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LRMBRE001

MSc PROPERTY STUDIES

Sustainable Construction Industry Strategies in South Africa: Specialization vs Diversification

A research project submitted to the University of Cape Town, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE PROPERTY STUDIES

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Abstract

The construction and Civil Engineering industry is characterized by high risks, but equally high returns. The dynamics and complexities of this industry and its cycles, make it an extremely volatile and difficult industry to operate within. This is evident in the number of construction companies currently struggling to remain solvent, have gone into business rescue, and filed for bankruptcy. This industry has historically struggled to position itself effectively to deal with a down turning macro-economic environment - When it is good, it is very good, but when it is bad, it is very bad. Typically, there have been two differing strategies – Specialisation and Diversification. Specialisation, on the one hand, enables contractors to fine-tune their skill set and gear their businesses accordingly, to enhance their competitive edge. However, the result is concentration risk. Diversification however, enables contractors to become more risk-averse, and thereby less sensitive to the extremes of the cyclical nature that the construction industry is characterised by. The application of portfolio theory to a portfolio of construction projects was investigated, advancing the existing research done by Kangari and Riggs. Whilst most research has been limited to listed construction company performance, this analysis differentiates itself as it focusses on the intrinsic performance of actual construction projects (assets), which together form a portfolio. The theory is motivated by the concept that in order to value the stock, one must value the business. Construction companies should pay more careful attention to the selection of their projects. Critically, they should avoid becoming heavily invested in one type of construction, but rather to find a balance that will provide diversified risk benefits. Becoming more diversified can be achieved by investing in different types of construction projects - reducing specific risk. However, the most diversified position can only be achieved when investing outside the field of construction completely, and thereby reducing not only specific risks, but systematic risks too. This enhances sustainability in a way that the construction industry has not yet experienced.

Declaration

I declare that the research assignment herewith submitted is of my own work only. I further declare that I have obtained the necessary authorisation and consent to carry out this research. It is submitted in partial fulfilment of the prescribed requirements for the degree of Masters of Science in Property Studies, at the University of Cape Town. It has not been previously submitted for any other degree here, or at another university.

Signed:

Signed by candidate

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(LRMBRE001)

Date:

31 September 2019

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- Finally, my family and friends that have supported me through-out this research report, but more so over the full duration of this MSc Degree.

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1. Introduction

1.1 Introduction

The construction industry is on the brink of collapse, reaching in the first quarter of 2018, a record low ((BER) 2018). There has since been very little improvement, with no signs of growth in the near future. From its high in September 2009, the construction sector has decreased its market cap by 68% whilst the JSE all-share index has grown by 129%, *(PwC 2016)*. This should be a serious concern. The construction sector forms the backbone to South Africa's economic and social development - It contributes almost 4% of the total national GDP alone (Crampton 2016). It provides physical infrastructure on which other economic industries depend. It was estimated that, for every rand spent on construction and other infrastructural developments, almost 50% filters through the physical building and civil engineering industry, resulting in expenditure in other industries and specialised classes of work. The construction sector was responsible for direct and indirect employment opportunities for more than 1.4 million people (CIDB 2017). However, as critical as this sector may be to the economy, the industry has been characterised by instability, volatility, declining business confidence, and ultimately poor investor sentiment. In the current market, this is no more evident than in the number of construction companies that are struggling to remain solvent, and are at risk of bankruptcy. The sustainability of this high-risk industry is critical however, not only to the players who operate within this field, but anyone invested in the success of the local markets.

Construction is typically described as a lagging industry (Slabbert 2017). Its economic cycle has a delayed reaction to macro-economic forces of the market. As the economy picks up momentum, the demand for development grows. However, this only translates to construction sector growth once the demand begins to increase sufficiently, to a point where investments become feasible, and construction can start. Whilst macro-economic forces dominate the growth and performance of all industries, the construction sector has seen to be more significantly affected. It is therefore critical to the sustainability of this sector, that strategic micro-economic techniques are determined, which can re-position these companies more efficiently with regards to managing risk and return. Portfolio management theory is one particular method, used in equity, shares and property portfolios - a strategic combination of assets are grouped together in order to provide an organisation with a more efficient position balancing risk and return. Macro-economic forces may still define the overall performance, but the impact of volatility is often significantly reduced. In construction, these macro-forces are driven by Public and Private Sector spend.

Both Public and Private Sector investment into the construction sector is critical to the sustainability of labour markets, and the performance of the economy. Public Sector capital expenditure was a high priority for the South African Government. It has historically adopted an aggressive strategy toward the procurement of construction works, with public sector spend alone estimated at R220 billion per year (CIDB 2017). Furthermore, Government has outlined their National Development Plan (NDP), which aims to address the infrastructure needs in order to fuel further economic growth. One of their core objectives is to increase infrastructure investment to 10% of the GDP by 2030. This plan has been set into action with the roll out of R947 billion rand's worth of investment over a three year period - starting 2017 (CIDB 2017). However, whilst Government may be committed to increasing infrastructure investment, actual expenditure has in recent years compared poorly, relative to forecast expenditure. According to Price Waterhouse Cooper's (PwC) Construction Sector Report 4th Edition, the actual capital expenditure underperformed every year from 2010 to 2015 relative to forecast capital expenditure. Over this same period, actual capital expenditure achieved was less than 75% of what had been forecast (PwC 2016). The point here, public sector (Government) spend is not reliable.

A significant portion of this public sector expenditure was undertaken by South Africa's three biggest public entities – Transnet, Sanral, and Eskom. These institutions account for between 40% and 60% of the total public sector capital expenditure (PwC 2016). Eskom has noted to contribute heavily to this expenditure, as a result of Governments recent focus towards power supply upgrades, accounting for more than that of Transnet and Sanral combined – this off the back of the construction of Medupi and Kusile power stations. Planned expenditure has been impacted by the tough economic conditions that local and international economies have been faced with. This translates directly on the construction industry, putting increased pressure on this sector and negatively impacting their forecast growth (Crampton 2016). This high concentration creates key dependency risk – the industry becomes reliant on a continuous source of work from just three public entities. Any disruption to one of these, creates significant downstream pressure.

Whilst public sector expenditure is a major driving force of the construction sector, private sector is also a significant contributor. Private Sector was heavily dominated by the contributions made from the mining sector. The dependency on the mining sector is clearly illustrated when capital expenditure (Private Sector) is plotted against the mining index. The graphs show a distinct trend, whereby a decrease in mining produces a corresponding and significant decrease in the capital expenditure. PwC reported that the mining sector has reduced capital expenditure by 31% over the past three years, a result of difficulties being experienced across this sector (PwC 2016). In 2016, the mining sector reported the lowest capital expenditure since 2007, with forecasts suggesting further decline. This decay however, has been offset by the increased investment in the energy sector. Here, growth in recent years has been positive. In 2016, PwC reported a 13% increase from the previous year's capital expenditure. Interestingly, even with Eskom's declining contribution of 96% to 69% of the total energy sector expenditure, the private sector reported an increase from 5% to 31% of the total expenditure, enough to cover Eskom's shortfall of R14 billion, and further contribute an additional R7 billion (PwC 2016). And yet, even with this offset, the construction sector remains distressed.

The Global Economic Crisis has hugely affected public and private capital expenditure. Whilst this has resulted in a substantial slowdown of the South African economy, the construction sector particularly has struggled to recover (Crampton 2016). PWC reported that the JSE all-share index remained flat, but the construction and materials index continued to decline, (PwC 2016). In order for the construction sector to maximize the value extracted from this reduced capital expenditure, it is critical to (a) increase margins, and/or (b) limit cost increases. However, this is difficult to achieve when (a) markets have become more competitive and increasing margins is unsustainable, and (b) construction input cost inflation is noted to be above the standard consumer price index (PwC 2016). This doubled-edged sword explains how the construction sector continues to decline in the current market, and without a strategic shift, this will continue to characterise the industry.

1.2 Background to the study

Since 2009, and post 2010 World Cup, the construction industry has experienced serious declining performance. To simplify the explanation - construction work available has diminished, resulting in increased competition, putting the construction industry under pressure. As a reaction to these conditions, margins progressively become tighter, profitability is eroded, liquidity starts to dry up, and sector performance becomes strained (PwC 2016). This chain reaction of events has been what defined the fundamental downturn of the construction sector.

The Construction Industry Development Board (CIDB) is the main authority that regulates the South African construction sector. The CIDB focuses on developing the industry in line with Governments transformation objectives. In their words, they aim to; "*play a leading role in promoting the development of the construction industry, thus ultimately contributing to the country's growth," (CIDB 2017, pp5-27).* The CIDB regulates all branches of the construction sector, including more than 170 000 contractors spread across various classes of work, from Civil Engineering works (CE), Electrical (EB/EP), Building (GB), Mechanical (ME), and Specialist works (SW). As reported in the CIDB 2016/2017 Annual

Report, the construction sector remains "*vulnerable and susceptible to the harsh impact of fluctuating market and economic conditions,*" (CIDB 2017, pp5-27). The number of downgrades, which result every year, as contractors fail to maintain their grading requirements, highlights this. Currently, 24% of contractors were downgraded. This was on top of the concession made by the CIDB board to suspend grade 2 and grade 6 downgrades, which allowed more than 500 contractors to retain their grading (CIDB 2017).

The focus of this study is on the Civil Engineering sector, although it is recognized that some contractors may be registered in multiple classes. This further narrows the sample size to just more than 46 000 CE contractors. Civil Engineering contractors are typically members of The South African Forum of Civil Engineering Contractors (SAFCEC). SAFCEC, in their own words aim to; "P*romote the image of the civil engineering construction industry by enabling members to deliver a professional construction service and encourage them to take care of their employees' safety and welfare, the environment and the community, thus providing a foundation for our country's development," (SAFCEC 2017).* Together, these organisations (CIDB, SAFCEC) aim to regulate the companies which operate within the sector, to promote the standardisation of the procurement process within the greater construction sector (CIDB 2017). The focus of this study relates specifically to main players in the civil engineering (CE) construction sector. SAFCEC have categorised the construction enterprises relative to the number of employment opportunities available, and range from (a) Small: Employing less than 100 people, (b) Medium: Employing between 100 and 1 000 people, to (c) Large: Employing more than 1 000 people (SAFCEC 2017). The CIDB however, use a register to grade and categorised construction enterprises according to their financial and works capabilities. "*It is mandatory for public sector clients to apply the Register when considering construction work tenders. The Register of Contractors facilitates public sector procurement and forms a key component of the public sector infrastructure regime", (CIDB 2017, pp5-27).* This grading scale ranges from Grade 1 to 9. The analysis is refined to only the 104 Grade 9 Civil Engineering contractors.

Within these 104 Grade 9 contractors, the focus shifts towards those that were listed. Listed companies that trade on the JSE publish their financial results, and so this enables an analytical approach to their performance. As indicated above, this refines the sample to 9 construction companies. Of these 9 large contractors, four had very recently made significant strategic changes to restructure their core business, and refocus on creating a more sustainable model. Group Five had done this by resizing their business with 255 staff members retrenched during the 2016/2017 period. They continued by selling off subsidiary businesses, including the disposal of (a) their Investment and Concessions Business to Greenbay Properties, (b) Group Five Pipes, and (c) other of its manufacturing assets (Slabbert 2017). "*In terms of Group Fives' newly-approved strategy it will exit the construction* *business where it is not considered sustainable and will retain a building and housing business plus a small South African civil engineering business,"* (Slabbert 2017). This proved to be too little, too late, as Group Five elected to go into business rescue early 2019. Aveng have followed a similar strategy, with the unsuccessful sale of their 51% share of construction company Grinaker-LTA. Whilst this deal was unsuccessful, it highlights the intended strategy of disposing what they regard to be an unsustainable assets (Slabbert 2017). Murray and Roberts have most recently undergone a massive restructuring as they exited the construction sector, with the sale of their local infrastructure and building businesses. This decision emphasises a strategic shift from heavy construction and materials, to focusing on metal and minerals, oil and gas, and power and water (SAFCEC 2017). WBHO however, have made strategic decisions to invest into the Australian market, and the UK market with their acquisition of a 40% share in Bryne Group (Slabbert 2017). The concern is that these changes are being forced onto these companies as a last effort attempt to salvage what is left of a decaying industry, and these strategic decisions are with the objective of repositioning the organisations to manage macro-economic volatility. Furthermore, is there a trend towards specialisation being the focus of these strategic moves as an alternative to the diversification strategy that has previously been preferred (Reardon 2018).

This contradicts conventional portfolio management theory. Kangari and Riggs are recognised for their research into construction management and the application of portfolio management theory. They took the following position; "*When a construction company invests in a variety of projects, the combination can be viewed as a portfolio of projects. Such a portfolio is efficient if the contractor can diversify the projects. In general, a diversified portfolio of projects is less risky than the average of the individual projects considered alone," (Kangari 1988, pp161-169).* Their work summarises the historic progression of Markowitz's basic portfolio theory from 1952 to 1959, to its initial application within a construction framework by Vergara and Boyer in 1979. This followed by Farid's work in 1981, demonstrating how portfolio management links to the Capital Asset Pricing Model, and finally to Kangari and Boyer's application of portfolio management theory based on net present value of cash flows. Their research concluded that the application of modern portfolio management theory in construction is limited (Kangari 1988). The mathematical models have a strong dependency on historical data, which was not available at the time of their research. Furthermore, the key variables were considered to be too complex to determine, thereby rendering the application of this theory mathematically impractical (Kangari 1988). However, today's modern business practices have since advanced, and the intrinsic value of information has motivated all industries to capture and record data on a level of detail, which is unprecedented. Building on the fundamentals set out by Markowitz, adapting the methodologies set out by Farid, Kangari, Boyer, and Rigs, and leveraging the data available from the case study, I expect to be able to add value to this academic body of knowledge.

1.3 Problem Statement

The problem intended to be addressed through this study may be summarised as follows:

The construction and civil engineering sector in South Africa is under significant financial pressure. The industry, and more specifically the large construction companies, are not strategically positioned to minimize the risks associated with macro-economic movements. There is a gap here in the knowledge. Such volatility has become synonymous with the construction sector and its economic cycles – When it's good, it's very good. But when it's bad, it's very bad. The result is such that a down-turn of the economy puts excessive strain on construction companies, translating to massive market capitalisation losses, extensive resizing through retrenchments and disposal of assets, and potentially wide spread liquidations. Furthermore, recovery periods for this sector are considerably longer than those experienced in other industries.

1.4 Research Questions

The research question may be stated as follows:

(a) What strategy, when choosing between specialisation and diversification, within construction companies improves sustainability and reduces concentration risk.

   i. How can Modern Portfolio Management Theory be applied in the context of large construction companies, and their portfolio of construction projects, to ensure that they are more efficiently positioned, to manage macro-economic movements?

1.5 Research Aim

The aim of this research is as follows:

To identify what key aspects of large construction companies make them susceptible to excessive cyclical volatility, and thereby define strategic tools and techniques that can be adopted to (a) minimize exposure, and (b) reduce the sensitivity, to macro-economic forces.

1.6 Research Proposition

The research proposition to be tested in this study is as follows:

Specialization, as opposed to diversification within the construction sector, is expected to reduce volatility, stabilise financial performance and shift the construction industry from high risk/return variances towards a more consistent and sustainable business model.

1.7 Research Objectives

The research objectives are outline:

(a) Define the significance of the construction sector in terms of the social and economic value that it provides in the South African economy, and thereby justify the significance of this research.
(b) Review the historical performance of the South African Construction Sector.
(c) Determine what aspects of a construction company impact most significantly on their performance.
(d) Determine whether a specialised construction strategy offers improved sustainability compared with that of a diversification strategy often used in share and equity portfolios.
(e) Examine, by case study, a real world portfolio of construction projects, and determine how volatility translates to risk and return.
(f) Propose a strategy that can implemented by large construction companies to reduce sensitivity to macro-economic forces.

1.8 Research Method – A Case Study Approach

The objectives outlined in Section 1.7 will be achieved through a quantitative analysis underpinned by a real world construction company case study. To this end, a rigid and structured methodology is established:

(a) Introduction – An initial conceptualisation of the research topic, and establishing the merit of such a study.
(b) Literature Review – An up to date review of the relevant literature, illustrating the chronological progression of the body of knowledge as well as the various schools of thought.
(c) Quantitative Analysis – A critical analysis of the construction sector, the large construction companies and their performance.
(d) Case Study – Identify an actual real-world example of a large construction company, and analyse their projects in terms of performance, returns, and volatility across different sectors.
(e) Interpretation of Data – A combination of graphical and statistical methods of analysis.
(f) Conclusions and Recommendations – Evaluate the results of the research, and solidify a conclusive result from which recommendations can be drawn.

1.9 Limitations

The following limitations are anticipated through this study:

(a) The case study is limited to one large construction company, as the information required for the analysis is confidential and only accessible by means of a contractual agreement and an existing relationship built on trust.

(b) The study refers to the latest reports that are available at the time of the research. However, these financial reports published by external organisations such as PWC, the CIDB, and SAFCEC are limited in that 2019 reports were in some cases not yet published at the time of the study.

(c) The study is limited in that there are two notable events, which have distorted the market. These include; (a) The 2010 Soccer World Cup, and (b) the recent accounts of collusion amongst large construction companies.

(d) Academic literature has been sourced for this study, however although it may be related to sustainable business strategies, it is often not specific to the construction industry.

1.10 Structure of Research Report

The research report will be structured using the following framework:

Chapter 1 – Here, an introduction to the thesis topic is provided. The aim is to outline a contextual basis from which the thesis will unfold. Critical to this section is to highlight the research problem, define the key research questions, objectives, and proposition. Furthermore, the research methodology is summarised briefly. The intention is to bring forward the merit of the research, and justify the significance/value-add that the study offers.

Chapter 2 – This chapter will provide a thorough literature review. The aim is to provide readers with an up to date and current assessment of the body of knowledge that underpins the thesis. Critically, a chronological build-up of information needs to be outlined.

Chapter 3 – The methodology is clearly defined in this section. The aim here is to outline as systematically as possible the appropriate steps, such that if anyone in future were to replicate a similar case study, a consistent result would be achieved.

Chapter 4 – The data is compiled in this section, and summarised carefully to bring forward the important information and results. Critically, the analysis and interpretation of the results are highlighted here, with the aim of presenting the findings for later discussions.

Chapter 5 – Discussion of Results is provided in this section of the study. The objective here is to draw from previous chapters, and attempt to create synergies between what the data reports, and the theory that has been conceptualised. The intention is to make sense of the outcome, and solidify a result that is conclusive and supported.

Chapter 6 – Finally, the conclusion aims to summarise the findings, and draw conclusive links back to the initial chapters. The goal is to provide answers to the research questions, assess the validity of the results, and identify the value-add through the study.

2. Literature Review

2.1 Introduction

The literature review focuses more specifically on construction economics. An up to date summary of the construction sector is provided – (a) The Construction Industry. This sets the context on which the subsequent topics are based. The focus of the literature review is progressively refined. Critically, focus points raised in the research proposal drive this review. To this end, the corner stone to the literature review is the sustainability of contractors and the construction business. The industry review therefore follows with (b) Sustainability of Contractors, (c) Evaluating the Financial Strength of Contractors, (d) Strategies for De-Risking the Construction Business, (e) Portfolio Theory Applied to a Construction Portfolio, and finally (f) Specialization vs. Diversification.

2.2 The Construction Industry

The business of construction is perceived with uncertainty, and assumed by investors to be more risky than other industries (Maria C.A. Balatbat 2010). Much of this stems from the ideas that construction companies are (a) poorly managed, (b) operate with high levels of debt, (c) have poor financial positions, and ultimately in many cases result in business failure (R.J Mason 1979). This sentiment translates to high levels of volatility in construction company share prices (Wagle 2006). However, underperforming share prices do not imply poor company performance. *"Poor share market price does not imply poor financial standing of a company. The ratios are calculated based on actual company performance, whereas the share price is dependent on the markets' perceptions and opinions, and trading volatility. And since many investors perceive that investing in construction carries risk, particularly with fluctuating economies, the disagreement between share price and ratios may be greater with construction companies than for companies in other industries,"* (J. Hood 2006, pp40-58). The question therefore is - Why are construction companies viewed differently from companies in other industries?

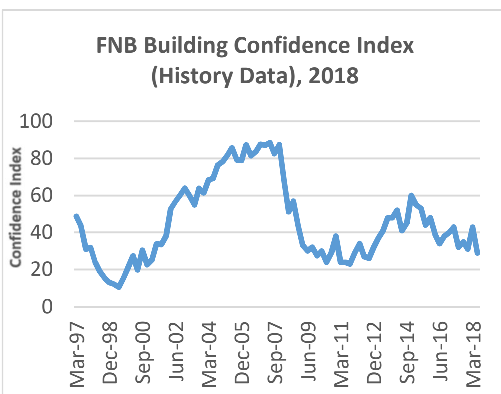
Research done by Peter Pilateris and Brenda McCabe, from the Department of Civil Engineering, University of Tornoto, into the financial evaluation of contractors, made specific reference to the differences between construction and other industries. Firstly, whilst most industries benefit from being located in a single place, immune to the effects of temperature, humidity and weather, construction is renowned for being at the mercy of the elements, and constantly changing locations (P. Pilateris 2003). This impacts on productivity which in turn can delay time, increase cost, and deter from quality. Secondly, most industries are in some form operating in a repetitive process – i.e. the same commodities are being produced, using the same methods, under the same conditions, with the same equipment/resources (P. Pilateris 2003). Construction on the other hand, is unique to each project, using different plans to meet different specifications, using different labour, under different site conditions, to satisfy different owner requirements. Thirdly, optimization in other industries is more easily achieved, compared to construction where prices are typically fixed up front with deadlines contractually agreed, to complete a product never built before (P. Pilateris 2003). These are all key differentiators discussed by Pilateris and McCabe, which impact how investors are likely to view construction companies relative to other industry. However, whilst this explains why investors may have differing views, it does not justify why construction is negatively perceived. This is more a result of poor risk management.

The construction industry is renowned for having a poor reputation for coping with risk (Roozbeh Kangari 1989). In most cases, the provision for risk is made by adding contingency to the project. This reactive approach is a result of many failings in the industry, where projects are delayed, run over budget, or produce substandard quality of work. This is concerning - Construction projects require significantly large capital investment, and risk management is increasingly more important where projects are complex, and there are more uncertainties (Roozbeh Kangari 1989). There are a variety of methods and tools for evaluating risk in construction. Most of these models are based on quantitative techniques, which require real project data. But, contractors are quick to blame the current state of the construction industry for poor performance and other business failings. The merit of these claims are discussed.

PwC's most recent publications on the construction sector explain – "*Construction work available has diminished, resulting in increased competition, putting the construction industry under pressure. As a reaction to these conditions, margins have progressively become tighter, profitability is eroded, liquidity starts to dry up, and sector performance becomes strained. This is no more evident than in the listed construction sector*," (PwC 2016). The analysis of the construction industry shows how the listed construction sector has underperformed relative to the JSE All-share index. "*Since 2009, where the JSE All-share index has increased in market capitalisation by 129%, the construction sector has lost 68% of its market capitalisation,*" (PwC 2016). A strong majority of the JSE listed construction companies reported a decrease in market capitalisation over this same period. This is a direct result of financial strain which construction companies are currently faced with. The FNB Building Economic Report recently reported on the current (2018) building and civil industry confidence. The Building Confidence Index was seen to be at a 6-year low. After rising to 43 index points in the first quarter of 2018, the FNB/BER Building Confidence Index fell to 29 index points by the second quarter. This is the first time the index has been below 30 since 2012, ((BER) 2018). Similar trends have also been seen with the Civil Confidence Index, which fell to a record low of 12 index points in same period. The current index level means that 85% of respondents are dissatisfied with prevailing business conditions. "*Construction activity continued to decline in 2018, underpinning the sustained low confidence,*" noted Jason Muscat, Senior Economic Analyst at FNB. According to Statistics South Africa, the real value of construction works fell by 2.6% year-on-year in 2018Q1, from a 6.9% contraction in 2017, ((BER) 2018).

