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Measuring Innovation in New Zealand Construction Organisations: Developing a Measurement Tool for Medium and Large Companies

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Civil Engineering

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In the name of Allah,

the Most Gracious,

the Most Merciful.

Abstract

Innovation is increasingly recognised as a crucial driver of productivity, competitiveness, and sustainability in the construction industry. Despite its importance, the construction industry has been lagging behind other sectors in this field and is characterised as a weak innovator due to many factors such as its project-based nature, fragmentation, and resistance to change. In New Zealand, these challenges are further exacerbated due to the absence of a comprehensive, context-specific tool for measuring innovation in medium and large construction organisations. Addressing this gap, the aim of this research was to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand.

A sequential exploratory mixed-methods design guided this research, comprising three interconnected stages. Stage one involved a comprehensive literature review, a rigorous inductive content analysis, and an expert-informed thematic categorisation, leading to the identification of innovation indicators structured under five categories of Innovation Potential: Workforce Skills and Human Resources Management, Organisational Structure, Business Strategy, Technology, and External Influences. This tool was further complemented by 36 questions for assessing the Business Innovation Score. Stage two applied the tool in two case study organisations, enabling empirical testing, refinement, and comparative analysis of innovation potential and performance. Stage three validated the tool through interviews with construction industry experts, further refining the tool, confirming its relevance, completeness, and applicability.

The research findings demonstrate that the developed tool is theoretically grounded, practically usable, and capable of providing diagnostic insights into organisational innovation capabilities. The tool highlights strengths and weaknesses across its categories, facilitates benchmarking, and offers a foundation for targeted strategies to improve innovation. By connecting a theoretical framework with empirical validation, this research contributes a robust innovation measurement tool tailored to the unique characteristics of the New Zealand construction industry. The developed tool has implications for both academic advancement and industry practice. This research provides a platform for policymakers, industry leaders, and organisations to systematically measure, monitor, and improve innovation within the New Zealand construction industry.

Dedication

To my Maman, who gave me wings

whom with her continuous love, I have all the courage I need to succeed

and

To my Baba, who gave me a crown

Whom with his continuous wisdom, I have all the strength I need to go beyond

Thank you

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To our almighty God, "Allah", as Allah gives strength with His help to whomsoever He wills. I express that without His daily help and guidance, this step could not have been within reach. I thank him indefinitely since the weaker I was and am, the stronger He was and will always be.

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List of Abbreviations

Abbreviation	*Full Form*
3D	Three-dimensional
AHP	Analytic Hierarchy Process
ASCE	American Society of Civil Engineers
AUBEA	Australasian Universities Building Education Association
BAU	Business as Usual
BIM	Building Information Modelling
C4.0	Construction 4.0
CA	Customer Attribute
CBT	Cloud-Based Technologies
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIARB	Chartered Institute of Arbitrators
CIE	Construction Industry Expert
COVID-19	Coronavirus Disease of 2019
CS	Case Study
DABC	Differential Artificial Bee Colony
EC	Engineering Characteristic
ECC	Engineered Cementitious Composite
ECI	Early Contractor Involvement
EDI	Engineering, Design and Innovation
EPS	Electronic procurement systems
Eurostat	European Statistics
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GII	Global Innovation Index
GPS	Geographic Positioning Systems
HR	Human Resources
IBT	Innovation Building Technology
IC	Innovation Capacity
ICT	Information and Communication Technologies
IP	Intellectual Property
IRD	Inland Revenue Department
KM	Knowledge Management
KPI	Key Performance Indicator
KVC	Knowledge Value Chain
LBP	Licensed Building Practitioner
LoC	Levers of Control
MBIE	Ministry of Business, Innovation & Employment
MBR	Mohammed bin Rashid
MCDM	Multicriteria Decision Making
MfE	Ministry for the Environment
MHUD	Ministry of Housing and Urban Development
MLQ	Multifactor Leadership Questionnaire
MMC	Modern Methods of Construction

NESTA	National Endowment for Science, Technology and the Arts
NZ	New Zealand
NZD	New Zealand Dollar
NZIOB	Building Institute Aotearoa (formerly the NZ Institute of Building)
OECD	Organisation for Economic Co-operation and Development
OPSI	Observatory of Public Sector Innovation
QR (code)	Quick Response (code)
R&D	Research and Development
RICS	Royal Institution of Chartered Surveyors
RMA	Resource Management Act
SBM	Slacks-Based Model
SDG	Sustainable Development Goals
SDLC	Software Development Life Cycle
SIMM-Q	Social Innovation Measurement Model Questionnaire
SME	Small to Medium-sized Enterprise
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
WIPO	World Intellectual Property Organisation

Chapter One: Introduction

1.1 Introduction to the Importance of Innovation and its Measurement in the Construction Industry

There is increasing pressure on construction industry companies to innovate if they want to remain competitive and meet the increasing demands of consumers. Innovation in the construction environment involves using new technologies, processes, or business models which improve performance and productivity. However, the industry is typically a weak innovator, resulting from its project-based nature and its need for collaboration between many stakeholders (Akunyumu et al., 2021). Knowing the different types of innovation - for example, technical (product and process innovation) and organisational - is vital for setting a theoretical base for innovation studies (Akunyumu et al., 2021).

In the construction industry, innovation is understood to be a decisive element for increasing quality, productivity, and overall performance. However, the industry is usually conservative and has a robust tendency for traditional methods and a resistance towards change. This conservative behaviour is in part due to the innovation's high-risk nature, especially when innovations are seen as possible failures rather than potential for improvement (Er, 2020).

Innovation is not only about the making of new technologies but also includes the adoption and change of business processes to better address the consumer's needs. This definition is important for the nature of innovation in the construction industry. Here, technological and process innovations are together necessary for improvement and for meeting rivals (Augustine & Imayavaram, 2021). Innovation can be driven by various elements, for instance, technology, market conditions, and changes to the environment. As a result, measuring innovation needs a structured strategy which takes into account different elements of innovation, ranging from individual impacts to organisational and country-level results (Augustine & Imayavaram, 2021).

Globally, the construction industry, similar to New Zealand (NZ), is valuing the necessity of using new technologies to improve sustainability, efficiency, and productivity. Examples of new technologies include cloud-based technologies (CBT), unmanned aerial vehicles (UAVs), and Building Information Modelling (BIM), which have become vital in improving project management, communication, and design accuracy. Implementing these technologies reflects a stronger tendency for innovation inside the construction industry (Chen & Chang-Richards, 2022).

In the construction industry, innovation usually has challenges similar to other industries, especially in the use of definitions and the measurement of results. It is important to take note of formal and informal institutional elements when considering innovation measurement. This

mindset is important for developing measurement tools to address specific requirements of the construction industry, as external networks and collaborative efforts are important elements for innovation (Wang & Chung, 2020).

The measurement of innovation is increasingly important for improving value and decision-making processes in organisations. Finding new ways to measure different areas of innovation is important for industries, including construction, since innovation is an important element for competitiveness and productivity (Ponta et al., 2021). Innovation measurement has improved to become a complex process as a result of the growing technological and competitive environments. There is a necessity for considering these complexities by focusing on multiple indicators which represent a more comprehensive perspective on innovation. This process is in line with the necessity for a well-defined innovation management process for the construction industry, which is a combination of elements which drive growth (Ponta et al., 2021).

The measurement of innovation is important for knowing how companies use both internal and external knowledge to achieve competitive advantages. This is especially important in industries like construction, which have collaboration and external partnerships as important elements of their innovation processes. The importance of creating effective metrics for innovation is usually neglected in innovation studies (Rosa et al., 2020). The complexity of projects usually requires collaboration with outside partners. There is the need for tools that can study both the inbound and the outbound aspects of innovation, and provide a good knowledge on the way. Innovation happens within and across organisational borders (Rosa et al., 2020).

Research on innovation-affecting indicators within the New Zealand innovation environment reflects the significant role these elements play in fostering innovation. This is very crucial in a geographically isolated country like New Zealand, a place where these indicators are thought to be the most important drivers of this science-dependent economy (Blair et al., 2020).

1.2 Background to the Research

1.2.1 Challenges Related to Innovation Measurement

Continuous innovation is necessary for growth, and we need to know how innovation works, guarantee its success and make it repeatable. Innovation needs to be based on our problems. We need to have a form of innovation process in place, and later we must further improve this process. This will allow one to compete against competitors. Therefore, we need to be able to measure innovation in relation to our market, rivals, clients and consumers, and gain feedback from the innovation process (Augustine & Imayavaram, 2021).

Innovation measurement in the construction industry has unique challenges. This is the result of stringent regulations and the special nature of its products. We understand that each construction project is unique, and this causes difficulties in having standardised innovation measurement tools. Usually, the innovation metric tools are designed for industries that have more standard processes and outcomes (Lo & Kam, 2021).

The nature of challenges that innovation faces is reflected in its measurement. These challenges include limited resources, focus on initial/project costs rather than whole of life cycle,

economic impacts, conservative mindset of the construction industry people, low level of support from governmental policies, the tendering system that focuses on price attributes instead of value, affordability of innovation, issues with data management, and laws that need to be updated and are further affected by low level of investment on research and development (R&D) (Adafin et al., 2022). The abovementioned barriers, which also represent the low level of resources on innovation, make any attempt to measure innovation challenging.

To have sustainable success, innovation measurement must evolve. The innovation measurement methods must continuously be upgraded to make sure they are reflecting the right results. Innovation measurement must consider the existing trends and norms, the desired technology and the existing competition to be comprehensive (Augustine & Imayavaram, 2021).

Measuring innovation through only one indicator is incorrect. This process is complex and is made up of numerous indicators relating to the strategies of the organisation, its processes and outputs. The most important indicators, including performance measures, must be recognised for innovation measurement (Lo & Kam, 2021). The measurement of performance affected by innovation is a great concept and includes various indicators, for example, innovation strategies of the company, clients' desires, market conditions, sharing of knowledge, training, creativity, and employee engagement (Lo & Kam, 2021).

Innovation measurement is complicated and requires attention to many aspects. Integration and balance between these aspects are necessary for comprehensively measuring innovation. Measurement of innovation performance is not just selecting the right metrics but also about merging those metrics in a coherent system to benefit from their full potential (Munck et al., 2020).

Researchers like Chen and Chang-Richards (2022) also emphasised on the significance of understanding the practical needs and motivations behind innovation adoption in New Zealand's construction industry. While the existing literature provides a foundation, there is still a need for more comprehensive studies that explore the long-term impacts of innovation implementation on project outcomes and industry practices.

1.2.2 Overview of the New Zealand Construction Industry

The construction industry plays an important role in New Zealand's economy. It contributes 6.3% of the Gross Domestic Product (GDP) and employs 10.7% of the nation's labour force (Ministry of Business, Innovation & Employment [MBIE], 2024a).

The industry has demonstrated strong growth, especially in the residential sector, supported by urban development and continued demand for housing, especially in cities like Auckland and Wellington (Stats NZ, 2022a). However, the industry is dealing with many challenges, including shortages in skilled labour, high cost of material, and changes to the regulatory system, which aim for sustainability and improvement in building standards (BDO New Zealand, 2024; Stats NZ, 2021a).

The residential construction sector is one of the main activity drivers within the construction industry. In 2022, residential building consents for new dwellings experienced record levels,

with Auckland leading in the number of new builds, similar to the previous years. For example, in the 12 months ending with September 2022, 21,985 consents were issued in Auckland, which showed an 11 per cent increase from the year before (Stats NZ, 2022b).

Although this demand is a sign of growth, costs of labour, more demand, and supply-chain disruptions have been among the causes of inflation in the final price of new homes. These events led to an annual inflation to 7.3 % in the consumer price index, representing a 32-year high figure (Stats NZ, 2022c).

In spite of these challenges, government plans such as the Building for Climate Change programme attempt to address both environmental and economic matters, and lead the industry towards practices that are more sustainable (MBIE, 2020a).

Infrastructure projects, like transport networks and public facilities, are an important part of the construction industry. The New Zealand Upgrade Programme is an important government initiative aimed at improving infrastructure investment (Ministry of Transport, 2020). These projects are expected to create many employment opportunities and strengthen transport infrastructure (MBIE, n.d.-a).

The National Construction Pipeline Report 2024 predicts that infrastructure activity will mainly remain steady at around NZD 13.6 billion (New Zealand Dollar) from 2025 to 2027 and rising to NZD 15 billion by the end of the mentioned period (MBIE, 2024b). This great investment demonstrates the important role of large construction companies in conducting the country's most important infrastructure projects. These large companies play a crucial role in driving innovation and implementing best practices, such as the use of digital construction technologies and prefabrication to improve efficiency in projects.

Innovation has been slow in the New Zealand construction industry in adopting and creating modern methods. The industry must prioritise the already proven innovative methods. The methods include off-site construction, financial tools and regulatory systems that support the industry. As we move forward with New Zealand's 2030 carbon reduction requirements, the construction industry has the necessary justification to invest in innovation and improve the quality of its output (Construction Sector Accord, 2023).

The government has implemented strategies in an attempt to identify what is necessary to optimise the construction industry in the future. These strategies aim to guide us to fewer emissions and more innovation, equity, productivity, resilience, and safety (Construction Sector Accord, 2022). The construction industry has demonstrated susceptibility to boom-bust cycles, and recently, the industry has been particularly weak. This is due to the reduction in residential construction activity and lower business confidence across all industries. The industry must become more resilient, productive, and confident (Construction Sector Accord, 2023).

New Zealand has plans to reach net-zero carbon emissions by 2050. The Building and Construction Sector must play its role towards this goal. This industry currently contributes approximately 20% of carbon emissions in New Zealand, and this happens through the materials and energy consumed in buildings. The Government is developing an Emissions Reduction Plan, which will define the changes required for New Zealand to reach its climate change goals (MBIE, 2020b). This plan provides many opportunities for innovation and

highlights the need for supporting companies practising within the construction industry to gain innovation capability.

1.2.2.1 Breakdown by Size and Key Players

The New Zealand construction industry is mainly constituted by small businesses, but medium and large companies have an important part in the industry's overall dynamics. (Stats NZ, 2023a). Medium-sized construction companies – which employ between 20 to 49 individuals – make up around 1% of all construction companies in New Zealand. This is while large companies – which employ more than 49 individuals – make up less than 1% of the construction companies. These companies play an important part in running the industry (Stats NZ, 2023a). It is notable that in the last few years, bigger construction businesses have led profitability growth (Stats NZ, 2020).

Medium and large construction companies are less affected by operating expenses compared to smaller companies. They also showed they have a more robust backbone when it comes to profit gains. The growth of operating profit for small construction businesses, which have one to 19 employees, reduced by 23.7 per cent between 2021 and 2022. Medium-sized businesses, which employ between 20 and 99 employees - medium-sized company definition used by the Ministry of Business, Innovation and Employment (MBIE) - also demonstrated a growth reduction, although less severe, at 12 per cent. During the same period, large businesses, with over 100 employees, managed to have a moderate 3.6 per cent growth rate (Stats NZ, 2023a; MBIE, 2024a). These numbers further result in access to more financial resources and facilitate leverage for the medium and large companies to invest more in innovations.

Low standardisation, coupled with a fragmented value chain, has resulted in many small companies practising within the construction industry. This has negatively affected innovation and digitalisation. In addition, these small companies have been the reason behind the construction industry being one of the least digitised industries throughout their assets, and in implementing digital technologies and equipping the labour force with them (Ribeirinho et al., 2020). The low rate of innovation is further exacerbated by the limited profit margins and risk-aversion culture affecting the construction industry. For instance, building information modelling (BIM) adoption rates are now at 60 to 70 per cent after 35 years of its initial introduction to the world. When compared with other industries, adoption rates for similar innovative technologies have achieved 90 per cent within 8 to 28 years since they were introduced (Ribeirinho et al., 2020). These low numbers would have been stronger if the culture of the construction industry permitted economies of scale, which would allow larger companies to operate and would result in more innovations happening.

According to research (Gong & Wang, 2022), large construction companies are the main contributors to technological innovation in the construction industry. In recent years, large construction companies have also invested more resources towards innovation (Lo & Kam, 2022).

The New Zealand construction industry includes 80,613 businesses, mainly small to medium-sized enterprises (SMEs) (Stats NZ, 2023a). The exact breakdown of these companies are 78,915 small, 1,299 medium, and 402 large companies (Stats NZ, 2023a). Major companies play a crucial role and include Fletcher Building, Downer Group, and Hawkins, which lead large commercial and infrastructure projects.

These businesses are at the core of both residential and non-residential construction projects, as well as important infrastructure projects. In the year 2023, the top 50 builders in the New Zealand construction industry started 612 projects altogether, while their combined value was NZD 8.4 billion. The top 10 builders together started work on 283 projects. These projects were worth more than NZD 4.8 billion (BCI Central, 2024).

In recent years, construction businesses owned by Māori have been growing. The numbers increased from 12.6% in 2011 to 14% in 2021. These businesses were mainly involved in construction services and residential/non-residential building construction (MBIE, 2024a).

The private sector is the largest player in non-residential building, and contributes 66% of the added value during the period 2023–2028. At the same time period, the central and local governments make up 22% and 12% respectively. (MBIE, 2023).

1.2.2.2 Unique Characteristics

New Zealand's construction industry must address unique challenges posed by the country's vast nature and history of repeated natural disasters, such as floods and earthquakes. This has led to increased attention towards strong infrastructure and disaster recovery programmes, especially after events like Cyclone Gabrielle (MBIE, 2024b). Infrastructure projects, particularly those on water and transport, have been emphasised on to strengthen resilience to confront future natural disasters. This encompasses great government investment in transport infrastructure and Three Waters projects, which focus on wastewater, stormwater, and drinking water systems (MBIE, 2024b). New Zealand government programmes like the Green Building Council's Green Star rating system (New Zealand Green Building Council, n.d.) invest on construction practices that are sustainable. These projects aim to lower emissions and boost energy efficiency within the industry (MBIE, n.d.-b).

The construction industry is managed by strong regulations initiated by the Building Act 2004, with a robust attention on resilience and sustainability, especially through programmes such as the Building for Climate Change Programme (MBIE, 2024a). The industry's regulations aim to ensure sustainability, quality, and safety. As a result, the complexity of New Zealand's consenting and regulatory systems possibly results in challenges for productivity and innovation. To address this, Building Act 2004 changes are necessary and will ease the way for innovations such as offsite prefabrication and manufacturing and by easing the process for approvals of efficient and innovative construction methods (MBIE, 2022)

Strategic and sustainable investment practices are vital for supporting a resilient construction industry. New Zealand's innovation targets are in line with sustainable construction initiatives around the world. This is demonstrated by various programmes supported by the industry and the government. By the year 2050, the Building for Climate Change Programme tries to achieve close to zero building-related emissions (MBIE, 2021).

In the 12 months leading to June 2023, the value of residential work projects was NZD 37 billion, which was 22 per cent higher compared to the 12 months prior to June 2022. During the mentioned year, costs of residential construction were 7.8 per cent higher, and costs of non-residential construction were 6.8 per cent higher. Also, during the same period, the value of non-residential building activity was up 28 per cent in the year ended June 2023 compared with

the year ended June 2022 (Stats NZ, 2023b). These figures reflect the volatility that is present within the New Zealand construction environment.

1.2.2.3 Engaged Ministries

- **Ministry of Business, Innovation and Employment (MBIE)**: MBIE plays an important role in regulating the construction industry, monitoring the implementation of the Building Act, and driving industry change through programmes like the Construction Sector Accord (2023). MBIE also plays an important role in focusing on standardising the industry, developing the workforce, performance enhancement, economic policies, and improving sustainability (MBIE, 2024c).

- **The Treasury** is at the centre of funding large infrastructure projects, especially in efforts for disaster recovery, with huge investments on the Infrastructure Action Plan and National Resilience Plan. The Treasury is also engaged in long-term infrastructure planning and managing economic policies that affect the construction industry (New Zealand Government, 2023; The Treasury, 2024).

- **Ministry for the Environment (MfE)**: MfE's regulations, particularly those under the Resource Management Act (RMA), have a great impact on the construction industry, promoting sustainability in the environment (Ministry for the Environment, n.d.).

- **New Zealand Infrastructure Commission**: is an autonomous Crown entity and is responsible for monitoring infrastructure development and its performance within the country, including in the construction industry (New Zealand Infrastructure Commission, n.d.).

- **Ministry of Māori Development**: supports the growth and development of Māori-owned construction businesses, and plays a great part in the industry (Ministry of Māori Development, n.d.).

- **New Zealand Transport Agency**: is tasked with planning and executing national transport infrastructure projects, and has a strong focus on resilience following recent natural disasters (New Zealand Transport Agency, n.d.).

- **Local Councils such as the Auckland Council**: are responsible for implementing long-term initiatives that include important infrastructure projects, usually with a focus on resilience and risk management (Auckland Council, n.d.).

1.2.2.4 GDP Contribution

The construction industry of New Zealand is an important contributor to its economy. It is the fifth largest industry and produces 6.3% of the real Gross Domestic Product (GDP) (MBIE, 2024a). It is also responsible for 8% of all imports during the year ending in 2023. Predictions show that construction activity will decrease to NZD 55.1 billion in 2025, further down from NZD 60.8 billion in 2023 and from NZD 55.6 billion in 2024. Predictions show construction

activity will experience a trend upwards from the year 2026, and will reach NZD 63.7 billion in 2029, as the residential sector recovers strength. New dwelling consents in New Zealand will decrease to a low of 30,000 in the year 2025 and then are expected to increase during the remainder of the period to 2029 (MBIE, 2024b). The construction industry's output has been hugely supported by infrastructure investments, especially affected by environmental disasters and the necessities of public infrastructure.

1.2.2.5 Employment

The scope of construction projects in New Zealand is broad. It covers residential, commercial, and infrastructure segments. As of June 2023, the construction industry employed approximately 308,500 people, making up 10.7% of the national employment (MBIE, 2024a). Over the past decade, the industry has experienced huge employment growth, with an increase of 140,800 workers, which depicts an annual growth rate of 6.3%, and is more than double the average growth rate among all industries (MBIE, 2024a). This demonstrates the industry's important role as a major employer in New Zealand, despite challenges such as labour shortages and financial stress within the industry.

According to Stats NZ's Quarterly Employment Survey (2023c), over the year ending in June 2023, the construction industry played a great role in driving the overall increase in filled jobs. There were 17,100 more filled jobs in the construction industry in the June 2023 quarter compared to the June 2022 quarter. This growth has been driven by a mix of elements, including the ongoing growth of the population, a strong pipeline of work in housing and infrastructure projects, and increasing demand for construction services. In recent years, due to these elements, construction has become one of the industries with the highest growth percentage in filled jobs (MBIE, 2024a).

Skilled construction workers were not only in high demand but also caused significant recruitment challenges. Results from MBIE's State of the Building and Construction Sector Report 2022 (Research New Zealand, 2022) demonstrate that 46% of business owners or managers who were surveyed had difficulty recruiting tradespeople. This was also relevant to team leaders and supervisors (21% reported difficulty) and technicians (22% reported difficulty) (Research New Zealand, 2022).

1.2.2.6 Comparison with the Global Construction Industry

Globally, the construction industry represents roughly 13% of the world's GDP, which is much higher than New Zealand's 6.3% contribution to its national GDP (World Economic Forum, n.d.; MBIE, 2024a). This difference demonstrates New Zealand's smaller construction market size and the small scale of construction activities when compared to larger construction markets around the world. It also shows specific challenges New Zealand deals with, especially driving from natural disasters and geographic isolation.

The global construction industry is also fragmented, which is similar to New Zealand, with a high number of small and medium enterprises (Ribeirinho et al., 2020). However, the global

market has more significant multinational corporations, which are less common in New Zealand as a result of its geographical isolation.

The construction industry employs about 7.7% of the workforce around the world. This figure is lower than New Zealand's 10.7% (International Labour Organisation, 2021; MBIE, 2024a), which shows a higher reliance in New Zealand on the construction sector for employment. Looking at the abovementioned employment percentage and the GDP contribution, it reflects a huge disparity between productivity rates in New Zealand and the averages in the rest of the world.

According to the New Zealand Infrastructure Commission (2022b), project costs (for instance land, equipment, materials, and labour), differences in physical context (for instance, built environment, geology, and climate), construction productivity, and policy and institutional settings for planning, consenting, and delivering infrastructure, represent some of the differences between the New Zealand construction industry with the global construction industry. New Zealand has lower construction-related salaries but higher costs for bare land, equipment, and some infrastructure construction materials. In New Zealand, the costs of vertical construction are comparable to other high-income countries. However, projects that need to buy a lot of land, machinery, or concrete may need more cost input within New Zealand (New Zealand Infrastructure Commission, 2022b).

1.2.3 Problem Statement - Research Gap

Limited investment in technology, low productivity, and lack of competition are among the challenges that the New Zealand construction industry faces. Projects such as the BRANZ industry transformation agenda aim to support innovation, but the industry has not been responsive to this support (Adafin et al., 2022). At the same time that innovations are improving around the world, the construction industry in New Zealand has been slow to adopt these new technologies. This gap provides a great potential for the industry to improve its innovation capability by adopting global best practices (Adafin et al., 2022).

Adopting digital technologies and new construction methods in New Zealand has started. This will lead to modernisation and will help overcome challenges like labour shortages and delays in project deliveries. Technologies such as sensor technology, Geographic Positioning Systems (GPS), and Building Information Modelling (BIM) are becoming increasingly popular among construction contracting firms and engineering consultancies. The benefits include onsite monitoring, visualisation, and data storage, and demonstrate the construction industry's tendency towards innovation (Chen & Chang-Richards, 2022).

The use of new and innovative technologies in New Zealand's construction industry has been slow. Technologies such as net-zero energy-building systems, smart city technology, and three-dimensional (3D) printing can be greatly beneficial for New Zealand. The challenge is in the implementation of these tools and localising their use, bearing in mind the special atmosphere of New Zealand (Adafin et al., 2022). The construction industry prefers traditional methods, and this negatively affects the adoption of innovation (Lo & Kam, 2021). This conservative approach is a significant barrier to improving productivity and innovation within the industry.

The New Zealand construction industry, including within its large projects, has been slow to benefit from adopting new procurement techniques. Although processes that can support innovation can be very beneficial for the organisation, their application in New Zealand is hindered by a traditional mindset that values cost over value and also by unclear legislation (Ying et al., 2022). The small size of the New Zealand construction market and the low level of competition negatively affect innovation. Local innovation guidelines and tools are necessary to help succeed in innovation initiatives (Ying et al., 2022).

As a consequence of growing population and urbanisation, the construction industry experiences both challenges and opportunities to evolve through innovation and new technologies (Chen & Chang-Richards, 2022). There is a strong tendency in the construction industry for the application of new and innovative technologies with the goal of reducing costs, improving safety, efficiency, sustainability and productivity. The new technologies of digitalisation and automation allow the evolution of the construction industry. This will transform the industry from a labour-dependent industry to a data-dependent industry (Chen & Chang-Richards, 2022). This indicates the importance of understanding the current state of New Zealand construction companies in using technology.

To address the intellectual needs for creative activities, we must improve our innovation measurement capabilities. To effectively understand the process of innovation, we must determine what is necessary for measurement and how this measurement is going to happen. As the pressure from the market increases on the companies, innovation becomes even more necessary to achieve customer satisfaction and to keep the company on a growth path (Augustine & Imayavaram, 2021).

Although there seems to be some hope for increased use of technologies in the New Zealand construction industry, there exist barriers such as limited knowledge on new technologies, old regulations and outdated contracting practices, and resistance to change. It is necessary to address these challenges to successfully implement and measure innovation in the New Zealand construction industry (Chen & Chang-Richards, 2022). The lack of empirical data regarding the successful use of global innovations represents a large research gap and provides an opportunity for research to fulfil the shortcomings (Adafin et al., 2022).

By investigating measurement frameworks from other industries, we find limitations in them for applying to the construction industry. Frameworks like the Innovation Process Model (Mishra et al., 2020) and the Enterprise Innovation Performance Model (Tian & Wang, 2022) had large-scale enterprises in focus. These models and their reliance on advanced infrastructure, complexity, and long development cycles make their use limited for smaller companies. Other models, such as Simons' Levers of Control Framework (Ruiter et al., 2022) and the Conceptual Framework for Innovation Building Technologies (Mlasi & Mahachi, 2023), require and depend on customer input, regional regulations, or external collaboration, and these challenges might not always be available in different regions or sectors. Similarly, the Dynamic Network Slacks-Based Model (Wang & Ren, 2022) also faces challenges with regional disparities and data availability. This is because the InnovationOne Framework's (Dobni & Wilson, 2024) focus on culture and its long-term strategy focus might not align with organisations looking at short-term, product-driven gains from innovation.

Frameworks like the Innovation Promotion Model (Fernando et al., 2021) and the Innovation Capacity Index (Carrillo et al., 2024) also demonstrate gaps in dealing with external drivers

like sustainability, regulations, and market dynamics, which are critical elements for innovation in construction. Models tailored for small or specific sectors, such as the Comprehensive Innovation Measurement Tool, which is designed for innovation in the farming industry (Farsani et al., 2024) and the Social Innovation Measurement Model Questionnaire (Ødegård et al., 2021), provide limited use for larger or more complex industries. These limitations collectively demonstrate a gap in existing frameworks and highlight the need for a tailored and practical tool capable of addressing the wide range of challenges experienced by medium and large-sized construction companies in New Zealand. Such a tool must be able to effectively measure potential for innovation and innovation performance while being capable of adapting to the unique nature of the construction industry.

Continuous innovation is necessary for the New Zealand construction industry and reflects the need for developing a detail-oriented and diagnostic tool for innovation measurement. A tool which addresses the creativity needs of businesses and is coherent with international trends. This tool development can be quite complicated and needs continuous calibration and adaptation to ensure it remains relevant to the changing industry environment. The tool must have the capability of measuring tangible and intangible outcomes together. The tool also needs a comprehensive approach which takes note of both process and cultural elements. Such a tool can provide useful diagnoses and results which could drive innovation forward.

1.3 Research Aims and Objectives

1.3.1 Research Aim

The primary aim of this research is to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand. This tool facilitates the identification and enhancement of innovation capabilities, addressing the current gaps in innovation measurement practices within the construction industry.

1.3.2 Research Objectives

To achieve this aim, the research pursues the following objectives:

1. Conduct a comprehensive investigation of existing literature on innovation measurement, with a focus on its application within the construction industry.
2. Develop a holistic and context-specific tool for measuring innovation within New Zealand construction organisations, tailored to the unique characteristics and challenges of the industry.
3. Implement and test the diagnostic tool through case studies with selected medium or large construction organisations in New Zealand to assess its practicality and functionality in real-world settings.
4. Evaluate the tool's validity and reliability in measuring innovation, ensuring its effectiveness and applicability across the industry.
5. Provide recommendations and strategic insights for improving innovation measurement practices within New Zealand construction organisations, based on the findings from the tool's implementation.

1.3.3 Research Questions

The following research questions are developed to guide this study and align directly with the research aim and objectives. These questions frame the scope of the research and help in structuring the investigation:

1.3.3.1 Primary Research Question

How can a diagnostic tool be developed to effectively measure innovation within medium and large construction organisations in New Zealand, addressing the unique characteristics and challenges of the construction industry?

1.3.3.2 Sub-Questions

1. How can innovation be effectively measured within medium and large construction organisations in New Zealand through identifying key factors and methods?

   This question focuses on identifying key factors and methods for measuring innovation within the New Zealand construction industry.

2. What are the strengths and weaknesses of existing innovation measurement frameworks and tools in the construction industry?

   This question aims to understand the gaps and opportunities in current innovation measurement practices, as identified in the literature review.

3. How can a context-specific diagnostic tool be developed using key factors to accurately measure innovation within New Zealand construction organisations?

   This question is concerned with the process of developing a tool tailored to the unique characteristics of New Zealand's construction industry.

4. How practical and functional is the developed innovation measurement tool within real-world settings?

   This question seeks to evaluate the applicability of the tool through case studies with selected construction organisations.

5. How reliable and valid is the diagnostic tool in measuring innovation across different types of construction organisations in New Zealand?

   This question explores the reliability and validity of the tool in ensuring that it is effective and applicable across various construction settings.

6. What strategic insights can be achieved and provided to enhance innovation measurement practices within the New Zealand construction industry?

This question addresses the recommendations that emerged from the diagnostic findings of the tool's implementation, with a focus on improving innovation measurement practices.

1.4 Significance of the Research for New Zealand

1.4.1 Theoretical Significance

This research contributes to the academic body of knowledge by advancing the understanding of innovation measurement within the construction industry, specifically focusing on medium and large construction organisations in New Zealand. While innovation management is a growing field, the measurement of innovation within construction, particularly in smaller economies like New Zealand, remains underexplored. By developing a comprehensive diagnostic tool, this research addresses a critical gap in the literature, offering a context-specific approach to innovation measurement that is tailored to the unique challenges of the construction industry of New Zealand.

Additionally, this research extends existing theories on innovation management by applying them to an industry that has historically been slow to adopt innovation. The integration of these theories into a practical, diagnostic tool not only strengthens the academic discourse on innovation measurement but also provides a framework that can be adapted to other industries with similar challenges. This work also contributes to filling the gap in empirical studies on how innovation can be effectively assessed in the construction industry, enhancing the understanding of innovation dynamics within the construction industry of New Zealand.

1.4.2 Practical Significance

Practically, this research has significant implications for the New Zealand construction industry. The development of a reliable and valid innovation measurement tool enables construction firms to better understand and manage their innovation capabilities, thus enhancing their competitiveness in both the domestic and international markets. By providing a clear framework for assessing innovation, this tool helps firms identify areas of strength and opportunities for improvement, leading to more strategic innovation investments and improved overall performance.

Moreover, the findings from this research inform policymaking and industry regulations. Policymakers and industry bodies, such as the Ministry of Business, Innovation and Employment (MBIE) and Construction Sector Accord, could utilise the insights to develop policies that encourage innovation within the industry. The tool could also be employed by professional bodies to establish benchmarks and standards for innovation within the construction industry of New Zealand.

Ultimately, the key beneficiaries of this research are construction firms, industry stakeholders, and policymakers. By enhancing innovation measurement practices, this research contributes to fostering a more innovative, efficient, and competitive construction industry in New Zealand.

1.5 Scope of the Research

The scope of this research is focused on the measurement of innovation within medium and large construction organisations in New Zealand. This research aims to develop a diagnostic tool tailored to the unique characteristics of the New Zealand construction industry, which has historically faced challenges in adopting systematic innovation practices. The study is limited to construction firms that operate within New Zealand, ensuring that the tool developed is contextually relevant and addresses the specific dynamics of the local industry.

While the focus is on medium and large firms, the insights gained from this research may be applicable to the broader construction industry, including small firms and other sectors that share similar innovation challenges. However, the research does not explicitly explore the innovation dynamics of smaller firms or sectors outside of construction, as the primary emphasis is on organisations with more substantial resources and capacity for innovation.

This research involves a thorough review of existing literature on innovation measurement, the development of a holistic tool, and the implementation of case studies within selected medium and large construction organisations in New Zealand. The scope is limited to these organisations, and the findings may not be directly transferable to international contexts without further adaptation. However, the tool itself is designed to be flexible and could potentially be adapted for use in other regions or industries with appropriate modifications.

A key task is how some elements can help to improve innovation and shape the future of construction organisations to make a more innovative industry. The findings inform construction firms and industry professionals in New Zealand of how to enable innovation. This research has been undertaken with a view to providing information on factors/attributes/indicators/elements considered significant in enabling a culture of innovation within an organisation, and determining their practical relevance to the New Zealand construction environment.

The focus of this study is on Medium (20 to 49 FTE (Full-Time Equivalent) employees) and large (50 or more FTE employees) construction organisations. In line with this, it was decided not to focus on small companies (0 to 19 FTE employees), and these companies are not included in the scope of this research. The reason for this focus is that medium and large companies have a fair foundation and resources to focus on innovation. As previously discussed in the *Overview of the New Zealand construction industry* section of this thesis, the New Zealand construction industry is composed of a diverse range of company sizes. Although small companies represent a larger number of registered companies in the construction industry, in the meantime, medium and large companies provide and ensure the completion of important projects. With their stronger resources, these companies foster innovation and execute large-scale projects which are crucial for the country's infrastructure and economic success.

Selecting companies from each of these categories - medium and large - allows this research to investigate the characteristics of these categories of companies. This selection for the research scope allows for the comparison of the similarities and differences that exist in each of these categories of companies.

1.6 Overview of the Research Methodology

The research for this thesis adopted a three-stage sequential exploratory mixed methods design (Creswell & Plano Clark, 2017), supported by a pragmatic research philosophy (Creswell & Plano Clark, 2017; Elgeddawy & Abouraia, 2024; Morgan, 2007). The primary goal was to develop, test, and validate an innovation measurement tool tailored specifically for medium and large-sized construction companies in New Zealand. Knowing the complex and multi-dimensional nature of innovation within the construction industry, this methodological design allowed for the gathering of both qualitative and quantitative data throughout separate but interconnected stages, ensuring both theoretical rigour and practical relevance.

In Stage One of the research, the innovation measurement tool was developed by implementing a rigorous inductive content analysis (Rimmel & Cordazzo, 2021; Vears & Gillam, 2022) of literature and was refined through an expert-informed thematic categorisation (Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021) process. This method involved categorising the innovation indicators into six categories, five capturing innovation potential (Workforce Skills and human resources (HR) Management, Organisational Structure, Business Strategy, Technology, and External Influences) and one capturing the actual innovation (Business Innovation Score). The tool was developed by adopting a 5-point Likert scale (Roselidyawaty & Mohd Rokeman, 2024; Koo & Yang, 2025; Shepard, 2024; Tanujaya et al., 2023), and with input and validation from academic supervisors, ensuring clarity and measurability.

Stage Two of the research focused on the empirical application of the tool within two purposefully (Bouncken et al., 2025) selected case study organisations in New Zealand. The participants first completed the innovation measurement tool and then participated in semi-structured interviews (Creswell & Creswell, 2018). The quantitative data were analysed using descriptive statistics (Alkharusi, 2022; Dong, 2023; Jones & Goldring, 2021), while the qualitative feedback that was gathered was analysed using thematic analysis (Braun & Clarke, 2021; Nowell et al., 2017). This stage of research provided internal validation (Yin, 2018) of the tool through revealing how it functioned within real-world organisational environments and resulted in iterative refinements of its content and structure.

Stage Three of the research involved validation (Ahmed et al., 2025; Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021; Yin, 2018) through semi-structured interviews (Creswell & Creswell, 2018) with five construction industry experts (CIEs). These experts critically evaluated the tool's construct validity (Yin, 2018), clarity, and industry applicability. The data gained in this stage confirmed the tool's comprehensiveness and practicality, and supported further refinements based on expert consensus.

Throughout all stages, triangulation (Bans-Akutey & Tiimub, 2021; Carter et al., 2014; Donkoh & Mensah, 2023; Meydan & Akkaş, 2024), both methodological (Creswell & Plano Clark, 2017) and source-based (Creswell & Creswell, 2018), was employed to strengthen the credibility (Lincoln & Guba, 1985; Sajoudi, 2018), and validity (Creswell, 2014) of the findings. Data were obtained from academic literature, organisational participants, and industry experts, in an attempt to ensure that the tool was robust, context-sensitive, and capable of

diagnosing strengths and weaknesses of the construction organisations in relation to innovation.

This comprehensive methodological approach ensured that the developed Business Innovation Measurement Tool is theoretically grounded, empirically validated, and practically applicable to the innovation contexts within New Zealand's construction industry organisations.

1.7 Thesis Structure

This thesis is structured in the following 7 chapters:

Chapter 1 introduces the importance of innovation and its measurement in the construction industry and focuses on New Zealand's unique challenges and the limitations of existing frameworks. It outlines the research aim, objectives, and questions, highlights the study's theoretical and practical significance, defines its scope, and presents an overview of the three-stage sequential exploratory mixed-methods design used to develop and validate the innovation measurement tool. This chapter is in line with objectives 1 and 2 of this research.

Chapter 2 reviews literature on innovation in construction and examines relevant theories. It evaluates existing innovation measurement frameworks, identifies weaknesses and gaps, and highlights the need for a comprehensive, context-specific tool for New Zealand's construction industry. The chapter introduces the two core components of the developed framework as being Innovation Potential and Business Innovation Score, forming the basis of the measurement tool. This chapter is in line with objectives 1 and 2 of this research.

Chapter 3 outlines the research methodology, adopting a pragmatic paradigm and a sequential exploratory mixed-methods design. It describes the three stages of the study (tool development, case study testing, and expert validation) along with the rationale for the case study approach, sampling strategy, data collection and analysis methods, validation techniques, and ethical considerations.

Chapter 4 presents the results of Stage Two of the research, where the innovation measurement tool is tested in selected medium and large New Zealand construction organisations. It analyses and reports company profiles, responses to each indicator, and the calculated Innovation Potential and Business Innovation Scores. The chapter also analyses the findings against organisational characteristics and market conditions, identifying trends, strengths, and weaknesses that inform the refinement, practicality and functionality of the tool. This chapter is in line with objectives 2, 3 and 5 of this research.

Chapter 5 presents the results of Stage Three of the research, where the innovation measurement tool is validated through interviews with construction industry experts. It summarises expert feedback on the tool's indicators, structure, and applicability, highlights suggested refinements, and confirms the tool's relevance, clarity, and practicality for measuring innovation in medium and large construction organisations in New Zealand. This chapter is in line with objectives 2, 4 and 5 of this research.

Chapter 6 discusses the findings from the case studies and expert validation in relation to existing literature and the research objectives. It identifies areas of convergence and divergence between the empirical results and prior studies and explains how the findings strengthen the developed

framework for innovation measurement in the New Zealand construction industry. Chapter 6 contributes to objectives 2, 3, 4, and 5 of this research.

Chapter 7 concludes the thesis by summarising how the research aim and objectives were achieved. This chapter presents the key outcomes of each stage and demonstrates the contribution of the developed innovation measurement tool to both theory and practice. It outlines how the tool addresses identified gaps, provides recommendations for industry and policy, acknowledges research limitations, and suggests directions for future studies. Chapter 6 contributes to objectives 2, 3, 4, and 5 of this research.

1.8 Chapter 1 Summary

Chapter 1 introduces the importance of innovation and its measurement within the construction industry. This chapter highlights the industry's dominant conservative culture and the growing need for innovation to support competitiveness, sustainability and productivity. This chapter also explains that while global trends showcase increasing adoption of technologies such as BIM, UAVs, and cloud-based platforms, New Zealand's construction industry has fallen behind in innovation implementation, which stems from issues such as structural challenges, regulatory barriers, and risk aversion.

This chapter presents critical challenges existing in the field of innovation measurement in construction, such as the uniqueness of projects, the low level of standardisation, resource constraints, and problems regarding data management. It provides a comprehensive overview of the New Zealand construction industry, discussing its economic significance, employment contribution, regulatory context, and key government stakeholders. Medium and large construction firms are emphasised here for their capacity to implement innovation due to stronger financial and operational structures.

A clear research gap is identified in the absence of suitable and useful innovation measurement tools tailored for the local context of medium and large construction organisations in New Zealand. Existing innovation models from other industries are found to be inadequate and incomprehensive, which justifies the need for a new and comprehensive diagnostic tool that captures both innovation potential and actual performance.

The aim of this research is to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand. This aim is supported by five specific research objectives and related research questions that guide the research. The research holds both theoretical and practical significance, contributes to academic discourse and dialogue, and offers actionable insights for industry practitioners and policymakers.

The research adopts a three-stage sequential exploratory mixed methods design. Stage One involved developing the innovation measurement tool through inductive content analysis of existing literature and further developing and refining it through expert-informed thematic categorisation. Stage Two applied the tool within two New Zealand case study companies, collecting data through questionnaires and semi-structured interviews. Stage Three validated

the developed tool and discussed its clarity and applicability through interviews with construction industry experts, confirming its robustness and practical relevance.

Finally, the chapter outlines the structure of the thesis and explains how each chapter aligns with the objectives of the research and contributes to the development, application, and evaluation of the innovation measurement tool.

Chapter Two: Literature Review

2.1 Introduction - Purpose of the Literature Review

The primary aim of this literature review is to set the foundation for developing and validating a tool that can measure innovation within New Zealand's construction industry. Through comprehending existing research on innovation and its measurement, this review aims to establish a comprehensive understanding of how innovation can be measured in a sector understood to have unique challenges, such as project-based work and supply chain fragmentation.

The tool, which is under development, seeks to fulfil significant gaps in current innovation measurement frameworks by introducing two important dimensions: Innovation Potential and Business Innovation Score. While many frameworks focus mainly on innovation outputs, this proposed measurement tool emphasises both the necessities, inputs and the outcomes, providing a more holistic view on innovation capacity in construction companies. Through addressing these gaps, this tool allows for a more accurate assessment of innovation activities and outcomes, helping strategic decision-making within medium and large construction organisations in New Zealand.

This literature review provides a comprehensive overview of existing knowledge on innovation measurement in the construction sector. A key driver justifying the conduct of this review is the need to support the development and validation of a tool that measures innovation in New Zealand's construction companies accurately. This tool attempts to address the sector's well-documented challenges. Also, by studying innovation frameworks, the literature review aims to fill critical gaps in measuring both Innovation Potential and Business Innovation Score, particularly within the unique context of New Zealand's construction industry.

This literature review investigates existing tools and frameworks for measuring innovation within the construction industry. Innovation for the construction sector is becoming increasingly necessary as the industry deals with challenges such as regulatory barriers, increasing costs, and more complexity in the management of projects. The New Zealand government emphasises the need for innovation as a key driver for growth and sustainability in the construction industry. In line with this, agencies such as the Ministry of Business, Innovation and Employment (MBIE) continue to invest in infrastructure and technology developments (MBIE, 2023). However, the existing tools and frameworks for measuring innovation, particularly those relevant to project-based industries like construction, do not fully capture the wide scope and impact of innovation activities. This review contributes towards the development of a novel tool to address these problems and to evaluate innovation in medium and large construction companies.

This literature review focuses on innovation measurement frameworks, highlighting their relevance and applicability to the New Zealand construction industry. Existing international frameworks such as the Oslo Manual from the Organisation for Economic Co-operation and

Development and European statistics (OECD/Eurostat, 2018), and the Global Innovation Index from the World Intellectual Property Organisation (WIPO, 2024), offer valuable insights into innovation measurement, but they often lack the nuanced understanding required for industries like construction, where innovation occurs in a highly fragmented and complex environment.

In the New Zealand context, the review examines how these global frameworks can be benefited from to meet the unique conditions of the local construction industry. Local conditions related to elements such as market conditions, government initiatives, and the regulatory landscape were considered so that the innovation measurement tool is tailored to New Zealand's needs. Additionally, the review highlights the improvement of innovation indicators, focusing on the construction sector's specific characteristics.

2.2 Innovation in Construction

Innovation is seen as a novel means to improve performance. Innovation is also considered a possible path for increasing profit margins. The construction industry is in high need of innovation. Additionally, continuous organisational success and further development can be achieved through innovations. Therefore, studying innovation is a key subject in need of great attention. This is while the construction industry has been known to be slow in innovating. Some of the reasons for the slow uptake and creation of innovation in the construction industry are that the projects are one-off, while the projects need collaboration from multiple participants (Akunyumu et al., 2021).

There is a positive relation between innovation and the contribution of the construction companies to economic growth. But unfortunately, in most countries, the perception towards the scale of innovation is that it is low. Critics must consider the nature and structure of the construction industry. To increase productivity and progress within the construction industry, innovation is necessary. In addition, the successful development and application of innovation can have great benefits for construction companies (Oladinrin et al., 2023).

Since the construction industry is experiencing a period of strategic transformation and industrial upgrading, business model innovations will play a great part in this process. Dynamic capabilities, which allow companies to adapt slowly to changes, are crucial for designing, improving and transforming the companies' business models and remaining in the competition (Wang et al., 2025). Also, as the construction industry faces environmental and internal challenges, there is a need for policies that support green and sustainable innovations. this is while the level of green innovation in the construction industry is not supportive of the industry's performance indicators (Lan et al., 2025).

Compared to other industries, technology adoption is happening at a slower rate within the construction industry. Businesses continue their search for innovative methods of remaining ahead and productive through the use of technology. However, the construction industry's productivity is unstable and even decreasing due to a lack of investment, partially to blame (Akinosho et al., 2020). The introduction of digital technologies such as Internet of Things (IoT), machine learning, Big Data and Artificial Intelligence (AI) into common construction practices can contribute towards placing the construction industry among the most productive

industries. Construction employees are usually reluctant towards innovation, and this is exacerbated if the innovation requires some training too (Akinosho et al., 2020).

Innovation in the construction industry is more complex than the common understanding of the practitioners, as the majority of systematic innovations are produced by the contractors and not by the construction industry's manufacturers (Ebolor et al., 2022). In addition, there are few incentives for the construction industry's manufacturers to innovate since they already effectively control the market and have dominance in the competition. These companies are already making huge profits, but their lack of innovation negatively affects economic growth (Ebolor et al., 2022).

Recent innovations, such as Construction 4.0 (C4.0), have greatly changed construction-related practices around the world. Such innovations, also facilitate the use of other innovations as well. Construction can benefit from innovations for construction, maintenance and design of infrastructure by integrating components. The construction industry's environment is facing great challenges in the recent era, and as a result, many useful innovations have been introduced to help address the problems that the construction industry faces (Lekan et al., 2021).

Digital technologies, especially Building Information Modelling (BIM), can facilitate efficient and effective solutions for the construction industry's problems. These solutions vary and include answers to inefficient use of resources, low quality, and time and cost overruns. These solutions can provide cost-effectiveness, timely delivery, safety, and improved productivity (Shojaei & Burgess, 2022). Employing digital innovations in the construction industry can lead to economies of scale and further reduce cost and project durations, reduce waste and minimise defects, and improve health and safety. It is also noteworthy that to improve productivity by transforming the construction industry through the use of innovative technologies, there is a need for a more highly skilled workforce (Shojaei & Burgess, 2022).

Er (2020) believes innovation is necessary for better outcomes in the construction industry. However, as a result of the project-based nature of the construction projects, making them temporary, sustaining innovation across different projects becomes extremely hard. The structure of the construction industry is such that teams are gathered for short-term projects. This, in turn, limits the opportunity for collecting, retaining and transferring knowledge, further resulting in innovation efforts being fragmented. This fragmentation negatively affects the organisational memory among projects and companies (Er, 2020).

Innovation requires the change of innovation inputs, together with knowledge, into innovation outputs. For instance, changes to the organisation or its marketing strategy, increasing the quality of its existing products or processes or introducing new products or processes. There is collective consent on the positive impact of innovation on economic development and growth (Cirera & Muzi, 2020). Innovation is the resemblance of the Schumpeterian process of "creative destruction", where innovative companies and entrepreneurs lead the productivity and efficiency growth. On the contrary, in developing countries, little is known about the impact of innovation. This, in turn, negatively affects policy development, to support innovation and lead to growth in the economy (Cirera & Muzi, 2020).

2.3 Definition of Innovation in Construction

Innovation within the construction industry can be defined as the successful development and implementation of new ideas, products, processes, or practices, with the goal of improving organisational efficiency and performance (Ying et al., 2022). More specifically, innovation involves adopting improved methods that can be either technology-based or organisational, allowing construction companies to manage growing complexities and improve project outcomes (Ying et al., 2022). In line with this, Oladinrin et al. (2023) prefer a definition of innovation as the actual application of a nontrivial change and improvement in a process, product, or system that is original to the institution generating the change (Oladinrin et al., 2023).

Dansoh et al. (2017) defined innovation for construction firms as the development of practical methods to solve problems they encountered on projects they executed. Similarly, innovation has been described as the consequence of the introduction of new products, processes, markets, organisational structures and new services (Gajendran et al., 2013).

Other researchers, such as Gledson and Phoenix (2017), chose to define innovation as ingenuity, entrepreneurship, process improvement, development, and growth. Lai et al. (2016) also defined innovation as the creation and implementation of changes that are new to the adopting unit or organisation.

Innovation in construction, particularly through the implementation of new and emerging technologies such as digital tools, automation, and new construction techniques, has significantly transformed how buildings are designed and constructed (Chen & Chang-Richards, 2022). The primary benefits include improvements in work efficiency, productivity, quality, and health and safety. Technologies such as BIM (Building Information Modelling), UAVs (Unmanned Aerial Vehicles), GPS, and sensor technologies are increasingly being adopted for design, data visualisation, and collaboration purposes, offering a competitive edge to construction organisations (Chen & Chang-Richards, 2022).

According to Lo and Kam (2021), in the context of Architecture, Engineering, and Construction (AEC) organisations, organisations can gain a competitive advantage only by managing effectively for today, while simultaneously creating innovation for tomorrow. The sector recognises that innovation is vital for organisational growth but has largely been slow in adopting process, product, and service innovations. A report by the Boston Consulting Group indicates that many AEC firms have been hesitant to fully embrace innovation, contributing to stagnation in labour productivity over the past five decades. The definition emphasises that innovation is not limited to technological advances but also includes sustainability strategies, knowledge sharing, and organisational support for creative solutions (Lo & Kam, 2021).

According to the Oslo Manual (OECD/Eurostat, 2018), innovation entails products or processes that are brought to the market and represent a considerable improvement. This Manual (OECD/Eurostat, 2018, p. 246) defines innovation as: “a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)”. Innovation may include novel ideas or enhancements in production methods that significantly depart from existing ones. During this research, to reach a standard

definition for innovation and to encompass a vast range of definitions from the extant literature, the definition given by the Oslo manual 2018 (OECD/Eurostat, 2018, p. 246), was chosen.

2.4 Theories on Innovation

In the following section, based on the existing literature on innovation, different theories on innovation are discussed. By doing so, a deeper insight into the background of research on innovation is presented. Also, the foundations are set to investigate the existing tools and frameworks on innovation measurement.

Ødegård et al. (2021) presented two theories on innovation, named under social innovation and responsible innovation. The theory of social innovation highlights the importance of collaboration and creating new relationships to address challenges in the construction sector. Given the complexity of construction projects, which often involve multiple stakeholders, social innovation can help overcome issues such as fragmented supply chains and project-based silos. Collaboration between contractors, suppliers, and other project participants is essential for implementing innovations that benefit the entire construction process (Ødegård et al., 2021). For measuring social innovation, collaboration, co-creation, and the perceptions of the actors are key components for the innovation process (Ødegård et al., 2021). The mentioned may be further developed into specific indicators for measurement purposes.

By critically analysing, we understand that while social innovations represent great opportunities for strengthening collaboration and dealing with the fragmented structure of the construction industry, their scalability and measurement remain barriers. Relying on short-term and project-based collaborations makes it hard to engage innovation in the industry, and the ethical considerations of responsible innovation add even more complexity to the innovation process. In addition, not having strong tools for measuring social innovation's effect has further limitations, not allowing the use of its full potential in construction.

Responsible innovation has in recent times gained further attention in the construction industry, since innovations must not only facilitate efficiency, but should also address social and ethical standards. Responsible innovation can support new technologies or processes introduced in construction projects to be aligned with broader societal objectives, for instance, sustainability and regulatory compliance (Ødegård et al., 2021).

Through detailed analysis, responsible innovation can provide a framework to ensure construction innovations are aligned with ethical and social norms, but its implementation will face challenges. Dealing with multiple stakeholders further complicates decision-making, and the economic pressures of the industry can limit the company’s desires to invest in practices that are in line with social responsibility. In addition, the regulatory barriers and the absence of strong measurement tools for studying responsible innovation cause even more barriers for its broader use and adoption. While the situation is promising, addressing existing barriers is vital for the success of innovation in the construction industry.

The construction industry is constituted of a complex supply chain, with many stakeholders like suppliers, subcontractors, and contractors, and collaboration between these groups is vital for the success of innovations. But this diverse range of stakeholders, often results in lack of

coordination, causing even further barriers for the adoption of innovative activities. The construction professionals are conservative by nature, and who show reluctance to change from conventional processes, also this behaviour poses great risks for innovation (Er, 2020). The Diffusion of Innovation (DOI) theory demonstrates that communication inside a community impacts the success or failure of the adoption of innovation. The fragmented structure and its over-reliance on conventional norms within the construction industry, negatively affects extant diffusion of innovations, and slows the process of innovation adoption across the construction sector (Er, 2020).

For the construction industry, innovation is vital to address ongoing problems on performance, efficiency, productivity. For the construction sector, innovation can be defined as the creation and implementation of new ideas, practices, and processes that improve productivity, efficiency, and overall performance (Adafin et al., 2022). Specifically, the construction industry is in need of distracting change to improve its outcomes, and this can be reached by either technical and non-technical innovations. Technical innovations are related to technological advancements in product and processes, for example prefabrication techniques, 3D printing, and Building Information Modelling (BIM). These technologies provide great potential for improving performance in projects, but their adoption has been steady as a result of to the fragmented structure of the construction industry (Gledson & Phoenix, 2017; Adafin et al., 2022). Non-technical innovations include improvements in management techniques and organisational structures, and encompass collaboration amongst stakeholders. The construction industry is over dependent on conservative and usual methods, which negatively affect the adoption of innovative methods. Specifically, the fragmentation of the construction industry causes obstacles for innovation. Temporary construction project teams dissolve after projects are completed, which makes it hard for transferring and even retaining knowledge (Adafin et al., 2022). The project-based nature of the construction industry makes these challenges even more effective. Each construction project is seen as a unique endeavour, which limits the use of beneficial innovative processes amongst multiple projects. In addition, the complexity of the supply chain, which involves numerous stakeholders like suppliers and contractors, further complicates the process of adopting novel methods and technologies (Adafin et al., 2022).

Collaborative partnerships within construction projects hugely influence the process of and innovation. Elements such as inexperience, cost, and reluctance are known and as impediments to innovation. In the meantime, teamwork and strong commitment support collaborative innovations in construction companies. The industry has also been negatively affected by low levels of digitalisation and inefficient project management, with many Architecture, Engineering, and Construction (AEC) companies preferring usual business methods (Lo & Kam, 2021). The construction industry is different to other sectors resulting from its many regulations and due to the complexity of recent construction projects. Unlike industries that focus primarily on product innovation, the AEC sector places equal, if not greater, importance on process innovations. The unique characteristics of construction, such as the need for regulatory approvals, complex planning, and non-standardised work sites, limit the direct application of innovation performance measures used in other industries. Additionally, the industry's project-based nature creates challenges in managing systemic innovation, as each project tends to be unique with no two construction sites or products being identical. This is contrary to other industries such as manufacturing, where standardisation and product innovation is much easier to achieve (Lo & Kam, 2021).

Ying et al. (2022) expressed that theories on innovation in construction emphasise technological and organisational processes as primary drivers. Innovations in human-ware, organisation-ware, and information-ware are critical to improving processes. Value innovation is a key theory that promotes radical changes in management and service-oriented strategies, focusing on the entire supply chain to drive organisational efficiency. This method of innovating facilitates stronger integration between stakeholders and strengthens the results of the projects (Ying et al., 2022). Construction innovation is believed to be different from other industries because of the industry's fragmentation, complex supply chains, and project-based nature. The temporary nature of construction projects and the involvement of many stakeholders make it even harder to innovate. In addition, compared to other industries, the industry faces unique problems such as high prices, overregulations, and limitations to the market, which restrict the adoption of innovation (Ying et al., 2022).

Due to the pressure from growing urbanisation and higher population, the construction industry has been dealing with both opportunities and challenges to change through innovations and by benefiting from the potential of technologies. For instance, a new manufacturer certification program has recently been introduced to change the current process of building consenting so it is more suited for innovative products and novel methods of construction (Chen & Chang-Richards, 2022). New and emerging technologies in digitalisation and automation offer the potential to transform the engineering and construction sector and change its image from labour-intensive to data-driven. The successful implementation of technologies in engineering practice could be impeded by various barriers, such as the industry's resistance to change and lack of knowledge of the processes and workflows of the technology (Chen & Chang-Richards, 2022). We can use the successful technology implementation case studies to motivate and encourage technology awareness and penetration among other organisations with little or low use of innovations, allowing for effective innovation transformation in the construction industry.

Augustine and Imayavarmban (2021) believe that innovation is the use of new knowledge for adding productivity or improving processes. Innovation processes usually are a response to various events and causes that can be from the market, technology, society, or even the environment. Innovations from various underlying causes require a special atmosphere if they are to be useful and successful in their aims. Measuring the impact of innovation through the change in productivity is still an area less studied. One reason for this is that many innovations are from a team or small group -team level- within the organisation, while innovations are measured at the organisational level. While measuring innovation, it is necessary to take locational elements such as national culture into account. Therefore, measuring innovation at regional levels -rural and urban- is also recommended. Innovation outcomes can be easily visible or not visible, and this is due to different indicators that make measuring innovation even harder (Augustine & Imayavarmban, 2021).

Davies et al. (2022) stated that organisational innovation can be defined by the interactionist paradigm. In this paradigm, performance is a result of interaction between formal processes and cultural characteristics. Culture has undocumented guidelines that define people's behaviours, while processes entail formal, written steps. Innovation performance relies on both of these elements. In addition, organisational culture has a significant part, especially in aspects such as risk avoidance and tolerating uncertainty, which have a positive impact on the outcomes of innovation (Davies et al., 2023). Construction innovation's reliance on formal processes and

organisational culture is eminent. The construction industry needs companies that are flexible and respond to novel ideas. Establishing external links with diverse teams and individuals with skills to discover contributes towards fostering innovation within the construction industry (Davies et al., 2023).

