shown in Figure 5.3 that designers have the foremost opportunity to eliminate any risks and challenges associated with a refurbishment project by allowing the input of other duty holders, especially that of the principal contractor. As depicted in Figure 5.2 the basis of the **ERIC** principle is to ‘**Eliminate**’ hazards and the resulting risk from a design. Where this is not possible then designers should **‘Reduce’** the effect of any ensuing risks by having to ‘**Inform’** other duty holders especially in relation to any residue risks. In sharing such information collectively, all duty holders can put into place ‘**Control’** measures to eliminate or manage the associated risks.

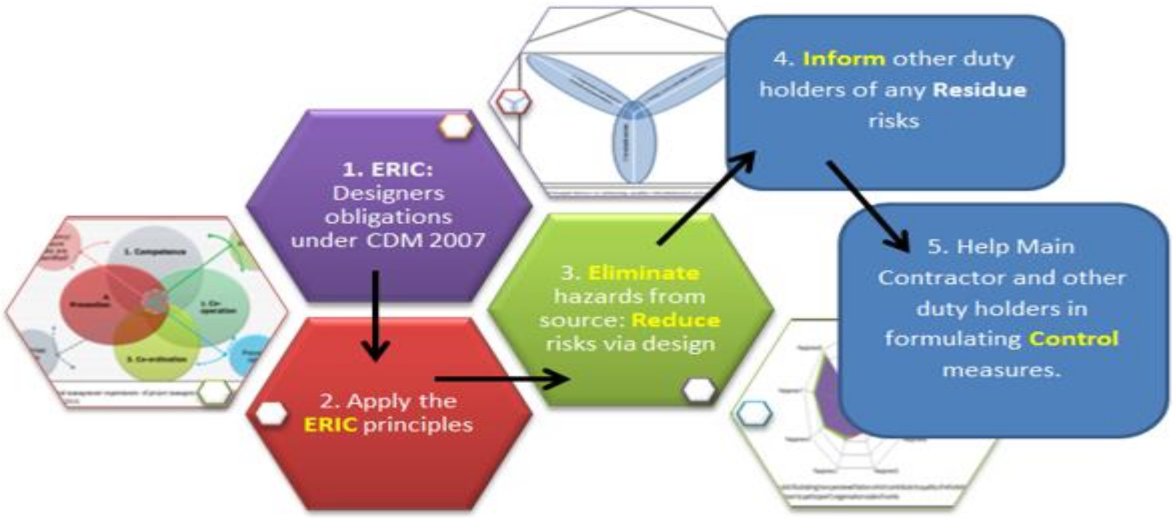


Figure 5.2: Design and its role in management of residue risks using the ‘Eric Principle’

The above information would seem to reinforce the HSE publication about ‘CDM 2007 in practice’ which implores the designer to communicate his ideas with other duty holders so that any design constraints are resolved with the collective input of all duty holders. Where any risks are difficult to ‘design-out’ these are referred to as residual risks. CDM imposes requirements on the designer to communicate and inform other duty holders – including the client. Figure 5.2 shows the important role that a designer has to play in the management of a refurbishment project. The figure reinforces earlier observations that duty holders must always cooperate and coordinate their activities in order to achieve the best outcome of a refurbishment project.

5.3.3 Cost and quality uncertainty: Table 5.2 has two factors at the bottom as the lowest ranked factors namely: 'accuracy and reliability of estimates' (QuaRef7) and 'ineffective quality control procedures' (QuaRef 8). Research findings by Rawlinson and Wilkes (2008), and GVAGrimley (2010) further suggest, that 'ineffective quality control procedures' (QuaRef8) have a profound effect on refurbishment success. This factor is ranked 8, at the bottom of the Table. This outcome is rather surprising however it also implies that practitioners underplay the impact that ineffective quality control has on the ultimate success of refurbishment projects. Practitioners having to exhibit lack of quality control would also be less predisposed to risk and therefore likely to subject other project members to risks and no doubt over a long and shorter term can also compromise the refurbishment quality of a building for which they are responsible.

Furthermore, the poor receptiveness to quality control appears to contradict the position taken by many in the field of refurbishment, for instance, NRM3 (2012) devoted an entire research publication to highlighting the extent to which 'ineffective quality control procedures' can subvert the smooth running of a refurbishment project and result in losses to the client or end user. Intermediate to the principle of quality management, Kangwa and Olubodun (2009) also established that although most refurbishment schemes take place in busy city centre locations - where space comes at a premium - quality control issues are similarly one of the factors refurbishment project managers are more likely to be concerned with. Indeed, Serpell and Alarcon (1998) also established that quality performance in projects stood out as an important multiplier function whose success is driven by the satisfaction projected by projects underwritten by repeat-clients. The only explanation that can be offered to justify the relatively low ranking by this study's sample is that as explained by Egbu (1995) quality control and lack of attention to risk management issues during small-scale refurbishment works are among the most challenging factors project teams struggle to resolve. Suffice to say smaller contractors have a skeletal management structure and might not afford well experienced and adequately trained refurbishment managers as these often attract heavy operating costs. Thus by and large refurbishment projects are the most dangerous projects.

5.4 Establishing extent of unanimity in the ranking of QuaRef

The previous section identified the order and importance placed on factors perceived to impact on refurbishment outcomes. This section will examine how refurbishment practitioners compare in their ranking of the factors identified above. In order to do this effectively, the extent of agreement among the practitioners with varying levels of refurbishment experience and how they compare in the ranking of factors which they perceive as critical to achieving high quality refurbishment outcomes will be investigated. The study will split the participants into two groups: practitioners with less or equal to 15 years of refurbishment experience in one group and those with over 15 years in another. The objective is to establish whether refurbishment experience influences the perception practitioners have about the factors critical to high quality refurbishment outcomes (QuaRef).

5.4.1 Rank correlation on QuaRef relative to refurbishment experience

In an attempt to ensure the study is able to investigate the effect of refurbishment experience on the perceived factors to high quality refurbishment outcomes, hypotheses had to be stated using a two-tailed approach as shown below in Figure 5.3.

- X is for ranks of practitioners with up to 15 years refurbishment experience;
- Y is for ranks of practitioners with over 15 years refurbishment experience.

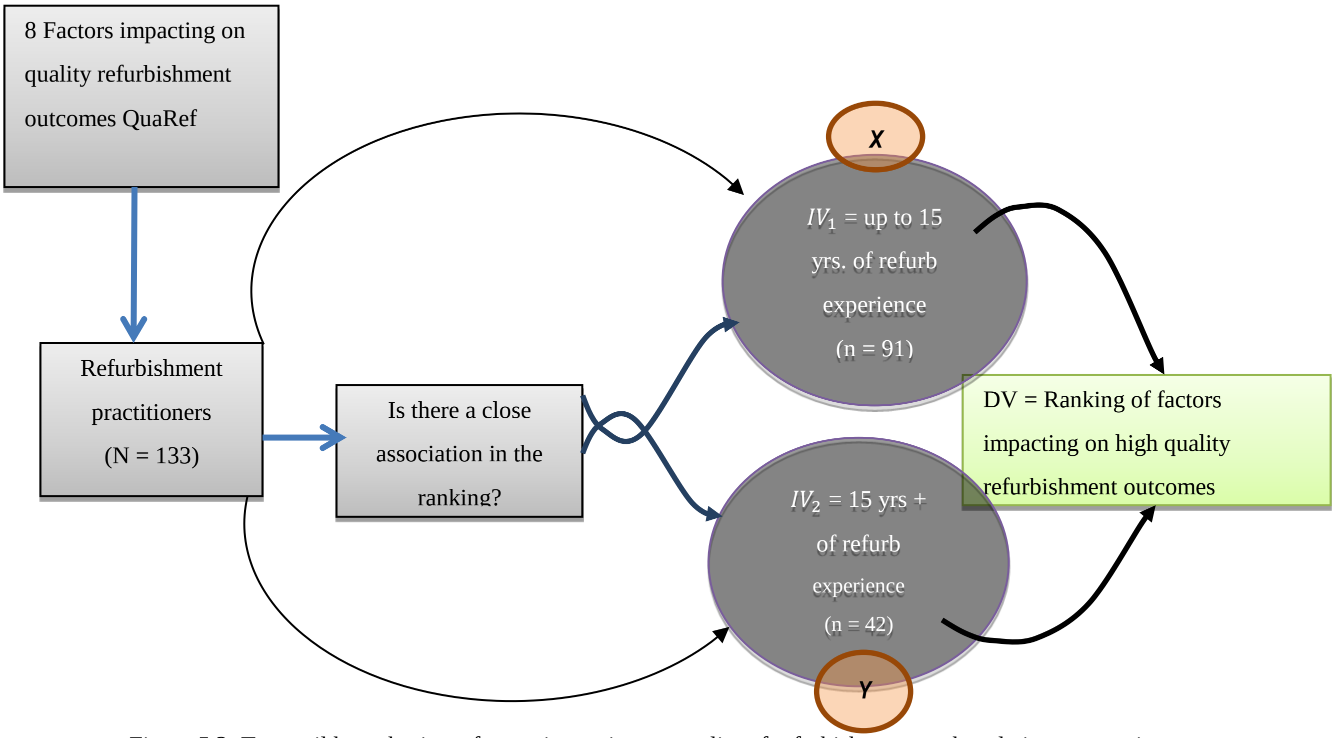


Figure 5.3: Two–tail hypothesis on factors impacting on quality of refurbishment works relative to experience

The following Null hypothesis and Alternative hypothesis are identified, namely:

Null Hypothesis:

H_0: No association in the ranking of QuaRef exists between the two groups of practitioners.

Alternative Hypothesis:

H_1: There is association in the ranking of QuaRef between the two groups of practitioners.

In order to explore any association in the ranks provided by heritage practitioners, the study will use Spearman test for rank correlation. The test is to establish whether large values of QuaRef ranks are those of practitioners with less than fifteen years of work experience or those with over 15years and above of refurbishment experience. The Whole Building Design Guide (WBDG, 2012) has hinted that the period it takes for a project manager to acquire full adroitness in handling multiple phases shown in Figure 5.4 of a project is nearly ten years.

Figure 5.4: Skillset attributes of a refurbishment manager (WBDG, 2012)

Accordingly, the sample for this part of the study had to be split on this basis. This constraint informed the choice of Spearman's (r_s) rank correlation coefficient test, as the most appropriate measure of how well practitioners with characteristics of X (n = 91) and Y (n = 42) (see Table 5.3 below) agreed in the ratings they enlisted to the eight QuaRef factors. As in the previous chapter, the Spearman rank correlation coefficient is given by the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where:

- n is the aggregate mean numbers; n is the total number of ranking for each group;
- d is the difference between X and Y ranks given as: R(*X*)-R*(Y);*
- r_s is the Spearman's rank correlation which measure the extent of linear agreement between X and Y variables.

Table 5.3 therefore, presents the results of the analysis of the groups based on refurbishment experience. The Table also presents the Mean values of QuaRef between the two independent variables by arranging the values in descending order and according to the rank order determined earlier in Table 5.2 against the aggregate sample N = 133.

Table 5.3 Comparative ranking of factors which contribute to high quality refurbishment works by experience

	N = 133	n = 91 up to 15 Yrs		n = 42 15 Yrs +			
Factors	Mean	X	*R(X)*	Y	*R(Y)*	*d*	d^2
QuaRef3	3.44	3.44	1	3.45	1	0	0
QuaRef2	3.37	3.37	2	3.36	2	0	0
QuaRef6	3.34	3.34	3	3.33	3	0	0
QuaRef5	3.28	3.28	4	3.27	4	0	0
QuaRef1	3.22	3.22	5	3.20	5	0	0
QuaRef4	3.12	3.12	6	3.12	6	0	0
QuaRef7	2.94	2.94	7	2.94	7	0	0
QuaRef8	2.57	2.57	8	2.55	8	0	0

$\sum d^2 = 0$

The test of hypothesis, is based on a Spearman rank correlation of r_s which is set at significance level of α = .05 where n = 8. The value obtained from the two-tailed test Table in Appendix E-2; the table contains the critical values of Spearman's rank correlation coefficients. Accordingly, using the derived sum of the squared difference in Table 5.3, the Spearman rank correlation as calculated from equation below gives an r_s correlation value of 1, denoting a perfect agreement.

$$r_s = 1 - \frac{6(0)}{8(8^2 - 1)}$$

$$r_s = 1 - \frac{0}{504}$$

$$\boldsymbol{r_s = 1}$$

As the test statistic follows a critical Table value of the Spearman's rank correlation coefficient of (α) 0.05 and given as above $\boldsymbol{r_s} = 1$, the study proceeds to conclude that the computed Spearman's rank correlation coefficient of 1 far exceeds the Table value of 0.738. As a consequence, the study proceeds to reject the Null (H_0) in favour of the alternative (H_1) hypothesis, implying the two sets of practitioners are inseparable. As the pairwise ranks generates a perfect linear relationship this would suggest - as further endorsed by Figure 5.6 below - that in so as far as refurbishment experience is concerned, identifying which factors impact more on the quality outcomes and refurbishment success is not dependent of the experience a refurbishment manager has.

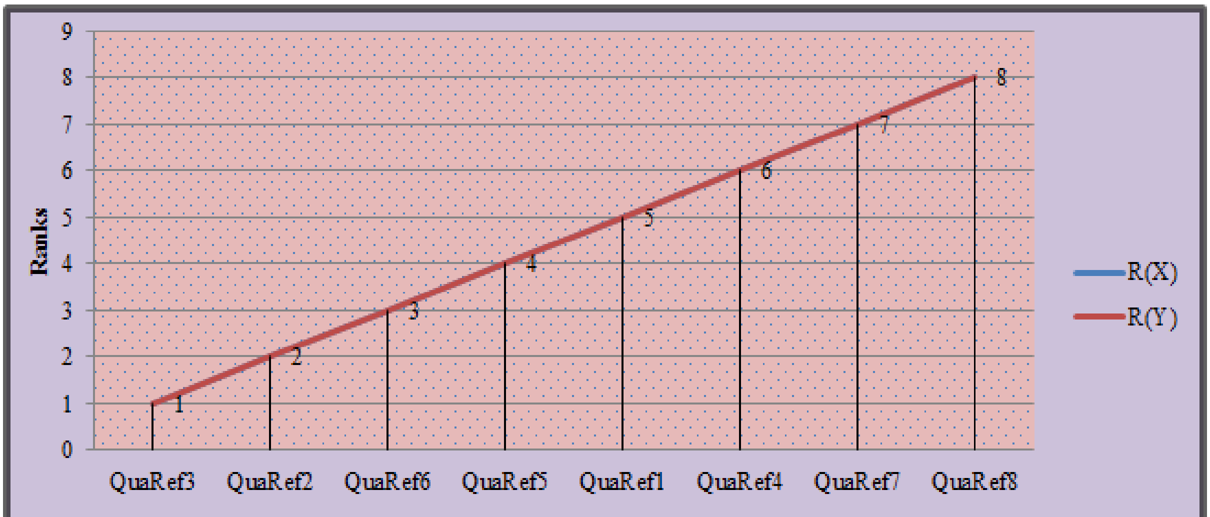


Figure 5.5: Scatterplot of factors which contribute to high quality refurbishment works (QuaRef 1-8)

This outcome although unexpected, would seem to indicate that refurbishment managers in either group are able to identify the factors that determine the standard of what is achieved during the refurbishment of a building. The outcome also appears to corroborate the position taken by the WBDG (2012) that experience, as a factor in making refurbishment decisions. Conversely, this outcome can also be seen in a positive light, it is tempting to opine that because of variance in the level of activities and the multifaceted nature of refurbishment activities in Figure 5.4, the individual managers who stay working in industry develop a skillset that improve how perform when handling all the technical challenges, risks and the multifarious elements associated with project- management of refurbishment schemes.

5.5 Barriers to achieving high Quality refurbishment works (BarQuRef)

In order to establish the magnitude of each of the barriers to successful refurbishment of existing buildings, the industry practitioners were prompted to respond by stating the extent to which they agreed or disagreed that the factors provided actually act as barriers to achieving high quality refurbishment works. Using a Likert scale (as explained in the earlier sections of this study) scores ranged from 0 = strongly disagree; 1 = disagree; 2 = undecided; 3 = agree to 4 = strongly agree was generated. The respective mean scores are shown in Table 5.4.

Table 5.4: Description of perceived barriers to achieving high quality refurbishment works

Factors	Description	Mean
BarQuRef1	Lack of information on past repair and maintenance works	2.52
BarQuRef2	Lack of funds	3.16
BarQuRef3	Dealing with tenants in occupied buildings	2.92
BarQuRef4	Design uncertainties	3.12
BarQuRef5	Difficulty in determining the extent of deterioration	2.98
BarQuRef6	Unrealistic time pressures	3.08
BarQuRef7	Lack of expertise to manage the challenges of the schemes	2.83
BarQuRef8	Restriction on extent of work when dealing with listed uildings	2.11
BarQuRef9	Difficulty in determining accuracy of contingency	2.23
BarQuRef10	Variation to works	2.39

5.6 Aggregate interpretation of the resulting ranks on BarQuRef

Table 5.5 presents the aggregate ranking of perceived barriers to achieving high quality refurbishment works by the practitioners. Those at the top received highest scores and have more bearing on the success of refurbishment projects. Equally, factors at the bottom of the table are collectively perceived to have the least impact albeit still making the top ten of issues that come in the way of efficient and successful refurbishment.

Table 5.5: Ranking of perceived barriers to achieving high quality refurbishment works

Factors	Factor description	Sample Mean	Rank	Implied term
BarQuRef2	Lack of capital	3.16	1	Cashflow, Design & Time uncertainties
BarQuRef4	Design uncertainties	3.12	2	
BarQuRef6	Unrealistic time pressures	3.08	3	
BarQuRef5	Difficulty in determining the extent of deterioration	2.98	4	Adroitness in incipient defects plasmolysis
BarQuRef3	Dealing with tenants in occupied buildings	2.92	5	Operational uncertainty
BarQuRef7	Lack of expertise to manage the challenges of the schemes	2.83	6	
BarQuRef1	Lack of information on past repair and maintenance works	2.52	7	Uncertainty of scope of works
BarQuRef10	Variation to works	2.39	8	
BarQuRef9	Difficulty in determining accuracy of contingency	2.23	9	
BarQuRef8	Restriction on extent of work when dealing with listed buildi	2.11	10	

However, although the participants' views provided a rank order based on the aggregate mean values, as expected, the top factors were identified and they relate to the four key implied themes as shown in Figure 5.6 and which are discussed in turn as follows:

1. Cash flow, Design and Time constraints:

- Lack of funds (BarQuRef2);
- Design uncertainties (BarQuRef4); and
- Unrealistic time pressures (BarQuRef6).

A review of wider literature corroborates that lack of funds in any development project, be it rehabilitation or new-works, has the potential to jeopardise the success of a project. For example, the NRM3 (2012) identified availability of funds as a possible risk factor in maintenance projects, under the Group Element of: Financial risks. It is certainly the case that any sector within construction responds sensitively to the macro and micro economic issues.

It is therefore, not surprising to find lack of funds referred to as BarQuRef2 came out as rank 1 and at the top of Table 5.5. Capital or cash flow issues will undermine any quality-success of a project and a refurbishment project is not immune or isolated from this.

Another factor at the top of Table 5.5 is **design uncertainties** (BarQuRef4) ranked second. Under the design and installation risks of the NRM3 (2012) design uncertainties was identified as a risk factor in maintenance projects. This is especially the case with major refurbishment projects where constraints imposed by ineffective design co-ordination or soundness of design data of the existing building structure may delay or limit the scope of the major refurbishment works to be carried-out, and if the aim is to achieve a level of performance equivalent to that of new-build lack of information leaves the designer uninformed.

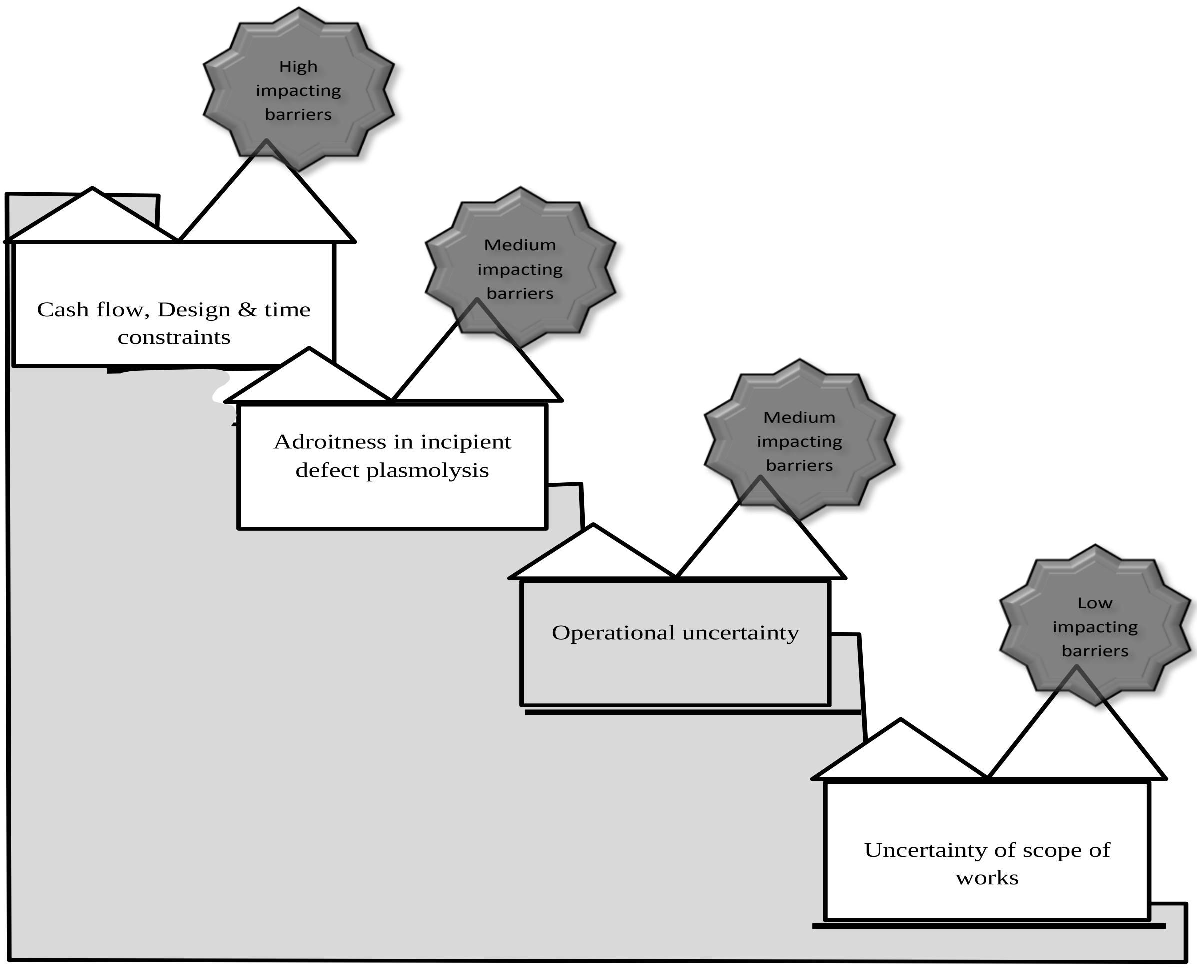


Figure 5.6: Perceived barriers to achieving high quality refurbishment works (BarQuRef)

On the other hand, **unrealistic time pressure** or timeframe (BarQuRef6) was also one of the factors found within the top three factors in Table 5.5. It is however, not surprising to find such a factor perceived as one of the biggest barriers to achieving high quality refurbishment works. As available evidence suggests, time and cost overruns have been acknowledged as the source of disputes in many development projects. This is due in part to the general belief that each and every project is unique and brings with it different challenges. The default setting by some managers is to succumb to setting unrealistic timeframes resulting in cost and time overruns.

2. Contingency and variation constraint

A further look at Table 5.5 shows the last three factors are: **variation to works** (BarQuRef10); **difficulty in determining accuracy of contingency** (BarQuRef5), and **restriction on extent of work when dealing with listed buildings** (BarQuRef8). It is not clear why practitioners would rank these factors at position 8, 9 and 10 in Table 5.5. However, available evidence from literature suggests that variation to original works simply implies that it is impossible to know in advance every issue or challenge that may be encountered when a refurbishment project commences. The only guarantee before actual works begins relates to unplanned items during the process of the works. As a consequence, many examples exist of projects finishing well over budget by enormous amounts and at worse some projects are abandoned even before completion of the works (Lock, 2007). This is mostly due to the inability of project participants to identify and manage risks and uncertainties effectively (Babangida et al., 2012b).

This would suggests that due to unforeseen circumstances in refurbishment works, sometimes changes to original works are instigated as a coping strategy to lack of information. For example, the refurbishment of the famous Savoy Hotel, in London was originally scheduled to take 16 months and estimated at £100m. However, the project ended-up taking nearly 36 months and cost about £220m. According to Kiaran Macdonald (the Managing Director of the hotel):

> *"Our focus was always to restore the Savoy to its former glory and we expected to do that within the £100m budget. But there was only a certain amount of investigative work we could do to ascertain the extent of the work required on the infrastructure while the hotel was still functioning. The opportunity to turn the plumbing off and cut into walls was very limited. We believed we had identified all the problems but once the hotel closed and we started peeling away the layers of the building, its condition was far worse than we had imagined".*

As a consequence of the foregoing, it is hard to understand why BarQuRef10 was ranked 8 in Table 5.5 giving the circumstance which usually leads to variation to works in refurbishment works. The research participants' aggregate view simply suggests that the occurrence of variation to works in any refurbishment project may not be a barrier to achieving high quality refurbishment works.

Another factor which was also found at the bottom of Table 5.5 is BarQuRef9 which relates to the **difficulty in determining accuracy of contingency**. It is also unclear as to why research participants prefer to rank this factor within the last three factors at the bottom of the Table. A review of literature suggests that in any development project this factor is stands out to be an important risk factor. This view corroborates GVAGrimley (2010) who opined that a higher level of contingency may be required to cater for the increased risk of unforeseen costs associated with refurbishment works. Thus, given this level of importance, the outcome is rather surprising.

On the other hand, the factor which was ranked last at the bottom of Table 5.5 is BarQuRef8, relates to the **restriction on extent of work when dealing with listed buildings**, with mean value of 2.11. This outcome is similarly revealing in that working on heritage buildings has its own limitations and one would have expected it higher in the table. Therefore the ranking of BarQuRef8 comes as a surprise but then again this type of work is specialised and still a rare experience for most refurbishment practitioners.

5.7 Exploration of variance in the ranking of BarQuRef

This section of the research explores the extent of agreement among research participants in ranking ten factors initially identified as barriers to achieving high quality refurbishment works (BarQuRef). In an attempt to ensure internal validity, on one part respondents were asked to identify which factors impact on quality of refurbishment outcomes (QuaRef). The data generated hitherto was more useful alongside that generated when isolating the perceived barriers to achieving high quality refurbishment outcomes.

As before described practitioners are split and grouped into two, based on the level of refurbishment experience within the industry as shown in Figure 5.7. The study objective being to detect further whether there is sufficient evidence to suggest that indeed experience does define the variations in the perception of barriers to achieving high quality refurbishment works.