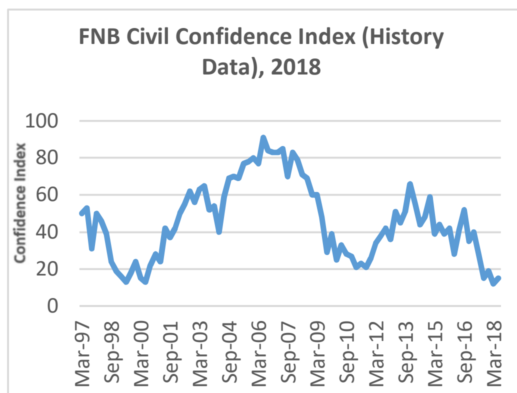
This confirms our opening statement that the construction and civil engineering sector under significant financial pressure. The sustained low confidence is explained by a deterioration in almost all of the underlying indicators, most notably construction activity and tendering competition, ((BER) 2018). The poor performance with regards to construction activity resulted in a further increase in tendering price competition, i.e. the extent to which firms have to downwardly adjust profit margins in order to put in a competitive bid. According to Muscat, "*almost all survey respondents stated that tendering competition in 2018Q2 was keener compared to a year earlier. It was last this high in 1999*", ((BER) 2018).

Figure 2.2.1: Building Confidence Index



((BER) 2018)

Figure 2.2.2: Civil Confidence Index



((BER) 2018)

2.3 Business Failure in the Construction Industry

As a result, business failure in the construction industry has become front of mind for most contractors. This data suggests that the probability of failure in construction companies has increased in recent years. Furthermore, the average age of a construction company is declining. These negative trends characterize the current state of the construction sector. The industry is fragmented, plagued with excessive competition, decreasing work supplies, and is highly sensitive to economic cycles. The result is such that business failure in construction is very high. In Kangari's research, he acknowledges that it is difficult to define the cause of business failure in construction companies, as they are highly complicated and extremely fast-paced businesses. However, for the majority, business failure is in some way related to financial management problems. Contractors are heavily reliant on the cash flow cycle of each individual project, and with cash flows in most cases negative at the start of any project, contractors are almost always fighting an uphill battle from the start, to try keep the contract solvent and self-sufficient. "*To succeed however, a company must not only avoid failure by remaining solvent, but also must earn enough profit to help the company expand, meet all its debts, and exceed the rate of other investment opportunities*," (Kangari 1987, pp172-190). This is critical to the sustainability of the greater business, as opposed to the individual project. Kangari's research into the failure of construction industry, was motivated by the growing number of construction companies that were seen to be going insolvent. Whilst there was a significant amount of knowledge around business failure, Kangari was not satisfied that this information was suitably applicable in a construction frame of reference. He was determined in finding a way of synthesizing such information into a plan that could be used to avoid failure in the industry. His research identified that the average age of a construction company at failure had declined. Kangari acknowledges that the construction industry has unique characteristics, which distinguish it from other economic sectors. He states; *"In construction, failure is a real possibility. It is fragmented, very sensitive to economic cycles, and highly competitive because of the large number of firms and relative ease of entry," (Kangari 1987, pp172-190).* Kangari attributes these main factors to the high rate of business failures. To this end, Kangari stresses the importance of financial monitoring, and specifically the use of key financial ratios to monitor and manage the risk of business failure.

In his attempt to define business failure in construction, Kangari refers to Dun and Bradstreet Corporation – a private corporation that at the time of his research maintained one of the largest sources of information on the construction industry. Dun and Bradstreet defined business failure as, a business which (a) Ceases operation following assignment or bankruptcy, (b) ceases operation with losses to creditors after such actions as foreclosure or attachment, (c) voluntary withdraws, leaving unpaid debts, (d) are involved in court actions such as receivership, reorganisation of arrangement, or voluntary comprising with creditors, (Corporation 1978-1986). Furthermore, Dun and Bradstreet's research defined the ten most common causes of business failures, based on statistical market data. Amongst these included: (1) Sales, (2) Expenses, (3) Assets and Capital, (4) Experience, and (5) Economic Factors, (Corporation 1978-1986). What was clear however, Economic Factors accounted for more than two thirds of all business failures. As a result, Kangari's research focussed heavily on the economic impact on business failures. "*Important causes of business failure in the construction industry are identified as; (1) Bad profits, (2) Management incompetence and lack of experience, (3)* *Inadequate Sales, (4) Loss of market and economic decline, and (5) difficulty collecting from customers*," (Corporation 1978-1986).

The difficulty lies in defining the exact cause of business failure, this due to the complex structure that defines most construction companies – the nature of the business of construction itself. This is confirmed by Kangari, who also notes that the precise cause of construction business failure is hard to determine. However, Kangari recognizes financial management as the most common reason for failure. "*Construction's reliance on a cash flow cycle for each project, with negative cash flows occurring at the start of most projects, making financial management a prime concern," (Kangari 1987, pp172-190).* The risk however, of being too cautious, may be in itself reason for failure in construction. As explained by Kangari, avoiding failure does not guarantee success. "*It is suspected that many more companies leave the construction field due to a lack of success than because of failure,*" (Kangari 1987, pp172-190).

2.4 Risk in the Construction Industry

Archer and Ghasemzadeh define risk as "*a combination of the probability of an event (usually an undesirable occurrence) and the consequences associated with that event,*" (N.P. Archer 1999, pp207-216). They explain how every project has some level of risk, and to identify this risk we must familiarize ourselves with each component or activity. This can be achieved with a work breakdown structure (WBS). "*Depending on the depth of analysis appropriate at the point in the project's life cycle, the WBS can range from relatively simple (e.g. development and market activities during early feasibility analysis of a new product) to complex (e.g. detailed breakdown of activities for the business plan prior to commitment for full scale development)," (N.P. Archer 1999, pp207-216).* Each potential risk event is identified, along with the probability of it occurring and the consequence if it were to occur. However, the concept of risk is not unique to construction.

Erikson, in 1979, outlined his interpretation of risk in construction. Here, he defines construction risk as *"exposure to possible economic loss or gain arising from involvement in the construction process," (Erikson 1979).* Farid, Boyer, and Kangari refer to this definition of risk in their work – Required Rate of Return in Construction. Critically, they identify two key points raised by Erikson and his definition of risk in construction - (a) there is risk in any economic related activity, and (b) risk can be perceived as a variability measure of all possible economic outcomes (Erikson 1979). Whilst they agree with Erikson on the first point, Farid, Boyer, and Kangari all raise concern over the second. They suggest that variance is not an acceptable measure of risk, because it accounts not only for downside risk, but also upside (Foad Farid 1987). This is a common debate in risk theory, where there are differing opinions around variability or variance used as a proxy for measuring risk. However, as explained by

Markowitz and Hoskins, distributions of returns are approximately symmetric, and therefore it can be safely assumed the standard deviation of returns to be a proxy for risk measures (Markowits 1952).

Risk is often categorised as systematic risk or unsystematic risk (Foad Farid 1987). Systematic risk, also referred to as non-diversifiable risk, cannot be diversified away. Here, they relate to the overall market, the greater economy, and changes in legislation. In construction, such systematic risks include inflationary and interest rate increases, skills and resource shortages, as well as global economic downturn. Unsystematic risk, also referred to as diversifiable risk, are those risks that are unique to the particular industry. These risks are not effected by economic, political or social factors (Foad Farid 1987). Examples of these in a construction context include weather, strikes, and other financial difficulties. Erikson further distinguishes risk in construction as Contractual or Construction (Erikson 1979). Contractual risks are those associated with the signed agreement, communication between the stakeholders, and other administrative functions. Construction risks are those that affect more directly the construction activities, such as weather, site conditions, acts of God, and availability of resources (Erikson 1979).

Farid, Boyer, and Kangari all agree that whilst risk cannot be completely eliminated, it must be carefully managed and accounted for. In construction, Farid and Boyer explain how contractors have traditionally accounted for risk - subjectively including an allowance for the perceived risk of the project, either in the form of a contingency or project mark-up (Foad Farid 1987, Clough 1975). *"It has been shown that mark-up is a function of the required rate of return (RRR) and the cash-flow schedule of the project," (Foad Farid 1987, pp109-125).* However, in today's market, the suitability of such methods has been criticised on the basis that (a) contingencies are now often prescribed by the client in the pricing document, and not the contractor, and (b) the mark-ups are often market related. As such, the contractor's ability to price for risk is somewhat removed and project-specific risk not sufficiently accounted for. Farid, Boyer, and Kangari aim to demonstrate the limitations of such approaches, by illustrating that there are better techniques. They explain how more recently, the weighted average cost of capital (WACC) has been used. Subsequently, the capital market theory was introduced by Sharpe (1964) and Lintner (1965), building off Markowitz portfolio theory. However, these methods focus more directly on the financial risk measures.

Abidali and Harris are more holistic in their assessment of risk in construction (Adnan Fadhil Abidali 1994). Besides the financial deficiencies associated with failing construction companies, Abidali and Harris have identified in their research, other factors which are characteristic of the construction industry. Central to this was the management component. Managerial efficiency is raised as one of the critical components that affect the success or failure of an organization (Adnan Fadhil Abidali 1994).

2.5 Evaluating Financial Strength

In recent years, the economic slowdown has caused many construction companies to be faced with difficult financial situations, (D. Singh 2006). The shrinking construction demand coupled with fierce industry competition has resulted in increased project failings in the form of delays, cost over-runs, and declining quality. There are an increasing number of construction companies experiencing cash flow constraints, and exposed to potential insolvency, (D. Singh 2006). Historically, research into the financial strength of construction companies was based on share price performance analysis. This was motivated by the fact that contractors have typically been private (owner-driven) businesses, and sourcing information was difficult. For listed companies however, financial information could be sourced. Typically, research into the financial strength of contractors, made use of two financial reports, (P. Pilateris 2003). These include (a) the income statement, and (b) the balance sheet. Income statements were best used to describe the operational process, and summarises revenue and costs, profits and losses. The balance sheet provided a broader snapshot of the greater businesses assets and liabilities, (P. Pilateris 2003).

When analysing construction companies, it is important to understand the listed construction sector not only by comparison with other listed construction companies, but also other listed sectors. This was the motivation behind research done by Balatbat, Lin, and Carmichael. Their research used a case study approach of the Australian listed construction sector, and with fundamental analysis, they were able to do a comprehensive assessment on a range of financial performance indicators for a 10-year sample. "*Construction companies have been found to be highly levered, to have weak financial positions and to be subject to large business cycle fluctuations. Consequently, share prices tend to overheat when the economy grows quickly, and then collapse when economy goes into recession,*" (Wagle 2006). Their research however, aimed to determine whether these share price fluctuations were as result of real economic fundamentals, or general market sentiment. Whilst it is unclear how financial ratios influence investor's behaviour, Balatbat, Lin and Carmichael agree that financial ratios remain the only hard information on which an investor is able to base their opinions on, (Maria C.A. Balatbat 2010).

Typical for construction sector research, information is scarce. This is a similar sentiment shared by Balatbat, Lin and Carmichael; "*Literature on the performance of Australian construction companies is scant,*" (Maria C.A. Balatbat 2010, pp140-158). As a result, their research was limited to the listed sector only, where detailed financial data was available for analysis. Their analysis used time series data to establish and compare (a) financial ratios, and (b) performance indicators, to assess the performance of these listed companies relative to other industry benchmarks. This approach was based a common trend in construction company analysis – Probability of Business Failure. To this end, two ratios were noted to underpin most construction financial analysis, (a) Return on Assets (ROA), and (b) Return of Equity (ROE), (Maria C.A. Balatbat 2010). The methodology has become very common in financial analysis of contractors, motivated by the fact that "*contractors around the world seemed to fail at higher rates and with more devastating effects than companies from other industry sectors*", (R.J Mason 1979, pp301-307). However, these financial ratio-based models are only able to give an indication of future performance, rather than an accurate prediction. Balabat, Lin, and Carmichael note that suitable financial models for construction companies remain "*undeveloped and unrealized*". For this reason, they believed it best to represent the data in its raw, unweighted state and thereby allow interested parties to assess the financial stability of companies using their own perspectives (Maria C.A. Balatbat 2010). Langford et al, made a similar conclusion in 1993, where he argues that whilst it remains unclear how financial ratios are able to steer investor sentiment, they (financial ratios) remain the only objective and analytical tools available to make comparisons between different investment vehicles, and thereby construct a fair and justified opinion on, (D. Langford 1993).

Critically therefore, the fluctuating nature of listed construction share prices does not necessarily indicate financial stress of the companies themselves. However, the concern highlighted was that listed construction share prices fluctuated more widely than other listed sectors (J. Hood 2006, Wagle 2006). This undermines the ability of construction companies to attract institutional investors who view construction companies as unattractive. "*Investors typically analyse historical share returns when choosing to buy or sell shares of listed companies because they represent the gain an investor obtains from their invested capital,"* (Maria C.A. Balatbat 2010, pp140-158).

However, Balatbat, Lin, and Carmichael argue that while historical share performance may steer investor sentiment, it is not an appropriate indicator on which to assess the overall performance of a company. In their research '*Management efficiency performance of construction business*', they attempt to debunk this perception. Here, their approach is more concerned with the financial analysis of the construction business using financial ratios, and comparing against industry benchmarks. Their argument was that financial ratios were not always in agreement with share price performance (Maria C.A. Balatbat 2010). Financial ratios are calculated based on actual company performance, compared to share prices, which are based on market sentiments. M. Doug shared a similar sentiment. He explains how other factors provide insight to a company's performance - "*It is usual to assess a company's ability to generate earnings and, more importantly, its capacity to pay dividends,"* (M. Dong

2004, pp121-158). Critically, Dong argues that the historical movement of share prices does not define the actual performance of a company – *"movement in share prices are value-related to investors, this is not an indicator of the overall performance of a company*," (M. Dong 2004, pp121-158). He suggested it to be more useful to evaluate a company's performance by measuring their ability to generate earnings and its capacity to pay dividends to shareholders. As a result, he focuses on earnings and dividends ratios in his analysis of companies. These measures defined:

A. Earnings per share (EPS)

This financial ratio is important to shareholders, management, and investors as it is a function of net profits after tax that can be apportioned to each share, (EF. Edum-Fotwe 1996). Typically, with construction companies, this ratio is expected to be considerably less than other blue chip companies are. This is partly because they are capital intensive, and depend heavily on their continued investment in revenue generating assets, and strong cash flows, (EF. Edum-Fotwe 1996).

B. Price to earnings (PE) ratio

This ratio evaluates the share price relative to the earnings of a company, (Maria C.A. Balatbat 2010). This is a useful indicator to show whether a share price is too high or too low. The concern is that some listed companies have a high PE ratio, and are therefore valued by the market greater than what the actual companies' ability to generate earnings. Typically, for construction companies, and the poor investor sentiment, PE ratios are low. This suggests that they are under-valued by the market, (Maria C.A. Balatbat 2010).

C. Dividend per share (DPS)

This measure provides an indication of what profits were distributed per share, (Maria C.A. Balatbat 2010). Investors need to be cautious here, as this figure, like EPS, is a function of how many shares are in issue. Critically however, this figure is often low for construction companies, who retain larger portions of their profits to drive the business, (Maria C.A. Balatbat 2010).

D. Dividend yield

Dividend yield is a function of dividends paid per share (DPS), and the share price, (Maria C.A. Balatbat 2010). This is typically a result of the low undervalued share prices characteristic of construction companies, rather than high dividends paid per share, (Maria C.A. Balatbat 2010).

E. Enterprise multiple (EV/EBITDA)

Enterprise value (EV) is determined by the market capitalisation, plus the total debt, and less the total cash, (Maria C.A. Balatbat 2010). EBITDA is the earnings before interest, taxes, depreciation, and amortisation. This ratio is the most widely used valuation multiple used for cross-sectional analysis of companies, mainly because it ignores the impact of differing taxation policies. This ratio gives an indication of whether a company is under or over-valued. Investors and analysts use this measure to assess a company's earning ability relative to its real value (including debt), (Maria C.A. Balatbat 2010).

F. Market capitalisation to trading revenue ratio

This ratio is similar to the enterprise multiple, except it measures market capitalisation relative to trading revenue, (Maria C.A. Balatbat 2010). Trading revenue is a proxy for the size of operations, and therefore its ability to generate revenue.

G. Price-to-book (P/B) value

This is a common measure of a company's market value by share price, relative to the net asset value per share, (Maria C.A. Balatbat 2010). If a company were to be over-valued, this would be characterised by a high P/B ratio.

However, what distinguishes this research was that the financial analysis made provision for intrinsic financial indicators – financial ratios that directly measure the true company performance, rather than just share price based performance measures. Profitability is the most important measure of a construction company's financial status, (Maria C.A. Balatbat 2010). This was shared by Fellows and Langford, who argue that profitability ratios are the most important criterion on which an assessment should be based. "*A company's ability to distribute healthy earnings is related to profitability. Higher profits usually lead to more dividend distributions. Also, profit growth is welcomed by the market because it demonstrates that the company is able to increase revenue while controlling cost," (Maria C.A. Balatbat 2010, pp140-158).* Here, the following financial ratios are defined:

A. Return on equity (ROE)

The true return on invested funds (equity) is determine by calculating the return on equity - dividing the net profit by the net worth of the company. This ratio is fundamental to an investor, as it reflects a company's ability to transform equity into profit, (Maria C.A. Balatbat 2010).

B. Return on assets (ROA)

Similar to ROE, return on assets (ROA) measures the company's ability to generate profits using its assets. Here, the total liabilities and shareholders' equity summed together, and the profits divided, to assess how effective the company is in its asset utilisation and profit generation, (Maria C.A. Balatbat 2010).

C. EBIT and EBITDA margins

One of the most important measures of any company's performance is the earnings before interest and taxes (EBIT). This margin is often used to determine earning power, by dividing the EBIT by the operating revenue, (Maria C.A. Balatbat 2010). In companies where depreciation is a significant portion of their financial statements, earnings before interest, tax, depreciation, and amortization (EBITDA) is used. Again, the margin is determined by dividing the EBITDA by operating revenue, (Maria C.A. Balatbat 2010).

D. Net profit margin

In many cases, an investor may only be interested in the final profit value. In such cases, this is the net profit after tax, divided by the operating revenue, (Maria C.A. Balatbat 2010).

E. NOPLAT margin

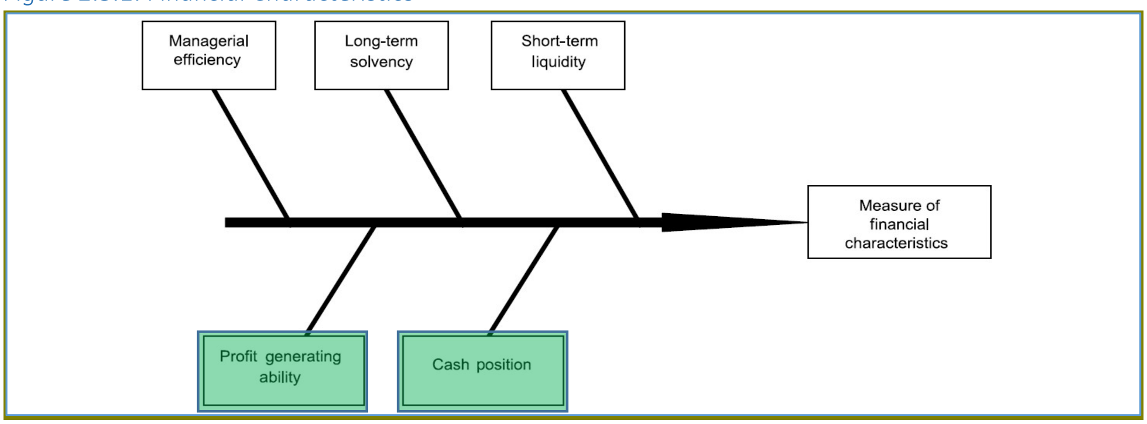
The net operating profit less the adjusted taxes (NOPLAT) margin is a function of a company's revenue generated through sales, removing the stresses of capital structures and facilities. These often skew the financial analysis if the company is heavily dependent on debt to fund their activities, (Maria C.A. Balatbat 2010).

In Singh and Tiong's research, '*Evaluating the Financial Health of Construction Contractors*', they review four models in the industry used for evaluating financial sustainability of construction companies. Kangari's model, based on five external macro-economic factors, was used to predict probability of business failure in the construction industry, (D. Singh 2006). Similarly, Russel and Jaselskis' logistic regression model made use of non-financial based variables, for predicting failure in construction companies, (D. Singh 2006). Abidali however, took a different approach, deriving a seven-variable model, which evaluated long-term solvency rather than probability of failure, (D. Singh 2006). This method was however criticized by Edum-Fotwe et al. due to inconsistencies in the results that this method generated, (EF. Edum-Fotwe 1996). As a result, Singh and Tiong advocate Mason and Harris's method. Here, Mason and Harris use discriminant analysis to propose a ratio model that could identify the financial status of contractors with financial distress indicators. The ratios aggregated using multiple regression, produce a Z-score used to grade contractors accordingly. Whilst similar criticism was noted by Edum-Fotwe regarding inconsistency, Singh and Tiong took comfort from the fact that the model proposed by Mason and Harris was derived from a case-study analysis, (D. Singh

2006). Here, a sample of 20 failed contractors and 20 non-failed contractors underpinned the development of the model.

One of the focus points in Singh and Tiong's research was the selection of financial ratios. They suggested that the financial strength of a contractor can be summarized by five simple ratios; (a) short-term liquidity, (b) cash position, (c) long-term solvency, (d) profit generating ability, and (e) managerial efficiency, (D. Singh 2006). Prakash and Karels, and their empirical research on bankruptcy raise similar measures. They suggested that signs of potential bankruptcy include; (a) negative net worth, (b) non-payment of creditors, (c) bond defaults, (c) inability to repay debts, (d) over drawn on bank accounts, and (e) failing to pay preferred dividends, (G.V Karels 1987). These signs are largely dependent on the amount of financial obligations, the liquidity of assets, the profit generating ability of the organization, and managerial actions, (G.V Karels 1987). The five key ratios illustrated in figure 2.5.1:

Figure 2.5.1: Financial Characteristics



(D. Singh 2006)

Through their analysis, Singh and Tiong determine that short-term liquidity (WC/CL) and long-term solvency (NW/TL) are the two most significant ratios – "*it is clear that the ratios WC/CL and NW/TL have the highest importance values or weights, indicating more discriminating power than the other financial ratios. This means that these two ratios are more important in assessing financial health*," (D. Singh 2006, pp161-166). This is a very real result. In the construction industry, a contractor is more likely to fail because of its inability to meet current liabilities. The liquidity status of a contractor is often more critical than its earning ability/ability to generate profit. However, as explained by Singh and Tiong – "*This does not discount the importance of a company's ability to generate profit, which is one of the most important of the criteria to remaining in business and growing,*" (D. Singh 2006, pp161-166).

Critically, this case-study research focusses more specifically on project-related performance. To this end, project cash position (revenue less cost) and project profit generating ability (allowable less cost) are analysed – highlighted green in figure 2.5.1 above. Short-term liquidity (the ratio of working capital to current liabilities), long-term solvency (the ratio of total net worth to total liabilities), and managerial performance (how efficiently the management is utilizing the resources at its disposal to generate respectable revenue) are all organizational factors. This research is unique in that project level data is aggregated, on the assumption that a construction company is only as effective as the productivity (performance) and efficiency of its individual assets (projects). To this point, the data is interpreted at a portfolio level, taking the view that a construction company is the sum of its assets/projects combined at a portfolio level. If the assets perform poorly, this will have a direct impact on the performance of the company. As a result, the concept of portfolio theory is investigated, and its applicability in a construction framework.