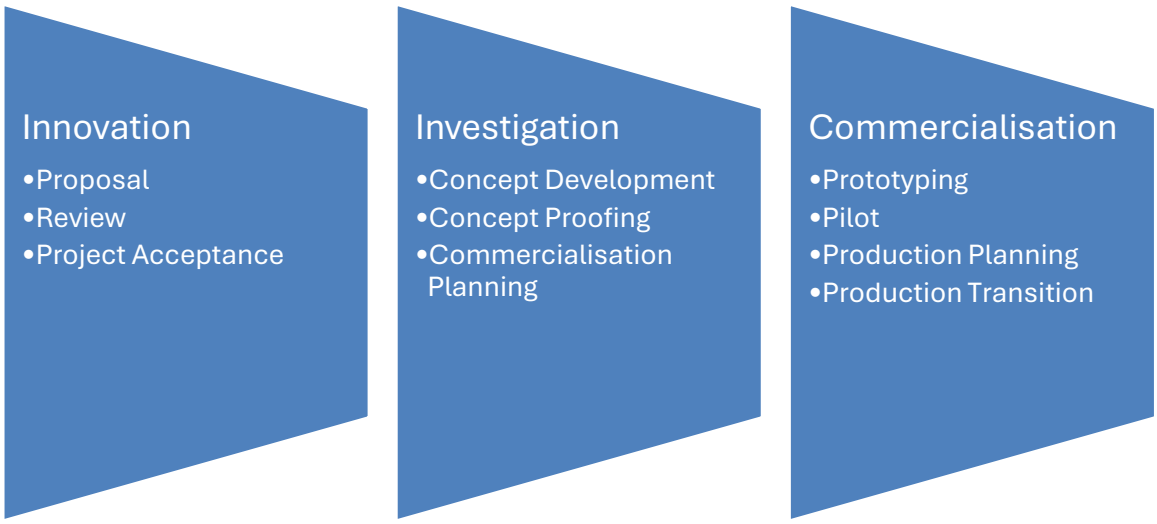
2.5 Existing Frameworks, Tools, and Models for Measuring Innovation

Previous literature has demonstrated a number of tools and frameworks for measuring innovation. What follows, is a representation of these tools and frameworks. By presenting these existing tools and frameworks, their strengths and weaknesses will be discussed. This will allow to identify gaps in the literature and demonstrate where existing studies do not provide adequate tools for measuring innovation in the New Zealand context. This research will make an attempt to find a solution that bridges these research gaps by offering a comprehensive, tailored approach to develop an improved diagnostic tool for measuring innovation in the construction industry.

2.5.1 Innovation Process Model

One of the innovation models that is discussed is the Innovation Process Model for technology development and adoption, which has been adapted from the Software Development Life Cycle (SDLC) process. This model can be used to fast-track the development of products inside the construction materials sector. It is made up of three stages: Commercialisation, Investigation, and Innovation, and each stage is broken down into distinguishable phases which are designed to systematically manage the process. This model has been used in multiple case studies inside the industry, for example, in semi-flexible extruded Engineered Cementitious Composite (ECC) pipes and concrete made up of ultra-high-volume fly ash (Mishra et al., 2020).

Figure 2.1: The Three-stage Product Development Innovation Process Model (Mishra et al., 2020)



The Innovation Process Model demonstrates multiple strengths. First, the model presents a structured process through the SDLC methodology, while presenting clearly defined roles, responsibilities, and predictable outcomes for each phase. In addition, adopting a multi-disciplinary team approach promotes collaboration between multiple functions like finance, manufacturing, and engineering, further facilitating smoother adoption of technology into construction projects. The Innovation Funnel also provides an ongoing flow of ideas from the project stakeholders and ensures a balanced portfolio of projects focused on innovations (Mishra et al., 2020).

However, this model has its own limitations. The long development cycles, which are the norm in civil engineering, usually cause problems in sustaining the required focus and maintaining continuous success. In addition, the model's focus on larger companies that are involved with industrial and infrastructure construction could eventually leave out relatively smaller players in the construction industry and limit its adoption.

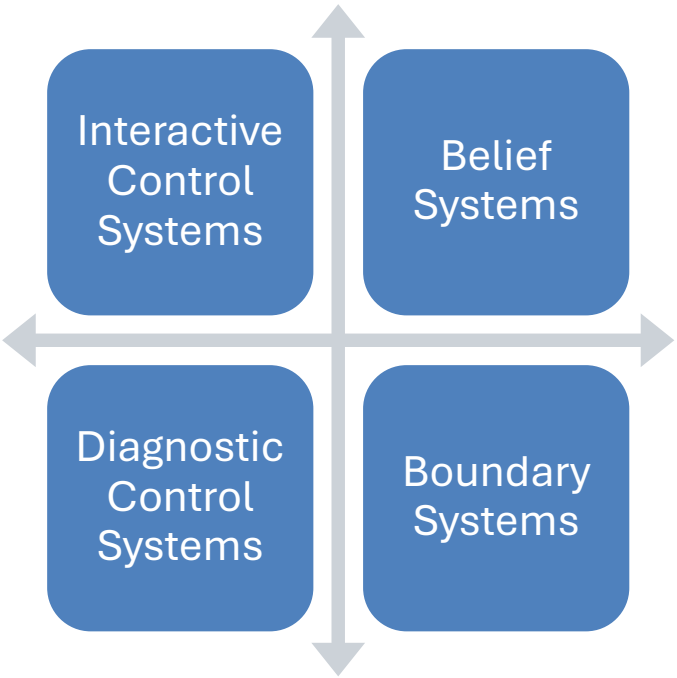
Table 2.1 Description, Strengths, and Weaknesses of the Innovation Process Model

Description	Strengths	Weaknesses
Adapted from Software Development Life Cycle (SDLC); 3 stages (Commercialisation, Investigation, Innovation) with phases; applied in construction materials (e.g., ECC pipes, ultra-high-volume fly ash concrete).	Structured SDLC process with clear roles and predictable outcomes; promotes multidisciplinary collaboration; Innovation Funnel ensures continuous flow of ideas and balanced project portfolio.	Long development cycles hinder momentum; biased towards larger companies, limiting adoption by smaller firms.

2.5.2 Simons' Levers of Control (LoC) Framework

Ruiter et al. (2022) discussed the use of Simons' Levers of Control (LoC) Framework for investigating how various systems for management control add to business model innovation in the circular economy of the Dutch construction industry. The framework consists of four levers: Interactive Control Systems, Boundary Systems, Diagnostic Control Systems, and Belief Systems. These levers allow companies to balance their existing strategies and explore new opportunities, which is vital for maintaining sustainability and supporting business models in the construction industry (Ruiter et al., 2022).

Figure 2.2: The four levers of control (Ruiter et al., 2022)



Belief Systems are vital for supporting innovation since they give the organisation a clear vision and mission and serve as the foundation for supporting innovation in the organisational business model in line with economic principles. These systems initiate and strengthen radical innovations, also allow companies to align their objectives with sustainability goals. Interactive Control Systems support a bottom-up process that allows creativity and communication inside organisations, while it also encourages collaboration and joint investigation for new business models. This is especially important in cooperations where private and public organisations work hand in hand to improve innovation (Ruiter et al., 2022).

Boundary Systems contribute towards establishing a code of conduct and strategic direction, while ensuring innovation efforts align with the organisation's mission for sustainability without deviating from previously established objectives. Diagnostic Control Systems are beneficial for controlling the success of business model innovations, especially when scaling up innovative solutions. Despite this, they are known for being less effective for the measurement of innovation in circular business models, resulting from the complexity of currently known indicators (Ruiter et al., 2022).

The Diagnostic Control Systems could not easily evaluate circular business models in an effective form. This is because currently known indicators usually fail to capture the wide and developing characteristics of innovations focused on sustainability. This, in turn, negatively affects their ability to measure actual contributions to the missions of the organisation. The framework heavily depends on cooperation amongst various organisations, and this could be hard to manage, especially when aligning the objectives and methods of different stakeholders. The success of these innovations is dependent on strong coordination and having similar risks, which is in reality not achievable most of the time.

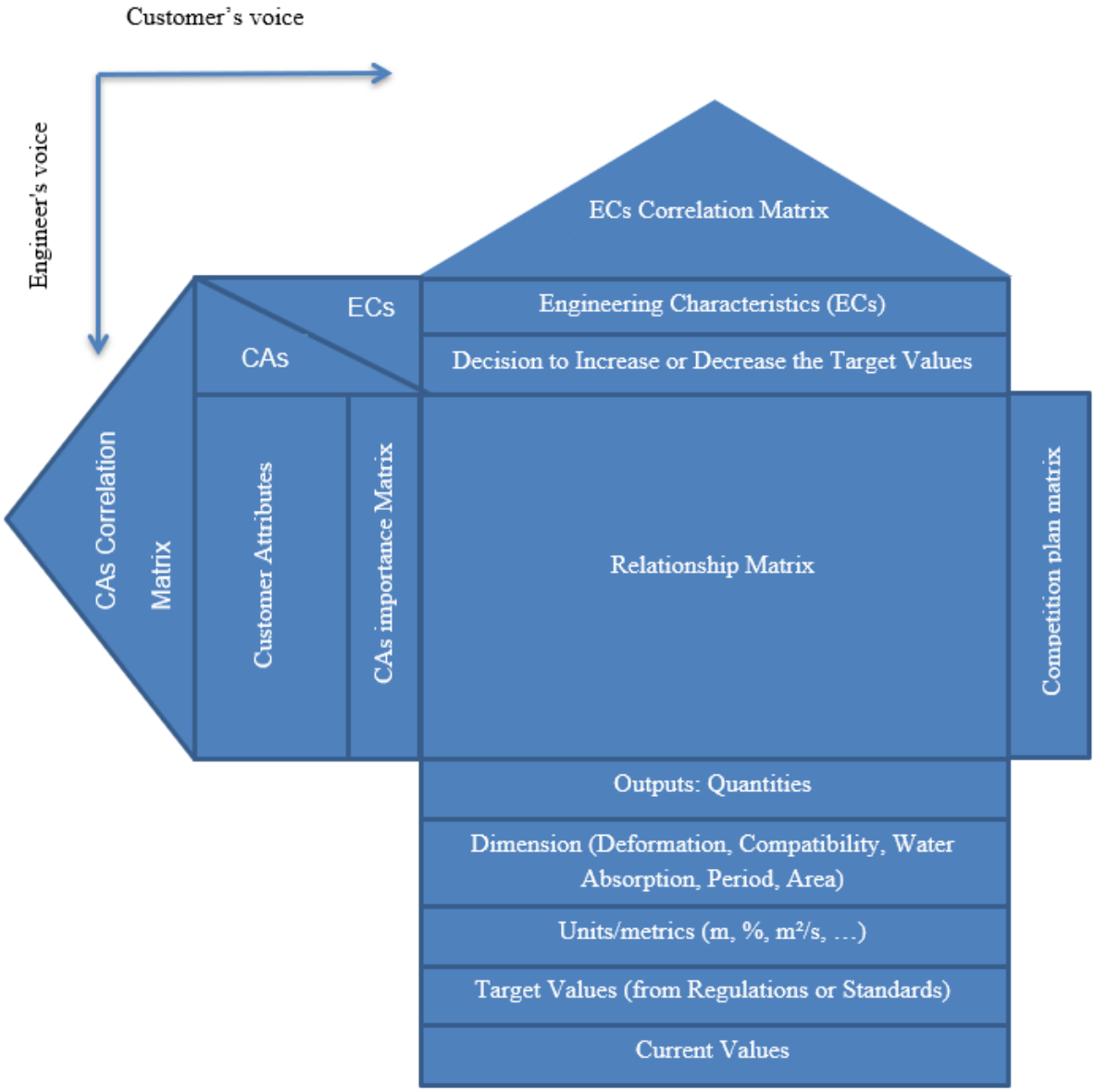
Table 2.2 Description, Strengths, and Weaknesses of the Simons' Levers of Control (LoC) Framework

Description	Strengths	Weaknesses
Four levers: Interactive, Boundary, Diagnostic, Belief Systems; applied to circular economy in Dutch construction industry.	Belief Systems align innovation with sustainability; Interactive Systems foster creativity and joint exploration; Boundary Systems provide codes of conduct; Diagnostic Systems help track scaling success.	Diagnostic Systems ineffective for circular/sustainability innovation due to rigid indicators; heavy dependence on cooperation between multiple organisations makes coordination difficult.

2.5.3 Conceptual Framework for innovation in house construction

Mlasi and Mahachi (2023), in their paper, discussed a Conceptual Framework for measuring innovation in the house building sector. They specifically focused on South Africa's Innovation Building Technologies (IBTs). The framework is a result of merging two methodologies: the House of Quality and Multicriteria Decision Making (MCDM), which includes the Analytic Hierarchy Process (AHP). The framework aims to assess and improve innovation during the construction of houses by implementing not only engineering characteristics (ECs), for example, structural integrity, but also durability and customer attributes (CAs), such as habitability and sustainability. The framework is attempting to boost customer satisfaction and comply with South African National Building Regulations (Mlasi & Mahachi, 2023).

Figure 2.3: Conceptual Framework for Innovation Building Technologies (IBTs) (Mlasi & Mahachi, 2023)



Merging customer and engineering ideas guarantees that the fulfilment of practical and end-user needs is adhered to during the innovation process. This makes the framework more comprehensive and customer-oriented. The use of Multicriteria Decision Making (MCDM) and AHP allows a systematic evaluation of priorities and provides a structured approach to decision-making during the process of construction. This framework creates flexibility by being compatible with both standardised and non-standardised construction practices, and this, in turn, makes it applicable to a broad range of housing projects.

The framework's reliance on input from the customers can limit its use in environments where customer feedback is not easily accessible or where customers don't have the technical knowledge to evaluate innovations in the construction industry. Also, relying on regulations from South Africa could potentially make the framework less useful in other countries, since in different countries, building codes and innovation practices are greatly different. The

complexity of applying both engineering and customer perspectives within one single framework will make it difficult for smaller construction firms that only have access to very minimal resources to apply the model effectively. In addition, this framework does not take into account external factors like market conditions, regulatory changes, or even technological advancements, which can affect the use and success of IBTs in the future.

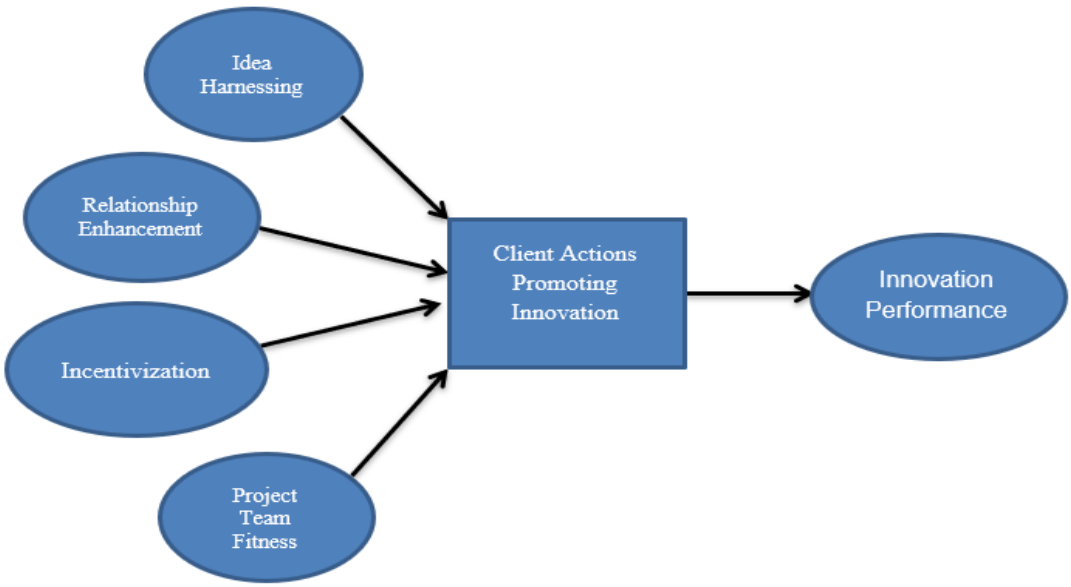
Table 2.3 Description, Strengths, and Weaknesses of the Conceptual Framework for Innovation in House Construction

Description	Strengths	Weaknesses
Based on House of Quality + Multicriteria Decision Making (MCDM/AHP); merges customer and engineering inputs for South African housing.	Customer-oriented, combining ECs (e.g., durability) and CAs (e.g., sustainability); systematic evaluation with MCDM/AHP; flexible for standardised/non-standardised practices.	Reliance on customer input (may lack technical knowledge); based on South African regulations, limiting transferability; too complex for smaller firms; ignores external factors like markets or regulations.

2.5.4 Innovation Promotion Model

Fernando et al. (2021) present an Innovation Promotion Model created specifically for construction projects. This introduces four key enablers of innovation at the project level: Idea Harnessing, Relationship Enhancement, Incentivization, and Project Team Fitness. These enablers are constructs within the model, and their goal is to advance innovation performance within construction projects through a focus on client-driven changes. The model was tested and validated by using information from 131 construction projects in Australia. Statistical analysis was engaged for investigating the relations between the constructs and innovation performance (Fernando et al., 2021).

Figure 2.4: Innovation Promotion Model (Fernando et al., 2021)



Innovation Promotion Model benefits from attention to project-level data and addresses a critical research gap in construction innovation literature. This is because most innovation research has traditionally focused on the firm-level data. This causes the model to be exceptionally practical for people within the construction industry. The use of client-led indicators, such as Idea Harnessing and Relationship Enhancement, promotes collaboration among project people and helps create a culture of innovation during the project lifecycle. As the model was validated using empirical data from real construction projects, strong evidence of its applicability in real project settings was achieved (Fernando et al., 2021).

Since the model relies on client-driven enablers, it might not fully account for the complexity of construction projects' innovation processes. In these construction projects, external factors such as market conditions, contractor innovation, and regulatory requirements play important parts. The usefulness of the model might be limited to projects where the client has a great impact on the project team and its processes. In projects with clustered teams or scattered hierarchical structures, the client's ability to directly impact innovation can be constrained. The model is designed mainly to be used inside single projects, and this limits its scalability when used in larger, multi-project companies or their single large projects. Focusing on project-level innovation might not totally account for the complexities of synchronising innovation across numerous projects or large construction programs. Applying the model's indicators, for example, Project Team Fitness and Relationship Enhancement, could face resistance within organisations that have already established strong processes of practice. In conservative construction cultures, project teams might be reluctant to implement novel and innovation-focused processes unless there is strong support from the leadership. The model's dependence on incentives could be hard to practice consistently across different types of projects. Some projects could need more noticeable rewards or incentives embedded in their contracts, and this is not fully covered in this model's framework. The model focuses on the role of leadership and project managers for supporting innovation, which makes the model dependent on the existence of strong leadership. In projects that do not benefit from strong leadership or lack expertise relevant to innovation, the model might not result in the intended outcomes.

By looking at the innovation measurement frameworks from different industries, valuable information can be collected. This facilitates a wider perspective on the measurement of innovation and will further strengthen the results of this research to consider different perspectives and views that are required for the creation of a framework to measure innovation in the construction industry. The following frameworks are not directly tailored for and consequently, are less compatible or practical for the construction industry:

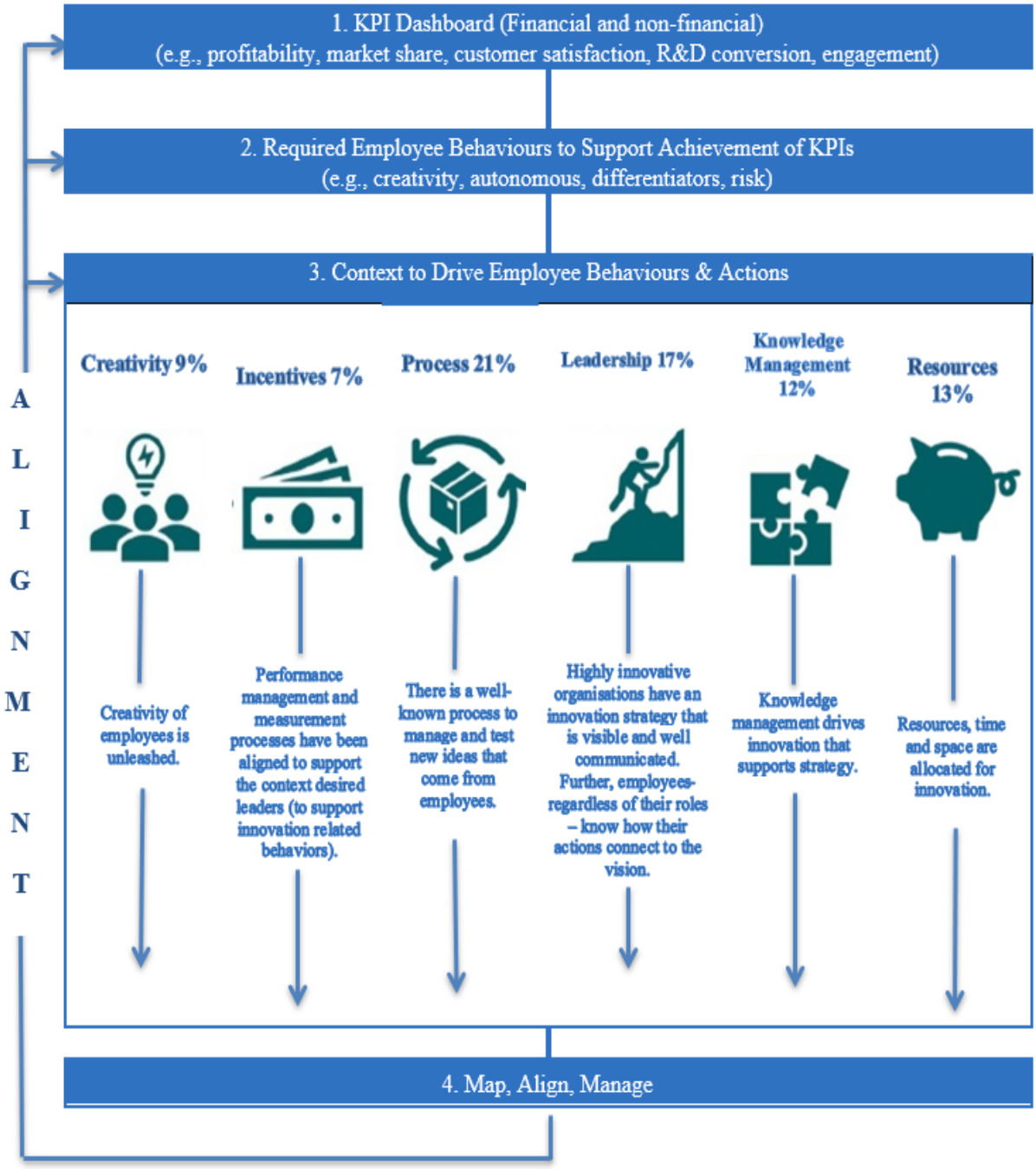
Table 2.4 Description, Strengths, and Weaknesses of the Innovation Promotion Model

Description	Strengths	Weaknesses
Four enablers: Idea Harnessing, Relationship Enhancement, Incentivization, Project Team Fitness; project-level focus; validated on 131 Australian projects.	Addresses gap by focusing on project-level innovation; encourages collaboration via client-led indicators; empirically validated.	Client-driven, may miss external factors; limited scalability beyond single projects; depends on leadership and incentives; resistance possible in conservative organisations.

2.5.5 InnovationOne Framework

Dobni and Wilson (2024) introduced the InnovationOne Framework as a tool with diagnostic capabilities. It can also measure and manage the innovation culture of companies. This framework encompasses 6 important factors which are essential for innovation culture: processes, leadership, resources, knowledge management, creativity, and incentives. This model is developed to help organisations measure their potential for innovation and to implement strategic actions to facilitate innovation. this framework values employee engagement and synchronises actions of the company with the organisational strategies.

Figure 2.5: The InnovationOne framework (Dobni & Wilson, 2024)



The InnovationOne Framework can set the scene for a structured approach to assess and manage innovation culture. This is important for the organisations that are attempting to maintain an innovative performance within. The 6 factors of the framework provide a holistic perspective for innovation and take factors such as creativity, leadership and available resources into consideration. This approach supports a multi-dimensional perspective that is consistent within different parts of the organisation. The InnovationOne Framework is designed to be diagnostic and holistic, and allows the organisations to diagnose the gaps in the company's innovation culture and the methods of applying the required remedies.

Although the InnovationOne Framework is strong, the leadership's support greatly impacts its effectiveness. The framework's success is also conditional on the available resources inside the company towards changing the organisational culture, which could be hard for some companies that have limited resources. in addition, the applicability of the framework may be limited to many industries. For example, the industries that are reliant on product innovation or rely on technology might not require the broad cultural perspective of the tool as useful. This, in turn, will affect the results of the framework's evaluation on the company's innovation capabilities. Since the framework focuses on long-term strategies, immediate results might not be achievable, and this can be problematic for organisations that seek short-term gains.

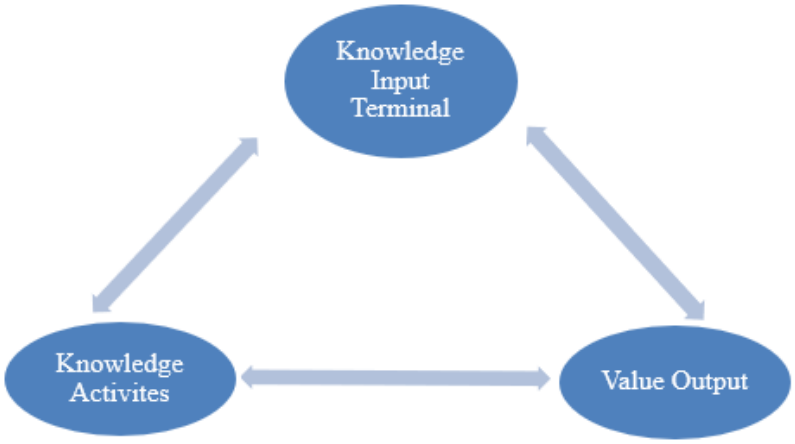
Table 2.5 Description, Strengths, and Weaknesses of the InnovationOne Framework

Description	Strengths	Weaknesses
Diagnostic tool to measure/manage innovation culture across six factors: processes, leadership, resources, knowledge management, creativity, incentives.	Provides holistic, multi-dimensional assessment of innovation culture; supports strategy alignment; identifies cultural gaps.	Effectiveness dependent on leadership and resources; less relevant for product/tech-focused industries; long-term focus unsuitable for firms seeking short-term results.

2.5.6 Enterprise Innovation Performance Model

Tian and Wang (2022) presented an Enterprise Innovation Performance Model, which was developed by implementing a Knowledge Value Chain (KVC) model. The KVC model has three main parts: knowledge activity, knowledge input, and knowledge output. the model focuses on how companies benefit from knowledge to support innovation, especially for technological innovation management. The KVC model merges edge computing and cloud computing technologies to enhance the scheduling of resources and to improve innovation performance by implementing better management strategies on knowledge (Tian & Wang, 2022).

Figure 2.6: The KVC model (Tian & Wang, 2022)



Additionally, Tian and Wang (2022) mention the use of multiple algorithms, such as the Differential Artificial Bee Colony (DABC) algorithm, to improve the performance of the model while dealing with multiple goals during the innovation activities by the company. These algorithms try to improve the efficiency of task completion, especially within collaborative environments. The KVC model strongly represents the role of knowledge management towards better innovations. The model addresses multiple perspectives, including knowledge acquisition and use of new technologies, and presents a structured approach for managing innovation. the use of cloud computing technologies further improves the capabilities of the model and allows companies to handle big data and technology more successfully. Benefiting from optimisation algorithms such as DABC supports the innovation process and improves the scheduling of resources and the completion of tasks for better management of company innovations (Tian & Wang, 2022).

This model relies on cloud technology and, consequently, its use may be limited for smaller companies which do not have the required infrastructure to implement high-tech computer systems. Although the model is theoretically robust, its application might be more beneficial only for larger companies that have a high volume of data and have large data sources. although the DABC algorithm improves efficiency, this improvement might not be effective for every type of innovation. Through further research, the model's flexibility and generalisability can be improved.

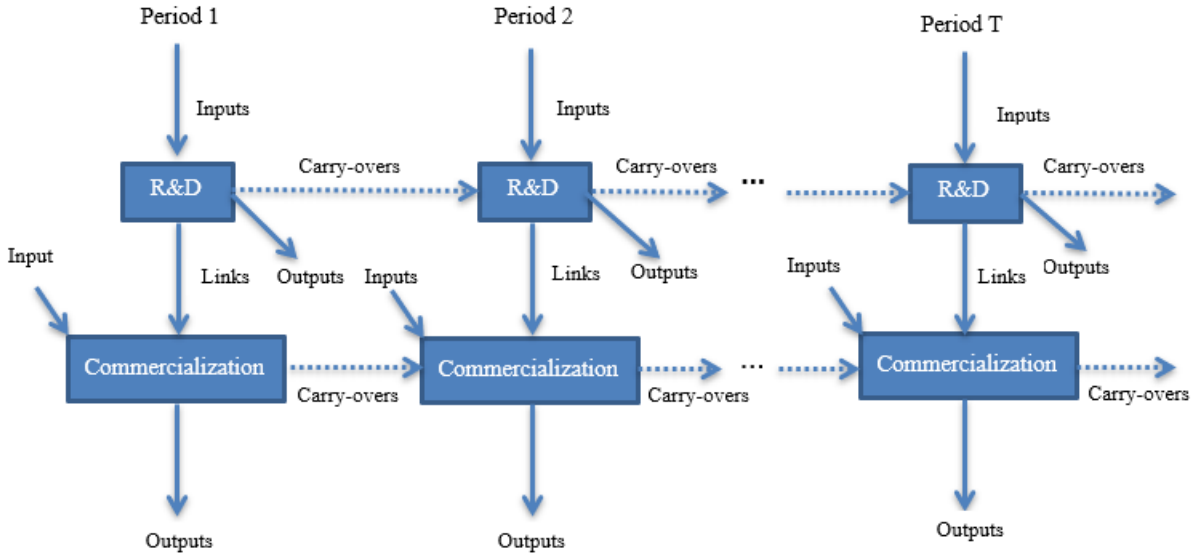
Table 2.6 Description, Strengths, and Weaknesses of the Enterprise Innovation Performance Model

Description	Strengths	Weaknesses
Knowledge Value Chain model with knowledge activity, input, output; integrates edge and cloud computing; includes optimisation algorithms (e.g., DABC).	Strong focus on knowledge management and technology adoption; cloud computing enables big data handling; optimisation algorithms improve efficiency.	Requires advanced ICT infrastructure, limiting SME adoption; mainly suited for large firms; flexibility and generalisability need further research.

2.5.7 Dynamic Network Slacks-Based Model (SBM)

Wang and Ren (2022) presented the Dynamic Network Slacks-Based Model (SBM). This model is used to measure efficiency in green technology innovation in many industries, including construction. This model encompasses the innovation process's dynamic characteristics and the structure of the network between research and development (R&D) and commercialisation. This method facilitates the measurement of overall, intertemporal, and divisional efficiency of green technology innovation in longitudinal studies. The tool uses multiple variables to measure the input and the output, such as environmental pollutants like CO2 emissions, PM2.5 concentrations, and SO2 emissions as unwanted outputs. This measurement model has been used to evaluate the efficiency of green technology innovation in 30 provinces of China during the period from 2012 to 2019 (Wang & Ren, 2022).

Figure 2.7: Dynamic Network Slacks-Based Model (SBM) (Wang & Ren, 2022)



The Dynamic Network SBM model is a comprehensive framework since it takes the dynamic nature of innovation activities into consideration. It measures efficiency during multiple periods of time instead of just measuring one single year. The value of this model is that it measures both R&D and commercialisation aspects and therefore reflects the full cycle of innovation, starting from knowledge creation to market impact. The model considers environmental pollutants as unwanted outputs and measures the economic and environmental impacts of innovation. This makes the tool relevant for assessing sustainable development.

The model has a high reliance on large data, such as data on emissions. This information is not easily collectable, and as a result, the applicability of this model becomes limited. Since innovation culture is different in various locations and regions, the model might not be able to capture these characteristics. Previous use of this measurement tool has demonstrated great locational differences in results. This itself is rooted in socio-economic disparities, which are not fully captured by the model (Wang & Ren, 2022). The complexity of this model, especially the need for measurement of intertemporal and divisional efficiency, will pose challenges for smaller companies or regions which do not have the required infrastructure or the expertise necessary for such detailed analysis.

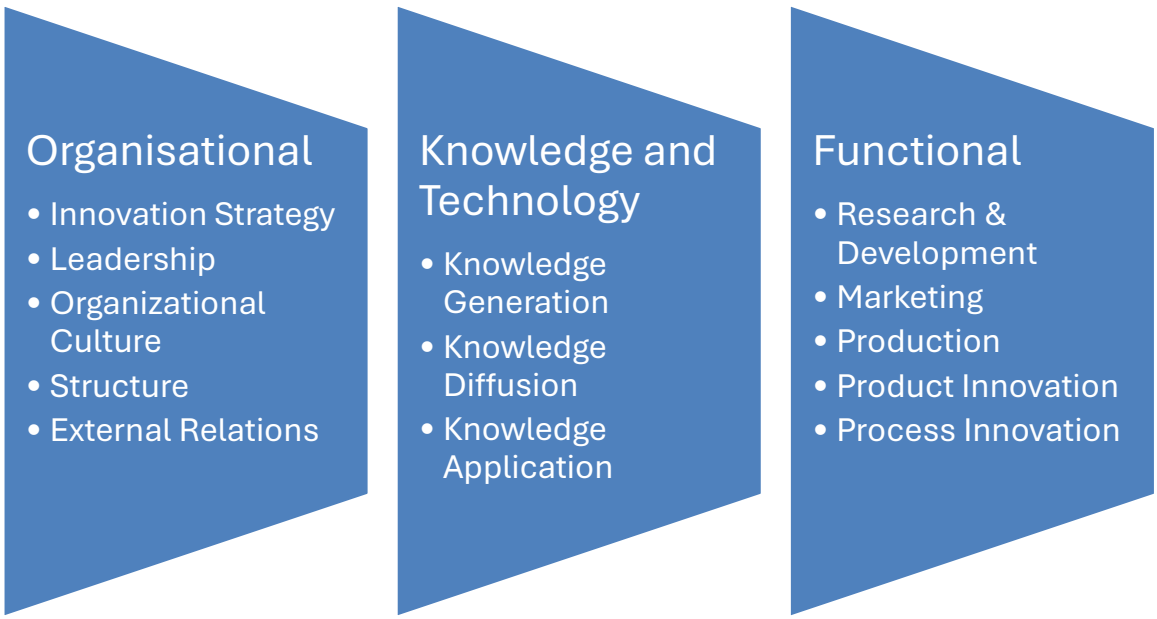
Table 2.7 Description, Strengths, and Weaknesses of the Dynamic Network Slacks-Based Model

Description	Strengths	Weaknesses
Measures efficiency of green technology innovation; covers R&D to commercialisation; includes pollutants (CO_2, PM2.5, SO_2) as unwanted outputs.	Captures dynamic, multi-period innovation efficiency; evaluates both economic and environmental impacts; comprehensive across R&D and commercialisation.	Data-intensive (emission data required); limited in regions lacking infrastructure; socio-economic disparities not fully captured; complex for smaller firms.

2.5.8 Innovation Capacity (IC)Index

The Innovation Capacity (IC) Index is a tool that can measure the capacity of the company for innovation within small and medium-sized enterprises (SMEs) in the metal-mechanical sector. This index investigates three main dimensions: Organisational, Knowledge, and Functional. These dimensions are defined through elements which together define the capacity or potential of the companies to innovate. Each dimension is assessed by using specific variables which evaluate indicators such as innovation strategy, leadership, organisational culture, research and development and production capacity. The average value of IC for the SME that were investigated was between 36.1 to 100. This demonstrates different levels of potential or capacity for innovation amongst companies (Carrillo et al., 2024).

Figure 2.8: Innovation Promotion Model (Carrillo et al., 2024)



The Innovation Capacity Index presents a holistic evaluation through investigating numerous dimensions of innovation (organisational, knowledge, and functional). By doing this, a comprehensive view of the company's innovation capability can be reached. Focusing on

internal and external management of knowledge through the knowledge dimension provides results on important aspects of SME's knowledge acquisition and utilisation for the purpose of innovation. The functional dimension, which has indicators focusing on product and process innovation, successfully measures the potential of SMEs for developing new products and enhancing their existing processes, further resulting in the company's overall innovation capacity.

Differences in the innovation capacity scores between different SMEs indicate that smaller and less older companies might find it harder to improve their innovation capacity. This is because of their limited resources for planning and knowledge management. This, in turn, demonstrates the model's limitations for supporting new businesses. Since IC focuses mainly on the metal-mechanical sector, its applicability to different industries is limited and necessitates changes to make it adaptable to other industries (Carrillo et al., 2024). The model largely relies on internal indicators such as organisational structure and leadership, and this might underplay the value of external environmental influences, such as market demand, regulatory changes, or competition, that are important for innovation, especially inside SMEs. The tool has less focus on sustainability, while this is important in recent innovations. The IC index does not measure environmental or social sustainability aspects of the company's innovations. This, in turn, is considered to be a negative issue, especially for companies with futuristic and global perspectives.

Table 2.8 Description, Strengths, and Weaknesses of the Innovation Capacity Index

Description	Strengths	Weaknesses
Measures innovation capacity in SMEs (metal-mechanical sector) across three dimensions: Organisational, Knowledge, and Functional.	Holistic assessment of organisational, knowledge, and functional innovation; strong on product/process innovation; evaluates SME potential comprehensively.	Smaller/newer firms disadvantaged by limited resources; sector-specific (metal-mechanical); underplays external influences (market demand, regulation, competition); limited sustainability focus.

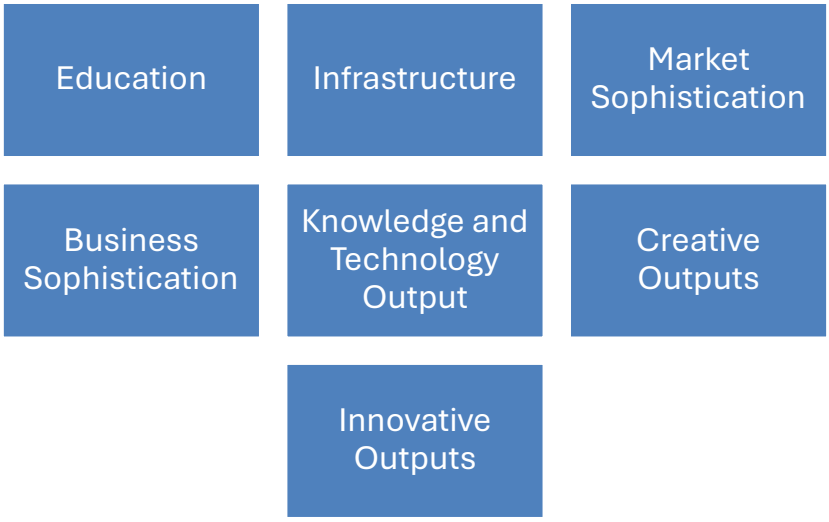
2.5.9 Comprehensive Innovation Measurement Tool at farms

Farsani et al. (2024) presented a paper on the Comprehensive Innovation Measurement Tool developed for measuring innovation on farms in Iran. Their tool was based on the OECD Global Innovation Indices as the initial basis for their research. The tool has 90 items across 7 dimensions for measuring innovation. The dimensions include:

1. Education: Measuring farmers' education and training level relevant to technology and innovation.
2. Infrastructure: Focusing on the use of Information and Communication Technology (ICT) and the relevant tools.
3. Business Sophistication: Evaluating the types of inputs used. This includes machinery and farming techniques.
4. Market Sophistication: Assessing access to credit for modernising the farm and input procurement.

5. Knowledge and Technology Outputs: Measuring productivity relevant to production factors and the use of technology.
6. Creative Outputs: Capturing trademarks and patents that are generated by farms.
7. Innovative Outputs: Includes product, process, and marketing innovation, measuring how farms adopt new products, processes, and marketing strategies (Farsani et al., 2024).

Figure 2.9: Innovation Promotion Model (Farsani et al., 2024)



The Comprehensive Innovation Measurement Tool focuses on local traits of the agricultural industry and attempts to document changes to the farm-level practices. The tool encompasses multiple dimensions ranging from technological infrastructure to market sophistication, which makes it a comprehensive framework for the measurement of innovation. Its focus on education and training helps cover the gaps in knowledge and skills as essential necessities for agricultural innovation.

On the other hand, the model relies heavily on the availability of infrastructure such as ICT. This is something that might not always be within reach, especially in rural or less developed areas, and this factor will reduce the applicability of the tool. Since the tool focuses on farm-specific innovation, it might not take external factors such as governmental policies or market conditions into consideration. Altogether, the model's design for agricultural innovation limits its application in other sectors.

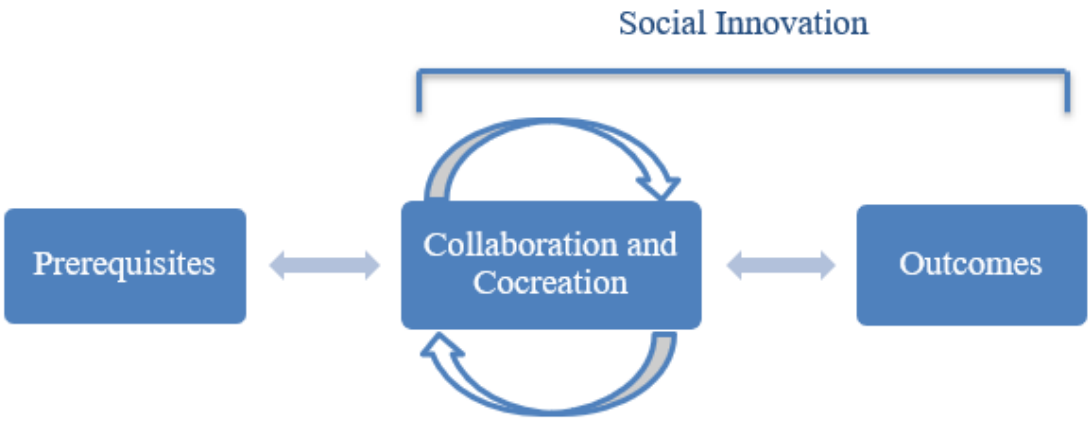
Table 2.9 Description, Strengths, and Weaknesses of the Comprehensive Innovation Measurement Tool at the farms

Description	Strengths	Weaknesses
90 items across 7 dimensions: Education, Infrastructure, Business Sophistication, Market Sophistication, Knowledge & Technology Outputs, Creative Outputs, Innovative Outputs.	Comprehensive, covering education, ICT, markets, and outputs; addresses knowledge/skills gaps in agriculture.	Heavily reliant on ICT infrastructure; sector-specific (farming); limited transferability to other industries; overlooks broader policies and market conditions.

2.5.10 Social Innovation Measurement Model Questionnaire (SIMM-Q)

Ødegård et al. (2021) in their paper discussed the Social Innovation Measurement Model Questionnaire (SIMM-Q). This model is designed to measure social innovation at the micro-level, mainly for the health and social care sectors. The model concentrates on relational aspects of the innovation process. Its main focus is on aspects such as collaboration and co-creation amongst stakeholders. The SIMM-Q was created to measure perceptions on innovation and emphasise how different professionals behave and have input towards the process of innovation. The model has 4 phases: brainstorming, decision-making, pilot testing, and testing the final version (Ødegård et al., 2021).

Figure 2.10: Social Innovation Measurement Model Questionnaire (SIMM-Q) (Ødegård et al., 2021)



The SIMM-Q model addresses a large gap in the innovation research field and focuses on social innovation at the micro-level. The tool provides a quantitative approach for measuring innovation, which is an area usually dominated by qualitative research. Through collaboration and co-creation, the SIMM-Q develops useful information on the drivers of innovation. These data are crucial for understanding the innovation process for industries that have stakeholders engaged, such as construction. The model also emphasises responsible innovation and ethical and society-related issues during the innovation process and even promotes sustainability.

Since the tool focuses on health and welfare services, this limits its broader application inside other industries like manufacturing or construction due to the differences in their nature. In addition, this tool is developed for social innovation, which makes it less useful for technological and product-based industries' innovations. These industries will require different metrics for the measurement of their innovations. The SIMM-Q is also effective for small-scale, micro-level studies, and its use is limited in larger, more complex innovation environments with many stakeholders and complicated collaboration schemes, like construction.

Table 2.10 Description, Strengths, and Weaknesses of the Social Innovation Measurement Model Questionnaire

Description	Strengths	Weaknesses
Four phases: brainstorming, decision-making, pilot testing, final testing; focused on health and social care sectors.	Provides quantitative approach to social innovation; emphasises collaboration, co-creation, ethics, and sustainability; fills gap in social innovation measurement.	Limited applicability outside health/welfare; not suited for technological/product innovation; designed for small-scale studies, less effective in complex industries like construction.

2.5.11 Global Innovation Index (GII)

The Global Innovation Index (GII) is a framework for measuring and comparing innovation indicators in different countries. The tool has 78 indicators classified into 7 pillars: Institutions, Human Capital and Research, Infrastructure, Market Sophistication, Business Sophistication, Knowledge and Technology Outputs, and Creative Outputs. These pillars cover a wide range of factors which can impact innovation. The results offer useful insights into the strengths and weaknesses of innovation processes and environments around the world (WIPO, 2024).

The indicators of GII can capture the inputs and outputs of innovation. The input pillars are: Institutions, Human Capital and Research, Infrastructure, Market Sophistication, and Business Sophistication, which measure the resources, systems, and conditions which facilitate, support and enable innovation. As an example, companies study their governance, legal frameworks and their interaction with laws to investigate their own quality and stability. Education, R&D expenditure, and research talent availability are investigated under human capital and research. ICT accessibility, ecological sustainability, and general infrastructure development are investigated under Infrastructure. Availability of credit, venture capital, and trade conditions is investigated under market sophistication. The role of knowledge workers, innovation linkages, and firms' ability to absorb knowledge is investigated through the business sophistication pillar (WIPO, 2024).

The output pillars are: Knowledge and Technology Outputs and Creative Outputs. They focus on the outcome of the innovation endeavours. These efforts encompass events such as patents, technological advancements, and the creation of cultural and creative goods (WIPO, 2024). For instance, the creation and diffusion of knowledge through metrics like patents and high-tech exports is investigated by the knowledge and technology outputs pillar, while intangible assets, creative goods and services, and online creativity are studied through the creative outputs pillar.

The GII covers a wide range of indicators and merges both qualitative and quantitative data. This allows a comprehensive study on innovation measurement. Through collecting data from different countries, the GII is a strong measurement tool that demonstrates the ability of the object under study to innovate. Pillars such as Institutions and Market Sophistication emphasise on the innovation’s systematic nature and highlight the value of governance, funding availability, and market conditions. The GII emphasises the creative economy and acknowledges the role of cultural and intangible assets in supporting innovation.

Although GII is useful for comparing innovation systems in different countries, unfortunately, it does not provide analyses specific to sectors. For example, in construction, known for its unique characteristics, the GII's indicators cannot collect data on novelty. The GII focuses more on traditional innovation outputs like patents and publications. In industries like construction, where innovation happens through improvements in processes or collaborative activities, the GII's metrics cannot adequately show actual innovation results. In addition, cumulative national data cannot address regional characteristics and dynamics specific to each industry. Especially for small countries like New Zealand, the GII might not correctly demonstrate the unique challenges and potential that the construction industry has within. The GII's indicators mainly focus on tangible outcomes and do not sufficiently focus on potential for innovation, which is crucial for understanding innovation inside the construction industry.

Table 2.11 Description, Strengths, and Weaknesses of the Global Innovation Index

Description	Strengths	Weaknesses
78 indicators in 7 pillars (Inputs: Institutions, Human Capital, Infrastructure, Market & Business Sophistication; Outputs: Knowledge & Technology, Creative Outputs).	Comprehensive global benchmarking; merges qualitative & quantitative data; strong focus on institutions, markets, and creative economy.	Not sector-specific (e.g., construction overlooked); overemphasis on patents/publications; ignores process/collaborative innovations; national-level data masks regional/industry dynamics; less effective for small economies like NZ.

2.5.12 Oslo Manual 2018

The Oslo Manual, published by the Organisation for Economic Co-operation and Development (OECD) in collaboration with Eurostat, is a globally recognised guide for the collection, reporting, and use of innovation data. It was first developed in the year 1992 and later revised multiple times. The latest edition was published in 2018 and aims to improve the measurement of innovation by embedding improvements in methodologies and extending its use across various sectors, including businesses, governments, and nonprofits. The manual provides a comprehensive framework for understanding innovation activities, focusing on their implementation, diffusion, and impact (OECD/Eurostat, 2018). The manual defines innovation as a "new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users or brought into use by the unit (process)" (OECD/Eurostat, 2018, p. 246). This broad definition allows the framework to encompass both technological and non-technological innovations.

Unlike previous editions, the 2018 Oslo Manual (OECD/Eurostat, 2018) extends its framework to all sectors of the economy, including households and non-profits, while it maintains a focus on business innovation. It discusses product innovations (defined as new or improved goods or services) and process innovations (known as improvements in methods of production or delivery). The manual focuses on understanding the important factors which affect innovation, for example, organisational capabilities, workforce skills, and external conditions like market

competition and government support. The manual addresses advances in digitalisation, data linkage, and survey design.

The Oslo Manual is a strong framework for measuring and investigating innovation systematically, while integrating input indicators (e.g., investment in R&D, human resources) with output indicators (e.g., patents, productivity growth). By agreeing on standard definitions and methodologies, the manual allows comparisons across the country. This trait makes the tool essential for benchmarking innovation performance nationally. The tool's inclusion of non-technological innovations and the focus on every economic sector reflect the manual's practicality in different contexts, including industries such as construction, which rely largely on organisational and process innovations. The manual is consistent with global policy programmes, for example, the Sustainable Development Goals (SDGs). It also develops insights for the design and evaluation of innovation policies.

Although the tool is comprehensive, it does not provide sector-specific measures that are tailored specifically to industries like construction. The manual prioritises quantitative indicators such as R&D expenditure and patent counts, which don't fully measure non-conventional innovations, like process improvements or collaborative practices, which are common and dominant in construction. The tool's need for advanced means, such as data linkage and digital tools, requires resources which is not at reach for small economies or for organisations with limited technical or technological ability.

The Oslo Manual 2018 (OECD/Eurostat, 2018) provides a basic framework for studying innovation, but it does not have the level of detail required for addressing the unique needs of construction. For instance, while it emphasises organisational elements and external conditions, it doesn't clearly take note of indicators such as client-driven demand for innovation, which are vital for measuring the potential for innovation and innovation outcomes. While the Oslo Manual is a nice tool for measuring and further investigating innovation at the macro level, its applicability to sector-specific matters is limited. For holistically reviewing innovation in the construction industry, a detailed and tailored framework that merges the principles of the Oslo Manual (OECD/Eurostat, 2018) with sector-specific traits is extremely necessary. This tailored tool will allow a much more accurate and practical assessment of innovation performance and will address gaps in the already existing frameworks.

Table 2.12 Description, Strengths, and Weaknesses of the Oslo Manual 2018

Description	Strengths	Weaknesses
Global guideline for innovation measurement; broad definition covering product & process innovations; integrates input/output indicators; applicable across sectors.	Provides a systematic, comparable framework; includes non-technological innovation; policy-relevant; consistent with SDGs; allows benchmarking.	No sector-specific indicators; emphasis on R&D/patents excludes non-conventional innovations (common in construction); resource-intensive (data linkage, digital tools); lacks detail for construction-specific client-driven demand.

2.6 Summary of Weaknesses of Existing Innovation Measurement Frameworks, Tools, and Models

Many innovation measurement frameworks and models have been developed for different industries, and each offers different ways to support and investigate innovation. However, these tools each come with their unique limitations, especially if applied and used in environments like the construction industry.

The Innovation Process Model, which has been adapted from the Software Development Life Cycle (SDLC) (Mishra et al., 2020), benefits from a systematically managed approach for the development of technology inside the materials sector of the construction industry. Although this model does provide clarity resulting from its staged approach, it still struggles to keep momentum during the long development cycles, which are typical for civil engineering projects. In addition, the tool's emphasis on larger companies comes with barriers for smaller firms, which might be disadvantaged due to the model's complexity and scale, needing many resources and attention.

Similarly, the Enterprise Innovation Performance Model (based on the Knowledge Value Chain, or KVC) (Tian & Wang, 2022) showcases the value of managing knowledge and utilises advanced methods such as edge-cloud computing. On the contrary, the need for complex resources could limit the tool's benefit for smaller companies, which usually don't have the necessary resources to adopt such systems. The model's complex nature and dependence on larger firms restrict its practicality even further for smaller companies.

The Simons' Levers of Control (LoC) Framework (Ruiter et al., 2022) is another model with easily noticeable weaknesses. While the model tends to support innovation by implementing management control systems, its Diagnostic Control Systems cannot measure the evolving traits of innovations focused on sustainability. This is a consequence of the limitations of predefined and rigid indicators. In addition, the framework's dependence on joint cooperation amongst multiple organisations will be hard to coordinate, especially while wanting to synchronise the objectives, processes and strategies of numerous stakeholders. This trait makes the successful implementation of the model dependent on strong collaboration, and this collaboration is not always achievable.

In the housing construction sector, the Conceptual Framework for Innovation Building Technologies (IBTs) (Mlasi & Mahachi, 2023) is a comprehensive approach which merges and benefits from customer and engineering inputs. However, the framework's strong need for information input from the customer limits the tool's practicality wherever customer input is unavailable or does not bring technical depth. Additionally, the framework's foundation being built on South African legal frameworks and environments makes it even less useful for other regions, and its complexity will even cause barriers for its adoption by smaller construction companies with low resources.

The Dynamic Network Slacks-Based Model (SBM) (Wang & Ren, 2022), which collects data on the efficiency of green technology innovation, also has its own range of challenges. The model depends heavily on the collection of large amounts of data, for example, data on emissions, and this reliance makes it extremely hard to apply in places that lack strong infrastructure for data gathering. Also, the model does not sufficiently take notice of regional

disparities within the innovation environment, which further leads to differences not being captured by the model.

Similarly, the InnovationOne Framework (Dobni & Wilson, 2024), tries to measure and contribute toward the management of innovation culture inside organisations. Although it does offer a multi-dimensional perspective for fostering innovation, the framework's effectiveness is extensively reliant on the commitment of the leadership and the amount of resources, which some firms lack. In addition, the industries that focus more on technical innovation or innovation driven through products might possibly find the framework's focus on cultural issues less necessary. Also, the framework's view on long-term and strategic issues will probably not be a priority for companies looking for quick gains through innovations.

The Innovation Promotion Model (Fernando et al., 2021), which is developed specifically for projects in the construction industry, focuses on client-driven enablers such as idea harnessing and relationship enhancement. However, it is heavily dependent on the client for inputs, and as a result, it may not sufficiently collect information in the various aspects and complexities of construction projects. In such construction projects, external factors like regulations and market conditions play a significant role that needs attention. Furthermore, the model relies largely on non-financial incentives, which will not be enough to motivate contractors for cooperation in financially competitive environments where monetary incentives are highly desired. The model's application is also limited to individual projects, which reduces its adoption for big construction programmes.

For the metal-mechanical sector, the Innovation Capacity (IC) Index (Carrillo et al., 2024) provides a holistic perspective on the capacity for innovation by investigating organisational, knowledge, and functional aspects of the case company under investigation. Negatively, its emphasis on internal traits like leadership and organisational structure neglects the importance of external issues such as market demand and competition, which are important for innovation. Additionally, the IC model does not have a strong focus on sustainability, while it is a necessary aspect for innovation in today's modern and competitive environment.

The Comprehensive Innovation Measurement Tool (Farsani et al., 2024), which was specifically developed for farm-level innovation within Iran, tries to measure a large number of activities related to innovation, but its use is hugely limited in the absence of infrastructure, like ICT, a resource that is not commonly available in isolated areas. Since the model focuses on innovations specific to the farms, its transferability and use are further limited for other sectors, and it needs vast modifications for adaptability and broader use.

The Social Innovation Measurement Model Questionnaire (SIMM-Q) (Ødegård et al., 2021) has proven itself to be useful for studying innovation inside the health and welfare sectors. However, it lacks broader usability in other industries, such as the manufacturing and construction industries. Its emphasis on social innovation at a small scale also limits its generalisability even further, causing it to be even less effective in larger and more complex environments attempting to innovate.

While the Global Innovation Index (GII) (WIPO, 2024) is useful and beneficial for national innovation ecosystems' comparisons, it shows great limitations when applied to unique sectors of the industry, such as construction. The GII cannot show analyses specific to the sector, which proves to be problematic in industries that have unique characteristics, such as construction. It tends to prioritise traditional innovation outputs, like patents and publications, and as a result,

cannot capture the process improvements and joint activities which are crucial for innovation in the construction industry. In addition, while gathering national data, regional differences and industry-specific dynamics and characteristics will be neglected, defining the tool as less effective to showcase the characteristics of smaller economies such as New Zealand. The GII also largely favours measurable outcomes and neglects important indicators of Innovation Potential, which are foundational for fostering and supporting innovation in construction.

While the Oslo Manual 2018 (OECD/Eurostat, 2018) provides a comprehensive framework for measuring and even analysing innovation systematically, it tends to show limitations when used for measuring sector-specific contexts, including the construction environment. Its reliance on generalised and standardised metrics across different contexts, for example, expenditure on R&D and counts of patent numbers, results in the non-traditional forms of innovation being left out. Indicators such as process improvements and collaborative practices are norms in construction. Also, the manual lacks attention to detail and does not take note of the unique problems inside the construction industry. This gap emphasises the need for a specifically tailored innovation measurement framework which has sector-specific indicators and is developed for better capturing the realities of innovation in the construction industry.

The following table presents a comprehensive comparison of the description, strengths and weaknesses of the existing frameworks, tools and models for measuring innovation:

2.7 The Gap in Innovation Measurement Literature

By critically analysing the already available innovation measurement frameworks, tools, and models, we find huge gaps, especially when applied to the construction industry. In spite of the numerous different approaches for support and measurement of innovation, these methods and tools usually fail to comprehensively address the many complexities of the construction sector, which are unique challenges. These matters represent a clear gap in the previous literature and show the need for the development of a comprehensive tool for innovation measurement, which is tailored specifically for the construction industry.

One of the most important matters is that a lot of the already existing models, like the Innovation Process Model (Mishra, Yu, & Leung, 2020) and the Enterprise Innovation Performance Model (Tian & Wang, 2022), are developed by having larger organisations in mind, which usually need high-tech and modern infrastructure and many resources. These models, which are adapted from industries which have different dynamics during their operations, cannot be useful for the smaller or more regionally scattered construction companies, which in fact dominate the majority of the sector. As an example, the Innovation Process Model (Mishra, Yu, & Leung, 2020) heavily depends on structured phases for the development of technology, while, on the contrary, its long development cycles and its focus on large-scale projects make it less useful for smaller construction companies, which require more agile and adaptable frameworks. In another example, the Enterprise Innovation Performance Model (Tian & Wang, 2022) focuses on knowledge management with the use of cloud-based technologies, which, in fact, a lot of the smaller construction companies might not have the resources to implement. This matter results in a large part of the construction industry not having the necessary tools to measure and look after their innovations.

Another example of major limitations of existing tools is their unique focus, such as Simons' Levers of Control (LoC) Framework (Ruiter et al., 2022) and the Conceptual Framework for Innovation Building Technologies (IBTs) (Mlasi & Mahachi, 2023), as they are specially developed for specific industries or regional regulations. The IBT Framework (Mlasi & Mahachi, 2023), as an example, is largely dependent on South African building laws, which makes it extremely hard to use in other places with different legal and market situations. In construction, where, as we know, regional regulations and market dynamics vary significantly, a one-size-fits-all approach is impractical. This matter shows the need for a flexible tool for innovation measurement, which can be used in different regulatory environments within the construction sector.

In addition, models like the Dynamic Network Slacks-Based Model (SBM) (Wang & Ren, 2022), that attempt to study green technology innovation, heavily depend on detailed and sometimes hard-to-access information. In the construction industry, where data collection is usually achieved from multiple projects and stakeholders, the need for large data, such as data on emissions, limits the model's applicability. The construction industry needs a tool which can provide useful analysis results without large data requirements. This allows the tool to function well in environments where data collection resources are limited or fragmented.

The InnovationOne Framework (Dobni & Wilson, 2024) and the Innovation Promotion Model (Fernando et al., 2021) depict a different set of challenges from the construction sector. Both models focus on long-term strategic change and the development of an innovation culture inside companies. Although this is required for sustainable innovation, the construction industry's project-based nature and temporary works often necessitate immediate innovation results. The Innovation Promotion Model (Fernando et al., 2021) studies client-driven indicators, but in many of the construction projects, external factors such as changes to regulatory systems, innovation from contractors, and conditions inside the market play a more effective part than the construction client's effect. Also, a heavy need for commitment from the leadership and the need for incentives further limit the model's effectiveness. Construction teams mainly operate under time and cost pressures that actually do not align with such long-term strategies.

The Innovation Capacity (IC) Index (Carrillo et al., 2024), and other models, like the Comprehensive Innovation Measurement Tool for Farms (Farsani et al., 2024), further demonstrate the large difference and incompatibility between innovation measurement tools in other industries and the specific needs of construction. These models often neglect external market indicators of innovation, for instance, competition and regulatory changes, that are vital in construction. In addition, they do not focus on sustainability, which is an increasingly important aspect of innovation in construction. Recently, green building practices and environmental considerations have become a necessity. The construction industry needs a tool that adopts sustainability metrics together with traditional innovation indicators, and allows companies to measure their innovation performance in line with environmental goals.

Although models like the Social Innovation Measurement Model Questionnaire (SIMM-Q) (Ødegård et al., 2021), are effective in sectors similar to health and welfare, they are not consistent with the unique challenges faced in construction. For example, in construction, technological innovation and process-based innovations are needed more than the social innovations, which are the focus of these models. The construction industry requires a tool which can integrate and benefit from both technical and process-based innovation

simultaneously. This method will support important matters of innovation unique to construction projects.