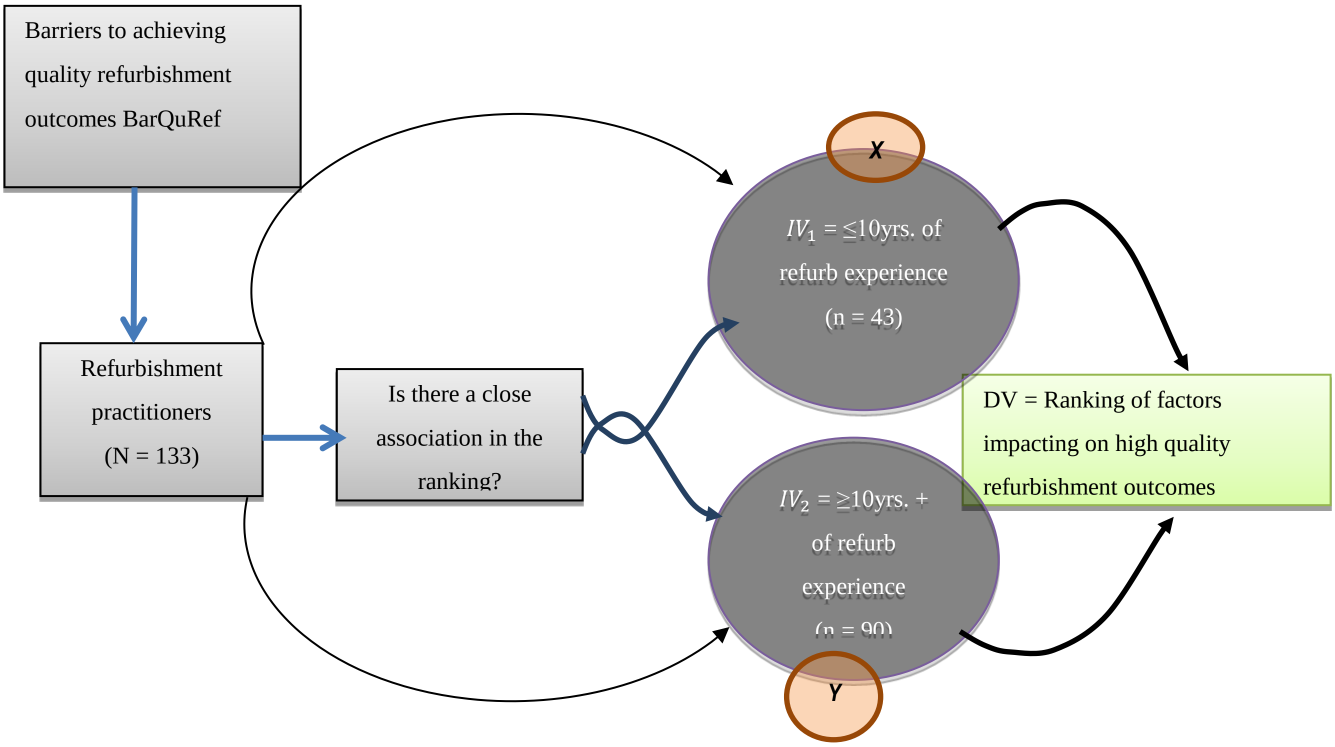


Figure 5.7: Two–tail hypothesis of barriers to quality refurbishment works relative

The first test will be carried-out to establish the extent of agreement relative to refurbishment experience. Spearman rank correlation coefficient r_s as before described will be used to test the two-tailed hypothesis explained as follows:

- X = practitioners with ≤10 years' experience (Independent Variable, IV_1);
- Y= practitioners with ≥10 years' experience (Independent Variable, IV_2).

Likewise, the following Null hypothesis and Alternative hypothesis were identified namely:

Null Hypothesis:

H_0: No association in the ranking of BarQuRef exists between the two groups of practitioners.

Alternative Hypothesis:

H_1: There is association in the ranking of BarQuRef between the two groups of practitioners.

Spearman rank correlation coefficient as measure of extent of agreement will provide the key computation values for the formula and from the r_s computation, the study will determine the extent of linear agreement between X and Y variables. Thus, from Table 5.6 the values are computed into the formula below:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Table 5.6: Ranking of barriers to achieving high quality refurbishment works by experience

	N = 133		n = 43 up to 10 Yrs		n = 90 10 Yrs +			
Factors	Mean	Rank	X	R(X)	Y	R(Y)	*d*	d^2
BarQuRef2	3.32	1	2.84	6	3.36	7	-1	1
BarQuRef4	3.10	2	3.40	4	3.53	4	0	0
BarQuRef6	3.09	3	2.70	8	2.60	9	-1	1
BarQuRef5	2.98	3	3.60	1	3.70	1	0	0
BarQuRef3	2.85	5	2.70	8	3.49	6	2	4
BarQuRef7	2.77	4	2.65	10	2.43	10	0	0
BarQuRef1	2.53	5	3.51	2	3.61	2	0	0
BarQuRef10	2.39	6	3.09	5	3.52	5	0	0
BarQuRef9	2.17	9	2.70	8	3.17	8	0	0
BarQuRef8	1.90	7	3.49	3	3.59	3	0	0
								$\sum d^2 = 6$

$$r_s = 1 - \frac{6(6)}{10(10^2 - 1)}$$

$$r_s = 1 - \frac{6(36)}{990}$$

$$\boldsymbol{r_s = 0.964}$$

As the test statistic follows a critical Table value of the Spearman's rank correlation coefficient of (α) = .05 where n = 10. In addition, the test procedure is ultimately to reject the null hypothesis (H_0) if $\boldsymbol{r_s}$ **>0.648** as obtained from the highlighted section of Appendix E-1 and given as in the computation below the value of $\boldsymbol{r_s}$ = 1, the study proceeds to conclude that a coefficient of 0.964 far exceeds the Table value of **0.648** leading to the rejection of the Null (H_0) in favour of the alternative (H_1) hypothesis; statistically, this implies that the two sets of practitioners are inextricable aligned in their ranking of barriers to high quality refurbishment outcomes. Figures 5.8 and 5.9 and Table 5.10 all confirm that the pairwise ranks generate a very high linear relationship in comparison to the mean value.

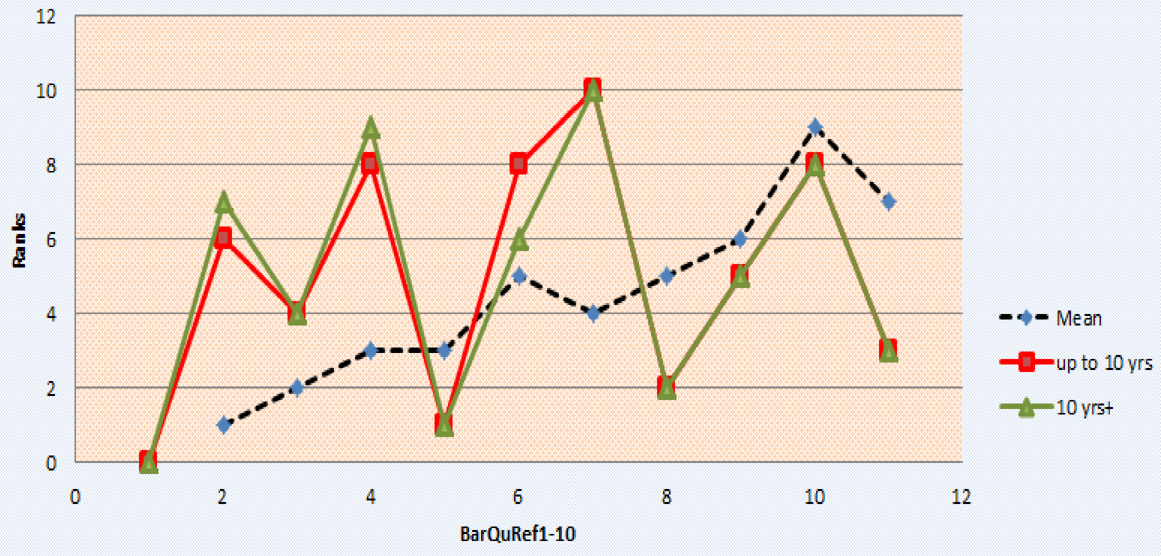


Figure 5.8: Scatterplot of ranking on BarQuRef relative to refurbishment experience

Table 5.7: Comparative rank order based on refurbishment experience

Factors	Mean	up to 10 yrs R(x)	10 yrs+ R(Y)
BarQuRef2	1	6	7
BarQuRef4	2	4	4
BarQuRef6	3	8	9
BarQuRef5	3	1	1
BarQuRef3	5	8	6
BarQuRef7	4	10	10
BarQuRef1	5	2	2
BarQuRef10	6	5	5
BarQuRef9	9	8	8
BarQuRef8	7	3	3

Therefore in so as far as experience is concerned, literature contradicts the study's findings by Cox and Griggs (1982) who presented the fact that experience predicates positively on quality success. With this in mind, the study set off hoping that experience and its relevance to a refurbishment practitioners' knowledge of the barriers to quality-success could not be questioned. It is this acceptance that somehow refurbishment experience must predicate the strategies and quality control measures project managers establish before and during the project. However, the Spearman rank correlation appears to suggest a strong correlation in the ranks and given the high value output of $r_s = 0.964$. On this basis, the study asserts that while experience informs refurbishment quality success, on account of what hinders refurbishment quality-success it is clear that there is unanimity among practitioners in the ranking of the order and severity of ten hindrances, leading to the conclusion that refurbishment success is independent of length of industry experience.

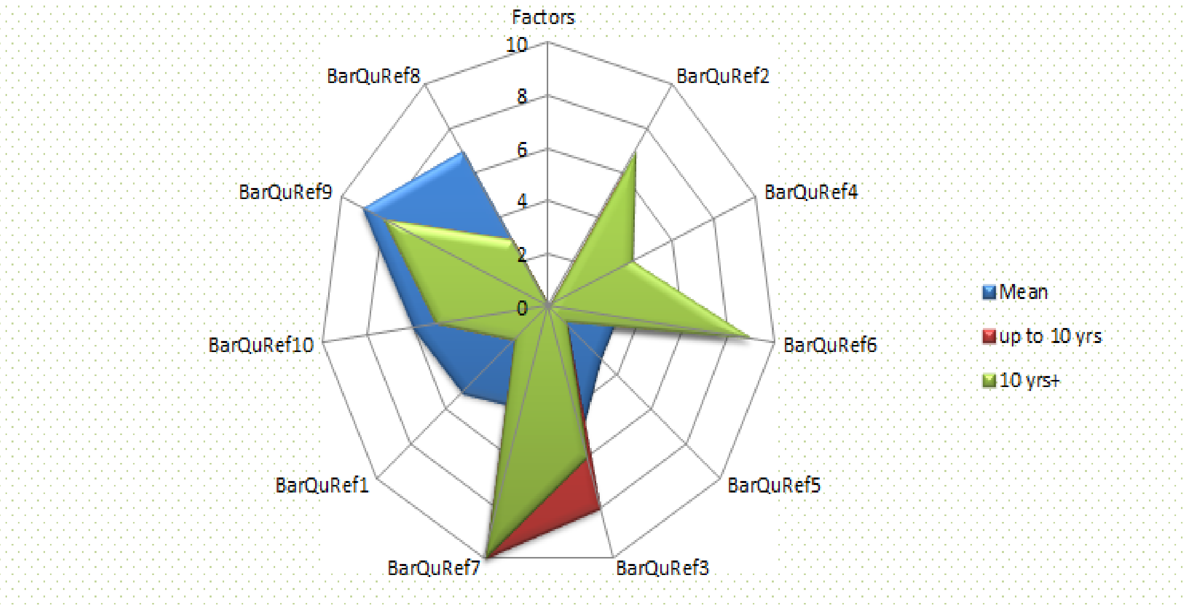


Figure 5.9: Radar graph of ranking of BarQuRef factors relative to refurbishment experience

5.8 Test of Independence in ranking of BarQuRef by experience

The previous section has established a strong correlation in ranking of barriers to refurbishment success (BarQuRef). The study is however, limited in attributing any effect experience may have for the simple reason that establishing a correlation is no evidence of establishing causation. A more robust statistical procedure beyond Spearman rank correlation is the use of Mann-Whitney Test of Independence or Kruskal-Wallis. Mann-Whitney Test was used in the previous chapter. A further affirmation of the effect of experience is reconsidered using the formula for smaller samples - meaning $n_1 \leq 10$ and $n_2 \geq 10$).

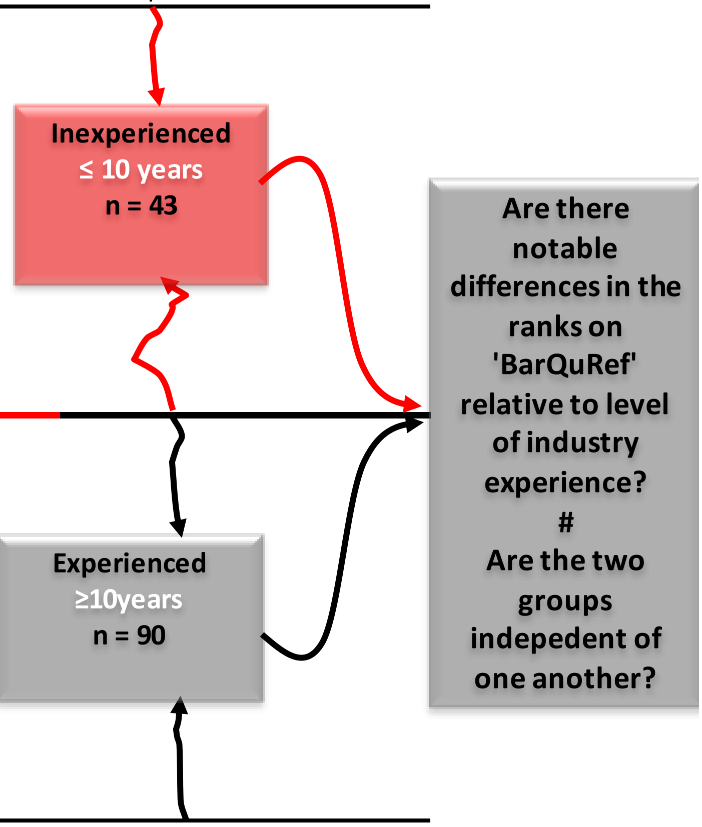
5.8.1 Mann-Whitney Test of Independence- setting hypotheses

As set out in Table 5.8, the hypotheses to guide the test are set out as follows:

- H_0: practitioners with '≤10 yrs ' and ≥10 years have identical ranks on BarQuRef
- H_1 practitioners with '≤10 yrs' and ≥10years differ in ranks on BarQuRef.

Table 5.8: Pooled barriers to quality of refurbishment works by refurbishment experience

BarQuRef5	3.60	1
BarQuRef1	3.51	2
BarQuRef8	3.49	3
BarQuRef4	3.40	4
BarQuRef10	3.09	5
BarQuRef2	2.84	6
BarQuRef6	2.70	7
BarQuRef3	2.70	8
BarQuRef9	2.70	9
BarQuRef7	2.65	10
BarQuRef5	3.70	1
BarQuRef1	3.61	2
BarQuRef8	3.59	3
BarQuRef4	3.53	4
BarQuRef10	3.52	5
BarQuRef3	3.49	6
BarQuRef2	3.36	7
BarQuRef9	3.17	8
BarQuRef6	2.60	9
BarQuRef7	2.43	10



The two sets of score are pooled with shared mean ranks or ties treated by assigning the average ranks resulting in Table 5.9 and computation table (Table 5.10).

Table 5.9: Rank order of pooled barriers to quality of refurbishment by experience

Factors	Mean	Ranks
BarQuRef5	3.70	1
BarQuRef1	3.61	2
BarQuRef5	3.60	3
BarQuRef8	3.59	4
BarQuRef4	3.53	5
BarQuRef10	3.52	6
BarQuRef1	3.51	7
BarQuRef3	3.49	8.5
BarQuRef8	3.49	8.5
BarQuRef4	3.40	10
BarQuRef2	3.36	11
BarQuRef9	3.17	12
BarQuRef10	3.09	13
BarQuRef2	2.84	14
BarQuRef9	2.70	16
BarQuRef3	2.70	16
BarQuRef6	2.70	16
BarQuRef7	2.65	18
BarQuRef6	2.60	19
BarQuRef7	2.43	20

Table5.10: Variation in ranking of barriers to achieving qualit of refurbishment works relative to practitioners experienc

	X		Y	
	n = 90		n = 43	
		Rank		*Rank*
Factors	Up to 10 yrs	*X*	10 yrs +	*Y*
BarQuRef2	3.36	11	2.84	14
BarQuRef4	3.53	5	3.40	10
BarQuRef6	2.60	19	2.70	16
BarQuRef5	3.70	1	3.60	3
BarQuRef3	3.49	8.5	2.70	16
BarQuRef7	2.43	20	2.65	18
BarQuRef1	3.61	2	3.51	7
BarQuRef10	3.52	6	3.09	13
BarQuRef9	3.17	12	2.70	16
BarQuRef8	3.59	4	3.49	8.5
		$T_{1=86.2}$		$T_{2=119.5}$

The test procedure is to determine U_1 and U_2 letting U be the minimum between U_1 and U_2. Using the table value from Appendix E-3 the computed value is derived at in the table looking down and across at $n_{1=}10$; $n_{2=}10$ picking the value based on the minimum of the two equations. Thus for T_1 the computation of U is:

$$U_1 = n_1 n_2 + \frac{n_{1(n_1 + 1)}}{2} - T_1$$

$$U_1 = (10)\ (10) + \frac{(10)(11)}{2} - 86.2$$

$$\underline{\boldsymbol{U_1 = 69}}$$

For T_2 the computation of U is:

$$U_2 = n_1 n_2 + \frac{n_{2(n_2 + 1)}}{2} - T_2$$

$$U_2 = (10)\ (10) + \frac{(10)(11)}{2} - 119.5$$

$$\underline{\boldsymbol{U_2 = 36}}$$

With the hypotheses set out as two-tailed (after Weiers; 2011; Kvanli et al 1992) the study adopts U = 36 (the minimum of U_1 *and* U_2). The table value $n_{1=}10$; $n_{2=}10$ =0.1575. Since the test is set out as a two-tailed approach, the significant value $\alpha = 0.05$ is divided by two (i.e. $\alpha/2$), giving a test value of 0.025. Thus as the Table value of 0.1575 is greater than $\alpha/2$ (i.e 0.025). The study therefore fails to reject the Null hypothesis and conclude that there is insufficient evidence to suggest a difference in the ranks. The null hypothesis was set out as below suggest there is similarity in the ranks.

H_0*:* practitioners with ‘≤10 years and ≥10 years have identical ranks on BarQuRef.

Figure 5.10 reinforces the conclusion that experience does not account for the performance in the ranking of BarQuRef. Indeed one can observe that the two camps of practitioners are perfectly correlated with only snippets of blue on the edges that are notable.

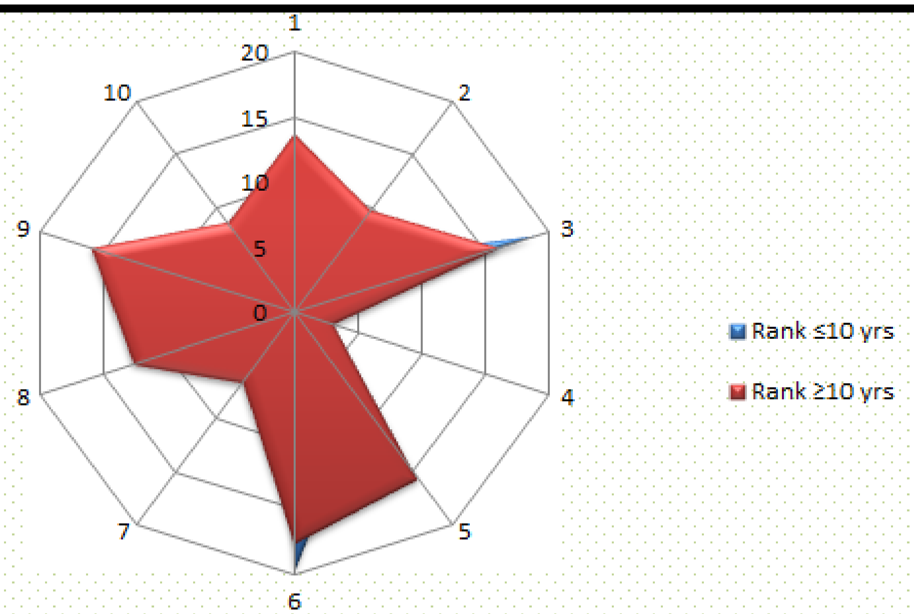


Figure 5.10: Comaprison of barriers to achieving quality refurbishment works by experience

Mann-Whitney being more rigorous in computation than Spearman ranks correlation helps to reinforce the same conclusions as that derived earlier: that experience does not account for the performance of practitioners in the ranking of BarQuRef. Similarly, as observed before, this is quite unusual and contrary to the norm which as Omardin and Ahmad (2011) have hinted, in stating that

> *" a combination of education and experience is the normal route to become manager………there are many attributes that a construction manager should possess in order to make the refurbishment project a success which are experience and decision making".*

The counter opposing results of this study may be due to chance or merely due to sample size or time when the research was carried out.

5.9 Effect of contractor designation on ranking of BarQuRef

Practitioners that took part in the study were evenly represented in terms of the type of contracting background. Some work for Principal or main contractors, others work for smaller subcontractors and some were employed by specialist contractors. This background is defined loosely as contractor designation and might shed more light on the way practitioners ranked the barriers to refurbishment quality-success. Therefore having done the comparative analysis between two means, this part of the study proceeds to establish the variance in practitioners' ranks on the barriers or threats to achieving high quality refurbishment - BarQuRef based on contracting designation.

The distribution of the respective groups of refurbishment experience are established in Table 5.11 and collated from the data ranks assigned by practitioners using a five point Likert scale where lower ranks represent higher disagreement and therefore the higher the mean scores the greater the extent of agreement. As there are more than two groups to compare an equivalent analysis of variance can best be executed using Kruskal-Wallis test using the formula:

$$KW = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{T_i^2}{n_1} - 3(n+1)$$

Accordingly, the arrangement is to set a one-tailed hypothesis:

Null Hypothesis:

H_0 The *K practitioners* have identical ranks on BarQuRef;

Alternative Hypothesis:

H_1 At least two of the *K* practitioners differ in their ranks of BarQuRef.

As previously explained, the Kruskal-Wallis allows the researcher to compare the mean ranks for all the *K* groups across the 10 levels of BarQuRef. The means for each group are identified in Table 5.11 and then pooled, as shown in Table 5.12.

The procedure is to assign ranks to each mean value, ensuring all mean-scores with the same values are assigned ties. Thus let $T_1 =$ the total of the ranks from the 'i' sample.

Once the pooled ranks are established, then the aggregate order dictates the order in which all the respective groups are organised and allotted to the respective means. An early inspection of Table 5.12 suggests that Principal contractors and Subcontractors are distinct to those who work for Specialist sub-contractors. The latter recorded mean scores largely low on the scale denoting that they are neutral or undecided on the statement representation of each barrier. Indeed by use of mere glance at the table one can see that Principal contractors are largely in agreement with the ranks with subcontractors, an indication that these come from the same background and have therefore similar intentions. Suffice to say no single Principal Contractor ends up one but by starting from being a smaller contractor or subcontractor.

Table 5.11:Rank order of BarQuRef across contractor designation

Factors	Mean	Organisation
BarQuRef1	3.55	
BarQuRef2	3.26	
BarQuRef3	2.78	
BarQuRef4	3.29	
BarQuRef5	3.6	PC
BarQuRef6	3.43	
BarQuRef7	2.89	
BarQuRef8	3.43	
BarQuRef9	3.14	
BarQuRef10	3.36	
BarQuRef1	2.16	
BarQuRef2	3.21	
BarQuRef3	1.84	
BarQuRef4	2.53	
BarQuRef5	2.21	
BarQuRef6	2.05	SpC
BarQuRef7	2.32	
BarQuRef8	3.26	
BarQuRef9	1.74	
BarQuRef10	2.42	
BarQuRef1	3.35	
BarQuRef2	3.09	
BarQuRef3	3.03	
BarQuRef4	3.15	
BarQuRef5	3.53	
BarQuRef6	3.21	SubC
BarQuRef7	3.41	
BarQuRef8	3.29	
BarQuRef9	3.12	
BarQuRef10	3.18	

Table 5.12: Pooled ranking of BurQuRef across contractor designation

Factors	Mean	Rank
BarQuRef5	3.60	1
BarQuRef1	3.55	2
BarQuRef5	3.53	3
BarQuRef6	3.43	4.5
BarQuRef8	3.43	4.5
BarQuRef7	3.41	6
BarQuRef10	3.36	7
BarQuRef1	3.35	8
BarQuRef4	3.29	9.5
BarQuRef8	3.29	9.5
BarQuRef2	3.26	11.5
BarQuRef8	3.26	11.5
BarQuRef2	3.21	13.5
BarQuRef6	3.21	13.5
BarQuRef10	3.18	15
BarQuRef4	3.15	16
BarQuRef9	3.14	17
BarQuRef9	3.12	18
BarQuRef2	3.09	19
BarQuRef3	3.03	20
BarQuRef7	2.89	21
BarQuRef3	2.78	22
BarQuRef4	2.53	23
BarQuRef10	2.42	24
BarQuRef7	2.32	25
BarQuRef5	2.21	26
BarQuRef1	2.16	27
BarQuRef6	2.05	28
BarQuRef3	1.84	29
BarQuRef9	1.74	30

Table 5.13: Kruskal-Wallis ranking of BarQuRef factors by contractor designation

Factors	Mean	*n = 80* Principal Contractor (PC)	*Rank PC*	*n = 19* Specialist Contractor (Spc)	*Rank SpC*	Sub Contractor (SubC)	*n = 34* *Rank SubC*
BarQuRef2	3.16	3.26	11.5	3.21	13.5	3.09	19
BarQuRef4	3.12	3.29	9.5	2.53	23	3.15	16
BarQuRef6	3.08	3.43	4.5	2.05	28	3.21	13.5
BarQuRef5	2.98	3.60	1	2.21	26	3.53	3
BarQuRef3	2.92	2.78	22	1.84	29	3.03	20
BarQuRef7	2.83	2.89	21	2.32	25	3.41	2
BarQuRef1	2.52	3.55	2	2.16	27	3.35	8
BarQuRef10	2.39	3.36	7	2.42	24	3.18	15
BarQuRef9	2.23	3.14	17	1.74	30	3.12	18
BarQuRef8	2.11	3.43	4.5	3.26	11.5	3.29	9.5
			100		*237*		*124*
			T1		*T2*		*T3*

From the equation:

$$KW = \frac{12}{30(30+1)} \sum_{i=1}^{k} \frac{T_i^2}{n_1} - 3(30+1)$$

Hence from equation *i* above:

$$\frac{12}{30(31)} \left[\frac{100^2}{10} + \frac{237^2}{10} + \frac{124^2}{10} \right] - 3(31)$$

$$\frac{12}{(930)} \left[\frac{10000}{10} + \frac{56169}{10} + \frac{15376}{10} \right] - 93$$

$$\frac{12}{(930)} [8154.5] - 93$$

$$105.22 - 93$$

$$\underline{\boldsymbol{KW = 12.22}}$$

Since the test statistic is to check the Table value for Chi-square as given in Appendix E2 = 5.99. Since the procedure is to reject H_0 if KW is $> \chi^2_{0.5.2}$ = 5.99; (*df = 3 -1 = 2*). The value of the KW = 12.22 far exceeds 5.99 leading to the rejection of Null hypothesis (H_0).

The study therefore proceeds to accept the Alternative H_1 and accept that there is sufficient evidence to suggest that at least two of the groups of practitioners based on contractor designation vary in their ranking performance of BarQuRef. This implies there is a distinctive difference in the rank values as is notable in Table 5.13. It is clear in the Table that scores for practitioners employed by Principal Contractors ($T_{1}=100$) are close enough to those of practitioners employed by Subcontractors ($T_{3}=124$) while practitioners who serve for Specialist contractors' have their mean ranks as the largest ($T_3 = 237$) and are thus very distinct.

The above sentiments are reinforced by the Scatterplot illustration of Figure 5.11 the extent to which practitioners actually differ based on the contractor designation. All the three groups vary visibly from the mean, an indication of variance in what practitioners experience and perceive as hindrances to their work.