2.6 Portfolio Theory Applied in a Construction Framework

Archer and Ghasemzadeh define a project as – "*a complex effort, usually less than three years in duration, made up of inter-related tasks, performed by various organizations, with a well-defined objective, schedule and budget,*" (N.P. Archer 1999, pp207-216). Further to this, their definition of a project portfolio is then – "*a group of projects that are carried out under the sponsorship and/or management of a particular organization. These projects must compete for scarce resources (people, finance, time) available from the sponsor,"* (N.P. Archer 1999, pp207-216). These definitions are applicable in the context of construction. A construction company takes on construction projects. The collection of these projects can be group into a portfolio. Therefore, the application of portfolio theory should be a logical result.

The initial research into the application of portfolio theory to a construction based investment model is seen in 1979. Vegara and Boyer's paper investigated the theoretical concepts of portfolio theory, and presented a probabilistic model for portfolio evaluation, (A.J. Vergara 1979). Their research was criticized for being too theoretical, and mathematically complex. It failed to translate the theory into practical techniques, and therefore it lacked applicability, (Kangari 1988).

In 1981, further research was done in the area of portfolio theory in a construction framework. Farid, built on from what Vergara and Boyer had researched, shifting his focus more towards Capital Asset Pricing Model (CAPM), (Farid 1981). Whilst the research built on the assumptions of portfolio theory, it too failed to bridge the gap between conventional portfolio models and actual construction portfolios, (Kangari 1988). During this same period, Kangari and Boyer continued to explore the application of portfolio theory to construction, using the net present value of cash flows. Their research highlighted the difficulties of this application to construction portfolios. However, they failed to discuss the detail behind the difficulties experienced, and ultimately no progression was made concerning the practical application to construction assets, (Kangari 1988).

Kangari and Riggs picked up the research again in 1988, trying to prove that a construction company could combine its projects into a portfolio that would provide an optimum risk versus return position. The theory suggested that when a construction company invests in a variety of projects, the combination could be viewed as a portfolio of projects. This portfolio would be less risky than the average of the individual projects in isolation, (Kangari 1988). Portfolio management theory is not however directly translatable to a construction portfolio, as with conventional property or securities. One of the fundamental differences is that construction projects are not divisible. However, central to portfolio management theory is the concept that the riskiness of a single asset held in a portfolio is different from the riskiness of that asset held in isolation. Critically, the construction project does not change in terms of its inherent risks, but rather the total combined project portfolio as whole becomes less risky, (Kangari 1988). Their research combined construction economics and portfolio management theory, focussing on understanding the basic concepts and fundamental assumptions of portfolio theory. They started by defining a portfolio of construction projects as a combination of two or more project investments. They explained how portfolio theory is primarily concerned with the careful and calculated selection of assets, one which provided (a) the highest expected return at the most optimal degree of risk, (b) the lowest possible degree of risk with still an optimum return, or (c) any combination in between which balances risk and return efficiently, (Kangari 1988).

Kangari and Riggs evaluated construction projects using expected returns as a proxy for return, standard deviation of expected returns as a proxy for risk, and coefficient of correlation of project returns as a proxy for correlation. The objective of their report was to evaluate the application of portfolio theory in construction, highlighting the difficulties associated with translating construction variables for portfolio methods of analysis. Further to this, they focused on the concept of portfolio diversification, with the aim of developing a probabilistic model for evaluating diversification.

As previously mentioned, Kangari and Riggs' model evaluated three key variables - expected return, risk, and correlation between projects. Here, they estimated the expected return for a project using the internal rate of return, which required a net cash flow based on expected revenues and expenses. The limitation of this method was that this information was often not available to researchers (Kangari 1988). Risk is measured using standard deviation of returns. This required historical return data for construction projects, however construction returns differ from securities in that project returns are recorded by a single figure, (Kangari 1988). This was not suitable to the portfolio theory model, which depends on multiple return figures to allow a standard deviation to be calculated. Kangari and Riggs' response to this was to create an upper and lower value based on an optimistic and pessimistic cash flow outcome, (Kangari 1988). Finally, the coefficient of correlation measures the correlation between assets. This was easily determined when analysing securities, but for construction projects, this information was not available. Kangari and Riggs develop a probabilistic model to evaluate correlation here.

Kangari and Riggs noted limitations to the application of portfolio theory in a construction portfolio in their research – Portfolio Management in Construction. Unlike securities, which can diversify industry, company and project characteristic risks, construction does not allow the same, (Kangari 1988). For example, all projects are exposed to the construction industry and furthermore, all projects are within one company. The result is such that the only risk that is diversifiable is Project Characteristic Risks, (Kangari 1988). Kangari and Riggs therefore concluded their research by identifying two major obstacles; (a) risk evaluation of each project, and (b) correlation coefficient between projects, (Kangari 1988). These are both fundamental aspects to portfolio management theory. "*The evaluation of these variables is difficult, time-consuming and complex which makes the application of portfolio theory in construction impractical*," (Kangari 1988, pp161-169). Other issues related to sourcing the appropriate data for mathematical analysis. This data was not typically available to researchers due to the financial sensitivity of the information. Finally, Kangari and Riggs concluded that the relative riskiness of an isolated project is reduced when introduced to a portfolio of projects, compared to holding the project on its own. They suggested: "*A construction project might be risky if held by itself, but if most of its risk can be eliminated by diversification of other projects, the project's relative risk, which is its contribution to the portfolio risk, may be small,*" (Kangari 1988, pp161-169).

Today however, the term portfolio is used more broadly in construction to describe a group of individual projects which share the same set of resources (human, material, time), and are executed under the management of an organization, (A. Kock 2016). This shift in thinking is a result of recent improvements and the increased competition within many of our industries, which has forced organizations to execute increasing numbers of projects concurrently. "*Most of the today's construction organizations are executing several projects concurrently, however, their management routines do not respond to the need of concurrent execution of projects*," (A. Kock 2016, pp115-129). Industry has moulded the concept of portfolio management, to a point where the term now defines the effective management of the right projects for an organization, considering the limited/fixed resources available, the capability of the organization, strategic objectives, and other environmental factors. This is shared by Kock and Meifort – "*Organizations need to hold a holistic view on their bunch of projects to achieve a sustainable success and competitive advantage*," (A. Kock 2016, Meifort 2016).

Recently, research into construction portfolio management has focused on software development. Bilgin and his team from the Department of Civil Engineering, Middle East Technical University, have combined the principals of portfolio theory and construction economics, to develop a software programme. They say; "(it) *will be useful for the adoption of portfolio management principles in construction companies by capturing project knowledge, enabling analysis of portfolios considering interdependencies between projects, enabling selection of the best portfolio considering priorities of the company and facilitation decision-making by providing visual representations of alternative scenarios*," (Gozde Bilgin 2018, pp1-11). This approach builds on from Kock and Meifort, and is notably different from historic portfolio theory research. Here, Bilgin and his team take the view that the main goal of portfolio management is to maximize the contribution of each project in a portfolio to an organization's success, (Gozde Bilgin 2018). Their train of thought tends more towards a project management realm. Portfolio management is used more loosely in the context of project demand, resource allocation, and organizational capabilities - "*the centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work to achieve specific strategic business objectives*", (Institute 2008). Ultimately, the result of their research was the development of a computer software programme they refer to as COPPMAN – Construction Project Portfolio Management. COPPMAN evaluates portfolios at a project level, with the ability of displaying key dependencies, provide insight to the current portfolio, as well as aid in the selection of new projects to the portfolio. Critically, the tool still requires further testing and is therefore dependent on the real application in the construction industry, (Gozde Bilgin 2018). With growing competition in the market, the calculated selection of projects is critical when managing a construction portfolio, (N.P. Archer 1999). Archer and Ghasemzadeh also make this point in their research on portfolio project selection. They suggest; "*Firms that wish to be competitive by selecting the most appropriate projects must therefore use techniques and procedures for portfolio selection that are based on the most critical project measures*," (N.P. Archer 1999, pp207-216). However, neither Archer and Ghasemzadeh, nor Koch, Belgin or Meifort refer to the broader issue at hand - This software is only able to optimize the selection of projects, but it is not a substitute for determining key business strategies. The decision remains: Does a diversified portfolio reduce the risk sufficiently, and compensate for the potential reduction in returns when compromising on specialization?

2.7 Specialization vs. Diversification

Most construction companies typically specialise in a particular type of construction. Specializing allows contractors to (a) perfect their skill, (b) improve efficiencies, (c) invest in specialised equipment, which differentiate them from their competitors, (d) build a market reputation, and ultimately enable a company to maximize their competitive edge. Furthermore, diversification is not always a feasible. However, diversification does not necessarily mean having to compromise on a company's specialisation. Projects, which fall within a similar field of construction, will tend to be highly correlated with each other, whilst projects within unrelated fields are more likely to have lower levels of correlation. As explained by Kangari and Riggs, for diversification to be effective, projects and project returns should have lower correlations. "*Since most projects are not perfectly correlated, diversification generally reduces, but does not eliminate portfolio risk," (Kangari 1988, pp161-169).*

Diversification is key to the portfolio theory - "*diversification is the reduction in risk that is obtained by investing in projects which are not perfectly positively correlated*," (Markowits 1952, pp77-91). Therefore, investing across various projects, which are not positively correlated, will mean that losses in one project may be offset by gains in another. To this point, correlation between projects is crucial. Kangari and Riggs identify four major risks, inherent to construction projects. These include; (a) Economic Risk, (b) Industry Risk, (c) Company Risk, (d) Project Characteristics Risk, (Kangari 1988). Economic risks are those that relate to general economic climate, including interest rate hikes, new laws and regulations, and naturally the state of the global economy. These risks affect all construction projects, and are not easily diversifiable, (Kangari 1988). Industry risks are those that relate specifically to the construction sector. These could typically include labour unions, changes to the tax reporting requirements and legislations, or even new industry codes and standards. These risks are only diversifiable by investing in other industries, which are not correlated (Kangari 1988). Company risks are those that stem directly from the company itself. Kangari and Riggs categorise these as either business risk or financial risk. Business risks are those that relate to company operations, and how it competes with others in the market. Financial risks are those associated with company operating costs. Company risks are therefore difficult, but not impossible to diversify, (Kangari 1988). Reducing company risk is part of strategic business management. Finally, project characteristic risk are those caused by events that are specific to the type of construction project, (Kangari 1988). This could include, site location, pricing/tender views, type of construction, project team and professionals, other stakeholders. These are risks not diversified, but rather managed – this is the nature of construction industry. Ultimately, by reducing risk, the probability of financial distress within a firm is also reduced, specifically due to liquidity issues, cash shortages, and possible insolvency, (Kangari 1988).

2.8 Concluding Remarks

The construction industry has been perceived with uncertainty, a high-risk business that has poor investor sentiment, and is highly sensitive to macro-economic cyclical fluctuations. The industry is renowned for having a poor reputation for coping with risk, where in most cases provisions for risks are made for in contingencies or project mark-ups. This is evident in the current state of the construction industry, where many contractors are cash strapped and exposed to potential bankruptcy - "*Construction work available has diminished, resulting in increased competition, putting the construction industry under pressure. As a reaction to these conditions, margins have progressively become tighter, profitability is eroded, liquidity starts to dry up, and sector performance becomes strained,"* (PwC 2016). As a result, business failure in the construction industry has become front of mind for most contractors. Historically, the performance of the construction sector was assessed based on share price performance. However, as outlined in the review, underperforming share prices do not imply poor company performance. The focus has therefore shifted towards an intrinsic company-level performance analysis. This motivates the project level analysis. The use of portfolio management theory in the context of a construction portfolio of projects has been criticised. Unlike securities, which can diversify industry, company and project characteristic risks, construction does not allow the same. All projects are exposed to the construction industry and furthermore, all projects are within one company. The result is such that the only risk that is diversifiable is Project Characteristic Risk. Whilst Kangari and Riggs may have concluded this, it is argued that the principles of portfolio theory are still applicable in addressing the debate around specialisation versus diversification. This analysis differs, using real project returns as a proxy for Asset Return, and using return volatility as a proxy for Asset Risk. The aim is to construct the ideal portfolio of projects that are well balanced, diversify risk, yield consistent returns, and provide sustainable profitability.

3. Methodology

3.1 Introduction

The aim of this chapter is to outline the methodological approach used in this thesis. There are fundamentally three aspects to this chapter. Firstly, the philosophical framework that underpins the research approach. Here, the different research philosophies are explored, which will define the strategy that will be followed. Secondly, the research strategy chosen. This section describes what, and why the research approach was chosen. Lastly, the empirical techniques used in the analysis phase. In this section, the research design and subject case are outlined, along with the units of the analysis, the data source, and the conceptual framework with the key limitations.

A case study approach was selected for its ability to assist as an evidence-based decision making technique, (P. Baxter 2008). As discussed by Yin (2003), a case study methodology is useful in research when; (a) the focus of the study is to address research questions related to the 'How' and 'Why' of the topic on hand, (b) those involved in the study cannot be manipulated in the responses they provide, (c) the contextual situation is significant to the phenomenon/issue we are investigating, and (d) the boundaries between the phenomenon and the context are not clear, (P. Baxter 2008).

Ultimately in this chapter, the aim is to provide a level of confidence to the reader, by establishing creditability, transferability, dependability and confirmability, (P. Baxter 2008). In order to achieve this, the methodology must comprehensively describe the procedure in a manner that will enable all future readers and researchers to understand the complexity of the phenomenon that is being investigating, and apply it to future investigations thereby allowing scalability.

3.2 The Research Approach

Choosing the best research philosophy is critical to the success of this thesis. This process is fundamentally driven by the research question and the focus of the study, however it is equally influenced by the nature of the topic and the ability to source data for the analysis. In doing so, the understanding of the philosophical underpinnings is key to the selection of the most appropriate approach.

A positivist philosophy assumes that there is an independent relationship between social reality and humans, (W. Orlikowski 1991). A critical philosophy is where the main objective is to critique the social norm and status quo, (Heinz K. Klein 1999). The research assumptions are however based on an interpretative philosophy. With an interpretive philosophy, there are typically no predetermined variables. The focus is on the complexity of human sense-making as the situation emerges (B. Kaplan 1994). A case study research approach has been chosen for the analysis, an approach that investigates a real-world problem or issue, using actual real-world examples to underpin the outcome, (Yin 1994). As a result, the case study methodology is used here in order to contextualise construction company sustainability, making use of a real-life construction company and actual project return data. Critically, the research approach requires intrinsic financial data relating to construction project returns. This data is typically not published, or well reported on. It is for this reason why a case study methodology has been chosen. This is similarly expressed by Yin, in his case study research. He explains how a case study approach can be especially useful where actual contextual situations of the research topic being studied are critical, but where the researcher has little or no control over the events as they occur, (Yin 1994). This is exactly how the research here has played out. Research is conducted on the construction sector, but from a project level return perspective. However, data was not readily available, nor was it published for public use. The solution was to find a real company that was willing to participate and provide confidential project level information.

3.3 The Case Study Strategy

A case study approach for a research thesis is an accepted methodology. The advantages of such a method in the research include; (a) the results are representative of a real world construction company scenario, (b) the data provides the analysis with very detailed information, and (c) it enables new research where there has been historically no research previously done. However, this methodology is not without criticism. Many critics argue that this methodology is subject to generalisation and interpretation - The data is open to research-bias, and allows for “thick-descriptions,” (Yin 1994). However, advocates of the case study approach suggest that no other method offers the flexibility, and the ability to highlight other categories and themes relevant to the subject (Orlikowski 1991).

Critically, there are different types of case studies, each one used to satisfy specific objectives. Yin, identifies three specific types; (a) Exploratory, (b) Casual, and (c) Descriptive, (Yin 1994). Exploratory case studies are characterised by the simple fact that they occur before a theory is actually identified. Here, an investigation is conducted by use of case study, and themes are identified through the analysis of data captured. The research question is subsequently formulated, and further more detail case study analysis can continue (Yin 1994). Casual case studies are fundamentaly based on cause-and-effect relationships. Here, case studies are used to investigate “explanatory theories of the phenomena,” (Yin 1994). Finally, Descriptive case studies are guided by a predetermined subject or research question. As explained by Yin; “*The descriptive case study will require a theory to guide the* *collection of data and this theory should be openly stated in advance and be the subject of review and debate and later serve as the 'design' for the descriptive case study*," (Yin 1994). Further distinctions are made regarding case studies. A case study can be characterised by the number of subject cases employed - Singular or Multiple (Yin 1994).

In conclusion, the research approach is best described as a Singular, Descriptive case study. There is just one subject case from which the data is sourced and analysed – hence Singular. The objective of the analysis is to support the predetermined problem statement - therefore Decsriptive.

3.4 Research Design

3.4.1 Selection of the case

As previously stated, the purpose of this thesis is to understand the dynamics around construction companies and their economic sustainability. In doing so, the focus here is on the interplay of two specific techniques used in the industry – Specialisation vs Diversification. The aim is to determine which of the two techniques provides greater sustainability for construction companies. A case study approach is used. Critically, an appropriate case is to be identified, the requirements for which include:

(a) The construction company should be a private entity - This is to ensure that public entities and non-profit organisations are excluded from the sample, as they can potential distort the results. Public companies are often immune to the economic realities that private entities are exposed to. Non-profit organisations do not participate competitively in the market and are not aligned with the research objectives.

(b) The construction company should be a minimum CIDB grading of 8 - This is to ensure that the construction company falls within the requirement of 'Large' construction companies for the analysis. As outlined in the research proposal, the objective was to evaluate the sustainability of large construction companies. Any construction company below an 8 CE grading is more likely to be classified as a small to medium construction company.

(c) The construction company should have a national footprint - This is to ensure that the company not be influenced by its position in a specific market, due to its location geographically. This aims to remove any company that would have capitalised a niche market, and potentially removed from a normal competitive market conditions.

(d) The construction company should be multidisciplinary - In order to test the hypothesis, returns of different types of construction projects were assessed. This is essential to the analysis: Specialization versus Diversification. Companies that operate within a specialised environment will not facilitate this analysis. Therefore, the sample was limited to multidisciplinary entities that align with the research objectives.

(e) The construction company should practice project specific financial reporting - Critical to the analysis is having financial project specific data. Much of the previous research into construction companies is limited to their 'macro-performance' – i.e. Total Company Returns. In these instances, research was limited to listed construction companies measuring performance by share price growth and dividends paid. Here, a 'micro-analysis' is the approach used. Returns are analysed at a granular level – i.e. Project Specific Returns. Therefore, the subject case needs to operate with strict reporting standards.

(f) The construction company should be able to provide access to their data - The analysis requires access to sensitive and confidential financial data. This often includes company specific pricing techniques, mark-ups, and profitability. Access to project specific cash flows, cost reports, budgets and financial reports. In many cases, companies are unlikely to share this information, however the analysis depends entirely of having access to this information.

Over a period of 8 months, starting April 2018, a single case was identified that satisfied the requirements in section 3.4.1. The reasoning for this specific case selection was in most parts a result of access to information. Whilst there were many potential sample cases that satisfied requirements (a) to (e), the obstacle was always requirement (f) – Access to confidential information. Therefore, as per the limitations outlined, this research thesis is ultimately a single-case case study. It is acknowledged that a multiple-case study would have been preferable, but due to the nature of the information required, and the limited accessibility thereof, this has not been achievable. Instead, a dense sample of sub-unit data was sourced to provide confidence in the analysis of data presented.

3.4.2 Sub-units of the analysis

This analysis represents a single-case case study. For the purpose of this thesis, the company (the subject case) remains confidential. However, it represents a large, privately owned, South African construction company – CIDB grade 9. The subject case is civil engineering focused, and originated as a heavy earthworks construction company. Since starting in 1994, it has grown to offer structures and infrastructure arms. In recent years, it has diversified its offering further, to include roadworks, energy, and pipelines. However, in order for the analysis to maintain an acceptable level of confidence, it requires at least three projects to have been completed for any individual project type. As a result of this constraint, and in the context of the data sourced, the sub-units of the analysis are defined: (a) Earthworks, (b) Structures, (c) Infrastructure.

Project type (a) Earthworks, include projects where heavy earth moving equipment is the focus of the cost and work. This includes landfills, bulk earthworks, earth-retaining walls, load and haul contracts, cut to fill platforming, and tailings dams. Project type (b) Structures, include concrete reservoirs, pump stations, bridges, chambers, gabion walls, and concrete retaining walls. These are typically projects where the bulk of the cost and work are related to concrete reinforce structural elements. Project type (c) Infrastructure, include projects that are township development related. This includes all essential services including water, electricity, sewerage, storm water, cable ducting, roads, minor earthworks, and minor structures.

It is expected that the three sub-units identified will provide sufficient data in order to facilitate an objective analysis. Each of the sub-units consist of several (more than three) real projects, and each project consists of a series of monthly financial reports. As a result, the sample size is expected to be sufficiently large enough to provide an acceptable level of confidence. This is critical to the success of the research. Whilst limited to only one subject case, the aim is to offset this limitation with a dense sample of financial reports.

3.4.3 Data Sources

Data collection was provided through primary sources. The subject case provided access to its archive of project specific financial reports for the past ten years – dating back to 2008. The analysis is limited to a six-year period starting January 2012 up until December 2017, based on the following reasoning:

(a) The data pre-2012 appeared to be inconsistent, with gaps in the records kept. Reporting appeared to be poorly archived, and as such the research restricts projects pre-2012.

(b) The data post-2008 is limited due to the 2007 financial crisis and 2010 soccer world cup, where the construction industry slumped. This is evident in the reduced number of projects that are on record during this period.

(c) This research thesis started in April 2018, and as such the data sourced was limited to early 2018. The research was limited to December 2017 to provide a full six-year snapshot of projects.

There are two main sources of data, the first being Figure 3.4.4.1 - Cash Flow Report, and the second being Figure 3.4.4.2 - Profitability Report. The format is specific to the subject case and the tailored financial reporting techniques. It is fundamental to the analysis that the following was understood; (a) what is being reported on each month, and (b) how this data should be interpreted.

The Cash Flow Report is a revenue versus cost reporting tool. It tracks actual revenue month on month, against actual costs incurred month on month. The aim of this report is to show the Net Cash that a project yields both on a total to date scenario, and a month on month basis. Column F – Brought Forward, captures the total to date revenue and costs for the project. Column G – Current, captures the current months claimed revenue and estimated costs. Columns H to K are the projected month on month revenue and costs. This is based on what work is programmed for the months ahead, and the corresponding costs associated with completing that work. Critically, Month 2 is a one-month projection, Month 3 is a two-month projection, Month 4 is a three-month projection, and finally Month 5 is a four-month projection. Naturally, the further projected, the less accurate the figures are expected to be. However, whilst a cash flow is important for a construction company's operating ability, the profitability of a project is equally important. A project may show cash positive, but may still be operating at a loss. For this reason, a Profitability Report is required.

The Profitability Report is a cost versus allowable reporting tool. It tracks month on month the total to date and monthly costs against the real revenue (allowable). An 'allowable' is the tendered (budgeted) provision made. The aim of this report is to remove any distortions in revenue, discounting any over claims and removing false revenue. This allows for an 'apples with apples' comparison – i.e. what the real profit is. Furthermore, columns A to C facilitates the final estimated allowable and final estimated costs, and as a result, the final estimated return.

3.4.4 Collection and Analysis

Collecting the data yielded a sample of 28 projects from ten years of archiving. This was refined to a six-year snapshot from 2012 to 2017, resulting in a sample of 24 projects. Each individual project had two financial reports per month. This resulted in 271 cash flow reports, and another 271 profitability reports. Using these reports, the following financial data is extracted:

(a) Month on month Net Cash – This represents only the current months revenue, less costs, to give a Net Cash for the month also referred to as the current month projection (Column G – Current), expressed as a percentage return.

(b) Total to date Net Cash – This represents the cumulative revenue, less cumulative costs, to give a total Net Cash to date (Column F – Brought Forward), expressed as a percentage return.

(c) Current Final Estimated Return – This represents an adjusted final estimated return, based on how the revenue and costs progress through the project. This is the revised final estimated return given the project dynamics, expressed as a percentage return (Cell C48 + C49).