The Global Innovation Index (GII) (WIPO, 2024) and the Oslo Manual (OECD/Eurostat, 2018) each present comprehensive frameworks for measuring and further analysing innovation. The GII uses 78 indicators, which are categorised into seven pillars, and cover inputs and outputs of innovation. The Oslo Manual provides extensive guidelines to be used amongst sectors, also businesses, governments, and non-profit organisations. This is while huge gaps are present in both frameworks if required to address the needs of specific sectors, especially the needs of the construction industry, as this research is concerned with. The GII relies on historically common output indicators of innovation, like patents and publications, and the Oslo Manual similarly has its emphasis on quantitative metrics such as company expenditure on R&D. Such processes for innovation measurement can't capture the non-traditional ways of innovating, which have become more common in construction. Examples of these recent types of innovation are improvements in processes, collaborative practices, and sustainability-driven advancements. Also to mention, both frameworks neglect to focus on the special traits of the construction industry, such as project-based work, fragmentation in its supply chain, and client-driven requests for innovation. The focus on nationwide data in the GII and the generalist and standardised method of the Oslo Manual also tend to neglect regional differences and don't address important aspects which are crucial for innovation in construction. These gaps define and emphasise the need for a tailored framework that merges the strengths of innovation tools such as GII and the Oslo Manual and is further capable of accounting for sector-specific traits to strongly assess and measure not only Innovation Potential but also realised innovation outcomes within industries like construction. This is even more necessary in particularly smaller economies such as New Zealand.

2.8 The Need for a Comprehensive Innovation Measurement Tool for the Construction Industry

Given these limitations, there is a clear need for a comprehensive innovation measurement tool specifically tailored to the construction industry. This tool must address the sector's unique characteristics, such as project-based work, multiple stakeholders, and the integration of both technological and process innovations. A comprehensive tool should:

- Be scalable, ensuring that innovation measurement is inclusive and adaptable to the varying sizes and structures of construction companies.
- Be specific to the sector and designed with the construction industry in mind. In addition, remaining flexible enough to be applied to different legal environments and market situations across different locations.
- Provide short-term and long-term innovation metrics, allowing for immediate feedback on innovation while also fostering sustained innovation over the course of longer-term strategies.
- Use sustainability metrics together with traditional innovation measures. This will enable construction companies to track not just their economic innovations, but also to their contributions to environmental preservation deeds, like reducing carbon emissions and adopting building technologies that are green and sustainable.

- Be adaptable to fragmented environments when collecting information, in an attempt to provide useful findings even at times when data collection is happening across multiple project cases or even regions, and ensure that innovation can be measured meaningfully and usefully without the need for relying on extensive sets of data.
- In addition to the abovementioned, the tool needs to be adaptable to the ever-changing nature of the construction industry, which often involves various projects in different scales, regulatory conditions, and market necessities. An adaptable tool would allow construction companies to modify the framework accordingly to the project needs or the contexts of the region. The tool will still be demonstrating a consistent approach in innovation measuring. This flexibility will support the tool for being useful in different types of construction projects, whether small-scale residential developments or large infrastructure projects. The tool will also accommodate the ever-increasing technological and environmental necessities of the industry.
- The tool is required to be comprehensive and holistic, to be able to capture the full array of innovation activities happening inside the construction industry. A holistic tool needs to merge technological, process-based, and organisational innovations in an attempt to ensure that all aspects of innovation are effectively measured. It must encompass not just product innovations but process improvements as well, to mention collaborative practices, and managerial-related matters that contribute to the success of the projects. Through facilitating a holistic view on innovation, the tool allows the construction companies to assess their performance regarding innovation, thereby reflecting the complex relations within their operations, to ensure that no critical areas are actually overlooked.

The development of a tool with the mentioned details not only fills a large gap in the currently existing literature but also provides beneficial results for the construction industry and potentially enables companies to meticulously assess and even improve their innovation capabilities. By concentrating on the special necessities of the construction sector, this comprehensive tool potentially presents a unified framework which improves performance in the area of innovation, supports collaboration, and is in line with the existing market demands and required sustainability goals.

2.9 Attributes affecting potential for innovation

Knowing the influential matters that impact an organisation’s potential to innovate is highly essential for fostering a culture that fosters creativity, adaptability, and continuous improvement. These attributes are across various dimensions. By identifying and analysing these important attributes, organisations can strengthen their position to improve their innovative capabilities, align with industry trends, and effectively respond to the demands of the market. A good understanding of these attributes is very important for New Zealand's construction sector. We need to bear in mind the unique challenges of geographic isolation, market size, and legal context. The following parts of this thesis explore the range of crucial attributes that define an organisation's potential for innovation and keep a focus on their relevance and implications for medium and large companies in New Zealand.

2.9.1 Adaptability and flexibility

Adaptability and flexibility are increasingly vital for innovation in the construction industry, as they enhance competitiveness and sustainability within the organisations (Ni et al., 2020). These attributes allow organisations to adjust according to technological changes and demands from the market (Abankwa et al., 2020). Flexibility within the organisations has a positive effect on competitiveness, with innovation taking on a mediating role (Ni et al., 2020). Adaptability in the construction of buildings leads to less use of resources for construction and less waste, while barriers to its adaptation do exist (Mlote et al., 2024). The AgiBuild framework, which is inspired by agile methodologies, is a very promising method for projects focused on building adaptation, and emphasises focus on the user while being adaptable (Ng et al., 2023). Assessing how adaptable the management systems are is essential for effective innovation inside construction organisations (Novykova et al., 2022). Overall, adaptability and flexibility are amongst the drivers of innovations in the construction sector.

2.9.2 Autonomy

Autonomy plays a huge part in fostering innovation inside organisations. Workers' autonomy positively impacts innovation (Adegbite et al., 2020), while additionally, job autonomy is positively correlated to innovative work behaviour from the employees (Putri & Prastika, 2024). Autonomy develops creativity, learning, and knowledge sharing among employees, further resulting in better performance in the job and more empowerment, eventually allowing innovation capability (Huu, 2023). Autonomy supported by leadership improves employees' innovative behaviour and individual creativity, which is also an influential element (Slåtten et al., 2020). It is important for the organisations to prioritise autonomy through facilitating the use of digital tools, training, and providing a supportive working environment (Huu, 2023). However, we also need to note that, as observed in some industries, autonomy might not always impact innovation (Adegbite et al., 2020).

2.9.3 Career Development

Training, skills and career development opportunities

Research indicates that training can have positive effects on innovation, but the impact varies across different types of innovation and organisational contexts. On-the-job training and employee education levels are positively associated with various forms of innovation in emerging markets (Na, 2021). However, the relationship between initial vocational training and technological innovation in SMEs is generally weak, with stronger effects observed only in microenterprises when accompanied by organisational learning (Matthies et al., 2023). Training has been found to enhance improved product innovations and both new and improved process innovations, but not new product innovations (Cozzarin & Percival, 2021). The Clear Ideas innovation training model, designed to improve idea generation and implementation competencies, has shown promising results in enhancing innovation capabilities and leading to workplace innovations, particularly in the public sector (Birdi, 2020). These findings suggest that targeted training interventions can contribute to organisational innovation, but their effectiveness may depend on specific factors and contexts.

Research indicates that innovation plays a crucial role in career development across various sectors. Career experts see innovation in career development covering a wide range, encompassing everything from initiating services to cross-sectoral synergies (Kettunen, 2023). For the entrepreneurs, creativity and innovation are amongst the main drivers of career advancement, and contribute to sustainable economic growth (Janošik et al., 2023). Inside organisations, traits related to personality affect innovation climate in an attempt to affect career growth, with care and willingness to gain experience being very beneficial in contexts that are highly innovative (Jiang et al., 2021b). In addition, self-leadership can positively affect innovative career performance and development between members of the faculty, while professional development becomes a mediating factor (Valizade Azar et al., 2023). These findings reflect the importance of supporting innovation within different professional environments for the aim of enhancing career development and eventually organisational performance.

2.9.4 Client's Understanding

About their needs, desires and requirements.

Client's understanding significantly affects innovation in construction. Client's focus has an additional partial mediation impact on the relationship between innovation and financial performance of the construction companies (Yusof et al., 2021). Clients play an important part in promoting innovation, with their systems of control impacting contractors' innovation potentials (Järvenpää et al., 2024). The use of organisational systems for control by clients greatly impacts for innovation in construction projects (Järvenpää et al., 2022). Client organisations are key to driving construction innovation, especially in the use of Building Information Modelling (BIM) and supporting flexibility in projects (Lindblad & Guerrero, 2020). This is while, clients' low uptake of Modern Methods of Construction (MMC) is influenced by them not having confidence in MMC companies, which highlights a communication issue in the construction sector (Saad et al., 2023).

2.9.5 Collaboration

Amongst departments and employees

Collaboration helps foster innovation within the construction industry. Research found that collaborative innovation activities positively affect knowledge sharing and innovation performance in supply chains of the construction industry (Shi et al., 2022). Collaboration between organisations is important for the best use of innovation resources, also for reducing costs, and mitigating risks in green building technology development (Zhang et al., 2023a). Research studies show that collaborative networks existing during construction projects are complex systems that tend to replace traditional organisational structures, with key actors proving to be actually very influential in innovation management (Zhang et al., 2020b). Amongst the elements influencing collaboration are trust, management of project uncertainty, client's capability to operate, and business relationships (Garcia & Murguia, 2021). Adopting innovations like lean construction, digital technologies, and collaborative contracts is further supported by inter-organisational collaboration inside complex networks for supply chains.

Understanding and supporting collaboration is highly important for the improvement of the construction industry (Zhang et al., 2020b; Garcia & Murguia, 2021).

2.9.6 Commitment

from employees towards tasks and duties

Research indicates that organisational commitment and innovation are closely linked in various industries, including construction. Management commitment positively influences supply chain integration and innovation performance in SMEs (Chen et al., 2023a). Organisational factors of commitment to innovation have a positive impact on innovative behaviours in SMEs (Dzieńdziora et al., 2022). The regional knowledge environment also plays a role in firms' commitment to innovation (Holl, 2020). Green innovation recognition can enhance organisational commitment and engagement in environmental sustainability (Naruetharadhol et al., 2021). However, implementing innovation in construction faces obstacles (Klosova & Kozlovská, 2020). Supplier performance measurement systems can impact commitment and project performance in construction (Patrucco et al., 2020). Employee job satisfaction and perception of responsible downsizing also influence innovation commitment (Tsai & Yen, 2020).

2.9.7 Communication

Communication plays a crucial role in innovation and performance within the construction industry. Effective communication positively influences strategic innovation, decision-making speed, and overall project success (Ngiri & Njagi, 2022; Rahimnia & Molavi, 2021). It also helps address management challenges in transport facility construction and network management (Matveeva et al., 2020; Demchenko et al., 2021). This is while barriers for communication can result in conflicts and negatively affect the project's success (Malik et al., 2021). Adopting innovative technologies such as BIM, automation, and virtual reality can potentially improve communication and productivity; however, their actual implementation is usually weak inside the construction sector (Klosova & Kozlovská, 2020). Improving the flow of information amongst project participants is very important for optimising construction processes, as well as for reducing delays (Kania et al., 2020). Additionally, effective communication of safety matters, while supported by digital technologies, is extremely important for preventing accidents on construction sites (Musarat et al., 2021). Altigether, improving communication strategies is very crucial for driving innovation and for improving performance in the construction industry.

2.9.8 Competition

in the market

Competition in general has a positive impact on innovation within the construction industry, and this happens, although with a complex relationship. Competition pushes firms to innovate in order to maintain competitiveness and remain in the competition (Canare & Francisco, 2021; O'Leary et al., 2022). This is particularly important for process improvements and marketing

(Canare & Francisco, 2021). Innovation improves competitive ability and project success (Wahid & Syafwandi, 2020; Zhang et al., 2023). This is while strong competition can negatively impact innovation through reducing available resources for R&D (Okrah, 2023). Additionally, the relationship between competition and innovation is also mediated by factors such as sustainability practices (Zhang et al., 2024a), capabilities to manage risks (Afraz et al., 2021), and performance of the business (Farida & Setiawan, 2022). Factors such as environmental regulations can potentially moderate the impact of innovation on competitiveness (Zhang et al., 2024a). Also, competition that stems from political matters may negatively affect green innovation, particularly in non-OECD and middle or low-income countries (Yang et al., 2023).

2.9.9 Cognitive Abilities

in particular idea generation and reasoning abilities of the workforce

Cognitive abilities, especially abilities for idea generation and reasoning, are important workforce attributes that impact employee performance. These cognitive abilities, merged with adaptability and flexibility, greatly contribute to the organisation's innovation activities through allowing effective participation in problem-solving and innovative processes (OECD/Eurostat, 2018).

The following research highlights the huge impact of cognitive abilities on the innovations of the construction industry. Studies found that cognitive processes such as green thinking and engagement in creative processes mediate the relationship between leadership and green innovation (Begum et al., 2022). Cognitive abilities like problem-solving, decision-making, and critical thinking are very important for identifying problems and finding innovative solutions during construction projects (Shehab & Hamzeh, 2024). In addition, the format of engineering information largely affects the development of a good working memory and retrieval, further affecting task performance during construction operations (Shi et al., 2020). While research is continuously growing on the interrelation between construction ethics and innovation (Oladinrin et al., 2023), there is a need for more detailed research on the role of cognitive abilities in driving innovations within the construction industry.

2.9.10 Contracts

Current forms of contract

Research on the development of innovation in construction contracts has found a complex interplay amongst contractual mechanisms and collaborative practices. While rigid management on contracts by itself does not hugely impact performance or even innovation (Klijn et al., 2023), network management and collaboration are extremely necessary to overcome unexpected challenges during the life cycle of complex projects (Klijn et al., 2023; Callens et al., 2021). Public-private partnerships (PPPs) may potentially develop an environment for innovation prior to the contracts, but might even limit innovation after contracts as a result of risk constraints (Liu et al., 2024). The type of control systems used by clients largely impacts the possibilities for innovation, together with output control potentially making a positive influence (Järvenpää et al., 2024). The elements of contract design, for

example, payment structure and contingency planning, could impact innovative output in collaborations amongst different companies (Mayer et al., 2022). In addition, project innovation is to a great extent correlated with the success of the contractors (Langston, 2023), and this highlights the great importance of balancing innovation and risk management in the construction contracts.

2.9.11 Contractor's Expertise

Research shows that contractor expertise and innovation are highly related inside the construction industry's environment. Contractor's success is largely correlated with innovation, as innovative projects show positive improvements on efficacy, efficiency, and profit margins (Langston, 2023). The special traits of the organisation, including the type of construction they are involved in, and professional affiliations, positively affect the construction industry's innovation (Weng et al., 2020). Innovation capability mediates the relationship between radical innovation and business performance in construction companies (Yusof et al., 2023). Collaborative procurement management can improve a project's innovation process and overall performance (Sayyed et al., 2021). However, eco-innovation adoption among contractors remains moderate, with technology being a crucial factor in driving implementation (Isa & Abidin, 2021). Accurate bid evaluation and contractor selection are critical for successful project outcomes and innovation (Oad et al., 2021). Accumulation of intellectual capital as an expertise is significant for a firm's competitiveness and innovation (Duodu & Rowlinson, 2021a). Ethical considerations in adopting innovations are gaining attention, though research on ethics and innovation in construction remains largely disconnected (Oladinrin et al., 2023).

2.9.12 Creativity

Creativity and innovation play crucial roles in the construction industry's development and productivity. Project managers' creativity, influenced by tacit knowledge sharing and emotional intelligence, significantly contributes to project success (Almashhour et al., 2024). Situated creativity emerges when project teams confront contextual complexities and move beyond routine practices (Lowe & Chiu, 2020). While technological advancement supports creativity and innovation, its direct effect on entrepreneurship development may not be significant (Juliana et al., 2021). Building the ability to be creative among civil engineering students is highly important for them to be capable of dealing with innovation challenges during construction projects (Zheng et al., 2020). The creativity of the employee plays a big part in supporting innovation and performance in the construction industry. Similarly, entrepreneurial leadership positively affects creativity during projects through supporting innovation ambidexterity (Khairuddin et al., 2021). Leadership that is empowering and stress stemming from the job largely strengthens the relationship between employee creativity and innovation output, while, on the contrary, workplace politics negatively affects it (Dost & Al Qatiti, 2023). Different types of rewards, including intrinsic, extrinsic, non-financial, and financial, could potentially improve employee creativity and result in innovation (Mdhlalose, 2024). Organisational innovation, extrinsic rewards, and intrinsic motivation could together help improve the creativity of the employees, which subsequently affects the performance of the

company (Yamin, 2020). Overall, fostering employee creativity is essential for organisational innovation and success in the construction sector (Chaubey & Sahoo, 2022; Hussain & Wahab, 2021).

2.9.13 Design Capabilities

Design capabilities play a crucial role in fostering innovation within the construction industry. Innovation capability mediates the relationship between radical innovation and business performance (Yusof et al., 2023). The implementation of digital technologies, such as Building Information Modelling (BIM), requires changes in organisational processes and strategies to enhance innovation potential (Sreckovic, 2020; Liu et al., 2021). Dynamic design capabilities, including user-centred design and meaning innovation, are built by selecting designers with specific individual capabilities and managing user involvement (Cautela et al., 2022). Design thinking practices in R&D help develop organisational innovative capability, leading to improved innovative performance (Robbins & Fu, 2022). The development of capabilities like programmatic spatial cost modelling can enhance competitiveness in architectural planning (Berg et al., 2020). It is also important to consider that developing design and innovation capabilities inside the public sector requires strong commitment from the high senior management for overcoming organisational barriers (Langham & Paulsen, 2020; Bocken & Geradts, 2020).

2.9.14 Digital Technologies

Digital technologies are changing the construction industry, as they offer many benefits and create opportunities for innovation. Building Information Modelling (BIM) is largely believed to be a very useful technology, as it enables improvement in designs, constructions, and the management of projects (Khonchev et al., 2023; Chen et al., 2021). Other notable technologies include, but are not limited to, virtual and augmented reality, drones, 3D printing, and automation (Samarasinghe & Wood, 2021; Klosova & Kozlovská, 2020). Such technologies improve the productivity, efficiency, safety, and quality during construction processes (Aliu & Oke, 2023; Chowdhury et al., 2019). In spite of their potential, the adoption of digital technologies in construction has historically fallen behind other industries, and this has been the result of various barriers (Klosova & Kozlovská, 2020). This is while the governments and leaders of the industry are now more aware of the need for digital transformation with the aim of improving the sector's performance (Turkova et al., 2020). As the industry is continuously evolving, benefiting from these technologies in the whole process of the construction lifecycle will be very important for totally understanding their full potential and addressing challenges in the future (Chen et al., 2022).

2.9.15 Employee Performance

cost reduction, productivity, effectiveness

Recent studies have demonstrated the importance of employee performance and innovation on the construction industry. Employee satisfaction, engagement, and productivity are extremely important elements that influence innovation and organisational success (Hanif et al., 2021; Park & Rahmani, 2020; Johar & Roopalatha, 2024). Elements such as work-life balance, mental workload, and job satisfaction have a great impact on the worker's performance inside the construction industry (Prasetya & Natalia, 2020). Employee satisfaction, especially regarding career opportunities, improves companies' performance on innovation (Park & Rahmani, 2020). Practices requiring high performance at work, together with extensive training and rewards based on performance, positively affect employees' performance and even creativity as they build trust in management (Jalali et al., 2023). Considering all employees being innovative capital is necessary and vital for organisations in today's fast-paced business environment (Echebiri, 2020). To address challenges such as poor project performance, quality and innovation, construction companies must focus on improving employee performance by implementing different measures (Chauke et al., 2022).

2.9.16 Employee Recognition

Performance appraisals, promotion and employee recognition

Recent research highlights the significant impact of employee recognition on innovation in the construction industry. Employee recognition fosters innovative workplace behaviour through increased helping behaviour (Bécuwe et al., 2020) and enhances job embeddedness, knowledge sharing, and service orientation (Ampofo et al., 2023). Pride mediates the relationship between recognition and task performance (Yang et al., 2022). Ambidextrous leadership promotes innovation through knowledge sharing (Haider et al., 2023), while HRM practices support employee voice and engagement in innovation (Azevedo et al., 2021). Activity recognition positively affects job performance through change support behaviour and innovative organisational culture (Jin & Kim, 2022). However, ethical concerns in adopting innovations are growing, with limited intellectual exchange between ethics and innovation researchers in construction (Oladinrin et al., 2023). Cultural context also influences innovation propensity in small to medium construction enterprises (Lijauco et al., 2020). These findings underscore the importance of recognition and organisational culture in fostering innovation within the construction sector.

2.9.17 Entrepreneurialism

The following research highlights the significant impact of entrepreneurship on innovation in the construction industry. Entrepreneurial leadership and innovation are closely linked in the construction industry, with studies showing positive impacts on both product and process innovation (Hoang et al., 2022; Khairuddin et al., 2021). While entrepreneurial leadership enhances creativity in construction projects through innovation ambidexterity (Khairuddin et al., 2021), innovation-driven entrepreneurship, particularly in high-growth startups, is a key driver of economic growth (Botelho et al., 2021). To stay competitive, construction entrepreneurs must adapt to technological advancements and sustainable development demands (Jain, 2023). Entrepreneurialism positively impacts innovation performance in construction firms, particularly small and medium-sized enterprises (SMEs) (Hoang et al.,

2022; Hoang et al., 2021). This relationship is mediated by factors such as innovation strategies, knowledge acquisition, and market-sensing capability (Hoang et al., 2022; Hoang et al., 2021). Entrepreneurship and networking, which are aspects of management support, directly influence both technological and non-technological innovation in construction firms (Wang et al., 2023). Strategic entrepreneurship can drive firm growth through product innovation, as demonstrated in the Turkish housing market (Ertuğral & Acar, 2022). Enterprise dynamic capability and organisational innovation environment partially mediate the relationship between entrepreneurship and innovation performance (Cui & Song, 2022). Policy, finance, and management support moderate the impact of entrepreneurship on managerial innovation capacity (Jin & Lee, 2020). However, collaborative culture does not significantly moderate the relationship between entrepreneurialism and creativity in projects (Khairuddin et al., 2021).

2.9.18 Environmental Barriers

Environmental barriers significantly impact innovation in the construction industry. Regulatory frameworks and legal constraints can hinder the adoption of green technologies and digital transformation for eco-innovation (Yordanova, 2024; Zhang et al., 2020). However, effective environmental regulations can promote greener technologies and improve innovation efficiency (Zhang et al., 2021a). The industry faces challenges in data collection, complex modelling, and emission classification when assessing environmental impacts (Sandanayake, 2022). The way an organisation's employees behave and resistance towards change also cause barriers for the application of environmental practices (Sartipi, 2020; Yordanova, 2024). In spite of these barriers, investing in innovation for environmental sustainability can trigger positive reactions from the stock market (Duong et al., 2021). Implementing environmental management practices can also potentially help with dealing with cost and knowledge related barriers towards innovation (Pekovic & Bouziri, 2021). To deal with these challenges, the construction industry has to pay attention to practices that are innovative and sustainable, for example, materials which are efficient in their energy consumption, in their designs, and focus on the use of renewable energy sources (Almakayeel et al., 2023; Cruz et al., 2023).

2.9.19 External Grants

Rewards, awards, grants, funds etc.

External funding is very important for supporting innovations inside the construction industry. Government incentives and strategies, as well as subsidies and grants, may potentially reduce costs on green buildings (Alshboul et al., 2022) and even additionally support innovations aimed at sustainability inside affordable housing projects (Moghayedi et al., 2022). Grants on R&D could support external finances for technological innovation, and may reduce the companies' limitations for liquidity (Moon, 2022). Different sources for external financing, including traditional bank loans, international funds, and newer forms of financing such as crowdfunding, deeply affect innovation adoption in companies (İncekara, 2022). Government subsidies and venture capital impact the different parts of the innovation process, as subsidies are more effective at the beginning of the process and venture capital focuses more on the end of the innovation development process (Kou et al., 2020). In general, external grants and

mechanisms for finance are important for supporting innovation within different sectors of the construction industry.

2.9.20 External Involvement

External involvement greatly affects innovation in construction and even other industries. Collaboration with consultants from outside the organisation can foster innovation by the management and develop organisational traits in complex construction environments (Hu et al., 2022). The involvement of the customer and suppliers has a positive effect on the success rate of new product development, and is further moderated by the culture of the organisation (Yang et al., 2020). External technology experts contribute to innovative work behaviour in collaborative R&D projects (Schepers et al., 2022). Engagement with external stakeholders, including scientific partners, suppliers, and customers, increases firms' likelihood of eco-innovation (Acebo et al., 2021). Various external knowledge sources, such as customers, competitors, consultants, and workshops, enhance firms' innovation capabilities in developing countries (Medase & Abdul-Basit, 2020). Combining internal and external R&D activities positively affects innovation performance, particularly in family firms (Muñoz-Bullón et al., 2020). However, ethical concerns in adopting innovations in construction are growing, highlighting the need for further research on the interrelations between ethics and innovation (Oladinrin et al., 2023).

2.9.21 Finish Price Focus and 2.9.22 Quality Focus

This element is also emphasised by the (Oslo Manual, 2018). This report believes that the companies need to make a choice on whether they will have their focus and attention on price or quality. This decision will greatly influence their innovation strategy and activities. Companies that focus on quality will produce innovations that are new to the market, while companies that focus on price are likely to have processes that are highly efficient. Therefore, it is recommended to collect data on whether and to what extent companies focus on the price or the quality during their activities. Balancing quality and innovation management can be challenging due to potentially conflicting philosophies (Pinto & Romero, 2020). Quality management practices are seen as crucial for enhancing innovativeness (Kuncoro, 2021).

2.9.23 Finances

Financial constraints significantly hinder innovation and productivity in the construction industry (Chundakkadan & Sasidharan, 2020; Sánchez Rodríguez, 2020). However, digital inclusive finance can foster innovation in construction enterprises (Li & Cao, 2024). Technological innovation expenditure may initially negatively impact financial performance but can lead to long-term benefits (Lee et al., 2020). Client focus and company type influence the relationship between innovation and financial performance (Yusof et al., 2020). The construction sector has historically been weaker than other industries in adopting innovative technologies, which could help its productivity (Klosova & Kozlovská, 2020; Laszig et al., 2020). Government support positively correlates with innovation activities, especially for small

and medium enterprises (Chundakkadan & Sasidharan, 2020). To promote innovation, the industry needs to address structural problems, increase R&D funding, and change thinking to better integrate new technologies (Oborin, 2020; Klosova & Kozlovská, 2020).

2.9.24 Fragmentation

Fragmented nature of the construction industry

The construction industry faces productivity challenges due to fragmentation, and this consequently hinders innovation adoption and implementation (Laszig et al., 2020; Riazi et al., 2020). Fragmentation results in inefficiencies in knowledge distribution and collaboration amongst stakeholders of the project (Aditra & Ekomadyo, 2021). To address these matters, different innovative approaches have previously been introduced, including but not limited to collaborative planning, relational contracting, and integrated project delivery (Elsayegh & El-adaway, 2021). Client organisations have an important part in supporting innovation, but their methods can lead to tensions outside the organisation (Lindblad & Guerrero, 2020). The use of technological innovations, like BIM, automation, and robotics, is considered necessary for higher productivity (Klosova & Kozlovská, 2020). This is while the transfer of innovations in construction is affected by social and contextual matters, highlighting the need for a holistic approach to gain a good understanding of adoption processes (Wafai & Aouad, 2023). Improving the organisational capabilities that could impact innovation could potentially mediate the relationship between innovation and business performance inside the construction companies (Yusof et al., 2023).

2.9.25 Government

Governmental guidelines play an important part in supporting innovation in the construction industry. Research has found that governmental plans and initiatives can support the adoption of green technology (Li et al., 2022), the improvement of collaborative innovation in projects focusing on green buildings (Zeng et al., 2022), and even green innovation inside urban areas (Li et al., 2022a). Different policy instruments, such as tax incentives, infrastructure support, and environmental regulations, have impacts on the organisations' behaviour towards innovation (Zeng et al., 2022; Zhang et al., 2021). This is because the actual effectiveness of these policies differs, as direct government investment has the largest impact on innovations focused on green technology (Li et al., 2022a). Policies promoting innovative city constructions have demonstrated positive impacts on green innovation within urban areas (Li et al., 2022b). In spite of these efforts, the construction industry is still behind other sectors in innovation use and implementation (Klosova & Kozlovská, 2020). To improve on these issues, governments and firms collaborate and communicate to develop strong innovation strategies (Sergeeva & Winch, 2020). This is while collaborative strategies that involve governments, construction companies, and universities could strengthen and support innovations in robotics and automated construction (Yi & Hiroatsu, 2022).

2.9.26 High Costs

The high costs that result from innovations in construction can cause great barriers to the adoption and use of innovations. Research has proven that construction professionals usually see innovations as potential sources of failure and costs because of their certification costs and the need for higher pay for skilled workers (Er, 2020). The high costs associated with innovative technologies are always considered a big barrier to their application in the construction industry (van Wyk et al., 2024; Klosova & Kozlovská, 2020). In spite of the strong capability of new technologies for improving productivity, the construction industry is always behind other industries in adopting new tools and novel methods (Laszig et al., 2020). However, there is research that suggests innovation could positively affect the firm's performance and survival (López & Yepes, 2020; Oborin, 2020). Research results indicate that, interestingly, while transparency regarding costs can potentially be beneficial for companies running on high costs and even for overall industry innovation, it can potentially hinder firms running on low costs and eventually further limit their ability to innovate (Jiang et al., 2021a). Geographic proximity, further supported by improvements on infrastructure, can in fact also support corporate innovation (Zhang et al., 2020c).

2.9.27 In-house Sourcing

The impact of in-house sourcing on innovation in the construction industry is complex and vast. Supply chain innovation positively affects competitive advantage through risk management capabilities (Afraz et al., 2021). Inward-sourcing capability, transitioning from foreign to local sourcing, enhances technical upgrading and innovation in emerging economies (Zhou et al., 2022). External knowledge sourcing exhibits an inverted U-shaped relationship with innovation efficiency (Asimakopoulos et al., 2020), while supply network complexity has varying effects on innovation performance (Sharma et al., 2020). Client organisations play a crucial role in promoting innovation, particularly in BIM implementation (Lindblad & Guerrero, 2020). However, ethical concerns in adopting innovations are growing (Oladinrin et al., 2023). Sustainability-oriented innovations in affordable housing are influenced by both internal and external factors, with external challenges being key drivers (Moghayedi et al., 2022). Overall, balancing internal capabilities with external knowledge sources is essential for fostering innovation in the construction industry.

2.9.28 Incentives

Performance appraisals, promotion and employee recognition

Employee incentives play a crucial role in fostering innovation within organisations, including the construction industry. Research indicates that both financial and non-financial incentives can positively impact innovation outcomes (Cheung et al., 2024; Villani et al., 2024). Employee stock ownership plans have been shown to increase patent applications in energy firms (Si et al., 2020), while intrinsic and extrinsic rewards can enhance employee creativity and innovation (Mdhlalose, 2024). The combination of explicit incentives for knowledge exchange and implicit career incentives for distal search behaviour can effectively drive innovation (Speckbacher & Wabnegg, 2020). In construction, incentives can improve project

performance by fostering interorganisational relationships (Zhu & Cheung, 2023). Behaviours of the leader that highly support motivation are also know to be associated with increased innovation behaviours from the employees (Gupta, 2020). In addition, incentivization could even be used to support the use of digital technologies inside the construction industry, even though the implementation might experience challenges (Ebekozien & Samsurijan, 2024).

2.9.29 Infrastructure

Recent research demonstrates the importance of infrastructure for better innovation in construction. High-speed railways can strengthen collaboration for innovation amongst cities, and have an exceptional benefit for less developed places (Wang & Cai, 2020; Hanley et al., 2022). Telecommunications infrastructure promotes green technology innovation by improving informatisation and corporate governance (Tang et al., 2021). Building Information Modelling (BIM) serves as a digital infrastructure model enabling construction innovation through systematic collaboration and digital ecosystems (Liu et al., 2022). Design-Build-Maintenance contracts tend to encourage long-term sustainable solutions compared to Design-Build contracts (Larsson et al., 2022). This is while the construction sector is historically known to be slow in innovation implementation, and this is because of a wide array of obstacles (Klosova & Kozlovská, 2020). The cascading impact of collaborative innovation on the existing infrastructure project networks is further impacted by the available structures in networks and even the initial adopters (Zhang et al., 2021b). Having an innovation ecosystem perspective has demonstrated potential to help find answers for societal challenges of the infrastructure sector, even though organisational and cultural challenges exist (Vosman et al., 2023).

2.9.30 Innovation Awareness

Awareness about innovative tools, methods and practices amongst the employees

The construction industry is always trailing behind other sectors in adopting innovative technologies that could improve its productivity (Laszig et al., 2020). Studies show a low level of awareness and application of automation techniques in developing countries (Oke et al., 2023; Olatunde et al., 2023). Research on Building Information Modelling (BIM) shows higher awareness when compared to other similar technologies (Olanrewaju et al., 2021; Olatunde et al., 2023). Some obstacles include high costs, limited awareness and knowledge, and, in addition, fear of change (van Wyk et al., 2024). Perceptions on innovation as incremental or radical influence innovation adoption methodology preferences and levels (Qi et al., 2023). Awareness and its challenges greatly impact the application of Internet of Things (IoT) technologies (Dosumu & Uwayo, 2023). With the aim of increasing innovation adoption, stakeholders are recommended to invest in research and development (van Wyk et al., 2024), while at the same time, governments, educational institutions, and professional bodies are required to collaborate if we are to achieve enhanced awareness (Oke et al., 2023). Addressing these matters may potentially result in the improvement of project performance and further sustainable construction practices.

2.9.31 Innovation Champion

Innovation champions play a huge part in promoting and implementing innovations in the construction industry. They help facilitate the adoption of novel technologies, new processes, and sustainable development projects (Hassan, 2023; Shea, 2021). Champions' activities and level of their impacts are defined by their commitment, experience, and the support they receive from the organisation (Shea, 2021). They help in framing the future of digital transformation within the construction industry (Ernstsen et al., 2021) and overcome barriers for the adoption process of innovation (Klosova & Kozlovská, 2020). Research has highlighted some of the key elements that are affecting innovation performance inside construction companies, including technological innovation and a culture that supports innovation (López & Yepes, 2020). In procurement, multiple types of champions exist as they change their roles according to organisational environments (Loosemore et al., 2022). The mentioned findings further emphasise the complex and multifaceted nature of innovation champions that contribute towards driving change and innovations within the construction industry.

2.9.32 Innovation Demand

Recent research emphasises the significant contribution of client demand towards driving innovation within the construction industry. The client's focus can positively affect innovation and, even further, financial performance inside the construction companies (Yusof et al., 2022). Public clients, especially, are known to be key influencers for supporting innovation, although their methods and approach may possibly lead to tensions inside organisations (Lindblad & Guerrero, 2020). The requirements of the clients and improvements in project performance are found to be critical drivers for innovation, and that can lead the organisations towards sustainable construction (Nguyen, 2023). It is worth noting that control systems used by the public clients have the potential to affect contractors' innovation possibilities, knowing that process control can potentially have negative impacts on innovation, while output control can even support it (Järvenpää et al., 2024). The low level of adoption for Modern Methods of Construction (MMC) by public clients in the United Kingdom is known to be related to a lack of confidence in MMC companies and not issues with the innovation itself (Saad et al., 2023). If clients are aiming to demand more innovation, they can focus strongly on idea harnessing, improved relationships, more incentives, and fitness of the project team (Fernando et al., 2021).

Changes in demand from the organisation have a huge impact on the level of innovation that they present to the client. This matter affects and leads the firm to offer either more or fewer innovations compared to an environment with no external impact from the client. Different levels of innovation demanded by the clients are, in fact, affected by how they react to the level of risk imposed on them from the product ecosystem (Yeo et al., 2022).

2.9.33 Innovation Non-Resistance

Resistance to innovation in construction is considered a barrier for the adoption and implementation of technology, as it affects growth and productivity (Klosova & Kozlovská, 2020; Qi et al., 2023). This resistance is a result of numerous factors, such as perceived risks,

concerns about efficiency, and equity matters (Wang et al., 2020). To reduce resistance, researchers suggest methods such as training, organisational support, and improved design system (Lawluvy et al., 2022). The main enablers of systemic innovation in construction companies include but are not limited to innovation support culture, external collaboration, and knowledge management (Duarte & Picchi, 2021). Resistance impacts innovation in multiple ways and can potentially hinder the relation between potential and realised innovation adoption capacity, further affecting the adoption and use of new information (Nowak, 2023). Understanding the perceptions of the practitioners on innovation, whether it be incremental or radical, can positively impact the decisions on adopting technology (Qi et al., 2023). To overcome resistance towards innovation, we need to have the right management strategies and find the right answers for the known barriers (Yener & Taşçıoğlu, 2020).

2.9.34 Innovation Strategy

Business strategy plays a great part in driving innovation and improving performance within the construction industry. Studies have demonstrated that business strategies that are known to be effective positively affect competitive advantage, while innovation and performance act as mediators (Farida & Setiawan, 2022; Iqbal et al., 2020). Business models are useful tools for strategy development and can facilitate strategic transformation within construction organisations (Das et al., 2023). To improve the adoption of innovations, construction organisations must align their strategies on innovation with their business models and concurrently improve communication (Ngiri & Njagi, 2022; Lo & Kam, 2022). Innovations in strategies for business models help towards sustainable value creation, improve the company's reputation and even provide benefits for the environment (Treptow et al., 2022). A strategically developed framework for the management of innovation in the construction organisations supports staff engagement and alignment with broader strategies of the organisational (Lo & Kam, 2022). Additionally, the alignment between strategy and innovation, supported by accounting information systems, is vital for improving performance in construction enterprises (Latifah et al., 2021; Lo & Kam, 2022). Programme management constructs, such as cooperation with the environment and knowledge transfer, support open innovation at the strategic level (Trzeciak et al., 2022). Additionally, open innovation positively influences organisational strategy and competitive advantage (Musiello-Neto et al., 2021). Innovation strategies can offer competitive advantages, even during crises (Truant & Broccardo, 2020).

2.9.35 Innovative Designers

Designers' approaches can lead to significant construction innovations, particularly in prefabrication (Koman, 2021). Advanced materials, such as concrete, are being developed for sustainable structures (Kioumarsi & Plevris, 2024). In the history of construction, important innovations have been realised as a result of designers' approaches that interpret function and construction together (Koman, 2021). Green architecture and designs that are focused on energy efficiency are becoming important in recent years, and promote the use of sustainable materials and sources of renewable energy (Umoh et al., 2024). This is while applying innovative solutions comes with risks, which require careful management (Medhat et al., 2022).

Electrical and electronic engineering takes on an important part in this transformation, with new technologies such as AI, IoT, and 5G helping to improve system performance (Chandra et al., 2024). Building Information Modelling (BIM) and automation are drastically changing electrical design, improving precision and collaboration (Mittal & Solano, 2023). Machine learning techniques are continuously developed to improve project scheduling and management of resources (Victor, 2023). Energy efficiency and sustainability are increasingly important in recent years, as new and innovative technologies in power supply systems and even novel sources of energy are under development (Bartenev et al., 2021; Ružičić et al., 2021).

The development of new processes has its own challenges but also has new opportunities for efficiency and sustainability by benefiting from additive manufacturing and automation (Adeleke et al., 2024). The application of systemic design innovations, like Mechanical, Electrical, and Plumbing (MEP) prefabrication, needs special consideration on value creation and its capturing within multiple organisations (Lavikka et al., 2021). Altogether, innovative thinking has a great share in support for construction innovation, but barriers for its implementation and the relevant ethical considerations need to be addressed for sustainable growth in the industry.

2.9.36 Jurisdiction

Regulatory and enforcement framework / Jurisdiction conditions

The existing legal framework largely affects innovations in the construction industry, in particular when promoting sustainable practices and green technologies. Research shows that regulations can potentially help improve environmental outcomes and largely support technological innovation (Mahmud et al., 2024; Zhang et al., 2021). This is while the connection between regulation and innovation is extremely complex, with possible even negative effects on the rate of innovation directly related to with regulatory standards (Aghion et al., 2023). Positive views on occupational health and safety guidelines are directly linked to higher innovations (Shin et al., 2021). Some of the regulatory challenges in technology and innovation include the nature of the industry itself and not having the necessary regulatory tools (Mengistu et al., 2024). To help achieve more innovations, better regulatory frameworks, stronger stakeholder engagement, and continuous monitoring are strongly advised (Mlasi & Mahachi, 2023; Laszig et al., 2020). European and national digital guidelines try to help achieve more innovation within construction (Parusheva & Aleksandrova, 2022). Legal initiatives based on transparency and strong collaboration can potentially help make the best use of emerging opportunities presented by new technologies (Mason, 2021). Having flexibility in construction standards and guidelines could support innovation and strengthen the built environment (Saber, 2021).

2.9.37 Knowledge Management

Knowledge management (KM) is extremely important for fostering innovation and improving organisational performance in the construction industry. KM processes, such as knowledge creation, sharing, storage, and acquisition, positively support innovation capability and

performance of the organisation (Migdadi, 2022). The application of knowledge management techniques could help support technological innovations and sustainable performance within construction firms (Khan et al., 2024). KM capabilities, especially knowledge acquisition, its application, and even protection, greatly impact organisational performance, as innovation behaves as a mediator (Idrees et al., 2023). Effective KM paves the way for a culture supporting continuous learning and innovative thinking in construction firms (Sergeeva & Duryan, 2021). The result of KM, organisational learning, and innovation models working together can help resolve the gap between scientific and social paradigms and support a consistent flow of information (McLeod & Stevens, 2021). In addition, environments favouring knowledge management systems positively impact KM activities and innovation performance of the organisations (Choi et al., 2019).

2.9.38 Labour Market

There exists a complex relationship between the dynamics of the labour market and innovation inside the construction industry. Although three-dimensional 3D printing technology has potential for increasing productivity and reducing labour needs (Hossain et al., 2020), the majority of the industry is slow to use innovative tools and technologies (Laszig et al., 2020). The rigidities of the labour market can have both positive and negative impacts on innovation, as sectors which invest in R&D and have the right knowledge management systems benefit from this rigidity (Hoxha & Kleinknecht, 2020; Kleinknecht, 2020). Employment levels are also affected by technological innovations in different ways, and this impact potentially creates new opportunities while also displacing workers (Su et al., 2022). Worker mobility greatly improves the innovation output of the companies, especially when workers are originally from the firms patenting the innovations (Braunerhjelm et al., 2020). The resilience of the regional labour market is affected by factors like economic pull capabilities of the construction sector and industrial concentration of the companies (Giannakis & Mamuneas, 2022). Having a balance in the labour market's regulations is quite important for helping innovations and guaranteeing continuous growth (Gao & Anwar, 2024). In recent years, issues related to labour, further exacerbated by the Coronavirus Disease of 2019 (COVID-19) pandemic, have highlighted the need for increased automation (Ogunrinde et al., 2022). Government's intervention through state ownership and political connections can potentially reduce the impacts of labour on innovation (Li et al., 2020a).

2.9.39 Lessons Learned

Management of lessons learned

The construction industry deals with many problems and obstacles relating to innovation and lessons learned management, especially after the Coronavirus Disease 2019 (COVID-19) pandemic. Lessons learned from the pandemic include a wide range of matters, including the need for improved health and safety measures, remote working capabilities, and supply chain management (Ogunnusi et al., 2022; Niroshana et al., 2022). Internet-based tools for managing lessons learned can possibly improve organisational learning and the transfer of knowledge amongst projects (Eken et al., 2020). Evaluations done after the project is finished are very

important for capturing and sharing knowledge, although many organisations have trouble dealing with formal processes (Resende et al., 2020). Developing countries must invest on improving their knowledge sharing and project management practices to find solutions for the existing barriers in large projects (Abu Aisheh & Issa, 2021; Sergeeva & Duryan, 2021).

2.9.40 Lifecycle Focus

A company approach towards innovation which aligns the innovation process with the project lifecycle and integrates the stakeholders can improve effectiveness (AlHarmoodi & Dulaimi, 2022). The construction industry has, in recent years, been adopting lifecycle strategies to improve innovation and sustainability. Business models have been reconsidered to support strategic transformation and value creation during every stage of the building lifecycle (Das et al., 2023; Munaro et al., 2021). Implementing Building Information Modelling (BIM) can facilitate innovation during design, construction, and operation phases of the projects (Villena et al., 2020). Life cycle thinking is extremely important for eliminating environmental impacts of building materials and for improving the management of waste (Huang et al., 2020; Lei et al., 2020). Electronic procurement systems (EPSs) are ever more in use for improving sustainability, as strategies are focusing on educating technology and innovation culture management (Yevu et al., 2022). These approaches help the transition towards a circular economy in construction and emphasise strategies that focus on slowing and closing resource flows (Munaro et al., 2021).

2.9.41 Macroeconomy

The following recent studies have focused on the complex relationships between macroeconomic factors and innovation. The quality of institutions, education, and openness of the trade positively support innovation, while direct investment from foreign countries might have a negative impact (Malik, 2023). Macroeconomic factors such as GDP, investment, and oil prices show positive relationships with innovation, whereas trade openness and CO2 emissions exhibit negative associations (Dritsaki et al., 2023). Public R&D investment is found to stimulate private R&D and boost long-term economic output (De Lipsis et al., 2022). Innovation positively affects GDP and various economic indicators but negatively correlates with self-employment (Dempere et al., 2023). Inflation's impact on innovation varies depending on the specific economic mechanisms involved (Chu, 2022). Gross domestic expenditure on R&D emerges as a significant factor in promoting economic growth (Kiselakova et al., 2020). During periods of economic uncertainty, firms tend to reduce innovation activities, with the effect moderated by factors such as asset redeployability and financial constraints (Harris et al., 2022).

2.9.42 Market Demand

Research indicates that demand has a positive impact on innovation, particularly in high-tech industries (Romero et al., 2022). Supply chain disruptions negatively affect organisational

performance, but innovation can moderate these effects (Kissi et al., 2021). Demand-driven policies positively influence firm innovation through R&D activities (Sein & Prokop, 2023). However, increased product features can lead to security vulnerabilities, affecting innovation strategies (Yeo et al., 2022). Overall, innovation is essential for productivity growth in construction, but its adoption and implementation face challenges (Laszig et al., 2020).

Market demand plays a crucial role in shaping innovation, particularly in emerging economies like China (Zhu & Wang, 2021). Customer reactions to security risks can significantly impact firms' innovation strategies (Yeo et al., 2022). While market structure may not directly influence innovation, patenting activities positively affect market structure in high and medium-technology firms (Dhanora et al., 2019). Whether the market orientation is responsive or proactive, it positively impacts innovations (Ma et al., 2021). A larger market size can destabilise the innovation dynamics because of its pro-competitive effect (Matsuyama & Ushchev, 2022). Policies that affect the demand side can, in fact, support eco-innovation through stimulating production activities (Lee et al., 2020). Barriers related to financial and demand are amongst the main obstacles for innovation (Zahler et al., 2022). This is while customers' perceptions and orientation positively affect innovation, while technological capability plays a mediating role (Aydin, 2021). These findings demonstrate the complex relation between market demand, innovation, and the organisational strategies amongst different contexts.

2.9.43 Multiple Market Focus

Recent research studied the complex relationship between innovation and being in multiple markets. Studies have found that multimarket competition can have an impact on innovation strategies in different ways (Lee et al., 2020). The number of market categories has been found to have an inverted U-shape relationship with the company's innovative efforts (Lo et al., 2020). Operating inside international markets and implementing digital technologies has a positive impact on innovation in new and developing markets (Dana et al., 2022). Even more than the market structure's impact on innovation, patenting innovations can have a positive influence on the market structure inside high and even medium-technology firms (Dhanora et al., 2019). Multinational enterprises (MNEs) have shown consistent innovative behaviour through many years and across regions, while, on the contrary, domestic firms are impacted by regional conditions (Gagliardi & Iammarino, 2020). The relation between international diversification and innovation is quite dynamic and very complex, requiring modern conceptualisation (Juergensen et al., 2022). Globalisation and innovation are connected in multiple dimensions, as exposure to international markets affects motives for innovation (Akcigit & Melitz, 2022).

2.9.44 Not Fearing from Risking

Not fearing from risking on innovation - Not showing risk-averse Behaviour - Showing risk appetite - Risk aversion - Uncertainty avoidance - Fear to risking - The fear to risking on innovation

Research indicates that risk-averse behaviour can negatively impact innovation in the construction industry (Ribeirinho et al., 2020). Construction professionals often view innovations as potential sources of failure instead of seeing them as sources of benefits, stemming from a conservative approach (Er, 2020). Risk aversion reduces the likelihood of adopting new technologies and systems, such as spatial-temporal decision support systems in construction logistics (Zhang et al., 2024b). High risk aversion and uncertainty avoidance mean that rules and plans are needed, and that novelty takes time to be accepted (Davies et al., 2023). However, a strong safety climate can promote more risk-averse decision-making, potentially improving safety outcomes (Bhandari & Hallowell, 2022). The relationship between innovation and risk is complex, with elements such as product unreliability, market competition, and development costs influencing innovation strategies (Zheng et al., 2023). To overcome these challenges, firms can focus on improving risk management capabilities, enhancing supply chain innovation, and strengthening buyer-supplier relationships to gain a competitive advantage (Afraz et al., 2021). Additionally, fostering knowledge sharing, innovation passion, and absorptive capacity can positively impact employees' innovation behaviour when dealing with the risks inherent with innovation (Ye et al., 2021).

It is worth mentioning that this indicator was greatly discussed during the interviews with the construction industry experts in stage 3 of this research, and therefore, the wording of this indicator experienced some changes. Also, risk appetite was suggested by one of the construction industry experts.

2.9.45 Organisational Support

Organisational support plays a crucial role in fostering innovation within construction firms. Perceived organisational support enhances innovative work behaviour through psychological empowerment (Park & Kim, 2022). Key elements enabling systemic innovation include innovation culture, external collaboration, knowledge management, and upper management support (Duarte & Picchi, 2021). Organisational characteristics positively influence construction innovation (Weng Seng et al., 2020). Organisational support for creativity positively affects innovation and market performance, especially in highly dynamic markets (Baccarella et al., 2022). Help-seeking and help-giving behaviours in a favorable work environment contribute to innovation performance (Yánez Morales et al., 2019). Elements like technology, equipment, and software acquisition are significant drivers of innovation in construction firms (López & Yepes, 2020).

2.9.46 Partnerships

Partnerships can help develop innovation inside infrastructure and public services, although their nature of impact is quite complex. While Public Private Partnerships (PPPs) provide an atmosphere for innovations before the contract is signed, results found that they could potentially lead to innovations after the contract has started. These barriers stem from risk-related constraints (Liu et al., 2024). Successful innovation in PPPs is directly related to factors such as procurement handling and outcomes, the composition of the consortium, and project

management of the public partner (Verweij et al., 2020). Together, contractual incentives and collaborative activities have demonstrated support for innovation in PPPs (Callens et al., 2021). In the broader context of partnerships between companies, technology and competition have a positive effect on organisational innovation (Franco & Haase, 2020). Previous research has indicated that only half of PPPs have historically shown the ability to support innovation (Brogaard, 2019). In line with this, small, centrally structured, and standardised partnerships are known to be the most successful in the implementation and use of technological innovations (Verhoest et al., 2024). The public partner's responsibility, especially regarding project management, also the selection of the consortium members, is very important for supporting innovation (Verweij et al., 2020). Although challenges exist, studies suggest that PPPs have the potential to perform similarly to or even better than traditional contracts. During these contracts, collaboration is a very strong driver for performance improvement and innovation (Koppenjan et al., 2022).

2.9.47 Presence of Technology

In recent years, the construction industry has been going through a digital transformation. Different technologies are impacting innovation and improving productivity. Some of the key technological innovations include but are not limited to building information modelling (BIM), automation, robotics, virtual/augmented reality, Internet of Things (IoT), and 3D printing (Klosova & Kozlovská, 2020; Samarasinghe & Wood, 2021; Chen et al., 2022). These innovations might potentially improve efficiency, safety, quality, and sustainability in the construction projects (Chen et al., 2022; Mustofa et al., 2023). This is while the construction industry is historically known to be slow in adopting new technologies when compared to other sectors (Laszig et al., 2020). Some of the barriers to innovation implementation include cultural resistance, lack of skills, and challenges related to regulatory matters (Wafai & Aouad, 2023). To fully realise the benefits that are achieved through technological innovations, we must make changes to construction culture, business models, regulations, education, and procurement practices (Chen et al., 2021). The adoption of these innovative technologies is extremely important for achieving improvements in productivity, cost reduction, and promoting construction practices which are sustainable (Silva dos Santos & Assayag, 2022; Mustofa et al., 2023).

2.9.48 Problem-Solving Techniques

Developing problem-solving techniques is extremely necessary for promoting creativity and innovation (Adeoye & Jimoh, 2023). Educational institutions can develop and improve these skills through investing on training and other similar approaches that are focused on students (Aliu & Aigbavboa, 2021). It is highly recommended to educate the project stakeholders on innovation techniques in an attempt to facilitate their use during construction projects (Musarat et al., 2022). According to research, problem-solving techniques are extremely valued by employers and can be further improved by adopting different methods, such as brainstorming, root cause analysis, and learning (Aliu & Aigbavboa, 2020; Adeoye & Jimoh, 2023). The principles of lean construction also provide support for innovation processes by helping identify the industry’s deficiencies (Etges & Caten, 2023). We can improve the effectiveness

of innovations by adopting problem-solving techniques such as design thinking during the design phase of a new product (Da Silva et al., 2020).

2.9.49 Product Markets

Proximity to product markets

Having Geographic proximity to markets and the sources of knowledge can improve innovation through providing the means necessary for information flows and strengthening the monitoring capabilities of the organisation (Zhang et al., 2020c). Proximity also affects the orientation and development of innovation networks between firms (Golra et al., 2023). Cognitive and social proximities with key customers promote green product innovation in SMEs (Han & Xu, 2021). Supplier cluster proximity improves speed to market for innovations (Pillai & Bindroo, 2020), while collaboration with cognitively proximate sources benefits firms' innovation output (O'Connor et al., 2021). Knowledge spillovers positively affect innovation success, particularly in markets with moderate competition (Arvanitis et al., 2020). Geographic proximity to environmental NGOs stimulates green innovation in heavy-polluting firms (Hu et al., 2021). However, imperfect competition in the construction industry can generate significant rents, potentially affecting innovation dynamics (Kroft et al., 2020).

The impact of market proximity on innovation in construction is multifaceted. Geographic proximity facilitates information flows, corporate innovation, and improves monitoring capabilities (Zhang et al., 2020c). Proximity improves speed to market for innovations (Pillai & Bindroo, 2020). Proximity between firms and their stakeholders positively influences innovation performance through absorptive capacity (Sánchez-García et al., 2023). Social and cognitive proximities with key clients promote innovation through value co-creation (Han & Xu, 2021). Collaboration with proximate sources, particularly suppliers, benefits firms' innovation output more than distant sources (O'Connor et al., 2021). In global virtual teams, non-spatial proximity fosters innovation through knowledge sharing (Hung et al., 2021).

2.9.50 Progress Monitoring

Research emphasises the ever-increasing importance of progress monitoring in construction for improving innovations in efficiency and safety. The traditionally applied manual methods consume too much time and labour, and are prone to making errors; consequently, in more recent years, there has been a growing interest in automated progress monitoring (Rehman et al., 2023; Musarat et al., 2024). Different technology options are currently considered for automated monitoring, for example, photogrammetry, sensors and unmanned aerial vehicles (UAVs) (Reja et al., 2022; Jacob-Loyola et al., 2021). Such technologies allow data collection, analysis, and visualisation in real-time, which helps make better decisions and have stronger project monitoring (Nakanishi et al., 2022). Building Information Modelling (BIM) has recently presented itself as a useful tool for integrating technologies similar to the abovementioned, and for creating digital twins of construction projects (Pal et al., 2023), which further helps with progress monitoring. Despite the potential benefits, barriers to using BIM for monitoring include rigid contractual clauses, lack of incentives, and the absence of reliable

automated monitoring tools (Ur Rehman et al., 2023). Future research needs to focus on comprehending holistic and automated methods that can cover all of the construction progress monitoring process, whether it be from planning up to the management of claims and disputes (Patel et al., 2022; Terzis, 2022).

2.9.51 Project-Baseness

Temporary/project-based nature of the construction projects

The temporary nature of the construction industry during its projects presents challenges for benefiting from innovation, since this trait causes barriers for incremental improvements and the transfer of knowledge (Ninan et al., 2022). This is while organisational structures based on the temporary nature of the industry also have a sense of urgency within and can support and improve innovation if properly managed (Poblete et al., 2022). Project-based organisations have trouble managing the temporary and permanent levels of the organisation when trying to train and diffuse innovations (Crespin-Mazet et al., 2021). To correctly address these barriers for innovation, studies suggest fostering flexible innovation strategies (Zhang et al., 2023c) that allow temporary organisations to focus on improving their dynamic capabilities (Spanuth et al., 2020). Government approaches and policies also affect innovation strategies of the project-based companies (Sergeeva & Winch, 2020). The diffusion of innovation within project-based companies involves formal and informal networks of communication, where many influential indicators, such as communities and networks of practice, play a crucial role in connecting temporary and permanent organisational levels (Crespin-Mazet et al., 2021).

2.9.52 Recruitment Policies

Effectively managing human resources is very important for the success of the organisation, as it is necessary to see employees as very valuable assets for the organisation (Pandey & Kshirsagar, 2024). Recruitment policies need to be flexible and adaptable to ever-changing environments (Purboyo et al., 2024). Policies on human resources, such as having autonomy on the job and getting paid based on performance, positively impact the company's innovation (Krammer, 2022). Recruiting migrants who are highly skilled can improve innovation performance (Laursen et al., 2020). Innovative strategies for recruitment, such as gamified assessments and using social media, are being leveraged to attract talent (Rai, 2024). Honouring diversity, adopting effective policies for recruitment, and valuing technological innovations are crucial for achieving better recruitment and innovation within the construction industry (Saikumari et al., 2023). The Oslo Manual (OECD/Eurostat, 2018) recommends special attention to recruitment policies for measuring innovation inside businesses and organisations. According to this manual, recruitment policies can impact the ability of a firm to benefit from the employee's potential for creativity and even from the other abilities of its employees. Employee recruitment policies that focus on creative skills for innovating can positively support innovations and even other broader goals.

2.9.53 Research and Development (R&D) Capability

According to research, R&D investment has a positive correlation with innovation output and the performance of the company (Gong & Wang, 2022). Additionally, the capability for innovation mediates the relationship between radical innovation and business performance (Yusof et al., 2023). Internal capability for R&D and realised capacity for accepting innovation positively impact innovation (Kim & Choi, 2020). R&D activities for adopting global norms and standards improve the company's capabilities for innovation (Ma & Ji, 2024). Technological capabilities and specific investment in R&D positively affect innovation (Yun, 2021). When compared with cooperation with other companies, cooperation with universities and research institutions has a higher positive impact on innovation capability (Liu et al., 2023). Innovation in management is known to be a very important moderator for transforming R&D results into successful product innovations (Heij et al., 2020). Working with external partners, especially on R&D, can potentially improve activities aimed at innovating (Sánchez-Sellero & Bataineh, 2021).

2.9.54 Response to Environment

Research has demonstrated that various regulations on environmental protection have different impacts on the efficiency of technology innovation (Zhang et al., 2021a). Environmental distresses such as the COVID-19 pandemic can initiate changes in innovation behaviour, while this change can be both positive and negative (Bolpagni et al., 2021; Singh & Bolpagni, 2023). Incremental environmental sustainability innovations have been found to positively affect businesses (Duong et al., 2021). National innovation systems can encourage sustainability and energy efficiency in construction (Mosurović Ružičić et al., 2021). Eco-innovations are crucial for improving organisational and technological reliability in construction (Chernyshev et al., 2021). Green innovations in construction contribute to creating sustainable cities, improving energy efficiency, and reducing environmental impacts (Redzhepov et al., 2024). Digital transformation is emerging as a key driver of green innovation in construction enterprises (Li et al., 2023). Construction activities still significantly contribute to environmental degradation, necessitating mitigation strategies and enforcement of environmental management systems (Kaja & Goyal, 2023). The industry is increasingly focusing on ESG (Environmental, Social, and Governance) factors and innovation to improve sustainability performance (Cruz et al., 2023). However, the widespread adoption of environmental construction practices faces behavioural challenges, which can be addressed using the diffusion of innovation theory (Sartipi, 2020).

2.9.55 Social Responsibility

Research indicates that corporate social responsibility (CSR) positively influences innovation in construction firms and other industries. CSR practices improve the performance of the firm in a U-shaped relationship (Zheng et al., 2024). This happens through improving job satisfaction and innovation (Palacios-Manzano et al., 2024). Some of the key aspects of CSR for construction companies include the special interests of the shareholder and the level of commitment from the government (Zhang et al., 2023b). The link between CSR and innovation

is stronger in countries which are governed under civil law (Chkir et al., 2021) and is different across different dimensions of CSR and different types of innovation (García-Piqueres & García-Ramos, 2020). CSR has a positive effect on innovation by leveraging on involvement of the employees and collaboration from the suppliers (Zhou et al., 2020). Cooperation within businesses partially mediates the relationship between CSR and innovation (Mendes et al., 2023). In China, CSR performance positively affects innovation, especially inside companies that perform under higher transparency and institutional ownership (Hao & He, 2022).

2.9.56 Social Skills

Through supporting effective social interactions, organisations can strengthen internal and external relationships, consequently improving their overall potential for innovation (Lianto et al., 2022). Recent research endorses the importance of social skills for innovation in the construction industry. Having social capital positively affects innovation performance, and this impact happens through the transfer of knowledge (Wang et al., 2021). Engineering education needs to pay special attention to social innovation skills to fully educate students for careers in which they are socially responsible (Marin Ruiz, 2021). The transfer of technological innovations within the construction industry is affected by social and contextual factors (Wafai & Aouad, 2023). Additionally, the culture of the working environment influences the tendency for innovation inside construction enterprises (Lijauco et al., 2020). Both hard skills and soft skills have a positive impact on the potential and ability to innovate, and this relation is mediated by organisational culture (Asbari et al., 2020). The mentioned findings highlight the complex relationship between social skills, culture, and innovation in the construction sector.