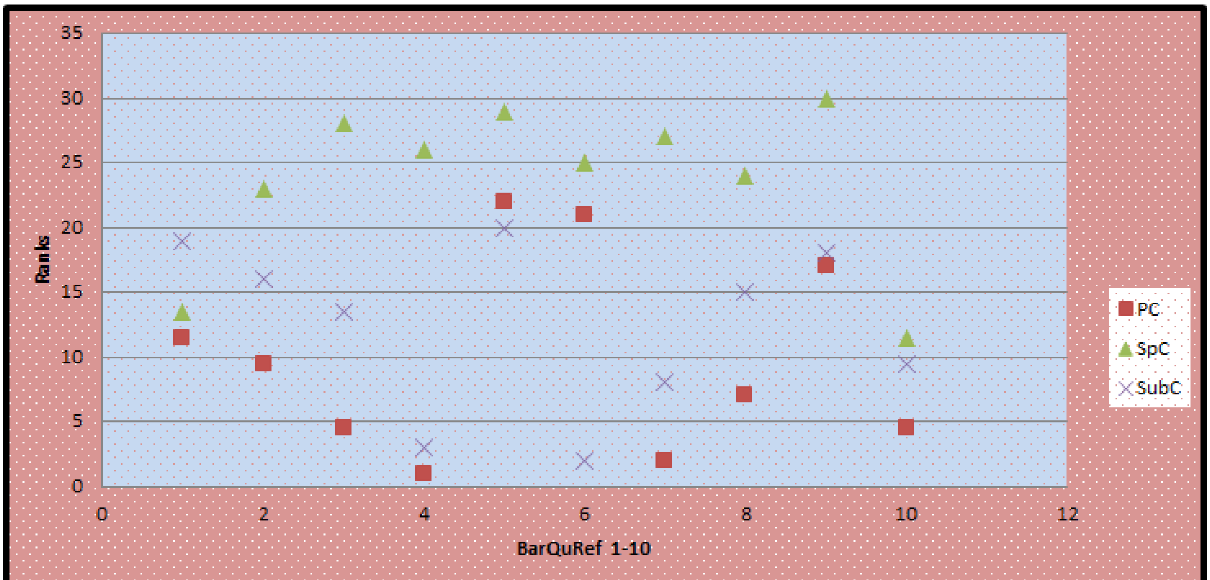


Figure 5.11: scatterplot of pooled ranks on BarQuref relative to contractor designation

This leads to the conclusion that the type of work undertaken through specialisation or contracting do impact on the type of barriers that practitioners face. This can be explained as relating to the fact that when contractors engage in work those who act as main contractors are similar both in attitudes and skill attributes because they tend to be general builders. They shoulder responsibility for tasking activities safely and hence have to be highly adept at identifying typical barriers to refurbishment success. As soon as the connotation of specialism is attached, contractors are choosing what they are very good at and are therefore less likely to understand all manner of construction/refurbishment barriers. This outcome implies that the practitioners have no identical perceptions about the hindrances or barriers likely to impinge on quality of refurbishment outcomes and that is predicated upon by the type of work they get involved with.

5.10 Summary

The study identified eight perceived factors contributory to achieving high quality refurbishment works as well as ten factors which are perceived to be barriers to achieving high quality refurbishment works.

Given the economic benefits refurbishment brings, it is essential to consider the significance of the factors which can enhance effective delivery of the project in terms of high quality standards as well as those factors which may act as barriers to achieving high quality projects. This is especially the case with larger refurbishment projects which could be exposed to many sources of risks and uncertainties.

Based on the analysis in this chapter, the reliability of the data was further validated by confirming the alternative (H_1) hypothesis implying the two sets of practitioners are inseparable. Thus, as the pairwise ranks generate a perfect linear relationship, identifying which factors impact more on the quality outcomes of refurbishment project is independent of the refurbishment manager's experience.

The findings of this chapter also identified ten factors which are believed to be barriers to achieving high quality refurbishment work. Based on the analysis in section two, the reliability of the data was verified by also confirming the alternative (H_1) hypothesis which statistically implies that the two set of practitioners are inextricably aligned in their ranking of barriers to high quality refurbishment outcomes and this is further demonstrated in Figure 5.8 and Table 5.7 which also shows the pairwise ranks generating a perfect linear relationship in comparison to the mean value. This also suggests that identifying the barriers to achieving quality outcomes of refurbishment projects is independent of the experience of a refurbishment manager. The finding in this section also shows that practitioners in both groups are in perfect agreement about both the rank order and magnitude of the barriers.

However, in order to validate the findings in this section, a further test was carried-out using a different statistical technique. On the contrary, the test proceeds to accept the Alternative H_1 hypothesis and accept that there is sufficient evidence to suggest that at least two of the groups of practitioners based on contractor designation vary in their ranking performance of BarQuRef. This implies there is a distinctive difference in the rank values as noted in Table 5.13. The above sentiments are reinforced by the Scatterplot illustration of Figure 5.11 showing the extent to which practitioners actually differ based on the contractor designation. All the three groups vary visibly from the mean, an indication that of variance in what practitioners experience and perceive as hindrances to their work. This outcome implies that the practitioners have different perceptions about the hindrances or barriers likely to impinge on quality of refurbishment outcomes.

The next chapter will further evaluate and analyse quantitative data for the purpose of identifying what can be perceived as risks and technical challenges in building refurbishment schemes.

CHAPTER SIX

Factors which contribute to risks and technical challenges (FarTech)

6.1 Introduction

This chapter follows on from the previous chapter which examined whether there are notable differences among practitioners in the ranking of factors which contribute to quality of refurbishment works and also the notable barriers to achieving high quality refurbishment works. Following the findings in the previous chapter, it was only appropriate for the study to investigate which factors contribute to risks, uncertainties and technical challenges associated with building refurbishment schemes. The information generated will contribute to understanding the risks and their impact within the refurbishment sector as a whole.

The chapter will therefore, interpret the data based on information provided by refurbishment practitioners and with the help of non-parametric statistical techniques such as spearman's rank correlation coefficient a cross comparison of consensus will be made as to the kind of factors likely to impact on the achievement of refurbishment project desired outcomes.

6.2 Factors which contribute to risk and technical challenges - FarTech

Refurbishment projects are fraught with exceptional risks and uncertainties regardless of size or location. The uncertain nature of refurbishment entails that at the outset, the project team must aspire to minimize or even eliminate certain risks and uncertainties by ensuring such risk are properly defined, managed and then mitigated rather than ignored.

This section therefore reviews an inventory of factors perceived to contribute to risk and technical challenges in building refurbishment schemes (FarTech). The impact of any risk factor on the effectiveness of risk management control tools available to a project manager is, so far, unquantified, yet these ought to be known and established. It is only by having such information that the day-to-day technical management challenges can be identified and then their impact known.

Industry practitioners were given a group of twenty five factors discerned from literature. The objective was to identify the most influential and not so influential factors to desired project outcomes. The previous chapter tested variation in the rank order based on important variables such as 'experience' contracting designation and predisposition to risk - Priskaver. In order to discern any meaningful interpretations, similar test are carried out in this section of the research data analysis.

Therefore, each of the twenty five factors was rated on a continuum using a Likert scale of 0-4; as alluded to in the preceding chapters, a score of 4 reflects a positive endorsement that a factor is a high risk item where as a score of 0 denotes a factor perceived to have little or no bearing on the refurbishment outcome. Since the latter are associated with the least impacting of factors and often demand measures that are 'so far as reasonably foreseeable' to be put in place, it is the former - the factors which generate the most concern among project managers and Clients alike – that this study is particularly concerned about. The reason being that, factors higher up in the table require duty holders to put in place 'practicable measures' otherwise serious injury, fatality or severe loss of resources will occur.

6.3 Exploration of FarTech factors

As in the preceding chapters, the exploration of FarTech factors is essential to the study in that these will help to:

- determine whether there is a consensus in the rank order among the practitioners;
- identify the most severe factors in terms of impact and control-management relative to varying practitioners' experience;
- identify the least severe factors in terms of impact and management.

In addition, the most immediate of the ensuing benefits lies with an understanding of the peculiarity of factors that define the severity of risks and how these dictate the strategies employed to ensure effective risk-control measures of refurbishment schemes. Having such information will help towards the broader education and training of industry practitioners. An inventory of the characteristics, quality factors and barriers will collectively, combine to inform the learning packages for refurbishment managers. These should reflect or inform good practice, especially given the current and ongoing drive to retrofit more existing buildings.

It is also good practice to identify risk factors at the inception of any project whatever the scale of the project. Any information generated as part of this process can only enable managers to identify and equip themselves with control tools necessary for the smooth running of the project. Therefore, an important question to ask industry practitioners is: why is refurbishment predicated by such severe risks and technical challenges to a point where refurbishment projects are difficult or nearly impossible to manage effectively?

Table 6.1 shows the initial contributory project risk factors as identified from initial desk study and piloting stages of the research. In order to generate the mean score for each factor, as before described, a Likert scale of 0 to 4 was provided where 4 = very high; 3 = high; 2 = medium; 1 = low; 0 = no risk. On aggregate, higher mean scores represent high scoring factors and thus are said to present the most severe risks; collectively, low scoring factors are equally the ones that present the least refurbishment risks to a project.

Table 6.1: Perceived factors which contribute to risk and technical challenges (FarTech)		
Factors	Description of factors	N = 133 Mean value
FarTech1	Difficulty in choosing the right procurement strategy	2.06
FarTech2	Difficulty in determining extent of structural defects	3.31
FarTech3	Lack of expertise of type of work	2.82
FarTech4	Cost and price uncertainty at inception	3.41
FarTech5	Inaccuracy and unreliable estimates	3.13
FarTech6	Designs uncertainty	3.20
FarTech7	Difficulty in predicting works completion time	3.54
FarTech8	Lack of information about original designs	3.35
FarTech9	Presence of harzardous substance	3.09
FarTech10	Obstruction imposed by ongoing occupancy	3.18
FarTech11	Lack of cooperation between project partners	2.70
FarTech12	Cost and time overruns	3.20
FarTech13	Problems associated with building regulations and statutory control	2.48
FarTech14	Restrictions on plant usage imposed by site location	2.31
FarTech15	Variations to scope of work	3.25
FarTech16	Problems with programming of works	2.71
FarTech17	Uncertainty over availability of materials	2.35
FarTech18	Health and safety	2.90
FarTech19	Unrealistic time pressures	2.38
FarTech20	Unclear client objectives	2.48
FarTech21	Difficulty in determining amount of contingency required	2.21
FarTech22	Insufficient access and space to site	2.33
FarTech23	Accidents and injury	2.25
FarTech24	Planning constraints	2.10
FarTech25	Disputes and claims	2.56

6.4 Aggregate rank order of refurbishment project risks

Table 6.2 presents the aggregate perception of risk factors. In order to make meaningful interpretation of the factors, a full description for each factor is given and then the implied meaning is offered to describe like-to-like factors based on designated terms. This analytical approach enabled the study to generate nine clear definitions which are integral to the original twenty five factors as depicted in Figure 6.1 and 6.2 respectively. The Key findings relating to the implied terms are outlined in turn:

Uncertainty in relation to project duration: A closer inspection of Table 6.2 shows that some factors have equal mean scores. As earlier advised, these are allotted an average position where the mean scores are given the average of their relative position. The group of risks at the top of Table 6.2 appear to corroborate with different author's views. In particular, Lock (2007) opined that the events and tasks leading to the completion of refurbishment projects cannot be predicted with complete accuracy at inception of a project mainly due to the presence of risk, hidden defects and uncertainty with regards to the structural stability of building elements and also the presence of incipient plasmolysis of defects all of which require experienced practitioners' knowledge.

Invariably Babangida et al, (2012b) have also suggested that the inability to predict project completion time may be due in part to lack of awareness of the extent of deterioration which is hardly obvious to the novice practitioner at the outset of a project. Hence, the resulting effects is that work begins and sometime it is some way into the project that new discoveries emerge leading to variations of contract, requests for extra time which ultimately affect costs. With these concerns in mind, it is no surprise that Lock (2007) was quick to caution against the danger of the effect of cost and time overruns while drawing the attention of practitioners to the fact that many refurbishment projects finish well over budget and by enormous amounts.

S/No	Factors	Description of factors	N = 133 Mean value	Rank	Designated terms
	Table 6.2: Aggregate rank order of perceived factors which contribute to risk and technical challenges (FarTech)				
1	FarTech7	Difficulty in predicting works completion time	3.54	1	Uncertainty over project duration and costs
2	FarTech4	Cost and price uncertainty at inception	3.41	2	
3	FarTech8	Lack of information about original designs	3.35	3	Synergy in designs and incipient plasmolysis of building defects
4	FarTech2	Difficulty in determining extent of structural defects	3.31	4	
5	FarTech15	Variations to scope of works	3.25	5	
6	FarTech6	Designs uncertainty	3.20	6.5	Effect of design-uncertainty on project costs and losses
7	FarTech12	Cost and time overruns	3.20	6.5	
8	FarTech10	Obstruction imposed by ongoing occupancy	3.18	8	
9	FarTech5	Inaccuracy and unreliable estimates	3.13	9	
10	FarTech9	Presence of harzardous substance	3.09	10	Risks appraisal competence management
11	FarTech18	Health and safety	2.90	11	
12	FarTech3	Lack of expertise of type of work	2.82	12	
13	FarTech16	Problems with programming of works	2.71	13	Dispute resolution management
14	FarTech11	Lack of cooperation between project partners	2.70	14	
15	FarTech25	Disputes and claims	2.56	15	
16	FarTech13	Problems associated with building regulations and statutory control	2.48	16.5	Synergy with Client team expectations
17	FarTech20	Unclear client objectives	2.48	16.5	
18	FarTech19	Unrealistic time pressures	2.38	18	
19	FarTech17	Uncertainty over availability of materials	2.35	19	Constraints imposed by site logistics
20	FarTech22	Insufficient access and space to site	2.33	20	
21	FarTech14	Restrictions on plant usage imposed by site location	2.31	21	
22	FarTech23	Accidents and injury	2.25	22	RIDDOR-related cost contigencies
23	FarTech21	Difficulty in determining amount of contingency required	2.21	23	
24	FarTech24	Planning constraints	2.10	24	Planning consent bureaucracy
25	FarTech1	Difficulty in choosing the right procurement strategy	2.06	25	

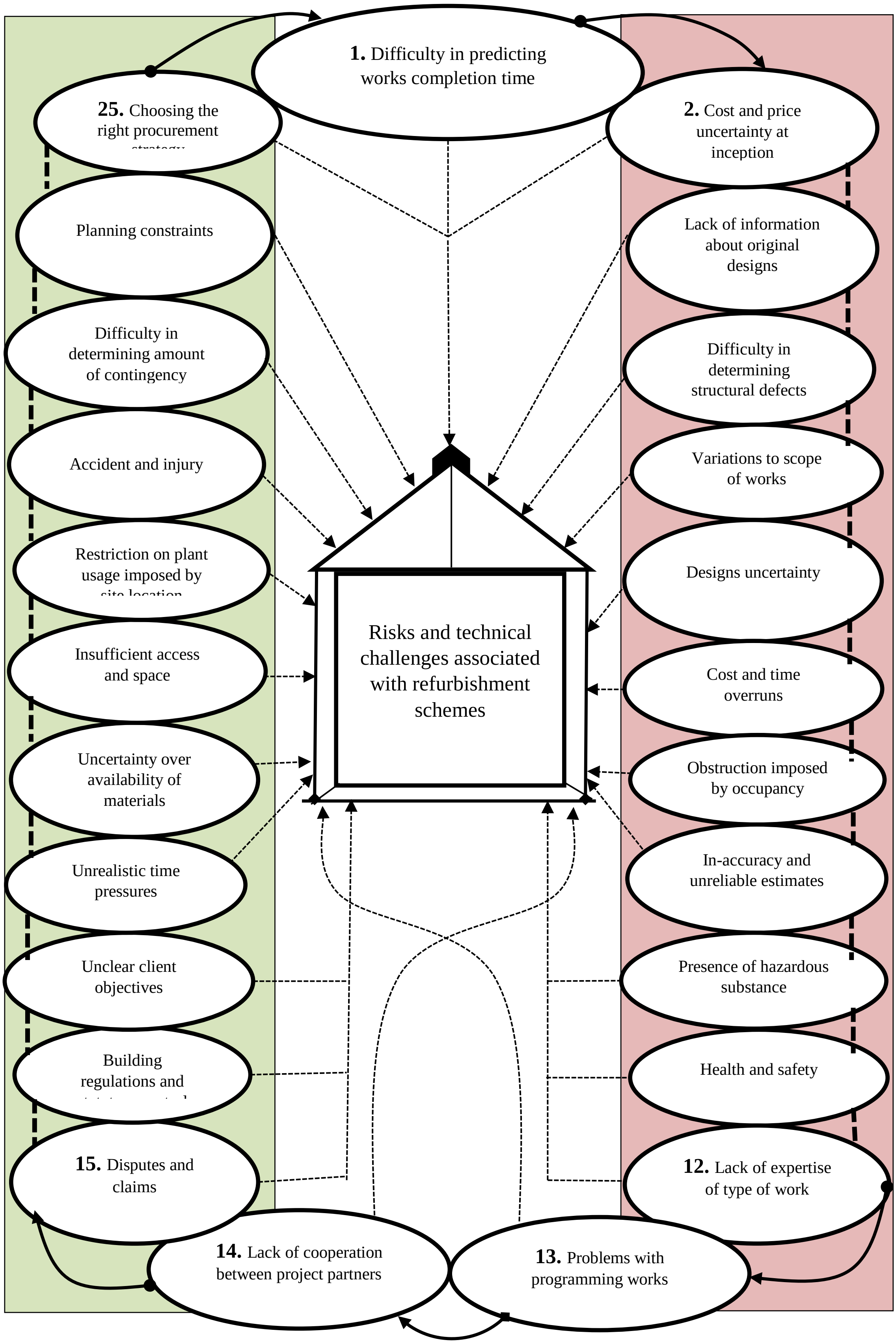


Figure 6.1: Depiction of high impacting to low impacting factors which contribute to risk and technical challenges (FarTech) in refurbishment schemes

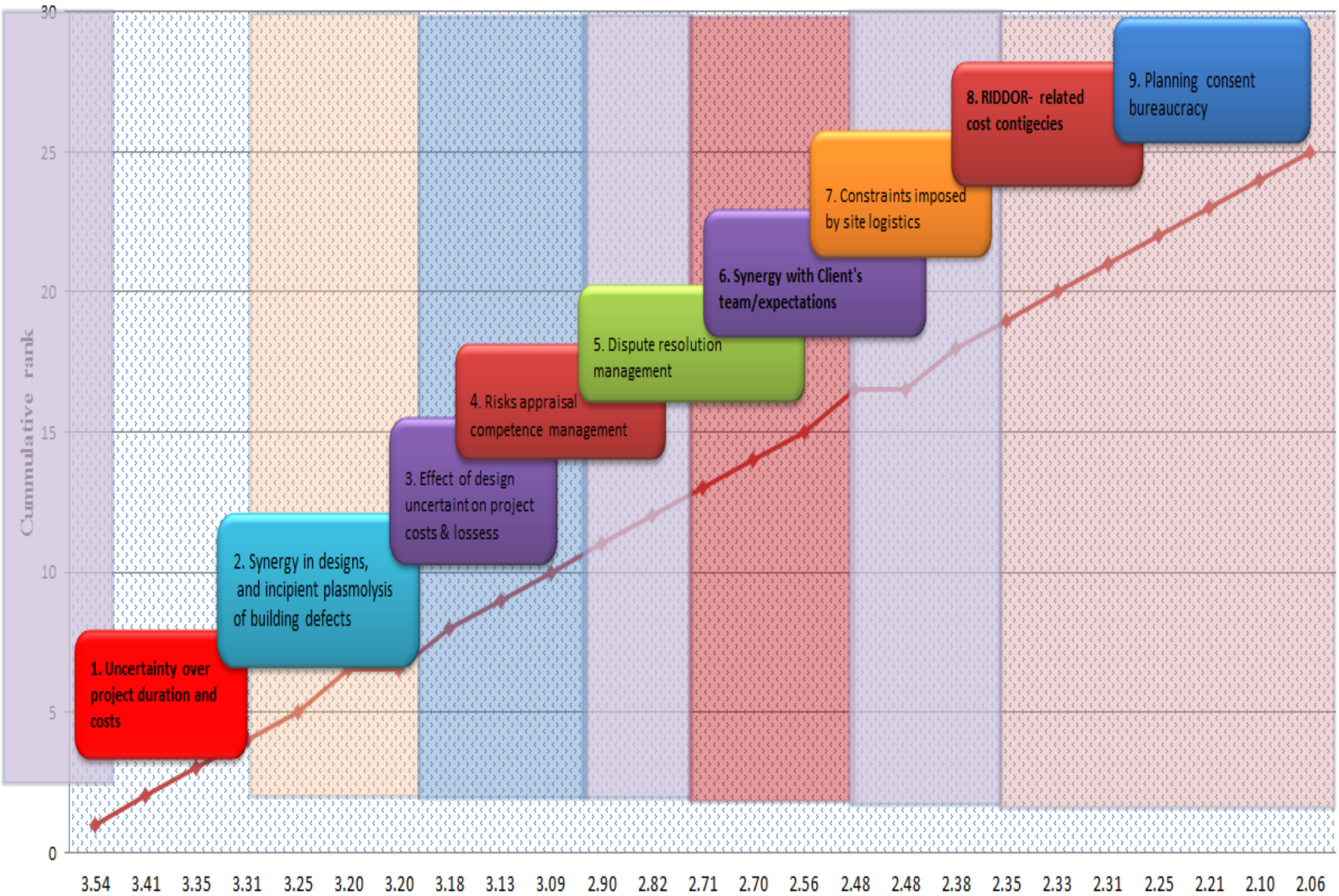


Figure 6.2: Hierarchy of perceived factors which contribute to risk and technical challenges at aggregate level

Additionally, Lock (2007) also found recurring themes among different scales of refurbishment projects and noted that they finish late; projects are abandoned even before completion; budgets are overinflated; and the scope of work is almost impossible to reconcile with design. As a consequence of the foregoing the study can affirm that by and large a majority of practitioners recognise too that there is often uncertainty in relation to project duration.

Synergy in design and incipient plasmolysis: It is not untypical to note the extent of unpredictability with refurbishment projects. Most building owners hardly keep a record of all the ongoing maintenance work to pass on to the designer. More often than not a designer has to rely on their own detective work and almost begins with a clean slate of information as if they were working on a new build scheme. Without the building owner passing on past repair and maintenance intervention records, the accuracy of what needs to be done or the depths or limits within the scope of the work requested by the owner might be left to the designer to decide. While in some cases this may not be a problem, refurbishment often involves desolate listed buildings; in some cases buildings that have suffered severe levels of obsolescence also require intrusive investigation and probing, the accuracy of which is dependent on the accuracy of the information as well as the access available which depends on the skill of the investigator. CIRIA (1994) have concluded that most practitioners have trouble in making an accurate assessment of the true extent of what structural elements are, why they have decayed and what caused the decay in the first place. As the study has established, work often begins even when both the diagnosis and prognosis are unclear; those elements which have to be repaired or replaced are only clearly interrogated as more discoveries are made. Amid a vacuum of information it is clear to see why such concerns are valid.

Effect of design uncertainty on project cost and losses: In outlining the challenges of refurbishment work Wilson and Kisk (2011) have hinted that unlike new build, uncertainty seems to be the preserve of refurbishment projects to a point where designers lack essential information about the existing buildings. Kemmer et al (2013) attribute the impact of uncertainty as one that contributes to non-continuous planning of the refurbishment process. Wilson and Kirsk (2011) further reiterated that designers may be extremely reluctant to commit and engage with the decision making process especially when there is a possibility of litigation should mistakes be made. Literature therefore appears to support the fact that uncertainty creates a mind-set of fear, especially in the vacuum of information. It follows therefore that given the above, the paucity in not knowing what brought about the defects in the first place, translates into cost uncertainty and thus the fear of follow-up losses.

Risk appraisal competence management: In chapter five, managing time, cost and uncertainty were among the highly perceived barriers to refurbishment of existing buildings. However, in chapter 4, the study explored what factors define the characteristics of building refurbishment projects, uncertainty associated with the manner in which risks transmute emerged as the most striking characteristic of building refurbishment projects. It comes as little surprise therefore that difficulties and challenges in the appraisal and management of risks is recognised as one of the most impacting factors in terms of risks and technical challenges in refurbishment projects.

Dispute Resolution management: This factor alone emanates from the fear mong practitioners that when you have many partners converging to undertake projects, this alone combined with general lack of information creates an environment for misrepresentation of information. Disputes and claims and inability to programme works efficiently due to overlapping activities remain a feature of new build, even when information flow is more streamlined. Given these constraints are apparent in new build, it is no surprise practitioners feel that the same concerns exist even more in refurbishment projects.

Synergy among project partners: It is common knowledge that unless there is commonality in approach and clear separation of interests, confusion is bound to create tension among project team members which could lead to disputes. This issue is more of a concern when dealing with listed building refurbishment projects as there are different agencies involved with different interests in a building when compared to with other project.

Constraints imposed by site logistics: Unlike new build where the land for the development may be in the middle of nowhere, refurbishment projects often involve a building already occupying an existing site which may be in a busy city-centre location. Kangwa and Olubodun (2010) found these sites to have their own characteristics which impose on the attributes that refurbishment managers have to possess. Kangwa and Olubodun (2010) have referred to constraints relating to inflexible-factors, namely site storage constraints; restricted working hours; one way systems; restrictions on crane usage; road closures; use of single lanes, narrow winding backstreets and limited parking and storage areas as among the inflexible features of a site that project managers have to contend with.

RIDDOR-related cost contingencies: How safe refurbishment projects are has already been referred to in the previous chapter. Literature suggests that four out of 5 projects visited by the Health and Safety Executive which had to be closed were refurbishment projects (HSE, 2013). As highlighted in Figure 6.4 the nature of this work has already been defined to be characterised by a great deal of uncertainty in terms of scope and cost. These factors will combine to make refurbishment projects (as reiterated by HSE, 2013) the most dangerous type of construction projects. The Reporting of Injuries, Diseases and Dangerous Occurrence Regulations 2013-RIDDOR require project managers to understand how to quantify risks and report their occurrence as they happen. However, with several agencies involved in refurbishment projects where information flow is not smooth, it is not surprising that compliance with RIDDOR on refurbishment projects is another factor which project managers find a main constraint.

Planning Consent bureaucracy: Project managers identified the difficulties in getting through the barriers of planning permission and the prolonged uncertainty as another factor to militate against effective management of refurbishment projects. Although this factor is the least in the table, mainly due to the fact that listed buildings are few, this factor is nonetheless an ongoing concern.

6.5 Comparative analysis of mean-ranking by refurbishment experience

This section of the research will attempt to carry-out a comparative analysis of FarTech factors in order to determine the extent of variation in ranks offered by practitioners. Similarly, industry experience is used to understand the differences in practitioners' perception and know-how of the technical risks and their impact on refurbishment schemes.

Cox and Griggs (1982) lamented that experience impacts on performance. This implies that among project managers, experience must impact upon identification of the risks and technical challenges and appropriately, the extent to which they react to identify a solution to the perceived challenges. Experience may be the key factor that bridges the difference between the different technical solutions provided on site and thus their impact.

As shown in Table 6.4, the practitioners were split into two different groups based on refurbishment experience. The first group is for practitioners with up to 10 years' refurbishment experience, thus labeled as *(X)*. The other group relates to practitioners with over 10 years of experience and labeled as *(Y)*.

As every test begins with a research question, the study's interest is to explore whether experience can be an overriding factor in influencing how practitioners perceive the risks and technical challenges and therefore how they put in place control measures to mitigate the associated effects.