(d) Total to date Actual Return – This represents the current total to date actual return (Cell G48 + G49). This is the actual return the project has achieved on a cumulative basis, expressed as a percentage return.

These four measures are the fundamental data on which the analysis is based. The aim is to triangulate these independent measures and potentially validate the case study further.

The projects were subsequently grouped by project type; (a) Earthworks, (b) Structures, and (c) Infrastructure. The result is such that for earthworks, structures, and infrastructure the samples sizes were 558, 140, and 268 respectively. The total population was 966 individual return measures. Critically however, the cash flow based returns showed significant variances and required data cleansing techniques to be applied. This is typically the nature of the construction industry - specifically cash flow reporting. This variance is attributed to two main factors. Firstly, there is often a disconnect between monthly claimed revenue, and the costs associated. Revenue is determine on a specific date, by calculating works completed. Costs however run to the end of the month. Progress payments therefore account for some costs incurred after the measurement of the claim was finalised. The result is such that the progress payments do not align with the reported costs. Secondly, projects are often front-loaded. This means that they are priced such that they generate cash more aggressively towards the start of the contract, to aid the contractor with cash flow constraints. This is often seen where the first progress payments approved include contractual start up payments, where costs have not even yet been incurred. This distorts the month on month net cash. In order to remove these effects, the cash flow data requires a 2-month average. This softens the impact of cost/revenue disconnect. Essentially, the variance is streamlined and better representing the true revenue/cost comparison i.e. Net Cash for the period.

Figure 3.4.4.1: Cash Flow Report Template

CASH FLOW PROJECTION

					Brought Forward	Current	Month 2	Month 3	Month 4	Month 5	Outstanding	Estimated Final	TENDER
SITE:											Time to Completion:		
CONTRACT No:											0 Months		
MONTH:													
REVENUE		VALUE OF WORK DONE											
		+	Escalation										
		±	Month MOS										
		Progressive MOS @											
		+	Provisional Sums										
		Sub - Total				-	-	-	-	-	-		
		Progressive Work Done			-	-	-	-	-	-	-		
		±	Over/Under Payments								-		
		CERTIFIED REVENUE				-	-	-	-	-	-		
		Progressive Certified Revenue			-	-	-	-	-	-	-		
		-	RETENTION	(5%)	-	-	-	-	-	-	-		
		+	Retention Release		-	-	-	-	-	-	-		
		Progressive Retention			-	-	-	-	-	-	-		
		CASH PAYMENT				-	-	-	-	-	-		
		Progressive Payment			-	-	-	-	-	-	-		
COSTS	1	SALARIES											
	2	WAGES:	PERMANENT										
			LIMITED DURATION										
	3	MATERIALS											
	4	SHUTTERING											
	5	PLANT: INTERNAL											
	6	PLANT: EXTERNAL											
	7	CONS:	GENERAL										
			FUEL										
	8	OTHER											
	9	SUBCONTRACTORS											
	10	PROVISIONAL SUMS											
		CONTRACT COSTS											
		Overheads		(5%)									
		Progressive Costs											
		NETT Profit Mnth											
		NETT Profit to Date											
		NETT Cash Mnth											
		NETT Cash To Date											

Figure 3.4.4.2: Profitability Report Template

PROFITABLILITY REPORT

	A	B	C	D	E	F	G	H	I	J
8		SITE:								
9		CONTRACT No:								
10		MONTH:								
12–14	FINAL ESTIMATED ALLOWABLE	ESTIMATED FINAL COSTS	ESTIMATED FINAL VARIANCE	DESCRIPTION		ALLOWABLE TO DATE	ESTIMATE TO DATE	CURRENT VARIANCE	VARIANCE LAST MONTH	CHANGE IN VARIANCE
15				Establishment:-						
23				On Cost:-						
24				Salaries.						
25				Wages.						
26				Plant	:Internal					
27					:External					
28				Consumables						
29				Other.						
30				Subcontractors						
31				Direct Costs						
32				Wages.						
33					*Materials Total*					
34				Materials						
35				MOS @ 100%						
36					*Plant Total*					
37					:Internal					
38				Plant	:External					
39					:Fuel					
40				Shutter						
41				Consumables.						
42				**Subcontractors**						
43				CPG Subcontractors						
44				General Subcontractors						
45				TOTAL WORK						
46				PROVISIONAL SUMS						
47				FINAL TOTAL						
48			5%	OVERHEADS	5%					
49				PROFIT	10.0%					
50				TOTAL ALLOW. REVENUE						
51				CERTIFICATE VALUE				Prev. month M Sheet cost.		
52				OVER/UNDER CLAIM				Prev. month Actual cost.		
53				ESCALATION REVENUE					Variance.	
54										

Subsequent to this data cleansing, the data is aggregated to a portfolio level. This is defined by the three sub-unit; (a) Earthworks, (b) Structures, and (c) Infrastructure. Each sub-unit categorises returns by type; (a) Month on month Net Cash, (b) Total to date Net Cash, (c) Current Final Estimated Real Return, and (d) Total to date Real Return – Table 3.4.4.1:

Table 3.4.4.1: Portfolio Level Overview

(a) EARTHWORKS				(b) STRUCTURES				(c) INFRASTRUCTURE			
Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)		Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)		Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)	
Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return

**Key: TTD – Total To Date*

The analysis consists of a three-element view. The first, a Portfolio Level Overview, is where the group of projects is reviewed, together with the aim of understanding at a high level the scope of the portfolio that defines the sample population. Here, the points of interest are not specifically related to project returns, but rather the granular project information. This includes; (a) Number of projects per project type, (b) Start Date, (c) End Date, (d) Original Project Value, (e) Final Project Value, (f) Original Budgeted Return, (g) Actual Final Return, and other project-related fields. This enables a better understanding of the portfolio in terms of exposure, bucketing the individual projects by pre-determined project value bands. Slicing the portfolio further, illustrates which project types are typically larger in terms of contract value, which project types have better yields, and which project types produces the greater variance in terms of original budget versus final actual achieved. This intrinsic data is critical to the understanding of the projects at a portfolio level.

The second, a Statistical Analysis, dissects the data compiled on project specific returns. Here, SPSS statistical software is used to complete a comprehensive first principal's analysis of the data. The aim is to first define what is being solved for. Once a clear understanding is achieved, the appropriate statistical technique is selected, the sample data is arranged in a format that will facilitate the analysis. The results (output) are subsequently be reviewed, and related back to the original research question. The methodology is defined below.

(a) Creating the Codebook

The data collection process yielded a set of research data – Data File. However, in order to do an SPSS analysis the project requires the data to be translated into a format that SPSS and the statistical analysis can read from. This process is termed Creating the Codebook. Here, the variables are identify and labelled. Unique to the data file, there are two variable types. As a result, a series of four codebooks were produced.

(i) Project Type Codebooks

1. Earthworks Codebook
2. Structures Codebook
3. Infrastructure Codebook

(ii) Return Type Codebook

4. Portfolio Return Codebook

The structure of the data file is now setup to facilitate further statistical analysis. However, it is essential that the data be screened for errors. The most efficient way to do so is to use descriptive statistics in SPSS. The process of screening and cleaning data is done using this two-step methodology. Firstly, the data is screened for errors by removing data points that fall outside the expected range. If the analysis is sensitive to outliers, these points will distort the results. In the analysis, the data is specifically continuous variables. This makes the screening process slightly more complex. In this case, a simple Minimum, Maximum, and Mean will highlight potential errors. Secondly, the errors in the data file are to be corrected. A simple high to low sort will arrange the data file, and locate these outliers more effectively. These data points are either corrected or removed from the data file - In this case, they were removed completely.

(b) Descriptive Statistics

Descriptive statistics are useful to illustrate the nature of the sample data. Now that the data is formatted, the descriptive statistical analysis is done with the aim of highlighting characteristics that speak to the research question. Furthermore, this step is critical as it defines what statistical techniques will be feasible going forward, depending on which of the individual assumptions of each individual test the data violates. The descriptive statistics defined include; (a) Mean, (b) Median, (c) Range, (d) Standard Deviation, (e) Skewness, and (f) Kurtosis.

(c) Assessing Normality

Assessing normality is a fundament test in any first principal's statistical analysis. Many of the statistical techniques going forward will assume that the sample data is normally distributed. Whilst normality can be determined from the Skewness and Kurtosis figures produced, the descriptive analysis to test for normality is preferred. Here, Kolmogorov-Smirnov's Sig ratio is used. Furthermore, graphical tools are used to illustrate this relationship of the data. This includes Histograms, Normal Q-Q Plots, Detrended Normal Q-Q Plots, and Box-plots.

(d) Graphs

Whilst much of this data provides numerical results as outputs for analysis, often the trends are not easily interpreted. In such cases, graphical illustrations are useful, however not all graph types are applicable to the data sample. Here, continuous variables are best represented in histogram graphs and box-plots. Histogram graphs are appropriate as they are typically used to display a single continuous variable. Here, histograms have been provided for each return type, and categorised by project type. This allows a comparison to be made between each project type, and the returns they yield. Box-plots are better suited to illustrating and comparing the distribution of scores on variables. Here, box-plots were used to explore the distribution by return type, but with the additional flexibility of adding one categorical variable – project type. The result is such that four individual box-plots are produced, one per return type, with three categorical variable – project type.

Choosing the correct statistical method depends ultimately on the research question, and the type of variables in the data set. In most statistical analysis, there are two main directions to choose from - Techniques to explore the relationship among variables, or techniques to explore the differences between groups? The first technique uses tools such as correlation, partial correlation, multiple regression, or factor analysis. All these methods seek to establish the relationship between continuous variable. These are however, not appropriate in the context of this analysis. Instead, the aim is rather to determine if there is a statistically significant difference amongst groups. In this case, the common techniques are T-tests, analysis of variance (ANOVA), or an analysis of covariance (ANCOVA).

(e) ANOVA

Typically, a t-test would be used to compare two different groups. However, in this case study, comparing the mean scores of more than two groups is more interesting. In this situation, the use of an analysis of variance test (ANOVA) is best suited. An F ratio is then calculated. This represents the variance between the groups, divided by the variance within the groups. Here, a larger F ratio would imply that there is more variability between the groups than there is within each group. The limitation with the ANOVA test is that it will only confirm that there is a difference between groups. It will not however tell you where this difference is – i.e. Between group 1 and 3, group 2 and 3, or group 1 and 2. For this, a post-hoc test is conducted. The Tukey HSD post-hoc test is used. Critically for the ANOVA analysis, the data is assumed parametric. The non-parametric alternative for the ANOVA test is the Kruskal-Wallis test.

The third analysis, a Portfolio Theory Analysis, uses Modern Portfolio Theory to address the research question more directly. Here, the focus is on analysing returns in terms of Mean, Standard Deviation, and Co-variance. Mean returns are used as a proxy for Expected Portfolio Return. Standard deviation is used as a proxy for risk. Co-variance is used to measure the correlation of different assets. The month on month returns proved to be too volatile due to the nature of construction, along with the month on month total to date returns which only established a stable position in the second half of the contract (this a result of the monthly claims becoming progressively a smaller proportion of the total to date claim). To this end, the portfolio analysis is applied only to the Final Estimated Project Returns. The methodology is outlined:

(a) Total Return Forecast - The Final Estimated Returns are tabulated, where the three project types are used as a proxy for asset classes. Mean, variance, and the standard deviation are solved for here.
(b) Covariance Matrix - Here, the covariance of variables is determined. The portfolio consists of three asset classes, therefore each variable is required to be tested against each other. The result is a 3 x 3 matrix of covariance's.
(c) Efficient Frontier - Finally, by adjusting the asset weighting, the corresponding risk (standard deviation) and return are calculated. Plotting these points on a graph yields an efficient frontier. Each line represents the risk-return trade off in a two-dimensional space.

The result is three separate analyses, used to understand the portfolio of projects.

3.5 Summary

To summarise, a conventional qualitative or quantitative approach was not possible here, as a sufficiently large enough sample size was not obtainable. To this end, a case study methodology was chosen as the method that would best facilitate the analysis, with the added advantage that real-life data could be analysed and hopefully provide insight to the dynamics of the research topic. The difficulty however, related to sourcing actual project related data as companies are cautious with publishing and or providing confidential project related information. After reviewing the different types of case studies, it was established that a single, descriptive case study approach would be used, as it enabled a micro-level analysis of actual individual project related returns.

A single subject case was identified, from which real project data over a 10-year period was obtained. The data sorted by project type, identified three buckets – Earthworks, Structures, Infrastructure. A 6-year sample defined 24 projects, 542 financial reports, and 966 project return measures. In order to ensure that the reader remains confident in the validity and creditability of the results presented, it was critical that sufficient detail was provided to justify the analysis. In doing so, the research method adopted a triangulation approach. Firstly, three methods of analysis were used, (a) Portfolio Level Analysis, (b) Statistical Analysis, and (c) Portfolio Theory Analysis. Furthermore, data was sourced from two separate financial reports – a cash flow, and a profitability report. The data was tested using statistical methods, and finally a portfolio theory based model was applied to the data. The results of this three-phased analysis are provided Section4 - Results.

4. Results

The results of the case study analysis are presented in this section of the report. There are three key components to this particular section of the report – (a) Portfolio Return Analysis Results, (b) Statistical Analysis Results, (c) Portfolio Management Theory Results. The return data has been sourced from actual construction project cost reports. See detailed reports attached in the annexure section. This data is subsequently analysed using statistical methods, the results of which are published here. Finally, a portfolio management theory approach is applied to the return data, in order to satisfy the objectives of this research report. However, before presenting these results it's important to understand the context of the analysis – a case study of an actual portfolio of projects. The results are presented here.

4.1 Portfolio Return Analysis Overview

The portfolio overview provides a high level breakdown of the subject case. The aim here is to provide context to the scope of the data that has been captured, as well as the composition of the portfolio. The projects range from late 2011 to early 2018, and split between three different construction types (asset classes) – Earthworks, Structures, and Infrastructure. These three asset classes are unique to the subject case. Other construction companies are likely to have different compositions, including amongst others (a) roadworks, (b) building, (c) pipeline, and (d) mining. The portfolio is summarised as follows.

4.1.1 Portfolio Summary

The result is a portfolio of 24 construction projects (assets), equating to over a billion rand worth of exposure.

Table 4.1.1.1: Portfolio Summary

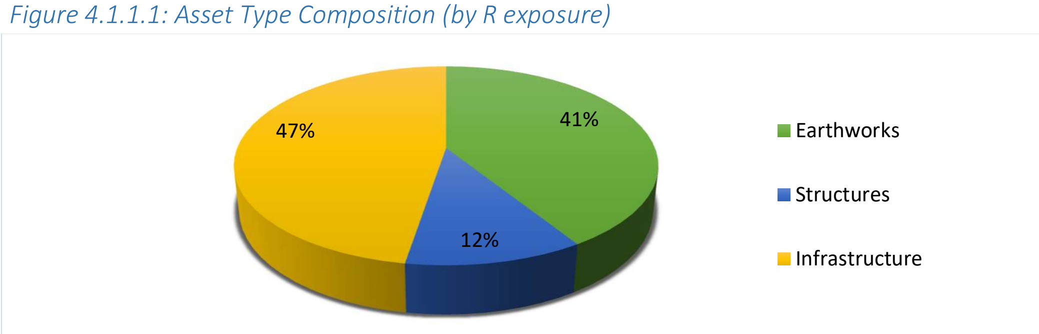
Asset (Project) Categories	Asset Count	Exposure	% of Total Book
Earthworks	16	R 488,755,893	41%
Structures	3	R 137,365,282	12%
Infrastructure	5	R 564,368,741	47%
Total	**24**	**R 1,190,489,916**	**100%**

The assets range from small R5mn contracts, to larger R150mn plus contracts. Critical information such as project returns, project durations, and contract values are tabulated below in table 4.2 – Detailed Portfolio Composition. The composition of asset type by rand exposure is illustrated by the pie chart figure 4.1.1.1. Earthworks are noted as the dominant asset class by number of projects, and Infrastructure is the dominant assets class by deal value.

Table 4.1.1.2: Detailed Portfolio Composition

No.	Project Code	Category	Original Contract Value	Final Contract Value	Budget Return	Actual Return	No. of Reports	Duration (months)	Start Date	End Date
1	542	Earthworks	28,305,277	29,200,163	15%	36%	9	10	Nov-11	Sep-12
2	547	Earthworks	5,020,285	5,582,836	18%	21%	5	5	Aug-13	Jan-14
3	552	Earthworks	12,400,000	13,441,664	10%	15%	7	8	Jan-12	Sep-12
4	557	Earthworks	22,067,241	22,441,483	13%	25%	7	7	Mar-12	Oct-12
5	559	Earthworks	63,000,000	63,324,877	18%	7%	17	17	May-12	Oct-13
6	560	Infrastructure	113,221,449	289,211,562	7%	15%	34	48	May-12	Apr-16
7	568	Earthworks	22,155,144	22,456,616	18%	-20%	9	27	Jun-12	Sep-14
8	570	Earthworks	50,700,000	50,700,000	13%	27%	3	4	Sep-13	Jan-14
9	571	Earthworks	12,266,710	11,815,397	17%	35%	6	6	Jun-13	Dec-13
10	578	Structures	119,442,571	131,891,575	6%	3%	20	30	Sep-13	Mar-16
11	579	Earthworks	12,907,183	45,319,703	20%	26%	8	25	Oct-13	Nov-15
12	587	Infrastructure	102,773,364	121,410,830	10%	-10%	14	43	Aug-14	Feb-18
13	596	Earthworks	36,645,280	37,181,837	16%	18%	11	15	Apr-15	Jul-16
14	599	Earthworks	42,650,000	56,297,339	11%	15%	15	25	Feb-15	Mar-17
15	600	Earthworks	35,723,505	48,879,678	13%	15%	12	25	Feb-15	Mar-17
16	608	Earthworks	65,385,268	68,658,856	15%	-30%	14	32	May-15	Dec-17
17	609	Earthworks	10,000,000	12,721,877	18%	23%	7	7	Jul-15	Feb-16
18	616	Infrastructure	164,199,190	208,624,265	9%	5%	11	13	Dec-16	Jan-18
19	618	Infrastructure	26,174,738	35,992,450	12%	23%	12	12	Feb-17	Feb-18
20	621	Structures	12,270,982	15,178,229	13%	23%	12	12	Feb-16	Feb-17
21	626	Earthworks	19,530,000	21,791,506	12%	3%	8	13	Jul-16	Aug-17
22	628	Earthworks	50,000,000	54,981,134	13%	21%	15	15	Sep-16	Dec-17
23	637	Infrastructure	158,000,000	116,687,542	13%	15%	9	10	Jan-17	Nov-17
24	639	Structures	5,651,729	6,753,591	16%	1%	6	10	Jul-17	Dec-17
			1,190,489,916	**1,490,545,010**			**271**	**419**	**Jan-12**	**Dec-17**

Figure 4.1.1.1: Asset Type Composition (by R exposure)



4.1.2 Asset Class Analysis

The subject case presented three distinctive asset classes – Earthworks, Structures, and Infrastructure. The analysis is as a result broken up into these classifications. The projects were analysed in terms of the nature of the work, and subsequently categorised into one of the three classes above. The value bands are also graphed. These are important to understanding the nature of the asset class, whether it's characterised by high or low value deals. Summarised in Table 4.1.2.1 are the asset classes, and the assets that have been allocated.

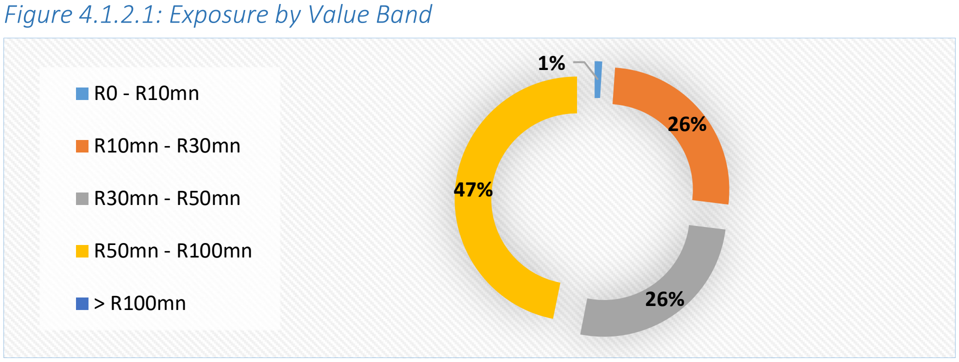
4.1.2.1 Earthworks

Earthworks contracts are characterised by activities relating to earthmoving. This includes landfill, mine rehabilitation, platforming, and other general earth-moving contracts. These activities are typically heavily dependent on plant and equipment, therefore labour and material costs are often a smaller proportion of the costs compared to plant and fuel. In the subject case, this asset class accounts for 16 of the 24 projects, and 41% of the full portfolio exposure. The average deal value is R30mn, with a diverse spread of contract values – Table 4.1.2.1. Almost half of this exposure is found within the R50 – R100mn value band. This suggests that there is a high concentration of the total exposure to just four deals.

Table 4.1.2.1: Earthworks Asset Summary

Earthworks				
Contract Value	**Exposure (R millions)**	**% of total exposure**	**Deal count**	**% of total exposure**
R0 - R10mn	R 5	1%	1	0%
R10mn - R30mn	R 127	26%	7	11%
R30mn - R50mn	R 128	26%	4	11%
R50mn - R100mn	R 229	47%	4	19%
> R100mn	R 0	0%	-	0%
	R 489	**100%**	**16**	**41%**

Figure 4.1.2.1: Exposure by Value Band



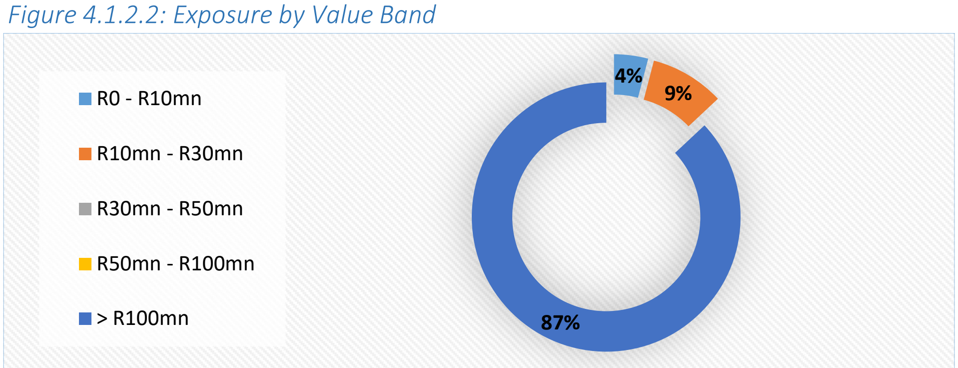
4.1.2.2 Structures

Structures projects are characterised by activities relating to concrete and reinforced structural elements. This could typically include bridges, retaining walls, culverts, reservoirs, and other reinforced concrete elements. These activities are heavily material driven, where concrete and steel form the bulk of the costs, and plant and labour a smaller proportion. This asset class accounts for only 3 of the 24 projects in the analysis, and 12% of the full portfolio exposure. The average deal value is R45mn, also with a diverse spread of contract values – Table 4.1.2.2. Almost all of this exposure is found within the +R100mn value band. This suggests that there is a high concentration of the total exposure to just one deal.