2.9.57 Society

There is a complex relationship between the behaviours and attitudes of society and innovation in construction. Environmental disasters such as COVID-19 can cause changes in innovation behaviours, which can be either positive or negative (Bolpagni et al., 2021). Society's perception of innovation as incremental or radical impacts innovation adoption, and often leads to resistance in accepting radical changes (Qi et al., 2023). Social capital has a positive impact on innovation performance and requires strong knowledge transfer (Wang et al., 2021). Recent research reflects the huge impact of social factors on innovations inside the construction industry. Cultural factors in society also affect the tendency for innovation (Lijauco et al., 2020). The social construct of the organisation's framework for technology provides ways for innovation transfer (Wafai & Aouad, 2023). These studies highlight the importance of social factors in driving innovation inside the construction industry.

2.9.58 Standards

Standards usually have a positive impact on innovation in construction and even other industries. Standards can increase innovation by reducing uncertainties around technological and legal matters (Wen et al., 2022), further improve R&D efficiency, and promote collaborative innovation (Zhang et al., 2020a). Within the construction industry, the impact of standards on innovation is more than the impact of economic growth. Research results show

that as standard changes 1%, innovation changes 1.27%. This is while a 1% change in the economy only brings around a 0.6% change to innovation (Sun et al., 2020). Standards can potentially lead to creativity through setting constraints and barriers that guide idea generation (Navarro Gonzalez, 2022). There is a complex relationship between standards and innovation, involving arguments, perspectives, and practice dimensions (Zissis, 2020). Although standards usually lead to benefits for innovation, their impact might vary based on different factors such as a country's level of development (Wayoro et al., 2024) and the abilities that technology developers and complementors have (Wen et al., 2022). Altogether, standards largely impact innovation promotion within many industries (Blind et al., 2023).

2.9.59 Strategic Plan

A strategic Plan for managing innovation inside construction organisations must have a special emphasis on staff engagement, align with the strategies of the organisation, and assess the contribution resulting from the innovation's impact (Lo & Kam, 2022). Some of the most important enablers of strategic innovation in construction companies are innovation culture, external collaboration, and support from the upper management (Duarte & Picchi, 2021). Strategy-related indicators aimed at sustainability, especially eco-innovation, have a positive influence on sustainability performance and brand value in the construction industry (Kinnunen et al., 2022). Based on research, business strategies positively impact competitive advantage, while performance and innovation are mediators (Farida & Setiawan, 2022; Ngiri & Njagi, 2022). Researchers suggest using business models as useful tools for formulating strategies and integrating technology (Das et al., 2023). Organisations must synchronise their innovation strategy with their organisational business model and should also improve communication (Ngiri & Njagi, 2022; Timchuk et al., 2021). These findings highlight the importance of a strategic plan for driving innovation in the construction industry.

2.9.60 Strategy Communication

Effective communication of the company's strategic plans to employees positively affects innovative performance. For this to happen, the company must facilitate faster decision-making and knowledge sharing (Rahimnia & Molavi, 2021; Haider et al., 2023). Effective communication of strategic plans to employees is essential for aligning organisational goals and fostering innovation (Ngiri & Njagi, 2022). Effective communication and information flow are essential for improving the construction process and reducing delays and variations (Kania et al., 2020). Furthermore, innovation should be oriented towards staff engagement, framed around organisational strategies, and contribute to organisational impact (Lo & Kam, 2022). The way the strategic plan is shared with the employees (written or other forms), the methods to monitor these plans and what is exactly covered in the strategic plan (finance, logistics, marketing, customer relations, etc.) also which activities are covered (like innovation), could contribute towards understanding the interconnection between strategy and innovation in the company (OECD/Eurostat, 2018). This indicator, strategy communication, was added to the tool to investigate how well the company's strategic plans are communicated to the employees. This is because having a common understanding of the aims, objectives, goals and strategies of the company amongst the employees is important for aligning the resources of the company.

2.9.61 Subsidies

Subsidies generally have a positive impact on innovation performance in various industries, including construction and green technologies. Multiple studies found an inverted U-shaped relationship between subsidies and innovation (Xu et al., 2023; Wu et al., 2020). R&D subsidies, in particular, show a notable positive effect on innovation in photovoltaic enterprises (Jiang et al., 2021c). The impact of subsidies can be moderated by factors such as internal control (Xu et al., 2022), ownership concentration (Wu et al., 2021), and carbon trading prices (Xu et al., 2022). However, subsidies may have a crowding-out effect on non-subsidised competing firms (Ding et al., 2022). Based on the company's characteristics, such as size, ownership, and location, subsidies can result in varying levels of effectiveness (Wang et al., 2022; Jiang et al., 2021c). Altogether, government subsidies help support innovation performance, but we must understand that their impact and success are affected by various factors and policy implementations.

2.9.62 Suppliers

The impact of suppliers on innovation in construction can be different depending on multiple factors. Innovations in the supply chain have a positive effect on competitive advantage. This relation depends on the organisation's risk management capabilities (Afraz et al., 2021). The proximity of the suppliers improves innovation speed (Pillai & Bindroo, 2020). Good suppliers build strong relationships, which lead to better innovation performance (Onofrei et al., 2020). Foreign suppliers can increase the company's investment in R&D and further result in innovation efficiency (He et al., 2021). Disruptions in the supply chains have a negative impact on organisational performance, but innovation can moderate this effect (Kissi et al., 2021). Innovation performance is positively impacted by stronger suppliers and is further improved by a formal evaluation of the suppliers (Du et al., 2023). Green public procurement can support the development and implementation of low-carbon innovations, while suppliers which are higher up in the supply stream influence the innovation ecosystem (Stokke et al., 2022).

2.9.63 Sustainability

Sustainability endeavours and environmental regulations have a positive impact on innovation and competitiveness within construction projects (Zhang et al., 2024; Nguyen, 2023). The adoption of innovations which have a special connection with sustainability, for instance, energy efficiency measures, can improve cooperation within national innovation systems (Mosurović Ružičić et al., 2021). Innovations which focus on environmental sustainability have shown a positive impact on reactions from the stock market within construction companies (Duong et al., 2021). Strategic sustainability matters, especially eco-friendly innovations, help improve sustainability performance and even brand value (Kinnunen et al., 2022). Meta-analysis has found a strong and positive relationship between innovation and sustainability performance within organisations (Kuzma et al., 2020). The merging of innovation and sustainability, which can be termed innovability, is recently emerging as a very important management strategy that can benefit competitive and sustainable companies (De la Vega Hernández & Barcellos de Paula, 2021). In addition, technological innovations within

supply chains for building materials, which also have a special attention to environmentally friendly matters, support sustainable construction practices (Mustofa et al., 2023).

2.9.64 Systems Skills

Systems skills, to understand, monitor, and improve socio-technical systems

Having systems skills is necessary for understanding, monitoring, and improving socio-technical systems inside a company, as this trait directly supports innovation capability. These skills allow different components of a company's operations to be effectively integrated and coordinated. This, in turn, ensures continuous enhancement and support of innovation processes (OECD/Eurostat, 2018). The relation between systems skills and innovation in construction is complex. By transforming processes and ecosystems, technical innovations such as digital entrepreneurship and BIM are helping innovation (Satalkina & Steiner, 2020; Liu et al., 2021). Also, responsible innovation is recently emerging as a concept within the construction design realm (Deppeler & Aikens, 2020). Systems thinking helps improve many forms of systemic innovation, where, as a few examples, we could mention technological integration, policy development, societal change, collaborative networks, and innovative processes (Midgley & Lindhult, 2021). By investing in system skills, companies can better benefit from their technological, organisational, and human resources. This, in turn, leads to smoother workflows and easier adaptability to changes. This comprehensive approach not only improves efficiency in operations but also helps environments which nourish innovative thinking and problem-solving, eventually improving the company's overall ability to innovate (OECD/Eurostat, 2018).

2.9.65 Tax

The taxation system and framework can have both a positive and a negative impact on innovation, especially within the construction and green building sectors. Although some studies have previously demonstrated that income and corporate taxes have a negative impact on innovation (Balsalobre-lorente et al., 2021; Najafov, 2021; Pelaez et al., 2024), other research found that targeted tax incentives can potentially help support R&D and innovation (Stantcheva, 2021; Akcigit & Stantcheva, 2020). In the construction industry, government tax laws and strong infrastructure support can promote collaborative innovation during green building projects (Zeng et al., 2022). Taxations focused on environmental matters have demonstrated the capability to improve corporate green innovation, especially within competitive markets and regions with lower market connections (Luo & Wu, 2023). How effective tax incentives can be depends on factors like the company's capacity to adapt and absorb, and the tailored design of tax policies (Walter et al., 2022). Policymakers need to pay special attention to balancing the costs related to innovation and incentives offered by he tax system, in an attempt to avoid support for unproductive innovations or negatively impacting operating budgets (Balsalobre-lorente et al., 2021).

2.9.66 Technical Expertise

Technical expertise is extremely important for supporting innovation in the construction industry. According to previous research, professional employees' knowledge has a great impact on decisions regarding innovation adoption (Weerapperuma et al., 2022). Independent technical managers with the relevant expertise can have a great impact on an organisation's innovative performance (Li et al., 2020b). Technical competency, communication skills, and the experience of experts also have a great influence on innovation performance (Lubua, 2022). Adopting advanced technologies such as BIM, automation, and IoT can lead to great changes regarding the industry's effectiveness and efficiency (Laszig et al., 2020). Having technical abilities, especially in advanced technologies such as BIM, robotics, and AI, contributes positively towards fostering innovation (Klosova & Kozlovská, 2020; Liphadzi & Yeko, 2023). In addition, holding technical construction expertise can help resolve disputes and conflicts which arise due to poor work quality (Zilberova et al., 2021). Factors which contribute to the value of technical expertise cover a wide range and consist of elements such as innovation rate, novelty, and profitability (Zolfaghar Arani et al., 2024).

2.9.67 Tender Process

The tender process has a huge effect on innovation in construction, as recent research focuses on methods to encourage and support innovations in tenders, especially public tenders (Lenderink et al., 2020). There have been studies on bid evaluation processes, which emphasise the importance of accounting for both quantitative and qualitative elements (Oad et al., 2021). Procurement strategies that encourage innovation have been developed, and especially focus on technology readiness and cooperation between the clients and contractors (Lenderink et al., 2022). Implementing new laws for the tender process has impacted bid prices and project durations (Al-Sabah & Abdulrahim, 2021). Similarly, legal reforms have supported innovation (Czarnitzki et al., 2020). In addition, open tenders have resulted in professionalisation, standardisation, and innovation amongst some sectors of the construction industry (Bergsgard & Nødland, 2020). Applying collaborative approaches such as Target Value Design during the tendering process has shown benefits like cost and waste reduction, and further led to satisfaction from the stakeholders (Musa & Pasquire, 2020), highlighting the instrumental value of innovation. These findings reflect the improving nature of tender processes and their potential to support innovations in construction.

2.9.68 Upper Management Support

Support from the upper management has a huge part in fostering innovation inside construction companies and is a key enabler for innovation (Duarte & Picchi, 2021). Upper management support positively affects innovation practices (Barham et al., 2020). Top management's communications with suppliers can improve innovation (Prokop & Hájek, 2023), while management innovation directly affects organisational performance (Aftab et al., 2022). Support from the senior management has been recognised as the most influential predictor of innovation within organisations operating under the public sector (Hijal-Moghrabi et al., 2020). Additionally, support from the top management strongly affects innovation, while it needs to

work alongside other factors such as technological infrastructure (Rajan et al., 2021). Similarly, innovation positively affects critical success factors relevant to project management within the construction sector (Alawamleh et al., 2020). Overall, support from the upper management is critical for growth and success in the construction industry.

In summary, the attributes discussed in this section, which affect the potential for innovation, will serve as foundational indicators in the development of an effective measurement tool for measuring innovation in the New Zealand construction industry. These attributes encompass various areas, represent different categories and will reflect the complex and multifaceted nature of innovation within construction organisations. Each attribute will be systematically categorised to ensure a good and comprehensive understanding of its role and relevance. This categorisation will be in line with the attempt to the creation of the Innovation Potential score. It will enable the assessment of an organisation's potential and capacity to innovate. By quantifying these attributes, the Innovation Potential score will provide a robust and practical metric for studying, measuring and improving innovation in New Zealand's construction industry. Later in this thesis's tool, by developing the indicators from the Business Innovation Score, the two elements of the Overall score will be joined. The following table presents the indicators known to affect the potential of the construction companies to innovate. Their literature sources are also presented in this table:

Table 2.13: Indicators Affecting Innovation Potential and their Sources

Indicator	Literature sources
Adaptability and flexibility	Ni et al., 2020; Abankwa et al., 2020; Mlote et al., 2024; Ng et al., 2023; Novykova et al., 2022
Autonomy	Adegbite et al., 2020; Putri & Prastika, 2024; Huu, 2023; Slåtten et al., 2020
Career development	Na, 2021; Matthies et al., 2023; Cozzarin & Percival, 2021; Birdi, 2020; Kettunen, 2023; Janošik et al., 2023; Jiang et al., 2021b; Valizade Azar et al., 2023
Client's understanding	Yusof et al., 2021; Järvenpää et al., 2024; Järvenpää et al., 2022; Lindblad & Guerrero, 2020; Saad et al., 2023
Collaboration	Shi et al., 2022; Zhang et al., 2023; Zhang et al., 2020; Garcia & Murguia, 2021
Commitment	Chen et al., 2023; Dzieńdziora et al., 2022; Holl, 2020; Naruetharadhol et al., 2021; Klosova & Kozlovská, 2020; Patrucco et al., 2020; Tsai & Yen, 2020
Communication	Ngiri & Njagi, 2022; Rahimnia & Molavi, 2021; Matveeva et al., 2020; Demchenko et al., 2021; Malik et al., 2021; Klosova & Kozlovská, 2020; Kania et al., 2020; Musarat et al., 2021

Competition	Canare & Francisco, 2021; O'Leary et al., 2022; Wahid & Syafwandi, 2020; Zhang et al., 2023; Okrah, 2023; Zhang et al., 2024; Afraz et al., 2021; Farida & Setiawan, 2022; Yang et al., 2023
Cognitive abilities	OECD/Eurostat, 2018; Begum et al., 2022; Shehab & Hamzeh, 2024; Shi et al., 2020; Oladinrin et al., 2023
Contracts	Klijn et al., 2023; Callens et al., 2021; Liu et al., 2024; Järvenpää et al., 2024; Mayer et al., 2022; Langston, 2023
Contractor's expertise	Langston, 2023; Weng et al., 2020; Yusof et al., 2023; Sayyed et al., 2021; Isa & Abidin, 2021; Oad et al., 2021; Duodu & Rowlinson, 2021; Oladinrin et al., 2023
Creativity	Almashhour et al., 2024; Lowe & Chiu, 2020; Juliana et al., 2021; Zheng et al., 2020; Khairuddin et al., 2021; Dost & Al Qatiti, 2023; Mdhlalose, 2024; Yamin, 2020; Chaubey & Sahoo, 2022; Hussain & Wahab, 2021
Design capabilities	Yusof et al., 2023; Sreckovic, 2020; Liu et al., 2021; Cautela et al., 2022; Robbins & Fu, 2022; Berg et al., 2020; Langham & Paulsen, 2020; Bocken & Geradts, 2020
Digital technologies	Khonchev et al., 2023; Chen et al., 2021; Samarasinghe & Wood, 2021; Klosova & Kozlovská, 2020; Aliu & Oke, 2023; Chowdhury et al., 2019; Turkova et al., 2020; Chen et al., 2022
Employee performance	Hanif et al., 2021; Park & Rahmani, 2020; Johar & Roopalatha, 2024; Prasetya & Natalia, 2020; Jalali et al., 2023; Echebiri, 2020; Chauke et al., 2022
Employee recognition	Bécuwe et al., 2020; Ampofo et al., 2023; Yang et al., 2022; Haider et al., 2023; Azevedo et al., 2021; Jin & Kim, 2022; Oladinrin et al., 2023; Lijauco et al., 2020
Entrepreneurialism	Hoang et al., 2022; Khairuddin et al., 2021; Botelho et al., 2021; Jain, 2023; Hoang et al., 2021; Wang et al., 2023; Ertuğral & Acar, 2022; Cui & Song, 2022; Jin & Lee, 2020
Environmental barriers	Yordanova, 2024; Zhang et al., 2020; Zhang et al., 2021; Sandanayake, 2022; Sartipi, 2020; Duong et al., 2021; Pekovic & Bouziri, 2021; Almakayeel et al., 2023; Cruz et al., 2023
External grants	Alshboul et al., 2022; Moghayedi et al., 2022; Moon, 2022; İncekara, 2022; Kou et al., 2020; Vadia & Blankart, 2021

External involvement	Hu et al., 2022; Yang et al., 2020; Schepers et al., 2022; Acebo et al., 2021; Medase & Abdul-Basit, 2020; Muñoz-Bullón et al., 2020; Oladinrin et al., 2023
Finish price focus and Quality focus	Oslo Manual, 2018; Pinto & Romero, 2020; Kuncoro, 2021
Finances	Chundakkadan & Sasidharan, 2020; Sánchez Rodríguez, 2020; Li & Cao, 2024; Lee et al., 2020; Yusof et al., 2020; Klosova & Kozlovská, 2020; Laszig et al., 2020; Oborin, 2020
Fragmentation	Laszig et al., 2020; Riazi et al., 2020; Aditra & Ekomadyo, 2021; Elsayegh & El-adaway, 2021; Lindblad & Guerrero, 2020; Klosova & Kozlovská, 2020; Wafai & Aouad, 2023; Yusof et al., 2023
Government	Li et al., 2022; Zeng et al., 2022; Zhang et al., 2021; Klosova & Kozlovská, 2020; Sergeeva & Winch, 2020; Yi & Hiroatsu, 2022
High costs	Er, 2020; van Wyk et al., 2024; Klosova & Kozlovská, 2020; Laszig et al., 2020; López & Yepes, 2020; Oborin, 2020; Jiang et al., 2021a; Zhang et al., 2020
In-house sourcing	Afraz et al., 2021; Zhou et al., 2022; Asimakopoulos et al., 2020; Sharma et al., 2020; Lindblad & Guerrero, 2020; Oladinrin et al., 2023; Moghayedi et al., 2022
Incentives	Cheung et al., 2024; Villani et al., 2024; Si et al., 2020; Mdhlalose, 2024; Speckbacher & Wabnegg, 2020; Zhu & Cheung, 2023; Gupta, 2020; Ebekozien & Samsurijan, 2024
Infrastructure	Wang & Cai, 2020; Hanley et al., 2022; Tang et al., 2021; Liu et al., 2022; Larsson et al., 2022; Klosova & Kozlovská, 2020; Zhang et al., 2021; Vosman et al., 2023
Innovation awareness	Laszig et al., 2020; Oke et al., 2023; Olatunde et al., 2023; Olanrewaju et al., 2021; van Wyk et al., 2024; Qi et al., 2023; Dosumu & Uwayo, 2023
Innovation Champion	Hassan, 2023; Shea, 2021; Ernstsen et al., 2021; Klosova & Kozlovská, 2020; López & Yepes, 2020; Fernando et al., 2021; Loosemore et al., 2022
Innovation demand	Yusof et al., 2022; Lindblad & Guerrero, 2020; Nguyen, 2023; Järvenpää et al., 2024; Saad et al., 2023; Fernando et al., 2021; Yeo et al., 2022
Innovation non-resistance	Klosova & Kozlovská, 2020; Qi et al., 2023; Wang et al., 2020; Lawluvy et al., 2022;

	Duarte & Picchi, 2021; Nowak, 2023; Yener & Taşçıoğlu, 2020
Innovation Strategy	Farida & Setiawan, 2022; Iqbal et al., 2020; Das et al., 2023; Ngiri & Njagi, 2022; Lo & Kam, 2022; Treptow et al., 2022; Latifah et al., 2021; Trzeciak et al., 2022; Musiello-Neto et al., 2021; Truant & Broccardo, 2020
Innovative designers	Koman, 2021; Kioumarsi & Plevris, 2024; Umoh et al., 2024; Medhat et al., 2022; Lenderink et al., 2020; Chandra et al., 2024; Mittal & Solano, 2023; Victor, 2023; Bartenev et al., 2021; Ružičić et al., 2021; Adeleke et al., 2024; Lavikka et al., 2021
Jurisdiction	Mahmud et al., 2024; Zhang et al., 2021; Aghion et al., 2023; Shin et al., 2021; Mengistu et al., 2024; Mlasi & Mahachi, 2023; Laszig et al., 2020; Parusheva & Aleksandrova, 2022; Mason, 2021; Saber, 2021
Knowledge management	Migdadi, 2022; Khan et al., 2024; Idrees et al., 2023; Sergeeva & Duryan, 2021; McLeod & Stevens, 2021; Choi et al., 2019
Labour market	Hossain et al., 2020; Laszig et al., 2020; Hoxha & Kleinknecht, 2020; Kleinknecht, 2020; Su et al., 2022; Braunerhjelm et al., 2020; Giannakis & Mamuneas, 2022; Gao & Anwar, 2024; Ogunrinde et al., 2022; Li et al., 2020a
Lessons learned	Ogunnusi et al., 2022; Niroshana et al., 2022; Eken et al., 2020; Resende et al., 2020; Abu Aisheh & Issa, 2021; Sergeeva & Duryan, 2021
Lifecycle focus	AlHarmoodi & Dulaimi, 2022; Das et al., 2023; Munaro et al., 2021; Villena et al., 2020; Huang et al., 2020; Lei et al., 2020; Yevu et al., 2022
Macroeconomy	Malik, 2023; Dritsaki et al., 2023; De Lipsis et al., 2022; Dempere et al., 2023; Chu, 2022; Kiselakova et al., 2020; Harris et al., 2022
Market demand	Romero et al., 2022; Kissi et al., 2021; Sein & Prokop, 2023; Yeo et al., 2022; Laszig et al., 2020; Zhu & Wang, 2021; Dhanora et al., 2019; Ma et al., 2021; Matsuyama & Ushchev, 2022; Lee et al., 2020; Zahler et al., 2022; Aydin, 2021
Multiple market focus	Lee et al., 2020; Lo et al., 2020; Dana et al., 2022; Dhanora et al., 2019; Gagliardi & Iammarino, 2020; Juergensen et al., 2022; Akcigit & Melitz, 2022

Not fearing from risking	Ribeirinho et al., 2020; Er, 2020; Zhang et al., 2024; Bhandari & Hallowell, 2022; Zheng et al., 2023; Afraz et al., 2021; Ye et al., 2021
Organisational support	Park & Kim, 2022; Duarte & Picchi, 2021; Weng Seng et al., 2020; Baccarella et al., 2022; Yánez Morales et al., 2019; López & Yepes, 2020
Partnerships	Liu et al., 2024; Verweij et al., 2020; Callens et al., 2021; Franco & Haase, 2020; Brogaard, 2019; Verhoest et al., 2024; Koppenjan et al., 2022
Presence of technology	Klosova & Kozlovská, 2020; Samarasinghe & Wood, 2021; Chen et al., 2022; Mustofa et al., 2023; Laszig et al., 2020; Wafai & Aouad, 2023; Silva dos Santos & Assayag, 2022
Problem-solving techniques	Adeoye & Jimoh, 2023; Aliu & Aigbavboa, 2021; Musarat et al., 2022; Aliu & Aigbavboa, 2020; Etges & Caten, 2023; Da Silva et al., 2020
Product markets	Zhang et al., 2020; Golra et al., 2023; Han & Xu, 2021; Pillai & Bindroo, 2020; O'Connor et al., 2021; Arvanitis et al., 2020; Hu et al., 2021; Kroft et al., 2020; Sánchez-García et al., 2023; Hung et al., 2021
Progress monitoring	Rehman et al., 2023; Musarat et al., 2024; Reja et al., 2022; Jacob-Loyola et al., 2021; Nakanishi et al., 2022; Pal et al., 2023; Ur Rehman et al., 2023; Patel et al., 2022; Terzis, 2022
Project-baseness	Ninan et al., 2022; Poblete et al., 2022; Crespin-Mazet et al., 2021; Zhang et al., 2023; Spanuth et al., 2020; Sergeeva & Winch, 2020; Crespin-Mazet et al., 2021
R&D capability	Gong & Wang, 2022; Yusof et al., 2023; Kim & Choi, 2020; Ma & Ji, 2024; Yun, 2021; Liu et al., 2023; Heij et al., 2020; Sánchez-Sellero & Bataineh, 2021
Recruitment policies	Pandey & Kshirsagar, 2024; Purboyo et al., 2024; Krammer, 2022; Laursen et al., 2020; Rai, 2024; Saikumari et al., 2023; OECD/Eurostat, 2018
Response to Environment	Zhang et al., 2021; Bolpagni et al., 2021; Singh & Bolpagni, 2023; Duong et al., 2021; Mosurović Ružičić et al., 2021; Chernyshev et al., 2021; Redzhepov et al., 2024; Li et al., 2023; Kaja & Goyal, 2023; Cruz et al., 2023; Sartipi, 2020

Social responsibility	Zheng et al., 2024; Palacios-Manzano et al., 2024; Zhang et al., 2023; Chkir et al., 2021; García-Piqueres & García-Ramos, 2020; Zhou et al., 2020; Mendes et al., 2023; Hao & He, 2022
Social skills	Lianto et al., 2022; Wang et al., 2021; Marin Ruiz, 2021; Wafai & Aouad, 2023; Lijauco et al., 2020; Asbari et al., 2020
Society	Bolpagni et al., 2021; Qi et al., 2023; Wang et al., 2021; Lijauco et al., 2020; Wafai & Aouad, 2023
Standards	Wen et al., 2022; Zhang et al., 2020; Sun et al., 2020; Navarro Gonzalez, 2022; Zissis, 2020; Wayoro et al., 2024; Blind et al., 2023
Strategic Plan	Lo & Kam, 2022; Duarte & Picchi, 2021; Kinnunen et al., 2022; Farida & Setiawan, 2022; Ngiri & Njagi, 2022; Das et al., 2023; Timchuk et al., 2021
Strategy communication	Rahimnia & Molavi, 2021; Haider et al., 2023; Ngiri & Njagi, 2022; Kania et al., 2020; Lo & Kam, 2022; OECD/Eurostat, 2018
Subsidies	Xu et al., 2023; Wu et al., 2020; Jiang et al., 2021c; Xu et al., 2022; Wu et al., 2021; Ding et al., 2022; Wang et al., 2022
Suppliers	Afraz et al., 2021; Pillai & Bindroo, 2020; Onofrei et al., 2020; He et al., 2021; Kissi et al., 2021; Du et al., 2023; Stokke et al., 2022
Sustainability	Zhang et al., 2024; Nguyen, 2023; Mosurović Ružičić et al., 2021; Duong et al., 2021; Kinnunen et al., 2022; Kuzma et al., 2020; De la Vega Hernández & Barcellos de Paula, 2021; Mustofa et al., 2023
Systems skills	OECD/Eurostat 2018, Satalkina & Steiner 2020, Liu et al. 2021, Deppeler & Aikens 2020, Midgley & Lindhult 2021
Tax	Balsalobre-lorente et al. 2021, Najafov 2021, Pelaez et al. 2024, Stantcheva 2021, Akcigit & Stantcheva 2020, Zeng et al. 2022, Luo & Wu 2023, Walter et al. 2022
Technical expertise	Weerapperuma et al. 2022, Li et al. 2020b, Lubua 2022, Laszig et al. 2020, Klosova & Kozlovská 2020, Liphadzi & Yeko 2023, Zilberova et al. 2021, Zolfaghar Arani et al. 2024
Tender process	Lenderink et al. 2020, Oad et al. 2021, Lenderink et al. 2022, Al-Sabah & Abdulrahim 2021, Czarnitzki et al. 2020, Bergsgard & Nødland 2020, Musa & Pasquire 2020

Upper management support	Duarte & Picchi 2021, Barham et al. 2020, Prokop & Hájek 2023, Aftab et al. 2022, Hijal-Moghrabi et al. 2020, Rajan et al. 2021, Alawamleh et al. 2020

Source: Compiled by the author based on insights from Zhang et al. (2024), Wen et al. (2022), and other references cited in the table

2.10 Business Innovation Score

Measuring innovation output is a complex task that involves various approaches and indicators. Researchers have proposed quantitative measures for innovation outcomes, including cost reduction and quality improvement (Rammer, 2023). Common innovation indicators include R&D expenditures, patent numbers, and implemented innovations (Dziurski, 2021). Innovation efficiency can be assessed using models measuring input versus output (Erdin & Çağlar, 2023). Studies have found a significant positive relationship between innovation input and output (Reis et al., 2021). This is while challenges exist for measuring innovation, especially in developing countries. This is due to structural and perception-related issues in the existing measurement tools (Cirera & Muzi, 2020). In recent years, patents especially related to environmental matters are increasingly being used to measure innovation output and innovation-related trends (Urbaniec et al., 2021).

The Business Innovation Score is a representation of one of the critical components of the innovation measurement framework, which is developed in this thesis. This score is designed with the purpose of evaluating the outcomes and performance aspects of innovation within construction companies and complements the Innovation Potential score. Through focusing on measurable indicators of innovative activities and relevant achievements, the Business Innovation Score provides very beneficial insights into how effectively organisations turn their innovation potential into actual innovations. This section outlines the development and conceptualisation of the score, while it offers an approach into the assessment and improvement of actual innovations in New Zealand's medium and large construction companies.

2.10.1 Innovation Outcomes: Products

Recent research has a strong focus on innovative materials and technologies that can or are transforming the construction industry. Building Information Modelling, automation, robotics, and virtual/augmented reality are continuously improving efficiency and productivity (Klosova & Kozlovská, 2020; Molchanova, 2023; Samarasinghe & Wood, 2021). Nanotechnology is improving the properties of materials and has even created self-cleaning surfaces (Molchanova, 2023). Sustainable materials such as engineered wood, recycled aggregates, and bio-based products are helping to reduce impacts on the environment (Iluyomade & Okwandu, 2024; Casini, 2022). Advanced and innovative concrete, smart coatings for materials, and high-tech/dynamic windows are contributing towards the improvement of building performance (Casini, 2022). 3D printing and techniques on prefabrication are revolutionising processes in construction (Najmi & Sharma, 2024; Samarasinghe & Wood, 2021). These innovations are

aiming to address challenges like the depletion of resources, carbon emissions, and the generation of waste (Iluyomade & Okwandu, 2024). But we must know that implementation of these innovations faces obstacles, including issues such as cost considerations and regulatory impediments (Iluyomade & Okwandu, 2024). Continued research and development are extremely important for helping drive sustainable construction practices forward (Frigione & Aguiar, 2020; Iluyomade & Okwandu, 2024).

According to the Oslo Manual, 2018 (OECD/Eurostat, 2018, p. 251), a product innovation is "a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market". In line with this, there was a need to embed questions into the tool regarding product innovations, innovative goods, and innovative services.

Overall, how do you rate your company's produced innovative goods during the past year?

Overall how do you rate your company's produced innovative services during the past year?

Please indicate the number of product innovations during the observation period.

2.10.2 Sales and Product Innovations

Research indicates that product innovations can positively impact sales growth in the construction industry. Eco-product innovations are valued by consumers and can lead to increased sales (Aibar-Guzmán & Somohano-Rodríguez, 2021). However, the relationship between patents and product innovation varies, with market leaders using patents differently from followers (Argente et al., 2020). Environmental sustainability innovations in construction have been shown to positively affect stock market reactions (Duong et al., 2021). Innovation in the construction industry has been shown to positively impact productivity, sales growth, and business performance (Laszig et al., 2020; Costantiello et al., 2021; Yusof et al., 2023). In line with this, there was the need to embed questions addressing sales into the tool:

Inside your company, what share of the total sales in the previous three years do you estimate is due to product innovations?

To what extent did your company's product innovations result in an increase in sales?

2.10.3 Profits and Product Innovations

Product innovations can lead to increased profits and reduced environmental impact (Awan, 2020). Elements influencing innovation include monopoly profits, future benefits, and competitive conditions (Arai & Morimoto, 2021). Recent research highlights the positive impact of innovations on profits in the construction industry. Innovations can enhance project efficiency, quality, and competitiveness (Blagodatskaya & Gromakova, 2023). Advanced materials, such as high-performance concrete and green composites, offer environmental benefits by reducing resource consumption and emissions (Nwokediegwu et al., 2024),

eventually leading to more profits for the company. To address the relationship between Profits and product innovations, the following questions were embedded into the tool:

To what extent did your company's product innovations result in an increase in profits?

What was your average profit margin for your company's product innovations?

2.10.4 Market Share and Product Innovations

Research indicates that product innovations can positively impact market share in the construction industry. Environmental sustainability innovations have been shown to increase stock market value for construction firms (Duong et al., 2021). Innovation dimensions, including product innovation, have a significant positive effect on market share (Johnson et al., 2021). While patents are associated with product innovation, market leaders tend to use patents to limit competition rather than introduce new products (Argente et al., 2020). Environmental performance is positively related to market share, especially when customer awareness and firm innovativeness are high (Rahman et al., 2020). In high-technology markets, product innovativeness influences technology switching behaviour, which can impact market share (Al-kwifi et al., 2021). A question, to collect data regarding the interrelation between innovations and market share, was embedded into the tool as follows:

What is the market share of the firm's product innovations out of all sales in the market for similar products?

2.10.5 Innovation Outcomes: Processes

Innovations enable seamless construction processes, reducing costs and environmental impact (Molchanova, 2023). Successful implementation requires an integrated approach, combining innovative design processes with construction strategies like prefabrication and just-in-time delivery (Staub-French et al., 2021). To facilitate innovation adoption, Gledson (2022) proposed an enhanced innovation-decision process model for construction. Innovative processes are crucial for enhancing competitiveness and efficiency in various industries. They involve the creation, implementation, and diffusion of new ideas, products, or processes (Hnatyshyn & Khanas, 2023; Anisimov et al., 2020). Effective management of innovative processes requires a process-oriented approach, focusing on business process allocation and resource optimisation (Anisimov et al., 2020; Tkalich & Iakovenko, 2022). Innovation in design processes is closely linked to scientific research and entrepreneurship (Eckert & Luo, 2022).

The Oslo Manual 2018 (OECD/Eurostat, 2018, p. 242) defines a business process innovation as "a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm". The Oslo Manual 2018 (OECD/Eurostat, 2018, p. 242) also classifies the business process innovations into the following categories, which were also used as the basis for developing evaluation questions in the business innovation measurement tool:

- production of goods and services
- distribution and logistics
- marketing and sales
- information and communication systems
- administration and management
- product and business process development.

Process innovations can lead to cost reductions and quality improvements, affecting firms' costs and, as a result, demand functions (Rammer, 2023), eventually leading to higher sales. The following question was also embedded in the tool, which addresses the impact of process innovations on sales:

To what extent did your company's business process innovations result in an increase in sales?

2.10.6 Operational Costs and Process Innovations

Process innovation in construction can lead to significant cost reductions and quality improvements. Studies have shown that implementing Building Information Modelling (BIM) technology can reduce total costs and improve key performance indicators (Smetanková et al., 2020). Target costing has also been found to optimise business processes and reduce operating costs in construction projects (Oncioiu et al., 2021). Industry-university consortia have enabled process innovations such as takt production and lean design management (Lavikka et al., 2020). Other effective strategies include prefabrication, just-in-time delivery, and integrated safety management (Staub-French et al., 2021). Organisational innovation plays a mediating role between process and product innovation in the construction industry (Rosa et al., 2023). Continuous improvement measures, focusing on non-physical waste reduction, can lead to cost reductions in overhead costs (Omotayo et al., 2020). Additionally, implementing carbon reduction strategies throughout the construction process can contribute to overall sector decarbonization (Arogundade et al., 2023). To investigate this effect, the following question was embedded into the innovation measurement tool:

To what extent did your company's business process innovations –directly or indirectly – led to a reduction in operational cost (per unit of output / per operation)?

2.10.7 Innovation Novelty and Impacts Assessments

Novelty, Innovativeness, Economic Impact

Recent research on innovation assessment in construction highlights the importance of evaluating both technical and economic aspects of innovative solutions (Pushkar & Sobolieva, 2022). Several studies propose methods to encourage and assess innovations in public tenders for infrastructure projects (Lenderink et al., 2020; Politi, 2021). The assessment of novelty and systems thinking in conceptual technological models has also been explored (Lavi et al., 2021). These findings contribute to a better understanding of innovation assessment and management in the construction sector. Approaches to innovation measurement include design thinking tools to evaluate innovative solutions from a consumer perspective (Pushkar & Sobolieva, 2022).

The complexity of construction projects necessitates considering innovativeness throughout the project lifecycle (Politi, 2021). The electric grid construction sector emphasises the need for variant design and complex economic-technical assessments of project innovativeness (Politi, 2023). Implementing innovative technologies can lead to increased efficiency, sustainability, and economic growth (Timchuk et al., 2021; Oborin, 2020). Economic impact assessments of construction innovations reveal positive effects on GDP and employment (Teo et al., 2022). To collect data regarding the Novelty, Innovativeness, and Economic impact of the process innovations of the company, the following questions are added to the innovation measurement tool:

How do you rate the … Novelty / Innovativeness / Economic impact …. of the innovations / most important innovation of your company during the past year?

2.10.8 Innovation and Business Profiling

The Oslo Manual 2018 (OECD/Eurostat, 2018) recommends the classification of companies into four different categories as follows: The companies can be either innovative or non-innovative, and further can be classified to see whether they are innovation-active or not. An innovative firm has had at least one innovation in the observation period. An innovation-active firm has been active in developing or using new or improved business processes or products during the observation period. A combination of these two terminologies is possible and will be measured within the tool. It would be quite rare for a company to not be innovative or innovation active at all. Relevant Questions were added to the innovation measurement tool to address this company classification/profiling.

2.10.9 Innovation Activities

The Oslo Manual 2018 (OECD/Eurostat, 2018) defines Business innovation activities as all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm. They include:

- *research and experimental development (R&D) activities*
- *engineering, design and other creative work activities*
- *marketing and brand equity activities*
- *intellectual property (IP) related activities*
- *employee training activities*
- *software development and database activities*
- *activities related to the acquisition or lease of tangible assets*
- *innovation management activities.*

Some of these activities were previously discussed in the Attributes affecting potential for innovation section of this thesis as well. To collect data around Innovation activities, a set of relevant questions, reflecting the eight indicators mentioned above, was added to the innovation measurement tool.

2.10.10 Innovation Projects

Innovation projects are crucial for companies to stay competitive in rapidly changing markets, but they often face high uncertainty and risk (Shenhar et al., 2020). Successful innovation projects require effective project management, combining innovation principles with execution strategies (Shenhar et al., 2020; Yordanova, 2020). Innovation project management spans various disciplines, including human capital, strategy, and knowledge management (Catto & Maccari, 2021). User acceptance is critical for innovative projects' success (Varga & Csiszárik-Kocsir, 2023). To maximise innovation project success, managers should focus on efficiency, results, and the particular characteristics of innovation (Catto & Maccari, 2021). A vast number of companies manage their innovation activities as projects focused on innovations. These projects are conceptualised as a "set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes" (OECD/Eurostat, 2018, p. 248). Therefore, a set of questions was embedded into the innovation measurement tool to collect data regarding the innovation activities of the companies, which will potentially lead to their intended innovations, objectives, resources and expected outcomes, as mentioned earlier in this paragraph. The questions are as follows:

For your company, please indicate:

- *Does your company organise your innovation activities on a project basis?*
- *The number of innovation projects undertaken during the past year.*
- *The number of innovation projects completed during the past year.*
- *The number of innovation projects ceased before completion during the past year.*
- *The number of ongoing innovation projects at the end of the past year.*

2.10.11 Follow-on Innovation Activities

Recent research on follow-on innovation activities highlights the complex interplay between patents, information transparency, and strategic management. Patents can both hinder and facilitate follow-on innovation, with their effects varying based on the original innovation's value (Gaessler et al., 2024). Information transparency in disclosures positively influences follow-on innovation by reducing uncertainty (Chen et al., 2023b). Firms strategically manoeuvre to maximise value from standard essential patents through early and targeted follow-on innovations (Yao et al., 2024). Measuring follow-on innovation accurately is essential for evaluating patent system effects and policy reforms (Freilich & Shahshahani, 2023).

Other than innovation activities, companies can also conduct follow-on activities, but within the observation period. These follow-on activities are extremely decisive for the success or failure of an innovation, but they are not part of the definition of an innovation activity (OECD/Eurostat, 2018). These follow-on activities can be in the form of: Follow-on marketing, promotions, sale, advertising, fairs, distribution, training related to the use of innovations during the past year, familiarising users with a firm's innovations, after-sales services, maintenance, operations management, utility improvement, installation, updating, repair services, guarantee, return schemes, information services, communication and alike

(OECD/Eurostat, 2018). These follow-on activities were embedded into questions within the innovation measurement tool. The question asks:

To what level does your company pursue any of the follow-on activities for their innovation projects?

2.10.12 Planned Innovation Activities and Expenditures

Research on planned innovation activities and expenditures highlights their importance for firm profitability and economic development. Planned innovation, measured by the interaction between innovation intention and activities, is associated with higher profitability for firms (Pham et al., 2021). Research and development (R&D) expenditures positively impact innovation in developing countries (Aftab et al., 2023). R&D investments - as a leading indicator of innovation - are crucial for maintaining ongoing innovation activities (Duarte et al., 2023). The steel industry has seen increased R&D expenditures related to Industry 4.0 implementation (Gajdzik & Wolniak, 2022). National medium-term innovation priorities and their budgetary support play a role in ensuring innovative economic development, with monitoring systems in place to track implementation (Kvasha et al., 2023). To collect data regarding the expenditures that a company plans to invest in their innovation activities, the following questions were embedded into the innovation measurement tool:

Does your company plan to conduct any innovation activities during the next two years?

Could you please indicate your company's planned annual innovation expenditures during the next two years?

What percentage of your company's expenditures is on innovation during the next two years?

How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the year after the reference year)?

The Business Innovation Score is a critical metric in this research, designed to measure the tangible outputs and performance aspects of innovation within construction organisations. This score classifies product and process innovations, and incorporates indicators like sales, profits, and market share as key outcomes of innovation activities. The inclusion of specific evaluation criteria, such as the number of product innovations, their impact on sales and profitability, and the role of business process innovations in cost reduction and operational efficiency, reflects the multidimensional nature of innovation in the construction industry. Through embedding tailored questions into the measurement tool, the score provides a detailed understanding of how construction companies in New Zealand turn their efforts towards innovation into success that can actually be measured, and which can be further aligned with the national and sector-specific goals set for innovation.

This tool also addresses existing gaps in previous innovation measurement frameworks through incorporating factors specific to the construction industry, which are usually overlooked in

commonly used models such as the Global Innovation Index (GII) (WIPO, 2024) or the Oslo Manual (OECD/Eurostat, 2018). For example, although these frameworks pay special attention to historically used metrics such as expenditure on R&D and number of patents, the Business Innovation Score of this thesis, in addition to these, evaluates follow-on innovation activities, such as marketing and after-sales services, in an attempt to provide a comprehensive view of the innovation lifecycle and its impact on the economy. The integration of these indicators guarantees that the score not only measures innovation outcomes but also is a reflection of their implications on business performance, competitiveness, and developments in the industry, especially in medium and large construction companies operating within the extremely different and unique context of New Zealand.

The score obtained from the questions in the Business Innovation Score section of the tool will be merged with the score from the Innovation Potential section to collectively form the Overall score of the Business Innovation Measurement Tool that will be developed in this thesis. The following table presents the indicators found impactful on the business innovation score of the construction companies to innovate. Their literature sources are also presented in this table:

Table 2.14: Indicators Affecting Business Innovation Score and their Sources

Indicator	Literature sources
Innovation outcomes: Products	Klosova & Kozlovská, 2020; Molchanova, 2023; Samarasinghe & Wood, 2021; Iluyomade & Okwandu, 2024; Casini, 2022; Najmi & Sharma, 2024; Frigione & Aguiar, 2020; OECD/Eurostat, 2018
Sales and product innovations	Aibar-Guzmán & Somohano-Rodríguez, 2021; Argente et al., 2020; Duong et al., 2021; Laszig et al., 2020; Costantiello et al., 2021; Yusof et al., 2023
Profits and product innovations	Awan, 2020; Arai & Morimoto, 2021; Blagodatskaya & Gromakova, 2023; Nwokediegwu et al., 2024
Market share and product innovations	Duong et al., 2021; Johnson et al., 2021; Argente et al., 2020; Rahman et al., 2020; Al-kwifi et al., 2021
Innovation outcomes: Processes	Molchanova, 2023; Staub-French et al., 2021; Gledson, 2022; Hnatyshyn & Khanas, 2023; Anisimov et al., 2020; Tkalich & Iakovenko, 2022; Eckert & Luo, 2022; OECD/Eurostat, 2018; Rammer, 2023
Operational costs and process innovations	Smetanková et al., 2020; Oncioiu et al., 2021; Lavikka et al., 2020; Staub-French et al., 2021; Rosa et al., 2023; Omotayo et al., 2020; Arogundade et al., 2023
Innovation novelty and impacts assessments	Pushkar & Sobolieva, 2022; Lenderink et al., 2020; Politi, 2021; Lavi et al., 2021; Politi, 2023; Timchuk et al., 2021; Oborin, 2020; Teo et al., 2022

Innovation and business profiling	OECD/Eurostat, 2018
Innovation activities	OECD/Eurostat, 2018
Innovation projects	Shenhar et al., 2020; Yordanova, 2020; Catto & Maccari, 2021; Varga & Csiszárik-Kocsir, 2023; OECD/Eurostat, 2018
Follow-on innovation activities	Gaessler et al., 2024; Chen et al., 2023; Yao et al., 2024; Freilich & Shahshahani, 2023; OECD/Eurostat, 2018
Planned innovation activities and expenditures	Pham et al., 2021; Aftab et al., 2023; Duarte et al., 2023; Gajdzik & Wolniak, 2022; Kvasha et al., 2023

Source: Compiled by the author based on insights from Gaessler et al. (2024), Lavi et al. (2021), and other references cited in the table

2.11 Summary of Findings in Stage 1 Literature Review

Chapter 2, which addresses stage 1 of this research, critically reviews existing literature to establish a foundation for the development of a comprehensive innovation measurement tool tailored to medium and large construction organisations in New Zealand. Chapter 2 is part of a process to address objectives 1 and 2, and answer the sub-questions 1, 2 and 3 of the research.

The chapter begins with a discussion on the need for innovation within the construction industry and outlines the unique challenges it faces. Challenges such as fragmentation, project-based work, and the complexities of the supply chain. The importance of both innovation potential and business innovation score is addressed in an attempt to create a holistic measurement framework. Definitions, theories, and the unique characteristics of innovation in the construction industry are studied. This section also presents how construction innovation is different from other industries.

A number of global innovation measurement frameworks, such as the Oslo Manual and Global Innovation Index, were critically analysed. Frameworks designed for specific sectors, including tools for social innovation and green technology, were investigated in an attempt to investigate their limitations, weaknesses and strengths, for implementation and use in the construction industry. A detailed discussion identified the weaknesses of the current innovation measurement tools and their lack of ability to address the specific needs of the construction industry. This includes not being able to adapt to fragmented project environments, not having enough focus on sustainability, and challenges relating to measuring collaborative practices. The chapter concludes by highlighting the gap and emphasising on the need for a comprehensive, innovation measurement tool specifically designed for the construction industry. The chapter emphasises on the importance of including a broad list of innovation indicators.

Organisational attributes which are important for supporting innovation were explored. These factors are related to innovation performance and provide a detailed and strong foundation for the diagnostic tool's development. The importance of assessing the outputs of innovation is

reflected in and emphasised through the concept of a Business Innovation Score. This part of the tool captures and measures the results of activities relevant to innovation. By encompassing and measuring both tangible and intangible outcomes, the score produces a strong understanding of innovation performance within construction organisations.

This chapter justifies the need for a tailored innovation measurement tool for addressing the complexities, uniqueness and the dynamic nature of the construction industry, in line with New Zealand's specific conditions. Based on the results of this first stage of research, which is presented as a literature review, and through the expert-informed thematic analysis and categorisation, the classification of the indicators into relevant categories was achieved. The following ***Business Innovation Measurement Framework*** is comprehended and proposed for the measurement of innovation in the New Zealand construction industry. It consists of two major categories: *Potential* and *Actual Innovation*.

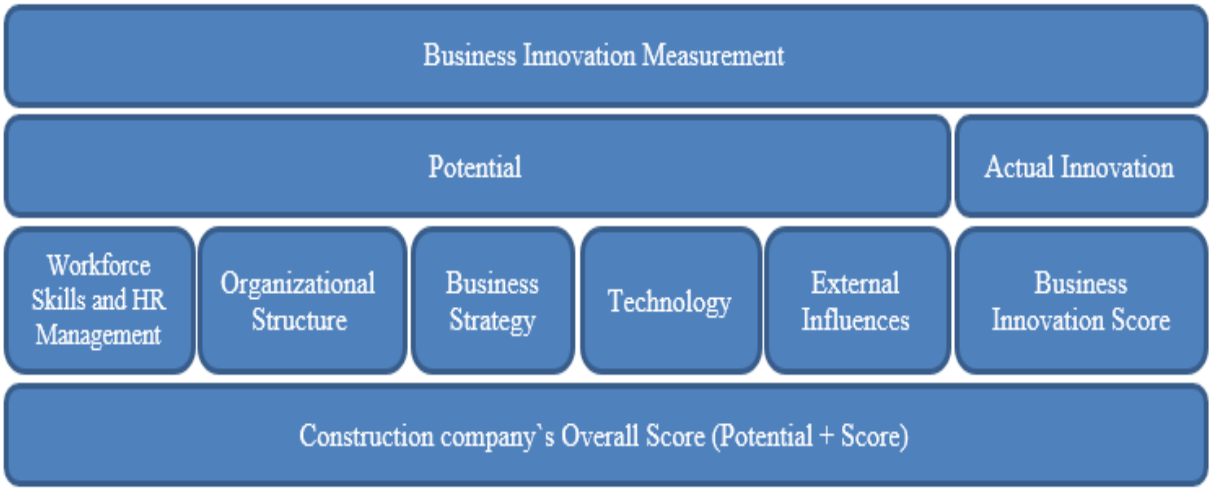
The *Potential* section consists of 5 subcategories:

- Workforce Skills and Human Resources (HR) Management,
- Organisational Structure,
- Business Strategy,
- Technology, and
- External Influences.

This is while the *Actual Innovation* is represented by the:

- Business Innovation Score.

Figure 2.11: Business Innovation Measurement Framework



Through collecting information on these categories, and by merging the scores of these categories using descriptive statistics, with respect to the measurement criteria and scales chosen for each indicator and question, depending on its nature, eventually the *Construction Company's Overall Score (potential + Score)* is developed.

Construction Company's Overall Score (potential + Score) represents the final result of the *Business Innovation Measurement Tool* based on this framework. Together with the analysis of the interviews' qualitative results and the analysis of the quantitative data collected from the case study construction company, the construction company can be studied, its potential for innovation will be identified, its innovation-related weaknesses will be diagnosed, and its innovation output will be investigated. The *Business Innovation Measurement Framework* is the bedrock of developing the *Business Innovation Measurement Tool,* developed specifically for the New Zealand construction companies. This tool facilitates finding remedies for the companies' innovation improvement plans, programmes, and strategies.

In more detail, the Business Innovation Measurement Tool functions as an input-output system which is designed for measuring innovation within New Zealand construction companies. The input consists of the data which are collected from tool respondents' answers to structured questions and indicators which are categorised across six categories - five categories under Innovation Potential and one category under Actual Innovation Score. These responses are quantified and processed with the use of descriptive statistics techniques that are aligned with the nature of each indicator and its respective measurement scale. The output is twofold: an Innovation Potential Score and a Business Innovation Score, which are then averaged to find and demonstrate the final Construction Company's Overall Score (potential + Score). This score represents the company's position within the Business Innovation Measurement Framework and serves as the final and conclusive result (output) of the tool. In conjunction with qualitative analysis of the interview transcripts and case study data, this framework facilitates and enables the identification of innovation capacity and potential of a construction company, diagnostic evaluation of its weaknesses in relation to innovation, and assessment of its actual innovation performance. Ultimately, this tool builds a foundation for developing targeted innovation improvement plans and strategies that are tailored to the needs of New Zealand's construction industry.

This is the end of the first stage of this thesis. In this stage, the research question was formulated, and the research gap was identified. Based on this, the scope, aim and objectives of the research were determined, and the research's primary question and the relevant sub-questions were defined. To fulfil these goals, the literature on innovation was comprehended. Following this, a list of indicators that affect innovation in the construction organisations was comprehended. This led to the development of an initial innovation measurement tool, which consists of 6 categories of questions measuring the innovation potential and the actual innovation of the construction organisations. Also, a framework for the measurement of business innovation in construction organisations is developed. The following figure 2.12 represents the steps taken to successfully complete stage 1 of this research:

Figure 2.12: Steps Taken to Successfully Complete Stage 1 of This Research

In the following chapter 3, the research methods incorporated for achieving the objectives of this research are presented. In the form of the second stage of research, in chapter 4, the tool is implemented into 2 construction case study companies to help test, further develop, and refine the tool. In the form of the third stage, in chapter 5, the tool is used to interview construction industry experts (CIEs) to validate, gain approval and confirmation, and to further improve and refine the tool. The results obtained in the three stages of the research are analysed and presented in the relevant chapters. In addition, chapter 6 presents the discussion of the results and findings. Also, chapter 7 of this thesis is dedicated to presenting the conclusions and recommendations achieved through this research.

Chapter Three: Methodology

3.1 Introduction

This chapter presents the methodological approach adopted to pursue the development, testing, and validation of a comprehensive innovation measurement tool designed for medium and large construction organisations in New Zealand. The primary aim of this research is to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand, in such a manner which is theoretically strong and practically easy to use. Due to the complex and multi-dimensional nature of innovation within the construction industry, a robust and adaptive methodology was necessary.

To achieve this goal, a sequential exploratory mixed methods design (Creswell & Plano Clark, 2017) was implemented. This design allows the researcher to begin research with qualitative exploration (through literature review and input from experts in the field) to start the construction of the tool. The research later proceeded to quantitative and qualitative testing within real organisational contexts. Each methodological stage provided unique insights into the overall tool development process. The earlier stages laid the theoretical and structural foundation, and the following later stages provided empirical validation and tool refinement, which were achieved through data provided by the respondents. This methodology chapter outlines the details of this process, which is structured around three key stages: 1) tool development through literature review and categorisation by experts; 2) empirical application in case study organisations; and 3) expert validation through semi-structured interviews.

3.2 Research Philosophy and Paradigm

This study adopts a pragmatic research philosophy, which reflects the main goal of developing a practically relevant and theoretically strong tool for measuring innovation in medium and large construction organisations of New Zealand. Pragmatism as a paradigm supports methodological pluralism, in which research methods are chosen on the basis of their capacity and potential to address and tackle the research problem instead of their magnitude of alignment with a particular philosophical stance (Creswell & Plano Clark, 2017; Elgeddawy & Abouraia, 2024; Morgan, 2007).

The pragmatic research paradigm, which is the foundation of this research, is guided by a pluralistic ontology that endorses the existence of multiple, context-dependent realities. The pragmatic research paradigm of this research also recognises an instrumentalist epistemology, in which knowledge is accepted as valid on the condition that it is practical, action-oriented, and capable of supporting real-world decision-making (Morgan, 2014; Creswell & Plano Clark, 2017).

In other words, during this research, the ontological position supports that reality is dependent on the context, and multiple realities might be in existence and could be shaped by factors such as industry conditions, organisational behaviour, and perspectives coming from the stakeholders. The epistemological stance of the research is action-oriented and focuses on outcomes and usability. This epistemology believes that knowledge is understood to be valid when it facilitates effective decision-making and endorses the measurement of innovation. This stance is consistent with pragmatism's strong emphasis on and support for actionable knowledge in organisational research (Kelly & Cordeiro, 2020).

This paradigm endorses this research's three-stage sequential exploratory design. In the first stage, literature and theory were used to place the innovation indicators into categories. In the second stage, the initially developed tool was quantitatively tested and qualitatively refined by application inside the case study organisations. This was done through interviews and Likert scale evaluations, contributing towards qualitative and quantitative triangulation. In the third stage of this research, the tool was further refined through collecting information from qualitative expert interviews and analysing these data. This iterative approach adheres to pragmatism's emphasis on solving real-world problems through integrated evidence (Florczak, 2014; Creswell & Plano Clark, 2017).

Additionally, this research employs replication logic in its multiple case studies (Yin, 2018) and further maintains transparency in research by documenting procedures and protocols in detail. The research design achieves external validity (transferability) and internal reliability through comparing findings from different organisational settings and methods. This pluralistic methodology is in line with the characteristics of pragmatism, which tends to evaluate knowledge based on its consequences and applicability (Hall, 2013; Kelly & Cordeiro, 2020; Morgan, 2014).

Pragmatism allows the researcher to merge qualitative techniques (such as expert-informed thematic categorisation, interviews, and narrative feedback) with quantitative tools (such as Likert-type survey instruments, spider diagrams, and statistical analysis). Therefore, this method, supported by pragmatism, leads to the enhancement, strength and applicability of the innovation measurement tool (Elgeddawy & Abouraia, 2024; Morgan, 2007; 2014).

In summary, the adoption of a pragmatic paradigm for this research allows for the flexible comprehension of theoretical insights, expert knowledge, and organisational realities for the development of a practical and strong innovation measurement tool. This achievement is the reflection of the central belief of pragmatism: what works in practice (Morgan, 2014).

3.3 Research Design Overview

This research adopted a sequential exploratory mixed methods design (Creswell & Plano Clark, 2017). This methodology allows for the systematic development and refinement of research tools through comprehending both qualitative and quantitative data within different stages of research (ATLAS.ti, 2025; Creswell & Plano Clark, 2017; Fetters et al., 2013; Mihas & Odum, 2019). This research design was chosen amongst other options to support the complex goal of developing an innovation measurement tool specifically tailored for medium and large construction organisations in New Zealand. As stated in chapter 1, section 1.1.4, Problem

statement - Research gap, there exists a notable gap in tools that reflect the unique operational, organisational, and contextual characteristics of the New Zealand construction industry.

The sequential exploratory design is implemented into three interrelated stages. The first stage addresses the conceptual development of the measurement tool during an inductive content analysis (Rimmel & Cordazzo, 2021; Vears & Gillam, 2022) of the existing literature in an attempt to extract indicators of innovation. In this stage, the literature review was followed by expert-informed thematic categorisation (Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021). The second stage was based on empirical testing within two case study organisations. In this stage, the tool was applied in real-world settings and evaluated by construction company employees. The third stage emphasised its approach to external validation by conducting interviews with construction industry experts who provided their assessments on the tool's relevance, clarity, and usability.

The rationale behind adopting a sequential exploratory approach is in its strength for providing depth and progression, from theoretical exploration to practical testing and validation (Gogo & Musonda, 2022; Njuangang et al., 2023). The implementation of this method ensured that the initial concepts extracted from the literature were not only grounded in theory but were also later examined and refined based on data collected from industry practitioners and experts. The use of both qualitative interviews and quantitative Likert-scale data facilitated the achievement of both breadth and depth regarding the understanding of how innovation can be measured effectively within construction companies (Ahmed et al., 2024).

Additionally, this research adopted triangulation as a technique of validation (Carter et al., 2014), rather than as an overarching design. Triangulation was employed for improving the credibility, depth of research findings, and validity of the research findings through the convergence of data collected from multiple sources and methods (Bans-Akutey & Tiimub, 2021; Donkoh & Mensah, 2023; Meydan & Akkaş, 2024). Specifically, the research engaged method triangulation (Carter et al., 2014) by combining qualitative and quantitative data, and engaged source triangulation (Carter et al., 2014) by collecting insights from academic literature, case study participants, and external experts. This process allowed the researcher to investigate the innovation measurement tool from multiple perspectives, resulting in an increase in confidence towards the tool's comprehensiveness and practical value.

This adopted research design was especially suitable for the New Zealand construction context, which is characterised by its unique environments and characteristics. These traits were extensively discussed throughout the different parts of section 1.2 of this thesis. By engaging with and collecting data from both internal company actors and external construction industry experts, the conducted research ensured that the tool faced and can address challenges from the real world and is aligned with conditions specific to the construction industry.

The sequential nature of this research allowed findings from each stage to inform the next stage. For instance, the names of the indicators found in the literature review were, in some instances, rephrased based on user feedback provided from case study participants. These revised indicators were then reviewed and validated again by experts, resulting in a feedback process which refined the tool through stages. This planned refinement not only strengthened the tool's theoretical validity but also supported its practical applicability (Fetters et al., 2013; Gogo & Musonda, 2022).

In summary, the design chosen for this research enabled the development of a new innovation measurement tool which is theoretically strong, empirically tested, and practically validated. Each stage of the research added unique insights. The combined use of mixed methods and triangulation laid the basis for a comprehensive methodological foundation for the research. The following sections of this chapter provide a detailed explanation of the methods employed in each stage of the research process. This was an endeavour for the support of the development of an innovation measurement tool which can provide not only academic rigour but also industry applicability. The stages of the research methodology are presented below in detail, demonstrating how each contributed to the overall aim of developing a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand.

3.4 Stage One: Tool Development Through Literature Review and Expert Categorisation

The first stage of this research focuses on the initial design and development of the innovation measurement tool. This stage starts with a comprehensive review of the existing and relevant literature, including but not limited to peer-reviewed academic articles, industry reports, policy documents, and established innovation frameworks. The goal was to identify a wide range of indicators that have been known to be somehow related to innovation, especially within the construction industry. In addition, sources from other industries were also considered in an attempt to ensure comprehensiveness.

The literature review stage of the research is a theoretical research, based on previous literature, and thus explores concepts on firms' attributes considered significant in enabling innovation in the construction industry. The literature review provided a general overview of recent research on organisational attributes that act as drivers, enablers, and barriers of innovation. The literature review also achieved an understanding of the current literature on innovation measurement in construction. The literature sources were accessed through databases, which provided numerous academic journals, conference papers and national reports. In addition, some textbooks found to be useful to the research process were referenced. Thus, a comprehensive literature survey was carried out to collect information on relevant research on this topic. The search process made use of the following search engines and paper archives: Google and Google Scholar, Emerald and Scopus, ASCE library and Science Direct Journal databases, as well as other archives. This extensive search strategy enabled this research to capture both formerly published papers and numerous recent national and international reports.