Table 6.3: Comparision of rank order based on refurbishment experience		
	n = 90	n = 43
Factors	*R(x) up to 10 yrs*	*R(Y) 10 yrs+*
FarTech7	1	1
FarTech4	2	2
FarTech8	3	3
FarTech2	4	4
FarTech15	5	5
FarTech6	6.5	6.5
FarTech12	6.5	6.5
FarTech10	8	8
FarTech5	9	9
FarTech9	10	10
FarTech18	11	11
FarTech3	12	12
FarTech16	13	13
FarTech11	14	14
FarTech25	15	15
FarTech13	16.5	16.5
FarTech20	16.5	16.5
FarTech19	18	18
FarTech17	19	19
FarTech22	20	20
FarTech14	21	21
FarTech23	22	22
FarTech21	23	23
FarTech24	24	24
FarTech1	25	25

As a consequence of the foregoing observations, this constraint informed the choice of Spearman's (r_s) rank correlation coefficient test as the most appropriate measure of variance within the variable of interest. Invariably, correlation test is a bivariate method for detecting how well practitioners, set out as in Table 6.4 with characteristics of X (n= 90) and Y (n =43), perceived the severity of each of the twenty-five risk factors. The Spearman's rank correlation coefficient as before defined is measured by the formula: $r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$

Thus the study set out a two-tailed test of hypothesis as follows:

Null Hypothesis:

H_0: No association exists in ranking of risk factors (FarTech) between two sets of practitioners based on refurbishment experience;

Alternative Hypothesis:

H_1: Association exists in ranking of risk factors (FarTech) between the two sets of practitioners based on refurbishment experience.

Table 6.4: Comparative rank order of FarTech relative to refurbishment experience								
	N = 133		n = 90 up to 10yrs		n = 43 10yrs+			
Factors	**Mean value**	**Rank**	X	R(x)	Y	R(Y)	(d)	d^2
FarTech7	3.54	1	3.54	1	3.55	1	0	0
FarTech4	3.41	2	3.41	2	3.42	2	0	0
FarTech8	3.35	3	3.35	3	3.34	3	0	0
FarTech2	3.31	4	3.31	4	3.32	4	0	0
FarTech15	3.25	5	3.25	5	3.26	5	0	0
FarTech6	3.20	6.5	3.20	6.5	3.21	6	0.5	0.25
FarTech12	3.20	6.5	3.20	6.5	3.20	7	0.5	0.25
FarTech10	3.18	8	3.18	8	3.18	8	0	0
FarTech5	3.13	9	3.13	9	3.14	9	0	0
FarTech9	3.09	10	3.09	10	3.09	10	0	0
FarTech18	2.90	11	2.90	11	2.88	11	0	0
FarTech3	2.82	12	2.82	12	2.83	12	0	0
FarTech16	2.71	13	2.71	13	2.71	14	-1	1
FarTech11	2.70	14	2.70	14	2.72	13	1	1
FarTech25	2.56	15	2.56	15	2.56	15	0	0
FarTech13	2.48	16.5	2.48	16.5	2.48	16.5	0	0
FarTech20	2.48	16.5	1.90	16.5	2.48	16.5	0	0
FarTech19	2.38	18	2.38	18	2.39	18	0	0
FarTech17	2.35	19	2.35	19	2.37	19	0	0
FarTech22	2.33	20	2.33	20	2.32	21	1	1
FarTech14	2.31	21	2.31	21	2.33	20	1	1
FarTech23	2.25	22	2.25	22	2.24	22	0	0
FarTech21	2.21	23	2.21	23	2.22	23	0	0
FarTech24	2.10	24	2.10	24	2.13	24	0	0
FarTech1	2.06	25	2.08	25	2.06	25	0	0
								$\sum d^2 = 4.5$

The appropriate test of hypothesis, after Howitt and Cramer (2011) is to reject the null hypothesis (H_0) set at a significance level α = .05 where n = 25 and if $\boldsymbol{r_s}$ > **0.336 -** the table value obtained from Appendix D-1 which contains the critical values of Spearman's rank correlation coefficient. Thus, from Table 6.4, the computation of r_s unfolds as follows:

$$r_s = 1 - \frac{6\ (4.5)}{25(25^2 - 1)}$$

$$r_s = 1 - \frac{27}{15600}$$

$$\boldsymbol{r_s = 0.998}$$

The test statistic follows a critical Table value of the Spearman's rank correlation coefficient which is given as $\boldsymbol{r_s} =$ 0.336. The computed $\boldsymbol{r_s}$ = **0.998** far exceeds the Table value of 0.336 as discerned from Appendix D-1. As a consequence of this result, the study proceeds to reject (H_0) in favour of the alternative (H_1) implying that a strong association exists between the two sets of practitioners relative to refurbishment experience.

The value of the computed coefficient value is high enough even at 99% confidence level whose value is given as 0.475. A further inspection of Table 6.4 shows a very close rank order between *R(x)* and *R(y)* and the scatterplot in Figure 6.3 underscores and substantiates the study's conclusion.

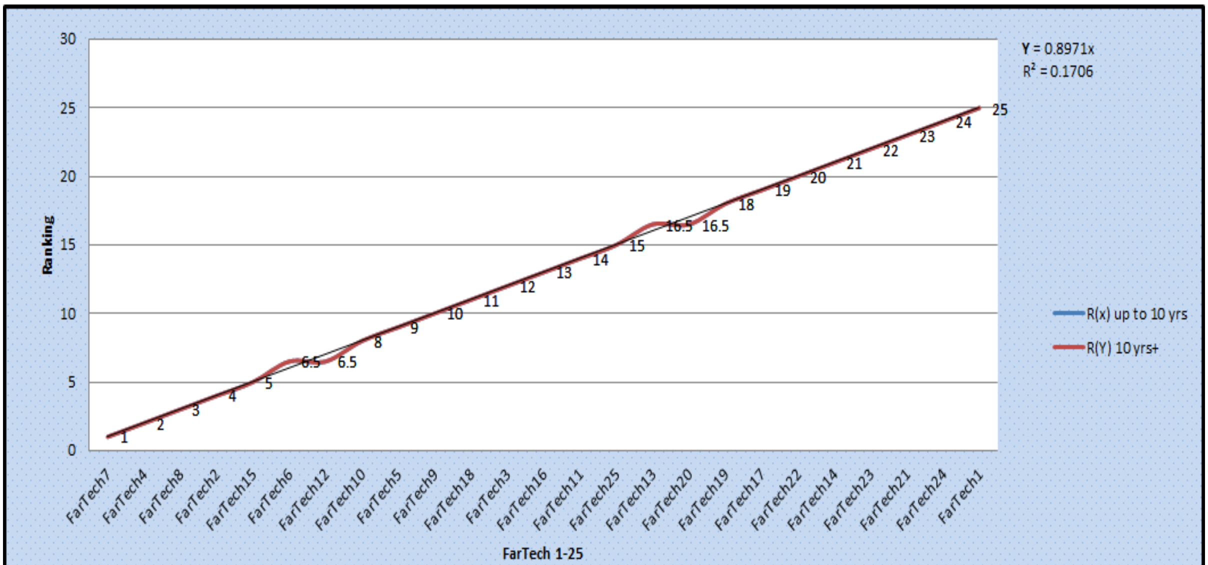


Figure 6.3: Scatterplot of FarTech relative to refurbishment experience

This inference to a strong association based on experience is further corroborated in Figure 6.4 where the plot graph of *R(x)* is perfectly overcast that of *R(y)* an indication of a very strong association.

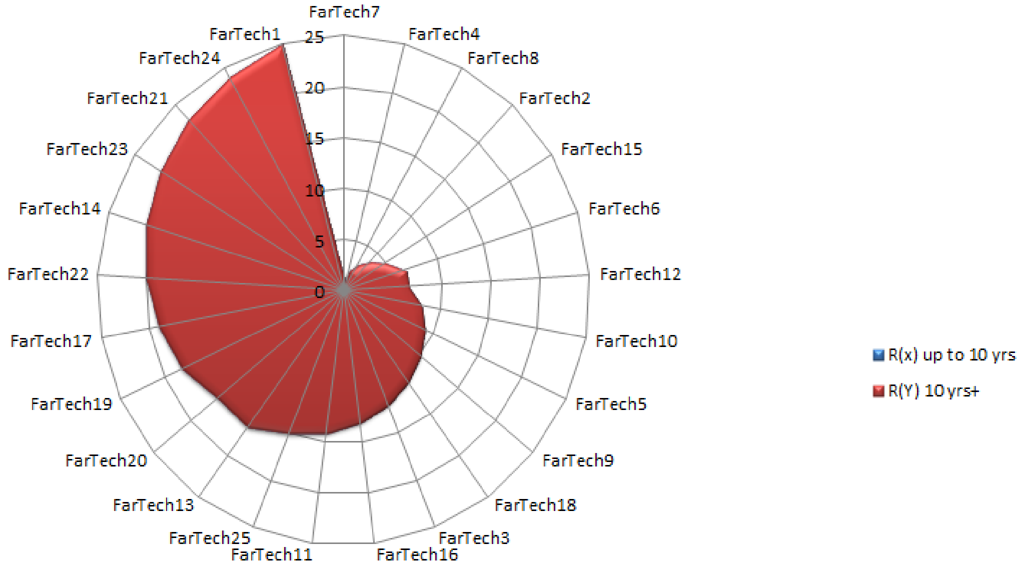


Figure 6.4: Radar graph of FarTech illustrating how closely mirrored the factors are relative to refurbishment experience

From this result therefore, it can be concluded that both groups of refurbishment practitioners have similar views as to the risk factors associated with refurbishment schemes and given how pronounced refurbishment projects are in terms of safety risks, it is no surprise that the practitioners do not have to work too long in industry to realise the potential dangers of working on refurbishment projects.

The implication of this outcome is that experience on its own is not sufficient to explain the differences by which the two sets of practitioners perceive refurbishment risk and any associated technical challenges in refurbishment schemes. This is not a surprise since at the inception of any refurbishment project; one of the challenges faced by any project manager is to undertake a risk assessment exercise which helps to identify the risks associated with the proposed work. Given the importance and scope attached to risk assessment, the Health and Safety Executive (HSE (2014) places culpability in the hands of the Principal Contractor. It is thus almost mundane and standard practice for any project manager to learn how to undertake thorough risk assessments.

Literature suggests that risk assessment is an essential and important step to successful management of a refurbishment project. Kangwa (2014) declares that quantification and management of projected risks are the key principles to the control of the transmutation of risks. This implies that those risks that are peculiar and therefore pertinent to the project are best identified by closely monitoring the key elements of the project and the extent to which the human interface interacts with the activities considered to be severe and likely to impact on the safety of the project personnel. Managing a project safely entails many things but potentially the need to fulfill three key objectives as enshrined in the safety law:

- Understanding the hierarchy of risk avoidance;
- Understanding the hierarchy of risk prevention; and
- Understanding the hierarchy of minimizing risks (should the above appear impossible to fulfill).

Figure 6.5: Hierarchy of risk control measures (Kangwa, 2014)

This assessment-procedure involves identifying the hazards and what risks are projected from the hazards. Any information gleaned thereafter helps identify the likelihood and severity level of the ensuing risks. As shown in Figure 6.5, Health and Safety Law places an absolute obligation on the Principal Contractor to ensure a safe working site.

6.6 Bivariate analysis of FarTech relative to Professional site-designation

Table 6.5 shows the comparative ranking of FarTech split on the basis of whether practitioners are site or non-site based professionals. The site based professionals are defined as Project Managers and Construction Managers while the non-site base professionals are considered to be the Architects, Building Surveyors and Quantity Surveyors.

In order to undertake bivariate data analysis, two set of variables have to be operational. Therefore, the main objective of this part of the study is to determine any sort of relationship or association on the ranking which may exist between the site based and non-site based professionals. This approach was prompted by the need to establish whether or not there would be any notable variations in the ranking of FarTech factors. It would be expected, given the differences in the experiences between the two camps that perceptions might vary. In order to proceed further, the site based professionals were labelled as X while the non-site based professionals were labelled Y. Similarly, two-tailed hypotheses were set with the computed relative mean ranks within X and Y as shown in Table 6.5.

Null Hypothesis:

H_0 is There is no association in the ranks between X and Y;

Alternative Hypothesis:

H_1 There is association in the ranks between X and Y.

After Kvanli (1992) and Kangwa (2004) only the relative mean rank position of each FarTech variables based on site based and non-site based were computed and the sum of the ranks generated in Table 6.5.

Table 6.5: Comparative ranking of FarTech against site-based and non site-based professionals

	Sample N = 133		Non site-based professionals n = 71 Architects/Building Surveyors/QS		Site-based professionals n = 62 Project /Site Managers			
Factors	**Mean**	**Rank**	**X**	***R(X)***	**Y**	***R(Y)***	**(*d*)**	d^2
FarTech7	3.54	1	2.95	7	2.95	8	-1	1
FarTech4	3.41	2	2.44	12	3.41	2	10	100
FarTech8	3.35	3	1.80	23	1.85	23	0	0
FarTech2	3.31	4	2.31	14	3.31	3	11	121
FarTech15	3.25	5	3.23	2	3.20	4.5	-2.5	6.25
FarTech6	3.20	6.5	3.22	3	3.20	4.5	-1.5	2.25
FarTech12	3.20	6.5	3.20	4	3.91	1	-3	9
FarTech10	3.18	8	2.59	11	2.61	12	-1	1
FarTech5	3.13	9	3.14	5	3.13	6	-1	1
FarTech9	3.09	10	3.10	6	3.08	7	-1	1
FarTech18	2.90	11	2.76	8	2.77	9	-1	1
FarTech3	2.82	12	2.72	9	2.74	10	-1	1
FarTech16	2.71	13	2.65	10	2.64	11	-1	1
FarTech11	2.70	14	2.41	13	2.42	13	0	0
FarTech25	2.56	15	2.30	15	2.31	14.5	0.5	0.25
FarTech13	2.48	16.5	2.06	19	2.07	20	-1	1
FarTech20	2.48	16.5	2.11	16	2.13	16	0	0
FarTech19	2.38	18	2.07	18	2.10	18	0	0
FarTech17	2.35	19	1.52	25	1.55	25	0	0
FarTech22	2.33	20	2.05	20	2.08	19	1	1
FarTech14	2.31	21	1.92	21	1.95	21	0	0
FarTech23	2.25	22	2.09	17	2.12	17	0	0
FarTech21	2.21	23	1.89	22	1.90	22	0	0
FarTech24	2.10	24	1.73	24	1.75	24	0	0
FarTech1	2.06	25	3.34	1	2.31	14.5	-13.5	182.3
								$\sum d^2 = 430$

When the value of the sum of the ranks, as given in Table 6.5, is computed in the Spearman rank correlation coefficient, a value of:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)} \rightarrow r_s = 1 - \frac{6\,(430)}{25(25^2-1)} \rightarrow r_s = 0.835$$

As before defined in the previous analysis of Spearman rank correlation, the computed value of r_s = 0.835 exceed the table value of α =0.05 shown as 0.336. Therefore, based on this value, the study can proceed to suggest that there is sufficient evidence of a significant positive relationship between ‘on-site’ refurbishment professionals and the ‘off-site’ refurbishment practitioners. This implies that a consensus was established on the identification of ranking of FarTech determined by whether practitioners are predominantly site-based or non-site based designation as shown in Table 6.6 and further corroborated in Figure 6.6. When the ranks between the two groups are plotted, the overcast between the two groups is reduced (as illustrated in Figure 6.6).

Table 6.6: Comparision of rank order relative to site-based and non-based practitioners

Factors	Mean Rank	*non site-ba*	*R(Y) Site-based*
FarTech7	1	*7*	*8*
FarTech4	2	*12*	*2*
FarTech8	3	*23*	*23*
FarTech2	4	*14*	*3*
FarTech15	5	*2*	*4.5*
FarTech6	6	*3*	*4.5*
FarTech12	7	*4*	*1*
FarTech10	8	*11*	*12*
FarTech5	9	*5*	*6*
FarTech9	10	*6*	*7*
FarTech18	11	*8*	*9*
FarTech3	12	*9*	*10*
FarTech16	13	*10*	*11*
FarTech11	14	*13*	*13*
FarTech25	15	*15*	*14.5*
FarTech13	16	*19*	*20*
FarTech20	17	*16*	*16*
FarTech19	18	*18*	*18*
FarTech17	19	*25*	*25*
FarTech22	20	*20*	*19*
FarTech14	21	*21*	*21*
FarTech23	22	*17*	*17*
FarTech21	23	*22*	*22*
FarTech24	24	*24*	*24*
FarTech1	25	*1*	*14.5*

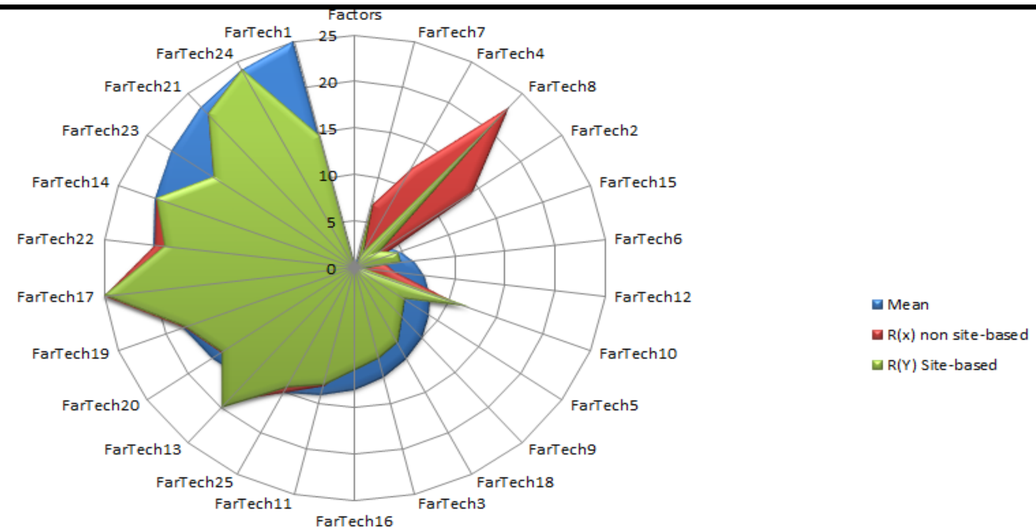


Figure 6.6: Radar graph illustration of FarTech factors showing how they are closely mirrored relative to professional designation

On the basis of the above observation, it is not surprising therefore that there is high association (84%) in the ranks between the two groups of practitioners in the magnitude and effect of the risk factors. Figure 6.6 not only shows how closely related the perceptions between the two groups are (as epitomised by the radar graphs in red and green) relative to the mean (radar graph in blue), but that also there are some differences (relating to 16% of cases) in the way each respective group of practitioners ranked the risk factors it considered to be the most severe. These notable differences are shown in Table 6.7.

A further inspection of Table 6.7 and Figure 6.6 shows the extent of agreement in the ranking and where it lies. The greatest difference is in the ranking of the top fifteen. The practitioners are highly correlated in ranks allotted to the factors between 16 and 25 (the last third of the Table 6.7). This implies the 16% variation lies in the factors within the top two thirds of the table relating to the factors with the most severe impact on risk and technical factors associated with refurbishment projects.

Table 6.7: Comparison of FarTech rank order relative to professional designation

(non-site based)		(Site based)		
Architects Building Surveyors Quantity Surveyors	Rank	Project managers Construction Managers	Rank	
FarTech 1	1	FarTech12	1	
FarTech 15	2	FarTech4	2	
FarTech 6	3	FarTech2	3	
FarTech 12	4	FarTech15	4.5	
FarTech 5	5	FarTech6	4.5	
FarTech 9	6	FarTech5	6	
FarTech 7	7	FarTech9	7	
FarTech 18	8	FarTech7	8	16% disagreement
FarTech 3	9	FarTech18	9	
FarTech 16	10	FarTech3	10	
FarTech 10	11	FarTech16	11	
FarTech 4	12	FarTech10	12	
FarTech 11	13	FarTech11	13	
FarTech 2	14	FarTech25	14.5	
FarTech 25	15	FarTech1	14.5	
FarTech 20	16	FarTech20	16	
FarTech 23	17	FarTech23	17	
FarTech 19	18	FarTech19	18	
FarTech 13	19	FarTech22	19	
FarTech 22	20	FarTech13	20	84% agreement
FarTech 14	21	FarTech14	21	
FarTech 21	22	FarTech21	22	
FarTech 8	23	FarTech8	23	
FarTech 24	24	FarTech24	24	
FarTech 17	25	FarTech17	25	

The last third of Table 6.7, accounts for the 84% correlation, albeit, it relates to factors least impacting on the technical risks and challenges to the refurbishment processes. The study can surmise from this that practitioners are more likely to agree on the factors that have the least bearing on the processes of refurbishment but not necessary on the ones with the most impact.

According to the offsite based professionals, the top three factors relate to, 'Offsite related parameters as the most pertinent issues summarised within the top three are:

1. FarTech1 (Difficulty in choosing the right procurement strategy);
2. FarTech15 (Variation to scope of works); and
3. FarTech6 (Designs uncertainty).

It comes as little surprise that off-site based practitioners readily agree on the effect that 'uncertainty in refurbishment information' has on the outline design outcomes of the refurbishment process. Indeed, these are practitioners from a design, building surveying and quantity surveying backgrounds responsible for defects diagnosis information, prognosis repair strategy information and refurbishment cost information. Any on ongoing uncertainties in these areas are therefore more likely to be heightened by the acute absence of information in the clients' briefs which also shape the early design outline and cost related information for the client.

It is observed that the derivative of uncertainty in refurbishment information (URI) exists in the challenges endured throughout the production of refurbishment projects, as witnessed by site-based refurbishment professionals. These are identified as site-related parameters (SRP). Among these, the top three most severe factors are the resulting effects of cost escalation and the fear of project overruns. These are directly related to the inaccuracies in the diagnosis of structural defects such that the initial scope of work is notoriously unreliable. Inaccuracies within the information flow affect the production process of refurbishment in the form of:

1. FarTech12 (Cost and time overruns);
2. FarTech4 (Cost and price uncertainty at inception); and are related to
3. FarTech2 (Difficulty in determining extent of structural defects).

The last third of Table 6.8 reflects the least impacting factors on the risks and technical challenges to the production of refurbishment projects. Again a close inspection shows that site-related refurbishment parameters reflected in the eleven factors ranked as least severe factors and which drew a nearly perfect closeness in the ranking by both groups to the same factors, namely:

- FarTech22 (Insufficient access and space to site);
- FarTech14 (Restrictions on plant usage imposed by site location);
- FarTech21 (Difficulty in determining amount of contingency required);
- FarTech8 (Lack of information about original designs);
- FarTech24 (Planning constraints); and
- FarTech17 (Uncertainty over availability of materials).

The combination of factors identified as least impacting reflects the ‘production factors’; these are by and large resolved through site experience whatever the scale of the refurbishment. It is clear that availability of materials to use in the refurbishment process; the planning consent process and design related information, plant usage and insufficiency of site boundary are the least impacting factors in refurbishment projects. Again it is notable that by the time a project commences, the bulk of the decisions around these areas will have been made with the input of the main contractor, designer and client representatives. Any other information is left to the site team to resolve as the work progresses. They are mundane production factors, hence located at the bottom of Table 6.7.

FarTech12 on the other hand relates to contingencies in refurbishment schemes. This outcome contradicts GVAGrimley (2010) who argued that a higher level of contingency may be required to manage the risk of unforeseen costs in refurbishment work. The result therefore suggests that, there is no risk of determining any high amount of contingency required in most refurbishment schemes or the availability of materials to be used in the production process. FarTech8 for instance, epitomises the extent to which it is the job of those on site to fill the information gaps residual in the client's brief and design outline.

Table 6.8: Interpretation of FarTech rank order relative to professional designation

non-site based		Site based		
Architects Building Surveyors Quantity Surveyors	Rank	Project managers Construction Managers	Rank	
FarTech 1	1	FarTech12	1	16% disagreement
FarTech 15	2	FarTech4	2	
FarTech 6	3	FarTech2	3	
FarTech 12	4	FarTech15	4.5	
FarTech 5	5	FarTech6	4.5	
FarTech 9	6	FarTech5	6	
FarTech 7	7	FarTech9	7	
FarTech 18	8	FarTech7	8	
FarTech 3	9	FarTech18	9	
FarTech 16	10	FarTech3	10	
FarTech 10	11	FarTech16	11	
FarTech 4	12	FarTech10	12	
FarTech 11	13	FarTech11	13	
FarTech 2	14	FarTech25	14.5	
FarTech 25	15	FarTech1	14.5	
FarTech 20	16	FarTech20	16	84% agreement
FarTech 23	17	FarTech23	17	
FarTech 19	18	FarTech19	18	
FarTech 13	19	FarTech22	19	
FarTech 22	20	FarTech13	20	
FarTech 14	21	FarTech14	21	
FarTech 21	22	FarTech21	22	
FarTech 8	23	FarTech8	23	
FarTech 24	24	FarTech24	24	
FarTech 17	25	FarTech17	25	

The findings hitherto have attempted to draw areas of consensus in relation to risk factors and technical challenges to refurbishment. It is clear from Table 6.8 that because of uncertainty of refurbishment information at the conceptual stages, the bulk of the decisions are left to be resolved by the onsite teams during the production process**.** As depicted in Figure 6.6 site-related parameters in refurbishment projects are overcast in increased uncertainty compared to new builds projects. This outcome reinforces the prevailing wisdom in literature which purports that refurbishment projects are more risky, dangerous and difficult to manage.

Indeed many other authors on refurbishment, for example Egbu (1996), Williams (1996) and Bertelsen (2003) have all defined the characteristics of refurbishment works as being complex, highly specialised, and containing elements of works which are unique to refurbishment and thus different to new build. Egbu (1996) has particularly emphasised that refurbishment projects are more difficult to manage, with a higher level of risk and uncertainty than new build.

6.7 Bivariate analysis of FarTech relative to Priskaver

This section of the study proceeds to establish if there are notable variations in the factors which contribute to risk and technical challenges in refurbishment projects. Two groups based on practitioners predisposition to risk (Priskaver) were generated as defined in chapter four (section 4.7) and are thus illustrated by Figure 6.7.

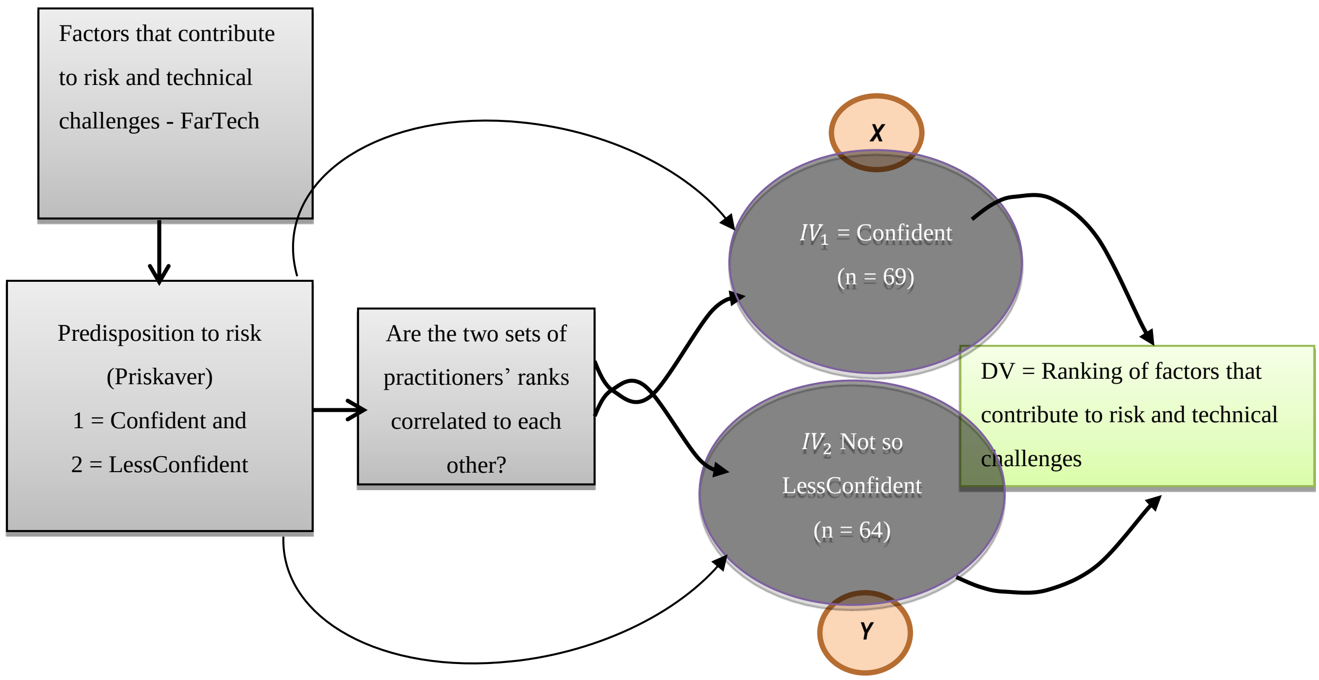


Figure 6.7: Two–tail hypothesis on FarTech relative to Priskaver

Null Hypothesis:

H_0: There is no relationship between the two sets of practitioners in the ranking of FarTech relative to Priskaver;

Alternative Hypothesis:

H_1: There is a relationship between the two sets of practitioners in the ranking of FarTech relative to Priskaver.