Table 4.1.2.2: Structures Asset Summary

Structures				
Contract Value	**Exposure (R millions)**	**% of total exposure**	**Deal count**	**% of total exposure**
R0 - R10mn	R 6	4%	1	0%
R10mn - R30mn	R 12	9%	1	1%
R30mn - R50mn	R 0	0%	-	0%
R50mn - R100mn	R 0	0%	-	0%
> R100mn	R 119	87%	1	10%
	R 137	**100%**	**3**	**12%**

Figure 4.1.2.2: Exposure by Value Band



4.1.2.3 Infrastructure

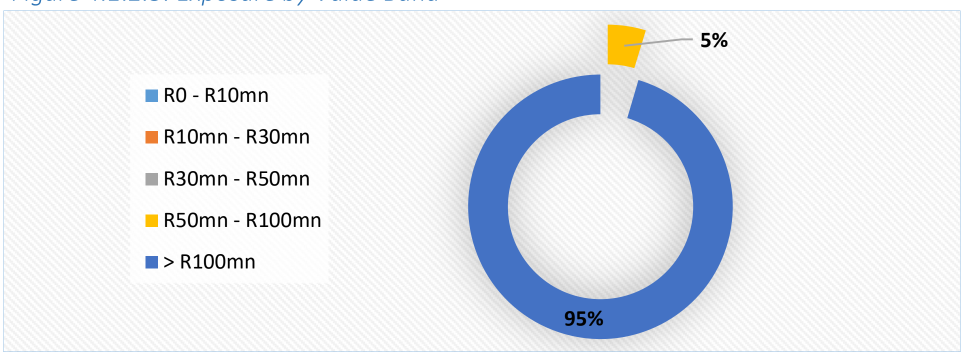
Infrastructure projects are characterised by activities relating to service installation, including storm-water, bulk and internal sewer, ducting, electrical lines, minor roadworks, pressurised water lines, and other key infrastructure. These activities are typically labour and material intensive. This asset class accounts for 5 of the 24 projects in the analysis, and 47% of the full portfolio exposure. The average deal value is R110mn – Table 4.1.2.3. All of this exposure is found in the +R50mn value bands.

This suggests that there is a high concentration of the total exposure to just five deals, all of which are of a high value nature.

Table 4.1.2.3: Infrastructure Asset Summary

Infrastructure				
Contract Value	**Exposure (R millions)**	**% of total exposure**	**Deal count**	**% of total exposure**
R0 - R10mn	R 0	0%	-	0%
R10mn - R30mn	R 0	0%	-	0%
R30mn - R50mn	R 0	0%	-	0%
R50mn - R100mn	R 26	5%	1	2%
> R100mn	R 538	95%	4	45%
	R 564	**100%**	**5**	**47%**

Figure 4.1.2.3: Exposure by Value Band



4.1.3 Return Analysis Data Results

The data analysis was sourced from actual construction cost reports. Two different reports were provided, the first being a monthly cash flow report, and the second being a monthly profitability report. The return data was aggregated for each individual project. The result was 24 different project data sets, each comprising of four return measures including (a) Month Only Net Cash, (b) Total to Date Net Cash Return, (c) Final Estimated Real Return, and (d) Total to Date Real Return. The first two return measures are sourced from the cash flow report, whilst the second two measures were sourced from the profitability report. After doing a high-level analysis, it was concluded that the data showed signs of extreme outliers, high volatility, and significantly large standard deviations. This is not unusual in construction and can be attributed to any of the following reasons:

- The contract may have been front-loaded, resulting in high revenue at a point in the contract where costs are low – translating to unrealistic returns in excess of 300%. This does not truly reflect real project returns.

- In instances where claims are paid out, contracts will show massive profits within the month only net cash reports. These abnormal returns are picked up as outliers.
- Bulk payments for materials, provisional sums, or other large contributions paid will reflect negatively on a projects monthly net cash returns. These would translate to seriously concerning negative returns.
- Over or under claims resulting from measurement and claims not aligning with monthly certified payments results in distorted net cash returns. This is very common in construction projects, where payments are certified post-measurement.

This motivated one of the fundamental clean-ups that was done to the data. In order to reduce the impact of such discrepancies, a two-month average was taken on the return data. This in effect, would smoothen the harshness associated with these isolated data points and aid to reduce the number of outlier's altogether. The results for each asset class are provided.

4.1.3.1 Earthworks

The result for Earthworks was a valid sample of 126 results for the cash flow analysis, and 153 results for the profitability analysis. It is clear that the sample cash flow data was not entirely complete for the analysis, with 27 missing results. This amounts to 17% of the sample, and is attributed to incomplete data from the subject case – indicative of reporting shortfalls.

Table 4.1.3.1.1: Earthworks Return Data Results

No.	Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)	
	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return
1	60%	52%	15%	36%
2	61%	55%	16%	36%
3	41%	51%	16%	36%
4	19%	47%	17%	36%
5	-5%	40%	19%	34%
6	-3%	32%	23%	39%
7	10%	29%	28%	37%
8	3%	24%	37%	37%
9	-9%	19%	35%	35%
10	-57%	17%	18%	84%
11	-100%	15%	18%	31%
12	-57%	15%	21%	23%
13	-57%	14%	23%	21%
14	-100%	14%	21%	18%
15	-100%	13%	10%	29%
16	6%	-18%	10%	18%
17	-21%	-18%	10%	23%
18	50%	-23%	10%	20%
19	48%	27%	12%	17%
20	70%	40%	12%	17%
21	79%	50%	15%	15%
22	55%	53%	10%	74%
23	33%	49%	13%	36%
24	-25%	44%	12%	24%
25	81%	48%	16%	27%
26	49%	50%	27%	30%
27	-21%	46%	24%	30%
28	14%	45%	25%	28%
29	-9%	44%	18%	66%
30	-100%	41%	18%	41%
31	-78%	40%	18%	19%

32	-1%	0%	17%	6%
33	9%	3%	17%	7%
34	-33%	-4%	17%	3%
35	-53%	-13%	14%	6%
36	-38%	-18%	15%	8%
37	-2%	-18%	14%	10%
38	-55%	-20%	14%	8%
39	-71%	-22%	13%	9%
40	-70%	-23%	13%	9%
41	-47%	-24%	12%	11%
42	-14%	-23%	11%	8%
43	75%	-16%	11%	10%
44	45%	-13%	7%	8%
45	-45%	-15%	9%	9%
46	-100%	-15%	7%	7%
47	178%	228%	18%	32%
48	-27%	-33%	18%	19%
49	-63%	-35%	20%	12%
50	-100%	-38%	20%	12%
51	-100%	-42%	7%	3%
52	-100%	-42%	8%	0%
53	-100%	-42%	4%	-4%
54	55%	71%	-19%	-17%
55	-6%	5%	-19%	-17%
56	20%	11%	23%	40%
57	-11%	2%	24%	17%
58	-41%	-15%	27%	40%
59	-70%	-31%	30%	43%
60	-50%	-37%	30%	42%
61	9%	-30%	39%	44%
62	12%	-23%	40%	43%
63	-100%	-27%	38%	32%
64	-100%	-29%	35%	37%
65	460%	391%	35%	35%
66	24%	162%	16%	44%
67	-63%	4%	33%	37%
68	-58%	-31%	27%	34%
69	-7%	-21%	26%	33%
70	69%	-12%	20%	68%
71	67%	-4%	16%	16%
72	57%	0%	17%	28%
73	4%	-6%	8%	-47%
74	54%	31%	12%	4%
75	49%	34%	12%	21%
76	36%	34%	18%	20%
77	102%	72%	17%	17%
78	104%	78%	12%	8%
79	79%	82%	18%	6%
80	35%	37%	18%	18%
81	22%	26%	12%	32%
82	1%	16%	12%	39%
83	-6%	8%	12%	19%
84	-9%	6%	12%	29%
85	-42%	0%	15%	16%
86	-47%	-4%	3%	11%
87	-84%	-11%	3%	10%
88	38%	57%	12%	10%
89	44%	46%	12%	11%
90	56%	50%	12%	10%
91	13%	16%	12%	17%
92	29%	23%	14%	19%
93	33%	26%	15%	19%
94	25%	26%	15%	19%
95	4%	12%	15%	19%
96	-9%	1%	12%	59%
97	87%	12%	24%	9%
98	-26%	5%	21%	15%
99	-30%	-3%	17%	20%
100	-30%	-8%	16%	22%
101	-20%	-10%	15%	20%
102	1%	-8%	14%	18%
103	11%	-5%	12%	14%
104	-4%	-4%	11%	13%
105	-16%	-5%	11%	12%
106	-4%	-5%	16%	16%
107	-5%	-5%	15%	16%
108	12%	-4%	12%	18%
109	12%	-3%	9%	8%
110	9%	-2%	9%	13%
111	-5%	-2%	3%	-4%
112	35%	-1%	-1%	-8%
113	62%	0%	-2%	-10%
114	-41%	0%	-15%	-14%

115	-15%	3%	-9%	-19%
116	75%	35%	-13%	-14%
117	79%	49%	-15%	-12%
118	69%	52%	-15%	-12%
119	28%	48%	-29%	-29%
120	241%	83%	-30%	-30%
121	244%	112%	-30%	-30%
122	59%	102%	31%	28%
123	63%	98%	30%	30%
124	21%	82%	30%	29%
125	4%	77%	27%	28%
126	-9%	75%	25%	22%
127	-	-	24%	20%
128	-	-	24%	20%
129	-	-	23%	19%
130	-	-	10%	1%
131	-	-	10%	-5%
132	-	-	9%	-11%
133	-	-	5%	-16%
134	-	-	4%	-12%
135	-	-	3%	1%
136	-	-	2%	2%
137	-	-	3%	3%
138	-	-	16%	33%
139	-	-	13%	42%
140	-	-	18%	42%
141	-	-	18%	42%
142	-	-	18%	40%
143	-	-	16%	35%
144	-	-	18%	33%
145	-	-	20%	31%
146	-	-	21%	28%
147	-	-	23%	26%
148	-	-	23%	24%
149	-	-	22%	22%
150	-	-	22%	22%
151	-	-	22%	22%
152	-	-	20%	22%
153	-	-	21%	21%

**Key: TTD – Total To Date*

Table 4.1.3.1.2: Codebook – Earthworks

Standard Attributes	Label	Earthworks (Month Only - Net Cash Return)	Earthworks (TTD - Net Cash Return)	Earthworks (Final Estimated - Real Return)	Earthworks (TTD - Real Return)
N	Valid	126	126	153	153
	Missing	27	27	0	0
Central Tendency and Dispersion	Mean	7.37%	20.20%	14.44%	18.77%
	Standard Deviation	74.23%	52.90%	12.15%	19.62%
	Percentile 25	-38.49%	-11.06%	10.92%	8.73%
	Percentile 50	1.93%	6.72%	15.22%	18.72%
	Percentile 75	44.73%	44.26%	20.57%	31.61%

**Key: TTD – Total To Date*

Mean returns range from 7.37% to 20.20%, with a standard deviation range of 12.15% to 74.23%. Cash flow return measures were noted to be significantly more volatile than the profitability return measure. This is confirmed by the standard deviations of 52.90% and 74.23% for cash flow measures, compared with 12.15% and 19.62% for profitability measures.

4.1.3.2 Structures

The result for Structures was a valid sample of 32 results for the cash flow analysis, and 38 results for the profitability analysis. As previously noted, this is a considerably smaller sample size than the other asset classes. Here, six missing results are identified, again in the cash flow analysis. This amounts to 16% of the sample, and attributed to poor reporting practices.

Table 4.1.3.2.1: Structures Return Data Results

No.	Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)	
	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return
1	103%	108%	6%	96%
2	66%	30%	6%	46%
3	25%	51%	6%	46%
4	-41%	34%	6%	34%
5	7%	26%	7%	12%
6	12%	21%	7%	13%
7	10%	19%	7%	11%
8	-4%	15%	6%	20%
9	0%	12%	6%	21%
10	-19%	9%	6%	17%
11	13%	10%	7%	16%
12	-22%	9%	7%	13%
13	-33%	7%	7%	16%
14	32%	8%	7%	12%
15	17%	8%	7%	10%
16	0%	8%	8%	10%
17	-3%	7%	8%	10%
18	-100%	3%	5%	5%
19	-100%	2%	4%	5%
20	446%	181%	3%	4%
21	415%	203%	14%	51%
22	7%	121%	24%	42%
23	-11%	87%	20%	36%
24	1%	71%	25%	35%
25	16%	58%	20%	27%
26	49%	55%	21%	28%
27	63%	56%	24%	27%
28	15%	54%	23%	25%
29	25%	47%	20%	20%
30	-8%	23%	20%	20%
31	-50%	16%	19%	19%
32	-100%	13%	23%	23%
33	-	-	16%	-13%
34	-	-	10%	2%
35	-	-	0%	-5%
36	-	-	5%	6%
37	-	-	3%	3%
38	-	-	1%	1%

**Key: TTD – Total To Date*

Table 4.1.3.2.2: Codebook - Structures

Standard Attributes	Label	Structures (Month Only - Net Cash Return)	Structures (TTD - Net Cash Return)	Structures (Final Estimated - Real Return)	Structures (TTD - Real Return)
N	Valid	32	32	38	38
	Missing	6	6	0	0
Central Tendency and Dispersion	Mean	26.00%	42.83%	10.79%	20.11%
	Standard Deviation	115.08%	49.77%	7.58%	19.20%
	Percentile 25	-14.85%	9.23%	5.82%	9.84%
	Percentile 50	7.06%	22.15%	6.75%	16.66%
	Percentile 75	25.24%	55.96%	19.86%	27.05%

**Key: TTD – Total To Date*

Mean returns range from 10.79% to 42.83%, with standard deviation range of 7.58% to 115.08%. Again, cash flow analysis was seen to be significantly more volatile than profitability reporting - Standard deviations were 49.77% and 115.08% for cash flow analysis, compared with 7.58% and 19.20% for profitability analysis.

4.1.3.3 Infrastructure

The result for Infrastructure was a valid sample of 80 results for the cash flow analysis, and 54 results for the profitability analysis. Here, 26 missing results are identified, all of which were noted in the cash flow analysis. This amounts to 33% of the sample, attributed again to poor reporting practices.

Table 4.1.3.3.1: Infrastructure Return Data Results

No.	Cash Flow: Net Cash Return (Revenue vs. Cost)		A-form: Real Return (Allowable vs. Cost)	
	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return
1	255%	275%	7%	82%
2	15%	49%	8%	48%
3	9%	20%	8%	20%
4	6%	14%	7%	18%
5	0%	8%	7%	6%
6	11%	9%	8%	8%
7	39%	14%	8%	9%
8	56%	21%	8%	17%
9	28%	23%	7%	20%
10	13%	21%	9%	22%
11	12%	20%	11%	20%
12	2%	17%	17%	19%
13	13%	16%	16%	17%
14	21%	16%	15%	18%
15	1%	15%	17%	18%
16	12%	15%	18%	20%
17	4%	14%	16%	16%
18	-23%	14%	15%	16%
19	-22%	14%	16%	16%
20	27%	14%	14%	15%
21	-2%	14%	14%	15%
22	12%	14%	14%	15%
23	-4%	14%	14%	14%
24	-18%	13%	14%	15%
25	-18%	13%	14%	15%
26	-100%	13%	14%	15%
27	146%	147%	14%	15%
28	-72%	-60%	14%	15%

29	68%	-34%	14%	14%
30	-2%	-22%	15%	15%
31	-33%	-24%	14%	15%
32	-21%	-23%	15%	15%
33	-17%	-22%	15%	15%
34	-39%	-24%	12%	66%
35	90%	115%	12%	66%
36	-5%	43%	7%	-6%
37	-38%	12%	4%	-4%
38	-48%	-3%	-10%	-20%
39	-58%	-14%	-8%	-16%
40	33%	-9%	-3%	-14%
41	123%	11%	-8%	-17%
42	60%	19%	-7%	-20%
43	-27%	15%	-8%	-20%
44	-75%	10%	-8%	-19%
45	-92%	6%	-8%	-17%
46	64%	8%	-8%	-17%
47	107%	10%	-10%	-19%
48	33%	40%	17%	10%
49	22%	29%	8%	11%
50	8%	22%	12%	14%
51	7%	17%	8%	10%
52	24%	18%	7%	8%
53	-2%	15%	7%	8%
54	-9%	11%	5%	9%
55	-	-	5%	4%
56	-	-	3%	3%
57	-	-	4%	3%
58	-	-	5%	4%
59	-	-	18%	28%
60	-	-	13%	22%
61	-	-	13%	22%
62	-	-	15%	21%
63	-	-	19%	21%
64	-	-	16%	23%
65	-	-	18%	24%
66	-	-	19%	24%
67	-	-	20%	23%
68	-	-	20%	22%
69	-	-	20%	21%
70	-	-	22%	24%
71	-	-	23%	23%
72	-	-	14%	93%
73	-	-	15%	82%
74	-	-	12%	60%
75	-	-	12%	11%
76	-	-	12%	10%
77	-	-	11%	18%
78	-	-	12%	20%
79	-	-	14%	22%
80	-	-	15%	22%

**Key: TTD – Total To Date*

Table 4.1.3.3.2: Codebook – Infrastructure

Standard Attributes	Label	Infrastructure Month Only Net Cash Return	Infrastructure TTD Net Cash Return	Infrastructure Final Estimated Real Return	Infrastructure TTD Real Return
N	Valid	54	54	80	80
	Missing	26	26	0	0
Central Tendency and Dispersion	Mean	11.04%	18.59%	10.04%	16.01%
	Standard Deviation	58.28%	46.55%	8.08%	21.64%
	Percentile 25	-18.34%	8.86%	7.20%	8.69%
	Percentile 50	6.55%	14.02%	12.49%	14.95%
	Percentile 75	26.94%	18.64%	15.03%	21.50%

**Key: TTD – Total To Date*

Mean returns range from 10.04% to 18.59%, with a standard deviation range of 8.08% to 58.28%. Cash flow analysis was also seen to be significantly more volatile than profitability reporting - Standard deviations were 58.28% and 46.55% for cash flow analysis, compared with 8.08% and 21.64% for profitability analysis.

4.2 Statistical Analysis Results

The results of the statistical analysis are present here. The data has been aggregated from actual construction project cost reports. This section focuses more critically on the statistical testing methods, compared to the previous section, which assessed the data from an asset level perspective. The analysis follows a first principal's statistical process, starting with summarizing the data set using a Descriptive Statistics Table. This followed by the Frequency Distributions, Testing for Normality, and finally the Analysis of Variance tests. Ultimately, the aim is to assess the nature of the data sets before following on with the Portfolio Management Theory Analysis. The structure remains consistent with the above analysis, and define the Asset Classes by Return Type. This translates to 3 asset classes, and 4 return measure, totalling 12 reporting fields.

4.2.1 Descriptive Statistics

The descriptive statistics provides a high-level summary of the results of the analysis. Here, the key statistics are provided, including (a) Number of results, (b) Minimum, (c) Maximum, (d) Mean, (e) Standard deviation, and (f) Skewness and Kurtosis. Cash flow based returns are characterised by significantly higher maximum returns, and significantly lower returns. This is the first indication that cash flow returns have excessive volatility. This is confirmed by their standard deviations, which by comparison to real returns are significantly higher. Skewness and Kurtosis are also recording higher measures for cash flow related returns.

Table 4.2.1: Descriptive Statistics

Descriptive Statistics									
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Earthworks (Month Only - Net Cash Return)	126	-100.00%	460.33%	7.3685%	74.23056%	2.205	0.216	11.157	0.428
Earthworks (TTD - Net Cash Return)	126	-42.07%	390.95%	20.1987%	52.90289%	3.464	0.216	20.065	0.428
Earthworks (Final Estimated - Real Return)	153	-29.80%	40.39%	14.4422%	12.14545%	-1.236	0.196	3.231	0.390
Earthworks (TTD - Real Return)	153	-47.37%	84.40%	18.7704%	19.62355%	-0.124	0.196	1.445	0.390
Structures (Month Only - Net Cash Return)	32	-100.00%	446.16%	26.0030%	115.08041%	2.846	0.414	8.926	0.809
Structures (TTD - Net Cash Return)	32	1.93%	202.94%	42.8302%	49.77474%	1.955	0.414	3.706	0.809
Structures (Final Estimated - Real Return)	38	0.31%	24.59%	10.7922%	7.57900%	0.677	0.383	-1.147	0.750
Structures (TTD - Real Return)	38	-13.13%	95.84%	20.1104%	19.20405%	1.744	0.383	5.454	0.750
Infrastructure (Month Only - Net Cash Return)	54	-100.00%	254.80%	11.0372%	58.28490%	1.538	0.325	5.242	0.639
Infrastructure (TTD - Net Cash Return)	54	-59.81%	275.09%	18.5912%	46.55496%	3.672	0.325	18.217	0.639
Infrastructure (Final Estimated - Real Return)	80	-10.31%	22.58%	10.0405%	8.07890%	-1.159	0.269	0.726	0.532
Infrastructure (TTD - Real Return)	80	-19.98%	93.43%	16.0082%	21.64015%	1.275	0.269	3.410	0.532

4.2.2 Frequency Distributions

Frequency distribution graphs are used to illustrate the number of occurrences for which the sample data set achieve a certain return score. They highlight where the bulk of the data points are located, but also where there are outliers. The shape of the graph also indicates concentration of the data, which is usually a good proxy for determining the mean.

4.2.2.1: Earthworks

Month only Net Cash Returns has mean return of 7.37%. It has a high standard deviation of 74.231%. This suggests that the data set is volatile, as well as a high probability of outliers. Taking a more progressive total to date view, these sensitivities are partly removed. The mean return increases to 20.20%, whilst standard deviation decreases to 52.90%. This implies that the data becomes less volatile on a total to date basis. However, it cannot be ignored – Month Only Returns have excessive volatility. The data set becomes progressively more stable at a total to date real returns level. The mean return sharpens to 18.77%, but standard deviation improves significantly to 19.62%. There are also noticeably fewer outliers. Finally, looking at Final Estimated Returns, it is note that the mean return stabilises at 14.44%, with a standard deviation of 12.145%. This is ultimately the most stable data set for this asset class.