During stage one, the literature review process was guided by the principles of inductive content analysis (Rimmel & Cordazzo, 2021; Vears & Gillam, 2022). During this stage, innovation indicators were identified by examining data without relying on predefined categories. While the review progressed, recurring patterns and themes emerged from the literature. As a result, key areas such as human resources (HR), organisational practices, strategic orientation, technological application, and external environmental influences were developed. It was through this data-driven process that indicators related to innovation were also identified. These indicators relate to both the potential of the companies for innovation and the actual innovation aspects and are necessary for the measurement of innovation.

Following the identification of indicators, a process of expert-informed thematic categorisation (Ahmed et al., 2025; Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021) was conducted. This process involved multiple structured meetings between the researcher and the two academic supervisors. These experts provided critical and valuable insights based on their expertise in the fields of innovation, measurement tool development and research methodology. Each indicator was examined with extreme care to determine conceptual definition and overlaps, thematic relationships, and logical groupings. Through an iterative and cyclical process of discussion, refinement, and consensus-building, the indicators of the tool were organised into six overarching categories. The tool development process was as follows:

3.4.1 Tool Development Process

The tool development process was an adoption and was based on Braun and Clarke's (2006) six-phase thematic analysis framework. As previously mentioned in section 3.4, in order to develop an initial tool which would be the basis of further stages, a process of expert-informed thematic categorisation (Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021) was engaged. In this stage, the researcher, together with his two supervisors, who were engaged as the expert panel, attempted to develop a basic classification of the indicators into a tool that could be used during the second and third stages of this research.

3.4.1.1 Tool Development Step 1: Data Familiarisation

Initially, through a comprehensive literature review, previous publications were collected and studied to comprehend a list of indicators that were found to be influential on the innovation of the organisations. Though this list was initial, it provided a basis for the categorisation. It was understood that the best way to first categorise the tool was to understand the impact of each of the indicators on the innovation of the organisations. This could be achieved by categorising the innovation affecting indicators into Enablers, Drivers, and Barriers of innovation. This was achieved, and in line with this, a paper was presented at the 42nd Australasian Universities Building Education Association (AUBEA) 2018 Conference titled Organisational attributes enabling innovative culture of the building industry. It became evident from the review of related literature that frequently occurring attributes have been identified as enabling, driving and barrier indicators of innovation. This, therefore, added to the current state of knowledge regarding issues relating to organisational attributes that can help promote innovation and to determine their practical relevance to New Zealand construction environment.

3.4.1.2 Tool Development Step 2: Initial Coding/Categorisation

In the second step of expert-informed thematic categorisation (Ahmed et al., 2025; Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021) with the engagement of the expert panel, the achieved list of enablers, drivers and barriers was classified into 6 initial categories. In this category, the indicators – preliminary and yet to be fully developed – were inserted. At this stage, the indicator titles were more explanatory rather than having a name tag and a category code being attached to the indicators. An attempt was made to put together any two

or many indicators that could fit in the same *barrel*. The criteria for this merge were to come up with indicator names that could represent one or a few of the explanations around any indicator. To facilitate this categorisation, a colour-coding scheme was adopted.

It was also during this step that 5-point Likert Scales (with explanation) were selected for measuring the indicators were chosen. This was done by developing rational wordings that would allow the measurement of that *barrel* of indicators. This process required special attention by the expert panel to make sure that the scales have the potential for capturing the required information. Each of the tool's indicators was translated into a measurable item formatted as a 5-point Likert scale (Kusmaryono et al., 2022; Mohd Rokeman, 2024; Russo et al., 2021). This allowed the tool's respondents to rate the extent to which the statement was relevant to their organisation. Extreme care was taken to ensure that the wording of each item was clear, as concise as possible, and without ambiguity. Multiple cycles of internal review and pre-testing were conducted to refine the phrasing, standardise the terminology, and strengthen the logical sequencing of items within each category. The reason the Likert scale was chosen for use was not only for its widespread acceptance in the field of research, but also for its suitability for capturing perceptions, attitudes, and organisational practices across a wide range of knowledge fields (Kusmaryono et al., 2022). In this research, the Likert scale provided a mechanism for quantifying qualitative constructs. As a result, it further enabled the comprehension of statistical analysis and graphical representation of the gained results (Mohd Rokeman, 2024). Further justification for the use of the Likert scale has been discussed in section 3.9 of this chapter.

This process for step 2 was an adoption and was based on Braun and Clarke's (2006) six-phase thematic analysis framework.

3.4.1.3 Tool Development Step 3: Theme/Mature Category Development

In this step, the initial categories from step 2 were reduced to 5 categories, and some were tagged with new names to represent the evolving categorisations of the indicators. These categories are:

- Workforce Skills and HR Management consisting with 16 indicators
- Organisational Structure consisting with 9 indicators
- Business Strategy consisting with 9 indicators
- Technology consisting with 7 indicators
- External Influences consisting with 27 indicators.

At this time, a sixth category of questions was added to represent the Business Innovation Score. Also, two other categories were added to measure the general resources of the company and to collect data on the demographic information related to the respondent. Also, the result tables were developed, result diagrams (spider diagrams) were developed, and the Overall score table was developed to represent the Business Innovation Measurement (Potential + Score) score. At this point, codes were assigned to each indicator. This process for step 3 was an adoption and was based on Braun and Clarke's (2006) six-phase thematic analysis framework.

3.4.1.4 Tool Development Step 4 and 5: Expert Review + Refinement of categories

During multiple meetings between the researcher and the expert panel for reviewing the tool, extensive, valuable feedback was received, and multiple iterations were developed that represented a more mature categorisation of the indicators and more developed measurement scales. Also, the indicators were given a short name (one word if possible) to make the tool easier to respond to. This is while to avoid subjective interpretations by the respondents, there was and is an explanation in front of each indicator. This was done initially for the Likert measurement scales as well, but was removed as a result of feedback from the expert panel during later reviews. In other words, the explanations were removed for the Likert scale since the expert panel felt confident that the Likert scales were self-explanatory by just one-word tags and no longer needed explanation for the response selection. The tool was continuously reviewed by the expert panel in multiple sessions and matured by the researcher in multiple iterations. This process for steps 4 and 5 was an adoption and was based on Braun and Clarke's (2006) six-phase thematic analysis framework.

3.4.1.5 Tool Development Step 6: Finalisation of Tool

This process allowed for the development of a tool that the expert panel found to be ready for use in the second and third stages of this thesis. Through case studies, which collect data from the respondents around their companies and around the capabilities and weaknesses of the tool, the tool is further developed and strengthened. Also, through interviews with the construction industry experts in the third stage of the research, the tool is even further developed and matured. The developed Business Innovation Measurement Tool and the indicators of each category are presented in Appendix 2 of this thesis.

The three stages of this research together form a triangulation approach, which allows for the validation of the results of this research and the validation of the developed "Business Innovation Measurement Tool" developed for the New Zealand construction organisations. Below is a summary of the 6 steps of the tool comprehension process which is an adoption and based on Braun and Clarke's (2006) six-phase thematic analysis framework.

Table 3.1: Summary of Initial Tool Development Process based on Braun and Clarke (2006)

Step	**Tool Development Actions**
1. Data Familiarisation	1. Conducted a comprehensive literature review. 2. Identified indicators influencing innovation in organisations. 3. Categorised indicators into "Enablers," "Drivers," and "Barriers." 4. Confirmed categories through presentation at conference 5. Established relevance of indicators to NZ construction environment.
2. Initial Coding / Categorisation	6. Collaboratively classified indicators into 6 preliminary categories with expert panel. 7. Inserted explanatory indicator titles (no codes yet).

	8. Merged similar indicators into shared "barrels." 9. Adopted a colour-coding system to organise indicators. 10. Designed 5-point Likert scales with explanatory wording. 11. Validated Likert scale suitability with expert panel input.
3. Theme / Mature Category Development	12. Reduced categories of innovation potential from 6 to 5 key themes: Workforce Skills and HR Management, Organisational Structure, Business Strategy, Technology, External Influences. 13. Added sixth category: Business Innovation Score. 14. Added categories for general company resources and respondent demographics. 15. Developed result tables and spider diagrams. 16. Created overall score table for Business Innovation Measurement (Potential + Score). 17. Assigned codes to each indicator.
4 & 5. Expert Review + Refinement of Categories	18. Conducted multiple review meetings with expert panel. 19. Iteratively refined category groupings and measurement scales. 20. Assigned one-word titles to indicators for clarity and usability. 21. Retained explanations for indicators to reduce misinterpretation. 22. Removed Likert scale explanations based on expert confidence in their clarity. 23. Tool was matured through ongoing review and refinement by the researcher.
6. Finalisation of Tool	24. Tool finalised and approved for use in Stage 2 (case studies) and Stage 3 (expert interviews). 25. Tool strengthened further through practical application and expert feedback. 26. Part of a triangulated research design for validation. 27. Supports the final development of a validated "Business Innovation Measurement Tool" for New Zealand's construction industry.

This first stage of this research played an important part in establishing both the theoretical foundation and the structural framework of the innovation measurement tool. It ensured that the tool was comprehensive, logically organised, and tailored to capture the traits of the complex nature of innovation as it takes place within the New Zealand construction industry context. Additionally, this stage laid the groundwork and formed the basis for the subsequent empirical testing stage of the innovation measurement tool's development process, where the tool was further improved through evaluation in real-world settings.

3.5 Stage Two: Case Study Testing in Construction Organisations

The second stage of this research involved the practical application and testing of the innovation measurement tool inside real organisational contexts. To achieve this, a multiple

case study strategy (Coombs, 2022; Hunziker & Blankenagel, 2021; Yin, 2018) was employed. It employed two purposefully selected (Bouncken et al., 2025) medium and large construction organisations operating in New Zealand. The rationale behind using a case study approach was based on its capacity and potential for enabling an in-depth investigation of complex matters through application in real-life settings (Simons, 2020; Stake, 2005; Yin, 2018). During the study 2 of this research, the case study approach allowed for a strong understanding of how the developed innovation measurement tool performs when applied within real organisational atmospheres.

Purposeful sampling method was implemented to identify and select the two case study organisations. The companies were chosen based on their industry and scale. Section 3.10 of this thesis discusses the sampling strategy in more detail. Within each case organisation, five participants were chosen based on their knowledge of their respective company's internal processes and their roles in either decision-making, leadership, or operations. These participants' characteristics and roles represented a cross-section of managerial, technical, and strategic positions, which ensured that responses to the tool covered a broad range of perspectives about the organisation. Each participant initially completed the innovation measurement tool, which was structured under six categories. The items of these categories are designed to measure and investigate both innovation potential and actual innovation of the case company under study.

Upon completion of responding to the tool, participants were engaged in semi-structured interviews (Creswell & Creswell, 2018) in an attempt to provide feedback on their experience in using the tool. The interview questions were open-ended and investigated the participants' overall impressions, including their initial reactions to the tool, their evaluation of the usefulness of the diagnostic results, and whether the tool results and outcomes aligned with their expectations. Specific questions were asked, aiming to prompt reflection on possibly missing elements of the tool, suggestions for its simplification, and its potential for application within their respective organisations. Participants were also helpful towards evaluating the clarity and wording of individual items of the tool, as well as being asked to identify and introduce any redundancies or gaps. This feedback was extremely constructive for understanding how users personally interpreted the tool. It was also very useful for investigating its ability to measure constructs that are related to innovation accurately and meaningfully in practice. These questions can be found in Appendix 3 of this thesis.

Quantitative responses from the structured spreadsheet were manually entered into a Microsoft Excel file, and immediately, spider diagrams were generated for each participant to visually represent and demonstrate their respective organisation's performance across the six innovation dimensions. These visualisations were then used during follow-up interviews to stimulate discussion and initiate reflection. By facilitating participants to view their scores graphically, the spider diagrams served as a reflective prompt and helped to further elaborate the respondents' self-assessed ratings. It also highlighted areas of strength or improvement for the case companies.

The comprehension of both quantitative and qualitative data during this stage of research provided a strong and rich basis for internal validation of the tool (Creswell & Creswell, 2018). The structured Likert-scale data provided numerical data on how participants rated each innovation indicator. In the meantime, the interviews gave further context to these ratings and allowed for the collection of insights that quantitative data could not reveal alone.

Interview recordings were transcribed verbatim and uploaded into NVivo 12 Pro software, where they were coded (Skjott Linneberg & Korsgaard, 2019) and analysed by implementing thematic analysis (Braun & Clarke, 2021; Nowell et al., 2017). This process involved open coding (Benaquisto, 2008a) for the identification of the recurring themes, followed by axial coding (Benaquisto, 2008b)for establishing relationships between the themes and the innovation measurement categories. Key themes which emerged from this analysis of the transcriptions included participants' perceptions about the tool's overall usefulness, its relevance to their respective organisations, clarity and wording of specific items, completeness of the content, the usefulness and accuracy of results from the diagnosis process, and suggestions on the possibility of simplifying and restructuring the tool.

Through the implementation of this process, the case study testing stage accomplished several goals. Firstly, it provided empirical evidence on the tool's usability in real-world construction industry settings. Second, it revealed insights into how the tool was actually understood and utilised by a diverse group of users. Thirdly, it generated qualitative data that contributed towards several refinements to the tool. Finally, the results of this process demonstrated the feasibility and practicality of using the tool as a reflective and diagnostic instrument within construction organisations.

By engaging directly with participants of real construction companies, this stage of the research helped ensure that the developed innovation measurement tool was not only theoretically sound and strong but also viable in practice. The obtained feedback contributed to a user-based tool refinement process and confirmed the tool's potential value as a resource for self-assessment and benchmarking within the construction industry. Using NVivo 12 Pro software, a thematic analysis (Braun & Clarke, 2021; Nowell et al., 2017) approach was used to find key insights, emerging issues, and opportunities for the tool's refinement. Descriptive statistics (Alkharusi, 2022; Dong, 2023; Jones & Goldring, 2021) from the analysis of Likert scale responses provided a quantitative overview of how participants rated various indicators related to their organisations. Together, the collected qualitative and quantitative data provided internal validation (Creswell & Creswell, 2018) of the tool and allowed for the tool's refinement based on direct user experience.

3.6 Stage Three: Expert Validation through Semi-Structured Interviews

The third and final stage of the research methodology involved an external validation (Coleman, 2022; Creswell & Plano Clark, 2017) process through implementing semi-structured interviews with 5 construction industry experts (CIEs).

The construction industry experts (CIEs) were a combination of measurement tool development experts, innovation experts, senior construction industry experts aware of the organisational culture, experts in organisational training, and the like. The construction industry experts (CIEs) were chosen based on their academic standing, reputation in the industry, and direct experience with innovation or performance measurement inside the New Zealand construction industry.

The purpose of this stage of the research was to critically evaluate the innovation measurement tool's construct validity (Yin, 2018), credibility (Lincoln & Guba, 1985; Sajoudi, 2018), content clarity, and practical utility. While the earlier stages of the research (literature review

and application of the tool in case study companies) provided a strong foundation, the inclusion of perspectives from external experts was necessary to ensure that the tool was not only relevant and understandable but also adaptable and scalable for wider use and practice inside the construction industry context.

During the interviews, an interview protocol was followed. Each expert was given a paper or digital - depending on the form of communication being face to face or online - copy of the innovation measurement tool, and a brief explanation information document about the tool and the research being conducted. This preparatory material provided the opportunity for experts to familiarise themselves with the tool in advance and ensured that the interview discussions were focused and informed. Each interview was conducted in a semi-structured format to provide grounds for consistency and flexibility. The interview questions were open-ended (Johannesson & Perjons, 2021). These questions are presented in Appendix 4 of this thesis. The reason for the interviews being held either in person or via video conferencing was dependent on expert availability and geographic location. All interviews were audio recorded with the participants' consent and later transcribed verbatim for analysis.

By reaching a point of saturation (Charmaz, 2006), on the data that was being given by the respondents, eventually the tool was validated, and the interviews were considered sufficient, In this stage of the research, 5 respondents were chosen since as the interviews went ahead, it was evident that the experts' views were similar to each other, and they were confirming the other experts. This meant that the data had reached a saturation point where the data that was being collected was repeating itself. In other words, the size of the sample participants is based on the expertise and experience of the respondents and on the level of agreement they depict (Aliakbarlou et al., 2017; Che Ibrahim et al., 2013; Okoli & Pawlowski, 2004).

Thematic analysis (Braun & Clarke, 2021; Nowell et al., 2017) was used to systematically analyse the experts' feedback. Coding (Skjott Linneberg & Korsgaard, 2019) of the transcripts were conducted using NVivo 12 Pro software. The data analysis revealed numerous key themes that confirmed the validity (Creswell, 2014) and utility of the tool. The analysis also highlighted areas for refinement. Experts consistently endorsed the logical grouping of the tool's indicators under the developed categories. They also further endorsed the comprehensiveness of the tool for capturing both innovation potential and actual innovation inside construction companies. The construction industry experts (CIEs) also approved and liked the tool's structure and format, which was seen as being very practical for use inside organisational assessment and strategic planning. The details of the results from the analysis of the data collected during stage 3 of this research are presented in chapter 5 of this thesis. This stage of research reinforced the potential value of the developed innovation measurement tool not only as a measurement instrument, but also as a practical resource for organisational learning and development.

Overall, the expert validation stage of this research served an important part in external validation (Coleman, 2022; Creswell & Plano Clark, 2017), and helped with ensuring that the tool was, at the same time, academically strong and operationally relevant. This research process confirmed the appropriateness of the tool's structure and content and offered useful suggestions for the developed tool's improvement. Applying the feedback received from the experts into the final version of the developed tool strengthened its credibility (Lincoln & Guba, 1985; Sajoudi, 2018), broadened its potential application, and endorsed its compatibility with the current industry needs and innovation practices.

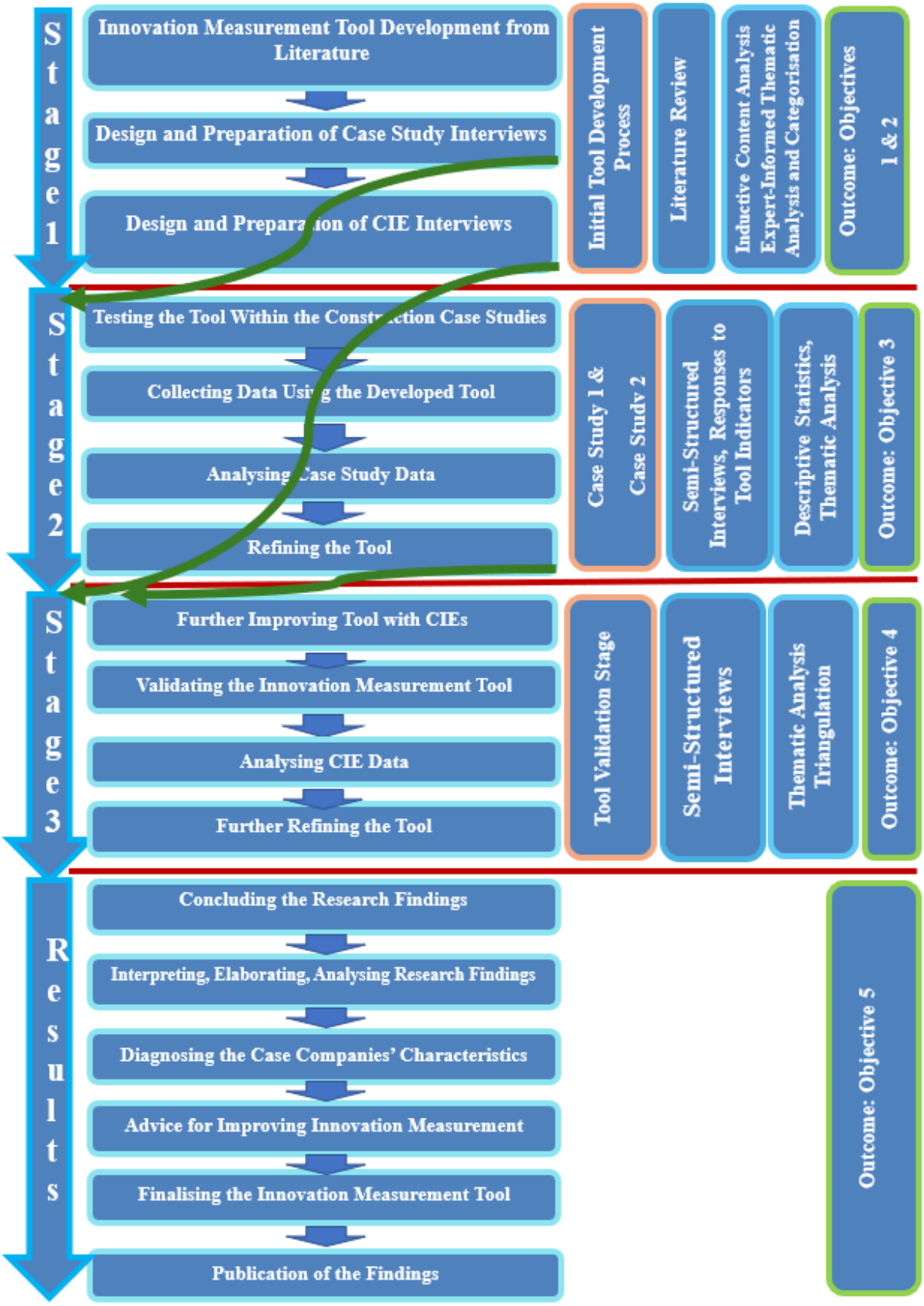
The insights gained during this stage of the research were very important for refining the final version of the innovation measurement tool. These results provided additional evidence on the tool's validity (Creswell, 2014), clarity, and contextual fit into the construction industry. This stage completed the three-stage methodology of this research and set the foundation for the analysis and the discussion presented in the following chapters of this thesis. This stage also contributed to the transferability (Ahmed, 2024; Johnson et al., 2020; Lincoln & Guba, 1985; Sajoudi, 2018; Stahl & King, 2020; Yin, 2018) of the tool and confirmed its alignment with both the theoretical principles and the practical needs of the industry.

Based on the previously stated information, the following summary in Table 3.2 represents the different stages of the research conducted during this thesis. Additionally, the stages altogether represent the framework for this research. Figure 3.1 also represents the description of the research framework in graphical format:

Table 3.2: Summary of Research Stages

Stage 1: **Description of research procedures:** formulate research question and identify research gap, comprehend the literature on innovation measurement, determine research scope, aim and objectives, building the comprehensive list of enablers/drivers/barriers of innovation + organisational attributes that affect innovation + indicators that allow the measurement of innovation, initial innovation measurement tool development, defining 6 categories (5 Potential + 1 Business Innovation) for the innovation measurement tool, design and preparation of case study interviews, design and preparation of construction industry expert (CIE) interviews **Research objectives addressed:** objectives 1 and 2 **Research sub-questions addressed:** sub-questions 1, 2 and 3 **Thesis chapters:** Chapters 1 and 2 **Data Sources:** relevant literature **Data collection method:** literature review **Data analysis method:** inductive content analysis, expert-informed thematic analysis and categorisation
Stage2: **Description of Research Procedures:** testing the innovation measurement tool within the construction organisation's context through case studies, collecting data regarding the construction organisations using the developed tool, analysing the data, including the companies' indicator scores and the responses to the interview questions, refining the tool. **Research objective addressed:** objective 3 **Research sub-questions addressed:** sub-question 4 **Thesis chapter:** Chapter 4 **Data Sources:** industry professionals, industry context, cases of study **Data collection method:** case study, semi-structured interviews, responses to tool indicators **Data analysis method:** descriptive statistics, thematic analysis
Stage 3: **Description of research procedures: c**ollecting further data regarding the tool and for its improvement from the construction industry experts (CIEs), validating the innovation measurement tool and the findings – by triangulating the research methods, refining the tool. **Research objective addressed:** objective 4 **Research sub-questions addressed:** sub-question 5 **Thesis chapter:** Chapter 5 **Data sources:** construction industry experts (CIEs) **Data collection method:** semi-structured interviews **Data analysis method**: thematic analysis

Figure 3.1: Description of Research Framework



3.7 Triangulation as a Validation Technique

During this research, triangulation was utilised as a validation technique (Carter et al., 2014) to improve the methodological strength, credibility, and comprehensiveness of the results and findings (Bans-Akutey & Tiimub, 2021; Donkoh & Mensah, 2023; Meydan & Akkaş, 2024). Triangulation, in the context of this research, was not used as a methodological framework. It was implemented as a strategic approach to confirm the results and ensure that the developed innovation measurement tool accurately reflected both the theoretical and the practical dimensions of innovation within the construction sector.

Given the multifaceted and complex nature of innovation, which spans across organisational structure, strategy, technology, human resources, and external influence categories, it was extremely important to validate the measurement tool through the use of multiple data sources and types of evidence (Creswell & Creswell, 2018). By engaging various stakeholder perspectives and data collection methods, triangulation contributed towards the achievement of construct validity, credibility, and trustworthiness on the tool.

During the three stages of this research, two main forms of triangulation were applied:

3.7.1 Method Triangulation

Method triangulation was involved with combining quantitative and qualitative data throughout the research (Creswell & Plano Clark, 2017). Quantitative data were extracted from responses to the tool items in the form of 5-point Likert scale questionnaire, which was administered during the case study stage. These responses provided measurable and quantifiable insights into how participants perceived and experienced innovation-related matters within their own organisations. Complementing this quantitative data, qualitative data were collected by implementing semi-structured interviews with both case study company participants and construction industry experts (CIEs). These interviews offered rich, explanatory insights that clarified or further expanded on the quantitative results. Qualitative narratives and their analysis results often explained and provided deeper interpretation and context to the quantitative and numerical results.

3.7.2 Source Triangulation

During this research, source triangulation (Creswell & Creswell, 2018) was also employed by collecting data and insights from three key sources: (i) the academic literature, (ii) participants from inside the case study organisations, and (iii) construction industry experts (CIEs) with recognised backgrounds in construction and innovation. Each group contributed very beneficial, unique and complementary perspectives towards the evaluation of the tool. The literature established the theoretical foundation and comprehensive coverage of the innovation affecting indicators, participants from inside the case study organisations contributed practical insights stemming from their operational experience, and the construction industry experts (CIEs) offered critical evaluations from both strategic and academic points of view. The convergence of themes and findings collected from these sources strengthened the overall confidence in the tool's validity (Naeem et al., 2023; Nowell et al., 2017; Lambert & Newman, 2022).

This triangulated validation approach demonstrated patterns of agreement and divergence that were very helpful for the refinement of the developed tool. For example, indicators that were consistently rated as clear and relevant across all three sources of data were kept and used without any modification. On the other hand, in instances where discrepancies between results were observed, like indicators which were questioned to be vague by respondents but were theoretically valid based on the information in the literature, were again reviewed, discussed, and revised as found necessary. This iterative process of refinement was directed using the principle of convergence (Direko & Davhana-Maselesele, 2017; Creswell & Plano Clark, 2011). The intention was not to force uniformity in results, but to achieve an innovation measurement tool which was driven by consensus and that balances theoretical soundness with industry practicality.

The role assigned to triangulation in this research is in line with the guidance offered by leading qualitative methodologists. Creswell and Creswell (2018), and Yin (2018), among other methodologists, have stated that triangulation improves the credibility of quantitative, qualitative and mixed-methods research by allowing researchers to verify their findings through multiple forms of evidence. Also, in line with these principles, triangulation during this research contributed towards achieving greater internal reliability, confirmability (neutrality and objectivity), and transferability (applicability of findings in other contexts) (Ahmed, 2024; Johnson et al., 2020; Stahl & King, 2020).

One of the important contributions of triangulation was that it also helped in finding blind spots and limitations that were present in the original design of the tool. The gained insights resulted in finding the necessary refinements. This improvement could not have been possible without input gained from diverse sources. Therefore, triangulation served this research not only as a mechanism for validation of the findings but also performed as a catalyst for tool improvement.

In conclusion, triangulation greatly improved the methodological strength of this research. Through systematically comprehending and comparing the insights from multiple methods (Meydan & Akkas, 2024) and different sources of data, this research ensured that the final version of the innovation measurement tool was well-grounded, validated, and capable of addressing the needs of the construction organisations in New Zealand.

3.8 Case Study

Many scholars, like Eliwa et al. (2022), have chosen the case study as their research method. Case study has always been a popular research method among researchers. Therefore, the overarching “research style” in this stage of the research is the case study method. Compared with other research methods, case studies can help researchers find the best variables that can indicate the concepts of the research, and they can often offer researchers new ideas based on the open questions from interviews. During research, further development of work provides information for the development of case studies, by analysing organisations/companies that implement innovations, their successful actions/processes, barriers and overcoming actions, and sources of new ideas. This creates an avenue for innovation acceleration in the industry (Adafin et al., 2022).

Case study research supports looking at the details of specific traits about the study case. The reality of the detailed study could affect the scale of the study at a time when there are limited

resources. The researcher could select the study cases based on the case being a representative of the population (Fellows & Liu, 2015). During a case study, the researcher might engage a variety of data collection strategies. For example, single or multiple approaches like interviews, etc., therefore, case studies consist of a unique method for research (Fellows & Liu, 2015).

In fact, case studies perform by theoretical generalisation, similar to experiments, instead of empirical/statistical generalisation (which is the process that engages surveys, that uses samples that are the manifestation of the population) (Fellows & Liu, 2015). This, in fact, was a strong justification for choosing the case study method as the method for collecting data during this PhD research. During the second stage of this research, the tool was tested on two construction companies, similar to experiments, which leads to theoretical generalisation. The following table represents the intended design, data collection source and study conclusions for the case study procedure:

Table 3.3: Design, Data Collection Source and Study Conclusions for The Case Study Procedure (Yin, 2018)

<table>
<tr><td rowspan="2"></td><td></td><td colspan="2">Data Collection Source</td><td></td><td></td></tr>
<tr><td></td><td>From an Individual</td><td>From an Organisation</td><td></td><td></td></tr>
<tr><td rowspan="2">Design</td><td>About an Individual</td><td>4) Individual behaviour
Individual attitudes
Individual perceptions</td><td>3) Individual employee records
Interview with individual's supervisor; other employees</td><td>If case is an individual</td><td rowspan="2">Study Conclusions</td></tr>
<tr><td>About an Organisation</td><td>1) Individual interviews
How organisation works
Why organisation works</td><td>2) Personal policies
Organisational outcomes</td><td>If case is an organisation</td></tr>
</table>

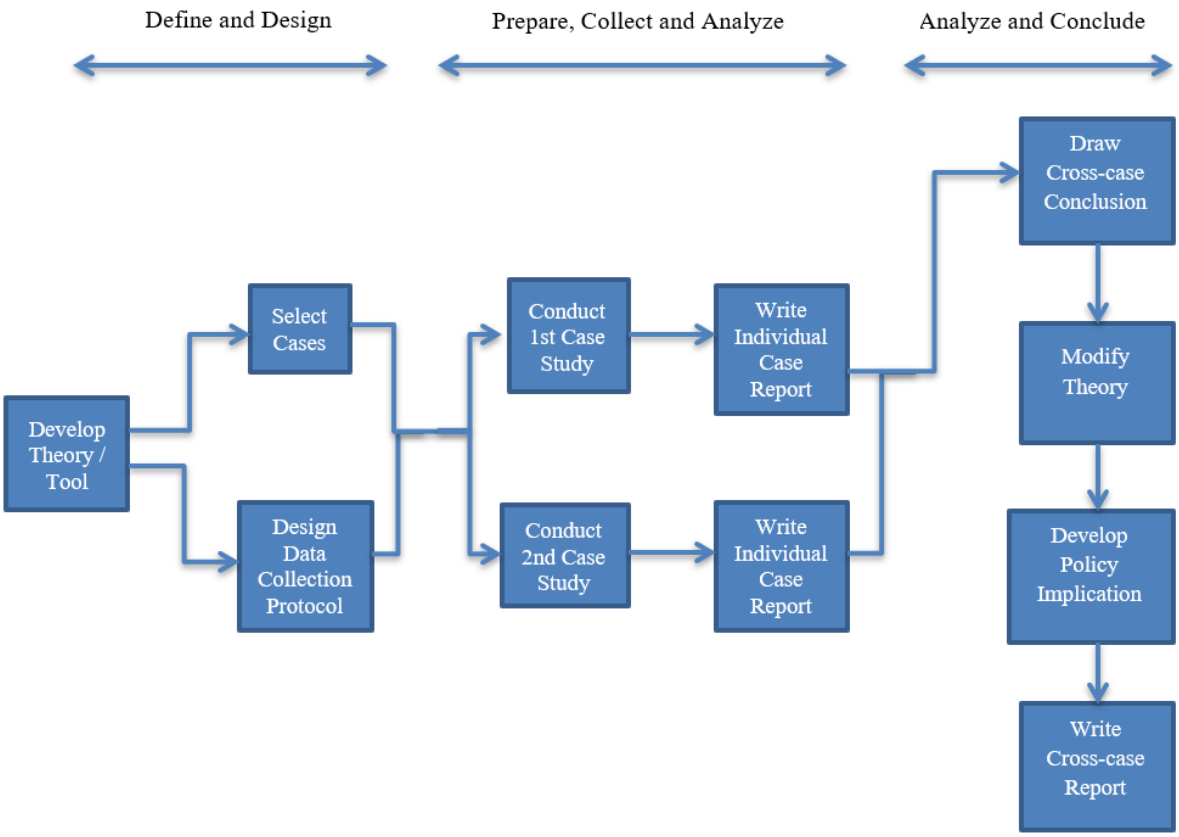
According to this table, since the data collection process during this thesis included the collection of information through interviews with individuals, about the case studies (organisations), the second stage of this research falls under the category named 1 in the table presented. The study cases were two organisations operating under the construction industry, and 5 interviewees (individuals) were interviewed from each organisation. The interviews were not about an individual's behaviour, attitudes or individual perceptions, so the case study research does not fall under category 4 of the table. Also, the case study research was not conducted by reviewing individual employee records or by interviews with an individual's supervisor or other employees about another employee. Therefore, category 3 of the table does not relate to the research done in this thesis. In addition, the case study research performed in this thesis was not performed by reviewing company policies and just organisational outcomes. Therefore, categorising this research under category 2 of this table would be irrational. As mentioned above, the research conducted on the 2 study cases during the second stage of this research would fit under category 1 of the table above.

3.8.1 Multiple-Case Study Design

This research benefited from an exploratory multiple-case study design (Yin, 2011; Yin, 2018). This design is in line with the goal of stage 2 of this research for testing and refining the newly developed innovation measurement tool within construction companies. Exploratory case studies are great choice amongst other types of case studies when the goal is to assess the applicability of a tool, phenomenon or concept in real-world environments and settings, especially where there is the need for means for defining the required questions and hypotheses for conducting consecutive studies (Baxter & Jack, 2008; Mills et al., 2010; 2008; Yin, 2018). The case studies that were conducted during stage two of this research allowed for practical evaluation and iterative refinement of the tool. Therefore, they are most accurately categorised as exploratory case studies.

During this research, two case studies were selected among multiple companies. This allowed for a comparison to be made between the two companies and further strengthened the results of the study (Yin, 2018). The following figure depicts the process adapted in this research for the multiple-case study procedure.

Figure 3. 2: Multiple-Case Study Framework (Yin, 2018)



The logic behind multiple-case designs is from literal and theoretical replication. The simplest multiple-case design is to select at least two cases that are literal replications. Selection of the cases needs awareness of the possible results, meanwhile, having the multiple-case research look at how and why the exemplary results could have happened and wishing for literal (or direct) replications of the outcomes in the cases (Yin, 2018).

Every design could result in success in case study research, provided the choice and resources are available, but the multiple-case design could be preferred to the single-case design. In fact, even a two-case case study is preferred over a single case study. Single-case studies are prone to many problems since all the resources and expectations are invested on one case. Also, the positive gains from having analysis from two or multiple cases is vital (Yin, 2018).

Therefore, the extensive literature review that was done in the first stage of this research, was complemented with two case studies in the second stage of this research. A similar approach was implemented by (Afzal & Shafiq, 2021; Boton et al., 2015; Nash et al., 2001) for their research.

The following table presents the various elements of the case study research design:

Table 3.4: Case Study Research Design

Purpose of Investigation	To address the following objectives of research: Objective 3: Implement and test the diagnostic tool through case studies with selected medium or large construction organisations in New Zealand to assess its practicality and functionality in real-world settings.
Case selection	Two companies were selected through purposeful sampling among the New Zealand construction companies. One of the companies was a medium-sized company that was a prefabricator, while the other company was a large company operating mainly as a main contractor. Senior management's support as the gatekeepers hugely facilitated the collection of data from these companies.
Object of Study	Two companies within the New Zealand Construction Industry were investigated for their characteristics regarding indicators relevant to innovation. Their innovation potential and business innovation were measured and investigated. Data was also collected for the further development of the innovation measurement tool.
Duration of Study	The case studies took place between 22/03/2021 (first interview) and 28/04/2021 (final interview)
Date collection	Data from the study cases were obtained by the researcher through qualitative in-depth interviews with open-ended questions, while the respondents also responded to the questions of the innovation measurement tool.
Data analysis	The data were thematically analysed using "NVIVO 12 Pro" software. Descriptive statistics were also engaged for quantitative data. The analysed data consisted of interview discussions, together with the answers obtained from the respondents for the indicator scores and the questions of the innovation measurement tool.
Validation	Validation of the findings was obtained by adopting a triangulation method consisting of three stages: 1) literature review, 2) case study interviews, and 3) interviews with the construction industry experts (CIEs). This is further discussed in section 3.15 of this research.

3.9 Justification for Using a Likert Scale

The underlying reason for using a 5-point Likert scale as the response format for the innovation measurement tool was supported by both methodological and practical considerations. Likert scales are widely used in social sciences, business research, and organisational assessments. This is because of the scale's ability to capture personal attitudes, perceptions, and behavioural preferences in a quantifiable format (Roselidyawaty & Mohd Rokeman, 2024; Koo & Yang, 2025; Shepard, 2024; Tanujaya et al., 2023). During this research, such characteristics were necessary.

One important benefit of the Likert scale is its ability to translate complex and often qualitative information into structured numerical data (Koo & Yang, 2025; Tanujaya et al., 2023). The nature of innovation is a multidimensional phenomenon which is also largely affected by its operating context. It is also affected and reliant on many factors. The Likert scale allows respondents to express their level of agreement with specific indicators related to the tool's categories. This, in turn, facilitates a systematic comparison between respondents, organisations, and categories (Koo & Yang, 2025; Tanujaya et al., 2023).

The 5-point scale was the specific choice of selection for this research and tool because it has the capacity to create a balance between response simplicity and discriminatory power (Aybek & Toraman, 2022). A scale with this length reduces the cognitive load on respondents while it still provides enough detail necessary for finding meaningful differences in perception. Additionally, including a neutral midpoint allows participants to express neutrality, doubt or uncertainty, which is extremely vital during exploratory and reflective measurements and studies in which respondents may not have full awareness or strong views on every single question and item (Aybek & Toraman, 2022; Preston & Colman, 2000; Sullivan & Artino, 2013).

Additionally, within scale development context, it is mentioned that using a 5-point response option has its advantages over using a 3-point response category in terms of reliability in the scale development process. This is while the 5-point scale does not have any major disadvantages compared to a 7-point response scale. Subsequently, it is recommended for researchers to use a 5- point response category, considering the ease of responding (Aybek & Toraman, 2022).

From a data analysis perspective, the used Likert scale provided the necessary platform for the application of descriptive statistics (Alkharusi, 2022; Dong, 2023; Jones & Goldring, 2021), graphical visualisations (such as spider diagrams) (South et al., 2022; Sullivan & Artino, 2013), and pattern recognition (Dalka et al., 2022; Mohd Rokeman, 2024; South et al., 2022) during case study evaluations. These outputs supported both individual feedback sessions and comparisons between cases, which helped to identify strengths, weaknesses, and strategic opportunities that are present within each organisation.

Furthermore, the decision to use a Likert scale was further supported by feedback from the research supervisors during the tool development stage and was proven to be a good choice through its application in real-world settings. Participants in both case study organisations and construction industry experts (CIEs) who reviewed the tool confirmed that the Likert scale format was a good choice for this research and the innovation measurement tool, as it was familiar, user-friendly, and well-suited to the type of judgments being asked.

In summary, the Likert scale played an extremely crucial part towards enabling the practical implementation of the developed tool and the interpretation of the research findings. Its use is consistent with the already established practices in the fields of organisational diagnostics and survey-based innovation research. This standard approach ensures that the tool remains accessible to users and reliable for academic inquiry.

3.10 Sampling Strategy

For the aim of this research's data collection, participants were selected based on purposeful (Bouncken et al., 2025) sampling strategy. To choose the participants of the research or the sites, documents or visual material purposefully, the qualitative researcher must select individuals who can contribute the most to investigating and understanding the research question and problem statement (Creswell, 2014).

This method allowed for a selection of two case studies among many construction companies. The companies were chosen based on their industry and scale. Company Case 1 is classified under medium-sized companies, while Company Case 2 falls under the category of large companies. Extensive details about the characteristics of the study cases are provided in section 3.12 of this chapter and sections 4.3.1 and 4.5.1 in chapter 4 of this research. Within each case organisation, five participants were engaged based on their knowledge of their represented company's internal processes and their roles in either decision-making, leadership, or operations. These participants' characteristics and roles represented a cross-section of managerial, technical, and strategic designations, which ensured that responses to the tool covered a broad range of perspectives about the organisation.

The construction industry experts (CIEs) were a combination of measurement tool development experts, innovation experts, senior construction industry experts aware of the organisational culture, experts in organisational training, and the like. The construction industry experts (CIEs) were chosen based on their academic standing, reputation in the industry, and direct experience with innovation or performance measurement inside the New Zealand construction industry. The details of the characteristics of the 5 construction industry experts (CIEs) are presented extensively in chapter 5. The selections proved to be a good choice as the research went further ahead. The results also proved that the selection criteria were appropriate.

The purposeful sampling (Bouncken et al., 2025) adopted for this research was strategically aligned with the objectives of each research stage. Purposeful sampling strategy is referred to choosing individuals or groups with great knowledge or experience related to the phenomenon which is under investigation (Creswell & Plano Clark, 2017). The purpose of this selection method during research was to gather rich insights relevant to the topic, which inform us of the capability of the innovation measurement tool for being used and applied in the New Zealand construction industry. The deliberate selection of interview participants from different professional roles and with varying levels of strategic involvement within their respective companies was extremely crucial for being able to triangulate feedback across organisational layers and was also important for ensuring the tool's broad relevance and interpretability (Meydan & Akkaş, 2024).

3.11 Gaining Access to the Case Studies

Another aspect that requires special attention during any research and especially during qualitative research, is the level of approval received from the gatekeeper. Gatekeepers are people who can provide permission and access to the case that is under investigation, and they have the authority to permit qualitative research to be conducted (Creswell, 2014). In the process of gaining access to the two study cases, it was important to gain full support from the gatekeepers. This has a huge impact on the future of research since it defines the scale of willingness of the participants to cooperate and share detailed information.

Case study 1 is a medium-sized company and a member of OffsiteNZ. Through communications with the people at OffsiteNZ, endorsement was gained by the Chief Executive Officer (CEO) of this organisation. The owner/CEO of Case Study 1 showed interest in participating in our research. Other than himself, he also selected 4 other employees to participate in the interviews.

Case study 2 is a large-sized company that is currently undertaking multiple projects around the North and South Islands of NZ. They are also very supportive of the research being conducted at Massey University and have initiated their interest in collaborating. I found this opportunity very welcoming, and after reviewing their portfolio and scale, I started communicating with them. Since initially it was required to make a high impression on the gatekeeper, the initial acquaintance was done by one of the School of Built Environment staff who has connections with the CEO of case study 2. This allowed for a very supportive endorsement from the CEO during research and positively impacted the participant's willingness to cooperate.

3.12 General Resources and Demographic Questions

Researchers (Aliakbarlou, 2018; Babaeian Jelodar, 2015; OECD/Eurostat, 2018) have previously emphasised the importance of a number of indicators for gaining knowledge about the respondents and the case organisation under study. For this allows an understanding of the unique characteristics of the study case. These sets of data are very useful for the analysis of the results as they indicate important information regarding the company and the respondents. Although these classifications and their impact on innovation measurement are not part of the objectives of this thesis, but in order to gain an insight about the characteristics of the study cases and the respondents, this information was collected during the interviews of study 2. These questions were classified under either General Resources or Demographic Questions category of questions. As these researches (Aliakbarlou, 2018; Babaeian Jelodar, 2015; OECD/Eurostat, 2018) have indicated, collecting information on the number of employees, volume of turnover, volume of assets, firm size, company's age, equity ratio, profit margin, ownership status, type of customers/clients, type of financing, company employees education, respondent/manager's highest education qualification, years of professional skills, managerial skills, Years of experience, demographic data on age, sex or gender identity, average tenure of your employees can be helpful in understanding the company under investigation.

These data were not used for the achievement of the objectives of this research and therefore were only collected but were not analysed in any way. These data were also not part of the purposeful sampling criteria for the sample selection during this research.

The following table presents a summary of the characteristics of the two case studies:

Table 3.5: Summary of the Characteristics of the Two Case Studies

	CS1	**CS2**
Office(s)	West Auckland, NZ	Auckland, Christchurch, Hamilton and Queenstown, all in NZ
Operation	Design, build and install pre-finished homes	Contractor (Main)
Year founded	2018	2013
Role	Contracting	Contracting
Operates under	Public and the private sector	Public and the private sector
Involved in	Residential Sector, Civil engineering and infrastructure	Residential to commercial, educational, clinical, community projects, industrial, fit-out and retail
Number of employees	20-49	50+
Company size	Medium	Large
Annual turnover	under $10 million	$100 million to $1 billion
Assets	less than $1 million	$10 million to $100 million
Profit margin	%20 to %40	less than %20
Equity ratio (debt vs equity)	%20 to %40	less than %20
Ownership	Standalone	Standalone
Part of an organisation	No	No
Domain	Domestic	Domestic
Clients	Governmental sector (Business to Government) and other businesses (Business to Business)	Governmental sector (Business to Government)

Resources for innovation	Internal	Internal
Employee tertiary education	%20 to %40	%25
Job related vocational training	%80	%100
Average tenure of employees	2 to 4 years	4 to 6 years

3.13 Data Analysis Procedures

A combination of qualitative and quantitative analysis methods was adopted for the analysis of the data, which were collected from case study interview participants and construction industry experts (CIEs).

3.13.1 Quantitative

Quantitative data that were collected from the Likert-scale responses were manually entered into a structured Microsoft Excel spreadsheet and analysed by implementing descriptive statistics (Alkharusi, 2022; Dong, 2023; Jones & Goldring, 2021) in an attempt to identify trends, score distributions, and indicator patterns within and across the two case study organisations.

As part of the quantitative data analysis, the questionnaire responses for each of the case study companies were analysed using a five-point Likert scale, with scores examined at three levels. Firstly, indicator averages were calculated to provide a balanced view across respondents and to reduce bias from individual departments. Secondly, respondent averages for each category of questions were calculated to capture perceptions within each of the categories. And finally, overall category scores were calculated by averaging all responses from all respondents of a case study within each category, which enabled the identification of strengths, weaknesses, and priority areas for improvement.

To help with the interpretation and engagement of data, spider diagrams were generated for each participant from the two case study companies, visualising their given responses across the six innovation measurement categories. These diagrams contributed by serving as both analytical tools and discussion prompts during case studies' follow-up interview communications.

3.13.2 Qualitative

Qualitative data analysis is frustrating and requires a lot of effort. The research findings do not develop spontaneously out of the raw data. The data requires lots of hard work to find the most beneficial elements and to merge them into a well-structured "story" which addresses the

research question and delivers perspectives that are reflective of the actual information (Miles et al., 2014).

Qualitative data were analysed by implementing thematic analysis (Braun & Clarke, 2021; Nowell et al., 2017). NVivo 12 Pro software was employed for managing coding and organising emerging themes. The analysis of the data began with open coding (Benaquisto, 2008a), through identifying recurring phrases, concerns, and ideas from interview transcripts. This was later followed by axial coding (Benaquisto, 2008b) to group related codes and connect them to the innovation measurement categories represented in the tool. This coding method, helped to develop more structured and detailed themes. Through combining these analytic approaches, the research ensured that quantitative results were enriched and strengthened by qualitative explanations, which enabled a comprehensive understanding on how case study participants and construction industry experts (CIEs) interpreted and evaluated the measurement tool.

Consistent with the pragmatic paradigm (Creswell & Plano Clark, 2017; Elgeddawy & Abouraia, 2024; Morgan, 2007) which was found to be the right paradigm for this research, the analysis of the collected data combined inductive development of themes with deductive refinement in later stages, as the patterns and categories were confirmed or further refined based on empirical testing in case studies and industry expert validations. The structure of coding included the first, the second and further cycles of coding. This resulted in the development of theory from the existing data. Eventually, this allowed the development of conclusions (Gioia et al., 2012). During both the first and the second cycle of coding, codes were developed at an early stage. This is while the codes were more developed during the latter stages. During the second cycle of coding, classifying, prioritising, integrating, synthesising, abstracting and conceptualising, and consequently theory building (Saldaña, 2021) were implemented. In qualitative research, together with the development of the research, the type of coding develops as well (Gehman et al., 2018).

During the second and third stages of the research, patterns, categories, and themes were inductively further developed, following and consistent with a bottom-up approach. The collected qualitative data were systematically organised into increasingly concise and meaningful sets or blocks of data. During this process, an iterative process was followed, moving back and forth between the emerging themes and the original data. This endeavour was continued until a comprehensive and robust set of themes was established (Creswell & Creswell, 2017). At that point, the established themes were once again reviewed to determine whether any additional supporting evidence could be added from the raw data, or even whether further data collection was necessary. Although the analysis was initially inductive, a deductive approach also played a significant role in the later stages of analysis, consistent with the approach described by Creswell and Creswell (2017).

It is worth mentioning that the interpretation and coding are not separate stages of research; rather, they are interrelated, which grow together but consist of distinct traits. Understandably, although the first round of coding depicts a more mechanical assigning of labels to parts of data, the actual interpretation of the codes and reaching a holistic conclusion from the codes is not mechanical (Skjott Linneberg & Korsgaard, 2019). Detailed views are necessary to develop patterns. The process of coding and analytical memorising facilitates the development of patterns in the data.

3.13.3 Tool Scoring and Logic

In this thesis, the Business Innovation Measurement Tool was designed around six main categories: five capturing Innovation Potential (Workforce Skills and HR Management, Organisational Structure, Business Strategy, Technology, and External Influences) and one capturing the Business Innovation Score. Each category of the tool consists of multiple indicators and is structured into questions that are measured on a 5-point Likert scale. However, the exact Likert scales varied depending on the type of indicator being assessed, as shown in Appendix 2. For instance, some indicators followed qualitative intensity scales (Very Low → Very High), while others used percentage ranges (0–20%, 21–40%, 41–60%, 61–80%, 81–100%) or numeric brackets (e.g., 1–5 innovations, 6–10 innovations, 11–15 innovations, 16–20 innovations). This tailoring ensured that each indicator was assessed in a manner appropriate to its nature and context

As for the scoring process, for each indicator, respondents selected a Likert score according to the relevant scale.

- **Indicator Average:** The responses for each indicator were averaged across all participants to produce an Indicator Average.
- **Respondent Average:** This was calculated using the average of the responses that each participant gave for the indicators of a category, and shows how each participant evaluated the five categories individually.
- **Category Overall Score:** This average was found as the average of all the responses given by all 5 participants from each case company for all of the indicators of a category of indicators, and was defined to form a Category Overall Score.

This three-tiered scoring (indicator, respondent, and category) allows both granular and holistic diagnosis of organisational innovation. Please note that during the interviews, only the Respondent Average was generated and discussed. Other descriptive statistics were later developed and are part of the generated report for each case company. These results are presented in Chapter 4 of this thesis and are based on calculations as follows:

- **Innovation Potential Score:** This score was calculated as the average of the Category Overall Score for the 5 categories that formed the Innovation Potential of the company in the tool and the framework.
- **Business Innovation Score:** This score was the average of the responses given by the 5 respondents of the case study company for the indicators of the Business Innovation Score category of questions. This score represents the actual innovation of the company.
- **Company's Overall Score:** This score was calculated as the average score of the two scores, being 1) Innovation Potential Score and 2) Business Innovation Score.

Additionally, during these calculations, the following decisions were made:

- **Weighting:** All indicators and categories were assigned equal weighting. This decision ensured transparency and avoided artificially privileging any single indicator. Equal weighting also reflected the exploratory nature of the study, since the emphasis of this research was on testing the comprehensiveness, diagnostic potential, practicality and functionality of the tool rather than enforcing pre-determined hierarchies.
- **Normalisation:** Because all responses were captured on 5-point scales, scores were directly comparable without additional need for statistical normalisation. The use of

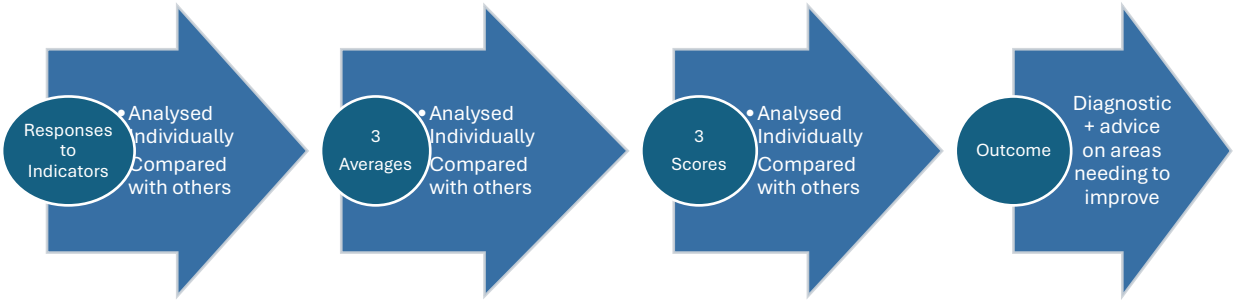
equal weighting across indicators and categories further simplified aggregation and ensured that the final scores reflected the unadjusted perceptions of participants.

Dashboard output: The calculated scores were tabulated and visualised through a dashboard that presents results at three levels:

- **Indicator-level tables and diagrams**, displaying averages for each indicator (Indicator Average).
- **Category-level tables and diagrams**, comparing the five Innovation Potential categories' averages (Category Overall Score) alongside the Business Innovation Score.
- **Organisation-level tables and diagrams**, representing the comparison of Innovation Potential Score and the Business Innovation Score, and eventually demonstrating the case company's overall score.

This layered presentation enables companies to interpret results at the micro (indicator), meso (category), and macro (organisation) levels. These scores highlight the overall strengths and weaknesses of the company and guide strategic decision-making. Therefore, the results obtained from the respondents answering to the tool's indicators were used to calculate the abovementioned averages and scores. These findings were elaborated and analysed at the three mentioned layers. The following flow chart represents the process of the data analysis that took place during the development of the report that was created for each case company, individually and comparatively between the two case companies:

Figure 3.3: Process of Data Analysis Using the Innovation Measurement Tool



These results and the achievements of the developed innovation measurement tool are extensively discussed in Chapters 4, 6, and 7 of this thesis.

- Sections 4.3.2 and 4.5.2 and their sub-sections discuss the data collected through the interviewee responses for the tool's indicators at 3 levels, individually for each case company.
- Sections 4.3.3 and 4.5.3 and their sub-sections, use these averages and scores together with the collected qualitative data to provide an in-depth analysis of the Innovation Potential Score of the two case companies and diagnose the root causes of these results individually for each case company.
- Sections 4.3.4 and 4.5.4 provide diagnostic insights for the business innovation scores of the 2 case companies, individually for each case company.
- Additionally, section 4.6 conducts a comparative study of two case study companies on their Innovation Potential Score and Business Innovation Scores.

- Eventually, section 4.7 presents a summary of the findings and discusses the Overall Scores of the two case companies.

This flow ensures that the collected responses to the indicators are translated into quantitative averages and scores, which are then systematically communicated through tabulated and visual outputs and are eventually translated into practical advice for companies to improve their innovation-related indicators. In line with these analyses, sections 4.3.5 and 4.5.5 provide an analysis of the qualitative responses collected during the interview questions, individually for each of the 2 case studies. A sample analysis is provided in Appendix 2, where raw survey responses from one of the interviewees are traced to the final dashboard result.

3.14 Saturation

According to Charmaz (2006), collecting data stops when we notice that the categories or the themes are saturated. This is at a time when you realise that the fresh data which is being collected does not demonstrate any novel views and does not demonstrate any new information. During all three research stages of the triangulation, saturation was achieved.

During the literature review stage of this research, through a rigorous literature search, a great number of publications were reviewed. Academic journals, conference papers and national reports were reviewed and used. In addition, some textbooks found to be useful to the research process were used. Thus, a comprehensive literature survey was carried out to collect information on relevant studies on this topic. Google and Google Scholar, Emerald and Scopus, American Society of Civil Engineers (ASCE) library and Science Direct Journal databases, as well as other archives, were engaged. This extensive search strategy proves to capture just about every previous publication. This comes as it was noted that reading further publication literature has become a repetition of the previously studied material. At this stage, the researcher gained confidence that the tool is comprehensive.

During the case studies, each case consisted of 5 respondents. This was done to ask the same set of questions from 5 different people in one company. This event captured the perceptions of different people regarding the company under investigation, and additionally, their perceptions regarding the tool and its questions. As the interviews went ahead, more and more repeated responses were being offered by the respondents, which not only validated and confirmed the responses of the other employees, but also represented a saturation point for the semi-structured in-depth interview stage of the triangulation stage of this research.

During the interviews with the construction industry experts (CIEs), the situation was different. Since these respondents were experts in the field in some way, they had extensive knowledge to offer regarding the further development of the field. To address this issue, it was found wise to allow the respondent to keep talking for as long as they wished. Some interviews continued for over 1 hour. As more responses were collected, once again, there was a point where repetition started to show itself and close to the end of the interviews with the construction industry experts, the offered information was no longer novel. For example, all of the respondents confirmed the significance of the identified items for measuring innovation in the construction industry. These items were previously identified and composed into the innovation measurement tool in stage 1 of this research and were also used for testing the tool on 2 case studies during stage 2 of this thesis. In other words, until reaching theoretical saturation, the construction industry expert (CIE) interviews were continued (Babaeian Jelodar & Shu, 2021;

Glaser & Strauss, 2017). This saturation reinforced the sufficiency of the sample sizes for capturing diverse viewpoints, which are relevant to the tool's development and validation.

3.15 Criteria for Judging the Quality of Research Design

According to Yin (2018), four tests form a common framework for assessing the quality of research. these are as follows: Construct validity, Internal validity, External validity and External Reliability (Replicability). After reviewing these criteria, Internal reliability is also investigated for this research.

3.15.1 Validity

One of the strength factors of research is its validity. This validity has its basis on the accuracy of the findings based on the researcher, the participant or the reader's perspective (Creswell & Miller, 2000) There are many terms in the research world which express validity and these are credibility, authenticity, trustworthiness and alike (Creswell & Miller, 2000) and validity is a highly addressed topic (Lincoln et al., 2011).

The 3 stages that are undertaken during the actual research process do, in fact, validate the findings (Creswell, 2014), and triangulation was chosen as the method of validating the findings of this research. Through investigating facts from multiple sources and employing them to develop a good logic and explanation for the themes, triangulation of different information sources happens. If the themes are developed by mixing multiple data sources or multiple views from respondents, in fact, the mentioned research methodology can add to the validity of the research (Creswell, 2014).

Some scholars (Shahbazpour, 2010) have previously used case study research for validating the findings of research. Holding interviews with construction industry experts of the study domain can also contribute towards the validation of the findings of the research (Egbelakin et al., 2015). During the stages of this research, all of the respondents were experts and professionals in the construction industry. The construction industry experts were a combination of measurement tool development experts, innovation experts, senior construction industry experts aware of the organisational culture, experts in organisational training, and the like. They all had a great understanding of the research under investigation. The number of construction industry experts (CIEs) was considered adequate since the respondents could answer in such a way that saturation point of data was obtained. All the respondents approved the significance of the identified items for measuring innovation in the construction industry that were earlier identified, comprehended and formulated by the research and literature review. Saturation of the findings of the whole research was possible to obtain, as the aim of the interviews with the construction industry experts in stage 3 was to validate and further refine the findings of the research that were previously found and comprehended in the first and second stages of this research.

3.15.1.1 Construct Validity

Yin (2018) recommends engaging different sources of information (triangulation) in a manner that encourages convergent lines of inquiry as a way of reaching construct validity. He defines construct validity as identifying the right operational measures for the concepts under investigation, which in this study is the innovation measurement tool. Through triangulation, this research was sufficient to satisfy construct validity. To ensure construct validity, the indicators that were included in the tool were derived from an in-depth and rigorous review of literature and were then categorised in consultation with the research's two supervisors. Multiple forms of evidence, being literature review, Likert-scale responses, interview narratives, and construction industry expert (CIE) evaluations, were used to assess each construct's real-world representation.

This research uses a triangulation study stage. This method usually engages two or more research techniques, which minimise or mitigate the deficiencies of each of the individual approaches. Also, the benefits of each technique alone and as a sum are synergistic. This technique allows for a multidimensional view of the research topic (Fellows & Liu, 2015). Therefore, triangulation has the potential to be used for every study. Triangulation is applicable to research that adapt multiple methodologies. It can also be used for individual parts of a research like data from questionnaires and participant observations (Fellows & Liu, 2015).

Triangulation between methodologies or within methodology maximises the external and internal validity and reliability (Arias Valencia, 2022; Donkoh & Mensah, 2023; Nha, 2021; Meydan & Akkas, 2024). This methodology has become more common in the recent literature and has demonstrated its ability to be a reliable method for conducting research (Babaeian Jelodar et al., 2022; Babaeian Jelodar & Shu, 2021; Neeraj et al., 2021; Sajoudi, 2018). The adoption of a triangulation method allows for the gathering of data from different sources and to draw stronger conclusions.