The ranking of the FarTech relative to Priskaver are shown in Table 6.9 and 6.10 respectively. The visual inspection appears to suggest there are differences in the perception of FarTech factors with the top third and last third for the groups quite distinct between the two groups. The only section that seems to show some areas of agreement in the ranks is the middle section.

Table 6.9: Perceived factors which contribute to risk and technical challenges relative to Priskaver

Factors	Confident practitioners	n = 69 52%	Rank
FarTech7	Difficulty in Predicting Works Completion Time	3.54	1
FarTech4	Cost and Price Uncertainty at Inception	3.41	2
FarTech8	Lack of information about original designs	3.36	3
FarTech2	Difficulty in determining the structural defects	3.31	4
FarTech15	Variations to Scope of Works	3.20	5
FarTech6	Designs Uncertainty	3.20	6.5
FarTech12	Cost and Time Overruns	3.19	6.5
FarTech5	In-Accuracy and Unrelaible Estimates	3.14	8
FarTech9	Presence of Harzardous Substance	3.10	9
FarTech18	Health and Safety	2.77	10
FarTech3	Lack of Expertise of Type of Work	2.74	11
FarTech16	Problems with Programming of Works	2.63	12
FarTech10	Obstruction Imposed by ongoing occupancy	2.60	13
FarTech11	Lack of Cooperation Between Project Partners	2.41	14
FarTech25	Disputes and Claims	2.31	15
FarTech20	Unclear Client Objectives	2.13	16.5
FarTech23	Accidents and Injury	2.12	16.5
FarTech19	Unrealistic Time Pressures	2.10	18
FarTech22	Insufficient Access and Space to Site	2.09	19
FarTech13	Problems Associated with Building Regulations and Statutory Control	2.07	20
FarTech14	Restrictions on Plant Usage Imposed by Site Location	1.95	21
FarTech21	Difficulty in Determining Amount of Contingency Required	1.89	22
FarTech1	Difficulty in choosing the right procurement strategy	1.85	23
FarTech24	Planning Constraints	1.76	24
FarTech17	Uncertainty over Availability of Materials	1.55	25

The question to ask is whether the two groups of practitioners' are independent or associated in the ranking of FarTech factors. In order to answer this question, Spearman rank correlation is used to test the mean ranks and how correlated they are.

Table 6.10: Perceived factors which contribute to risk and technical challenges relative to Priskaver

Factors	LessConfident practitioners	n = 64 48%	Rank
FarTech4	Cost and price Uncertainty at inception	3.41	1
FarTech22	Insufficient access and space to site	3.35	2
FarTech3	Lack of expertise of type of work	3.31	3
FarTech6	Designs uncertainty	3.29	4
FarTech12	Cost and time overruns	3.27	5
FarTech7	Difficulty in predicting Works completion time	3.22	6
FarTech13	Problems associated with building regulations and statutory control	3.13	7
FarTech11	Lack of cooperation between project partners	3.09	8
FarTech15	Variations to scope of works	2.99	9
FarTech24	Planning constraints	2.95	10
FarTech2	Difficulty in determining the structural defects	2.77	11
FarTech18	Health and safety	2.74	12
FarTech5	In-accuracy and unrelaible estimates	2.64	13
FarTech20	Unclear client objectives	2.62	14
FarTech19	Unrealistic time pressures	2.41	15
FarTech17	Uncertainty over availability of materials	2.31	16
FarTech10	Obstruction imposed by ongoing occupancy	2.13	17
FarTech16	Problems with programming of works	2.12	18
FarTech8	Lack of information about original designs	2.1	19
FarTech14	Restrictions on plant Usage imposed by site location	2.08	20
FarTech1	Difficulty in choosing the right procurement strategy	1.95	21
FarTech25	Disputes and claims	1.9	22
FarTech23	Accidents and injury	1.85	23
FarTech9	Presence of harzardous substance	1.74	24
FarTech21	Difficulty in determining amount of contingency required	1.54	25

Using the formula as a measure of correlation and as before described,

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

The interest is to explore the extent to which the two groups of practitioners described in one group as confident: comprising individuals who would not proceed with any work unless they are confident that the measures in place are adequate enough to mitigate any foreseeable risks. The other group of LessConfident individuals who feel they have not enough skills to manage projects safely.

As shown in Table 6.11, the mean values associated with each group are compared to the mean and the difference in their rank position is taken from the mean, squared and the total of the squared sum is computed into the Spearman rank correlation to work out the extent of association or agreement in the relative positioning of each of the twenty five factors.

Table 6.11: Comparative rank order of FarTech relative to predispotioning to risk

	Sample N = 133		n = 69 Confident		n =64 LessConfident			
Factors	Mean	Rank	X	$R(x)$	Y	$R(Y)$	(d)	d^2
FarTech7	3.54	1	2.95	9	3.22	6	3	9
FarTech4	3.41	2	3.41	1	3.41	1	1	1
FarTech8	3.35	3	3.36	2	2.1	19	-17	289
FarTech2	3.31	4	3.31	3	2.77	11	-8	64
FarTech15	3.25	5	3.20	4.5	2.99	9	-4.5	20.25
FarTech6	3.20	6.5	3.20	4.5	3.29	4	0.5	0.25
FarTech12	3.20	6.5	3.19	6	3.27	5	1	1
FarTech10	3.18	8	2.60	13	2.13	17	-5	25
FarTech5	3.13	9	3.14	7	2.64	13	-6	36
FarTech9	3.09	10	3.10	8	1.74	24	-16	256
FarTech18	2.90	11	2.77	10	2.74	12	-2	4
FarTech3	2.82	12	2.74	11	3.31	3	8	64
FarTech16	2.71	13	2.63	12	2.12	18	-6	36
FarTech11	2.70	14	2.41	14	3.09	8	6	36
FarTech25	2.56	15	2.31	15	1.9	22	-7	49
FarTech13	2.48	16.5	2.07	20	2.62	14	6	36
FarTech20	2.48	16.5	2.13	16	3.13	7	9	81
FarTech19	2.38	18	2.10	18	2.41	15	3	9
FarTech17	2.35	19	1.55	25	2.31	16	9	81
FarTech22	2.33	20	2.09	19	3.35	2	17	289
FarTech14	2.31	21	1.95	21	2.08	20	1	1
FarTech23	2.25	22	2.12	17	1.85	23	-6	36
FarTech21	2.21	23	1.89	22	1.54	25	-3	9
FarTech24	2.10	24	1.76	24	2.95	10	14	196
FarTech1	2.06	25	1.85	23	1.95	21	2	4

$\sum d^2 = 1632.5$

Computing the sum of the squared ranks in the equation gives the study a $r_s = 0.372$

$$r_s = 1 - \frac{6(1632.5)}{25(25^2-1)} = 0.372$$

As throughout this study the significance level (α) is set at 0.05, where n = 25, the test procedure is to reject the null hypothesis (H_0) if $\boldsymbol{r_s}$ **>0.400**; where 0.400 is obtained from Spearman rank correlation table in Appendix D - 1 which contains the critical values of

Spearman's rank correlation coefficient. As our computed value of 0.372 is less than the table value the study concludes there is insufficient evidence to reject the null hypothesis and therefore concludes and establishes the position stated in the null hypothesis: there is no relationship between the two sets of practitioners in the ranking of FarTech relative to Priskaver. This means there are differences in the perceptions held by the two groups as evidenced in the ranking relative to Priskaver.

Confident Priskaver

It is interesting to note in Table 6.12 that the practitioners (n = 69; thus 52%) that expressed confidence in their own ability to understand the concept of risk management in refurbishment projects appear to mirror the rank order as that generated at aggregate level (refer to Table 6.2).

Table 6.12: Ranking of FarTech factors based on confident Priskaver

Factors	Confident practitioners	n = 69 52%	Rank	Designated terms
FarTech7	Difficulty in Predicting Works Completion Time	3.54	1	1. Uncertainty over project duration and cost
FarTech4	Cost and Price Uncertainty at Inception	3.41	2	
FarTech8	Lack of information about original designs	3.36	3	2. Synergy in designs and incipient plasmolysis of building defects
FarTech2	Difficulty in determining the structural defects	3.31	4	
FarTech15	Variations to Scope of Works	3.20	5	
FarTech6	Designs Uncertainty	3.20	6.5	3. Effect of design-uncertainty on project costs and losses
FarTech12	Cost and Time Overruns	3.19	6.5	
FarTech5	In-Accuracy and Unrelaible Estimates	3.14	8	
FarTech9	Presence of Harzardous Substance	3.10	9	4. Risks appraisal competence management
FarTech18	Health and Safety	2.77	10	
FarTech3	Lack of Expertise of Type of Work	2.74	11	
FarTech16	Problems with Programming of Works	2.63	12	5. Dispute resolution management
FarTech10	Obstruction Imposed by ongoing occupancy	2.60	13	
FarTech11	Lack of Cooperation Between Project Partners	2.41	14	
FarTech25	Disputes and Claims	2.31	15	
FarTech20	Unclear Client Objectives	2.13	16.5	6. Synergy with Client team RIDDOR expectations
FarTech23	Accidents and Injury	2.12	16.5	
FarTech19	Unrealistic Time Pressures	2.10	18	
FarTech22	Insufficient Access and Space to Site	2.09	19	7. Site logistics onsite related parameters
FarTech13	Problems Associated with Building Regulations and Statutory Control	2.07	20	
FarTech14	Restrictions on Plant Usage Imposed by Site Location	1.95	21	
FarTech21	Difficulty in Determining Amount of Contingency Required	1.89	22	8. Off site related parameters
FarTech1	Difficulty in choosing the right procurement strategy	1.85	23	
FarTech24	Planning Constraints	1.76	24	9. Like to like constraints in heritage assets
FarTech17	Uncertainty over Availability of Materials	1.55	25	

This result confirms the supposition that refurbishment projects are challenging to manage; more complex as they demand increased synergy in defect diagnosis and prognosis and these are reflected by practitioners who are confident about risk management within building refurbishment activities. The important point to take from this is the confirmatory aspect of the hierarchy within the nine factors initially identified and confirmed at the aggregate level, by Professional site-designation and as just outlined by Priskaver. In so far as the study is concerned, the training refurbishment managers are given should reflect the concerns raised so far as well as reiterated and validated in Table 6.12 and 6.13 respectively.

Table 6.13: Ranking of FarTech factors relative to Unconfident Priskaver

Factors	LessConfident practitioners	n = 64 48%	Rank	Designated terms
FarTech4	Cost and Price Uncertainty at Inception	3.41	1	
FarTech22	Insufficient Access and Space to Site	3.35	2	
FarTech3	Lack of Expertise of Type of Work	3.31	3	1. Uncertainty in refurbishment information (Uri)
FarTech6	Designs Uncertainty	3.29	4	
FarTech12	Cost and Time Overruns	3.27	5	
FarTech7	Difficulty in Predicting Works Completion Time	3.22	6	
FarTech13	Problems Associated with Building Regulations and Statutory Control	3.13	7	
FarTech11	Lack of Cooperation Between Project Partners	3.09	8	
FarTech15	Variations to Scope of Works	2.99	9	
FarTech24	Planning Constraints	2.95	10	
FarTech2	Difficulty in determining the structural defects	2.77	11	
FarTech18	Health and Safety	2.74	12	2. Offsite related uncertainty-parameters (Orup)
FarTech5	In-Accuracy and Unrelaible Estimates	2.64	13	
FarTech20	Unclear Client Objectives	2.62	14	
FarTech19	Unrealistic Time Pressures	2.41	15	
FarTech17	Uncertainty over Availability of Materials	2.31	16	
FarTech10	Obstruction Imposed by ongoing occupancy	2.13	17	
FarTech16	Problems with Programming of Works	2.12	18	
FarTech8	Lack of information about original designs	2.1	19	
FarTech14	Restrictions on Plant usage Imposed by Site Location	2.08	20	
FarTech1	Difficulty in choosing the right procurement strategy	1.95	21	3. Site related uncertainty parameters (Srup)
FarTech25	Disputes and Claims	1.9	22	
FarTech23	Accidents and Injury	1.85	23	
FarTech9	Presence of Harzardous Substance	1.74	24	
FarTech21	Difficulty in Determining Amount of Contingency Required	1.54	25	

Professional site-designation: A closer inspection of Table 6.13 focuses the thinking around the LessConfident Priskaver. These individuals are unconfident because going by the results in this study, as generated in Table 6.13; they are practitioners who see the most severe factors to be instigated by factors due to uncertainty in the refurbishment information (URI). All the factors that negate effective risk management seem to originate from the ineffective flow of refurbishment information and the highest concern among these is cost of the work right from the inception stages. It is clear, reading into this, that the fear of cost and time overruns is also directly related to uncertainty in design; the difficult in predicting when the works can complete.

Offsite related uncertainty-parameters (ORUP): The lack of coordination in the gathering of information at the inception stages is rooted in the ineptitudes of practitioners contracted by the Client and perhaps the experience and knowhow of the client. If the terms of the scope of work are not clear, this generates unrealistic expectations about completion dates as well as the lack of knowledge on how to match the demands imposed on listed buildings (e.g. only using like for like materials).

Site related uncertainty-parameters (**SRUP**): It is no coincidence therefore that the cumulative effect from uncoordinated refurbishment information and any gaps left in the development stages have a ripple effect on the production aspects of a refurbishment scheme. The extent to which barriers and technical challenges are resolved on site is directly proportional to the quality of information gathered during the briefing stages. A lack of effective input into the design will affect the operations on site and therefore the quality and effectiveness of the project.

Given the foregoing, it is imperative that refurbishment practitioners are trained and given the level of knowledge that reflects the sort of operation they are involved in. The paradigm of training relative to the professional site designation implies practitioners designated to offer services that are site based must be equipped with information that prepares them well on how to deal with resolving 'Site related uncertainty-parameters' (SRUP) albeit cognisance of the fact that they have to appreciate the effect of increased 'Uncertainty in the refurbishment information' (URI) and the negative impact arising from 'Offsite related uncertainty-parameters' (ORUP). Those practitioners that are designated to operate on a project may require CPD training targeted at providing information that encourages predisposition to risks associated with the projects. Following the above analysis, it is certainly the case that a strong relationship exists which can be surmised as follows:

Uncertainty in refurbishment Information (URI): will, at the inception stages, affect the design, standard and effectiveness of the clients' project brief as well as 'Offsite related uncertainty-parameters' (ORUP). These two parameters (URI) and (ORUP) will dictate the magnitude of uncertainty and thus the effectiveness of what transpires on site (thus 'Site related uncertainty-parameters' - SRUP). The shorter notation of this sequence of events can be denoted as below:

[URI + ORUP = SRUP]) …….1

Whether practitioners on site are more Priskaver or less Priskaver will also have an influence on their ability to manage a refurbishment project efficiently, thus:

(Priskaver^{-1} or Priskaver^{2})

Therefore, SRUP is a function of Priskaver^{-1} or Priskaver2. This can be noted as:

SRUP (Priskaver^{1}) or SRUP (Priskaver^{2})

From equation 1 therefore:

[URI + ORUP = SRUP (Priskaver^{1}) (Priskaver^{2})]……2

Therefore, training of refurbishment managers has to take into account the Professional Site-designation. This implies that given the wide agreement in literature that refurbishment projects are dangerous, complex, and difficult to coordinate, the most effective approach is training practitioners to be able to differentiate services on the basis of whether their services are site based or offsite based.

6.8 Summary

The study has explored the factors that contribute to risks and technical challenges of refurbishment projects. The 133 practitioners were split on the basis of experience to determine the effect of experience on performance in the ranking of FarTech factors. The study surmised that experience does not explain the perception practitioners have when ranking factors that impinge on the technical challenges to refurbishment. There was no difference between practitioners with up to ten years refurbishment experience and those with experience over 10 years.

At an aggregate level the nine definitional factors were generated to represent all the twenty five factors which represent the various risks and technical challenges associated with refurbishment schemes. Figure 6.8 summarises these using a dog leg staircase analogy with factors at the base of the flight considered the most severe and thus having a greater impact on the refurbishment process. Those higher up in the dogleg flight such as ‘Uncertainty over project duration and costs’ have the highest bearing and thus contribute to more refurbishment challenges.

The study also found that when practitioners are split on the basis of their professional background i.e. whether they offer services that are predominantly site based or non-site based, that they were highly correlated in the ranking (84%). There were only 16% of cases in which slight variations occurred and this was in the factors perceived to have higher bearing on the refurbishment process while the extent of agreement was high in the ranking of the least impacting factors.

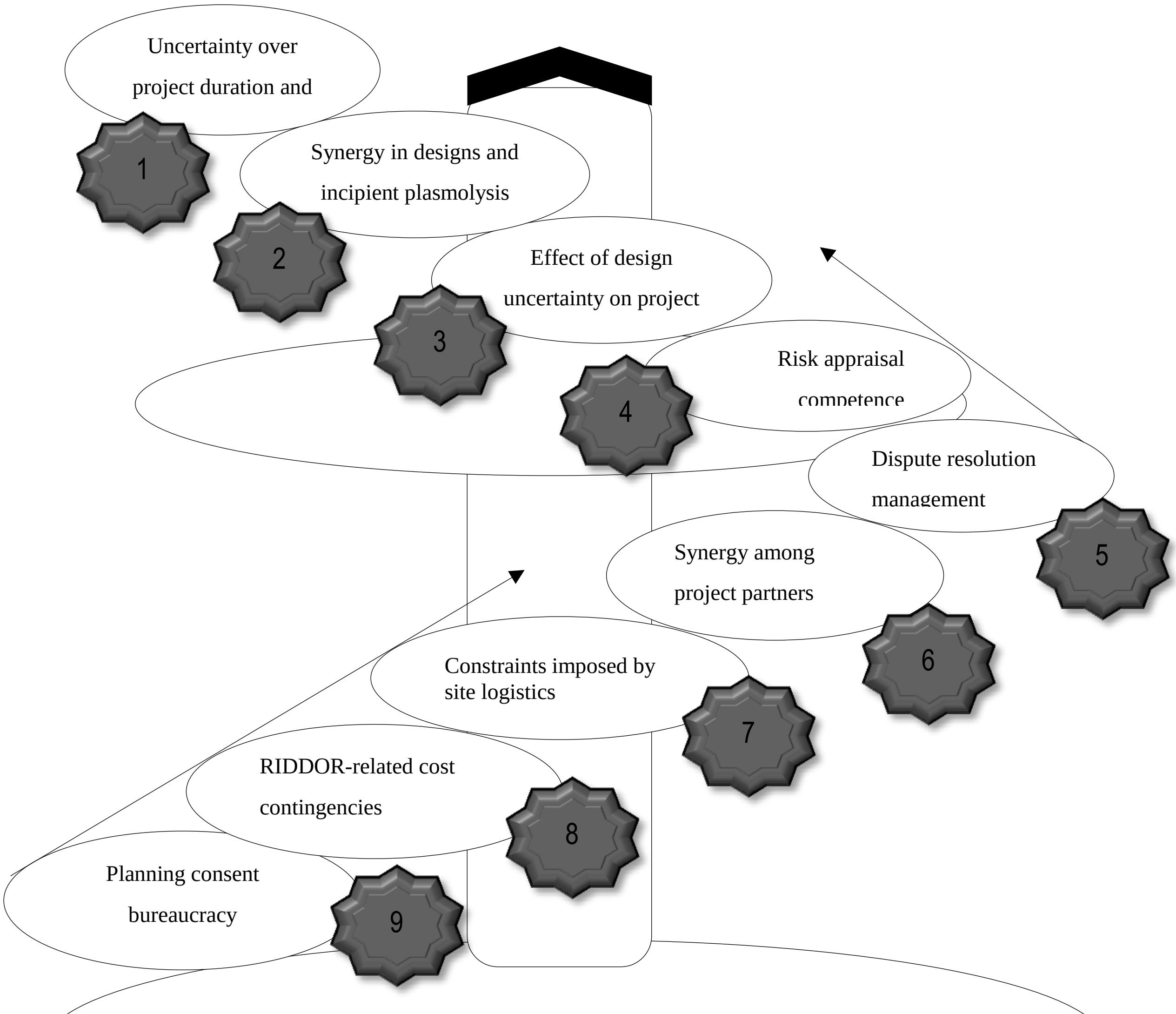


Figure 6.8: Hierarchy of factors which challenge the achievement of refurbishment projects desired outcomes

Accordingly the offsite based professionals seem to reflect their experience by giving scores to those factors that generate uncertainty but originating away from site. These were surmised to be **'Offsite related uncertainty parameters** and included the following:

1. FarTech1 (Difficulty in choosing the right procurement strategy);
2. FarTech15 (Variation to scope of works); and
3. FarTech6 (Designs uncertainty).

The study also observed the fact that site-based professionals utilised their site experience in identifying the most severe risk factors. Arguably, the top three factors also reflected onsite related parameters according to their daily refurbishment experiences S**ite-related uncertainty-parameters namely**:

1. FarTech12 (Cost and time overruns);
2. FarTech4 (Cost and price uncertainty at inception); and
3. FarTech2 (Difficulty in determining extent of structural defects).

The combination of factors least impacting on the technical challenges was seen to be related to the day-to-day production aspects of the refurbishment process. However it emerged that in so far as refurbishment is concerned, the extent of ‘Uncertainty in refurbishment information’ flow in a refurbishment scheme explained the general apprehension about the accuracy of defects diagnosis, effectiveness of the follow-on prognosis and costs associated with design outlines.

In order to produce efficient refurbishment managers that are equipped with the training attributes that reduce the effects associated with uncertainty in refurbishment information, such training should perhaps impose a shift to design and build for refurbishment schemes. The argument is that design and build allows contractors to upskill their own managers within the organisation structure (thus learning on the job). The training ought to be designed with the view to optimising the existing curriculum so that it is infused with the outcomes put forward by this study. More importantly, it is critical to ensure the training packages are designed and delivered with full understanding of the separate needs of respective professionals involved in the refurbishment process. As suggested in this study, one surest approach would be to distinguish delivery on the basis of Professional site-designation. The site based and offsite based professionals receive similar learning packages but with varying emphasis reflecting their knowledge needs.

CHAPTER SEVEN

Satisfaction with the implementation of refurbishment works (SatRef)

7.1 Introduction

It has been established in chapter six that refurbishment projects are not only complex but characterised by uncertainty. The wide ranging risks and technical factors as well as challenges that define the refurbishment processes make the schemes complex. The chapter also established that as a result of the inherent complexity, refurbishment information is difficult to collect and assimilate due to the nature of refurbishment works. The issue of residual risks due to incomplete design details and information was perceived to be an offsite related uncertainty-parameter and likely to have a ripple effect on site related uncertainty-parameters. These issues contrive to make refurbishment projects costly, challenging to plan and manage and difficult to control in terms of meeting targets and therefore unsafe and dangerous.

As a result of the foregoing inherent uncertainty in refurbishment information this chapter seeks to detect the refurbishment activities likely to generate more satisfaction in implementing of refurbishment projects.

7.2 Satisfaction with the implementation of refurbishment works (SatRef)

The study has so far examined the characteristics of the refurbishment process. It also explored the factors which contribute to quality-success of refurbishment projects; barriers to achieving quality and the risk and technical challenges. Therefore, equipped with this information, it is only logical for the study to further investigate and establish:

- What aspects of refurbishment activity bring most satisfaction among practitioners?

Although success has always been identified as the ultimate goal of every activity, and construction projects are no exception, however, the definition of success often changes from project to project (Parfitt and Sanvido, 1993). Traditionally, success may be defined as the extent to which the expectations of projects are met. In line with this definition of project success, Lim and Mohammed (1999) suggest that project success should be viewed from different perspectives of individuals and the goals related to a variety of elements such as finance, education, and professional issues as well as social and technical aspects. Similarly, Chan et al (2002) opined that delivering a project successfully may require the effective management of project team members in addition to various types of constraints.

It is therefore appropriate to understand what project success entails if only understanding the extent to which research participants are satisfied with the implementation of refurbishment schemes can be perceived. Hence, the study focused on understanding the key areas which practitioners perceive as generating the most satisfaction in implementation of refurbishment works.

As in previous chapters, a Likert scale was used to derive the position of each satisfaction dimension using a scale of 0 to 4. Eleven factors were identified from an initial desk study as shown in Table 7.1. Thus, the acronym SatRef refers to the satisfaction with implementation of the identified items of work in refurbishment schemes and will be used throughout this section of the analysis.

Table 7.1: Description of satisfaction with implementation of refurbishment works

Factors	Description	Sample Mean
SatRef1	Quality of refurbishment projects undertaken	2.64
SatRef2	Avoiding disputes	2.33
SatRef3	Accuracy and reliability of estimates	2.34
SatRef4	Information on past repair and maintenance	2.41
SatRef5	Project programming	2.58
SatRef6	Identification and management of risks	2.32
SatRef7	Knowledge of structural defects	2.55
SatRef8	Incorporation of sustainable concepts	3.02
SatRef9	Management of health and safety	2.18
SatRef10	Meeting deadlines	2.49
SatRef11	Cooperation between project partners	2.59

7.3 Ranking of SatRef

The aggregate rank order is shown in Table 7.2 and in order to read further into the outcomes initial analyses will establish the underlying themes in the rank order. This will then allow the study to detect further, any level of consensus both in the rank order as well as the combination of independent variable factors that may help to explain the notable relationships as perceived by practitioners.

The Table shows the consensus ranking of SatRef factors. The factors that generate the most satisfaction are the ones higher up in the table.

Table 7.2: Ranking of satisfaction with implementation of refurbishment works

Factors	Description	Mean	Rank	Implied meaning
SatRef8	Incorporation of sustainable concepts	3.02	1	Low carbon driven retrofitting
SatRef5	Project programming	2.64	2	
SatRef1	Quality of refurbishment projects undertaken	2.59	3	
SatRef11	Cooperation between project partners	2.58	4	Synergy in dispute resolution
SatRef10	Meeting deadlines	2.55	5	
SatRef2	Avoiding disputes	2.49	6	
SatRef3	Accuracy and reliability of estimates	2.41	7	Credibility of refurbishment information
SatRef4	Information on past repair and maintenance	2.34	8	
SatRef7	Knowledge of structural defects	2.33	9	Diagnosis of structural defects and associated risk
SatRef9	Management of health and safety	2.32	10	
SatRef6	Identification and management of risks	2.18	11	

1. Low carbon driven retrofitting: The highest ranked factors are:

- Incorporation of sustainable concepts SatRef8;
- Project programming SatRef5; and
- Quality of refurbishment works SatRef1.