Figure 4.2.2.1.1: Earthworks – Month Only Net Cash Return

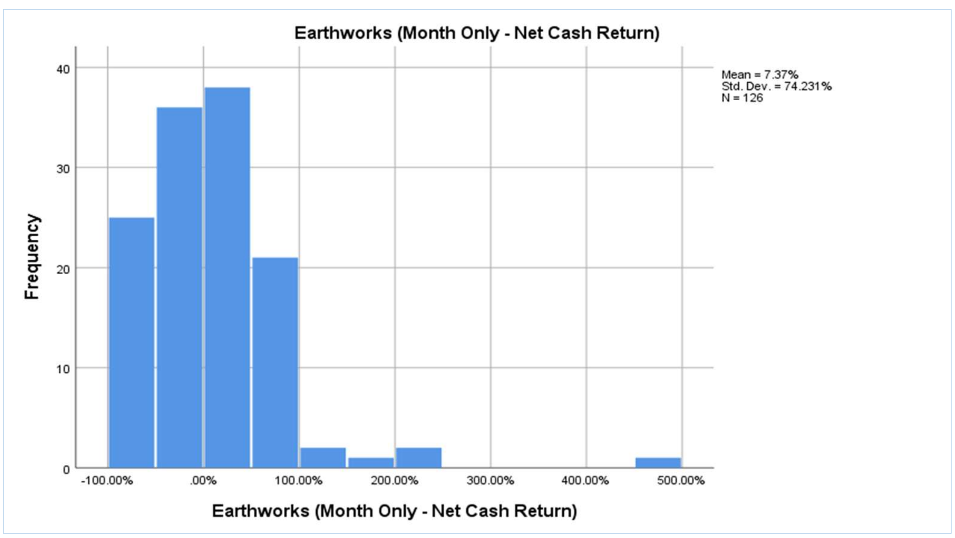


Figure 4.2.2.1.2: Earthworks – Total to Date Net Cash Return

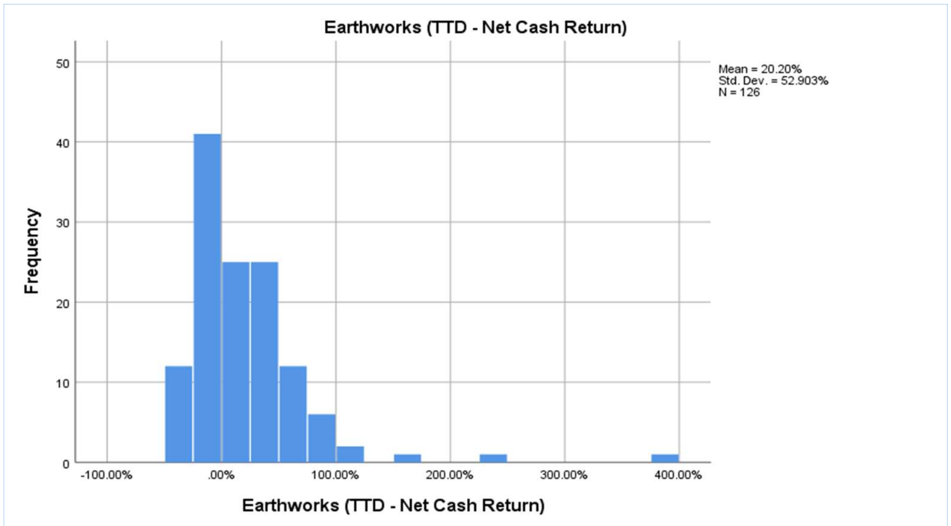


Figure 4.2.2.1.3: Earthworks – Total to Date Real Return

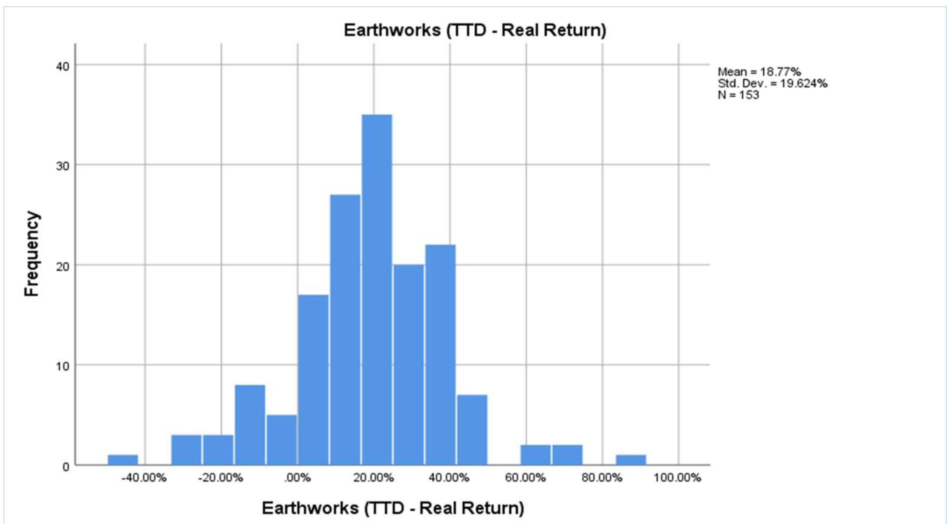
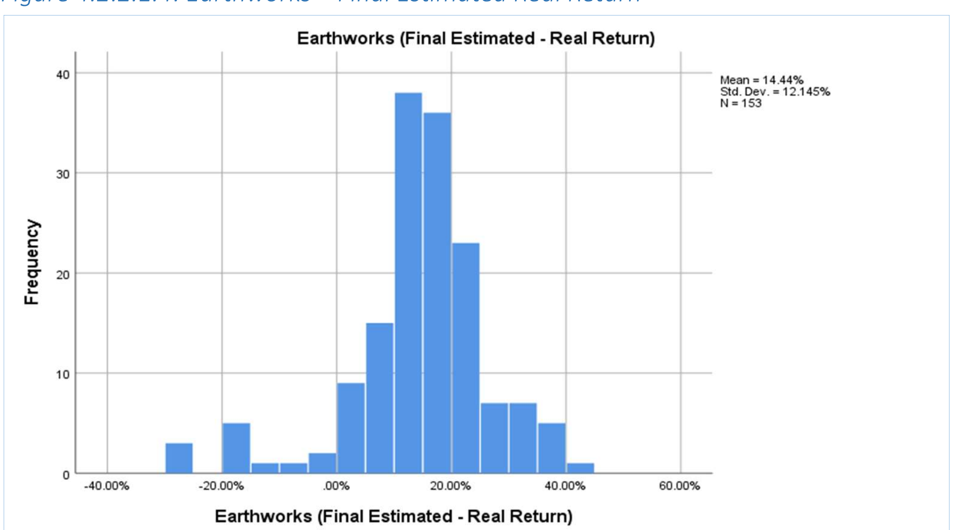


Figure 4.2.2.1.4: Earthworks – Final Estimated Real Return



4.2.2.2: Structures

Month only Net Cash Return has mean return of 26.00% for the Structures asset, with a high standard deviation of 115.08%. This suggests that the data set is also volatile, and has a high probability of outliers. The total to date view has a mean return of 42.83%, whilst its standard deviation decreases to 49.775%. This implies that the data becomes less volatile on a total to date basis. The data set becomes further more stable looking at total to date real returns level. The mean return sharpens to 20.11%, and the standard deviation improves significantly to 19.204%. There are also noticeably fewer outliers. Finally, looking at Final Estimated Returns, it is noted that the mean return stabilises at 10.79%, with a standard deviation of 7.597%. This is ultimately the most stable data set for this asset class. Critically, the data set is smaller by comparison to Earthworks and Infrastructure. The effect is such that the results are likely to be significantly more sensitive to any outliers in the sample data set. Ultimately, the Final Estimated Returns prove to be the more stable data set.

Figure 4.3.2.2.1: Structures – Month Only Net Cash Return

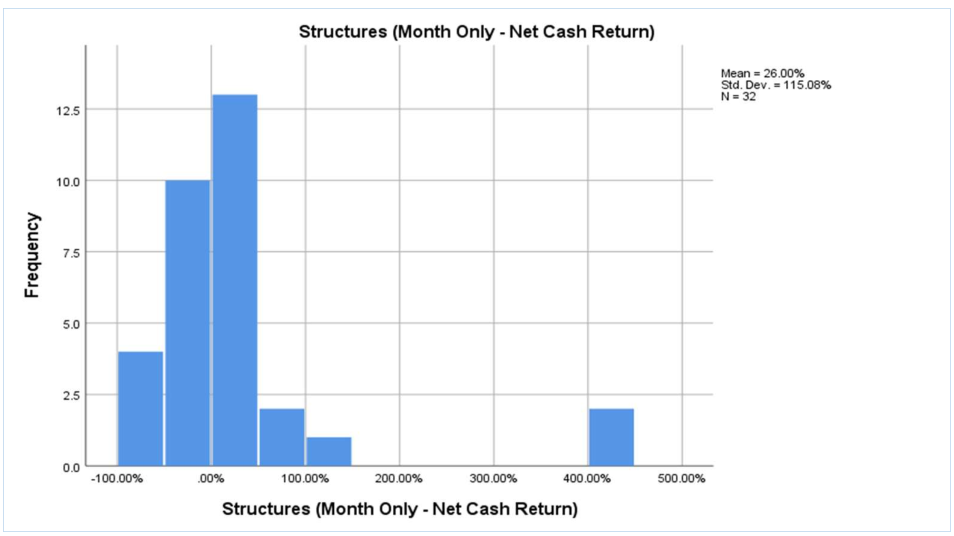


Figure 4.2.2.2.2: Structures – Total to Date Net Cash Return

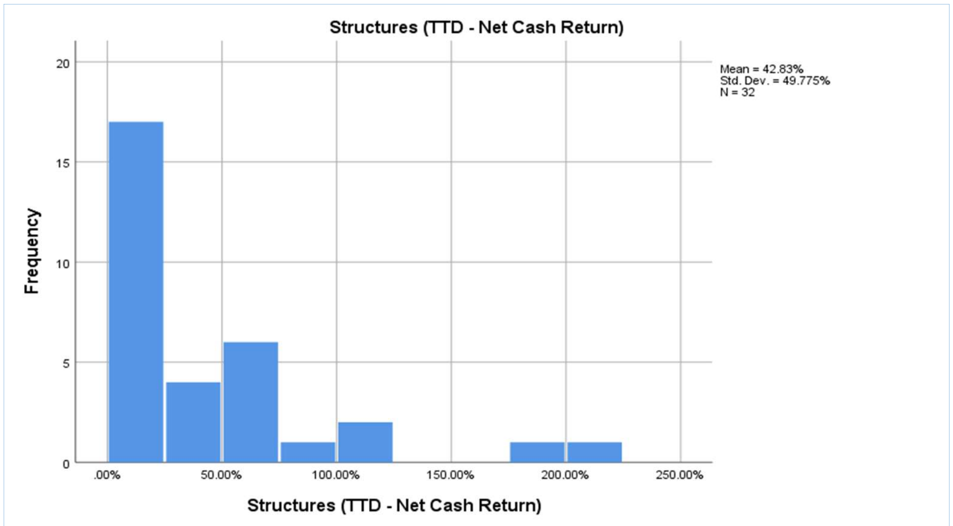


Figure 4.2.2.2.3: Structures – Total to Date Real Return

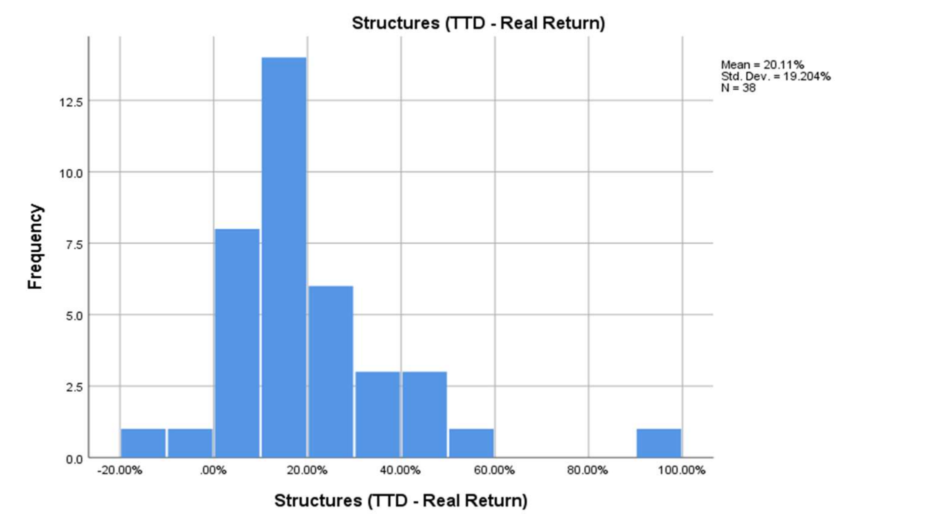
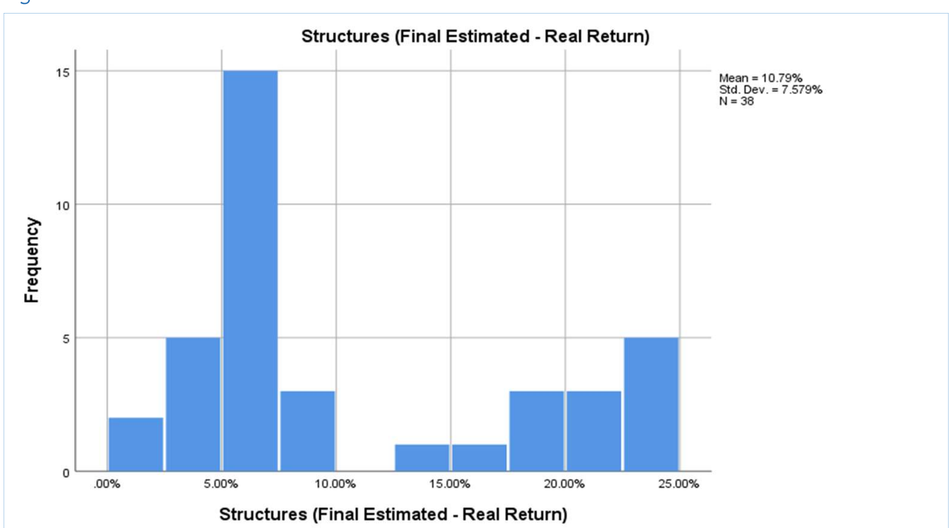


Figure 4.2.2.2.4: Structures – Final Estimated Real Return



4.2.2.3: Infrastructure

Month only Net Cash Return has mean return of 11.04% for the Infrastructure asset, with a standard deviation of 58.285%. The total to date view has a mean return of 18.56%, whilst its standard deviation decreases to 46.555%. This implies that the data becomes less volatile on a total to date basis. The data set becomes further more stable when looking at total to date real returns. The mean return sharpens to 16.01%, and the standard deviation improves significantly to 21.64%. Finally, looking at Final Estimated Returns, it is noted that the mean return stabilises at 10.04%, with a standard deviation of 8.074%. This is ultimately the most stable data set for this asset class.

Figure 4.2.2.3.1: Infrastructure – Month Only Net Cash Return

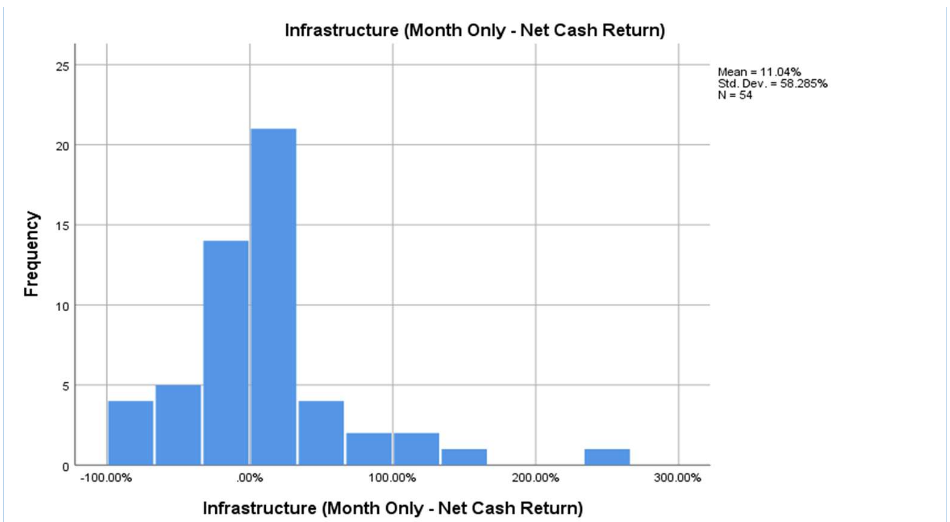


Figure 4.2.2.3.2: Infrastructure – Total to Date Net Cash Return

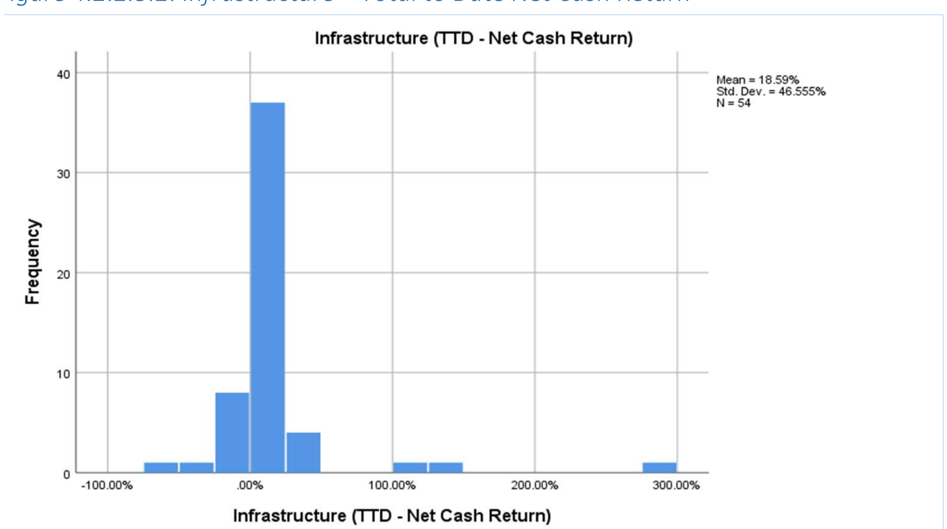


Figure 4.2.2.3.3: Infrastructure – Total to Date Real Return

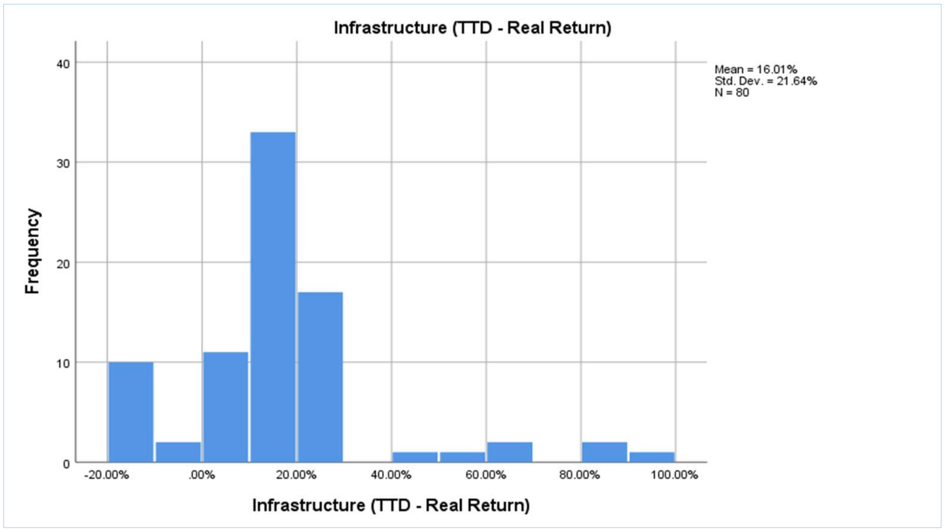
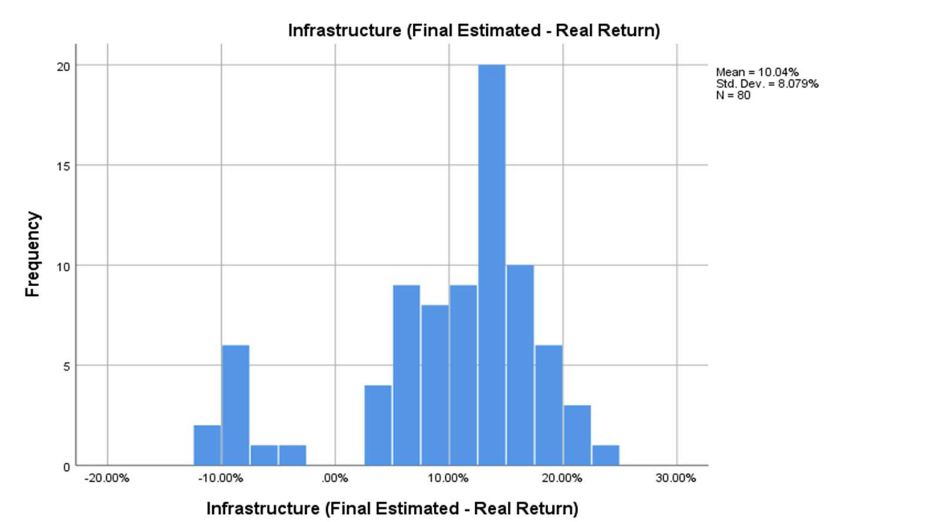


Figure 4.2.2.3.4: Infrastructure – Final Estimated Real Return



4.2.3 Testing for Normality

Testing for normality is critical to the subsequent stages of the analysis. Here, two methods were used, (a) a theoretical statistical check of the underlying data, and (b) a graphical depiction of the results to visually assess normality. The data here is categorised by return type rather than asset type. Two statistical techniques are used namely the Kolmogorov-Smirnoff Test (K-S) and the Shapiro-Wilk Test (S-W). In doing so, reliance is placed on the p-value being $p > 0.05$ for a normal distribution. The graphical techniques used include a histogram and Q-Q Plot, the results of which are presented.

4.2.3.1 Case Processing Summary

Here, the summary of the data statistics are provided. The purpose of this is to ensure that the data is correctly captured. Here, it is confirmed that the number of samples add up correctly to 212 and 271 for cash flow and profitability returns respectively.

Table 4.2.3.1.1: Summary of Cases

	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Month Only - Net Cash Return	212	78.2%	59	21.8%	271	100.0%
TTD - Net Cash Return	212	78.2%	59	21.8%	271	100.0%
Final Estimated - Real Return	271	100.0%	0	0.0%	271	100.0%
TTD - Real Return	271	100.0%	0	0.0%	271	100.0%

**Key: TTD – Total To Date*

The descriptive results of the analysis are also detailed for each of the return types. Month Only Returns are noted as highly volatile irrespective of the asset class. The variance and standard deviations are both the highest of all the return types here. By comparison, Final Estimated Returns are seen to be far more stable. Here, variance and standard deviations are significantly less than Month Only Returns. In fact, they are the lowest of all the return types. This further motivates the use of this data set in the subsequent analyses. The more relevant information is highlighted in the Table 4.2.3.1.2. This is not to say that the other data is not important, but for the purpose of the investigation, the highlighted figures are critical. Skewness and Kurtosis are often used to assess normality in data sets. However, these are highly dependent on the sample size and are often substituted with more comprehensive tests for normality.

Table 4.2.3.1.2: Descriptive Summaries for Normality Test

			Statistic	Std. Error
Month Only - Net Cash Return	Mean		11.1157%	5.36646%
	95% Confidence Interval for Mean	Lower Bound	0.5370%	
		Upper Bound	21.6945%	
	5% Trimmed Mean		3.8747%	
	Median		3.9618%	
	Variance		6105.356	
	Std. Deviation		78.13678%	
	Minimum		-100.00%	
	Maximum		460.33%	
	Range		560.33%	
	Interquartile Range		60.78%	
	Skewness		2.640	0.167
	Kurtosis		12.307	0.333

TTD - Net Cash Return **Key: TTD – Total To Date*	Mean		23.2053%	3.52596%
	95% Confidence Interval for Mean	Lower Bound	16.2547%	
		Upper Bound	30.1559%	
	5% Trimmed Mean		17.4576%	
	Median		13.8775%	
	Variance		2635.669	
	Std. Deviation		51.33876%	
	Minimum		-59.81%	
	Maximum		390.95%	
	Range		450.77%	
	Interquartile Range		44.05%	
	Skewness		3.147	0.167
	Kurtosis		15.984	0.333

Final Estimated - Real Return	Mean		12.6310%	0.64954%
	95% Confidence Interval for Mean	Lower Bound	11.3522%	
		Upper Bound	13.9098%	
	5% Trimmed Mean		13.0885%	
	Median		14.0802%	
	Variance		114.335	
	Std. Deviation		10.69278%	
	Minimum		-29.80%	
	Maximum		40.39%	
	Range		70.19%	
	Interquartile Range		10.75%	
	Skewness		-0.914	0.148
	Kurtosis		2.796	0.295

TTD - Real Return **Key: TTD – Total To Date*	Mean		18.1429%	1.22469%
	95% Confidence Interval for Mean	Lower Bound	15.7317%	
		Upper Bound	20.5540%	
	5% Trimmed Mean		17.4486%	
	Median		17.5430%	
	Variance		406.465	
	Std. Deviation		20.16097%	
	Minimum		-47.37%	
	Maximum		95.84%	
	Range		143.21%	
	Interquartile Range		19.20%	
	Skewness		0.565	0.148
	Kurtosis		2.370	0.295

4.2.3.2 Results of Normality Test

The results of the statistical tests for normality are concerning. Both the Kolmogorov-Smirnov test and the Shapiro-Wilk test reported significant results (Sig. = .000). Therefore, taking this conclusion, the null hypothesis that the data comes from a normal distribution for each one of the return types is rejected. Reverting to graphical support to check normality in the data. Critically, it is expected that the data be non-normal, but the data may be ‘near-normal’.