There are similar triangulation approaches towards research within the construction literature. Other scholars have also adopted a similar approach towards research (Babaeian Jelodar & Shu, 2021). This is because, similar to this research, using multiple sources for gaining knowledge is a common method for presenting detail, depth and validity for the research areas that are not structured (Schmidt et al., 2017; Shelton et al., 2016). Babaeian Jelodar and Shu (2021) adopted a very similar triangulation approach to their research when compared to the method used in this thesis research. They used the following three stages: First, a literature review stage to investigate the current trend in the field. This stage of the research also develops the structure and helps in the formulation of the case study stage, and it also defines the strategies for the interview questions in the third stage. The second stage, which is the case study stage, developed detailed knowledge and extended the generalisability of the research findings. The cases were selected with the aim of having the potential to add to the existing knowledge around the research question and the aim of the research. The third stage was semi-structured interviews with experts, and this stage was complementary and a decisive part of the research. This stage of the research is engaged to develop further explanatory power and to allow detailed discussion and analysis. This also provides validity for the findings of the research. Also, a similar approach was engaged for the research in other research by Babaeian Jelodar et al. (2022) and Neeraj et al. (2021).

3.15.1.2 Internal Validity

As defined by Yin (2018), internal validity refers to the extent to which research establishes a credible explanation about the relationships between the variables, in particular within research which seeks to explain how and why certain phenomena occur. This research benefited from two main analytical strategies, which were pattern matching and explanation building, in an attempt to improve the internal validity across all three stages of the research.

In stage one (tool development), explanation building was utilised through the process of expert-informed thematic categorisation (Ahmed et al., 2025; Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021). Indicators that can influence innovation were extracted from the existing literature and then categorised based on their theoretical relevance. Through iterative engagement with the research's two supervisors as expert reviewers, explanations were developed around how each indicator logically contributes to either the Innovation Potential or Business Innovation Score. Discussions on the meaning, theoretical relevance, and indicator groupings helped with the establishment of a strong foundation, which is necessary for a structured innovation measurement framework. Although quantitative data were not involved at this stage of the research, this explanatory narrative grounded the conceptual structure of the tool that was under development.

In Stage Two (Case Study Application in Companies) of this research, both pattern matching and explanation building were strongly engaged. The innovation scores that were produced from the Likert-scale tool were presented in visual formats (spider diagrams) and used as the basis for semi-structured interviews with company participants. Pattern matching was used to assess alignment or divergence between the quantitative profiles of each company and the qualitative reflections provided by interviewees. Where responses confirmed the data patterns (e.g., low scores in one indicator aligned with a participant's recognition of an underlying cause), internal validity was reinforced. Where divergences occurred, they informed deeper explanation building, prompting the identification of organisational contextual factors or decisions that clarified why a specific innovation level had emerged.

In Stage Three (Expert Validation), internal validity was again reinforced through pattern matching and explanation building. Experts were asked to review the tool and provide feedback based on their industry and research experience. Their narratives were thematically analysed and compared with the theoretical rationale behind the tool's development. Pattern matching occurred where the construction industry expert (CIE) views were in line with the tool's indicator structure and phrasing. In cases where the industry expert's statements diverged, explanation building was employed to reflect on these different insights, which led to beneficial and meaningful refinements. These justifications were also documented to demonstrate how the final structure of the tool maintained internal coherence and supported causal explanations, thereby reinforcing the internal validity of the research findings.

Across all three stages of the research, these strategies provided a strongly structured way to evaluate emerging constructs and refine our understanding. The combination of pattern matching to confirm expected relationships, and explanation building to interpret, elaborate and discuss deeper causal mechanisms, assured that the findings and the developed tool were internally valid and conceptually grounded in both empirical data and industry expert reasoning.

3.15.1.3 External Validity (Transferability in qualitative studies)

External validity refers to the extent to which the findings of the research can be generalised or transferred to other contexts or settings (Yin, 2018). In a qualitative research, this concept is often defined as transferability and is achieved through thick description and replication logic (Yin, 2018) rather than statistical generalisation. In order to achieve external validity during this research, multiple strategies were engaged across all three stages of the research.

In Stage One (Tool Development), external validity was addressed by implementing a systematic and transparent process of expert-informed thematic categorisation (Ahmed et al., 2025; Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021). Indicators were found from the literature and then categorised with the involvement of an expert panel. This process was not only documented in detail but was also grounded in established innovation theories, thereby providing conceptual replicability (Yin, 2018). The development of the tool using replicable logic and theoretical justification paves the way for future researchers to apply or adapt the tool to other sectors or regions.

In Stage Two (Case Study Application in Two Companies), external validity was supported through the use of replication logic (Yin, 2018) across multiple cases. Each company was treated as an independent case, and a similar data collection protocol was used in both contexts. As shown in Table 3.4, the research followed Yin's (2018) recommended multiple-case study process: beginning with theory development, followed by case selection, and then data collection using a consistent protocol. The findings from each company were first analysed individually and then compared for finding similarities and differences. Where convergent findings emerged across cases, confidence in their broader applicability was strengthened. Divergences were explained through contextual variables, improving the strength and depth of the analysis and offering detailed and beneficial insight for potential transfer.

In Stage Three (Expert Validation), further support for external validity was achieved through the involvement of construction industry experts who were external to the original case companies. These experts reviewed the tool and were able to validate whether the indicators and measured categories were relevant and applicable across the wider New Zealand construction sector. Their perspectives confirmed the tool's broader utility and relevance, thereby supporting both conceptual and practical transferability.

Throughout all stages, the research employed thick, rich descriptions of the case study organisations, their innovation contexts, and the participants' roles and backgrounds. These descriptions allow readers and future researchers to determine the applicability of the findings to their own settings, which is a core principle of qualitative transferability. By documenting each stage of research with precision and extensive detail, and by employing expert feedback beyond the original cases of data collection, the study reinforces its external validity and demonstrates how its findings can be transferred or replicated into comparable settings.

3.15.2 Reliability

The following subsections, 3.15.2.1 and 3.15.2.2, discuss internal reliability and external reliability (replicability), respectively.

3.15.2.1 Internal Reliability

Internal reliability in this research was maintained through multiple key strategies during the tool development and empirical validation stages. One primary method was the use of team discussions and consensus-building with the expert panel during the categorisation and refinement of the indicators. Regular review meetings facilitated interpretive alignment among the researcher and the research supervisors, minimising discrepancies in understanding and coding (Nowell et al., 2017). This process of collaborative analysis supports internal reliability by reducing individual subjectivity and ensuring shared meaning across researchers (Saldaña, 2021).

In the qualitative analysis phase, NVivo 12 Pro software was employed to manage the coding of interview transcripts (Skjott Linneberg & Korsgaard, 2019), which ensured consistent data handling and auditability. A systematic coding framework, beginning with open coding (Benaquisto, 2008a) and advancing through axial coding (Benaquisto, 2008b), was adopted in line with established qualitative methodologies (Braun & Clarke, 2021; Skjott Linneberg & Korsgaard, 2019). This coding process, which was conducted in multiple phases, further strengthened internal reliability by facilitating the development of coherent themes through structured interpretive processes (Saldaña, 2021).

Additionally, triangulation within the methodology enhanced internal reliability by allowing convergence of data from diverse sources, being literature, case study participants, and construction industry experts, thereby supporting consistent findings across contexts (Meydan & Akkaş, 2024; Donkoh & Mensah, 2023). This approach aligns with recommendations from recent literature that highlight how triangulation within a single methodology maximises internal reliability by corroborating findings across methods and participants (Arias Valencia, 2022).

3.15.2.2 External Reliability (Replicability)

External reliability can be defined as showing that the stages of the study – like its data collection procedures – can be repeated, while achieving the same results (Yin, 2018). For the aim of making sure the research results are reliable, it was made sure that there was a study protocol, and the procedures of the case studies were documented for as many of the steps as possible. This method is recommended by Yin (2018; Yin, 2009). He recommends following a study protocol and database. These are discussed in the relevant chapters of the thesis.

Also, as recommended by (Gibbs, 2018), the collected transcripts were and must be checked to assure that they do not hold obvious errors during transcription. Also, it was made sure that there exists no drift in the definition of codes, a change in the meaning of the codes during the coding process and stages. This was accomplished by repeatedly comparing information with the codes and by taking notes about the codes and their definitions (Gibbs, 2018). Some scholars (Lincoln & Guba, 1985; Sajoudi, 2018) recommended that during a qualitative research, validity and reliability could be obtained by trustworthiness., presented four measures for trustworthiness:

- Credibility: which looks at the study being reasonable. This was achieved through methodological triangulation (use of multiple methods: Literature review, interviews with participants from case studies, expert interviews), member checking during interviews (participants could reflect on spider diagram outputs), and transparent documentation of the tool refinement process.

- Transferability (qualitative equivalent of external validity discussed above): the research results having the ability to be transferred to another context. This was supported by providing thick description, which allowed others to assess whether the findings can be applied to different contexts.

- Dependability: the process and audit trail engaged in research being clearly defined and available for reviewing. Throughout the three research stages, this was maintained through the use of detailed documentation of the research process, consistent data collection and handling procedures, use of structured interview protocols, and ongoing consultation with academic supervisors of the research. All interviews were audio-recorded, transcribed, and coded systematically. The use of NVivo software provided an additional audit trail, which ensured transparency and replicability of the analytic process.

- Confirmability: showing evidence that the procedure that was explained, did really occur. Throughout the three research stages, this was supported by maintaining an audit trail of decision-making processes and the use of NVivo software. Confirmability was also reinforced by preserving the documentations of the decision-making processes, which helped maintain transparency in data analysis and supported claims with evidence.

These criteria collectively enhanced the overall rigour and quality of the study and supported the trustworthiness of the innovation measurement tool developed.

3.16 Ethical Considerations

Studies that engage humans are usually troublesome. During this research, it was necessary to understand to some extent the culture of the organisation under study. The following precautions were employed to protect the participant's rights:

1) The purpose and aim of the research were explained orally and in text to make sure that the interviewee clearly understood them.

2) Written consents from the interviewees were received based on the purpose and aim of the research, which was explained to them.

3) An ethics approval was obtained from Massey University's Human Ethics Committees, and the interviewee was informed about this.

4) The participant was briefed regarding the data collection devices, as in this case, it was the mobile phone's voice recording application.

5) Verbatim transcriptions, reports, and data analysis can be made available to the participants upon request.

6) the interviewee's wishes, interests and rights were and will be prioritised during the time of result publication, and

7) The reports were comprehended based on the anonymity of the participants.

Ethics approval was obtained from Massey University's Human Ethics Committees on the 8th of June, 2020 (Ethics Notification Number: 4000022772). The low-risk notification for this project is valid for a maximum of three years. Research Information Sheets, Invitation to Participate in a Research Interview and Research Consent Forms were designed and used during the data collection stage of research. Appendix 1 includes the related ethics document.

The participants were informed of the following statement at the beginning of the interviews:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact: (Research Ethics) at

Email: humanethics@massey.ac.nz

Ethics Notification Number: 4000022772"

3.17 Summary

This chapter has presented a detailed account of the research methodology that was employed in this research. It aimed to develop, test, and validate a comprehensive tool for measuring innovation in medium and large construction organisations within New Zealand. By adopting a sequential exploratory mixed methods design, the research strategically integrated qualitative and quantitative approaches across three distinct research stages to ensure that the resulting tool was theoretically sound, empirically tested, and practically applicable.

The methodology began with a rigorous literature review and expert-informed categorisation process, which formed the conceptual and structural foundation of the innovation measurement tool. This first stage of research led to the identification of innovation indicators, grouped into six key categories that capture both innovation potential and actual innovation. Benefiting from expert insights, the tool was constructed with careful attention to conceptual clarity, indicator phrasing, and its measurement format.

The second stage involved the application of the tool within two case study construction organisations. Using a combination of structured Likert-scale responses and qualitative interviews, this stage provided valuable insights about the tool's usefulness and contextual relevance. The feedback received from the interview participants not only validated the tool's conceptual structure but also led to refinements that improved its practicality for organisational use. The integration of visual tools, specifically spider diagrams, further supported engagement with the measurement findings.

In the third stage, the tool was subjected to further validation through interviews with five construction industry experts (CIEs) from academia and industry. These experts evaluated the tool based on its conceptual soundness, relevance, and operational feasibility. Their feedback highlighted both strengths and opportunities for refinement, particularly in terms of wording precision, user support materials, and potential future enhancements such as digital implementation. This stage added a critical layer of external validation and ensured the tool's confirmation across different domains of expertise.

This chapter also discussed the use of triangulation as a validation technique and highlighted how method and source triangulation were utilised to reinforce the robustness and quality of the research. By benefiting from diverse data types and participant perspectives, being academic, industrial, organisational and expert, the research ensured convergence and consistency in findings. This, in turn, greatly helped towards the validation and iterative improvement of the measurement tool.

Ethical considerations were also addressed in detail, emphasising the study's adherence to formal ethical approval processes, informed consent protocols, and data privacy guidelines. The commitment to ethical research practice extended to the researcher's reflexive stance and careful engagement with organisational gatekeepers and each individual participant.

Overall, the methodological design and execution ensured that the innovation measurement tool developed through this research is not only academically rigorous but also grounded in the realities of the construction industry. It represents a significant contribution to the field of innovation measurement and offers a practical resource for companies wanting to assess, benchmark, and improve their innovative capabilities.

The next chapters present the findings derived from the tool's application in real contexts and from industry expert validation. These chapters detail the results obtained from both quantitative and qualitative data, discuss the patterns and themes that emerged, and explore their implications for research, future policies, and industrial practice.

Chapter Four: Case Studies - Results from Testing the Innovation Measurement Tool on New Zealand Construction Organisations

4.1 Introduction

This chapter presents the results obtained through implementing the innovation measurement tool within two New Zealand construction organisations. These findings represent the second stage of the research and serve as the core component of the three-stage triangulation framework. The results were later validated through industry expert feedback in stage three of the research.

During the second stage of this research, the innovation measurement tool was practically applied and tested inside real organisational contexts. For this stage, a multiple case study strategy (Coombs, 2022; Hunziker & Blankenagel, 2021; Yin, 2018) was adopted. This strategy employed two purposefully selected (Bouncken et al., 2025) medium and large construction organisations operating in New Zealand. The rationale behind using a case study approach was based on its capacity and potential for facilitating an in-depth investigation of complex matters through application in real-life settings (Simons, 2020; Stake, 2005; Yin, 2018). During the second study of this research, the case study approach allowed for a strong understanding of how the developed innovation measurement tool performs when applied within real organisational atmospheres.

This stage directly addressed objective 3 and contributed towards the fulfilment of objectives 2 and 5 of this research. First, it tested the tool within the New Zealand construction organisations. Second, it helped towards the development of a holistic tool for measuring innovation within the New Zealand construction organisations. This stage of the research, by creating a measurement tool, also contributed towards providing diagnostics and advice for improving innovation measurement within the New Zealand construction organisations. Extensive detail of this stage of research is presented below.

In this chapter, the results that were obtained during the case studies are presented. With the purpose of delivering the information obtained from the respondents, this chapter first discusses the details of the data collection process during the first case study. This is followed by the demographics of the first case study. Afterwards, the responses provided by the interviewees while addressing the indicators of the Innovation Potential Questionnaire are analysed. This is followed by an in-depth analysis of the innovation Score of the company, which investigated the root causes of the results. The next section of this chapter presents the results obtained by studying the case companies using the measures of the Business Innovation Score section of the developed business innovation measurement tool. This section looks more into the outputs of innovation during the observation period rather than the potential for innovation. Also, this

is followed by an analysis of the responses of the interviewees for a number of open-ended questions, aiming to further improve the business innovation measurement tool of this thesis.

The abovementioned sections of this chapter were repeated for CS2. Further in this chapter, the results from a comparative study of the two case studies comparing CS1 and CS2 are presented. For this comparison, initially, the results obtained from two case studies on the 5 categories of the innovation potential were compared. This was followed by comparing the two case companies for their business innovation score. Finally, the overall results of the two companies were comprehended into one table for comparison.

4.2 Overview of Tool Implementation -Testing the Tool on Case Study 1

During this case study interview, the respondents were given another chance to review the information sheet that was already sent out to them with the invitation email. Also, clear instructions were given regarding the aim and the objectives of the research and of the purpose of the interviews. Once verbal approval was given to conduct the interview, the respondents were asked to sign the consent form that was provided.

The respondents were then given time to review the "Business Innovation Measurement Tool" that is tailored for the NZ construction industry. They were also asked to rate their company based on their personal views. The tool was printed on large A2-sized paper to make it easy for the respondents to read and respond to the question. The five main categories that the respondents needed to address were as follows. These categories measure the "potential" of the company to innovate:

- Workforce Skills and HR Management
- Organisational Structure
- Business Strategy
- Technology
- External Influences

The respondents were then asked to rate the "Business Innovation Score" of the company. This section attempts to measure the "actual" innovation of the company rather the potential.

At this stage, the respondents were also asked to respond to questions regarding the

- "General Resources"

  of the company, and to the

- "Demographic questions".

This set of data is very useful for the analysis of the results as it indicates important information regarding the company and the respondent.

The respondents were then shown the spider diagrams that are generated instantly and spontaneously once the scores are entered for each question based on the answers provided by the respondents. It is worth mentioning that at this stage, the researcher, who is also the conductor of the interview, had to enter the responses into the Excel file as the respondent finished answering each sheet. This facilitated the instant generation of the spider diagrams. The spider diagrams were, at this stage of the interviews, reviewed together between the

interviewer and the interviewee. Eye-catching drops or jumps in the scores for any question were reviewed, and the averages for each category were compared with other categories. Also, the mean score for the categories which comprise the “Innovation Potential Score” was compared with the actual “Business Innovation Score”. Finally, the “Overall Score” was generated as the final score for the company. The mentioned scores for each category individually and collectively are the basis for the analysis of the case study company. The results for each company could be compared with other companies individually or collectively to help them improve. Also, the industry averages could be populated and used as a basis for the support of innovation within the NZ construction industry. The results could further benefit development purposes.

At the final stage of the interviews, the interviewees were asked a number of open-ended questions to gain their insights regarding the tool and its further improvement. The questions are presented in Appendix 3. What follows are the details of the mentioned process.

4.3 Study Case 1

The first case that was studied is a privately owned company based in West Auckland. They design, build, and install pre-finished homes throughout the Greater Auckland region. Case study 1 is a very young company and was founded in 2018. Based on the company website, their vision and mission have a great emphasis on innovation.

By reviewing the respondents' answers for the tool’s questions on the General Resources page, it was found that Case Study 1, which is referred to as CS1, has a contracting role and operates and contracts under both the public and the private sector. CS1 is involved in the residential sector, as well as the civil engineering and infrastructure sector.

SC1 has 20-49 employees and is considered to be a medium-sized company. This study case has a turnover of under $10 million annually and owns less than $1 million of assets. The company was established less than five years ago. They are using a profit margin of between %20 to %40.

CS1 has an equity ratio of 20% to 40%, and the company runs as a standalone ownership – is not part of an organisation – and operates on domestic projects. CS1 addresses customers and clients in the governmental sector (Business to Government) and also deals with other businesses (Business to Business). CS1 operates with the governmental sector on national, regional, and local levels. This company uses internal resources (vs. equity, debt, mixed, financial transfers, etc.) for the innovation activities of the company. Between 20% and 40% of the company’s employees have a tertiary education. This is while %80 of the company’s employees have vocational training relevant to their duties. The average tenure of the employees in their positions is 2 to 4 years.

4.3.1 Case Study 1 – Demographics

During CS1, five separate semi-structured interviews were conducted. For the purpose of this publication, the respondents are coded as CS1-Int1 to CS1-Int5. The demographic information of the respondents is presented as follows:

Table 4.1: Demographic Information of the Interview Cases for the Study Case 1

Interviewee / Question	**CS1-Int5**	**CS1-Int2**	**CS1-Int3**	**CS1-Int4**	**CS1-Int5**
Role	Health & Safety After-Sales-Care Systems	Project Management	Management	Administration + Accounts	Contracting
Sector History	Private Sector	Private	Private	Private	Public + Private
Type of Construction	Residential	Residential	Residential	Residential	Residential
Profession	Administration + Health & Safety	Project Manager	Project Management + Builder	Accounts	Project Manager/ Builder
Designation	Administration	Project Manager	Project Manager	Accountant	CEO + Board Member
Highest Academic Qualification	Last Year High School - Human Resources Management	Master of Science Project Management	Level 4 Carpentry + Level 4 Site Supervisor	School Certificate	Carpentry (NZQA level 4)
Professional Qualification or Membership	No	No	No	No	Certified Builder + LBP
Years of Experience	0 - 5	16 – 20	11 – 15	0 - 5	21
Years of Management	0 - 5	6 – 10	6-10	0 - 5	11-15
Age Range	21 - 29	40 to 49	50 to 59	50-59	30 to 39

During CS1, 5 people were interviewed altogether. The respondents had roles in different sectors of the company. Three people were from the management team, while one person was from the accounts team and one person from the admin team. All respondents had a history of working in the private sector, while one respondent had also experience working for the public sector. The respondent's highest academic qualification was between the last year of high school and a Master of Science in Project Management, while 2 respondents had level 4 carpentry certificates. Only one respondent had a Professional Qualification as a Certified builder and Licensed Building Practitioner (LBP). The respondents' average years of experience in the construction industry were 11 years, while the managerial experience average of the respondents was 7 years. Eventually, the average age of the respondents was 43 years.

Interviewee 5 was the CEO and board member of the company, and due to his role high in the organisational structure, CS1-Int5 was highly informed regarding the in-depth information required for the interview. CS1-Int5 was also the gatekeeper to the company and had been connected through OffsiteNZ official's endorsement.

4.3.2 Case Study 1 – Innovation Potential Questionnaire

Based on the interview protocol that was planned, CS1-Int1 to CS1-Int5 were given the questionnaire tool to fill out before the qualitative interview questions were asked. What follows are the responses that CS1 respondents have provided.

As previously discussed in section 4.2, the respondents were first given a chance to review the interview information sheet. Later, they were introduced to the definitions and expressions that are used throughout the innovation measurement tool. This is required to achieve a common understanding regarding the terminology used in the tool.

4.3.2.1 Innovation Potential - Workforce Skills and HR Management

During this interview process, the first of five pages was given to the respondents. This page consists of 5-point Likert scale questions regarding the "Workforce Skills and HR Management" of the company under study. The respondents were asked to demonstrate "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS1 for the question on Workforce Skills and HR Management.

Table 4.2: Results - Workforce Skills and HR Management for CS1

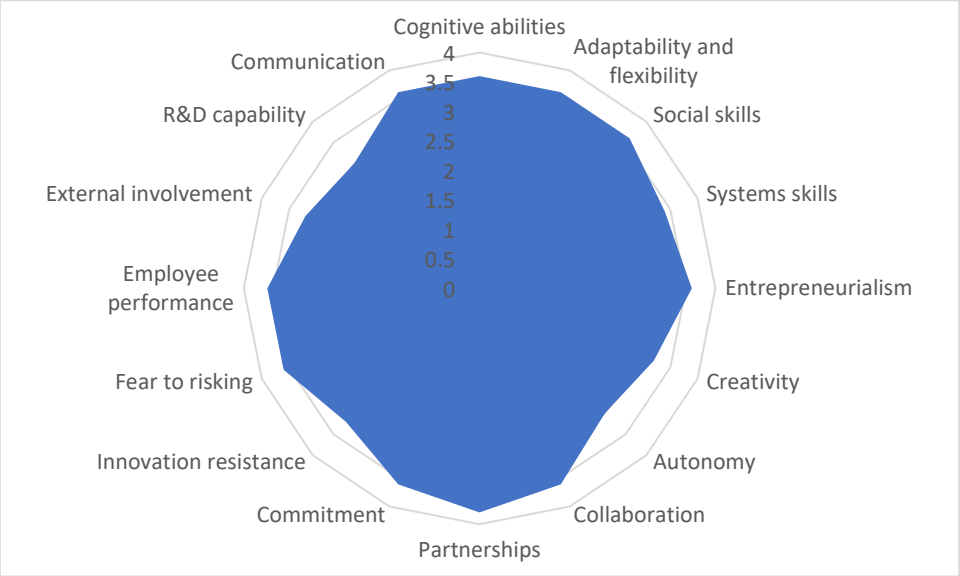
	Indicator	**CS1 - Int1**	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
WF&HR 1	Cognitive abilities	3	4	3	4	4	**3.6**
WF&HR 2	Adaptability and flexibility	3	4	3	4	4	**3.6**
WF&HR 3	Social skills	3	4	3	4	4	**3.6**
WF&HR 4	Systems skills	3	4	4	3	3	**3.4**
WF&HR 5	Entrepreneurialism	3	3	4	3	5	**3.6**
WF&HR 6	Creativity	2	4	3	3	4	**3.2**
WF&HR 7	Autonomy	3	3	3	3	3	**3**
WF&HR 8	Collaboration	3	4	3	4	4	**3.6**
WF&HR 9	Partnerships	3	4	4	4	4	**3.8**
WF&HR 10	Commitment	4	3	4	4	3	**3.6**
WF&HR 11	Innovation resistance *	3	3	3	4 *	3	**3.2**
WF&HR 12	Fear of risking *	3	4	3	4	4	**3.6**
WF&HR 13	Employee performance	3	4	3	4	4	**3.6**
WF&HR 15	External involvement	2	4	4	3	3	**3.2**
WF&HR 16	R&D capability	2	3	4	3	3	**3**
WF&HR 17	Communication	3	4	3	4	4	**3.6**
Respondent's Average		**2.88**	**3.69**	**3.38**	**3.50**	**3.69**	
Overall Score							**3.5**

* Reversed to account for the indicator question's wording error

The overall average score for the company's Workforce Skills and HR Management is 3.5. The respondents gave an above average score for the indicators in this category, The respondents seem to be exceptionally happy with company's "Collaboration with partners" while the believe there is room for improvement in with the level of "Creativity", "Autonomy", "Innovation residence", "The fear to "Risking on innovation" and "External network involvement".

While reviewing the responses, it was understood that two indicator questions needed rewording. Because WF&HR 11 and WF&HR 12 had initially been written in a negative format, the results had to be reversed in the Likert scale. To avoid this in future research, the wording was amended in the final tool. This achievement was one of the benefits of triangulation, as it allowed feedback from multiple sources and strengthened the results of the findings. The figure below is a Radar (Spider) Diagram depicting the indicator averages for Workforce Skills and HR Management:

Figure 4.1: Workforce Skills and HR Management for CS1



4.3.2.2 Innovation Potential: Organisational Structure

The second set of questions regarding the company's potential to innovate concentrates on the "Organisational Structure" of the organisation. The respondents were asked to demonstrate: "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS1 for the question on Organisational Structure.

Table 4.3: Results - Organisational Structure for CS1

	Indicator	**CS1 - Int1**	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
Org 1	Organisational support	3	4	3	3	4	**3.4**
Org 2	Upper management support	4	4	4	3	5	**4.0**
Org 3	Innovation Champion	4	3	4	2	2	**3**
Org 4	Recruitment policies	3	3	4	3	3	**3.2**
Org 5	Employee recognition	4	3	3	3	4	**3.4**
Org 6	Incentives	3	1	3	3	5	**3**
Org 7	Knowledge management	3	3	4	3	3	**3.2**
Org 8	Lessons learned	3	3	3	3	3	**3**
Org 9	Career development	3	3	2	3	4	**3**
Respondent's Average		**3.33**	**3**	**3.33**	**2.88**	**3.66**	
Overall Score							**3.24**

Based on the results obtained from the respondents, CS1 obtained a high score for the upper management and decision makers' support for innovations. This is while the company needs to invest more on the “Innovation Champion” as someone directly tasked with managing the innovation practices within the company. CS1 also did not achieve a high score on the item relating to incentives for employee performance in suggesting ideas for innovation or in developing innovations. The interesting thing about the responses of the interviewees on this item was that they had different opinions on it. Therefore, this matter needs to be addressed and diagnosed. There may be different reasons for this, relating to different departments, perceptions and expectations about incentives, or it might be a matter of information on incentives not properly shared amongst employees. The respondents thought that there is not enough management on “lessons learned”, also on training, skills and “career development” opportunities. These findings highlight the developed tool’s strengths in diagnosing the strengths and weaknesses of the company under investigation.

The average score for each indicator individually and for the response of each respondent is presented in Table 4.3. The overall score for the company CS1, in relation to its Organisational Structure, is 3.24. The figure below is a Radar (Spider) Diagram depicting the indicator averages for organisational Structure:

Figure 4.2: Organisational Structure for CS1

4.3.2.3 Innovation Potential: Business Strategy

The third set of questions regarding the company's potential to innovate concentrates on the "business Strategy" of the organisation. The respondents were asked to demonstrate: "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS1 for the question on the Business Strategy of the organisation.

Table 4.4: Results - Business Strategy for CS1

	Indicator	**CS1 - Int1**	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
BS 1	Strategic Plan	4	3	3	4	5	**3.8**
BS 2	Strategy communication	3	3	2	3	4	**3**
BS 3	Progress monitoring	3	3	3	4	4	**3.4**
BS 4	Innovation Strategy	3	3	3	4	4	**3.4**

BS 5	Finish price focus	4	3	4	4	3	**3.6**
BS 6	Quality focus	4	4	4	4	5	**4.2**
BS 7	Multiple market focus	3	3	Pass	3	4	**3.25**
BS 8	In-house sourcing	4	3	3	4	3	**3.4**
BS 9	Lifecycle focus	3	3	4	3	4	**3.4**
Respondent's Average		**3.44**	**3.11**	**3.25**	**3.66**	**4**	
Overall Score							**3.5**

In relation to the company's Innovation business strategy, the respondents showed a relatively higher satisfaction with the company's "Strategic plan" and "Quality focus". The respondents also demonstrated less satisfaction towards the company's strategic plan focus on multiple markets simultaneously - "multiple market focus" – and the way and extent that the company's strategic plans are communicated to the employees.

The average score for each indicator individually and for the response of each respondent is presented in Table 4.4. The overall score for the company CS1, in relation to its business strategy, is 3.5. The figure below is a Radar (Spider) Diagram depicting the indicator averages for Business Strategy:

Figure 4.3: Business Strategy for CS1

4.3.2.4 Innovation Potential: Technology

The main objective of the fourth set of questions was to find information about the Technology of the firm. The interviewees were given questions asking to what extent the following factors were present in their organisational interactions. The following table represents the results obtained for this set of questions from the five interviewed employees at CS1.

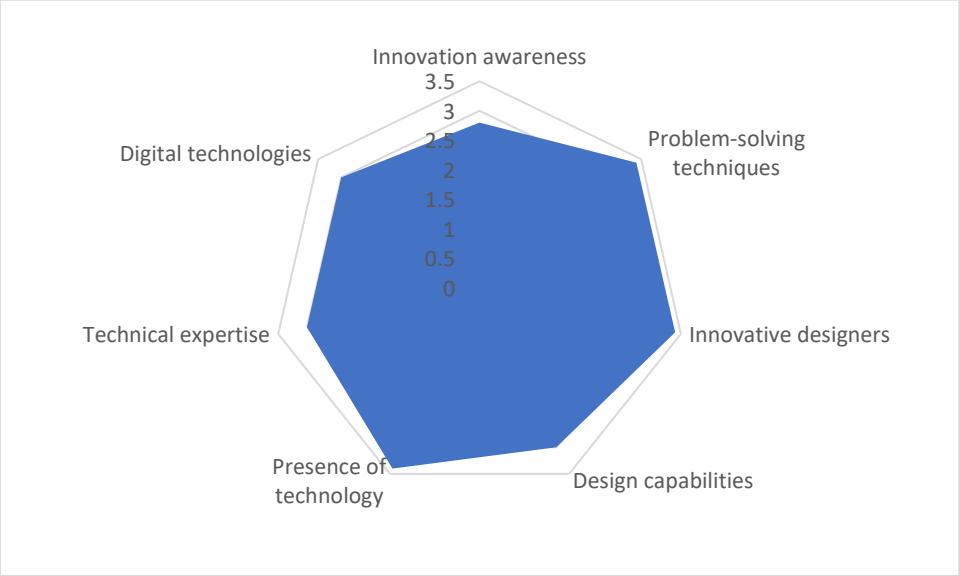
Table 4.5: Results – Technology for CS1

	Indicator	**CS1 - Int1**	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
Tech 1	Innovation awareness	2	3	1	4	4	**2.8**
Tech 2	Problem-solving techniques	3	4	3	4	3	**3.4**
Tech 3	Innovative designers	3	4	3	3	4	**3.4**
Tech 4	Design capabilities	2	3	3	3	4	**3**
Tech 5	Presence of technology	3	3	4	3	4	**3.4**
Tech 6	Technical expertise	3	3	3	3	3	**3**
Tech 7	Digital technologies	3	2	2	4	4	**3**
Respondent's Average		**2.71**	**3.14**	**2.71**	**3.42**	**3.71**	
Overall Score							**3.14**

Overall, the responses seem to be lower in this category compared to other sets of questions for the innovation potential of the company. This is reflected in the overall score for this category, which is 3.14. The respondents gave a very low score for the question addressing awareness about innovative tools, methods and practices amongst the employees – "Innovation awareness". In this sense, this matter needs to be diagnosed, and attempts to increase this score must be made. The respondents also gave an average score to the "Design Capabilities", "Technical Expertise" in emerging technologies and "Digital Technologies", platforms and analytics. It is understood that these indicators also need to be improved. There is a requirement to investigate the root causes of these relatively low scores on the "technology" capability of CS1. Evidently, the lack of technology-related indicators is negatively affecting the innovation potential of the companies, including CS1.

The average score for each indicator individually and for the response of each respondent is presented in Table 4.5. The overall score for the company CS1, in relation to its technology, is 3.14. Below figure is a Radar (Spider) Diagram depicting the indicator averages for technology:

Figure 4.4: Technology for CS1



4.3.2.5 Innovation Potential: External Influences

The fifth and last page on the measurement tool was to find the potential of the company to innovate under the influence of the external factors. The respondents were asked to score, to what extent and how did each of the items/indicators contributed to innovation within their company. The table presented below represents the results obtained for the fifth set of questions.

Table 4.6: Results - External Influences for CS1

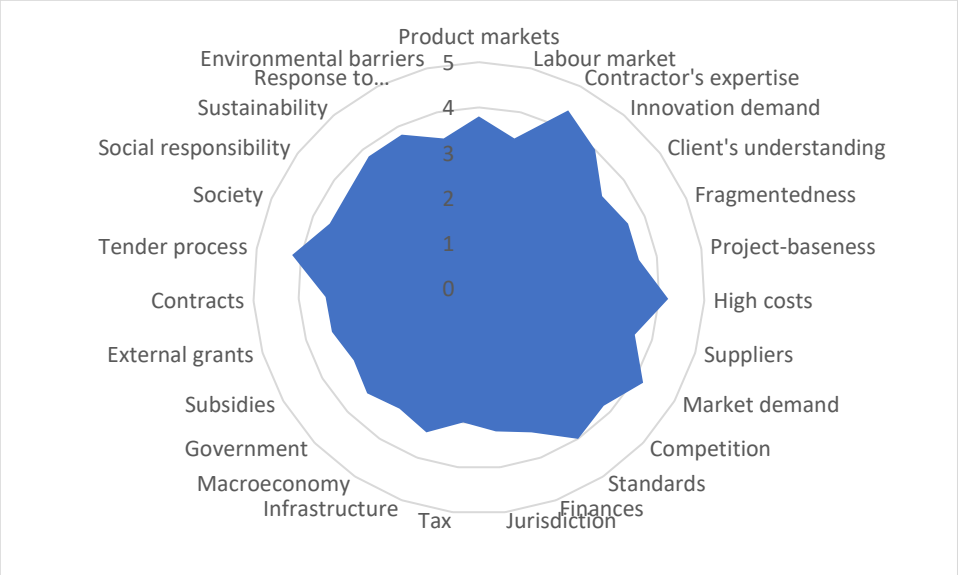
	Indicator	**CS1 - Int1**	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
Ext 1	Product markets	4	4	4	4	3	**3.8**
Ext 2	Labour market	4	4	3	2	4	**3.4**
Ext 3	Contractor's expertise	5	4	5	4	4	**4.4**
Ext 4	Innovation demand	4	3	5	4	4	**4**
Ext 5	Client's understanding	5	3	3	3	3	**3.4**
Ext 6	Fragmentation	4	3	3	4	4	**3.6**

Ext 7	Project-baseness	5	3	4	3	3	**3.6**
Ext 8	High costs	5	3	5	4	4	**4.2**
Ext 9	Suppliers	5	4	2	3	4	**3.6**
Ext 10	Market demand	4	5	5	3	4	**4.2**
Ext 11	Competition	4	3	4	4	4	**3.8**
Ext 12	Standards	5	3	3	4	5	**4**
Ext 13	Finances	4	3	5	4	1	**3.4**
Ext 14	Jurisdiction	5	3	3	3	2	**3.2**
Ext 15	Tax	3	3	3	3	3	**3**
Ext 16	Infrastructure	3	3	5	3	3	**3.4**
Ext 17	Macroeconomy	3	4	3	3	3	**3.2**
Ext 18	Government	5	3	4	3	2	**3.4**
Ext 19	Subsidies	5	3	3	3	2	**3.2**
Ext 20	External grants	4	3	5	3	2	**3.4**
Ext 21	Contracts	3	3	4	4	3	**3.4**
Ext 22	Tender process	4	4	5	4	4	**4.2**
Ext 23	Society	4	3	3	4	4	**3.6**
Ext 24	Social responsibility	4	3	3	4	4	**3.6**
Ext 25	Sustainability	3	3	5	4	4	**3.8**
Ext 26	Response to Environment	4	3	5	3	4	**3.8**
Ext 27	Environmental barriers	5	3	3	3	3	**3.4**
Respondent's Average		**4.18**	**3.29**	**3.88**	**3.44**	**3.33**	
Overall Score							**3.63**

The overall score obtained for this category was the highest score (3.63) amongst the five sets of questions for the innovation potential. Since the Likert scale developed, rated the impact score on a 5-point scale ranging from 1 for strongly negative, 2 for negative, 3 for neutral, 4 for positive and 5 for strongly positive, a high overall score indicates that CS1, has had a relatively positive impact from external factors on their innovations.

The average score for each indicator individually and for the response of each respondent is presented in Table 4.6. The lowest score obtained in this section was a 3 out of 5 (average), which indicates that there are no negative impacts from external factors on the company CS1's innovation. The figure below is a Radar (Spider) Diagram depicting the indicator averages for External Influences:

Figure 4.5: External Influences for CS1



4.3.3 Case Study 1 – In-depth analysis of the Innovation Potential Score of the Company – Root Cause Diagnostics

An in-depth investigation of the existing characteristics of CS1 allows to understand the underlying facts which define the innovation capability of this company. The responses to the questionnaire questions gave a score on the scale of 5 for each indicator. These scores were thematically analysed on both the individual level and the comprehensive level. The individual scores allowed to see particular opinions about any specific indicator. When put together, an average was obtained for each indicator, "Indicator Average", which allows for evaluating the company on the basis of that particular indicator by using the average of different opinions from different employees. This is rather important because it allows to see the score for an indicator, smoothed from one-sided opinions of any particular department in the case under study. Also, the respondent's average was found for each category of questions. This is also a good way to investigate the perception of each respondent – and potentially department – towards any of the five categories of innovation potential. A third average was also found, which is the overall average for all the responses that the respondents gave for all the indicators of that particular category, "Overall Score". This score is used as the final score of the case

under investigation for that particular category. The overall score allows for the diagnosis of the "categories" that need special attention, while, as mentioned above, the indicator averages display the indicators of strength and weakness.

The interviews, which were recorded, consist of two sections that followed. The first section was while the interviewee was responding to the questionnaires. The communications between the facilitator and the interviewee allowed the gathering of important, first-hand information regarding the case under study. While the respondent was filling the questionnaire, his/her comments, enquiries, explanations, and doubts were recorded to further improve the tool and to study the company in detail.

The questionnaire was followed up by open-ended questions from the interviewee. The questions are presented in Appendix 3. These questions were aimed at gaining feedback from the respondent regarding the tool. The respondent's comments allowed addressing the aim and objectives set for this thesis. The audio transcripts were transcribed initially by using artificial intelligence. The transcriptions were double-checked and triple-checked manually by the researcher. The notes were thematically analysed using "NVIVO 12 Pro" software. The findings in this second stage of the research were in line with and part of the three-stage triangulation framework adopted for this research. This framework provided strength and validated the findings of the research.

What follows is an insight into the analysis of the communications that happened during the five interviews with five employees in CS1.

4.3.3.1 Diagnostic Insights - Workforce Skills and HR Management

In regard to Workforce Skills and HR Management, it seems like the overall score of 3.4 indicates a mild consent towards the indicators. It was understood that CS1 uses employees from different levels of knowledge and expertise. At such companies, there are employees who take on the role of innovation champion (as indicated in section 2.9.31) and show more potential towards the indicators of this category than others. According to CS1 - Int1: *"One of our team members , extremely well qualified, multiple qualifications."*

This indicates that due to the different levels of expertise amongst employees, conducting innovation programs can be rather cumbersome at some stages and needs special attention from the decision makers. The respondent also indicates that technical expertise (section 2.9.66) and presence of technology (section 2.9.47) are not sufficiently observed amongst the employees' systems skills (section 2.9.64). This event led to the eventual final overall score - Business Innovation Measurement (Potential + Score) – of CS1 being lower in comparison with CS2. These scores are presented in section 4.7 of this thesis. In line with this, CS1 - Int1 continued to mention: *"Very, almost computer illiterate. Learning systems can be quite difficult. So, it's things like that. it's my role here. In particular, I tried to encourage use of systems and processes and things like that. I created the operational manual and things like that, trying to kind of improve it. So, we can all be on the same page."*

By looking at the results and by reviewing the responses of the respondents, it is evident that CS1 has some room for improvement. CS1 has a relatively small number of employees while using other contractors. One respondent believed that if they are going to use "*extremely qualified*", then they will have to pay more. This belief tries to "*get the job done*" by using the "*not so skilled workforce*". This is contrary to what a construction company needs to have a high potential for innovation. These traits were reflected in sections 2.9.9 Cognitive abilities,

2.9.12 Creativity, 2.9.48 Problem-solving techniques, 2.9.35 Innovative designers, 2.9.13 Design capabilities, and 2.9.66 Technical expertise of this thesis. In line with the findings in study 1 of this thesis, the lack of these traits inside the company, leading to this belief, is somewhat behind the relatively lower overall score of CS1.

The company has hired people who might not have construction experience but have the relevant "*skills required*". There is a culture of "*learn as you go*" in the company, which is good for the future of the company, but needs to be balanced with the required expertise mentioned in the previous paragraph. Perhaps the company requires several "*super experienced*" people, and this is indeed something to consider in the hiring strategy in the future.

CS1 does have some processes going on to manage communication, workforce skills and HR. For instance, Buildertrend software is being used for project management. This software allows for the generation of reports. Health and safety reports are used for the HazardCo and H&S management. Minutes are a usual for documentation purposes. Buildertrend is also used for accounting reports and similar uses. The mentioned is in line and a reflection of the sections 2.9.47 Presence of technology, and 2.9.14 Digital technologies, previously discussed in study 1 of this thesis.

It was in the meantime understood from the respondents that things don't always go according to expectations, and they are "*not always finding resolutions at the time.*" It was also understood that even when there is a resolution for a problem, "it is not easy to get everyone on board." These statements from the respondents affirm that the hired employees with a low level of knowledge and expertise have not been finding innovative solutions for the company's problems. This finding confirms the relation between the previously mentioned organisational attributes in this current section 4.3.3 of the thesis, and the potential for a construction company to innovate.

It is also important to understand that having Creativity (section 2.9.12) is one of the indicators for innovation in the company in the proposed innovation measurement tool for the construction industry. As mentioned above, the employees don't seem to have many of the traits required for innovation as CS1–Int1 explains: *"I'm personally not the most creative person in the world. I know that I am a box ticker. I'm very compliance versus creative".*

It also seems like there is high consent over employee performance (section 2.9.15) (cost reduction, productivity, effectiveness). CS1–Int5 believes that the employees are doing a good job in this regard. There is the belief that they have invested in this regard, and this is the result of the previous attentions received (sections 2.9.45 Organisational support and 2.9.68 Upper management support). It is evident that there might be different opinions on this case from different departments, and this is definitely a place for discussion for further attention to get a higher score and eventually a higher contribution towards innovations of the company.

In regard to external involvement (2.9.20 External involvement), the indicator average is 3.2, while there are instances of responses from some respondents as low as 2.0. This trait is necessary for innovation, as found in study 1 of this thesis, and the lack of this trait has, in part, negatively affected the potential of CS1 to innovate. This is definitely an indicator that requires special attention. CS1–Int5 quoted: *"External involvement. Yeah, we could do better in that. We'll go average could do better in external involvement."*

Another indicator from the workforce skills and HR management that received special attention was "WF&HR 12" (section 2.9.44). It was initially stated as follows:

Table 4.7: Indicator WF&HR 12 for CS1

Fear to risking	The fear to risking on innovation	Very Low	Low	Average	High	Very High	Score 1-5

It was found that due to the nature of the wording, it was required to rephrase this indicator to fit the 5-point Likert Scale which followed. This was done as part of the development process of the tool and was used in the later stages of the research. This feedback, once again, affirmed the value of triangulation as a validation technique, through collecting data from multiple sources (section 3.7.2 Source Triangulation) and using multiple methods (section 3.7.1 Method Triangulation). The respondents expressed that they did not fear innovation, rather, they expressed that the "*CS1 is conducting operations and projects that other builders refuse to do*" so they are "*not afraid of risk*", and this is known as one of CS1's causes of success and is validating the findings of stage one of this thesis.

In regard to the indicator measuring R&D capability (section 2.9.53), the average score is 3.0. This score is relatively low. The respondents did have an overall similar understanding towards the low capability of CS1 in this indicator. They believed that there is a low potential for research and development in the company. We here need to remember that R&D capability is a leading indicator for innovation and one of the most important indicators found in stage 1, section 2.9.52. This is because the governments and policy makers like to see this indicator as one of the criteria for their decision-making on innovation. It was evident that CS1 depends highly on external sources for knowledge and innovative ideas. CS1 - Int5 mentioned that they "*prefer to use external resources for the Research and Development of the company*".

Interestingly, CS1 - Int5 viewed this participation in the research as part of their innovation and external engagement, which is a good sign for the potential of this "Innovation Measurement Tool", which was developed during this research. CS1 is eager to use the results of this research to diagnose their strength and weaknesses and use it in their future company developments. This was also a further validation of the capability of the developed tool for being adopted within the New Zealand construction organisations.

Through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.3.5), the respondents collectively confirmed the findings of this tool under the workforce skills and HR management (section 4.3.2.1) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.3.2 Diagnostic Insights - Organisational Structure

The next category of indicators that were discussed comprises 9 questions focusing on the organisational structure of the company. These indicators and the scores given by the respondents of CS1 have previously been presented. The overall score for this category is 3.24, which is a relatively good score. The scores are relatively evenly distributed, and there are no extreme jumps in the scores.

During the interviews, the respondents addressed a number of issues which help diagnose the company's innovative capability further. The following data, together with the scores for the indicators, helped greatly in addressing the research objectives.

CS1 seems to have a good approach towards its organisational structure. CS1 - Int1 had a very interesting review of the organisational matters within the company. He/she believed that everything must be focused on process improvement. They are trying to improve continuously, while there are obstacles along the way. There is a difference between small team improvement vs "massive organisation" improvement. CS1 - Int1 believes improvement is easy as long as there is a desire to find easier ways to do the tasks. He/she believes there is still room for improvement of the organisational structure (section 4.3.2.2) and processes and expresses that they "are trying".

There is also the requirement of "*getting everyone on board*", which interprets into focus required for matters relating to Knowledge management (section 2.9.37), and Lessons learned (section 2.9.39) from the organisational structure category, also Strategy communication (section 2.9.60), and Progress monitoring (2.9.50). CS1–Int1 believes the "*struggle*" in this matter is related to the existence of "*different departments*" in the company. Similarly, CS1-Int5 also believes there is "*still room for improvement in organisational structure"*. These findings confirm the importance of the indicators mentioned in this paragraph for a construction company to be innovative, both potentially and in practice.

CS1-Int2 gave a relatively low score to the indicator addressing incentives (section 2.9.28). While he/she gave it a score of 1, CS1–Int5 gave it a 5. The other respondents gave it an average score of 3. This score could be interpreted from multiple perspectives. It could be due to the departments of the respondents or the interviewees' designation in the company. In this case, the latter is evident but does not rule out the need for further investigation and remedy to understand why this level of difference and dissatisfaction is happening inside the company. CS1-Int2 believes the management needs to "*offer incentives*" to the people down the line, and this will lead to "*some motivation*". He/she believes that suggestions and innovations – for example, engaging a particular machine in building walls – will lead to a reduction of the time required for the task. CS1-Int2 emphasises that this needs to be recognised by the management team through incentives.

On the other hand, CS1-Int5 believes there have been good incentive programs within the company. He/she expresses that there is the "*idea box*" scheme running in the company. This is used as a method to incentivise the employees to "*suggest new ideas*". Each month, the best idea of the month is implemented, a draw is done, and two people are taken to Fiji to get a chance to build houses for charity. These findings demonstrate the capability of the developed tool in this thesis in diagnosing where problems exist inside construction companies. These issues need to be addressed to increase the potential of the construction company to innovate.

The indicator relating to Knowledge management (section 2.9.37) had a large number of respondents from CS1 interested in responding. The average score for this indicator from the responses is 3.2 without any great discrepancies in the responses. Indeed, this indicator is very important for the innovation of the company, as well as for any other company goals and projects, which were stated in section 2.9.37 of this thesis. CS1 seems to have "*production meetings*", but according to CS1-Int1, it seems like "*the meeting results don't always go further than they probably should*". The reason was mentioned to be "*lack of time, lack of potential and not really looking to process improve*". He/she also mentions that the reason these meetings don't go well is that the employees are not always prepared for these meetings, but there has been a focus on this to improve inside the company. They are trying to make these "*production meetings*" a norm as an attempt to improve communication (section 2.9.7) and knowledge

management (section 2.9.37) practices. The respondents inside CS1 were aware of the importance of these indicators for improving the potential of the construction company to innovate, and this further validates the findings of stage 1 of this research.

In regard to other knowledge management practices, CS1 implements some other knowledge management practices as well. They use checklists and project management software (section 2.9.47). Buildertrend software has been adopted for the management of projects. Buildertrend has the ability to generate reports to share knowledge. CS1-Int1 mentioned reports on health and safety to HazardCo as one of the instances of the application of these reports. Taking minutes and notes from meetings and site visits is also a common practice within the company. Another instance of report generation by the Buildertrend software is for the accounts team. These reports have helped the employees once there is a need to communicate and share knowledge, but there is room for improvement, as mentioned, "*we're not always finding resolutions at the time*". Also, CS1-Int1 believes that even after finding resolutions for the problems, there is still a need for collaboration (section 2.9.5) and commitment (section 2.9.6) from the employees. These comments highlight and validate the importance of the mentioned indicators for innovation and its measurement.

CS1–Int1 does insist that these weaknesses have had an impact on the innovativeness of the company and "prohibits innovation". CS1 has created and endorsed an "*operational manual*" as a form of foundation or "*crib*" for their knowledge management (section 2.9.37) practices. The employees are recommended to write daily logs in the section relevant to their department. The employees are recommended to especially write any "*changes*" in their circumstances. This is indeed a great way to capture the innovation of the company. The daily log documents any changes made in any section of the company. One of the main reasons why CS1 has decided to do so is to be able to maintain operation in the event of "*the loss of an employee*". CS1 has tried to invest in this daily log and has faced challenges in "*getting responses from everyone*". This diagnosis highlights the areas within the company needing improvement and reflects the ability of the innovation measurement tool in providing recommendations and strategic insights for improving innovation measurement practices within New Zealand construction organisations. This was mentioned in objective 5 of this research.

CS1-Int2 also has a positive view toward this measurement tool and believes it could be used as a platform for knowledge management (section 2.9.37) as well. The tool can be used as a basis for discussion of the project improvement and lessons learned (section 2.9.39) document for future practices as part of the organisational process assets documentation. The tool can also be the lead for the monthly meetings to see where there is a need for improvement and to mitigate the errors. This trait of the tool can help with the company's understanding of innovation and especially its measurement, and contributes towards objective 5 of this research.

What was interesting during the interviews was that CS1-Int5, who is the CEO of CS1 and a board member, believes that the processes of knowledge dissemination from one employee to the other does not exist to a necessary level inside CS1, but he/she believes the company manages to "*get on top of it*". So, the diagnosis report highlighted this gap inside CS1 as an area needing future attention.

The next indicator that received special consideration from CS1-Int2 was *Lessons Learned* (section 2.9.39). CS1-Int2 validates that the innovation measurement tool is a great facilitator for getting feedback from the employees. He/she believes that different employees, depending on their department and level of engagement and designation in the company, have different opinions towards the indicators and questions discussed in the measurement tool. The result could be a combination of academic and practical feedback added to the *lessons learned* (section 2.9.39) database. The comprehension of these learned lessons allows for the

minimisation and mitigation of errors and mistakes. This could be achieved through the use of the innovation measurement tool as a leading guide. As the use of this tool increases within the company, further checklists could be tailored to address the company's needs. This allows for focusing on the traits that require special attention, and the checklists, processes and improvements could be focused on them.

Another indicator that CS1-Int1 discussed was the level of support towards innovation that was given by the organisation, which was discussed under the organisational support (section 2.9.45) indicator. CS1-Int1 expressed that he/she has tried to "*encourage the use of systems and processes*" and the like. He/she has "*created the operational manual*" (section 2.9.59 Strategic Plan) in an attempt to develop a structure and improve the organisational system and structure (section 4.3.2.2). This allows for a common understanding of the organisational structure, goals, and strategies (section 4.3.2.3). Eventually, this leads to more systematic innovations within the company.

This fact was endorsed by the CEO as CS1-Int5, who believes that the "*performance appraisal*" organisational processes have the ability to find the right candidates for the positions. He emphasises that there is no need to seek creative skills within the employees, as the employees who pass the "*performance appraisal*" have "*creative skills*" (section 2.9.12) as part of their traits.

It must be again mentioned that through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.3.5), the respondents collectively confirmed the findings of this tool under the organisational structure (section 4.3.2.2) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.3.3 Diagnostic Insights - Business Strategy

The third category of questions in the innovation measurement tool consisted of 9 enquiries about 9 indicators relevant to the Business Strategy of the organisation/company. These indicators, previously in stage 1 of the research (section 2.9 Attributes affecting potential for innovation), were found to be influential for the innovation potential of the construction companies. As previously discussed in section 4.3.2.3, the overall score for this category, based on the responses provided by the respondents, was 3.5. This score is a joint place for the second-highest score, which indicates that the employees are fairly happy, compared to the other categories, with the company's business strategy. This could potentially support the innovation potential of the company and, as a list of leading indicators, raise hope for more innovations to take place within the company CS1. From the score given to the indicator coded under BS2: Strategy Communication (Indicator Average = 3), it is evident that CS1 needs to invest more in matters related to communication. This indicator had previously been found to be influential for innovation in section 2.9.60 of this thesis. What follows is the result of thematic analysis on the interviews with the 5 employees in CS1.

Cs1-Int1 has a positive view towards the business strategy of the company. It is evident from his/her words that he/she has high trust towards the management of the company and exceptionally towards the CEO. He/she highly believes there is a good strategy in place and that cooperation exists towards having a common understanding and to improve the business

strategy of the company. CS1-Int2 seems to be the least satisfied with the business strategy of the company. His/her average score, 3.11, is the least amongst the respondent averages. He/she gave a consistent score of 3 to most of the indicators, which indicates the CS1-Int2 has a neutral perspective towards the majority of the indicators in the business strategy category.

CS1-Int4 gave the second-highest score (3.66) to this category amongst the interviewees and had a very interesting view towards some of the indicators. He/she believes: "*The strategic plan (section 2.9.59) is well established but is not being communicated (section 2.9.60) well enough to the employees*". We discuss this further ahead in this chapter as CS1-Int5 indicated that: "*The strategy is deliberately communicated less than it normally is*", and the reason is that he/she expressed that: *"There are future plans at the development stage. These future plans will be communicated to other employees at the right time".* These statements confirm and validate the importance of the strategic plan (section 2.9.59) and strategy communication (section 2.9.60), which were previously found to be influential for innovation in stage 1 of this research.

In line with the low score for strategy communication (section 2.9.60), CS1-Int4 believes that the reason lies in the "*low number of employees"* to take care of the communication processes. CS1-Int2 adds to the comments relating to the finish price focus (section 2.9.21) indicator, expressing that since there is a need to make a bid during tenders, there might be occasions where the prices might be "*under-priced*". This is while there is no chance to "*compromise on the quality*". This is causing a dilemma where quality (section 2.9.22) and price (section 2.9.21) are definitely intertwined. This matter is also endorsed by CS1-Int3 by giving the same score of 4 for BS4 and BS5.

It was quite interesting that CS1-Int5, who is the CEO of the company, expressed that he "does *not want to be price-focused".* He emphasises that the company has a strategy to deal with the price, and that is to have a higher volume of production. He expresses that the company is quite aware of its price strategy and does not aim to bring the price down. He emphasises that *"They are happy where the prices are at the moment, and they are focused on other parts of the business".* He expresses that CS1 is not the cheapest nor the most expensive and focuses on *"delivering"* the tasks. He also clearly emphasises that if any client has a focus on the price, then *"we're not the company for you".*

In regard to the in-house sourcing (section 2.9.27), CS1-Int3 gave a score of 3 for this indicator. He/she expresses that there is room for improvement since they *"have been using outside suppliers for the company's requirements and only recently the company has been looking into expanding their supplier list".*

CS1-Int5, as the CEO of the company, demonstrates a long-term strategic perspective towards the strategy of the company. He, throughout the interview, expressed his passion towards the future of the company and his will to see the company grow; it was evident that his long-term perspective can potentially benefit the innovation of the company. At one stage, CS1-Int5 clearly stated that *"you invest money to make money".* This clearly points to the lifecycle perspective (section 2.9.40) of the CEO, and this view can be observed in the other employees as well. These statements also confirm and validate the importance of Innovation activities (section 2.10.9), Innovation projects (section 2.10.10) and planned innovation activities and expenditures, which were discussed in section 2.10.12 of this research.

The interesting thing about some of the questions was that some employees from different departments and designations did not know the answer to them, while other employees answered those questions. For instance, CS1-Int3 and CS1-Int4 did not know whether the company had a Multiple Market focus (section 2.9.43) or not. This matter confirms that the

interviewees have a different set of skills and knowledge, and therefore, their perspectives add to the comprehensiveness of the gathered information. This was anticipated through the research design incorporating source triangulation as indicated in section 3.7.2.

Regarding the quality of the houses built by CS1, it seems like the company has a huge focus on quality (section 2.9.22). The average score for this category given by the respondents is 4.2, which indicates that this claim is true. CS1-Int1 informed that CS1 builds a lot of houses up to the Homestar standards.

Regarding the strategic plan (section 2.9.59) of the company, it is evident that there is a high focus on it. The average score given to this indicator is 3.8, which is one of the highest scores for this category. CS1-Int5, who gave the score of 5 to the strategic plan of the company, believes the strategic plan is "*fairly strong, although a lot of employees don't know that yet".* He also emphasised that the strategy has *"purposefully not been communicated"* to the employees. CS1-Int5 stated that: *"We've got some large things in the fire, but at the moment we don't want to speak about it with employees until the time is right".*

In addition, CS1-Int5 believes that if they "*needed to communicate the strategic plan, the company is able to do so".* Strategy communication was previously communicated in section 2.9.60 of this thesis, and the fact that CS1-Int5 emphasises its importance in their decision about the right time to communicate their business strategy validates its importance for innovation inside CS1. He believes that once they decide to implement the strategic plan, their resources will align towards that goal. He insists that the company is currently focusing on older plans. Confirming this statement from CS1-Int5, the respondents gave the lowest score of 3.0 in the Business strategy category to the strategy communication (section 2.9.60) indicator. CS1-Int3 endorsed this by giving a score of 2: poor, also agreeing that the employees are not aware of what's going on inside the company as far as strategy is concerned.

Through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.3.5), the respondents collectively confirmed the findings of this tool under the business strategy (section 4.3.2.3) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.3.4 Diagnostic Insights - Technology

The fourth category of questions in the business innovation measurement tool was aimed at the Technology (section 4.3.2.4) of the company. This category consists of 7 questions. The overall average score for this category, based on the responses provided by the respondents, is 3.14. Two of the respondents scored below 3:average, and three respondents gave a score of more than 3 as their respondent's average. The only indicator that received a score of less than 3 as the indicator average was Innovation awareness (section 2.9.30). What follows is the result of an in-depth thematic analysis of the communications that were discussed during the interviews with the respondents.

CS1-Int1 believes that since CS1 is made up of a small team, this is making it harder to find resources, including human resources, to pursue technological advances. This is while there are employees in the company that are *"extremely well qualified".*

CS1-Int2 adds to the discussion regarding the use of technology (section 2.9.47) inside the company by saying that it is a norm in CS1 to look for innovative solutions and use different tools for problems and matters. The aim is, for example, to be able to minimise the labour hours by using *"spray paint"* or finding better ways to *"open doors"* in the houses that are being built. These solutions could lead to a lot of time and cost savings. He/she also believes that there is a need for incentives (section 2.9.28) for the employees to back these plans. For instance, if any employee has proposed any solution that has led to cost reductions or the minimisation of time for the project, there could be *"bonuses"* given to that employee as an incentive to motivate future suggestions.

CS1-Int4 also adds to the discussion relating to the technology category of the innovation measurement tool. In regard to the design capabilities (section 2.9.13), presence of technology (section 2.9.47) and technical expertise (section 2.9.66), he/she believes that since "none" of the employees in CS1 have this capability, they all "rely on somebody in *the outside world to do that"*. He/she expresses that: *"There are times when they do desire to develop something new, the employees and especially the employees on the manufacturing team, don't have the skills to do it"*.