From the foregoing therefore, it is only appropriate to suggest that research participants pay more attention to issues relating to how sustainable concepts as currently pronounced in the low carbon agenda and the Climate Change Act. It comes as no surprise to see that SatRef8 is ranked highest in Table 7.2 as developers are faced with the challenges to comply with the current legislation to minimise carbon emission in existing buildings. Indeed, the modern concept of sustainable development is increasingly gaining international recognition (Babangida et al, 2012b). These growing concerns partly informed the decisions of the UK government to enact and promulgate laws that will minimise the effects of carbon emissions in buildings.

Similarly, the Task Force on Sustainable Development (2007) indicates that the built environment sectors must act and engage pro-actively with the sustainable development agenda in order to achieve the anticipated improvements that will enable minimising the environmental impact of existing buildings. Hence, both Corus (2010) and Swan et al (2013) reiterated that refurbishing existing buildings has the potential to reduce energy use and carbon emissions while at the same time reducing their running costs as a result of lower energy bills. Overall, the process entails that the building benefits from the quality-success and thus is a win-win situation for the user.

2. Synergy in dispute resolution: The next important factor which defines the next tier of satisfaction is a constituent of factors that enable practitioners to resolve conflicts from several sources, e.g. ensuring there is increased cooperation among duty holders (SatRef11). This result is quite revealing in that the previous chapter established that refurbishment (unlike new build) is synonymous with increased ‘Uncertainty in refurbishment information flow. Therefore it would appear that where practitioners attempt to resolve any conflict due to omission in the accuracy of the information provided, the level of satisfaction generated is highly appreciated and quite rightly very motivating.

Fewer conflicts among project partner (SatRef2): the study also established that the lack of cooperation among project partners sometimes leads to friction which may lead to uncertainties especially those relating to design at inceptions. The result of this is that where the client improves on their design brief, and in doing so provides further clarity to the designer, the availability of new information not only reduces uncertainty but helps the onsite team in meeting deadlines easily (SatRef10). These three factors feed into the proposed notion that ‘Offsite related uncertainty-parameters’ already impact on the factors that negate the quality of the refurbishment works.

Practitioners appear to endorse the position taken by the study that if ‘uncertainty in refurbishment information’ is reduced, this can only lead to improved cooperation among partners and enhance the possibility of meeting deadlines as well as eliminate points of contention during the production stages. Accurate, information can only improve understanding, eliminate waste and ambiguity.

3. Credibility of refurbishment information: The foregoing discussion all support the findings by other commentators on refurbishment management: that refurbishment projects are more dangerous (HSE, 2013), complex and challenging (Young et al 1994; highly risky (Egbu, 1994; 1997); difficult to control and manage (Rahmat (1997) require highly experienced practitioners (Egbu 1998) and have a lot more hidden challenges compared to new build (Kangwa and Olubodun, 2010; Rahmat, 2011). All these point to the negative effect uncertainty has on project planning and management. The solution to such problems lies in ensuring the ‘uncertainty of refurbishment information’ is reversed by providing ‘credible refurbishment information’.

4. **Diagnosis of structural defects and associated risks:** The next set of factors that are associated with increased satisfaction are those which bring about desired outcomes especially factors intrinsic to the understanding of the nature, source and causes of structural defects in buildings (Plasmolysis). There is a direct relationship between understanding building defects and the prognosis that follows.

If these two factors are managed efficiently, then the management of risks associated with very decayed structural elements can be resolved due to having full and accurate information; thus the rate at which the risks mutate can also be managed (Trisma). In other words the ability to manage risks is a function of how predisposed refurbishment managers are to understanding risks (Priskaver). Trisma and Priskaver attributes ensure that hazards are identified and corresponding adequate control measures are established. It is not surprising therefore that these factors also generate moderate satisfaction although at the aggregate level they are the lowest rated factors.

7.4 Evaluation of rank order of SatRef factors

This section aims to look at the ranking order of the factors in order to develop an understanding of the observations made by industry practitioners. This part of the analysis aims to examine the extent and/or level of satisfaction with the implementation of refurbishment works by research participants in relation to level of refurbishment experience. The objective is to establish whether there are any notable variations in the rank order of SatRef factors relative to experience and contractor designation.

7.5 Analysis of relationship in ranking of SatRef factors

This section will explore the extent of agreement among research participants in ranking the eleven identified items of SatRef. Research hypotheses were identified as follows:

- X refers to those practitioners with up to 10 years' refurbishment experience;
- Y refers to those practitioners with over 10 year's refurbishment experience.

As in previous analyses the Null hypothesis and Alternative hypothesis were identified on a two-tailed basis as follows:

Null Hypothesis:

H_0: There is no relationship in ranking of SatRef between the two sets of practitioners based on refurbishment experience;

Alternative Hypothesis:

H_1: There is a relationship in ranking of SatRef between the two sets of practitioners based on refurbishment experience.

The generated sums of ranks for the computation of r_s in the equation below are shown in Table 7.3.

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Table 7.3: Ranking of SatRef by practitioners experience

	N = 133		n = 91 up to 10 Yrs		n = 42 10 Yrs +			
Factors	Mean	Rank	X	R(X)	Y	R(Y)	*d*	d^2
Satref8	3.02	1	3.18	3	2.00	11	-8	64
SatRef5	2.64	2	2.28	9	3.19	6	3	9
SatRef1	2.59	3.5	3.36	1	3.68	1	0	0
SatRef11	2.58	3.5	3.12	6	3.53	2	4	16
SatRef10	2.55	5	3.23	2	3.41	3	-1	1
SatRef2	2.49	6	3.16	4	3.24	5	-1	1
SatRef3	2.41	7	2.14	11	2.97	8	3	9
SatRef4	2.34	8	2.42	8	2.24	9	-1	1
SatRef7	2.33	9	2.22	10	2.21	10	0	0
SatRef9	2.32	10	3.14	5	3.38	4	1	1
SatRef6	2.18	11	2.98	7	3.13	7	0	0
								$\sum d^2 = 102$

Throughout this study the Spearman rank correlation of r_s has been tested at a significance level of α = .05. Therefore, where n = 11, the procedure is to reject the null hypothesis (H_0) if $\boldsymbol{r_s}$ >**0.623** as obtained from Appendix D - 1 which contains the critical values of Spearman's rank correlation coefficient. Hence from the equation above, the computation of r_s is set out as follows:

$$r_s = 1 - \frac{6(102)}{11(11^2-1)} = \mathbf{0.536}$$

As the test statistic follows a critical Table value of the Spearman's rank correlation coefficient of (α) 0.05 and given as above r_s = 0.536, the computed spearman's rank correlation coefficient (r_s) = 0.536 does not exceed the Table value of 0.623. As a consequence, the study finds insufficient evidence and fails to reject (H_0) implying that there is no relationship in ranking of SatRef between the two set of practitioners based on refurbishment experience.

This outcome shows statistically that there is some variance in the perceptions relative to refurbishment experience. The scatter plot in Figure 7.1 also affirms this conclusion that although the coefficient value is slightly high [0.536 at (α) 0.05], nonetheless there is a wide scatter in the factors, evidence that there are areas of differences or disagreements. The plot graph in Figure 7.2 also highlights the same observation.

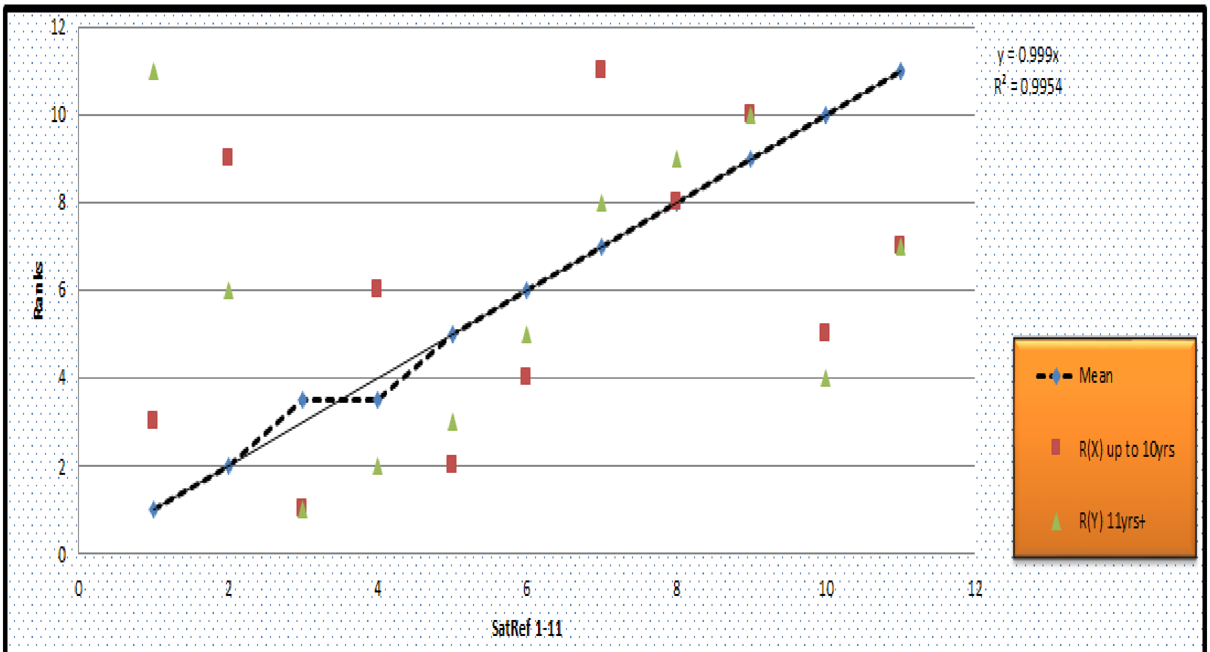


Figure 7.1: Scaterplot of SatRef relative to refurbishment experience

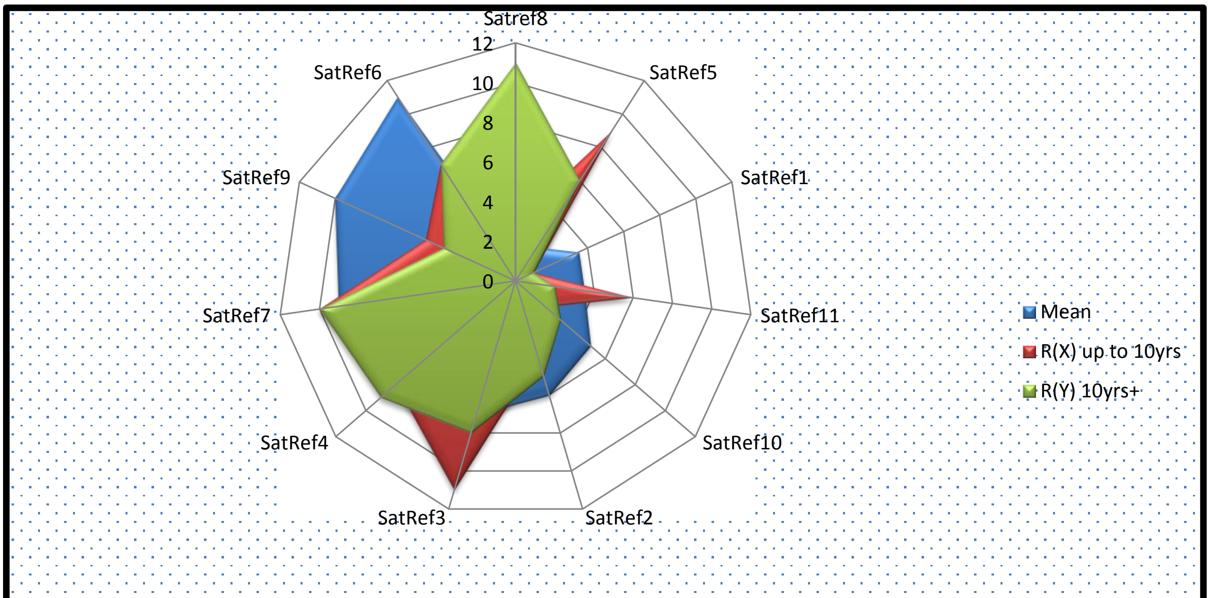


Figure 7.2: Radar graph of SatRef relative to refurbishment experience

Indeed the areas of disagreement between the two groups of practitioners are shown in Table 7.4: Both sets of practitioners agree as SatRef1 (Quality of refurbishment projects undertaken) generates the most satisfaction. This observation should direct attention to the fact that the intention behind every client who commissions a project is to end up with a building that operates to serve the needs of the user or occupants which meets current regulations and standards. This is the only area where there is unanimity as shown in Table 7.4.

The shaded areas are the factors where two sets are completely juxtaposed. It appears that practitioners with less than 10 years of experience are highly satisfied where the scope of the works is to improve the energy performance of an existing building. Practitioners with over 10 years' experience on the other hand feel completely the opposite. The reason for this could only be that the latter are out of touch with modern trends; this a sign that experience sometimes breeds complacency.

Table 7.4: Variations in ranking of factors which generate satisfaction in refurbishment works

Factors	R(X) up to 10yrs		R(Y) 10yrs+
SatRef1	1	SatRef1	1
SatRef10	2	SatRef11	2
Satref8	3	SatRef10	3
SatRef2	4	SatRef9	4
SatRef9	5	SatRef2	5
SatRef11	6	SatRef5	6
SatRef6	7	SatRef6	7
SatRef4	8	SatRef3	8
SatRef5	9	SatRef4	9
SatRef7	10	SatRef7	10
SatRef3	11	Satref8	11

The findings corroborate Lam *et al* (2010) who identified six key performance indicators for building maintenance projects to include sustainability and safety in terms of environmental friendliness of the project, cost, time, quality and functionality of the refurbished project. It is therefore, not surprising to see that research participants are more satisfied with how these factors were carried-out in most of their refurbishment projects.

7.6 Comparison of variance on SatRef relative to contractor-designation

Based on the foregoing analysis, the research has determined the views or ranking of SatRef based on practitioners' refurbishment experience. This section therefore, attempts to further examine the variance in the rank order of SatRef by evaluating more than two groups of data values. This procedure is hoped to be achieved by using the Kruskal-Wallis test. The procedure will enable the research to establish the closeness or distinctness of the research participants ranking of SatRef based on the type of contractor organisations they work for: namely:

- Principal contractor;
- Subcontractors; and
- Specialist contractors.

As there are more than two groups to compare, the analysis of variance using the Kruskal-Wallis test is the ideal and relevant technique. The procedure allows the mean values of the SatRef factors of each *K* values to be pooled and arranged accordingly, assigning ranks to the value as shown in Table 7.4 and 7.5 respectively.

In order to ensure the KW statistic follows a chi-square distribution with *k -1*df, the study should reject the H_0 if KW is >$\chi^2_{a.df}$ the critical value of chi-square curve α = 0.05 n = 11 and 10 degrees of freedom.

Null Hypothesis:

H_0 The *K refurbishment practitioners* have identical ranks on SatRef;

Alternative Hypothesis:

H_1 At least two of the *K refurbishment practitioners* differ in their ranks of SatRef.

Table 7.5: Pooled rank order of SatRef by contracting designation

Variables	Factors	Mean	Organisation
1	SatRef1	3.36	
2	SatRef10	3.15	
3	SatRef9	3.14	
4	SatRef2	3.13	
5	SatRef8	3.10	
6	SatRef11	3.03	PC
7	SatRef6	2.93	
8	SatRef4	2.41	
9	SatRef7	2.26	
10	SatRef3	2.24	
11	SatRef5	2.16	
1	SatRef1	3.68	
2	SatRef11	3.53	
3	SatRef10	3.41	
4	SatRef9	3.38	
5	SatRef2	3.24	
6	SatRef5	3.19	SubC
7	SatRef6	3.13	
8	SatRef3	2.97	
9	SatRef4	2.24	
10	SatRef7	2.21	
11	SatRef8	2.00	
1	SatRef1	3.11	
2	SatRef5	3.05	
3	SatRef10	3.00	
4	SatRef11	3.00	
5	SatRef3	2.95	
6	SatRef7	2.79	SpC
7	SatRef9	2.26	
8	SatRef6	2.16	
9	SatRef2	2.05	
10	SatRef8	1.95	
11	SatRef4	1.84	

Table 7.6: Allotted rank order of SatRef by contracting designation

Factors	Mean	Alloted rank
SatRef1	3.68	1
SatRef11	3.53	2
SatRef10	3.41	3
SatRef9	3.38	4
SatRef1	3.36	5
SatRef2	3.24	6
SatRef11	3.19	7
SatRef10	3.15	8.5
SatRef6	3.15	8.5
SatRef9	3.14	10
SatRef2	3.13	11
SatRef1	3.11	12
SatRef8	3.10	13
SatRef5	3.05	14
SatRef5	3.03	15
SatRef10	3.00	16.5
SatRef11	3.00	16.5
SatRef3	2.97	18
SatRef3	2.95	19
SatRef6	2.93	20
SatRef7	2.79	21
SatRef4	2.41	22
SatRef7	2.26	23.5
SatRef9	2.26	23.5
SatRef3	2.24	25.5
SatRef4	2.24	25.5
SatRef7	2.21	27
SatRef5	2.16	28.5
SatRef6	2.16	28.5
SatRef2	2.05	30
SatRef8	2.00	31
SatRef8	1.95	32
SatRef4	1.84	33

From Table 7.5 the different groups are presented showing the respective mean values within each contractor-designation. The allotted ranking of factors presented in Table 7.6 determines the rank order of the factors with the most satisfying areas in the top of Table 7.6. Using Table 7.6 the pooled ranks are then represented in Table 7.7 for computation of KW.

Therefore from Table 7.6 and 7.7 respectively, the Kruskal-Wallis test given is derived from the formula:

$$KW = \frac{12}{n(n+1)} \sum_{i=1}^{k} + \frac{T^2}{n1} - 3(n+1)$$

Similarly, T_1 = the total of the ranks from the 'i' sample and the values of $T_1, T_2,$ and T_3 taken from Table 7.6 the Table value for Chi-square as given in Appendix D - 1; the study should reject H_0 at 2 degrees of freedom should KW $>\chi^2_{0.5.2}$ = 5.99.

Table 7.7: Rank order of SatRef by contracting designation

Factors	N = 133 Mean	*n = 80* Principal Contractor (PC)	*Rank PC*	*n = 19* Specialist ontractor (Spc	*Rank SpC*	*n = 34* Sub Contractor (SubC)	*Rank SubC*
SatRef8	3.02	3.10	13	1.95	32	2.00	31
SatRef5	2.64	2.16	28.5	3.05	14	3.19	7
SatRef1	2.59	3.36	5	3.11	12	3.68	1
SatRef11	2.58	3.03	15	3.00	16.5	3.53	2
SatRef10	2.55	3.15	8	3.00	16.5	3.41	3
SatRef2	2.49	3.13	10.5	2.05	30	3.24	6
SatRef3	2.41	2.24	25.5	2.95	19	2.97	18
SatRef4	2.34	2.41	22	1.84	33	2.24	25.5
SatRef7	2.33	2.26	23.5	2.79	21	2.21	27
SatRef9	2.32	3.14	9	2.26	23.5	3.38	4
SatRef6	2.18	2.93	20	2.16	28.5	3.13	10.5
			180		*246*		*135*

$$\frac{12}{n(n+1)}\left[\frac{180^2}{11} + \frac{246^2}{11} + \frac{135^2}{11}\right] - 3(n+1)$$

$$\frac{12}{33(34)}\left[\frac{180^2}{11} + \frac{246^2}{11} + \frac{135.5^2}{11}\right] - 3(34)$$

$$\frac{12}{(1122)}[110103.72] - 102$$

$$108.06 - 102$$

$$Hence, \qquad \boldsymbol{KW = 6.06}$$

The computed value of 6.06 exceeds the chi-square Table value of 5.99 at α = 0.05 and 2 degrees of freedom. Thus given the computed *KW* value is higher than the Chi-square table, the study proceeds to reject the Null hypothesis and concludes that there is sufficient evidence to project differences in the perception of factors which give satisfaction to practitioners relative to contracting designation. In other words there are differences in the ranks provided by the three groups of practitioners. Indeed a further inspection of Table 7.6 shows that the sums of the ranks across the three groups are distinct i.e. $T_{1\,=\,180;}$ $T_{3\,=\,135}$; $T_{2\,=\,246}$.

This result implies that the contractor-organisation one works for (for example, Principal contractor, Sub-contractor or a Specialist contractor), influences the degree of satisfaction with refurbishment work. Indeed, a further inspection of Table 7.5 shows that at the top of 11 items drawn from the pool, four of the top highest are attributed to the ranks provided by practitioners employed by subcontractors. Also of all the 11 factors in the first thirds are between subcontractors and principal contractor and none at all for the specialist explained also by the larger sums of ranks for $T_2 = 246$.

Rahmat (1997) concluded that refurbishment projects are predominantly organised by a large number of smaller subcontractors. The outcome of Kruskal-Wallis appears to endorse this view. Rahmat (ibid) was also quick to establish a relationship between increased level of confusion and uncertainty among parties to a refurbishment project with the unusual number of subcontracted packages compared to a new-build project (and the number scale of contractors involved on any single refurbishment project).

Highlighting the implications of too much interdependence among players in refurbishment projects, Young *et al* (1994) also identified some key implications namely:

- requires closer monitoring, supervision and coordination;
- need more interpersonal skills communication of refurbishment managers;
- requires close long term relationships between the main and subcontractors.

If these concerns are synonymous with refurbishment, it is no surprise the scatterplot in

Figure 7.3 affirms that it is the subcontractors' perception that accounted for the highest scored SatRef factors. This outcome affirms the position for the study: that subcontractors are the ones involved in the coordination, of various packages on a refurbishment project.

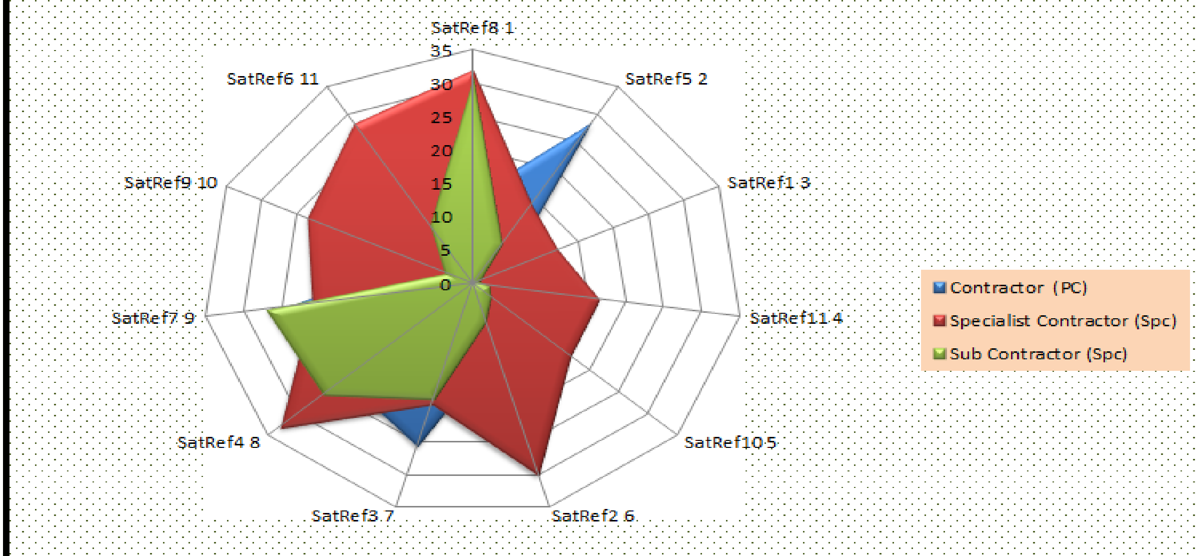


Figure 7.3: Plot graph of pooled ranks on SatRef by contracting designation

Equally, it can be noted in Figure 7.3 that specialist contractors have the least ranked values. Certainly of the last 11 items in Table 7.6, five were provided by specialist contractors. This outcome leads to the conclusion that the specialist contractor is less likely to be involved to the same extent and degree as the subcontractor. By the same token, their experiences on SatRef are different.

The above outcome seems to endorse the projected observations by CIOB (1987) that although specialist contractors in the refurbishment sector were likely to find an increase in the workload, it is the general contractors that would still carry out most of the refurbishment packages. From Table 7.8, the study affirms the CIOB report that, the proportion in the dominance of subcontractors remained the same. 85.5% of practitioners captured by the study main contractors and subcontractors. Of this proportion, 60% were main contractors while 21% were subcontractors and 19% specialist contractors.

Table: 7.8: Cross tabulation of percentage of Area of specialism (AOS) by contracting designation and gender

	Principal contractor		Sub Contractor		Specialist contractor			ProSid
Specialization	Male	Female	Male	Female	Male	Female	Total	
AOS1	8	2	1	3	1	1	16	
AOS2	17	6	8	2	4	1	38	
AOS3	7	1	6	1	2	0	17	71.0 ORUP
AOS4	16	1	4	0	2	2	25	
AOS5	15	7	8	1	5	1	37	62.0 SRUP
Total	63	17	27	7	14	5	133	

Percentages								Percentages
	Principal contractor		Sub Contractor		Specialist contractor			
Specialization	Male	Female	Male	Female	Male	Female	Total	
AOS1	6.0	1.5	0.8	2.3	0.8	0.8	12.0	
AOS2	12.8	4.5	6.0	1.5	3.0	0.8	28.6	
AOS3	5.3	0.8	4.5	0.8	1.5	0.0	12.8	53.4 (ORUP)
AOS4	12.0	0.8	3.0	0.0	1.5	1.5	18.8	
AOS5	11.3	5.3	6.0	0.8	3.8	0.8	27.8	46.6 (SRUP)
Total	47.4	12.8	20.3	5.3	10.5	3.8	100.0	

KEY:		
AOS1	Architects	ORUP
AOS2	QS	
AOS3	Building Surveyors	
AOS4	P/Managers	SRUP
AOS5	C/Managers	
ORUP	Offsite related uncertainty parameters	
SRUP	Site related uncertainty parameters	
ProSid		

This high proportion of subcontractors and main contractors although consistent with previous findings that in a typical refurbishment project there are more subcontractors than specialist contractors (CIOB, 1987; Young and Egbu, 1994; Rahmat, 1997; Ali and Rahmat, 2011), nonetheless has its implications. There are several lessons that the study can draw attention to:

- The refurbishment sector needs to address the effect of Uncertainty in refurbishment Information;
- To date, there is no study that has put forward a current, reliable, operational and therefore working strategy or model to facilitate for the shortcoming in the flow of refurbishment information;

- As a result of both of the above points, there is prevailing uncertainty of refurbishment information among refurbishment managers;
- Some authors have identified the problem (Egbu, 1994; Rahmat, 1997; Young and Egbu 1998; Rahmat, 2011) but as yet there is no model or system dedicated to improving the credibility of refurbishment information.

At a time when the refurbishment sector is expected to see increased retrofit activity following the commitments under the Climate Change Act (2008), the industry will see an increase in the number of owner-occupiers improving their properties. The same is expected of owners of commercial buildings. These owners will want to upgrade their properties by improving the energy efficiency. Unless some personal professional competence programmes are introduced in these areas, the already over burgeoned level of uncertainty in refurbishment information can only get worse.

As illustrated in Table 7.8 a strategic approach will be to distinguish training provision between different professions involved in refurbishment. The study therefore suggests a targeted approach so that information is provided with a dichotomy effect in mind: on one hand the effect should be directed to address 'site related uncertainty-parameters' and on the other hand the 'offsite related uncertainty-parameters'.