Table 4.2.3.2: Results of Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Month Only - Net Cash Return	0.136	212	0.000	0.781	212	0.000
TTD - Net Cash Return	0.165	212	0.000	0.748	212	0.000
Final Estimated - Real Return	0.099	271	0.000	0.935	271	0.000
TTD - Real Return	0.108	271	0.000	0.947	271	0.000
a. Lilliefors Significance Correction						

**Key: TTD – Total To Date*

4.2.3.3 Graphs

Graphical tools are used to further establish whether there is a level of normality in the data set. A non-normal result is expected, as its unlikely to achieve a perfect normal distribution with raw construction return data. To this end, two graphical tools are used, (a) histogram, and (b) a Q-Q Plot.

(i) Month Only - Net Cash Return

The histogram and Q-Q Plot confirm that the data set for Month Only Returns is non-normal. There are outliers noted on the histogram, which create a positive skew to the data. These outliers are further highlighted by the Q-Q Plot.

Figure 4.2.3.3.i.a: Histogram

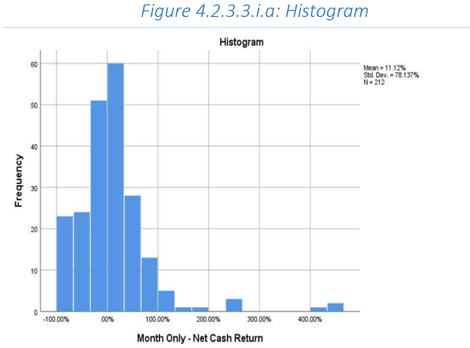
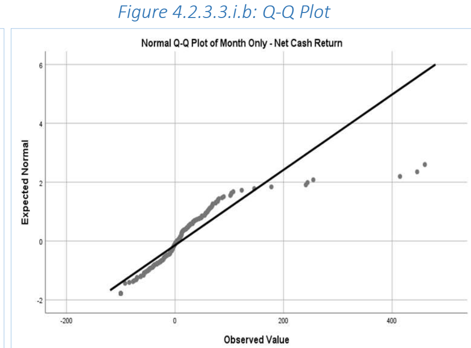


Figure 4.2.3.3.i.b: Q-Q Plot



(ii) TTD – Net Cash Return

A similar result is noted for Total to Date Returns. The histogram and Q-Q Plot illustrate a non-normal distribution, with significant skew resulting from the outliers that exist in the data set.

Figure 4.2.3.3.ii.a: Histogram

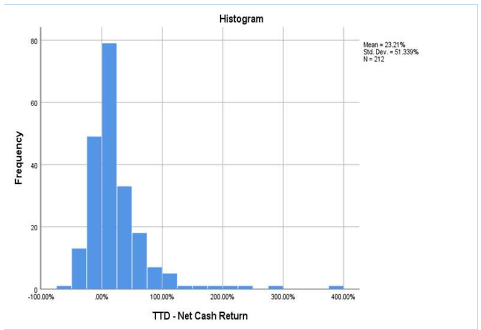
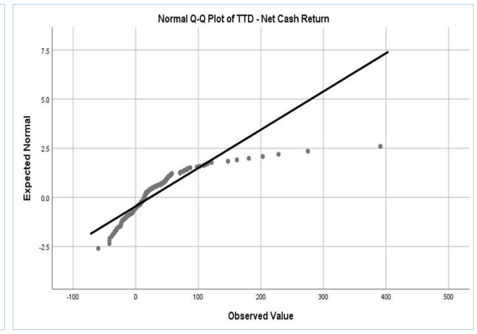


Figure 4.2.3.3.ii.b: Q-Q Plot



(iii) Final Estimated – Real Return

The distribution here may be considered non-normal. However, in the context of the data sourced, and by comparison to the other asset classes, the result is arguably 'near-normal'. With exception to a few outliers, there is only minor skewness to the histogram - This can be overlooked. The Q-Q Plot is also by no means representative of a perfectly normal distribution. However, it can be concluded that much of the points are closer to the line that would indicate normality. On this basis, the distribution is regarded as 'near-normal'.

Figure 4.2.3.3.iii.a: Histogram

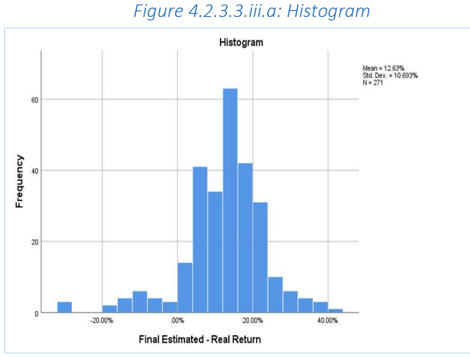
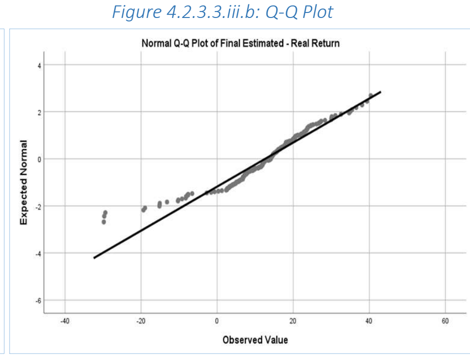


Figure 4.2.3.3.iii.b: Q-Q Plot



(iv) TTD – Real Return

Similarly, the data set relating to Total to Date Real Returns would be regarded as 'near-normal'. Technically speaking, it is by no means a true normally distributed data set. By comparison however, this data set is considered to be 'near-normal', overlooking the outliers noted on the Q-Q Plot.

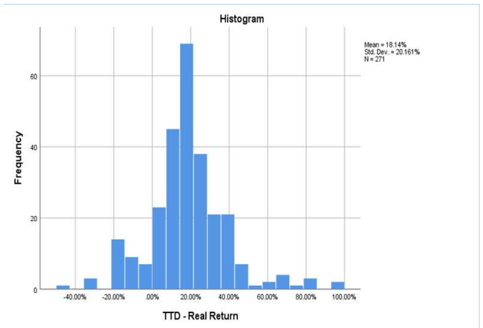


Figure 4.2.3.3.iv.a: Histogram

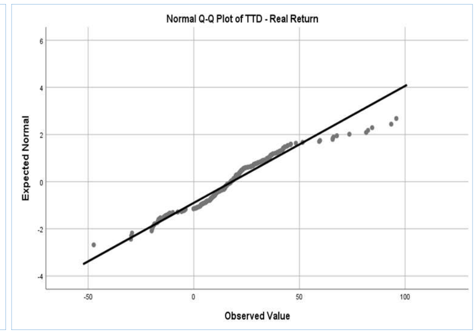


Figure 4.2.3.3.iv.b: Q-Q Plot

4.2.4 ANOVA

Now that normality and non-normality has been established in the data sets, the analysis of variance can be completed. Due to the nature of the data set, a T-test will not suffice. There are more than two groups, and as such, an ANOVA analysis is required. An ANOVA tests the variance between groups, using a null hypothesis that states that all variances are equal. If the null hypothesis is rejected, the ANOVA test will not however tell where these differences occur. A post-hoc test will need to be conducted. The results are presented.

4.2.4.1 Test of Homogeneity of Variances

Comparing the mean returns of more than two groups, requires an ANOVA analysis. The ANOVA analysis makes the homogeneity assumption – the population's variances are all equal. Typically, one would ignore this assumption if the groups were of equal size, however, since the sample size differs homogeneity in the data set first needs to be tested. This done using a Levine Test – Testing of Homogeneity of Variance. The results are presented in Table 4.2.4.1. Critically, in order for a Levine's Test to produce a significant result, Sig < 0.05. In this case, we would reject the hypothesis that variances are equal, as we would have violated the homogeneity of variance assumption needed for an ANOVA.

Table 4.2.4.1: Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Month Only - Net Cash Return	Based on Mean	1.690	2	209	0.187
	Based on Median	1.106	2	209	0.333
	Based on Median and with adjusted df	1.106	2	138.960	0.334
	Based on trimmed mean	1.125	2	209	0.327
TTD - Net Cash Return	Based on Mean	2.346	2	209	0.098
	Based on Median	1.885	2	209	0.154
	Based on Median and with adjusted df	1.885	2	208.927	0.154
	Based on trimmed mean	2.231	2	209	0.110
	Based on Mean	1.950	2	268	0.144

Final Estimated - Real Return	Based on Median	2.791	2	268	0.063
	Based on Median and with adjusted df	2.791	2	238.810	0.063
	Based on trimmed mean	2.015	2	268	0.135
TTD - Real Return	Based on Mean	0.238	2	268	0.788
	Based on Median	0.279	2	268	0.757
	Based on Median and with adjusted df	0.279	2	252.148	0.757
	Based on trimmed mean	0.249	2	268	0.780

*Key: TTD – Total To Date

4.2.4.2 Analysis of Variance

Having satisfied the homogeneity of variance assumption, the ANOVA test can continue. The aim of this is to establish whether there is a significant difference between the group means. This null hypothesis is based on the Sig < 0.05, in which case the null hypothesis would be rejected, and conclude that there is a significant difference. The results of the ANOVA test are tabulated in Table 4.2.4.2. Critically, we look to the Sig column for this confirmation. The result is such that Final Estimated Real Returns produced a significant result (Sig. < 0.006).

Table 4.2.4.2: Analysis of Variance

		Sum of Squares	df	Mean Square	F	Sig.
Month Only - Net Cash Return	Between Groups	8861.746	2	4430.873	0.724	0.486
	Within Groups	1279368.406	209	6121.380		
	Total	1288230.152	211			
TTD - Net Cash Return	Between Groups	14613.024	2	7306.512	2.820	0.062
	Within Groups	541513.057	209	2590.972		
	Total	556126.081	211			
Final Estimated - Real Return	Between Groups	1167.225	2	583.612	5.266	0.006
	Within Groups	29703.355	268	110.833		
	Total	30870.579	270			
TTD - Real Return	Between Groups	571.912	2	285.956	0.702	0.497
	Within Groups	109173.529	268	407.364		
	Total	109745.441	270			

*Key: TTD – Total To Date

4.2.4.3 Robust Tests of Equality of Means

The result produced, and highlighted in Table 4.2.4.2, requires a further check F-test, using both the Brown-Forsythe method and Welche method. Here, an adjusted F-ratio is determined, to confirm whether this result is in fact correct. The result here is that there remains a significant difference between Final Estimated Real Return and the other asset classes – Sig. < 0.004 and Sig. < 0.001 for the Welche and Brown-Forsythe methods respectively. Continuing with an appropriate Post-hoc test, in order to identify where this difference occurs.

Table 4.2.4.3: Robust Tests of Equality of Means

		Statistic[a]	df1	df2	Sig.
Month Only - Net Cash Return	Welch	0.393	2	71.534	0.676
	Brown-Forsythe	0.553	2	60.471	0.578
TTD - Net Cash Return	Welch	2.931	2	78.712	0.059
	Brown-Forsythe	3.010	2	116.486	0.053
Final Estimated - Real Return	Welch	5.819	2	114.975	0.004
	Brown-Forsythe	7.313	2	212.586	0.001
TTD - Real Return	Welch	0.657	2	96.984	0.521
	Brown-Forsythe	0.702	2	155.076	0.497
a. Asymptotically F distributed.					

**Key: TTD – Total To Date*

4.2.4.4 Post Hoc Tests - Tukey HSD

One of the limitations of the ANOVA test is that whilst it is able to tell that there is a significant difference between the groups, it is unable to tell where this difference is located. For this reason, a Tukey HSD post-hoc test is required. The results of the Tukey post-hoc analysis are provided – Table 4.2.4.4. Critically, we seek to locate a result in the 'Mean Difference' column, which is marked with an asterisk. Alternatively, we look for a significant result – i.e. Sig. < 0.05. Here, for Final Estimated Real Returns, there lies a significant difference between group 1 and 3 (Earthworks and Infrastructure).

Table 4.2.4.4: Post-hoc Test Results

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Month Only - Net Cash Return	1.00	2.00	-18.634%	15.488%	0.453	-55.19%	17.93%
		3.00	-3.669%	12.726%	0.955	-33.71%	26.37%
	2.00	1.00	18.634%	15.488%	0.453	-17.93%	55.19%
		3.00	14.966%	17.454%	0.668	-26.24%	56.17%
	3.00	1.00	3.669%	12.726%	0.955	-26.37%	33.71%
		2.00	-14.966%	17.454%	0.668	-56.17%	26.24%
TTD - Net Cash Return	1.00	2.00	-22.631%	10.076%	0.066	-46.42%	1.15%
		3.00	1.608%	8.279%	0.979	-17.94%	21.15%
	2.00	1.00	22.631%	10.076%	0.066	-1.15%	46.42%
		3.00	24.239%	11.356%	0.085	-2.57%	51.04%
	3.00	1.00	-1.608%	8.279%	0.979	-21.15%	17.94%
		2.00	-24.239%	11.356%	0.085	-51.04%	2.57%
Final Estimated - Real Return	1.00	2.00	3.650%	1.908%	0.137	-0.85%	8.15%

		3.00	4.402%*	1.453%	0.008	0.98%	7.82%
	2.00	1.00	-3.650%	1.908%	0.137	-8.15%	0.85%
		3.00	0.752%	2.074%	0.930	-4.14%	5.64%
	3.00	1.00	-4.402%*	1.453%	0.008	-7.82%	-0.98%
		2.00	-0.752%	2.074%	0.930	-5.64%	4.14%
TTD - Real Return	1.00	2.00	-1.340%	3.658%	0.929	-9.96%	7.28%
		3.00	2.762%	2.785%	0.583	-3.80%	9.33%
	2.00	1.00	1.340%	3.658%	0.929	-7.28%	9.96%
		3.00	4.102%	3.976%	0.558	-5.27%	13.47%
	3.00	1.00	-2.762%	2.785%	0.583	-9.33%	3.80%
		2.00	-4.102%	3.976%	0.558	-13.47%	5.27%
*. The mean difference is significant at the 0.05 level.							

Key: TTD – Total To Date

4.2.5 Kruskal-Wallis Test

In order to assess whether or not a non-parametric test would yield a different result, a Kruskal-Wallis test has been conducted. The test is used as a non-parametric alternative to the ANOVA test. The result here was such that there is significant differences identified in both Total to date Net Cash, and Final Estimated Real Returns. P < 0.008 and P < 0.000 respectively. This further confirms the outcomes in table 4.2.4.4 – Final Estimated Returns are significantly different to the other groups. The results are illustrated below in table 4.2.5.1.

Table 4.2.5.1: Kruskal-Wallis Test Results – Table 1

1= Earthworks, 2= Structure, 3= Infrastructure		N	Mean Rank
Month Only - Net Cash Return	1.00	126	104.48
	2.00	32	109.72
	3.00	54	109.30
	Total	212	
TTD - Net Cash Return	1.00	126	99.83
	2.00	32	137.19
	3.00	54	103.89
	Total	212	
Final Estimated - Real Return	1.00	153	154.82
	2.00	38	107.45
	3.00	80	113.58
	Total	271	
TTD - Real Return	1.00	153	143.31
	2.00	38	137.39
	3.00	80	121.36
	Total	271	

Key: TTD – Total To Date

Table 4.2.5.2: Kruskal-Wallis Test Results – Table 2

	Month Only - Net Cash Return	TTD - Net Cash Return	Final Estimated - Real Return	TTD - Real Return
Kruskal-Wallis H	0.337	9.598	20.412	4.132
df	2	2	2	2
Asymp. Sig.	0.845	0.008	0.000	0.127
a. Kruskal Wallis Test				
b. Grouping Variable: 1= Earthworks, 2= Structure, 3= Infrastructure				

**Key: TTD – Total To Date*

4.3 Portfolio Management Theory

The results of the portfolio management model, applied in the context of a portfolio of construction projects, are presented in Table 4.3.1. The analysis is structured by (a) summarising the individual asset return data, variance and standard deviation, (b) calculating the covariance matrix, and (c) the portfolio returns, variance and standard deviation. The efficient frontier is achieved by varying the asset weighting, and plotting the corresponding return and variance (risk). Critically, return variances require knowledge regarding; (a) what the asset weighting is, (b) the individual variances, and (c) all covariance's between asset classes.

4.3.1 Total Return Forecast

The results presented here are categorized by asset type rather than return type – Earthworks, Structures, and Infrastructure. The reason for this is (a) we are critically assessing these assets at a portfolio level as opposed to an asset level, and (b) we have rejected the data for return types other than Final Estimated Real Returns - a result of excessive volatility in the returns recorded. The results are summarized here.

Table 4.3.1: Total Return Forecast

	EARTHWORKS	STRUCTURES	INFRASTRUCTURE
MEAN RETURN	14.4%	10.8%	10.0%
VARIANCE	1.475%	0.574%	0.653%
STANDARD DEVIATION	12.145%	7.579%	8.079%

Interpreting the returns, it is noted that Earthworks based projects are seen to produce the highest returns, as confirmed by the mean return of 14.4%. This is followed by 10.8% and 10.0% for Structures and Infrastructure based projects respectively. Variance here is a measure of on average how different each of the data points differs from the mean – squared difference. Again, Earthworks is seen to have the higher variance, recorded as 1.475%. This followed by 0.653% and 0.574% for Infrastructure and Structures projects respectively. This suggests that Earthworks returns are significantly more volatile than both other asset classes. Standard deviation here indicates how spread out the data set is. Since it is the square of the variance, naturally the higher the variance the higher the standard deviation. As a result, it is no surprise that Earthworks has the higher standard deviation of 12.145%, followed by 8.079% and 7.579% for Infrastructure and Structures respectively. It is therefore concluded, Earthworks contracts produce not only higher returns, but also potentially lower returns. Furthermore, these returns are significantly more volatile than the other asset classes.

4.3.2 Covariance Matrix

The covariance matrix is provided in Table 4.3.2. The covariance of assets is central to Modern Portfolio Theory. The diagonals represent the variance of each asset class. The 'off-diagonals' indicate the correlation between paired assets, and therefore a measure of how changes in one asset are likely to influence changes in the other. Critically, covariance does not indicate the magnitude of the relationship. It simply indicates whether two assets are positively or negatively related.

Table 4.3.2: Covariance Matrix

	EARTHWORKS	STRUCTURES	INFRASTRUCTURE
EARTHWORKS	0.014751188	0.000198197	0.002634507
STRUCTURES	0.000198197	0.005744122	0.001750541
INFRASTRUCTURE	0.002634507	0.001750541	0.006526866

4.3.3 Portfolio Risk and Return

Finally, the total portfolio return model is outlined in Table 4.3.3. The sample table provided below is simply an indication of the model created. Using the solver function in Excel, the Portfolio Return is input, and back solved for the asset weighting. Here, it can be seen how a portfolio return of 14.44% translates to a 100% Earthworks weighting. The result further confirmed with the portfolio variance of 1.475% and the portfolio standard deviation of 12.145% - these tie back to the initial assessment of Earthworks on an individual asset level.

Table 4.3.3: Portfolio Risk and Return Model

	EARTHWORKS	STRUCTURES	INFRASTRUCTURE
WEIGHTING	100%	0%	0%
		*MUST BE EQUAL TO 100%	100%
PORTFOLIO RETURN	14.442%	*SUMPRODUCT	
PORTFOLIO VARIANCE	1.475%	*SUMPRODUCT(MMULT)	
PORTFOLIO STANDARD DEVIATION	12.145%	*SQRT	

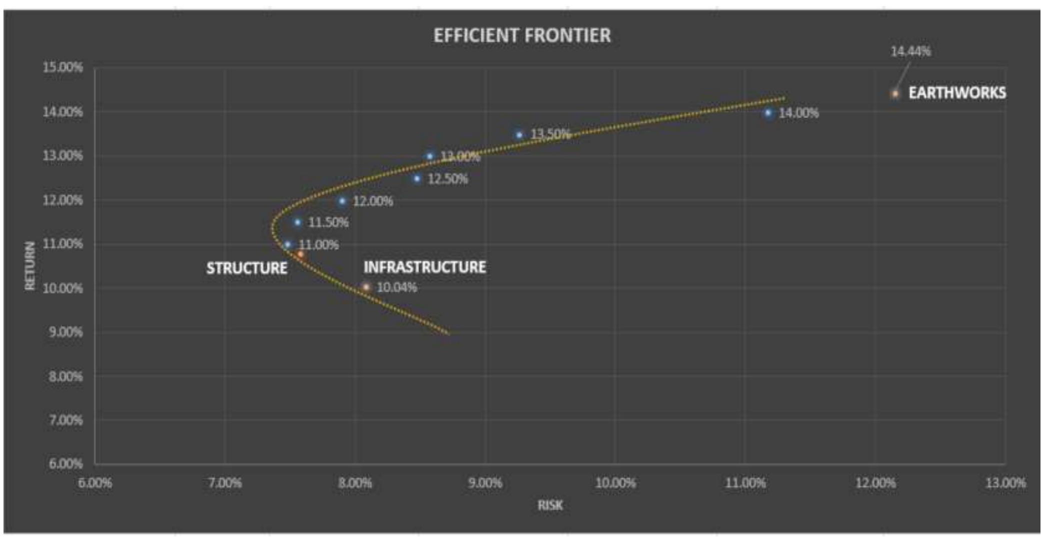
4.3.4 Efficient Frontier

The efficient frontier is tabulated below in Table 4.3.4. The data set out here is a result of an iterative solution using the Return Model set out in Table 4.3.3. Start by determining the minimum return. This is achieved by using an Infrastructure only weighting analysis. The maximum portfolio return corresponds to an Earthworks only weighting. This defined the return range from 10.04% to 14.44%. To conclude the efficient frontier, set out a series of returns in-between this range, and plot on the efficient frontier.

Table 4.3.4: Efficient Frontier

PORTFOLIO	EARTHWORKS	STRUCTURES	INFRASTRUCTURE	RETURN	STANDARD DEVIATION
EARTHWORKS ONLY	100%	0%	0%	14.44%	12.15%
STRUCTURES ONLY	0%	100%	0%	10.79%	7.58%
INFRASTRUCTURE ONLY	0%	0%	100%	10.04%	8.08%
Absolute Min - 10% Return	0%	0%	100%	10.04%	8.08%
11.00%	22%	0%	78%	11.00%	7.48%
11.50%	33%	0%	67%	11.50%	7.55%
12.00%	45%	0%	55%	12.00%	7.90%
12.50%	56%	0%	44%	12.50%	8.47%
13.00%	64%	16%	19%	13.00%	8.57%
13.50%	74%	26%	0%	13.50%	9.26%
14.00%	90%	0%	10%	14.00%	11.17%
Absolute Max - 14.44% Return	100%	0%	0%	14.44%	12.15%

Figure 4.3.4: Efficient Frontier



The result is a range of positions identified, that would provide a more efficient position relative to risk and return. Whilst Earthworks contracts are high yielding projects, they are also inherently more risky - confirmed here in the frontier. By diversifying construction projects to include a combination of Structures and Infrastructure, risk is reduced considerably, although at the expense of total portfolio return.

5. Discussion of Results

The aim of this chapter is to discuss the results presented in the Section 4. Whilst in the previous section the objective was to summarise the results of the analysis, here the objective is to critically assess the validity and applicability of these results. Further to this, to contextualise the results within the subject topic, and potentially set out the key findings to be summarised in the conclusion. The purpose here is simply to respond to the research questions and propositions. The chapter is set out in a similar format to the previous section, where the discussion is broken down into – Portfolio Return Analysis, Statistical Analysis Results, and Portfolio Management Theory. These three components are the fundamental structure of the analysis, and hence this has defined the structure of this section of the report too.

5.1 Portfolio Return Analysis

At a portfolio level, the subject case is sufficiently suitable for the analysis. This is based on the following strengths. Firstly, the subject case has provided detailed costing reports for all projects from 2011 to 2018. The analysis apportioned a 6-year sample, starting January 2012 and ending December 2017. This period is considered a reasonably undistorted period in the context of the macro-economic environment. Critically, this period excludes (a) The Financial Crisis, and (b) the 2010 Soccer World Cup. Both these events would have distorted the results of the analysis, as the returns would not reflect market norms. Therefore, the period of this analysis is representative of a real construction market. Secondly, the subject case produced 24 projects during this period. This is an acceptable sample size based on (a) over R1bn of exposure to various construction projects, (b) 271 financial reports for the analysis, and (c) 966 return actual project return measures.