This is due to the fact that the manufacturing team is not comprised of *"skilled labour"* (sections 2.9.48, 2.9.13, and 2.9.66). Therefore, any attempt to have the employees achieve a technical task is going to end in failure. This was eventually reflected in the relatively low results that CS1 demonstrated for its Business Innovation Score.

CS1-Int5 also adds to the comments made regarding the technology of the company by mentioning that, the systems and processes, the innovations, the software packages used for the management of the projects, the checklists used within the company, the in-house capabilities of the company, the *"Earmark"* machines, etc. are all part of the technology of the company (section 2.9.47). He insists that: *"there's no point in just plugging in expensive machines if you don't have the systems, the capabilities and the order book to do so"*. He believes technology is expensive, but at the same time, it is the *"low-hanging fruit in regard to innovation"*. He believes the technology mentioned is the fundamentals of innovation, and if someone can get them right, it will lead to profit. He also believes that the profit gained through technology can be used to further support technology, innovation, and the development of the company. He again emphasised that the finished price (section 2.9.21) should not be the focus of the company, and good quality (section 2.9.22), healthy, fast, and sustainable housing should be the main focus of the company.

CS1-Int5 believes that the company is still low in the technology sector, but they are deliberately low. His average score for this category, being the CEO, is 3.71, which indicates that he is aware that the company needs to improve in this category. He states that the company is recently set up and that the cost of technology is the reason they have decided not to invest too much in technology. He states that they have a strategy to keep the tasks manual. As mentioned above, he states that technology is "deliberately" kept low in the company since he believes they should "not buy the low-hanging *expensive fruit without the order books and the sustainability to keep it going"*. These comments are consistent with the low results for the CS1's business innovation score and confirm and validate the importance of having a strong technological background to succeed in innovation, particularly to have the 7 technology-related indicators that were found to be influential for a construction company's innovation during stage 1 of this research.

It must be again mentioned that through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.3.5), the respondents collectively confirmed the findings of this tool under the technology (section 4.3.2.4) category and found them useful for their

companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.3.5 Diagnostic Insights - External Influences

The fifth and last category of the questions relating to the innovation potential of the company, in the innovation measurement tool, measures the impact of the External Influences (section 4.3.2.5) on the innovation potential of the construction companies. This category consists of 27 indicators measured on a 5-point Likert scale. These indicators were previously, in stage 1 of this research, found to be influential for the innovations of construction companies. The overall average for this section is 3.63, which is the highest score amongst the scores. This means that the impact of this category on innovation has been positive. The overall attitude of the employees towards the external factors was positive. So, it could be seen that CS1 has been able to handle the impacts of the external factors to a great extent, so they won't affect the company's performance or the innovation of the company. In this category, no indicator achieved an average of less than 3.0 based on the average of three scores given to the indicators by the five respondents. What follows is an insight into the topics discussed during the filling of the fifth category of the questionnaire. The below-mentioned are comprehended and analysed through an in-depth thematic analysis.

Based on the comments given by CS1-Int4, the company has made more profit during the observation period, which is defined as the past one year, compared to the year before, and this is *"due to COVID-19 (Coronavirus Disease of 2019)"*, but it does not come easy and needed a lot of effort. He/she is happy with the tender process (section 2.9.67). Also, the market demand (section 2.9.42) is not affecting the company, but the competition (section 2.9.8) in the market has definitely affected the company. He/she has given a neutral score for the client's understanding (section 2.9.4), meaning they are not affected by it, but mentions that *"some of them aren't pretty clever"*. CS1-Int4 gave a low score of 2:negative to the impact of the labour market (section 2.9.38) on the company, indicating that since there was "*no labour in the market"*, the company has been negatively affected. In addition to the shortage of labour on the market, there is also a shortage of skilled labour (section 2.9.64), which further exacerbates the situation. This indeed has a hugely negative impact on the innovation capability of the company.

CS1-Int5 believes the company has been affected by the impact of COVID-19. He adds that the external influences are *"one of the biggest risks"* for the company, and they *"have very little control over"* it. He adds that they are hugely affected by the Jurisdiction (section 2.9.36) system, and he calls it *"terrible"*. His score for jurisdiction was 2:negative. He also adds that there are *"systems"* in place to take care of these impacts. One of the ways that company CS1 is dealing with this matter is through a lawyer. But these so-called systems induce a further impact on the company as they need extra effort and resources in order to operate. CS1-Int5 was also unsatisfied with the markets for finance (section 2.9.23), the government (section 2.9.25) support towards innovation, public support through subsidies (section 2.9.61) and external grants (section 2.9.19), such as rewards, awards, grants, funds, etc. On the other side, in addition to the above-mentioned, he was happy with the following indicators and gave them a score of 4 indicating that the impact if these indicators on the company and/or its innovation are positive: contractor's expertise (section 2.9.11), innovation demand (section 2.9.32)

meaning market/owner/client demand for innovation, fragmentation (section 2.9.24) meaning fragmented nature of the construction industry, high costs (section 2.9.26) meaning affecting high cost of projects, suppliers (section 2.9.62) meaning goods and services suppliers, market demand (section 2.9.42) meaning structure of market demand, competition (section 2.9.8), tender process (section 2.9.67), society (section 2.9.57) meaning society's attitude towards innovation, social responsibility (section 2.9.55), sustainability (section 2.9.63) meaning natural and environmental sustainability conditions and changes, response to environment (section 2.9.54) meaning natural and environmental sustainability conditions and changes.

He also seemed extremely happy with the impact of Standards: Standards/Codes (industry-wide co-ordination) (section 2.9.58) on the company's innovation capabilities and the company's overall performance relating to standards, and gave this indicator a score of 5: strongly positive.

CS1-Int5, in relation to Client's understanding about their needs, desires and requirements (section 2.9.4), believes that since they are a prefabricating factory, "the clients expect them *to have this understanding"*. Regarding finances (section 2.9.23), he/she commented that since the company is an off-site manufacturer, they cannot get paid by the client *"until the house lands on site"*. This matter has been affecting the company in regard to finances, and therefore, the budget and resources. This matter could impact the potential of the company to innovate, and these indicators were found to be influential for innovation in stage one of this research. These comments further indicate the reason why CS1-Int5 has given a score of 1:strongly negative to the finances (section 2.9.23) indicator. It is understandable that the construction industry works in clusters, and that has led to the Fragmentation (section 2.9.24) of the industry. CS1-Int5 also accepts and validates this fact. He also mentions that they are aware and have attempted to *"nullify"* that. CS1 has made attempts to keep the prices down and believes that the impact of high costs (section 2.9.26) on the company not only has not been negative but has also worked in favour of CS1, as they have been able to *"keep them down"*.

CS1-Int5 continued to comment regarding the other indicators. He adds that the company has implemented systems and structures in place to figure out how to beat the market demand (section 2.9.42) and the existing competition (section 2.9.8) in the market. It seems that the Project-baseness (section 2.9.51), which represents the temporary/project-based nature of the construction projects, does not impact CS1 in any way. Therefore, the impact is neutral. This matter has been reflected in the score of 3 given by CS1-Int5 and endorsed by the indicator average of 3.6 given by the 5 respondents. The reason behind this neutral response lies in the company management plans, as CS1-Int5 indicates that CS1 has its own *"criteria"*. CS1 is also *"on top of"* the matters relating to goods and services suppliers (section 2.9.62) by implementing *"systems in place"*.

As previously mentioned, there seems to be a constructive approach in place within CS1 for the management of the impact of external factors on the company. This means that the company and its plans are not affected by the outside-company factors. This in line leads to the success of the company, its plans and in line with this, its innovations. The external factors have not only not impacted the company, but in many cases, they have worked in favour of the company and its plans. As a result, it is understood that the indicators that are mentioned under category 5 (external influences) of the innovation measurement tool have been working in favour of the innovations of CS1. Therefore, although the Business Innovation Score of CS1 is lower than CS2 (which is discussed in section 4.5), the positive impact of the external factors on this score is evident.

Through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.3.5), the respondents collectively confirmed the findings of this tool under the external

influences (section 4.3.2.5) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.4 Diagnostic Insights – Business Innovation Score for CS1

The next section of the business innovation measurement tool measures the Business Innovation Score of the company under study. This section looks more into the outputs of innovation during the observation period rather than the potential for innovation. For the aim of this matter, a number of definitions were introduced and given to the interviewees at the beginning of the interviews.

These definitions looked into defining the following: observation period, business innovation, product innovation, business process innovation, Innovation activities, innovation projects, and follow-on activities.

- "Question a" of this section defines the business innovations of CS1. This question aimed to understand the names of the business innovations of CS1. The interesting outcome was that none of the 5 respondents responded to this question. There could be numerous reasons for this outcome. It could be because of the nature of the short length of the interviews and the time allocated for each interview. Therefore, the respondents would not be too eager to answer this question. Also, it could be because the respondent might have been familiarised in the previous 5 categories of the questions with the Likert scale, box ticking method of responding and as a result, responding in a written format might not be desirable. Also, it seems like the respondent needs to investigate the company documents or enquire from other employees for the right answer to this question. Altogether, what could be sensed from these blank responses is that none of the 5 interviewees had the names of the business innovations of the company prepared or in their memory.

-"Question b" of this section of the tool, attempted to measure the products Innovation of CS1 (sections 2.10.1 to 2.10.4). This subcategory consists of 8 questions that were categorised using 5-point Likert scale. These questions can be found in Appendix 2 of this thesis. The overall score for this category, based on all the responses provided by the 5 interviewees, was 2.8. Although the higher this score, the more innovative the company is, and there are more and better innovations happening inside the company, it is still preferable not to interpret this score as a single score. This is due to the nature of questions and the different Likert scales used in this sub-category. The following table represents the summary of the responses provided by the 5 respondents.

Table 4.8: Results - b) Products Innovation for CS1

	CS1 - Int1	CS1 - Int2	CS1 - Int3	CS1 - Int4	CS1 - Int5	Indicator Average
BI 1	4	3	3	4	4	**3.6**
BI 2	3	4	4	4	4	**3.8**

BI 3	1	2	2	1	3	**1.8**
BI 4	2	3	2	5	4	**3.2**
BI 5	3	3	2	2	3	**2.6**
BI 6	3	3	2	2	3	**2.6**
BI 7	3	2	2	2	3	**2.4**
BI 8	2	1	3	3	3	**2.4**
Respondent's Average	**2.625**	**2.625**	**2.5**	**2.875**	**3.375**	
Overall Score						**2.8**

BI 1: Overall, how do you rate your company's produced "innovative goods" during the past year (section 2.10.1)?

The average response for this category sits at 3.6, indicating that the respondents believed the company's "innovative goods " during the last year were "moderate to high".

BI 2: Overall how do you rate your company's produced "innovative services" during the past year (section 2.10.1)?

The average response for this category sits at 3.8, indicating that the respondents believed the company's "innovative services " during the last year were "moderate to high" but closer to the "high" range.

BI 3: Please indicate the number of product innovations during the observation period (section 2.10.1).

The average response for this category sits at 1.8, indicating that the respondents believed the company had produced "6 to 8" innovations during the past year. Only CS1-Int5 believed that the company had produced "11 to 15" product innovations during the observation period. This could be because he, as the CEO, has information about more departments compared to other employees.

BI 4: Inside your company, what share of the total sales in the previous three years do you estimate is due to product innovations (section 2.10.2)?

The average response for this category sits at 3.2, indicating that the respondents believed 41% to 60% of the company's sales are related to product innovations that have taken place inside the company. This question is rather interesting because it was one of the few questions that the Oslo Manual (OECD/Eurostat, 2018) recommended to look at the previous three years, rather than just the observation period of one year. This in turn is due to the fact that innovations need time until they can reach the market and show their impact on the financial documents of the company.

BI 5: To what extent did your company's product innovations result in an increase in sales (section 2.10.2)?

The average response for this category sits at 2.6, indicating that the respondents believed that 21% to 40%, somewhere around the 30% mark, was the impact of the company's product

innovations on an increase in sales. It is worth mentioning again that this figure is for the observation period, while BI4 looked at the three-year increase.

BI 6: To what extent did your company's product innovations result in an increase in profits (section 2.10.3)?

The average response for this category sits at 2.6, indicating that the respondents believed that the company's product innovations accounted for an increase in the profits of 21% to 40%.

BI 7: What was your average profit margin for your company's product innovations (section 2.10.3)?

The average response for this category sits at 2.4, indicating that the respondents believed that 21% to 40% was the average profit margin for CS1's product innovations.

BI 8: What is the market share of the firm's product innovations out of all sales in the market for similar products (section 2.10.4)?

The average response for this category sits at 2.4, indicating that the respondents believed that, amongst all similar products, CS1 has been able to achieve 21% to 40% of the market share.

- "Question c" of this section of the tool attempted to measure the Innovation outcomes: Processes (section 2.10.5) of CS1. This subcategory consists of 8 questions that were categorised using 5-point Likert scale. Also, each question has a slot where the respondents could include the name of innovation(s) that they are referring to. The respondents were asked to rate their company's developments, during the past year, in relation to the following Innovation outcomes: Processes (section 2.10.5).

- BI 9: Production of goods or services
- BI 10: Distribution and logistics
- BI 11: Marketing and sales
- BI 12: Information and communication systems
- BI 13: Administration and management
- BI 14: Product and business process development.

BI 15: To what extent did your company's business process innovations result in an increase in sales (section 2.10.5)?

The average response for this category was 3.0, which indicates that the respondents believed that the business process innovations of CS1 resulted in 41% to 60% increase in sales.

BI 16: To what extent did your company's business process innovations –directly or indirectly – led to a reduction in operational cost (per unit of output / per operation) (section 2.10.6 Operational costs and process innovations)?

The average response for this category was 2.0, which indicates that the respondents believed that the business process innovations of CS1 resulted in 21% to 40% reduction in operational cost (per unit of output / per operation).

These questions can be found in Appendix 2 of this thesis. The overall score for this category, based on all the responses provided by the 5 interviewees, was 3.15. Similar to the comments mentioned above for question b, interpreting this score is not intended. The following table represents the summary of responses provided by the respondent for this sub-category.

Table 4.9: Results - c) Business Process Innovation for CS1

	CS1 - Int1	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
BI 9	3	3	3	4	4	**3.4**
BI 10	3	3	3	3	4	**3.2**
BI 11	3	3	4	3	4	**3.4**
BI 12	4	3	2	4	4	**3.4**
BI 13	4	3	2	4	3	**3.2**
BI 14	4	3	3	4	4	**3.6**
BI 15	3	3	3	2	4	**3**
BI 16	2	3	2	1	2	**2**
Respondent's Average	**3.25**	**3**	**2.75**	**3.125**	**3.625**	
Overall Score						**3.15**

- "Question d" of this section of the tool, attempted to measure the Innovation novelty and impacts assessments (section 2.10.7) of CS1. As previously indicated in chapter 2, section 2.3 and 2.4, the basic requirement for an innovation is that it must be significantly different from the firm's previous products or business processes. This subcategory consists of 3 questions that were categorised using 5-point Likert scale. Also, each question has a slot where the respondents could include the name of innovation(s) that they are referring to. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to express if they "Don't know" about any of these questions. The questions measure the rate of:

- BI 17: Novelty
- BI 18: Innovativeness
- BI 19: Economic impact

of the innovations / most important innovation of CS1 during the past year. The following table represents the summary of the responses provided by the five interviewees for this section. The overall score for this subcategory is 3.27, which indicates a "Moderate" response from the respondents.

Table 4.10: Results - D) Innovation Novelty and Impacts Assessments for CS1

	CS1 - Int1	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
BI 17	3	2	3	3	4	**3**

BI 18	3	3	4	4	4	**3.6**
BI 19	2	3	5	3	3	**3.2**
Respondent's Average	**2.67**	**2.67**	**4.00**	**3.33**	**3.67**	
Overall Score						**3.27**

- "Question e" of this section of the tool attempted to investigate the Innovation and business profiling (section 2.10.8) of CS1. As previously indicated in section 2.10.8, the innovation status of a firm is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. The respondents were asked to choose under which business profile they would place CS1 as a company. This subcategory consists of 4 boxes that the respondents had to choose from. The following table depicts the mentioned question boxes:

Table 4.11: e) Innovation and Business Profiling for CS1

An innovative firm: reports one or more innovations within the past year.	A non-innovative firm: reports no innovations within the past year.
An innovation-active firm: was engaged at some time during the past year in one or more activities to develop or implement new or improved products or business processes for an intended use.	The firm is not engaged in innovation activities and has not introduced any innovations in the observation period.

The respondents unanimously outlined that CS1 has been "An innovative firm" and "An innovation-active firm" during the past year.

- "Question f" of this section of the tool attempted to measure the Innovation Activities (section 2.10.9) of CS1. As previously indicated in section 2.10.9, Innovation activities include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm. The respondents were asked to respond to what extent during the past year has their company undertaken any of the following activities:

- BI 20: Research and experimental development (R&D) activities
- BI 21: Engineering, design and other creative work activities
- BI 22: Marketing and brand equity activities
- BI 23: Intellectual Property (IP) related activities
- BI 24: Employee training activities
- BI 25: Software development and database activities
- BI 26: Activities related to the acquisition or lease of tangible assets
- BI 27: Innovation management activities.

The responses were provided with a five-point Likert scale. The overall average for this subcategory of question was 3.05, indicating a "Moderate" response by the respondents. As

recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, this sub-section included a box slot for each question to respond whether the activity was conducted for innovation purposes. The respondents answered with a response of either Yes or No.

Table 4.12: f) Innovation Activities for CS1

	CS1 - Int1	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Average**
BI 20	2	2	3	2	4	**2.6**
BI 21	3	3	3	3	4	**3.2**
BI 22	3	3	3	3	4	**3.2**
BI 23	2	3	2	3	4	**2.8**
BI 24	2	4	1	3	3	**2.6**
BI 25	5	4	3	4	4	**4**
BI 26	4	3	3	2	5	**3.4**
BI 27	2	3	2	3	3	**2.6**
Respondent's Average	**2.88**	**3.13**	**2.50**	**2.88**	**3.88**	
Overall Score						**3.05**

- "Question g" of this section of the tool attempted to gather data on Innovation Projects (section 2.10.10) of CS1. As previously indicated in section 2.10.10, many innovation-active firms organise their innovation activities as innovation projects, defined as a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes. The respondents were first asked whether their company organises its innovation activities on a project basis. This sub-section is followed by 4 questions aiming to gather more data on the innovation projects of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to indicate if any of the questions in this sub-category is "not relevant". These questions are presented in Appendix 2 of this thesis. The following table represents the summary of the responses provided by the 5 interviewees for the questions in sub-section g:

Table 4.13: g) Data on Innovation Projects for CS1

	CS1 - Int1	CS1 - Int2	CS1 - Int3	CS1 - Int4	CS1 - Int5	Indicator Average
innovation activities on a project basis?	yes	no	no	pass	yes	
BI 28	2	3	4	3	3	**3**
BI 29	1	3	3	3	3	**2.6**
BI 30	1	1	2	2	1	**1.4**
BI 31	2	2	2	3	2	**2.2**
Respondent's Average	**1.5**	**2.25**	**2.75**	**2.75**	**2.25**	
Overall Score						**2.3**

It is interesting that there were different responses to the question asking whether inside CS1, the innovation projects are organised on a project basis. This leaves much interpretation and is definitely something to further investigate. The main reason for this might be that the employees are from different positions within the company and might not be aware of the innovation projects that are being undertaken within CS1.

BI28: the average response for the question BI28 is 3 indicating that "2 to 5" innovation projects were undertaken during the past year.

BI29: the average response for the question BI29 is 2.6 indicating that "1 to 2" innovation projects were completed during the past year.

BI30: the average response for the question BI30 is 1.4 indicating that "0" projects were ceased before completion during the past year.

BI31: the average response for the question BI31 is 2.2 indicating that "1 to 2" innovation projects were ongoing at the end of the past year.

- "Question h" of this section of the tool attempted to gather data on Follow-on Activities (section 2.10.11) of CS1. As previously indicated in section 2.10.11 of this thesis, other than innovation activities, companies can also conduct follow-on activities, but within the observation period. These follow-on activities are extremely decisive for the success or failure of an innovation, but they are not part of the definition of an innovation activity. The respondents were asked to what level CS1 pursues any of the follow-on activities for their innovation projects? This sub-section is followed by 3 questions aiming to gather more data on the Follow-on activities of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to indicate the "Description of Activity". These questions are presented in Appendix 2 of this thesis. The following table represents the summary of the responses provided by the 5 interviewees for the questions in sub-section h:

Table 4.14: h) Follow-On Activities for CS1

	CS1 - Int1	CS1 - Int2	CS1 - Int3	CS1 - Int4	CS1 - Int5	Indicator Average
BI 32	3	3	2	3	4	**3**
BI 33	3	3	1	3	3	**2.6**
BI 34	5	3	4	4	4	**4**
Respondent's Average	**3.67**	**3.00**	**2.33**	**3.33**	**3.67**	
Overall Score						**3.2**

BI 32: Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc. The average response for the question BI32 is 3, indicating that the pursuit of Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc., was "moderate" during the past year.

BI 33: Follow-on training related to the use of innovations during the past year/familiarising users with a firm's innovations. The average response for the question BI33 is 2.6, indicating that follow-on training and familiarising of the users with CS1's innovations was "low" during the past year. This indeed needs improvement as it allows for innovation, further performance of the company and leads to more benefits and further profits.

BI 34: After-sales services/maintenance/operations management/utility improvement/installation/updating/repair services/guarantee/return schemes/information services/communication, etc. The average response for the question BI34 is 4.0, indicating that the abovementioned follow-on activities were "highly" practised in CS1 during the past year.

- "Question i" of this section of the tool attempted to gather data on planned innovation activities and expenditures (section 2.10.12) of CS1. As previously indicated in section 2.10.12 of this thesis, research on planned innovation activities and expenditures highlights their importance for firm profitability and economic development. Data on planned innovation activities can also help assess the likely impact of recent changes in the innovation environment of firms. The respondents were asked to answer 4 questions on this sub-category, aiming to gather more data on the Planned innovation activities and expenditures of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to allow them to indicate that they "Don't know" the response for any of the sections. These questions are presented in Appendix 2 of this thesis.

- The respondents were first required to answer whether company CS1 plans to conduct any innovation activities during the next two years. The following table represents the summary of the responses. Interestingly, two of the respondents decided to pass on answering this question.

Table 4.15: CS1's Plans to Conduct Innovation Activities During the Next Two Years

	CS1 - Int1	CS1 - Int2	CS1 - Int3	CS1 - Int4	CS1 - Int5	Indicator Summary
Does your company plan to conduct any innovation activities during the next two years?	Yes	Yes	Pass	Pass	Yes	YES

The achieved results indicate that CS1 is planning to conduct innovation activities during the next two years.

This sub-category was followed by two questions, BI35 and BI36 (section 2.10.12), with a response slot based on a 5-point Likert scale. The following table presents the summary of the responses provided by the 5 interviewees for the two Likert scale questions in sub-section i:

Table 4.16: i) Planned Innovation Activities and Expenditures for CS1

	CS1 - Int1	CS1 - Int2	CS1 - Int3	CS1 - Int4	CS1 - Int5	Indicator Average
BI 35	Don't know	1	Pass	Pass	2	**1.5**
BI 36	Don't know	2	Pass	Pass	2	**2**
Respondent's Average	**Don't know**	**1.5**	**Pass**	**Pass**	**2**	**1.75**
Overall Score						**1.75**

BI 35: CS1's planned annual innovation expenditures during the next two years: The average response for the question BI35 is 1.5, indicating that CS1 is planning to spend $100k to $500k annually during the next two years.

BI 36: What percentage of your company's expenditures is on innovation during the next two years? The average response for the question BI35 is 2.0, indicating that CS1 is planning to invest 20% to 40% of its expenditure on innovation during the next two years.

The overall score for this subcategory is 1.75. Once again, due to the nature of the questions and due to the different Likert scales used, the overall score is not interpreted. It is only used as a basis for comparison between companies, though.

As previously stated in section 2.10.12, the final question in this sub-category, which is also the final question for this section, is as follows:

How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the

year after the reference year) (section 2.10.12)? The respondents had three choices: Rise / Stay the same / or Fall. The following table represents the summary of the responses for this question:

Table 4.17: CS1's Total Expenditure on Innovation Change During the Next Two Years

	CS1 - Int1	**CS1 - Int2**	**CS1 - Int3**	**CS1 - Int4**	**CS1 - Int5**	**Indicator Summary**
How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the year after the reference year)?	Don't know	Stay the same	Pass	Pass	Rise	**Rise**

Altogether, trying to put more weight on the response provided by CS1-Int5, who is the CEO of the company, it seems like there will be a rise in the total expenditure on innovation during the next two years compared to this year.

One of the problems CS1 is facing is also the limited amount of budget that they have, and this is a matter which definitely relates to the size of the company. The need for financial support was previously discussed in section 2.10.12 (Planned innovation activities and expenditures) of this thesis, and low resources were demonstrated to negatively affect innovations of the company. The relatively low score of CS1 for its Business Innovation Score and even Overall Score is partially affected by these low resources.

Through responding to the tool's questions, which were presented in section 4.3.4 and responding to the interview's open-ended questions (Appendix 3 – analysed in section 4.3.5), the respondents from CS1 collectively confirmed the findings of this tool under the Business Innovation Score (section 2.10) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.3.5 Analysis of the Responses from CS1 for the Interview Questions

Once the respondents had finished answering all the questions in the innovation measurement tool, including the question on the General Resources of the company and the Demographic questions, the interviewees were asked a number of open-ended questions. The questions are presented in Appendix 3 of this thesis. The questions aimed to address the aim and objectives of the thesis.

Question 1: What did you think about the tool? How did you find it?

CS1-Int1 believed the questions of the tool were easy to understand. He/she believes that it is great that the tool has found the bits and pieces.

CS1-Int2 also thinks that the tool is pretty good. He/she believes every part of the tool was understandable, especially the graph (spider diagram). He/she also believes that the tool is pretty easy and handy also has all the relevant questions and information required for the organisation. He/she also believes that the hard work done to develop this tool is evident.

CS1-Int3 believes that not all of the questions were relevant to one position in the company, and indeed, this was evident and intentional. He/she believes that she is only able to respond to questions about financial matters. This is because each employee is from a different department. CS1-Int3 believes the tool is "*pretty accurate*" and the results are too. He/she believes that the results and the spider diagrams are a good reflection of the responses provided by the respondent.

CS1-Int4 thinks that this tool could help the company and might lead to the company achieving a better score in the indicators. According to him/her, the tool could eventually lead to being more innovative and, as a result, more "*successful*".

CS1-Int5 is positive towards the tool. He believes there should be a high focus while answering the questions. He emphasises that it is important to have a good understanding of the intended perception of the question. He also agrees that reviewing the tool in a workshop mode could reduce these problems because of the higher extent of time available.

Altogether, these comments were found to be extremely useful for the research as they confirmed and validated the correctness and accuracy of the research findings from stage 1 of the research.

Question 2: Is there anything missing that you could think of?

CS1-Int1 believes that the tool was comprehensive, and it was the result of everyone's answers altogether. The tool demonstrates the "*how much we (CS1) can improve*." This means that the tool could demonstrate how CS1 can improve the innovations of the company. The tool demonstrates the areas where CS1 is lacking. As an example, he/she believes that the tool shows that the creativity (section 2.9.12) score demonstrated the need for improvement in this indicator. The tool also allows for an understanding of separate responses in a comprehensive way.

CS1-Int2 believes the tool is comprehensive, and it covers everything.

CS1-Int3 thinks there could be some construction-related questions added. He/she believes that every company and every sector is unique. Therefore, it might be a wise decision to edit the tool accordingly for specific companies. He/she adds that CS1 is a company operating under the construction sector, while due to its prefabricating nature, it has a manufacturing and production line nature to it as well. This should be noted.

CS1-Int4 and CS1-Int5 both believe the tool has covered everything and is comprehensive.

Comprehensively, the comments from these 5 respondents affirmed and validated the tool's findings as a useful and comprehensive tool for measuring innovation within the construction industry of New Zealand, which validates the findings of stage 1 of this research.

Question 3: Would diagnostic be useful? Are the results useful?

CS1-Int1 believes the results of the innovation measurement tool are accurate and can be very useful for the benefit of CS1. He/she believes diagrams are a better way of illustrating the results as they demonstrate what the reader is looking for.

CS1-Int2 believes the diagnostics, results and diagrams are very useful. He/she also thinks that some people might prefer a different type of result demonstration than spider diagram. Perhaps a bar or pie chart, etc. According to CS1-Int2, the results could be used to diagnose the areas that require improvement, especially in the technology category, training, and incentives. He/she believes the tool could help the leadership if the company move from management to more of a leader type. Training will also help to further improve the capabilities of CS1 and cover the gaps. Incentives can also help to achieve further innovation.

CS1-Int3 also thinks that diagnostics is useful. He/she believes the results could be more useful for the management level or the company level. Based on the comments given by CS1-Int3, the results are useful to understand and see the factual information from inside the company. The tool also helps to understand the areas that are required or desired to work on for further improvement. CS1-Int3 believe the results are pretty accurate, and once he/she see the results from everyone else, more information could be extracted.

CS1-Int4 thinks that the results demonstrate the gaps and capabilities in a comprehensive way. This indeed is how he/she perceives the aim of the tool is, to see the gaps and/or the strengths. Hence, to fix where the attention is required.

CS1-Int5 also supports the usefulness of the tool and says that the tool is "*100%*" beneficial. He believes the tool allows the whole company to "*focus on the right areas and understand where each staff member is placed on the same scale*". He also adds that the tool has the ability to demonstrate the different perspectives of the management, labour force and other employees. This, in turn, allows one to "*focus on the right department*". Indeed, this fact was observed throughout the analysis of the responses given by different employees to the questions of the tool. The scores were different, and the comments were also different. When CS1-Int 5 was asked whether the scores that the employees give could be different from his scores, he said: "potentially yes", which is crucial for collecting data from different sources and departments and is also in line with the Source Triangulation (section 3.7.2) approach of this research.

Together, the 5 respondents of this research confirmed and validated the findings of this research during stage 1, for diagnosing the construction companies' innovation-related indicators to find the strengths and weaknesses. They also confirmed and validated the usefulness of the results that the tool represents.

Question 4: Would it be useful for your company to use this tool?

CS1-Int1 mentioned that the tool could potentially be useful for CS1, but it is required to have a review once a year to see the gaps and strengths. Then the results could be compared with the previous years to see how the scores and other matters have changed.

CS1-Int2 also endorses that the tool can be useful for CS1 to use. He/she believes that the results demonstrate the areas that require improvement. He believes there is emphasis required, especially for the technology category indicators. He/she also believes that training is necessary, and incentives should also be in place, especially for innovations. There is a need to catch the ideas, and since the employees are from different backgrounds, this allows for the catchment of data from different backgrounds. Some of these ideas could be simply explained in "layman's *terms"*. This is because some of the employees have more technical knowledge than academic knowledge. The tool allows for the catchment of data from different perspectives, especially as a mix of practical and academic perspectives. He/she also adds that monthly meetings and/or meetings at the end of the projects could be organised to review the tool and focus on the gaps and areas that require improvement. This also allows for the gathering of lessons learned, and everyone can be involved in the discussions to facilitate a common understanding. The meetings mentioned can also lead to the minimisation and/or elimination of errors. The discussions and documents that come out of the innovation measurement tool discussion meetings become *"organisational process assets"* and are used to develop more checklists for further use.

CS1-Int3 also mentions that the tool is useful for use in CS1. He/she mentions that the basis of the tool is somehow similar to what CS1 uses to evaluate employees for employment purposes. Since the output of this innovation measurement tool is also similar to the tool used by CS1 for human resourcing, the respondent found a familiar understanding of the results. He/she also believes that the output results from the innovation measurement tool are very useful. He/she believes that the tool can be engaged quite often. For example, every three or six months. This gives an indication of the scale of innovativeness the people are at, or where the gaps are. This also allows for the capture of different perspectives from different employees. Also, if there is a comment on a particular item from different employees, it indicates that the mentioned indicator or issue requires special attention.

CS1-Int4 and CS1-Int5 also endorse the use of the innovation measurement tool. CS1-Int5 believes that the tool could be used for reviews twice a year. This would facilitate the analysis of data across the whole company. Once the gaps and areas that require attention are recognised, there is a need to develop strategies to *"improve morale, interpretation and employee input. It's like it's the Ethos. The team would use the information for their own benefit".* When asked whether CS1-Int5, as the CEO of CS1, would consider the use of any external people to conduct workshops and help with raising the score for the indicators, as an example regarding communications and knowledge management practices, he responded that "depending on the circumstances", it is something that they would like. He also agrees that by disseminating information, some employees could teach other employees.

These comments endorse and validate the usefulness of the developed innovation measurement tool for the construction companies operating in New Zealand. The 5 respondents validated the usefulness of the tool developed in stage 1 of this research.

Question 5: Are the results what you would expect? Are you surprised?

CS1-Int1 mentioned that the results are what he/she was expecting and that the results are "*accurate*".

CS1-Int2 mentioned that since CS1 is a young and growing company, he/she expected the results to be between three and four range. CS1 is currently in the process of picking itself up.

He/she believes that the overall score is "*accurate*", but in fact, the company score is lower than what is expected from it, and CS1 needs to improve.

CS1-Int3 endorses that the results are as expected and that he/she was not surprised by the results. He/she believes the tool itself was surprising and that the outcome is *"very accurate"*. He/she believes that the outcome results are relevant, and the tool results demonstrate the required information.

CS1-Int4 endorses the results and believes that they are *"right"*.

CS1-Int5 also believes the results are *"as expected"* and that, depending on the company budget, special consideration should be given to the budget allocation. This is especially important since CS1 is a growing company. He believes that the tool did represent what he was expecting from the company and that the tool is a good scale to measure the innovation of the company.

Therefore, these 5 respondents approved and validated the diagnostic capability of the developed innovation measurement tool from stage 1 of this research. This is in line with the method and source triangulation approach selected for the validation of the findings during this research.

Question 6: How would you simplify this tool?

CS1-Int1 believes the tool was comprehensive and covers everything. There might be a necessity to have sufficient information regarding the outcome of the diagnostics and data analysis. He/she believes the tool is simple enough, especially since it is in Excel format, and it was easy for him/her to understand.

CS1-Int2 believes the tool has an "*academic*" sense to it. It could include practical questions. This facilitates the collection of data on innovation from the builders. This is because CS1 needs to acquire new tools to improve; therefore, the builder's input is required. These data could be incorporated into the company's future strategy and budget. These data might not be available from the responses provided by the office-level employees. This means that project-level questions should be implemented in the tool.

CS1-Int3 believes the vocabulary of some of the questions could be amended and simplified. This allows the respondents who do not have a strong English language background to be at more ease while responding.

CS1-Int4 believes one way to simplify this tool is to have the respondents *"just work on one area at a time"*. There could also be ways to just simplify the tool and perhaps even *"generalise"* some of the categories. This might potentially lead to more focus and deeper insights from the respondents.

CS1-Int5 believes one way of simplifying is to adopt an iPad – i.e. software/website/app – to respond by just ticking the boxes. Therefore, using more digital platforms for the ease of the respondent could simplify the data collection process.

Question 7: Do you have any further feedback?

CS1-Int1 did not have any further comments, and CS1-Int2 again restated that some project-level questions could further help make the tool even better.

CS1-Int3 and CS1-Int4 did not have any further comments. CS1-Int5 liked the fact that the diagnostics were available very early in the process. As the CEO, he looks forward to hearing more about the diagnostics and the analysis of the responses, together with the board members. He thinks there is potential for further collaborations in research or implementation of the tool inside the company CS1. CS1-Int5 was very happy and satisfied to have participated, together with his colleagues, in the interviews.

This section is the end of the analysis of the responses gathered from CS1. In the next section of this chapter, the responses gathered from Case Study 2 (CS2) are discussed. Similar to what was done for CS1 as part of study 2 of this research, the data collected from CS2 were used to validate the findings from stage 1 of this research. This is in line with the source and method triangulation approach chosen for this research. These findings were further evaluated in stage 3 of this research through interviews with construction industry experts (CIEs) as the last stage of the 3-stage triangulation data validation strategy of this research.

4.4 Testing the tool on Case Study 2

In Case Study 2, the innovation measurement tool was tested following a semi-structured interview process similar to Case Study 1. Participants reviewed the information sheet and provided their consent before evaluating their company by using the tool, which assessed five categories of innovation potential and one category for actual innovation. The tool, presented on A2 sheets, allowed respondents to evaluate their organisation. The results were immediately visualised through spider diagrams using an Excel template. These visual outputs were then discussed with the participants to identify trends and compare innovation potential with actual performance. Additional demographic and general resource data were also collected to help with and support the analysis. The interviews concluded with open-ended questions (presented in Appendix 3) to gather feedback on improving the tool. This process has been presented in more detail in section 4.2 of this research. What follows is the details of the mentioned process.

4.5 Study Case 2

Study case 2 is a large-scale company which was founded in 2013. They have offices in Auckland, Christchurch, Hamilton and Queenstown. Their business is backed by solid governance. Study case 2 looks to build proactive partnerships with its clients and to deliver outstanding buildings for the communities. Study case 2, which is referred to as CS2, operates under both the public and the private sector. CS2 is mainly involved in the commercial sector but also has projects under the residential, educational, clinical, community projects, industrial and fit-out sectors as well.

CS2 has more than 50 employees and is considered to be a large company. This study case has a turnover of $100 million to $1 billion annually and owns $10 million to $100 million of assets. The company was established 5 to 10 years ago. They are using a profit margin of less than %20. CS2 has an equity ratio (debt vs equity) of less than %20. The company runs as a standalone ownership – is not part of an organisation – and operates on domestic projects. The company is fully owned by NZ nationals. CS2 addresses customers and clients in the governmental sector (Business to Government) and is not publicly listed on the stock exchange. CS2 operates with the governmental sector on national and regional levels. This company uses internal resources (vs. debt, mixed, financial transfers, etc.) for the innovation activities of the company. % 25% of the company's employees have tertiary education, and these educations are % 100% job-specific. The average tenure of the employees in their positions is 4 to 6 years. These data were obtained from the responses provided by CS2-Int4, who operates as the CEO of CS2.

4.5.1 Case Study 2 – Demographics

During CS2, similar to CS1, five separate semi-structured interviews were conducted. For the purpose of this publication, the respondents are coded as CS2-Int1 to CS2-Int5. The demographic information of the respondents is presented as follows:

Table 4.18: Demographic Information of the Interview Cases for the Study Case 2

Interviewee / Question	**CS2-Int5**	**CS2-Int2**	**CS2-Int3**	**CS2-Int4**	**CS2-Int5**
Role	Contracting	Commercial Manager for North Island	Contracting	Owner/Client	Contracting
Sector History	Public Sector	Public Sector	Public Sector	Private Sector	Private Sector
Type of Construction	Residential	Commercial	Commercial	Commercial	Commercial
Profession	Engineer	Quantity Surveyor	Digital Innovation	Engineer	Quantity Surveyor
Designation	Reginal Manager	Reginal Leadership	Engineering Manager	CEO	Commercial Business Manager
Highest Academic Qualification	BE Civil (Hons) MBA	Bachelor of Science	Master of Science Level 8	H3 certificate in Engineering and	Master of Science

				The school of life	
Professional Qualification or Membership	Engineering New Zealand	A-CIARB RICS	Building Institute Aotearoa (formerly NZIOB)	No	No
Years of Experience	16 – 20	16 – 20	6 – 10	40	16 – 20
Years of Management	11 - 15	6 - 10	0 - 5	16 – 20	6 - 10
Age Range	40 to 49	30 to 39	30 to 39	50 to 59	40 to 49

During CS2, 5 people were interviewed altogether. The respondents had roles in different departments of the company. All five people were from the management team, while one person was the CEO of the company. Three respondents had a history of mainly working in the public sector, while two respondents had experience working mainly in the private sector. The respondent's highest academic qualification was between an H3 certificate in Engineering and a Master of Science. Two of the respondents had no professional qualification or memberships, while from the three other respondents one had professional qualifications and memberships in Engineering New Zealand, another in A-CIARB (Chartered Institute of Arbitrators) and Royal Institution of Chartered Surveyors (RICS) and the last respondent in Building Institute Aotearoa (formerly the NZ Institute of Building – NZIOB). Three of the respondents ticked the 16 to 20 years of experience box, one respondent ticked the 6 to 10 years of experience box, while the CEO of the company has 40 years of experience in the construction industry; therefore, the average was 20.4 years. The managerial experience of the respondents ranged from zero to 5 years, up to 16 to 20 years of experience; therefore, the average was 9.9 years. Eventually, the average age of the respondents was 42.5 years.

As mentioned before, interviewee 5 was the CEO and board member of the company, and due to his high role in the organisational structure, CS2-Int4 was highly informed regarding the in-depth information required for the interview. CS2-Int4 was also the gatekeeper to the company and had been connected through one of the lecturers at Massey University, who endorsed this case study.

4.5.2 Case Study 2 – Innovation Potential Questionnaire

Based on the interview protocol that was planned (explained in section 4.2), CS2-Int1 to CS2-Int5 were given the questionnaire tool to fill out before the qualitative interview questions were asked. What follows are the responses that CS2 respondents have provided.

As previously discussed in section 4.2, the respondents were first given a chance to review the interview information sheet. Later, they were introduced to the definitions and expressions that

are used throughout the innovation measurement tool. This is required to achieve a common understanding regarding the terminology used in the tool.

4.5.2.1 Innovation Potential - Workforce Skills and HR Management

Following this section, the first of five pages was given to the respondents. This page consists of 5-point Likert scale questions regarding the "Workforce Skills and HR Management" of the company under study. The respondents were asked to demonstrate "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS2 for questions on Workforce Skills and HR Management.

Table 4.19: Results - Workforce Skills and HR Management for CS2

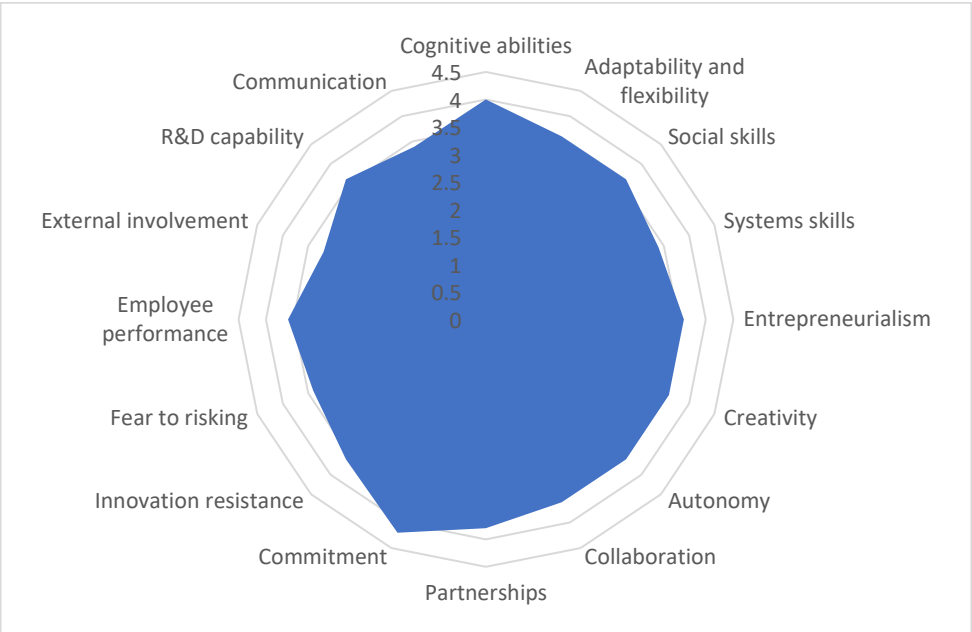
	Indicator	**CS2 - Int1**	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
WF&HR 1	Cognitive abilities	4	4	4	4	4	**4**
WF&HR 2	Adaptability and flexibility	4	3	4	3	4	**3.6**
WF&HR 3	Social skills	4	4	3	3	4	**3.6**
WF&HR 4	Systems skills	2	3	4	4	4	**3.4**
WF&HR 5	Entrepreneurialism	3	4	3	5	3	**3.6**
WF&HR 6	Creativity	3	4	4	4	3	**3.6**
WF&HR 7	Autonomy	4	3	3	4	4	**3.6**
WF&HR 8	Collaboration	4	3	4	3	4	**3.6**
WF&HR 9	Partnerships	4	4	3	4	4	**3.8**
WF&HR 10	Commitment	4	4	4	4	5	**4.2**
WF&HR 11	Innovation resistance *	5	3	4	3	3	**3.6**
WF&HR 12	Fear of risking *	4	3	4	3	3	**3.4**
WF&HR 13	Employee performance	4	3	4	3	4	**3.6**

WF&HR 15	External involvement	3	4	3	3	3	**3.2**
WF&HR 16	R&D capability	4	4	4	2	4	**3.6**
WF&HR 17	Communication	3	3	4	3	4	**3.4**
Respondent's Average		**3.69**	**3.50**	**3.69**	**3.44**	**3.75**	
Overall Score							**3.6**
* Reversed to account for the indicator question's wording error							

The overall average score for the company's Workforce Skills and HR Management is 3.6. The respondents gave an above-average score for the indicators in this category. The respondents seem to be exceptionally happy with the company's "Cognitive abilities" and "Commitment ", while they believe there is room for improvement in the level of "Systems skills", "Fear of risking", "External involvement" and "Communication". The average score for each indicator individually and for the response of each respondent is presented in Table 4.19.

While reviewing the responses, it was understood that two indicator questions needed rewording. Because WF&HR 11 and WF&HR 12 had been written in a negative format, the results would require to be reversed in the Likert scale. To avoid this in future research, the wording was amended in the final tool. To avoid this in future research, the wording was amended in the final tool. This achievement was one of the benefits of triangulation, as it allowed feedback from multiple sources and strengthened the results of the findings. The figure below is a Radar (Spider) Diagram depicting the indicator averages for Workforce Skills and HR Management:

Figure 4.6: Workforce Skills and HR Management for CS2



4.5.2.2 Innovation Potential: Organisational Structure

The second set of questions regarding the company's potential to innovate concentrates on the "Organisational Structure" of the organisation. The respondents were asked to demonstrate: "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS2 for the question on Organisational Structure.

Table 4.20: Results - Organisational Structure for CS2

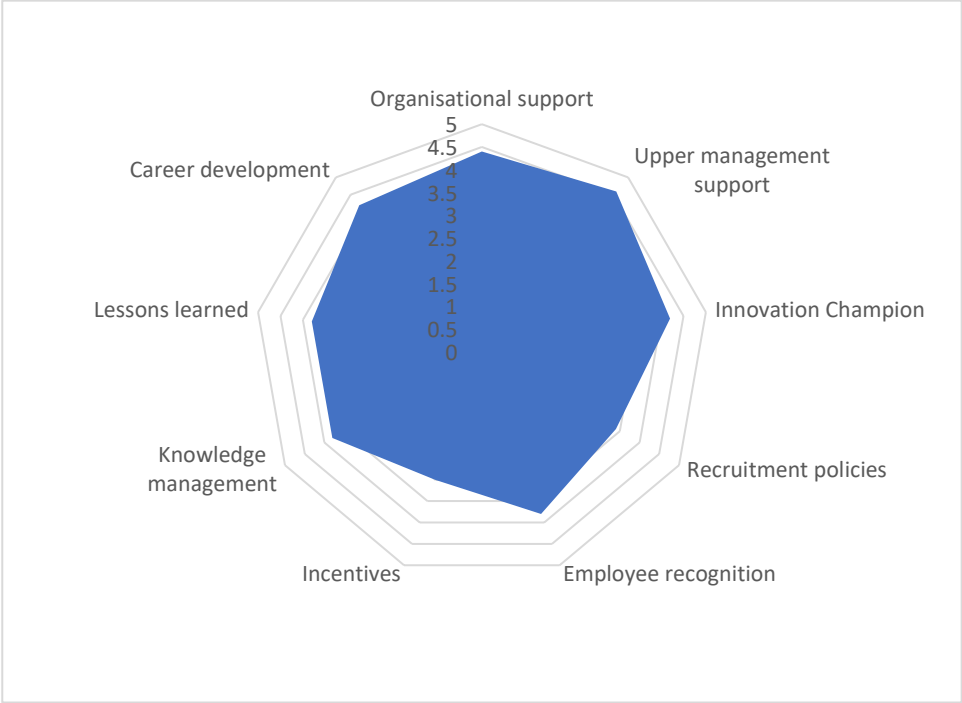
	Indicator	**CS2 - Int1**	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
Org 1	Organisational support	5	4	4	4	5	**4.4**
Org 2	Upper management support	5	4	5	4	5	**4.6**
Org 3	Innovation Champion	5	3	4	4	5	**4.2**
Org 4	Recruitment policies	3	3	3	3	5	**3.4**
Org 5	Employee recognition	3	4	4	3	5	**3.8**
Org 6	Incentives	2	3	3	3	4	**3**
Org 7	Knowledge management	4	3	3	5	4	**3.8**
Org 8	Lessons learned	3	4	4	4	4	**3.8**
Org 9	Career development	5	4	4	4	4	**4.2**
Respondent's Average		**3.89**	**3.56**	**3.56**	**3.78**	**4.56**	
Overall Score							**3.91**

Based on the results obtained from the respondents, CS2 obtained a high score for the "upper management and decision makers' support" for innovations and for "Organisational support". This is while the company needs to invest more in the "Recruitment policies" as Employee recruitment policies that seek creative skills for innovativeness. Also, there is a need for further improvement in the score for the indicator measuring "Incentives" of the company. It seems

like there is a higher need for focus on incentives for employee performance in suggesting ideas for innovation or in developing innovations. Similar to the responses that were given at CS1, interestingly, the respondents had different opinions on the item relating to incentives. Therefore, this matter needs to be addressed and diagnosed. Again, there may be different reasons for this, relating to different departments, perceptions and expectations about incentives, or it might be a matter of information on incentives not properly shared amongst employees.

The average score for each indicator individually and for the response of each respondent is presented in Table 4.20. The overall score for the company CS2, in relation to its Organisational Structure, is 3.91. The figure below is a Radar (Spider) Diagram depicting the indicator averages for organisational Structure:

Figure 4.7: Organisational Structure for CS2



4.5.2.3 Innovation Potential: Business Strategy

The third set of questions regarding the company's potential to innovate concentrates on the "business Strategy" of the organisation. The respondents were asked to demonstrate: "To what extent do you find the following traits present within your organisation?". The following table demonstrates the results obtained from the 5 respondents in CS2 for the question on Business Strategy of the organisation.

Table 4.21: Results - Business Strategy for CS2

	Indicator	**CS2 - Int1**	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BS 1	Strategic Plan	5	4	4	5	5	**4.6**
BS 2	Strategy communication	5	4	4	5	5	**4.6**
BS 3	Progress monitoring	5	3	3	5	4	**4**
BS 4	Innovation Strategy	5	4	3	4	4	**4**
BS 5	Finish price focus	3	3	4	3	3	**3.2**
BS 6	Quality focus	4	4	4	3	3	**3.6**
BS 7	Multiple market focus	3	3	3	4	3	**3.2**
BS 8	In-house sourcing	5	4	3	4	4	**4**
BS 9	Lifecycle focus	4	3	4	4	3	**3.6**
Respondent's Average		**4.33**	**3.56**	**3.56**	**4.11**	**3.78**	
Overall Score							**3.87**

In relation to the company's Innovation business strategy, the respondents showed a relatively higher satisfaction with the company's "Strategic plan" and "Strategy communication". The respondents also demonstrated less satisfaction towards the company's "Finish price focus" and "Multiple market focus" at the same time. The average score for each indicator individually and for the response of each respondent is presented in Table 4.21. The overall score for the company CS2, in relation to its business strategy, is 3.87. Below figure is a Radar (Spider) Diagram depicting the indicator averages for Business Strategy:

Figure 4.8: Business Strategy for CS2

4.5.2.4 Innovation Potential: Technology

The main objective of the fourth set of questions was to find information about the Technology of the firm. The interviewees were given questions asking, "To what extent were the following factors present in their organisational interactions?" The following table represents the results obtained for this set of questions from the five interviewed employees at CS2.

Table 4.22: Results – Technology for CS2

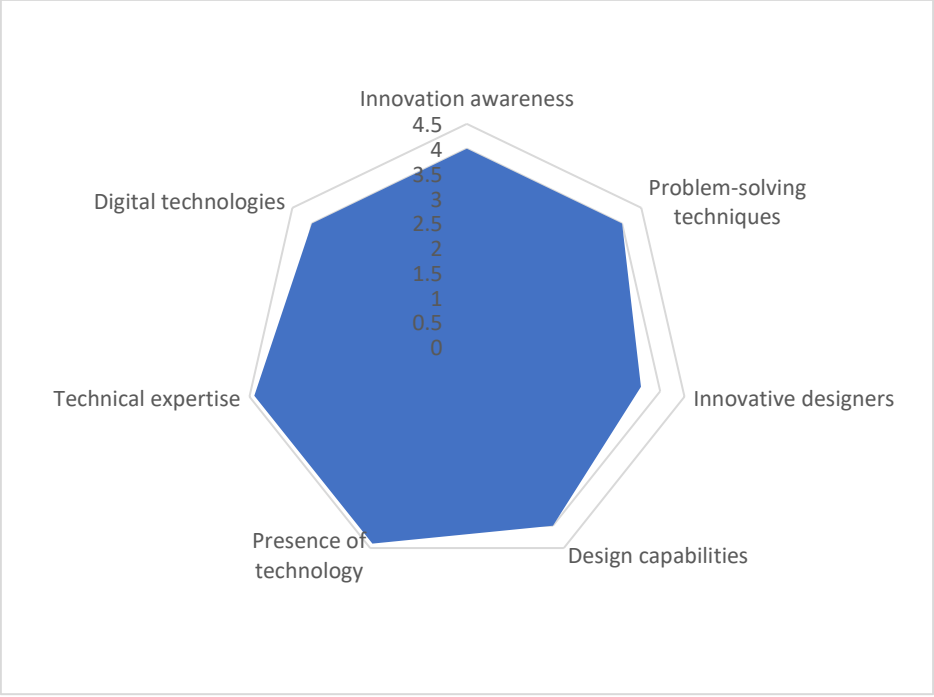
	Indicator	**CS2 - Int1**	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
Tech 1	Innovation awareness	4	3	3	5	5	**4**
Tech 2	Problem-solving techniques	4	4	4	4	4	**4**
Tech 3	Innovative designers	4	4	3	4	3	**3.6**
Tech 4	Design capabilities	5	4	4	3	4	**4**
Tech 5	Presence of technology	5	4	4	4	5	**4.4**
Tech 6	Technical expertise	5	4	4	4	5	**4.4**

Tech 7	Digital technologies	5	3	4	4	4	**4**
Respondent's Average		**4.57**	**3.71**	**3.71**	**4.00**	**4.29**	
Overall Score							**4.06**

The overall score obtained for this category was the highest score (4.06) amongst the five sets of questions for the innovation potential. Since the developed Likert scale, rated the impact score on a 5-point scale ranging from 1 for very low, 2 for low, 3 for average, 4 for high and 5 for very high, a 4.06 overall score indicates that CS2 has had a "high-very high" impact from technology on their innovations.

The lowest score obtained in this section was a 3 out of 5 (average), which indicates that there are no negative impacts from technology on the company CS2's innovation. The lowest indicator average for this section was for "innovative designers" (3.6), which measures the designer's understanding of innovations. The term designers describes architects, structural, mechanical and electrical engineers. The figure below is a Radar (Spider) Diagram depicting the indicator averages for technology:

Figure 4.9: Technology for CS2



4.5.2.5 Innovation Potential: External Influences

The fifth and last page on the measurement tool was to find the potential of the company to innovate under the influence of the external factors. The respondents were asked to score, "To

what extent and how did each of the items/indicators contribute to innovation within their company?" The table presented below represents the results obtained for the fifth set of questions.

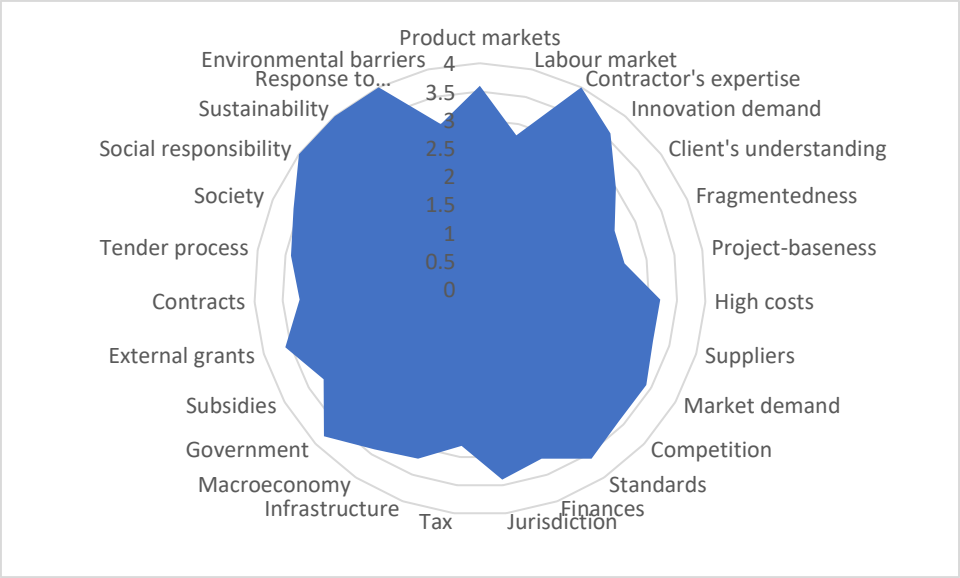
Table 4.23: Results - External Influences for CS2

	Indicator	**CS2 - Int1**	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
Ext 1	Product markets	3	4	4	4	3	**3.6**
Ext 2	Labour market	3	2	3	2	4	**2.8**
Ext 3	Contractor's expertise	3	4	5	4	4	**4**
Ext 4	Innovation demand	4	2	5	4	3	**3.6**
Ext 5	Client's understanding	4	2	4	2	3	**3**
Ext 6	Fragmentation	3	4	2	2	2	**2.6**
Ext 7	Project-baseness	3	4	2	2	2	**2.6**
Ext 8	High costs	3	4	3	4	2	**3.2**
Ext 9	Suppliers	3	3	4	4	2	**3.2**
Ext 10	Market demand	5	3	4	2	3	**3.4**
Ext 11	Competition	3	4	3	4	3	**3.4**
Ext 12	Standards	4	3	4	4	3	**3.6**
Ext 13	Finances	3	3	3	4	3	**3.2**
Ext 14	Jurisdiction	3	3	4	4	3	**3.4**
Ext 15	Tax	3	3	3	2	3	**2.8**
Ext 16	Infrastructure	3	3	3	4	3	**3.2**
Ext 17	Macroeconomy	3	4	3	5	2	**3.4**
Ext 18	Government	3	3	5	4	4	**3.8**
Ext 19	Subsidies	3	3	4	3	3	**3.2**
Ext 20	External grants	3	4	4	4	3	**3.6**

Ext 21	Contracts	3	3	2	4	4	**3.2**
Ext 22	Tender process	3	4	3	4	3	**3.4**
Ext 23	Society	4	4	4	2	4	**3.6**
Ext 24	Social responsibility	3	4	4	5	4	**4**
Ext 25	Sustainability	3	4	4	5	4	**4**
Ext 26	Response to Environment	3	4	4	5	4	**4**
Ext 27	Environmental barriers	3	3	3	3	3	**3**
Respondent's Average		**3.22**	**3.37**	**3.56**	**3.56**	**3.11**	
Overall Score							**3.36**

Overall, the responses seem to be lower in this category compared to other sets of questions for the innovation potential of the company. This is reflected in the overall score for this category, which is 3.36. Since the developed Likert scale, rated the impact score on a 5-point scale ranging from 1 for strongly negative, 2 for negative, 3 for neutral, 4 for positive and 5 for strongly positive, a score of 3.36 for the overall score indicates that CS2 has had a “neutral-positive” impact from external factors on their innovations. The respondents gave a relatively low score for a number of questions addressing “Labour market”, “Client's understanding”, “Fragmentation”, “Project-baseness” and “Environmental barriers”. In this sense, this matter needs to be diagnosed, and attempts to increase this score must be made. The respondents also gave an average score to the impact of “High costs”, “Suppliers”, “Finances”, “Infrastructure”, "Subsidies”, and “Contracts”. It is understood that these indicators also required to be improved. There is a need to investigate the root causes of these negative “external influences” on the innovative capability of CS2. These impacts could be managed appropriately. Evidently, not addressing these low scores is negatively affecting the innovation potential of CS2. The figure below is a Radar (Spider) Diagram depicting the indicator averages for external influences:

Figure 4.10: External Influences for CS2



4.5.3 Case Study 2 – In-depth analysis of the Innovation Potential Score of the Company – Root Cause Diagnostics

Case Study 2 involved an in-depth analysis of the company's innovation potential score through root cause diagnostics. This study was conducted using both quantitative and qualitative methods. The company's innovation potential was assessed by using a questionnaire, with scores on a 5-point scale and analysed descriptively and thematically at both the individual and comprehensive levels. Additionally, indicator averages helped to smooth out departmental bias, while each respondent's category score and each category's overall score highlighted strengths and weaknesses across the five innovation potential categories of the measurement tool developed in stage 1 of the research. Interviews conducted during the questionnaire process captured real-time insights, including the respondents' comments and queries, which further enriched the tool's development and the understanding of the company's innovation context. These interviews were followed by open-ended questions (presented in Appendix 3), and all audio data were transcribed in detail, manually verified multiple times, and analysed using NVivo 12 Pro to extract meaningful themes which are aligned with the thesis objectives. This process was explained in more detail in section 4.3.3.

The findings in this second stage of the research were in line with and part of the three-stage triangulation framework adopted for this research. This framework provided strength and validated the findings of the research.

What follows is an insight into the analysis of the communications that happened during the five interviews with five employees inside CS2.