It goes without saying that practitioners who specialise in design, structural surveys and go on to inform the client in areas such as costs, quality and the standard of retrofit required would be directed towards a package developed as Offsite related uncertainty-parameters CPDs. Equally site based refurbishment professionals would have to complete Onsite related uncertainty training. Each CPD path should aim to provide iterative information that helps managers to improve in the areas that eliminate pockets of uncertainties they encounter in their work.

The results of this study therefore concur with findings elsewhere (Rahmat, 1997; Young et al., 1994), which state that the state of in completeness of design before refurbishment projects are undertaken on site undermines the performance of the project team.

> '*A project that is ill defined and is outside the range of experience will be relatively uncertain in its performance. ……..a project that demands new answers leads to uncertain work and requires additional management'* (Rahmat, 1997, p. 106).

Given the foregoing, there is no doubting the impact uncertainty of refurbishment information has on the refurbishment team whether they are offsite or site based. As earlier alluded, any shortfall in design information has a residue effect on cost, quality and duration of the project. Uncertainty of refurbishment information impacts on the team's level of uncertainty in resolving site assembly issues within the refurbishment scheme. With refurbishment generally consider to be as increasingly complex, characterised by poor communication (Egbu, 1994); and lack of risk management skills (Trisma); poor awareness on Plasmolysis; inadequate specifications and a higher ratio of changes made by architects as the work progresses, (Okoroh, 1992) it is difficult for refurbishment contractors to define the exact cost and scope of work in advance.

In view of the above concerns refurbishment managers should be subjected to more CPD training than project managers in the new build sector. The issues raised hitherto are critical to providing a conducive and progressive management environment where some of the issues can be tackled head on; such inroads are needed in this sector.

7.12 Summary

The chapter identified level of satisfaction with the implementation of refurbishment works based on practitioners' experience and contractor designation. In order to achieve this, eleven factors were identified from an initial desk study and presented to practitioners in order to provide a rank order. In this section of the study, four key areas that generated the most satisfaction were identified, namely:

- Low carbon driven quality success;
- Synergy in dispute resolution;
- Credibility of refurbishment information; and
- Diagnosis of structural defects and associated risks.

Consequently, the importance of each implied meaning or designated terms was discussed. From the eleven rankings of satisfaction with the implementation of refurbishment works undertaken by research participants, the top three reflected the much talked about case for sustainable concepts in relation to quality of works. Hence, it was clear from this ranking to suggest that, although the sustainable development concepts are increasingly gaining recognition worldwide, its popularity in the UK cannot be overemphasised, with government targets being identified in order to minimise carbon emissions from existing buildings.

As a consequence, refurbishment is believed to present excellent opportunities for reducing energy consumption in buildings. The planning and implementation of project activities is also highlighted as an essential requirement in any development project, be it refurbishment or new-works, especially as it relates to health and safety, an area reported to present more accidents and injuries than any other area within the construction industry, while there appear to be huge penalties for disregarding safety coordination on refurbishment sites. Given this importance, it is believed that proper attention to detail is usually given on refurbishment projects from inception through to completion in order to successfully manage projects.

Based on the analysis in this chapter, the reliability of the data was validated by confirming the Null (H_0) implying that there is no relationship in ranking of SatRef between the two sets of practitioners based on refurbishment experience. Thus, the pairwise rank does not generate a perfect linear relationship. This would suggest that identifying which factors practitioners are more satisfied with, in terms of implementation of refurbishment works varies relative to managers' refurbishment experience.

To further substantiate this claim, the study explored the impact of 'contractor designation' to reveal any notable differences in ranking the SatRef factors. To this end, the study concluded that the K levels have the same perceptions on SatRef. This result implied that whatever contracting organisation one works for (for example, Principal contractor, Sub-contractor or a Specialist contractor), what gives satisfaction to refurbishment work is not related to size or type of contracting organisation.

The study also pointed out that in order to resolve the uncertainty in refurbishment information, CPD should be developed and directed towards both resolving the site related uncertainty-parameters and Offsite related uncertainty-parameters to ensure 'Credibility of refurbishment information'.

CHAPTER EIGHT

Discussion and development of framework

8.1 Introduction

This chapter aims to integrate the findings of the research by formulating the conceptual framework on risk and uncertainties associated with refurbishment. Furthermore, the findings of the research will be worked into logical conclusions which will highlight the most important points for improvement as well as making recommendations for further research and this will form part of the next chapter.

A number of reports from both government and other researchers have highlighted the importance and contribution of the refurbishment sector to the economy. Researchers have also warned of the risks and technical challenges associated with refurbishment processes. To highlight the importance of risk assessment in managing refurbishment schemes, the HES (2009) suggests that firms involved in refurbishment or maintenance should ensure that the work is planned properly and that sensible measures are taken to ensure that both workers and the public are not exposed to risk. This indicates a clear need for research in this area in order to enable proper implementation and management of the schemes effectively.

8.2 Overview of the research

The main aim of the research is to explore and evaluate the types of risks, uncertainties and technical challenges associated with building refurbishment schemes within the UK refurbishment sector with the ultimate aim of developing a framework. To this end, the research identified some important questions namely:

- What are the major risks, areas of uncertainties and technical challenges associated with building refurbishment schemes?
- What are the likely impacts of the risks on refurbishment projects' desired outcomes?
- Which are the most difficult risks in terms of management of refurbishment schemes?

Equipped and prepared with these questions in mind, the research developed with four research objectives which were intended to enable the research to attain or accomplish the goals or targets as follows:

- To critically evaluate the characteristics of building refurbishment schemes;
- To analyse key factors that contribute to achieving quality of refurbishment schemes and barriers to achieving quality of refurbishment schemes;
- To evaluate and analyse the factors that contribute to risks and technical challenges in refurbishment schemes;
- To develop a conceptual framework for risks and uncertainties associated with building refurbishment schemes.

All the objectives were addressed in different chapters of this research. For example, objective one was addressed in chapter four and it identified factors which are believed to be typical characteristics of refurbishment schemes (ChaRef). The second objective was dealt with in chapter five which was directed at understanding the key factors which contribute to quality of refurbishment works (QuaRef) as well as factors which act as barriers to achieving high quality refurbishment works (BarQuRef). Chapter six dealt with objective three of the study by identifying factors which contribute to risks and technical challenges associated with building refurbishment schemes while the last objective is presented in this chapter.

8.3 Decision Framework based on refurbishment information uncertainty

Miles and Huberman (1994) and Robson (2002) defined a conceptual framework as a visual or written product which depicts or explains the main things to be studied such as key factors, concepts, variables and presumed relationships among them either graphically or in narrative form. Hence a conceptual framework would appear to mean that it must contain the system of concepts, theories that supports and informs one’s belief, expectations and assumptions.

According to literature, risk in construction is the object of attention mainly due to time and cost over-runs. Akintoye and MacLeod (1997) described risk as a variable in the process of a construction activity whose variation results in uncertainty of the final cost, duration and ultimately, the quality of the project. The combination of different risk factors can make refurbishment of existing buildings highly risky and consequently affect the desired project outcomes. It is therefore appropriate to suggest that in refurbishment, an area which is faced with various unknowns, unexpected and unpredictable events and often undesirable situations will need further attention and a mechanism to identify any source of uncertainty. When risks are unidentified and not properly managed, they consequently affect project objectives.

Risk analysis relates to a systematic technique which is aimed at understanding the extent of uncertainties associated with refurbishment activities. Risk analysis has often been used to mitigate and predict the impact of risks and uncertainties associated with construction and refurbishment projects. There are various methods of analysing risks and uncertainties such as Monte Carlo simulation, decision trees, sensitivity analysis (Flanagan and Norman, 1993; Akintoye and MacLeod, 1997; Babangida *et al.,* 2014a) and Failure, Mode Effect and Critically Analysis (Lock, 2007; Babangida *et al.,* 2014).

Although, these methods have been used extensively in different projects, one of the weaknesses of these methods is that the procedures are mainly mathematical or probability oriented approaches which hardly show the relationship between variables (Han and Diekmann, 2004). As a consequence, a strategy for risk identification and analysis is required in any project so as to model the factors which contribute to uncertainty. The aim of risk identification and analysis is to provide an estimated impact and monetary value of a risk and also to get a sense of the range of possible outcomes across good and bad scenarios (Babangida *et al.,* 2014a). The extent to which the identification and analysis will influence the effectiveness of the technique employed and its contribution to the overall refurbishment project success is directly proportional to the implementation of the steps in the process.

Indeed, designing and developing a systematic technique for managing and decreasing refurbishment risk and uncertainty is not only required but will also provide profitable information to practitioners. It is these aims that the proposed framework will hope to achieve. Figure 8.1 presents the proposed refurbishment decision framework based on information uncertainty. The framework is designed in three phases beginning with the uncertainty of information to a practitioner in Phase One. This phase presents a number of stages where a practitioner will have to deal with challenges to ensure certainty of refurbishment information on the project. Phase two deals with the certainty of information having dealt with the level of uncertainty in previous phase. This phase also presents a number of stages to manage challenges which a practitioner may encounter. However, Phase three focused on Implementation of the refurbishment project based on assumptions that a practitioner will have gone through the various stages of the two previous Phases.

8.4 Application of decision framework in refurbishment schemes

Phase one:

1. **Establish clear refurbishment goals based on level of uncertainty:** At this level, there is a requirement for setting project goals by paying attention to client’s brief and requirements and composing a risk management team. The team should conduct meetings for project risk planning in this level and should aim at maximising team work for managing the project risk by considering the project goals.
2. **Identify and define areas of uncertainties:** Following the previous level of establishing the refurbishment project goals, the risk management team should identify any potential challenges or areas of uncertainties associated with the project.

3. **Is there uncertainty around expected quality outcomes?** Following the previous level, a NO answer to this question means that the project can move to the next phase. However, where the answer is a YES, the framework reconnects the next level to determine and ascertain the causes of uncertainty around expected quality outcomes.
4. **Ascertain causes:** Following the previous level faced with uncertainty of final outcome of refurbishment works, this level will collect more data in order to deal with uncertainty and may also require additional site visit and the carrying out of a structural survey.
5. **Is there uncertainty in adeptness at Plasmolysis, Priskaver and TRISMA?** This level requires a detailed structural survey in order to identify the extent of defects and works to be undertaken and the types of risks present in order to enable the achievement of project objectives. Where this is carried-out effectively and the answer to the question is a NO, the project can safely move to the next phase. Where the answer is a YES, the framework reconnects to the next level of the framework for further investigation.
6. **Carry-out additional training and ensure that all areas of uncertainty are followed-up and well defined against desired outcomes:** Following the previous level which deals with uncertainty, the next stage of the framework is to provide training to project partners before going further in the project. This is to educate team members on the extent of defects and possible risks that may jeopardise the achievement of project desired outcomes.

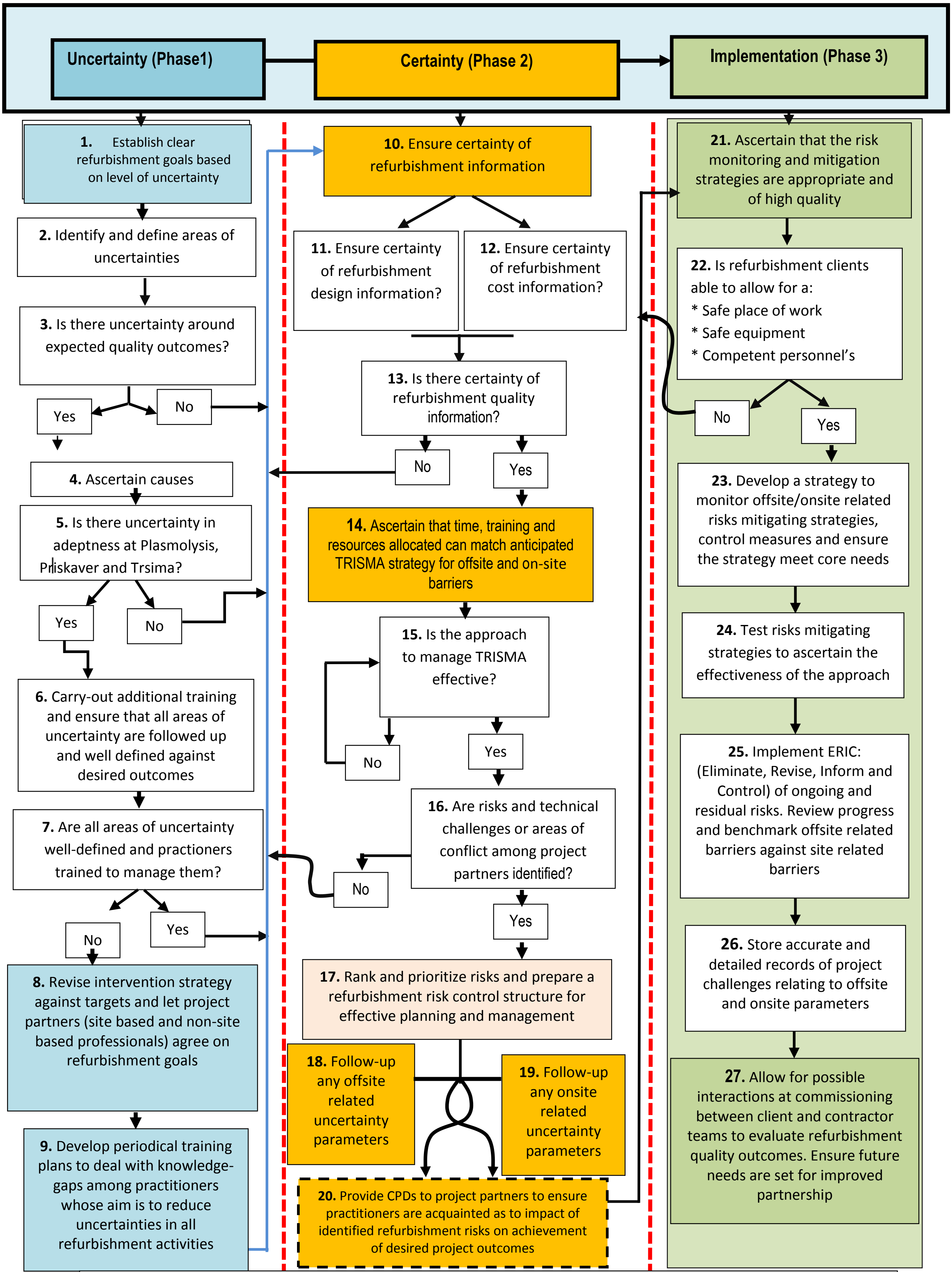


Figure 8.1: A framework of risks and uncertainties in refurbishment schemes

7. **Are all areas of uncertainty well defined and practitioner's trained to manage them?** The importance of information in understanding uncertainties of refurbishment processes has been highlighted in foregoing chapters of this study due to the fragmentation and complexity associated with refurbishment schemes. At this level of the framework, it requires all areas of uncertainty to be identified before going further in the project. If the answer is a YES, then it requires moving to the next phase of the project however, where the answer is a NO, then the project should reconnect to the next level in phase one.
8. **Revise intervention strategy against targets and let project partners agree on refurbishment goals:** This level is a continuation of the previous level where the answer to the question is a NO. This requires a revisit to the intervention strategy to ensure that the strategy conforms to the targets of the project by ensuring that project partners agree on common ideas to maximise outcomes.
9. **Develop periodic plans to deal with knowledge gaps among practitioners and aim to reduce uncertainties in all refurbishment activities:** At this level of the framework, it requires the risk management team to develop a plan based on the results of the revised intervention strategy in the previous level. The plan should aim at managing all uncertainties before moving to the next phase of the framework.

Phase two:

10. **Ensure certainty of refurbishment information:** Following previous stage in previous phase, this first level of phase two requires the risk management team to scrutinize the amount of information available to them from all previous stages in phase one. The team must examine and ensure the certainty of refurbishment information before moving to the next stage in phase two.

11. **Ensure certainty of refurbishment design information?** At this level of phase two, the risk management team should examine the certainty of information required to implement designs before moving ahead to the next level of the framework.
12. **Ensure certainty of refurbishment cost information?** Further to the previous level, the risk management team should also ensure that there is certainty of cost information as it relates to the design and quality outcomes of the project.
13. **Is there certainty of refurbishment quality information?** The expected quality of the refurbishment project is of paramount importance to all team members. It is therefore, at this stage that the team must ensure that there are no hidden hindrances to achieving high quality works by scrutinizing the certainty of information gathered. Where the answer to the question is a NO, the process should go back to the first level of this phase to ensure that there is certainty of all information at hand before going further to the next level. However, where the answer is a YES, the process should reconnect to the next level of the framework.

14. **Ascertain that time, training and resources allocated can match anticipated TRISMA strategy for off-site and onsite barriers:** Following the previous levels after ensuring certainty of design, cost and quality information, this stage requires the risk management team to ascertain that the amount of time and resources allocated can match anticipated support to the strategy for managing uncertainties.
15. **Is the approach to manage TRISMA effective?** There is need for a strategy to implement the risk management process hence; this level of the framework requires the risk management team to examine whether the strategy is designed to deliver a risk free refurbishment project. The question requires an answer before moving further. If the answer to the question is a NO, the process should go back to ensure there is a strategic approach to delivery before moving ahead to next level. However,

where the answer is a YES, the process requires the team to proceed to the next level of the framework.

16. **Are risks and technical challenges associated with the project identified and included in a risk register?** The aim of this level is to understand the impact of risk and ensure that there is a plan or strategy to manage or mitigate the risks. This stage of the framework requires informed knowledge of the types of risks identified which should be placed in the project risk register. If the answer to the question is a NO, the process should go back to ensure that all risks are identified and their impact on the project is well known before moving ahead to the next level. However, where the answer is a YES, the process requires the team to proceed to the next level of the framework.

17. **Rank and prioritise risks and prepare a refurbishment risk control structure for effective planning and management:** Having identified the types of risks that the project is faced with, this process requires the risks to be ranked according to their impact and likelihood of occurrence on the project. This will enable the possibility of prioritising the risks according to high importance to low, and this should lead to placing the risks in a risk breakdown structure. It is important for the risk management team to apply best practice risk management arrangements to ensure that the current standards and regulations are adhered to for example, the CDM Regulations. If this is done effectively, the project can move to the next level.

18. **Follow-up any off-site related uncertainty parameters:** At this level, a follow-up of any offsite related uncertainty parameters is required in order to understand if there are any offsite related barriers which the project is exposed to and identify any possible solution to managing them effectively and efficiently with a view to achieving the refurbishment project's desired outcomes..

19. **Follow-up any on-site related uncertainty parameters:** Similarly, this level goes hand-in-hand with the previous level and it also requires a follow-up on any on-site related uncertainty parameters in order to understand if there are any on-site related barriers which the project is exposed to and then identify any possible solution to managing them effectively and efficiently with a view to achieving the refurbishment project's desired outcomes.
20. **Provide Continuous Professional Development (CPDs) to project partners to ensure practitioners are acquainted with the impact of identified refurbishment risks on the achievement of desired project outcomes:** The study identified certain risks and technical challenges associated with building refurbishment schemes. To this end, the importance of training and development of practitioners must be optimised and confronted efficiently in order to improve refurbishment practices and minimise uncertainties. Therefore, CPD packages should be designed to cover the areas identified by this study and to provide adequate knowledge to practitioners. At this level of the framework, if training is provided to practitioners, the project can move to the next phase of the framework.

Phase three:

21. **Ascertain that the risk monitoring and mitigation strategies are appropriate and of high quality:** This phase is aimed at ensuring successful outcome of the refurbishment project. It follows from previous phase where the process ensured there is certainty of refurbishment information and further identified the types of risks in the project. This level of phase three attempts to ascertain the quality of risk monitoring and mitigation strategies and to further investigate the appropriateness of the strategies and whether they suit the needs of the project with a view to delivering desired outcomes.

22. **Is the refurbishment client able to allow for safe place of work, safe equipment and competent personnel?** This level requires the employer to ensure an adequate safe working environment is provided by adhering to the CDM standards in terms of working on construction sites before going further in the project. The level also requires project partners or employers' advisers to ensure all that is required is in place. This can be probed by answering the question, where the answer to the question is a NO, the process should be repeated to ensure that there is certainty of safe working environment before going further to next level. However, where the answer is a YES, the process requires the team to proceed to the next level of the framework.
23. **Develop a strategy to monitor off-site and onsite related risks mitigating strategies, control measures and adapt strategy to meet core needs:** This follows from the previous level and it attempts to identify a systematic technique to monitor the progress of risks mitigating strategy in order to meet core needs of the project. It will require meetings and information sharing in order to ensure that the risks and uncertainties associated with the project are managed and controlled effectively.
24. **Test risks mitigating strategies to ascertain the effectiveness of the approach:** Having established a strategy to monitor progress of the refurbishment project risks, it should be implemented properly and thus the strategy should be scrutinized to test its effectiveness and identify any changes that may be required.
25. **Implement ERIC (Eliminate, Revise, Inform, and Control) arrange regular meetings to review progress and benchmark barriers to encourage improvements:** This level requires further analysis of the process by implementing the ERIC Principle to Eliminate, Revise, Inform and Control associated risks by reviewing the process using both offsite and onsite related barriers to ascertain that the project is on track.

26. **Store accurate and detailed records of project challenges relating to offsite and onsite parameters:** This level requires record keeping of project challenges in order to assist project team members in the post-occupancy stage and also in making informed decisions on similar future refurbishment projects.
27. **Allow for possible interactions at commissioning between client and contractors to evaluate refurbishment quality outcomes and ensure future needs are set:** The level requires risk management team members to interact with other stakeholders to evaluate the entire process and to ensure that the needs of the project have been met.

8.5 Limitations of the study

The study aimed at developing a refurbishment focused framework for risk and uncertainty based on available information at the inception of the project. Thus, one of the limitations of the study is that it was directed towards building refurbishment practitioners working for contracting organisations. Although these practitioners are believed to have adequate knowledge and information needed for the study to achieve the set objectives since refurbishment contractors are charged with the responsibility of coordinating and delivering the projects according to the specification of the client, the views of practitioners working for clients were not represented.

In order for the findings in this study to inform the constraints faced by practitioners a similar study that identifies the challenges and perceptions within the clients' team is needed. Such a study would not only capture the client's needs but also help in creating an inventory of quality determining factors as perceived by those who represent the needs of clients. While the above limitation was known to the researcher, due to time and financial constraints, the study did not seek the views of clients and this means it did not allow the wider views of all professionals to be captured.

Another limitation of the study is the inability to gather responses from a larger population. The study initially attempted to gather up to 900 refurbishment contractors however, this proved difficult mostly due to time and financial constraints. Hence, a population of 450 were generated. Additionally, the random sampling of the population also affected the ability of the researcher to identify a large number of the contractors in two of the regions selected. As a result, the study population was limited to 150 contractors in each of the three regions identified as the targeted areas. Although time and financial constraints affected the study, however, it was believed that if the study captured all regions within England, a large number of refurbishment contractors could have been generated thus, providing a better representation of the views of refurbishment practitioners.

8.6 Summary

This chapter provided an overview of the research and also highlighted the relevance of a decision framework within the refurbishment sector. In order to understand the significance of the decision framework, literature was incorporated to support the position of the study with views of authors from previous studies.

Based on the research findings, the chapter was able to develop the conceptual framework of factors which will assist in efficient management of building refurbishment schemes. The absence of a refurbishment focused framework informed the basis of this research, hence the chapter established effective and efficient knowledge associated with those factors which provide construction industry practitioners with the most important information in this regard and thus, the research justified its aim and objectives.

CHAPTER NINE

Conclusion and recommendation

9.1 Introduction

The study investigated the risks, uncertainties and technical challenges associated with building refurbishment schemes. This chapter will outline and summarise the main conclusion and recommendation of the research in relation to the key findings from which the relevance in addressing the original aim and objectives will be discussed.

The recommendation will be restricted to further research and will be limited to the most important facts of the research which also stem from the literature review and findings of this research in order to direct research efforts into potential improvement in the refurbishment sector.

9.2 Conclusions

The research commenced with an in-depth review of literature which suggested that the UK have some of the oldest building stock in Europe, with almost a quarter of buildings in England built before 1919 and only about 2% of the total stock built between 2001 and 2003. This clearly suggests that most of the building stock pre-dates the emergence of modern concepts of sustainable development, thus much of the existing building stock is classified as outdated, obsolete and inefficient. This is at a time when there is the increased growing pressure to meet targets for zero carbon buildings by improving aged buildings to current standards. This is as a result of the global demand for sustainable energy efficient buildings from both regulators and occupiers to provide improved interior comfort for existing building users.

There is no widely used, understood and accepted framework to inform refurbishment practitioners about the risks and technical challenges associated with the refurbishment schemes. Therefore in order to fill the gap research was carried-out with a view to providing a better understanding of the structure and impact of risks and uncertainties in building refurbishment schemes.

From a review of literature, it was also clear that while building refurbishment is believed to be a well-established alternative to demolition and new-build, for many years, since demolition and new-build places increasing pressure on existing landfills and that refurbishment presents a means of improving the value and performance of existing buildings without the economic and environmental costs associated with new-build construction, dealing with existing buildings is also believed to introduce many sources of risks and uncertainties which can affect the scope of work, the total cost and the time or schedules. As a consequence of the foregoing, literature also suggests that failure to deal effectively with risk can lead to significant cost overruns, schedule delays and the inability to achieve the desired project outcomes.

Developing a framework that provides support for decision makers in pinpointing the vital elements that define the significance and characteristics of the factors which can enhance effective delivery of refurbishment projects in terms of high quality standards as well as those factors which may act as barriers was chosen for this study. A further exploration of the source of risks and technical challenges and how these manifest at various levels to create uncertainty in refurbishment schemes were extensively reviewed and believed to be nonexistence. The absence of a template model that resolves these issues led to developing a conceptual framework.

Within this framework the research carried-out extensive literature review to uncover a wide range of information which relates to the impact and sources of risks in refurbishment schemes. Having reviewed the relevant literature, the study conducted semi-structured interviews with refurbishment practitioners in order to identify the key factors that contribute to risk and technical challenges associated with uncertainty in building refurbishment schemes.

Conducting the interviews assisted in developing a questionnaire data collection instrument which was sent out to refurbishment practitioners across several regions within England (as detailed in chapter three). In total, 450 questionnaires were distributed to research participants through emails, post and also through refurbishment site visits within the Northwest of England. However, 133 questionnaires' (30% return rate) were received as valid copies having filled-in all the required information. Hence, after receiving a satisfactory response to the questionnaire survey which commenced by examining the typical characteristics of refurbishment schemes, this section identified eight factors believed reflect the characteristics of typical refurbishment works - ChaRef. Analysis of the data generated three groups which helped to explain all the eight factors. The three groups enabled the study to make the following conclusions:

Transmutation of Risk Management –Trisma: At aggregate level, the study surmised that risks are not permanent but will change relative to conditions on site and the rate at which they will change and the direction they will take as a result of the change must be known in order to be managed or their effect mitigated. This outcome demonstrates an increasing concern that:

- Refurbishment projects are prone to more accidents than equivalent new-build projects as the sector accounts for a substantial proportion of injuries and fatal accidents. This would explain furthermore why that there are more accidents in refurbishment projects than there are in new-build projects;

- As a result of the above observation, it is comes as no surprise that managing refurbishment projects is often faced with some unique problems in dealing with people, lack of information and clarity on past weakness inherent in the original design, as well as any poor workmanship likely to have impacted on the quality of the assembly process compounded by lack of information regarding past maintenance interventions contribute to increasing uncertainty on how to define the precise scope cost and duration of refurbishment process. This environment itself often leads to uncertainties hence, it is appropriate to conclude that what all refurbishment projects share in common is a greater risk profile than equivalent new-build project where individual risk or a combination of the risks may jeopardise the achievement of projects desired outcomes;
- The fact that managing refurbishment is underscored around uncertainty mainly due to insufficient and incomplete information and also under changing conditions means that refurbishment projects are more economically uncertain than equivalent new-build projects. This is mainly because the challenge imposed by uncertainty may lead to the occurrence of large variation orders to a project mainly due to the unknown nature of a building and where this is the case, a higher level of contingency may be required for the purpose of the increased risk of unforeseen costs associated with the schemes and in order to deal with any unexpected difficulties.