At a project (asset) level, the subject case is characterised by three asset classes – Earthworks, Structures, and Infrastructure. Whilst this has been sufficient for the purpose on this analysis, future investigations may benefit from a more diverse offering. There is a skew towards earthworks in the sample data. Earthworks account for 16 of the 24 projects - 67% of all the data. The balance is split 3 structures, and 5 infrastructure projects. Accepting the data is representative of the subject case, the limited number of structures and infrastructure projects are potential weaknesses to the analysis. Earthworks contracts had a diverse value spread, with a good balance of low, medium and high contract values. The average contract value was R30mn, with almost half this exposure to the R50mn – 100mn value band. By asset count, earthworks contracts accounted for 67% of the total portfolio assets, and by exposure earthworks account for only 41% of the total portfolio exposure. This disconnect suggests that on average earthworks contracts are of a lesser value than the other assets. Structures contracts made up the smallest proportion by asset count (13%), and by exposure (12%). The average contract value was R45mn. This is distorted due to the low number of projects in the subject case, and is not representative with a high standard deviation. Infrastructure projects accounted for a small proportion – only 20% of the projects within the sample. However, this 20% amounts to 47% of the total exposure. This suggests that on average infrastructure projects are considerably larger than the other assets. This was confirmed in the analysis – Infrastructure projects are on average R110mn by contract value. Ultimately, the subject case was suitable for the analysis, based on the above portfolio and asset level overview.

Project returns have been analysed using both a cash flow and profitability measures. Four separate returns were calculated, including (a) Month Only Net Cash Return, (b) Total to date Net Cash Return, (c) Final Estimated Real Return, (d) Total to date Real Return. Earthworks had the largest valid samples, with 153 results, compared to structures and infrastructure with 38 and 80 respectively. However, there were missing results noted in the asset classes – all of which occurred in the cash flow analysis data. This was attributed to poor reporting practices within the subject case organisation. Infrastructure had the largest missing results (26). This amounts to 33% of the Infrastructure sample size. Earthworks and structures amounted to 16% and 17% missing data by sample size respectively. Similar inconsistencies were noted in the mean returns. Mean cash flow analysis returns were significantly more volatile than mean profitability returns. Using standard deviation as measure of volatility, standard deviations are significantly higher in cash flow returns than profitability returns. Furthermore, the standard deviation for Final Estimated Return measure was consistently the lowest of all the return measures, in each one of the asset classes. This confirms that the Final Estimated Return was the most stable return measure. Whilst this trend presented itself in each one of the asset classes, there were no apparent trends noted with the four mean return measures in each one of the asset class - i.e. No return measure was categorically higher or lower than another.

5.2 Statistical Results

The results of the statistical analysis are presented in section 4 of the report. Here, the results are critically assessed, understanding from a statistical perspective whether the data collected has merit. The analysis was broken down into Descriptive Statistics, Testing for Normality, Analysis of Variance, and Kruskal-Wallis Test. The determination of the sequence of statistical testing was outlined in the methodology section Chapter 3. Critically, each of the four return measures were reviewed.

5.2.1 Descriptive Statistics

From Table 4.2.1 - Descriptive Statistics, Final Estimate Returns provide the most consistent results. Earthworks was seen to produce the highest mean return of 14.44% compared with 10.79% and 10.04% for structures and infrastructure respectively. However, it also shows the greatest variability. The minimum statistic return was -29.80% and the maximum is 40.39%, and has a standard deviation of 12.14%. This compared to structures and infrastructure, which has a minimum statistic return of 0.31% and -10.31% respectively, a maximum statistic return of 24.59% and 22.58%, and a standard deviation of 7.58% and 8.08%.

Typically, a symmetrical distribution would yield a skewness of between -0.5 and +0.5 – i.e. normally distributed. A moderate skew would be defined between -1 and -0.5, or +0.5 and +1. Anything outside this range is highly skewed. By this definition, with exception to one result, all the distributions were highly skewed. This is to be expected, and speaks to (a) the nature of construction returns, and (b) the relatively small sample size. However, more critically, comparing the skewness of cash flow returns versus profitability returns, there was a clear pattern. Cash flow returns (Month Only Net Cash, Total to Date Net Cash) show distinctively higher skewness than profitability returns (Final Estimated Real Return, Total to date Real Return). In fact, profitability returns are close (relatively) to a normal distribution. However, there were no apparent trends when comparing skewness by asset type – i.e. No asset type is more 'normally distributed' than any other.

The analysis of Kurtosis illustrates similar results. Typically, Kurtosis figures closer to 0 would suggest a normal distribution. Here, almost all the figures were positive suggesting that the data has significant exposure to outliers – Leptokurtic Distribution. This was also expected. The construction industry is characterised by inconsistent and volatility in returns. However, a comparison was drawn between cash flow returns and profitability returns. Kurtosis was seen to be consistently higher for cash flow returns compared with profitability returns, and profitability returns are close (relatively) to a normal distribution. There were no apparent trends when comparing kurtosis by asset type – i.e. No asset type is more 'normally distributed' than any other.

5.2.2 Testing for Normality

Here, the return data sets produced a Sig. = .000 (significant) result. The null hypothesis was therefore rejected, and therefore the data was not normally distributed. However, for larger samples ($n > 50$), these two tests can be sensitive to outliers. The result of non-normality is rejected, and reverting to graphical methods to assess otherwise. Here, a combination of

Histograms, Q-Q Plots, and Box-Plots were used. The results illustrated non-normal distributions for (a) Month Only Net Cash, and (b) Total to date Net Cash. Normal distributions or rather near-normal distributions were noted for (c) Final Estimated Returns, and (d) Total to date Real Returns. This is has been established from the histograms and Q-Q plots primarily. "*As long as the data is approximately normally distributed, with a peak in the middle and fairly symmetrical, the assumption of normality has been met," (Pallent 2011).* On this basis, both a parametric and non-parametric analysis are required going forward.

5.2.3 Analysis of Variance (ANOVA)

Due to the nature of the data sample sizes, it first had to be confirmed that the data set did not violate the homogeneity assumption critical to the ANOVA analysis. A Levine's Test was conducted to the test for homogeneity of variance. The result of the Levine's Test was successful. All data sets had a significant result – i.e. Sig > 0.05. This confirms that the groups do not violate the homogeneity assumption for the ANOVA test.

The ANOVA test was subsequently run. The critical result of this analysis was that only Final Estimated Return produced a significant result of 0.006 ($p < 0.05$). This was reported as $F(2,268) = 5.266$, $p < 0.006$. Here, the 'F' identifies the analysis as an F-test (ANOVA). The '2' represents the between groups degree of freedom (*df*), and the '268' represents the within groups effect. The '5.266' is the F ratio determined, and corresponds to a significance of $p < 0.006$. Since the homogeneity of variance had not been satisfied, further checks must be done using the Robust Tests of Equality of Means. An adjusted F ratio was established using (a) Brown and Forsythe Test, and (b) Welch Test. The result was for both tests a significant difference was identified, with $p < 0.001$ and $p < 0.004$ for each method respectively. The null hypothesis, that all groups have equal variances, was rejected. Further to this, one group was significantly different – Final Estimated Real Returns. Taking this further, a post-hoc test was required, to establish where this difference was being experienced.

The Tukey HSD method was chosen for the post-hoc analysis. The result of the post-hoc test was a multiple comparison table - to locate exactly where there difference between groups occurs. The result of this analysis was that within the Final Estimate Real Returns, Earthworks (1) and Infrastructure (3) had statistically significantly differences. In each case Sig $p < 0.008$ was less than the rule $P < 0.050$ for significance.

Ultimately, the data set provided for cash flow returns and profitability returns were not exactly normally distributed. However, this was to be expected with real construction projects return. Returns are highly sensitive to (a) site conditions, (b) tender and pricing views made, (c) weather and other unforeseen element, and (d) labour and material supply and demand. It was expected that Month only returns specifically would be highly volatile. This has been confirmed in the cash flow analysis, which measure returns on a net cash basis – i.e. Revenue less cost. Real returns were expected to be less sensitive to the month on month fluctuations. This was also confirmed in the profitability analysis, which used real returns – i.e. True revenue less cost. Critically, an acceptable level of normality was achieved with the profitability return measures. Specifically, Final Estimated Real Returns proved to be the least volatile – the lowest standard deviations, and the most normal – the smallest skewness and kurtosis. The analysis of variance produced a similar result, where Final Estimated Returns were proven to be significantly different to the other return measures. The post-hoc test determined the difference to be between Earthworks and Infrastructure asset classes. To this end, the analysis going forward made use of Final Estimated Real Returns as the data set, where variance here was measured as a proxy for risk. A portfolio level analysis is discussed in Section 5.3.

5.3 Portfolio Management Theory Results

The results of the application of portfolio management theory to a portfolio of construction projects is presented here. The data set used was based on Final Estimated Real Returns. The portfolio is summarised by (a) Mean Return, (b) Variance, (c) Standard Deviation. Each construction type defines a separate asset class. Earthworks produced a mean return of 14.4%, compared with 10.8% and 10.0% for Structures and Infrastructure. This result confirms the initial thoughts around project returns – Projects with a strong earthworks component are typically more profitable than those that are more structures and infrastructure based. The variance for Earthworks was reported as 1.475%, with a standard deviation of 12.145%. This is considerably higher than both Structures and Infrastructure, which reported 0.574%, 7.579% and 0.653% and 8.079% respectively for variance and standard deviation. This result once again confirmed the initial sentiments around risk and return in construction type projects. The more profitable projects are also characterised by higher levels of variance and volatility – i.e. Earthworks returns are therefore not only higher, but lower in some cases where projects are profitable. Interestingly, Infrastructure projects by comparison to structures based projects produced slightly lower returns, but with an increased variance and volatility.

A portfolio of Earthworks only contracts would yield the highest return, but also with the highest risk. Risk here is a measure of variance in returns, and speaks to the volatility of the asset class to produce consistent returns going forward. A Structures only portfolio would yield a lower return than Earthworks only, but this would be achieved at a lower risk. Returns are therefore considered far more consistent and this makes for more accurate projections. Finally, an Infrastructure only portfolio would yield lower returns than both Structures and Earthworks projects. However, whilst it may offer less risk than Earthworks, it proved to be slightly more risky than a Structures only portfolio. Therefore, Infrastructure projects do not serve to de-risk a Structures portfolio as they would with an Earthwork only portfolio. However, when combining the different assets into a portfolio of three assets, a more efficient position was achieved concerning total portfolio risk and return.

Adjusting the portfolio weighting of each asset was tabulated and graphed with the efficient frontier. Here, the result was such that an Earthworks contractor was able to de-risk a portfolio with the addition of both Infrastructure and Structures based projects. The result was a reduced return, but also a considerably reduced risk position.

5.4 Concluding Discussions

Finally, the discussion of results was concluded by reviewing the research objectives, highlighting how and where these objectives have been addressed through the research report;

(a) Define the significance of the construction sector in terms of the social and economic value that it provides in the South African economy, and thereby justify the significance of this research.

This was been addressed in the introduction. The significance of the construction sector is in the jobs it creates (directly and indirectly), the revenue and contribution to the national GDP, and the development and upliftment of the country and people. The significance of this research is therefore to stress exactly this, and more critically how volatility can be reduced and sustainability improved.

(b) Review the historical performance of the South African Construction Sector.

This was achieved in both the introduction, and the literature review. The research made use of construction sector reports, which defined how the sector had performed. Reference was made to the local construction markets, the listed construction sector, and the governing and regulatory bodies that manage the construction industry. A performance review of the construction sector was done by comparison between the historical performance of the listed construction sector and the JSE. The result was that after the economic crisis, the construction sector had continued to decline, even whilst the JSE had completely recovered and continued to grow. Macro-economic forces such as the global economic crisis and 2010-world cup were noted to have affected the performance of this sector, specifically the 2010 world cup that created a false sense of security in the industry, and was illustrated by the sharp collapse post-2010.

(c) Determine what aspects of a construction company impact most significantly on their performance.

This has been also been addressed through the case study. The subject case was project driven, and therefore relied on a constant flow of contracts to support the business. This was seen in Section 4 – Results. The subject case had numerous projects within the period analysed. Unlike other asset classes, these projects had a defined lifespan, as seen with the defined start and end dates. Linked to this, four key aspects were identified that most significantly affected the performance of the company. These included; (a) a heavy reliance on cash flow, (b) volatility of returns, (c) low mark-ups, and (d) a poorly diversified portfolio.

(d) Determine whether a specialised construction strategy offers improved sustainability compared with that of a diversification strategy often used in share and equity portfolios.

This has been a focal point to the analysis. The result was addressed in the Discussion of Results section, as well as the Conclusion. Specialisation has its benefits for construction – (a) compete more aggressively, (b) improve market capitalisation, (c) more focussed company gearing in terms of skills, resources, and equipment, (d) and enhancing future earning ability. However, specialisation should not be at the expense of diversification. Sustainability requires diversification in uncorrelated assets. The Efficient Frontier specifically addresses this objective. It proves that specialisation in Earthworks for the subject case, would increase returns at the expense of risk. Sustainability would therefore be reduced.

(e) Examine, by case study, a real world portfolio of construction projects, and determine how volatility translates to risk and return.

This was provided for in the Results section of the report. Here, the case study results were provided for a real world construction company and a portfolio of projects. Volatility was identified in the return data captured, specifically with cash flow related return measures. Earthworks contracts had the highest volatility in returns recorded, and thereby regarded as the highest risk. However, it also recorded the highest average return. Therefore, volatility translates to higher risk, but equally higher returns. The Efficient Frontier illustrates the impact of volatility on risk and return. The higher returns were noted for Earthworks contracts, but at an equally higher risk. Lower returns were noted for Structures and Infrastructure projects, with equally lower risk. Therefore, volatility is directly linked to higher risk and higher returns. Sustainability requires reduced volatility, and in our subject case this would translate to a diversified portfolio of contracts.

(f) Establish a strategy that can implemented by the case study construction company, to reduce sensitivity to macro-economic forces.

This was addressed in the Discussion of Results, and Conclusion sections of the report. Whilst macro-economic forces uncontrollable, the subject construction company would be able to reduce the sensitivity to such forces. Diversification was a recommended strategy, but more specifically diversification with assets that are negatively correlated. Diversification with other construction types does not solve to reduce risk to macro-economic forces.

6. Conclusion

6.1 Introduction

Finally, this concluding chapter aims to summarise the outcomes of the report. In order to satisfy the research question, reference is made back to the first chapter and provide the closing statements supported by some of the key findings of the analysis. Following this, recommendations are provided for construction companies, based on the results presented above. Furthermore, the limitations of this report are addressed, highlighting key areas of concern for future research. The concluding remarks are intended to highlight the benefit of this report, and how through this research, value has been added to the greater body of knowledge.

6.2 Summary of Findings

Reviewing the problem statement – "*The construction industry, and more specifically the large construction companies, are not strategically positioned to minimize the risks associated with macro-economic movements. Such volatility has become synonymous with the construction sector and its economic cycles. When it's good, it's very good. But when it's bad, it's very bad. The result is such that a down-turn of the economy puts excessive strain on construction companies, translating to massive market capitalisation losses, extensive resizing through retrenchments and disposal of assets, and potentially wide spread liquidations. Furthermore, recovery periods for this sector are considerably longer than those experienced in other industries."* Through the research, this has been illustrated to be true for the majority of contractors. Referring back to the literature review, current market information was provided, illustrating how the construction sector had reached a record lower in business confidence. Combined with this, information was presented on the current value of the listed construction sector. The listed construction sector had lost 68% of its market cap, in the same period in which the JSE increased by 129%. This confirms that the construction industry, specifically the large (listed) contractors, are not positioned to effectively deal with down turning macro-economic environment.

Further to this, the aim of the research is reviewed, as proposed in the initial stages of the report – *"Identify what key aspects of large construction companies make them susceptible to excessive cyclical volatility, and thereby define strategic tools and techniques that can be adopted to (a) minimize exposure, and (b) reduce the sensitivity, to macro-economic forces."* To this point, using a case study approach, the following characteristics were identified, which expose contractors to industry volatility:

(a) Firstly, contractors are heavily reliant on cash flow, and projects are typically cash negative at the start. This forces contractors to be highly levered, financing the projects through most of the construction phase. Any delayed payments, unforeseen cost increases, unpaid claims, or unachievable tendered rates, all translate to financial pressure on the contractor. This is fundamentally unsustainable.

(b) Secondly, the volatility of returns, specifically month-only net cash return and total to date net cash return. The analysis showed these returns to be non-normal, and recorded the highest signs of variation and volatility. This makes cash flow forecasting for contractors exceptionally difficult – Cash flow forecasting is fundamental to business sustainability.

(c) Thirdly, project mark-ups are too low. Contractors take on far more risk than they are adequately compensated for. In the case of a risk event occurring, the contractor is severely financially impacted. This low mark-up is a result of excessive competition within the industry, forcing contractors to price more aggressively. The result is that mark-ups are eroded, contractors become claim conscious, and quality is often compromised.

(d) Finally, the fourth characteristic is that contractors are poorly diversified. In most cases, contractors diversify by expanding the scope of construction projects. These are positively correlated assets – as proven in the analysis. Therefore, whist they aid to reduce specific risk, they do not provide sustainability to systematic risk factors – macro-economic downturn of the construction sector.

6.3 Recommendations

The following recommendations are provided in response to the key findings outlined above:

(a) Firstly, to address cash flow constraints, construction companies should be limited to the number of projects they are able to do, as well as cumulative exposure by contract value. This is not a new concept. Similar to banks, lending exposure is restricted by enforcing banks to hold a similar proportion in capital and thereby ensuring they do not lend beyond what they can afford to repay investors at any point in time. This concept could be adapted to a construction framework. Currently, CIDB only regulate the value for which a contractor is qualified to tender for, by grading them on their ability. However, there are no limits to the amount of contracts a contractor can run concurrently, not by cumulative contract number nor cumulative amount. By enforcing a limit here, this will ensure better contract governance, as contractors are less likely to become cash strapped, and over exposed.

(b) Secondly, volatility in returns needs to be solved for. Cash flow projections need to become far more consistent, and far more predictable. However, this is more difficult to solve for as construction, by its nature, is unpredictable. Critically therefore, whilst we may not be able to predict construction failings, having the right people on site, those that are qualified, experienced and pro-active, goes a long way to reduce this risk and manage exposure. This may be the only solution to this problem.

(c) Low mark-ups are a result of excessive competition. Excessive competition is due to a limited or reduced amount of work available. Solving for this relates to the broader topic of the macro-economy that drives public and private sector spend. This is beyond the scope of this research report. However, the consideration of minimum mark-ups, or regulatory mark-up thresholds is front of mind. Enforcing adequate mark-ups ensures that the construction sector is properly regulated, and ensures sustainability to the greater industry.

(d) Finally, and more in line with the research agenda, is the topic of diversification. Construction companies should pay more careful attention to the selection of their projects. Critically, they should avoid becoming heavily invested in one type of construction, but rather to find a balance that will provide diversified risk benefits. Becoming more diversified, can be achieved by investing in different types of construction projects - reducing specific risk. However, becoming the most diversified can be achieved by investing outside the field of construction completely – reducing systematic risk.

To conclude the recommendations, and in the context of the case study, the recommendation is to have a diversified, well balanced, but anchored portfolio. A contractor should not ignore the benefits of being specialised in a specific construction type. Furthermore, diversifying a construction portfolio does not necessarily have to be at the expense of their specialisation. For example, being specialised in Earthworks, would allow the contractor to compete more aggressively in this segment of the market. Gearing their company accordingly can have major benefits, where skills, resources and equipment can be perfected, enhancing their future earning ability - This is where the portfolio should be anchored. Thereafter, a focussed diversification strategy should be a priority. The addition of Structures and Infrastructure projects here, reduced the overall portfolio return but provided a more efficient risk-weighted return position – well balanced. Finally, complete diversification needs to integrated, with investment into non-construction related assets – diversified.

6.4 Conclusions

The construction sector is indirectly the backbone to the economy. However, the sustainability of this industry needs massive improvement. Volatility, instability, and business confidence are unacceptable for a sector that forms such an integral part of social and economic development. Drawing back on the research proposition – "*Specialization, as opposed to diversification within the construction sector, is expected to reduce volatility, stabilise financial performance and shift the construction industry from high risk/return variances towards a more progressive, sustainable business model*." **This has proven to be false.** Specialization in Earthworks, for the subject case, resulted in increased returns, but also increased risk. The industry needs to shift from a return driven mind-set, to a more sustainable risk-weighted return approach. Critically, contractors need to be less concerned with what they stand to make (Return), but more concerned about, not only what they, but also what everyone else (directly or indirectly associated), stand to lose (Risk).

One particular method of achieving a more sustainable risk-weight return position, as per the research above, is by using a portfolio-based approach. Modern Portfolio Theory, applied to a construction portfolio, has the ability to provide a risk vs return framework from which investors or company stakeholders can fine-tune their asset selection, and re-balance their portfolio of projects in a more efficient risk vs return position.

Key to this is the calculated process of asset selection, and diversification. This case study illustrated that asset selection provides contractors with the ability to reduce the risk of their portfolio. However, it also showed how diversification is not entirely achieved with a portfolio of different project types. This was evident with the positive correlation noted between the three project types. In order to achieve a satisfactory level of diversification, the construction industry needs to consider investing in non-construction related assets – specifically those that are negatively correlated. This, 'insurance policy' type strategy will negatively impact their returns in a bullish market, but it will reduce the potential for loss in a bearish market.

Ultimately, we strive to redefine the risk vs return nature of the construction industry. This research proves that construction cash flows and returns are highly volatile, and inevitably make contractors vulnerable in market downturns. Diversification enables contractors to become more risk-averse, and thereby less sensitive to the extremes of the cyclical nature that the construction industry is characterised by. Achieving this mind-set shift is likely to be very difficult. Contractors will revert to the days of "When it's good, it's very good – when it's bad, it's very bad." This needs to end. Instead, contractors should diversify so that going forward – when it's good, it's reasonably good, and when it's bad, it's not unreasonably bad. Ultimately, moving away from an industry characterised by high peaks and low troughs, to a more sustainable cycle of gradual fluctuations.

6.5 Recommendations for Future Research

The following recommendations have been identified for future research. These are based on some of the limitations which are noted in this research report:

(a) Firstly, this analysis was limited to actual project returns. This micro-level analysis is different from conventional construction industry return analysis, which focusses on total company performance. The approach is based on the concept – '*You must value the business to value the stock*'. This study focusses on project specific returns, aggregated to a portfolio level. Future research may benefit from a combination, including more in-depth company level analysis. The motivation here is that certain assets might generate more income than recorded at a project level. For example, if earthwork contracts enabled the company to use its own equipment, the profit from revenue generated via an intrinsic asset, would enhance the returns considerably - This is true project return.

(b) Secondly, another limitation of this analysis was that total returns were not calculated. For example, Infrastructure projects may have the lowest percentage return, but the average contract value was significantly larger than Structures and Earthworks projects. Therefore, the total return as a rand value is significantly more beneficial to a contractor, than higher percentage return on a smaller contract amount. Critically, the research analysed returns on the total asset class. It therefore is less concerned with value of each individual contract, but rather the return of the complete asset class. Future research would benefit from doing a financial analysis to determine total return.

(c) Thirdly, future research would benefit from further case studies on other large construction companies. The analysis was limited to just one contractor, and the information that they had on record. More case studies, with different construction types, would significantly improve the understanding of portfolio management theory applied to the construction framework. Further to this, I feel there is a lack of intellectual and academic knowledge about this industry, and therefore add to the current body of knowledge.

(d) Finally, future research may benefit from using a non-numerical approach to risk analysis in construction. Here, a statistical based, probabilistic approach has underpinned the analysis. The limitation is that the risks are only evaluated in terms of numbers and figures. Some risk factors are only able to be captured using language and words. Here, conceptual risk modelling may provide an interesting alternative to the conventional statistical base models.

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Appendices

(Refer to Appendix A attached)