Adroitness of incipient building defects (Plasmolysis): the study also investigated the effect of experience in efficient management of various refurbishments projects. Experience is associated with increased reliability of decisions made by experienced practitioners. Thus, the study re-affirms the old adage that experience is the best teacher; it defines the varying performance notable among practitioners.

Consistent with the expectation that uncertainty about the specific structural defects associated with a building in need of refurbishment intervention yields further uncertainty about the refurbishment process. It was concluded that while there are instances when the more experienced practitioners are able to provide a more accurate diagnosis about the probable causes to any underlying failure in building materials there are equally instances when the opposite is the case. The study cited a lack of understanding as to the effect of plasmolysis or the micro loss of failure that begins at the cellular membrane to any building material and which the study believes denotes the actual root cause of a building defect as adding to increased uncertainty and lack of informed diagnosis.

Given the foregoing, the study's conclusion that in the refurbishment sector there is a widely acceptable dictum that it is to tolerable to uncover defects as the work progresses and a practitioner simply needs to adjust their prognosis and remedial strategy. The fact that refurbishment projects are exposed to more site discoveries as the project develops helps to explain why there are uncertainties in the information associated with the works at the outset of the projects. In the light of this, the study proceeded by offering an explanation that refurbishment projects are more complex to design and coordinate than equivalent new-build projects mostly due to ineffective design co-ordination as a result of being fragmented subject to uncertainty.

The study observed that training programmes in the form of refurbishment-CPDs aimed at improving the practitioners' prior-knowledge of building defects are overdue. The fact that it is not mandatory for building owners to keep records of past repair or remedial activities helps to elucidate why many practitioners are susceptible to making wrong diagnosis and prognosis of the remedial strategies. Given this deficiency, the study concluded that it was all the more necessary that refurbishment practitioners are given CPD training tailored to foster more understanding about the effects of uncertainty in refurbishment information.

The study also sought to examine rank order of eight factors which contribute to quality of refurbishment works and following non parametric statistical testing was able to draw the three key areas as follows:

The decision to refurbish a building is made when a building is deemed unfit for purpose in its present form. This often involves identifying the most deteriorated parts of the building. In order to understand which factors are more related for improving the quality of refurbishment projects, the study concluded that:

More cooperation and adeptness is required between the designers, clients and contractors as miscommunication within and between different corporate structures and the lines of communication between professionals may be a source of uncertainty especially towards knowledge of structural defects.

It was further observed that in the majority of cases, knowledge of structural defects or extent of deterioration at inception of the project is highly desirable before any informed decision can be made. This is mainly due to the danger of the constraints arising from the condition of existing building fabric.

Another important factor likely to impact on quality of refurbishment schemes related to the appropriateness of design. The study observed that in some cases a refurbishment project starts without complete design information. However, when one considers that well informed designers have greater opportunity to eliminate any risks and challenges associated with a refurbishment project any refurbishment scheme that commences when design is not complete subjects all those involved in the implementation stages to more risks and danger to their own safety.

As a result of the foregoing, the study further concluded that, it is difficult to manage refurbishment projects efficiently because inherently:

- Refurbishment projects are highly specialised and require specialist expertise and experience to plan and coordinate as they are fragmented and complicated;
- Increased uncertainty implies any initial estimates about the schedule project duration are likely to be unrealistic leading to impracticable time pressures
- The accuracy and reliability of estimates is likely to be very poor which adds further implications as to the quality of refurbishment works and if not optimised would lead to incorrect project estimates which would also have a detrimental impact on overall project goals.

  If the above concerns prevail, then effective quality control procedures which are a requirement in achieving quality of refurbishment works and are perceived as one of the most difficult job dimensions in refurbishment projects will also suffer.

Having identified what factors determine the quality of refurbishment schemes, the study proceeded to establish the factors which are perceived as barriers to refurbishing an existing building to high quality standards. At aggregate level the study identified three key factors as follows: cash flow; design and time related uncertainties.

Firstly, in terms of cash flow, ‘Lack of available funds is the biggest barrier to achieving high quality refurbishment works as capital or cash flow issues will undermine any quality-success of a project. Refurbishment projects should therefore commence with proper allocation of funds;

Secondly, with regard to design uncertainty, the study observed that refurbishment projects are characterised by high levels of uncertainty which affect the ability to identify work packages at inception. Such uncertainties will further affects the design co-ordination and consequently limit the scope of the major refurbishment works to be carried-out. Uncertainties in design are therefore a barrier to achieving quality of refurbishment works.

Thirdly, practitioners are unanimous in thinking that another source of disputes in many development projects is the unrealistic timeframes in refurbishment projects which may cause project failure and cost overruns;

Having identified the factors that impact negatively and positively on the refurbishment process, it was important for the study to compile a list of factors which contribute to risks and technical challenges (FarTech) associated with refurbishment works. The research identified 25 risks and technical challenges which were further allocated into nine groups, namely:

- Uncertainty over project duration and costs;
- Synergy in design and incipient plasmolysis of building defects;
- Effect of design-uncertainty on project cost and loses;
- Risk appraisal competence management;
- Dispute resolution management;
- Synergy with client team expectations.

The main conclusions drawn by the study were that in refurbishment projects there is uncertainty in relation to project duration and associated costs because the events and tasks leading to the completion of refurbishment projects cannot be predicted with complete accuracy at inception of a project mainly due to hidden defects and other uncertainties.

Consistent with the concerns raised when the barriers to refurbishment were raised, this part of the study again paid credence to the fact that in refurbishment schemes accurate diagnostic and prognosis of structural defects should precede the effectiveness and outcome of a refurbishment scheme. In the light of this, refurbishment schemes demand for more synergy among project partners. They need to understand the concept of incipient plasmolysis of building defects; how defects have occurred and more importantly, will require designers to rely on their judgement to make an accurate assessment of the true extent of structural defects to understand why a building has decayed. The study observed that Designers often lack information about the existing building and the paucity in not knowing what brought about the defects in the first place, translates into cost uncertainty and thus the likelihood of follow-up losses

Despite the above observations, the study also established from the rank order of the technical factors that work often begins even when both the diagnosis and prognosis are unclear and thus those elements which have to be repaired or replaced are only clearly defined as the works progresses while more discoveries are made. These shortcomings led the study to affirm the impression that considering that refurbishment takes place in an environment where risks are subject to high mutation, it is no surprise that dispute resolution management is another factor that appears to overbear the process. The effect of design uncertainty on project cost lead to ill-informed risk appraisals.

The least three overarching factors turned out to relate to areas where practitioners have little say in that they tend to be beyond the bound of a project scheme, such in the location of a project as well as those that are legislative in nature, namely:

- Constraints imposed by site logistics;
- Riddor related cost contingencies;
- Planning consent bureaucracies.

These areas present the least challenges in that project teams often find a way of managing around them. However, given the dominance of uncertainty in refurbishment information; cost and lack of synergy in diagnosis and prognosis of building defects, the exploration of the 24 risks and technical challenges brought home to demonstrate how risky and difficult the process of managing refurbishment works can be. These issues contrive to make refurbishment projects costly, challenging to plan and manage and difficult to control in terms of meeting targets and they are also inherently unsafe and dangerous.

Despite these gloomy impressions, the last issue the study explored focused on specific areas that practitioners felt generated more satisfaction in the delivery of refurbishment projects. This question broadly identified the key role and benefits enshrined in the refurbishment as a process. In order of importance, of the eleven areas discerned from literature, the study was able to group these into four key areas, as follows:

- Low carbon driven retrofitting;
- Synergy in dispute resolution;
- Credibility of refurbishment information;
- Diagnosis of structural defects and resolving associated risks.

The conclusions drawn from the above rank order are that developers are faced with the challenges to comply with the current legislation to minimise carbon emissions from existing buildings. The modern concept of sustainable development is increasingly gaining international recognition thus, there is satisfaction among refurbishment practitioners on achieving low carbon driven quality-success of refurbishment.

Likewise, it is clear that industry practitioners identify that the lack of cooperation among duty holders sometimes leads to un-informed clients' brief and thus design uncertainties. Therefore, where 'uncertainty in refurbishment information' is reduced, it will minimise errors resulting in improved quality-success of the refurbishment schemes. It is clear that synergy in dispute resolutions can enhance the possibility of meeting deadlines as well as eliminate points of contention during the production stages.

Furthermore, the foregoing appear to endorse earlier assertions that refurbishment projects are characterised by more hidden challenges compared to new build projects mainly due to uncertainty at inception. The antithesis to such consequence therefore, lies in ensuring that the uncertainty of refurbishment information is reversed by providing 'credible refurbishment information to project partners.

There seems to be a direct relationship between adeptness at understanding building defects and the prognosis that follows by understanding of the nature, source and causes of structural defects in buildings (Plasmolysis). The rate at which the risks mutate can therefore be managed by ensuring that hazards are identified and correspondingly adequate control measures are established, hence, adeptness at Plasmolysis, Priskaver and Trisma is required.

In summary, there are distinctive features in the management of refurbishment projects, for example the need for cooperation between project partners will bring about cohesion and eliminate ambiguity. They also requires unity among project partners or team members as well as formal and informal collaborations as well as a flexible approach to challenges imposed by level of uncertainties in order to tackle and manage any issue of importance in the cause of delivering projects' desired outcomes. Therefore, the appropriate approach must be holistic in nature if uncertainties associated with refurbishment projects can be managed effectively.

The conclusions therefore provide guidance to the refurbishment practitioners to balance the extent of uncertainty in refurbishment projects and also devise a means for alternative solutions. However, it would appear from the findings of the research that there is no substitute to the requirement of specialist expertise to enable the selection of the most appropriate solution for a particular case and to effectively manage the challenges associated with refurbishment schemes. The study understands that experience will inform the contractors' decision and will assist in considering a wide range of options to plan and manage the schemes effectively with a view to overcoming potential challenges imposed by risk and in achieving refurbishment projects desired outcomes. The developed framework will also assist practioners' in making an informed decision to manage the schemes effectively.

9.3 Recommendations for further research

With the establishment of the barriers, challenges to refurbishment process and with a view to improving the process and management of refurbishment projects effectively in-depth study should be conducted to investigate what defines experience and the type of skillset required of a project manager to effectively manage major refurbishment projects. Given the effect of information-uncertainty that surround the refurbishment process, a study should be carried-out to investigate the need for Continuous Professional Development (CPD) training for refurbishment managers which should aim at understanding all types of risks associated with refurbishment projects and possible management techniques.

Furthermore, as a result of the high levels of uncertainty in refurbishment projects, there is no substitute for understanding the extent of structural defects at the outset of the project. A study should be conducted to develop a procedure for minimising the extent of uncertainty which usually slows or delays work and which sometimes leads to conflicts among project partners.

A study on how to enhance cooperation between refurbishment project managers would also be desirable. The study should aim at understanding how to minimise friction between project team members and work towards common project goals. Having identified the types of risks and technical challenges associated with refurbishment projects in this study, research is needed to establish which risks are peculiar to types and sizes of refurbishment projects especially given the on-going emphasis on low carbon retrofitting.

The study also pointed out that in order to resolve the uncertainty in Refurbishment information, CPD should be developed and directed towards both resolving the site related uncertainty-parameters and Offsite related uncertainty-parameters through ensuring 'Credibility of refurbishment information'

In the light of low carbon driven refurbishment schemes, a similar study can be carried out to identify the technical challenges associated with new knowledge in this sector both from product innovation as well as knowledge of the long term limitations, failures and shortcomings which emerges from structural detailing.

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APPENDICES

APPENDIX - A

Conference papers

Babangida, I., Olubodun, F. and Kangwa, J. (2014) Managing the Effects of Risk and Uncertainty in Building Refurbishment Projects, *Proceedings of the International Council for Research and Innovation in Building and Construction (CiB) Conference,* 28^{th}-30^{th} January 2014, Organised by Hariot-Watt University Edinburgh, UK and University of Lagos, Nigeria;

Babangida, I., Olubodun, F. and Kangwa, J. (2014) An Appraisal of Risk Allocation Strategy in PFI Construction Projects in the UK, *Proceedings of the International Council for Research and Innovation in Building and Construction (CiB) Conference,* 28^{th}-30^{th} January 2014, Organised by Hariot-Watt University Edinburgh, UK and University of Lagos, Nigeria;

Babangida, I., Olubodun, F. and Kangwa, J. (2012) Building refurbishment: Holistic evaluation of barriers and opportunities *In*: Smith, S.D (Ed) *Proceedings of the 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 1289-1298; [Internet] Available at < http://www.arcom.ac.uk/-docs/proceedings/ar2012-1289-1298_Babangida_Olubodun_Kangwa.pdf> (Accessed 12^{th} April 2014).

Babangida, I., Olubodun, F. and Kangwa, J. (2012) Assessment of risk and Technical Challenges Associated with Building Refurbishment Schemes, *Proceedings of the Construction, Building and Real Estate (COBRA) Annual Research Conference of the Royal Institution of Chartered Surveyors (RICS),* Sept 11^{th} – 13^{th}, Las Vegas, USA;

Babangida, I., Olubodun, F. Sustrisna, M. and Kangwa, J. (2011) The Allocation of Risk in Private Finance Initiative (PFI) Construction Projects in the UK, *Proceedings of the University of Bolton Annual Research and Innovation Conference,* 28^{th} – 29^{th} June 2011, Bolton, UK, The University of Bolton.

APPENDIX B - 1

Questionnaire Cover Letter

Dear Sir/Madam,

Hierarchical Structuring and Evaluation of Risks for Building Refurbishment Schemes

The Faculty of Engineering, Sports and Sciences is conducting a research funded by the University. The research of which relates to risks and uncertainties associated with building refurbishment schemes within the UK construction industry.

If you choose to participate, a questionnaire is attached for completion at your earliest convenience (if possible within two weeks of receipt). Please be assured that all information provided will be treated with strict confidence and will **ONLY** be used for the purpose of this research. Both your identity and that of your organisation shall remain confidential.

Should you be interested in the findings of the research, please provide your contact details on the questionnaire.

Please return completed questionnaire to:

Ibrahim Babangida
Room G1 - 03
Faculty of Engineering, Sports and Sciences
The University of Bolton – BL3 5AB
Tel: 01204 903527
Email: i.babangida@bolton.ac.uk

Thank you in anticipation of your cooperation.

Yours Sincerely,

Ibrahim Babangida
Researcher

APPENDIX B - 2

Research Questionnaire

Hierarchical structuring and evaluation of risks, uncertainties and technical challenges faced by building refurbishment contractors

Please respond to the following questions by ticking **[√]** *in the appropriate box or by writing your answer in the space provided. All information provided will be treated with strict confidence.*

Note: *For the purpose of this study, refurbishment simply refers to any work carried-out on existing buildings to enable repairs, renovation, rehabilitation, retrofit, modernisation and/or conversion to be achieved, excluding routine maintenance such as daily cleaning and decoration. Risk herein refers to the uncertainty about the outcome of any given refurbishment activity or work package.*

Section 1: General Information

1. Job Title of Participant……………………………………………………………………………………………

2. Your Gender: Male [ ] Female [ ]

3. What is your professional discipline?

Architecture [ ] Quantity Surveyor [ ] Building Surveyor [ ]

Project Manager [ ] Construction Manager [ ]

4. How many years of refurbishment experience do you have?

[ ] 0 – 5 yrs [ ] 6 – 10 yrs [ ] 11 – 15 yrs

[ ] 16 – 20 yrs [ ] Over 21 yrs

5. How would you describe your organisation?

a. Principle Contractor [ ]

b. Specialist Contractor [ ]

c. Sub-Contractor [ ]

d. Client [ ]

6. Number of employees in your organisation

Under 10 [ ] 11 – 50 [ ] 51 – 100 [ ] Above 100 [ ]

7. What scale of refurbishment projects does your organisation undertakes?

[ ] Minor Refurbishment

[ ] Medium Refurbishment

[ ] Major Refurbishment

8. How confident are you about the concept of risk in refurbishment?

[ ] Very Confident

[ ] Confident

[ ] Partially Confident

[ ] Not Confident

Section 2: About Risks and Refurbishment Schemes

9. Characteristics of refurbishment work

Please indicate to what extent you are agree or disagree with the following characteristics of refurbishment works compared with new-build projects	**Strongly agree 4**	**Agree 3**	**Undecided 2**	**Disagree 1**	**Strongly disagree 0**
Higher risk than an equivalent new –build					
Requires more expertise					
More complex to design and coordinate					
Poses more challenges in programming site activities					
More Economic uncertainties					
Prone to more accidents					
Requires more collaboration between project partners					
More challenges in occupied buildings					
More site discoveries as project progresses					

10. Factors which contribute to quality of Refurbishment work

Please indicate how significant the following factors are in achieving the quality objectives in refurbishment works.	**Very Significant 4**	**Significant 3**	**Average 2**	**Insignificant 1**	**Very Insignificant 0**
Access and space					
Knowledge of structural defects					
Tripartite cooperation between clients, designers and contractors					
Avoidance of unrealistic time pressures					
Experience of type of work					
Appropriates of Design					
Accuracy and reliability of estimates					
Effective quality control procedures					

11. Barriers to achieving quality of refurbishment work

Please indicate to what extent you agree or disagree that the following factors are barriers to achieving quality of refurbishment works	4 Strongly agree	3 Agree	2 Undecided	1 Disagree	0 Strongly disagree
Lack of information on past repair and maintenance works					
Availability of finance					
Dealing with tenants in occupied buildings					
Design uncertainties					
Difficulty in determining the extent of deterioration					
Lack of expertise to manage the challenges of the schemes					
Restriction on extent of work when dealing with listed buildings					
Difficulty in determining amount of contingency					
Variations in work					
Practical difficulties of site activities which cannot be predicted in advance					

12. Factors which contribute to risk and technical challenges

To what extent is there a probability of occurrence of the following perceived risks and technical challenges in refurbishment projects	4 Very High	3 High	2 Medium	1 Low	0 No risk
Lack of information about original designs					
Difficulty in determining the extent of deterioration/structural defects					
Lack of experience of type of work					
Cost/price uncertainty at inception					
In-accuracy and unreliable estimates					
Designs uncertainties					
Difficulty in predicting completion time					
Difficulty in choosing the right procurement strategy					
Presence of hazardous					
Obstruction imposed by occupancy					
Lack of cooperation between project partners					
Cost and time over-runs					

Q12 continued To what extent is there a probability of occurrence of the following perceived risks and technical challenges in refurbishment projects	**Very High 4**	**High 3**	**Medium 2**	**Low 1**	**No risk 0**
Problems associated with building regulations					
Restriction on plant usage imposed by site location					
Variations to scope of works					
Problems with programming of works					
Uncertainty over availability of materials					
Health and safety issues					
Unrealistic time pressures					
Unclear client objectives					
Difficulty in determining amount of contingency					
Insufficient access and space to site					
Accident and injury					
Planning constraints					
Dispute and claims					

13. Satisfaction with implementation of refurbishment work

Please indicate to what extent you are satisfied or not satisfied with the following features in refurbishment works	**Very satisfied 4**	**Satisfied 3**	**Undecided 2**	**Unsatisfied 1**	**Very unsatisfied 0**
Quality of refurbishment projects undertaken					
Identification and management of risks					
Avoiding disputes					
Meeting deadline					
Management of health and safety					
Accuracy and reliability of estimates					
Knowledge of structural defects/deterioration					
Incorporation of sustainable concepts					
Information on past repair and maintenance					
Project programming					
Cooperation between project partners					

Section 3: Additional Comments:

Please add any additional information you may have in relation to risks associated with building refurbishment schemes:

Thank you very much for your interest in contributing to this research. If you are interested in the summary of the research findings, either by post or email, please provide your details below:

APPENDIX C - 1

Interview Cover Letter

Semi-Structured Interview Participant Information Sheet

Dear Sir/Madam,

Hierarchical Structuring and Evaluation of Risks for Building Refurbishment Schemes

Thank you very much for your interest in contributing to this study. I am a Doctor of Philosophy (PhD) degree student in Built Asset Renewal Management at the University of Bolton, Greater Manchester. The research is aimed at developing a conceptual framework to model the factors that contribute to risks and uncertainties in building refurbishment schemes and how it can lead to improvement.

This information sheet is to help you to understand what the research is about. Please take time to read the following information carefully.

1. We intend to gather as much information as possible by way of talking to a number of individuals and organisations about their experiences of risks, uncertainties and technical challenges in refurbishment schemes and what can be done to improve on future refurbishment proposals.

2. The interview will be transcribed into written text and a copy can be sent to you upon request.

3. Should you agree to take part? All the information you provide will be treated with strict confidence and will ONLY be used for the purpose of this research. The data will be treated in accordance with the Data Protection Act 2003 and will be disposed of in a secure manner.

If you require any further information please, do not hesitate to contact me at the following address:

Ibrahim Babangida
Faculty of Engineering, Sports and Sciences
The University of Bolton
Deane Road; Bolton - BL3 5AB

APPENDIX C - 2

Interview Consent Sheet

Please tick box

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions ☐

I understand that my participation is voluntary and I can withdraw at any time ☐

I agree to take part in the above study ☐

I am aware of, and consent to audio recording of the interview ☐

Name --

Signature --

Date --

University of Bolton

Discussion Questions for Semi-Structured Interviews

- What is your opinion on the structure and content of this research questionnaire?
- Having gone through the questionnaire in its entirety, do you agree that the objectives of this research are likely to be achieved?
- Likert scale coding was introduced in the questionnaire to measure the extent of agreement of participants' opinion, what do you think of it?
- Building refurbishment is claimed to carry more risk than an equivalent new-build project. Based on your experience, do you think that the risks, areas of uncertainty and technical challenges identified in this research reflect those associated with refurbishment schemes?
- What is your opinion on targeting refurbishment contractors as research participants?
- Do you think the content of the questionnaire will not discourage participants from taking part in the research?
- In what way can this questionnaire be improved in order to achieve the research objectives?

APPENDIX C - 4

Interview Sheet

Mr XX…

Job title/Position:

Company name and address:

Number of employees:

Number of years of refurbishment experience and working within the construction industry:

Company's annual turnover:

Date of interview:

Time of interview:

Response to interview questions:

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APPENDIX C - 5

Interview Responses

Comments made during Interviews

I can endorse the structure of the questionnaire but the contents lack chronological order and will require improvement so as to achieve the research objectives.

The content of the questionnaire is about right, apart from some repeated questions which should be reviewed.

Targeting refurbishment contractors as respondents is important as in most cases they are exposed to the processes and procedures of the works on project sites and will therefore have relevant information.

You should avoid double barrel questions where you ask 2 questions in one sentence as you may end up getting a wrong answer which may mislead your findings.

Going by the aim and objectives of your research, I think the questionnaire captured the most important areas. However, it can be improved in terms of clarity and structure.

You have a large list of factors which relates to the type of risks and uncertainties in refurbishment. Some of the risks have similar meaning. I will suggest you narrow it down to the most important issues and discard the rest.

The importance of a refurbishment focused procedure for dealing with risk and uncertainty is such that it will assist both clients and practitioners in making informed decisions before the commencement of a project thereby minimising failure.

Respondent 1

Respondent 2

Respondent 3

Respondent 4

Respondent 5

Respondent 6

Respondent 7

Comments made during Interviews

The data collection instrument contains some double barrel questions which participants will struggle to understand and that will affect their answers and subsequently the objectives of the research

No doubt, there is a need for a technique which should provide clarity in terms of those risks and uncertainties in refurbishment projects. This will be a welcome addition in the refurbishment sector.

The Likert scale coding is important to in order to assist in your final analysis as the coding will inform the basis for analysis and the coding should be explored properly.

Your search for factors which contribute to risks and uncertainties should focus on what may jeopardise the achievement of refurbishment project objectives.

There is chronological thinking in some of the questions in section two which is the most important section of the questionnaire but it still needs to be beefed-up.

The configuration of the questions in section two relating to refurbishment schemes should be reviewed and some questions need rephrasing. There is also repetition which must be avoided.

Question 15 in section two may not be needed as the previous question covers that area effectively. You may need to delete this question or direct it towards understanding how the management of refurbishment risk can be improved.

******Important comments by research participants during interviews which were considered and reflected in the data collection instrument to enable the study to capture a wide range of relevant information***

APPENDIX D - 1

Critical value for Spearman's rank order correlation coefficients r_s Tables

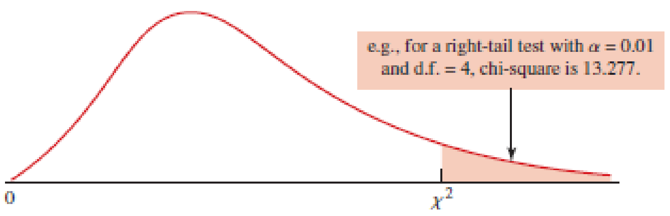
Critical Values of Spearman's Rank Correlation Coefficient, r_s, One-Tail Test. (For a two-tail test, the listed values correspond to the 2α level of significance.)

n	$\alpha = 0.05$	$\alpha = 0.025$	$\alpha = 0.01$	$\alpha = 0.005$
5	0.900	—	—	—
6	0.829	0.886	0.943	—
7	0.714	0.786	0.893	—
8	0.643	0.738	0.833	0.881
9	0.600	0.683	0.783	0.833
10	0.564	0.648	0.745	0.794
11	0.523	0.623	0.736	0.818
12	0.497	0.591	0.703	0.780
13	0.475	0.566	0.673	0.745
14	0.457	0.545	0.646	0.716
15	0.441	0.525	0.623	0.689
16	0.425	0.507	0.601	0.666
17	0.412	0.490	0.582	0.645
18	0.399	0.476	0.564	0.625
19	0.388	0.462	0.549	0.608
20	0.377	0.450	0.534	0.591
21	0.368	0.438	0.521	0.576
22	0.359	0.428	0.508	0.562
23	0.351	0.418	0.496	0.549
24	0.343	0.409	0.485	0.537
25	0.336	0.400	0.475	0.526
26	0.329	0.392	0.465	0.515
27	0.323	0.385	0.456	0.505
28	0.317	0.377	0.448	0.496
29	0.311	0.370	0.440	0.487
30	0.305	0.364	0.432	0.478

APPENDIX D - 2

Critical value for Chi-square distribution for Kruskal-Wallis statistic

The Chi-Square Distribution



For α = Right-Tail Area of

d.f.	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01
1	0.00016	0.00098	0.00039	0.0158	2.706	3.841	5.024	6.635
2	0.0201	0.0506	0.103	0.211	4.605	5.991	7.378	9.210
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345
4	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277
5	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086
6	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812
7	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475
8	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090
9	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666
10	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209
11	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725
12	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217
13	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688
14	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141
15	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578
16	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000
17	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409
18	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805
19	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191
20	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566
21	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932
22	9.542	10.982	12.338	14.042	30.813	33.924	36.781	40.290
23	10.916	11.689	13.091	14.848	32.007	35.172	38.076	41.638
24	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980
25	11.524	13.120	14.611	16.473	34.382	37.652	40.647	44.314
26	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642
27	12.879	14.573	16.151	18.114	36.741	40.113	43.195	46.963
28	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278
29	14.256	16.047	17.708	19.768	39.087	42.557	45.722	49.588
30	14.953	16.791	18.493	20.599	40.256	43.773	46.979	50.892
40	22.164	24.433	26.509	29.051	51.805	55.759	59.342	63.691
50	29.707	32.357	34.764	37.689	63.167	67.505	71.420	76.154
60	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.381
70	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.42
80	53.540	57.153	60.391	64.278	96.578	101.88	106.63	112.33
90	61.754	65.647	69.126	73.291	107.57	113.15	118.14	124.12
100	70.065	74.222	77.930	82.358	118.50	124.34	129.56	135.81