4.5.3.1 Diagnostic Insights - Workforce Skills and HR Management

In regard to Workforce Skills and HR Management for CS2, the overall score of 3.6 indicates positivity from the employees of CS2 towards the performance of the company on the

indicators of this category. CS2-Int4, as the CEO of the company, is quite positive on the potential of the company around these indicators. As an example, he believes that *"internal communication"* is hugely focused on. The average score for this indicator (section 2.9.7 communication) is 3.4. This is because three of the other respondents gave an average score of 3 for this indicator.

In regard to entrepreneurialism (section 2.9.17), CS2-Int5 believes that the company has employees who are *"very entrepreneurial"* compared to other employees who just go ahead with business as usual, but are open to change. He also believes that *"younger generation are more eager to pick work up quicker and develop it"*. The average score of this indicator is 3.6.

Regarding the indicator measuring innovation non-resistance (section 2.9.33), which gained the average score of 3.6, CS2-Int5 believes that the employees are *"quite innovative"*, but there is a need to address *"innovation uptake*. *The employees who work on the construction site mainly follow instructions and have their minds set on just finishing the tasks."* This matter indicates the need for a strong *"change management"*. This does not mean that there is resistance towards innovation from these workers; rather, it is a matter of innovation uptake. This matter is mainly with the older workers, as younger workers are better at innovation uptake. This understanding, in turn, highlights the need for *"continual improvement"* or, in other words, career development (section 2.9.3), such as training, skills and career development opportunities. The average score for the career development indicator of this tool is 4.2, which indicates that CS2 is "very highly" focused on this factor.

The other indicator that received special focus during the interview was "not fearing from risking" (section 2.9.44). CS2-Int5 emphasises that *"innovation comes by fear. The fear of change, fear of the outcome and fear of the potential downside".* This indicator received an average of 3.4 for the available potential of the company on this indicator.

Through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.5.5), the respondents collectively confirmed the findings of this tool under the workforce skills and HR management (section 4.5.2.1) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.5.3.2 Diagnostic Insights - Organisational Structure

Similar to the interview protocol used for interviewing CS1 cases, the respondents of CS2 were next shown 9 questions on indicators which measure the organisational structure of the company. These indicators and the scores given by the respondents of CS2 have previously been presented in section 4.5.2.2. The overall score for this category is 3.91, which is a good score and very close to the "High" range. The scores are relatively evenly distributed, but there seems to be a negative view towards the available incentives (section 2.9.28) for innovation in the company.

The respondents presented their responses, which depicted the potential of the company to innovate based on the organisational structure indicators. While they were responding, they also indicated a number of issues, which are presented below.

According to CS2-Int4, career development (section 2.9.3) is highly focused within the company. Also, the average score for this indicator is 4.2. He mentioned that the company often

does a great deal of off-site training with the staff. This training includes all the employees, including the management. For example, the company invited Eric Murray, an Olympic rower, to give a speech to the employees. CS2 has also invited New Zealand Special Air Service personnel to present a speech on leadership, innovation, field thinking and the ability to be agile. He also believes that, in regard to training, it is important to work within a framework.

When CS2-Int4, as the CEO of CS2, was asked what would be the best approach for the company to cover the flaws, he responded: *"Since some of the employees are quite young, and the young generation is usually sitting behind a computer".* This is while the construction industry requires a lot of field work. Therefore, many young employees avoid going into the field or may not understand the nature of field work. This matter requires special attention from the managers to deal with *"constructive conflict"*. One of the approaches that CS2 has taken to deal with this matter is to have *"training focused on constructive conflict to approach employees and get them to do tasks".*

CS2 also values the history and culture of NZ. They invited a number of people from the Māori community and engaged them in the training program for the employees. CS2-Int4 added: *"We're going to bring in some people who will give us some training and education around Māori. What does that mean for the history of NZ? And it's important when we're dealing with Otunui and Ōtāhuhu."*

Also, on the topic of training (section 2.9.3) on sustainability (section 2.9.63), CS2 has some training around what is being implemented inside the company. At CS2, the system supports the policy. There is a team at CS2 that writes the procedures. Also, there are competency checks within the company to make sure that the employees understand the procedure (section 2.9.59 and section 2.9.60). CS2 has also been working with the Ara Polytechnic Institute to get a course certified where the employees enter CS2 after high school, and while they are at CS2, with the training and experience that they gain, they receive a diploma.

Regarding the incentives (section 2.9.28) indicator, which gained an average of only 3 and has the lowest average in this category, similar to CS1, there was a discrepancy between the responses of the employees. There was a 2, three 3's and a 4. This matter needs a deep investigation into the possible reasons. Again, it could be a matter of perception or a matter of lack of awareness of the available incentives, or even a difference in the incentives offered for different departments.

Regarding upper management support (section 2.9.68) for innovation, it was noted that in the CS2 organisational chart, as innovation is focused on, electronic data interchange is also focused on. This is an indicator of the presence of technology (section 2.9.47) inside CS2. A leadership team (section 2.9.68), which works alongside the construction arms for innovation, engineering, and design-related work, is also engaged. CS2-Int4 *"Highly"* emphasised the importance and impact of leadership (section 2.9.68) on the organisational culture of the company. When asked about the extent of this impact, he added: *"significantly"*. This indicator received the highest score for the indicator average (4.6), which shows that the employees *"Very Highly"* find upper management support present within the CS2's organisation.

It must be again mentioned that through responding to the interview's open-ended questions (Appendix 3, analysed in section 4.5.5), the respondents collectively confirmed the findings of this tool under the organisational structure (section 4.5.2.2) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.5.3.3 Diagnostic Insights - Business Strategy

The third category of the indicators in the innovation measurement tool consisted of a set of questions addressing the Business Strategy of the company. As previously indicated in section 4.5.2.3, the average score for this category was 3.87, which indicates that the respondents rated the business strategy of the company to be "strong" and even close to the "very strong" category. What follows are the discussions and comments from the respondents of CS2 on the 9 indicators of this category.

CS2-Int3 mentioned that the company does have a strategic plan (section 2.9.59), which has both top-down and bottom-up approaches. However, he believes that *"in terms of implementation of business strategy (strategic plan), or the cleanliness of the business strategy (strategic plan), it is not up to level yet."* He believes that *"since there is the need to focus on the forecasts, and on the plan for the next 3 to five years, or even 10 years, although being hard to predict, it is only possible to get an indication of the people inside the company, and still there is no clear mindset of where the company is heading"*. He also indicates that the company's strategy is still incomplete.

According to CS2-Int4, the company's business plan is issued to all of the employees on the *"Jostle",* which is a cloud-based intranet software: *"The CEO and the executive team go on a roadshow and sit down with every single employee in the business and take them through the business plan page by page by line. So, every single employee, 150 employees know exactly what they need to do in order to achieve their goals for their reward in the award of the business"*. This matter indeed allows the employees to add synergy to the company's plans and reflects CS2's focus on the communication of the strategy (section 2.9.60) to the employees. The mentioned business plan filters down into the company policies, then filters down into procedures, then falls down into measurables that are put into each individual contract, on the projects, systems, procedures, etc. Therefore, *"everything links through to the business plan"*.

The strategic plan (section 2.9.59) of CS2 also addresses career development (section 2.9.3) through targeting internal competencies. This is done in collaboration with the Ara Polytechnic Institute at Christchurch. Ara certifies the competency procedures. The aim is to use these competency certificates for a level 6 graduate diploma in construction management. The company is also working with Massey University to source cadets from Massey. The aim is to allow the students, at the end of a 4-year plan, to understand *"not just the academic side of things, but the realities of working in a construction company and what that means, including innovation"*. CS2-Int4 added that innovation covers a wide range of matters, *"not just limited to drone deployment and digital twins"*. Innovation also includes commercial contracts, the mental state of the employees, the process of dealing with the customer and the public. Innovation also includes people's wellness, diversity, and social procurement. Since CS2 is looking for incremental improvements, CS2-Int4 believes that innovation should be right through the business and everything we do: *"you only have to win a race by points of seconds"*.

In line with the finish price focus (section 2.9.21), according to CS2-Int3, since *"the weights of the price might be different in different projects"*, it could not be concluded that CS2 has a business strategy that has a focus on the finish price. The indicator average was 3.2 based on the provided responses, which also supports this comment.

Regarding the indicator lifecycle focus (section 2.9.40), which received the average score of 3.6, CS2-Int5 expressed that many of the material that are used in the projects is *"determined by the client"*. Therefore, from an innovation perspective, there needs to be an emphasis on the *"benefit of investment on the lifecycle versus return"*. He goes on to give an example of the

solar panels as a false economy, where it is not going to *"get you what you pay"*. He believes the company could further improve on this category, and this could be done through monitoring and documenting the developments as the products are in use. This allows the comparison of the actual outcome versus the expected outcome. The achieved documentation results could be used as a basis for future plans and are in line with the indicator addressing lessons learned (section 2.9.39).

Through responding to the interview's open-ended questions (Appendix 3), the respondents collectively confirmed the findings of this tool under the business strategy (section 4.5.2.3) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.5.3.4 Diagnostic Insights - Technology

Following the same interview protocol adopted for CS1, the fourth category of questions in the business innovation measurement tool was aimed at the Technology (section 4.5.2.4) of the company. This category consists of 7 questions. The overall average score for this category, based on the responses provided by the respondents, is 4.06 and is the highest overall average amongst the 5 categories. There were many 5s awarded in this category, and the lowest marks were as high as 3. This indicates that the respondents were happy about the level of technological attributes present at the company. During stage 1 of this research, these indicators were found to be influential for the innovation of the company, and these high scores indeed have a huge impact on the potential of CS2 to innovate.

What follows are the results of an in-depth thematic analysis of the communications that were discussed during the interviews of the respondents from CS2 and on the technology category's indicators.

CS2-Int2 believes that they are particularly focused on technology. They *"have got specific people who may not be revenue generating but employed for the purpose of driving Technology (section 2.9.31)"*. CS2-Int2 sees them as overhead costs and long-term investments. He believes this investment results in innovation. He adds that the *"time and the investment we've put into it is definitely above and beyond all the businesses I've come across, and it's going to pay dividends in the near future (section 2.9.68)."* This investment allows CS2 to stay *"ahead of the curve"* while many of the innovative technologies have not been implemented yet.

CS2-Int4 adds that technology is quite high in CS2. There are 3 employees who are directly engaged with technology-related matters in CS2 (section 2.9.31). These employees travel around New Zealand to implement innovation in CS2 together with *"Trimble"* software. Based on the interview responses, some of the technologies that have been adopted in the CS2 projects are: digital twinning, prefabricated vertical risers, prefabricated horizontal risers, prefabricated lift shafts, prefabricated internal walls, prefabricated deflection heads, etc. In one project in Christchurch, 150 tons of panels were precast, 12 of them onsite, and they were stood up using the traditional tilt-up method. This method of precasting saved 3 months on a program. In a different project in Auckland, a unique design was incorporated to conserve resources.

CS2-Int4 also added that external parties are involved in delivering innovation and construction technology in the company (section 2.9.20). He added that CS2 is not mapping technology and

is not capturing the data (section 2.9.39). He added that this matter is annoying him. He goes on to mention that they have not realised how they can commercialise what they are doing in the construction technology space (sections 2.10.2 to 2.10.6). So, one of the things that is being done is engaging external parties to come in and help with this matter (section 2.9.20). It is expected that they will write assessments about the current situation within the company and an assessment of *"what the market can sustain"* (section 2.9.42). This is because the market needs an increase in knowledge around what can be done with construction technology. CS2 plans to embed sensors inside one of its innovative construction projects within Auckland. Through these sensors, air quality will be measured, energy usage will be monitored, and asset management will be registered. This allows for documenting how the building is functioning (section 2.9.39) and adopts a lifecycle perspective into focus (section 2.9.40).

It must be again mentioned that through responding to the interview's open-ended questions (Appendix 3), the respondents collectively confirmed the findings of this tool under the technology (section 4.5.2.4) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.5.3.5 Diagnostic Insights - External Influences

Similar to the first case study on CS1, the fifth and last category of the questions relating to the innovation potential of the company, in the innovation measurement tool, measures the impact of the External Influences (section 4.5.2.5) on the innovation potential of the construction companies. This category consists of 27 indicators measured on a 5-point Likert scale. The overall average for this section is 3.36, which is the lowest score amongst the scores. The average of 3.36 means that the impact of this category on the innovation of CS2 has been Neutral-Positive. These indicators were previously, in stage 1 of this research, found to be influential for the innovations of construction companies.

What follows is an insight into the topics discussed during the filling in of the fifth category of the questionnaire within the business innovation measurement tool. The below mentioned are comprehended and analysed through an in-depth thematic analysis.

According to CS2-Int4, the New Zealand construction industry is *"on its knees and in a very, very bad state. The costs are very expensive (section 2.9.26), the developments are very slow, and the industry is very poor. There is a lot of border for the work. There is no authority (section 2.9.25) to comprehend and put the industry together. There is a lot of talk but little action in the industry. There is little investment (sections 2.10.8, 2.10.9, 2.10.10 and 2.10.12) in research and development (section 2.9.53) and the businesses are very small".* CS2-Int4 also predicts that it is only going to get worse in the Auckland Market (sections 2.9.38, 2.9.42 and 2.9.49) over the next 5 to 7 years: *"it is going to be diabolical, to tell the truth".*

According to CS2-Int4, who is the CEO of CS2, for instance, every school in New Zealand needs more classrooms and more teaching space. It takes two years to build a classroom from concept to actual construction. There is also a need to take into account the demographics and the movement of people from regions to understand the needs. The school building process includes research studies, funding process, concept designs, master planning, market justification, actual design, build and delivery. This process is very slow and takes a lot of time,

and impacts the companies and the industry. In this sense, CS2-Int4 believes that innovative *"modular classrooms"* could solve the problem. He added that: *"I just personally cannot understand why we do not make modular classrooms and put them on the back of a truck and put them anywhere in New Zealand."* This allows quick changes to the schools based on changing needs as a result of *"changes in the demographics"*. This process is also applicable to the *"social and affordable housing projects"*.

This is while some of the external factors not only have not impacted the company, but they have also worked in favour of the company and its plans. As a result, it is understood that some of the indicators that are mentioned under category 5 of the innovation measurement tool have been working in favour of the innovations of CS2.

Through responding to the interview's open-ended questions (Appendix 3), the respondents collectively confirmed the findings of this tool under the external influences (section 4.5.2.5) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and literature review in stage 1 and literature review in stage 1.

4.5.4 Diagnostic Insights - Business Innovation Score for CS2

Similar to the interview protocol used for Case Study 1, the next section of the innovation measurement tool, as indicated in Chapter 2 of this thesis, measures the Business Innovation Score of CS2. This section looks more into the outputs of innovation during the observation period rather than the potential for innovation. The analysis of the responses is as follows:

- "Question a" of this section defines the business innovations of CS2. This question aimed to understand the names of the business innovations of CS2. The interesting outcome was that 4 of the 5 respondents did not respond to this question. This matter happened during CS1 as well. The same reasons that were given as possible causes of not responding to this question are relevant to CS2 as well. As previously mentioned, there could be numerous reasons for this outcome. It could be because of the nature of the short length of the interviews and the time allocated for each interview. Therefore, the respondents would not be too eager to answer this question. I could be due to lack of knowledge, or it could be because the respondent might have been familiarised in the previous 5 categories of the questions with the Likert scale, box ticking method of responding and as a result, responding in a written format might not be desirable. Also, it seems like the respondent needs to investigate the company documents or enquire from other employees for the right answer to this question. Altogether, what could be sensed from these blank responses is that 4 of the interviewees did not have the names of the business innovations of the company prepared or in their memory.

The responses provided by CS2-Int5, for the name of business innovations are as follows: construction technology, in-house engineering and design, off-site manufacturing, after-sales management and lifecycle costs, software implementation, competency scheme, form of contracts/approach, etc.

-"Question b" of this section of the tool, attempted to measure the products Innovation of CS2 (sections 2.10.1 to 2.10.4). This subcategory consists of 8 questions that were

categorised using 5-point Likert scale. These questions can be found in Appendix 2 of this thesis. The overall score for this category, based on all the responses provided by the 5 interviewees, was 2.95. Although the higher this score, the more innovative the company is, and there are more and better innovations happening inside the company, it is still preferable not to interpret this score as a single score. This is due to the nature of questions and the different Likert scales used in this sub-category. The following table represents the summary of the responses provided by the 5 respondents.

Table 4.24: Results - B) Products Innovation for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 1	4	3	3	4	5	**3.8**
BI 2	4	3	4	4	5	**4**
BI 3	2	1	2	2		**1.75**
BI 4	2	2	2	4	4	**2.8**
BI 5	4	3	3	4	4	**3.6**
BI 6	4	3	2	3	4	**3.2**
BI 7	2	3	2	3	1	**2.2**
BI 8	2	2	2		1	**1.75**
Respondent's Average	**3**	**2.5**	**2.5**	**3.43**	**3.43**	
Overall Score						**2.95**

BI 1: Overall, how do you rate your company's produced "innovative goods" during the past year (section 2.10.1)?

The average response for this category sits at 3.8, indicating that the respondents believed the company's "innovative goods " during the last year were "moderate to high".

BI 2: Overall, how do you rate your company's produced "innovative services" during the past year (section 2.10.1)?

The average response for this category sits at 4.0, indicating that the respondents believed the company's "innovative services " during the last year were "high".

BI 3: Please indicate the number of product innovations during the observation period (section 2.10.1).

The average response for this category sits at 1.75, indicating that the respondents believed the company had produced "6 to 8" innovations during the past year. Only CS2-Int2 believed that the company had produced "1 to 5" product innovations during the observation period. CS2-Int5 did not respond to this question.

BI 4: Inside your company, what share of the total sales in the previous three years do you estimate is due to product innovations (section 2.10.2)?

The average response for this category sits at 2.8, indicating that the respondents believed 21% to 40% of the company's sales are related to product innovations that have taken place inside the company. This question is rather interesting because it was one of the few questions that the Oslo Manual (OECD/Eurostat, 2018) recommended to look at the previous three years, rather than just the observation period of one year. This, in turn, is due to the fact that innovations need time until they can reach the market and show their impact on the financial documents of the company.

BI 5: To what extent did your company's product innovations result in an increase in sales (section 2.10.2)?

The average response for this category sits at 3.6, indicating that the respondents believed that 41% to 60%, somewhere around the 50% mark, was the impact of the company's product innovations on an increase in sales. It is worth mentioning again that this figure is for the observation period, while BI4 looked at the three-year increase.

BI 6: To what extent did your company's product innovations result in an increase in profits (section 2.10.3)?

The average response for this category sits at 3.2, indicating that the respondents believed that the company's product innovations accounted for an increase in the profits of 41% to 60%.

BI 7: What was your average profit margin for your company's product innovations (section 2.10.3)?

The average response for this category sits at 2.2, indicating that the respondents believed that 21% to 40% was the average profit margin for CS2's product innovations.

BI 8: What is the market share of the firm's product innovations out of all sales in the market for similar products (section 2.10.4)?

The average response for this category sits at 1.75, indicating that the respondents believed that, amongst all similar products, CS2 has been able to achieve 0% to 20% of the market share. Probably around 17.5% based on the average obtained.

- "Question c" of this section of the tool, in a protocol which is exactly matching the protocol used for the study of CS1, attempted to measure the Innovation outcomes: Processes (section 2.10.5) of CS2. This subcategory consists of 8 questions that were categorised using 5-point Likert scale. Also, each question has a slot where the respondents could include the name of innovation(s) that they are referring to. The respondents were asked to rate their company's developments during the past year in relation to the following innovation outcomes: Processes (section 2.10.5).

- BI 9: Production of goods or services
- BI 10: Distribution and logistics
- BI 11: Marketing and sales
- BI 12: Information and communication systems
- BI 13: Administration and management
- BI 14: Product and business process development.

BI 15: To what extent did your company's business process innovations result in an increase in sales (section 2.10.5)?

The average response for this category was 2.0, which indicates that the respondents believed that the business process innovations of CS2 resulted in 21% to 40% increase in sales.

BI 16: To what extent did your company's business process innovations –directly or indirectly – led to a reduction in operational cost (per unit of output / per operation) (section 2.10.6 Operational costs and process innovations)?

The average response for this category was 1.6, which indicates that the respondents believed that the business process innovations of CS2 resulted in 0% to 20% reduction in operational cost (per unit of output / per operation). Probably somewhere around the 16% mark based on the average results provided.

These questions can be found in Appendix 2 of this thesis. The overall score for this category, based on all the responses provided by the 5 interviewees, was 2.8. Similar to the comments mentioned above for question b, interpreting this score is not intended. The following table represents the summary of responses provided by the respondent for this sub-category.

Table 4.25: Results - C) Business Process Innovation for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 9	4	4	3	3	5	**3.8**
BI 10	2	2	2	3	2	**2.2**
BI 11	4	3	3	3	3	**3.2**
BI 12	4	3	3	3	3	**3.2**
BI 13	2	2	3	4	4	**3**
BI 14	4	3	3	3	4	**3.4**
BI 15	2	1	2	4	1	**2**
BI 16	2	1	3	1	1	**1.6**
Respondent's Average	**3**	**2.375**	**2.75**	**3**	**2.875**	
Overall Score						**2.8**

- "Question d" of this section of the tool, attempted to measure the Innovation novelty and impacts assessments (section 2.10.7) of CS2. As previously indicated in chapter 2, sections 2.3 and 2.4, the basic requirement for an innovation is that it must be significantly different from the firm's previous products or business processes. This subcategory consists of 3 questions that were categorised using 5-point Likert scale. Also, each question has a slot where the respondents could include the Name of innovation(s) that they are referring to. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to express if they "Don't know" about any of these questions. The questions measure the rate of:

- BI 17: Novelty
- BI 18: Innovativeness
- BI 19: Economic impact

of the innovations / most important innovation of CS2 during the past year. The following table represents the summary of the responses provided by the five interviewees for this section. The overall score for this subcategory is 3.00, which indicates a "Moderate" response from the respondents.

Table 4.26: Results - D) Innovation Novelty and Impacts Assessments for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 17	2	2	4	3	3	**2.8**
BI 18	3	3	3	4	4	**3.4**
BI 19	4	2	2	3	3	**2.8**
Respondent's Average	**3**	**2.33**	**3**	**3.33**	**3.33**	
Overall Score						**3**

- "Question e" of this section of the tool, as previously decided for the interview protocol of this section, attempted to measure the Innovation and business profiling (section 2.10.8) of CS2. As previously indicated in section 2.10.8, the innovation status of a firm is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. The respondents were asked to choose under which business profile they would place CS2 as a company. This subcategory consists of 4 boxes that the respondents had to choose from. The following table depicts the mentioned question boxes:

Table 4.27: E) Innovation and Business Profiling for CS2

An innovative firm: reports one or more innovations within the past year.	A non-innovative firm: reports no innovations within the past year.
An innovation-active firm: was engaged at some time during the past year in one or more activities to develop or implement new or improved products or business processes for an intended use.	The firm is not engaged in innovation activities and has not introduced any innovations in the observation period.

The respondents unanimously outlined that CS2 has been "An innovative firm" and "An innovation-active firm" during the past one year.

- "Question f" of this section of the tool, following the predetermined interview protocol, attempted to measure the Innovation Activities (section 2.10.9) of CS2. As previously indicated in section 2.10.9, Innovation Activities include all developmental, financial, and commercial activities undertaken by a firm that are intended to result in an innovation for the firm. The respondents were asked to respond to what extent during the past year has their company undertaken any of the following activities:

- BI 20: Research and experimental development (R&D) activities
- BI 21: Engineering, design and other creative work activities
- BI 22: Marketing and brand equity activities
- BI 23: Intellectual Property (IP) related activities
- BI 24: Employee training activities
- BI 25: Software development and database activities
- BI 26: Activities related to the acquisition or lease of tangible assets
- BI 27: Innovation management activities.

The responses were provided with a five-point Likert scale. The overall average for this subcategory of question was 3.28, indicating a "Moderate" response by the respondents. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, this sub-section included a box slot for each question to respond whether the activity was conducted for innovation purposes. The respondents answered with a response of either Yes or No.

Table 4.28: F) Innovation Activities for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 20	4	3	3	4	4	**3.6**
BI 21	5	3	4	4	4	**4**
BI 22	5	2	4	3	3	**3.4**
BI 23	3	2	2	2	3	**2.4**
BI 24	4	4	4	3	3	**3.6**
BI 25	5	3	3	2	4	**3.4**
BI 26	5	3	3	1	2	**2.8**
BI 27	3	1	4	3	4	**3**
Respondent's Average	**4.25**	**2.63**	**3.375**	**2.75**	**3.375**	
Overall Score						**3.28**

- "Question g" of this section of the tool, in order to fulfil the recommendations of the interview protocol, attempted to gather data on Innovation Projects (section 2.10.10) of CS2. As previously indicated in 2.10.10, many innovation-active firms organise their innovation activities as innovation projects, defined as a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes. The respondents were first asked whether their company organises its innovation activities on a project basis. This sub-section is followed by 4 questions aiming to gather more data on the innovation projects of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to indicate if any of the questions in this sub-category is "not relevant". These questions are presented in Appendix 2 of this thesis. The following tables represent the summary of the responses provided by the 5 interviewees for the questions in sub-section g:

Table 4.29: G) Data on Innovation Projects for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
innovation activities on a project basis?	No	Yes	Yes	Yes	Yes	
BI 28	4	3	3	4	3	**3.4**
BI 29	4	2	2	3	2	**2.6**
BI 30	2	1	2	1		**1.5**
BI 31	4	3	2	4		**3.25**
Respondent's Average	**3.5**	**2.25**	**2.25**	**3**	**2.5**	
Overall Score						**2.72**

For the question addressing whether inside CS2 the innovation projects are organised on a project basis, only CS2-Int1 responded 'No'. The remaining 4 respondents agreed that inside CS2, the innovation projects are organised on a project basis. The main reason for this might be that the employees are from different positions within the company and might not be aware of the innovation projects that are being undertaken within CS2. Further investigation could potentially lead to the diagnosis of deficiencies within the company.

BI28: the average response for the question BI28 is 3.4 indicating that "2 to 5" innovation projects were undertaken during the past year.

BI29: the average response for the question BI29 is 2.6 indicating that "1 to 2" innovation projects were completed during the past year.

BI30: the average response for the question BI30 is 1.5 indicating that "0" projects were ceased before completion during the past year. Based on the individual responses, some interviewees gave a higher score for this indicator. This indicates that they believe there were a number of- up to 5 - innovation projects that ceased before completion during the past year.

BI31: the average response for the question BI31 is 3.25 indicating that "2 to 5" innovation projects were ongoing at the end of the past year.

- "Question h" of this section of the tool attempted to gather data on Follow-on Activities (section 2.10.11) of CS2. This is in line with the previously determined interview protocol and was also administered for CS1. As previously indicated in section 2.10.11 of this thesis, other than innovation activities, companies can also conduct follow-on activities, but within the observation period. These follow-on activities are extremely decisive for the success or failure of an innovation, but they are not part of the definition of an innovation activity. The respondents were asked to what level CS2 pursues any of the "follow-on" activities for their innovation projects? This sub-section is followed by 3 questions aiming to gather more data on the Follow-on activities of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to indicate the "Description of Activity". These questions are presented in Appendix 2 of this thesis. The following tables represent the summary of the responses provided by the 5 interviewees for the questions in sub-section h:

Table 4.30: H) Follow-On Activities for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 32	2	3	3	3	1	**2.4**
BI 33	3	3	4	3	4	**3.4**
BI 34	2	3	3	2	3	**2.6**
Respondent's Average	**2.33**	**3.00**	**3.33**	**2.67**	**2.67**	
Overall Score						**2.8**

BI 32: Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc. The average response for the question BI32 is 2.4, indicating that the pursuit of Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc. was "Low" during the past year. This indeed helps with the diagnosis of where the company lacks and needs innovations, and to understand whether it has received less focus on this category in the past. This allows to help and remove the innovation barriers and deficiencies inside CS2.

BI 33: Follow-on training related to the use of innovations during the past year / familiarising users with a firm's innovations. The average response for the question BI33 is 3.4, indicating that follow-on training and familiarising of the users with CS2's innovations was "Moderate" during the past year. This indicator also needs improvement as it allows for the further performance of the company and leads to more benefits and further profits.

BI 34: After-sales services/maintenance/operations management/utility improvement/installation/updating/repair services/guarantee/return schemes/information services/communication, etc. The average response for the question BI34 is 2.6, indicating that the abovementioned follow-on activities were practised "Low" in CS2 during the past year.

- "Question i" of this section of the tool attempted to gather data on planned innovation activities and expenditures (section 2.10.12) of CS2. As previously indicated in section 2.10.12 of this thesis, research on planned innovation activities and expenditures highlights their importance for firm profitability and economic development. Data on planned innovation activities can also help assess the likely impact of recent changes in the innovation environment of firms. The respondents, following the predetermined interview protocol, were asked to answer 4 questions on this sub-category, aiming to gather more data on the planned innovation activities and expenditures of the firm. As recommended by the Oslo Manual (OECD/Eurostat, 2018), in addition to the previous questions in this section, a slot was added for the respondents to allow them to indicate that they "Don't know" the response for any of the sections. These questions are presented in Appendix 2 of this thesis.

- The respondents were first required to answer whether the company CS2 plans to conduct any innovation activities during the next two years. The following table represents the summary of the responses.

Table 4.31: CS2's Plans to Conduct Innovation Activities During the Next Two Years

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Summary**
Does your company plan to conduct any innovation activities during the next two years?	Yes	Yes	Yes	Yes	Yes	YES

The achieved results indicate that CS2 is planning to conduct innovation activities during the next two years.

This sub-category was followed by two questions as BI35 and BI36 (section 2.10.12) with a response slot based on a 5-point Likert scale. The following table presents the summary of the responses provided by the 5 interviewees for the two Likert scale questions in sub-section i:

Table 4.32: I) Planned Innovation Activities and Expenditures for CS2

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Average**
BI 35	3	2	Don't Know	3	2	**2.5**
BI 36	1	1	Don't Know	1	1	**1**
Respondent's Average	**2**	**1.5**		**2**	**1.5**	
Overall Score						**1.5**

BI 35: CS2's planned annual innovation expenditures during the next two years: The average response for the question BI35 is 2.5, indicating that CS2 is planning to spend $500k to $1 million annually during the next two years on innovation.

BI 36: What percentage of your company's expenditures is on innovation during the next two years? The average response for the question BI35 is 1.0, indicating that CS2 is planning to invest 0% to 20% of its expenditure on innovation during the next two years.

The overall score for this subcategory is 1.5. Once again, due to the nature of the questions and due to the different Likert scales used, the overall score is not interpreted. It is used as a basis for comparison between companies, though.

As previously stated in section 2.10.12, the final question in this sub-category, which is also the final question for this section, is as follows:

How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the year after the reference year)? The respondents had three choices: Rise / Stay the same / or Fall. The following table represents the summary of the responses for this question:

Table 4.33: CS2's Total Expenditure on Innovation Change During the Next Two Years

	CS2 - Int1	**CS2 - Int2**	**CS2 - Int3**	**CS2 - Int4**	**CS2 - Int5**	**Indicator Summary**
How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the year after the reference year)?	Rise	Rise	Rise	Rise	Rise	**Rise**

Based on the responses provided by the respondents, there will be a rise in the total expenditure on innovation during the next two years compared to this year.

Through responding to the tool's questions, which were presented in section 4.5.4 and responding to the interview's open-ended questions (Appendix 3 – analysed in section 4.5.5), the respondents from CS2 collectively confirmed the findings of this tool under the Business Innovation Score (section 2.10) category and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from this case study in stage 2 and the literature review in stage 1.

4.5.5 Analysis of the Responses from CS2 for the Interview Questions

As planned for the interview protocol, once the respondents had finished answering to all the questions in the innovation measurement tool, including the question on the General Resources

of the company and the Demographic questions, the interviewees were asked a number of open-ended questions. The questions are presented in Appendix 3 of this thesis. The questions aimed to address the aim and objectives of the thesis.

Question 1: What did you think about the tool? How did you find it?

CS2-Int1 believes that some of the questions were objective, and to get a full understanding of the situation inside the company, there is a need to talk to the finance department and alike. He believes that the tool is very useful: *"Definitely a good tool to get us thinking about where we sit on this innovation spectrum".*

CS2-Int2 believes that the tool is good, and it is generating some interesting data. He believes that since CS2 is the *"stakeholder of several stakeholders"* in projects, it is not possible to control the implementation of innovation all the time. CS2 can drive innovation, and it is doing it at the moment. CS2's model of *"design and construct"* allows CS2 to control design, and this gives an opportunity to implement innovative ideas. This is while there exists a constraint on the budget and the time. This is also while time and budget savings are expected and happening as a result of innovations. The life-cycle cost is also a matter of concern and needs to be addressed with innovations. These matters need to be taken into account when dealing with clients of CS2, for example, schools and universities.

CS2-Int3 believes that there were many questions in the tool, but they are *"categorised well in a structural way"*. He believes that the tool's questions are *"applicable to the firm as well".*

CS2-Int4 says he found the tool to be fine. He thinks some of the questions are a bit confusing, but as he sees the graphed out, the way the results are presented, it becomes clear what the aim is. He expressed that he found the spider diagrams useful and found them as a means of understanding the *"wellness"* of the company in the areas based on the tool's categories. As previously mentioned, CS2-Int4 is the CEO of CS2, and he added that if the tool helps him improve his business, he is *"all there".*

CS2-Int5 believes that the tool was *"pretty good".* He sees it *as "thought-provoking"* to see innovation as a project and measure its output. He expresses that CS2 has not been fully doing this. He thinks that sustainability, broader outcomes, and social procurement are hot topics of the day that need attention. He thinks these are already being addressed at CS2 *"naturally",* but they are not separated from Business as Usual (BAU) definitions. He believes that CS2 has been *"working on and doing the best we can",* but they now understand that they need to *"define and measure what they're doing".*

Altogether, these comments were found to be extremely useful for the research as they confirmed and validated the correctness and accuracy of the research findings from stage 1 of the research.

Question 2: Is there anything missing that you could think of?

CS2-Int2 believes the tool is *"specific but broad at the same time"*. He believes the tool covers everything in broad terms. He also believes that the tool could be tailored to be project-level based rather than organisational-level based as well. The tool could also be tailored to address the specific sector that each company is operating under. Altogether, he believes that the

current tool is *"good for the general industry"*. CS2-Int3 mentioned that since he is personally from a technology background, he would have preferred to see more items in the technology category. For this aim, he believes some of the indicators could be further broken down into specific technologies. CS2-Int5 also thinks that the tool could be tailored to address more items on construction projects rather than organisational-level questions.

Comprehensively, the comments from the respondents affirmed and validated the tool's findings as a useful and comprehensive tool for measuring innovation within the construction industry of New Zealand, which validates the findings of stage 1 of this research.

Question 3: Would diagnostic be useful? Are the results useful?

According to CS2-Int1, diagnostics could definitely be useful. It allows to see the areas that require improvement. He believes that even with support for innovation from the senior management level, there is a need to create the right system structure so that the support filters down to everybody, and this is where this innovation measurement tool could support innovation.

According to CS2-Int2, diagnostics would definitely be useful. The aim is to make sure *"everyone understands the plan".* And since in big companies, managing innovation is hard, this tool can help. Diagnostics allows to see the trends and understand the benefits of innovation. He added that diagnostics allows to see the strength areas regarding innovation, also allows to manage the procurement process, and to define governmental policies. This allows to direct the innovation measurement tool's data to specific issues *"where we feel innovation could provide solutions, more in a benefit".*

Interviewee CS2-Int3 believes that the diagnostics would be useful. He added that the diagnostics allows the chance to see the results of different people in the company merged together and compared.

Together, the respondents of this research confirmed and validated the findings of this research during stage 1, for diagnosing the construction companies' innovation-related indicators to find the strengths and weaknesses. They also confirmed and validated the usefulness of the results that the tool represents.

Question 4: Would it be useful for your company to use this tool?

CS2-Int1 believes the tool will be very useful to use in the company. He also believes that the results could be compared between different organisational and project levels to find differences in perspectives and to fill the gaps.

CS2-Int2 also believes that the tool will be useful for CS2. He added that the tool could gather information from all the CS2 employees and improve the employees' understanding of what is going to be done around innovation. The tool could also clarify information on the employees' perceptions and clear misconceptions. He added that the collection of the data is one side, and the interpretation of it is another. He expresses that since the tool collects a lot of information, this information could be well used and benefited from. He mentioned that he acknowledges that a lot of effort must have been put into the process of developing this tool.

According to CS2-Int3 believes that CS2 can try the tool in practice. He believes that since they are already conducting annual studies using similar tools and questionnaires, the employees will easily respond to the questions. He believes that answering the questions in multiple sessions might be better. This is because a change in the organisation is also a gradual process.

CS2-Int4 believes that this tool should first be implemented in the "C Suite" of the company, being the Chief Executive Officer (CEO) and Chief Financial Officer (CFO), since they usually *"run the innovation side of things"*. This approach will potentially engage the younger employees with the leadership panel as well, and this is desired by the young employees. He added that the tool definitely highlights the need to understand what the requirements are to become innovative.

These comments endorse and validate the usefulness of the developed innovation measurement tool for the construction companies operating in New Zealand. The respondents validated the usefulness of the tool developed in stage 1 of this research.

Question 5: Are the results what you would expect? Are you surprised?

In response to question 5, CS2-Int1 believed that the tool does demonstrate what he was expecting. Cs2-Int2 also believed that the results were encouraging. He mentioned that through using the tool, he has been able to understand that there is *"a lot of potential for innovation in the business, because people think construction, buildings, have always been built this way. And how much can you innovate? But yeah, there is a lot there. And I really do believe it. Just a time thing."*

CS2-Int3 confirms the results in the sense that he believes that the innovation potential in the company is good, but there is still room for improvement in the output sector. He believes that this is the *"reality of inside the company"*.

The respondents approved and validated the diagnostic capability of the developed innovation measurement tool from stage 1 of this research. This is in line with the method and source triangulation approach selected for the validation of the findings during this research.

Question 6: How would you simplify this tool?

CS2-Int 2 believes there should be fewer technical terms used, and the terminology should be simplified. CS2-Int3 also thinks there is room to shorten the questions, and at the same time, he emphasises that innovation is a broad term. He goes on to say that perhaps the tool can be divided into parts to make it shorter to respond at once, or the tool could be embedded in an online platform.

Question 7: Do you have any further feedback?

CS2-int1 believes the tool is good work and that it is important for the industry. CS2-Int 3 also thinks that the tool is good. CS2-Int2, CS2-Int4 and CS2-Int5 did not provide any further feedback.

This section is the end of the analysis of the interview responses gathered from CS2. This is in line with the source and method triangulation approach chosen for this research. These findings were further evaluated in stage 3 of this research through interviews with construction industry experts (CIEs) as the last stage of the 3-stage triangulation data validation strategy of this research. In the next section of this chapter, a comparison of the results obtained during the two case studies is made.

4.6 A Comparative Study of Two Case Studies – CS1 vs. CS2

Already during this chapter, sections 4.2, 4.3, 4.4 and 4.5, results obtained from each of the two case studies were presented and analysed separately in detail. The results for each case study comprised of introduction, demographics, scores of the innovation potential questionnaire, root cause diagnostics and in-depth analysis of the innovation potential score of the company, diagnostic insights from the business innovation score for the case company, which was followed by analysis of the responses from the case company for the interview questions. The following section attempts to compare the results obtained from the two companies in an attempt to further analyse their innovation potential (sections 4.3.2 and 4.5.2), also their business innovation score (sections 4.3.4 and 4.5.4).

4.6.1 Innovation Potential Questionnaire

The first comparison is made for the results obtained for the innovation potential section (4.3.2 and 4.5.2) of the innovation measurement tool. This is an attempt to make a comparison between the potential of each company in each indicator, also in each category as a whole.

4.6.1.1 Innovation Potential - Workforce Skills and HR Management

In the workforce skills and HR management category, CS1 achieved an overall score of 3.5 (section 4.3.2.1) while CS2 scored 3.6 (section 4.5.2.1). The following table compares the indicator averages for each of the indicators:

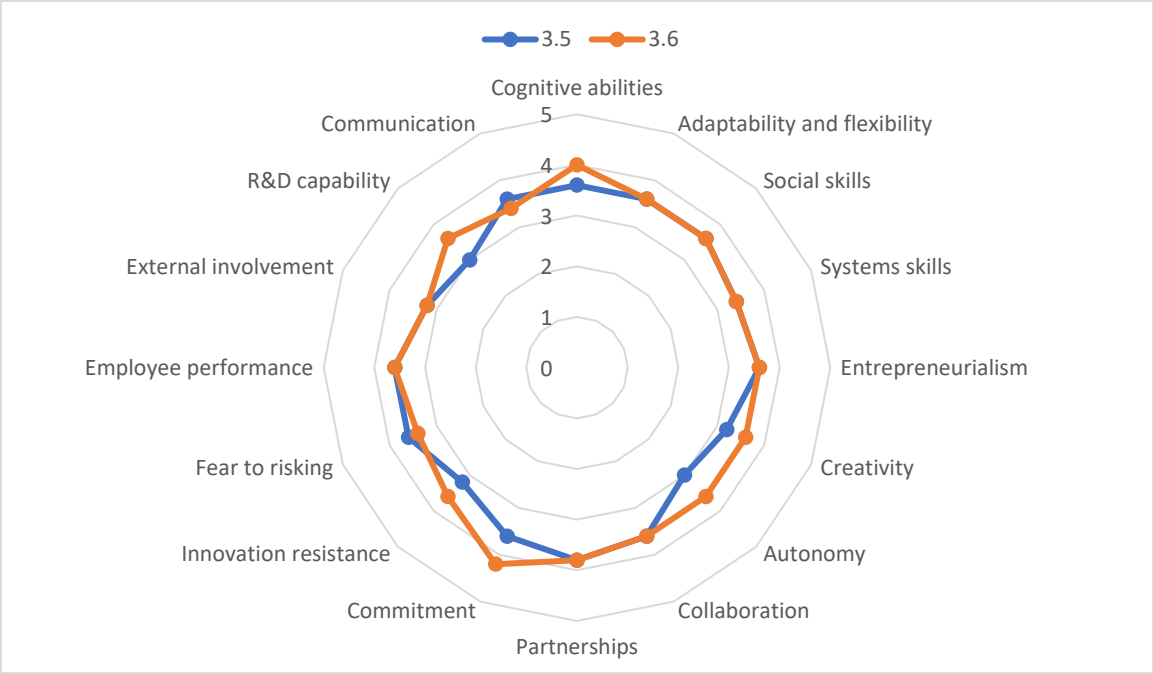
Table 4.34: Comparison of the Indicator Averages for CS1 And CS2 on Workforce Skills and HR Management

	Indicator	**CS1**	**CS2**
WF&HR 1	Cognitive abilities	3.6	4
WF&HR 2	Adaptability and flexibility	3.6	3.6
WF&HR 3	Social skills	3.6	3.6
WF&HR 4	Systems skills	3.4	3.4
WF&HR 5	Entrepreneurialism	3.6	3.6
WF&HR 6	Creativity	3.2	3.6
WF&HR 7	Autonomy	3	3.6
WF&HR 8	Collaboration	3.6	3.6
WF&HR 9	Partnerships	3.8	3.8
WF&HR 10	Commitment	3.6	4.2
WF&HR 11	Innovation resistance	3.2	3.6
WF&HR 12	Fear to risking	3.6	3.4
WF&HR 13	Employee performance	3.6	3.6
WF&HR 15	External involvement	3.2	3.2
WF&HR 16	R&D capability	3	3.6
WF&HR 17	Communication	3.6	3.4
	Overall Score	**3.5**	**3.6**

Based on the indicator averages presented above, CS2 obtained a higher score in most of the indicators. The background for these scores has previously been presented in sections 4.3.2.1, 4.3.3.1, 4.5.2.1 and 4.5.3.1 of this thesis. The differences were exceptionally noticeable on

Autonomy, Commitment and R&D capability. These higher scores for innovation potential indicators in the workforce skills and HR management category are partially effective for the higher overall score of CS2.

Figure 4.11: Comparison of the Indicator Averages for CS1 and CS2 on Workforce Skills and HR Management



4.6.1.2 Innovation Potential: Organisational Structure

On the organisational structure category, CS1 achieved an overall score of 3.24 (section 4.3.2.2) while CS2 scored 3.91 (section 4.5.2.2). Based on the data collected through the tool and the interviews (sections 4.3 and 4.5), this result was indeed expected and confirmed. CS2 has a stronger backbone and structure, and this is greatly influencing the innovation potential of CS2, in this instance, the organisational structure category. Consequently, these results describe the higher overall score of CS2. The following table compares the indicator average for each of the indicators:

Table 4.35: Comparison of the Indicator Averages for CS1 and CS2 on Organisational Structure

	Indicator	**CS1**	**CS2**
Org 1	Organisational support	3.4	4.4
Org 2	Upper management support	4.0	4.6
Org 3	Innovation Champion	3	4.2

Org 4	Recruitment policies	3.2	3.4
Org 5	Employee recognition	3.4	3.8
Org 6	Incentives	3	3
Org 7	Knowledge management	3.2	3.8
Org 8	Lessons learned	3	3.8
Org 9	Career development	3	4.2
	Overall Score	**3.24**	**3.91**

Based on the indicator averages presented above, CS2 obtained a higher score in most of the indicators. The background for these scores has previously been presented in sections 4.3.2.2, 4.3.3.2, 4.5.2.2 and 4.5.3.2 of this thesis. The differences were exceptionally noticeable on Organisational support, Upper management support, Innovation Champion, Lessons learned, and Career development.

Figure 4.12: Comparison of the Indicator Averages for CS1 and CS2 on Organisational Structure

4.6.1.3 Innovation Potential: Business Strategy

On the business strategy category, CS1 achieved an overall score of 3.5 (section 4.3.2.3) while CS2 scored 3.87 (section 4.5.2.3). The results of this category are relatively close since both

companies' management expressed confidence in their business strategy. The comments supporting this confidence are previously presented in this thesis (sections 4.3.3.3 and 4.5.3.3). The following table compares the indicator averages for each of the indicators:

Table 4.36: Comparison of the Indicator Averages for CS1 and CS2 on Business Strategy

	Indicator	**CS1**	**CS2**
BS 1	Strategic Plan	3.8	4.6
BS 2	Strategy communication	3	4.6
BS 3	Progress monitoring	3.4	4
BS 4	Innovation Strategy	3.4	4
BS 5	Finish price focus	3.6	3.2
BS 6	Quality focus	4.2	3.6
BS 7	Multiple market focus	3.25	3.2
BS 8	In-house sourcing	3.4	4
BS 9	Lifecycle focus	3.4	3.6
	Overall Score	**3.5**	**3.87**

Based on the indicator averages presented in this table, CS2 again obtained a higher score in most of the indicators. The background for these scores has previously been presented in sections 4.3.2.3, 4.3.3.3, 4.5.2.3 and 4.5.3.3 of this thesis. The difference was exceptionally noticeable in the Strategic Plan and Strategy communication. In this category, CS1 obtained a higher score than CS2 in two indicators, namely Finish price focus and Quality focus. Both companies scored a similar score for the indicator addressing Multiple Market Focus. The reason for CS2's low scores in the last three indicators is mainly around the managers' perceptions towards the company and industry.

Figure 4.13: Comparison of the Indicator Averages for CS1 and CS2 on Business Strategy

4.6.1.4 Innovation Potential: Technology

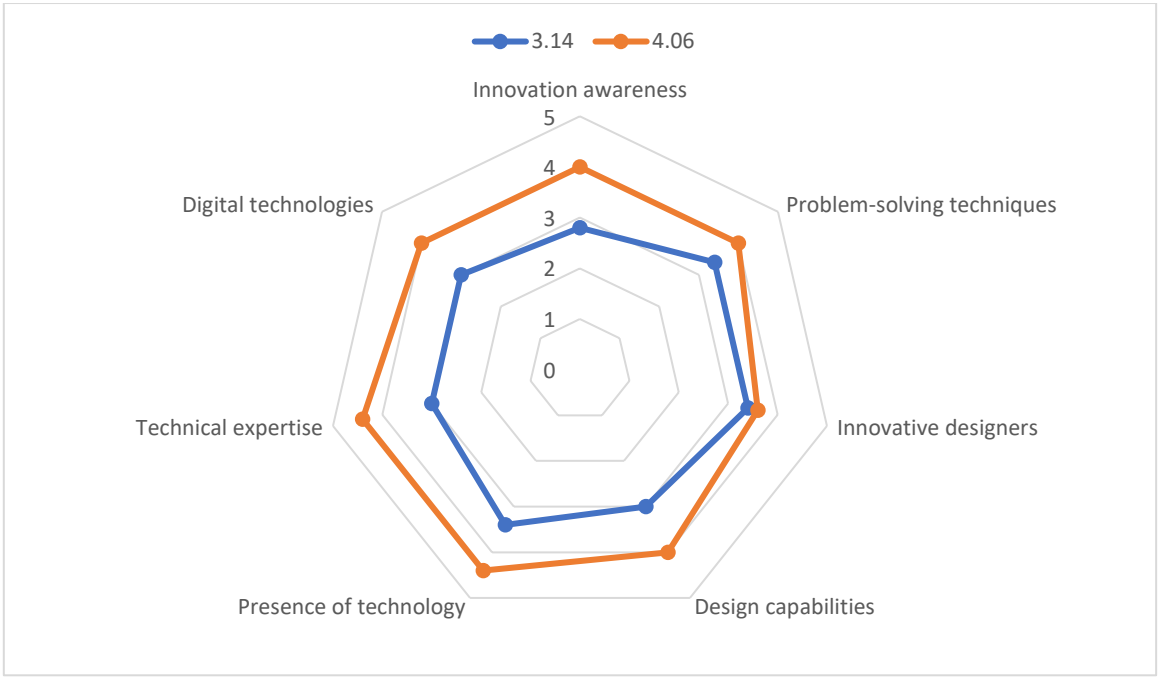
In the technology category, CS1 achieved an overall score of 3.14 (section 4.3.2.4) while CS2 scored 4.06 (section 4.5.2.4). The results of this category were as expected since CS2 has a very strong approach towards technology, while CS1 does not see much benefit in investing in technology directly. The comments supporting these two scores are previously presented in sections 4.3.3.4 and 4.5.3.4 of this thesis. The following table compares the indicator averages for each of the indicators:

Table 4.37: Comparison of the Indicator Averages for CS1 and CS2 on Technology

	Indicator	**CS1**	**CS2**
Tech 1	Innovation awareness	2.8	4
Tech 2	Problem-solving techniques	3.4	4
Tech 3	Innovative designers	3.4	3.6
Tech 4	Design capabilities	3	4
Tech 5	Presence of technology	3.4	4.4
Tech 6	Technical expertise	3	4.4
Tech 7	Digital technologies	3	4
	Overall Score	**3.14**	**4.06**

Based on the indicator averages presented above, CS2 once again obtained a higher score in most of the indicators. The differences were exceptionally noticeable on Innovation awareness, Design capabilities, Presence of technology, Technical expertise and Digital technologies. The huge difference in the technical expertise indicator was evident throughout the data collection phase of the case studies and in the discussions from the interviewees presented throughout sections 4.3 and 4.5 of this research. The background for these scores on the technology indicator has been previously discussed and analysed in sections 4.3.2.4, 4.3.3.4, 4.5.2.4 and 4.5.3.4 of this thesis.

Figure 4.14: Comparison of the Indicator Averages for CS1 and CS2 on Technology



4.6.1.5 Innovation Potential: External Influences

On the external influences category, CS1 achieved an overall score of 3.63 (section 4.3.2.5) while CS2 scored 3.36 (section 4.5.2.5). The results of this category were as expected. The nature of work within the two case study companies and their target market is totally different. As a result, the impact of external influences on the two companies is different. Also, CS1 is a medium-sized company which is leaner and in addition, it was evident during the interviews that CS1 has had a stronger response plan to address the impact of external influences on the company. The comments supporting these two scores are previously presented in sections 4.3.3.5 and 4.5.3.5 of this thesis. The following table compares the indicator averages for each of the indicators:

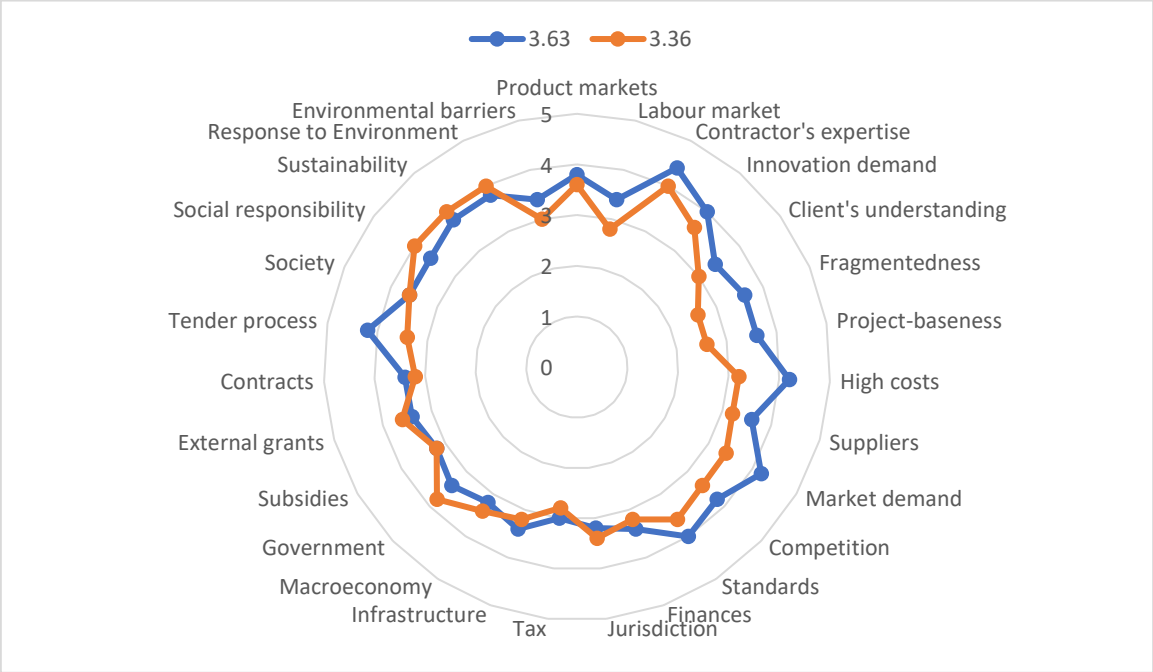
Table 4.38: Comparison of the Indicator Averages for CS1 and CS2 on External Influences

	Indicator	CS1	CS2
Ext 1	Product markets	3.8	3.6
Ext 2	Labour market	3.4	2.8
Ext 3	Contractor's expertise	4.4	4
Ext 4	Innovation demand	4	3.6
Ext 5	Client's understanding	3.4	3
Ext 6	Fragmentation	3.6	2.6
Ext 7	Project-baseness	3.6	2.6
Ext 8	High costs	4.2	3.2
Ext 9	Suppliers	3.6	3.2
Ext 10	Market demand	4.2	3.4
Ext 11	Competition	3.8	3.4
Ext 12	Standards	4	3.6
Ext 13	Finances	3.4	3.2
Ext 14	Jurisdiction	3.2	3.4
Ext 15	Tax	3	2.8
Ext 16	Infrastructure	3.4	3.2
Ext 17	Macroeconomy	3.2	3.4
Ext 18	Government	3.4	3.8
Ext 19	Subsidies	3.2	3.2
Ext 20	External grants	3.4	3.6
Ext 21	Contracts	3.4	3.2
Ext 22	Tender process	4.2	3.4
Ext 23	Society	3.6	3.6
Ext 24	Social responsibility	3.6	4

Ext 25	Sustainability	3.8	4
Ext 26	Response to Environment	3.8	4
Ext 27	Environmental barriers	3.4	3
	Overall Score	**3.63**	**3.36**

Based on the indicator averages presented above, contrary to the 4 previous categories, CS1 obtained a higher score in most of the indicators. The background for these scores has been previously discussed in sections 4.3.2.5, 4.3.3.5, 4.5.2.5 and 4.5.3.5 of this thesis. The differences were exceptionally noticeable on the Labour market, Fragmentedness, Project-baseness, High costs, Market demand and Tender process. CS2 obtained a higher score in a number of indicators. It could be concluded that CS1 is coping with the impact of the external factors better than CS2.

Figure 4.15: Comparison of the Indicator Averages for CS1 and CS2 on External Influences



4.6.2 Business Innovation Score

On the external business innovation score category, CS1 achieved an overall score of 2.89 (section 4.3.4) while CS2 scored 2.87 (section 4.5.4). It is quite interesting to see the score for the output of innovation being the same for both companies. The respondents from CS1 were quite positive about the innovation output in their company. This is while during the interview, the respondents from CS1 highlighted many factors that need focus in order to see improvement in the innovation potential of CS1.

On the other hand, the respondents in CS2 were very confident in the innovation potential of their company and contrary to that, they were not happy with the level of innovations that were happening in CS2. They mentioned many factors, and mainly, the lack of a measurement tool and documentation were the reasons for the respondents from CS2 giving low scores to the indicators of business innovation.

The comments supporting these two scores are previously presented in sections 4.3.4 and 4.5.4 of this thesis. The following table compares the indicator averages for each of the indicators for the two case companies:

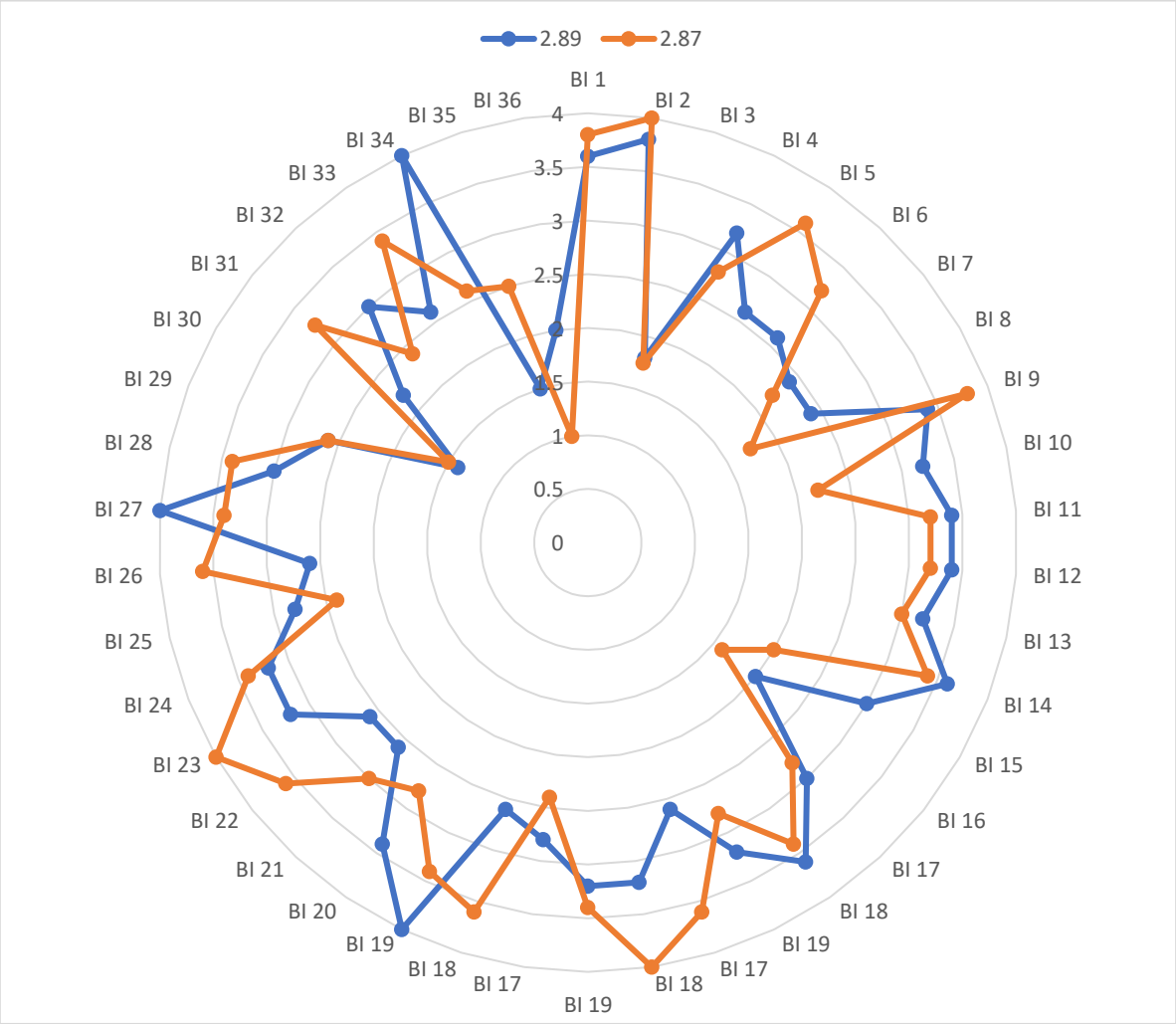
Table 4.39: Comparison of the Indicator Averages for CS1 and CS2 on their Business Innovation Score

	CS1	**CS2**
BI 1	3.6	3.8
BI 2	3.8	4
BI 3	1.8	1.75
BI 4	3.2	2.8
BI 5	2.6	3.6
BI 6	2.6	3.2
BI 7	2.4	2.2
BI 8	2.4	1.75
BI 9	3.4	3.8
BI 10	3.2	2.2
BI 11	3.4	3.2
BI 12	3.4	3.2
BI 13	3.2	3
BI 14	3.6	3.4
BI 15	3	2
BI 16	2	1.6
BI 17	3	2.8
BI 18	3.6	3.4
BI 19	3.2	2.8
BI 20	2.6	3.6
BI 21	3.2	4
BI 22	3.2	3.4
BI 23	2.8	2.4
BI 24	2.6	3.6

BI 25	4	3.4
BI 26	3.4	2.8
BI 27	2.6	3
BI 28	3	3.4
BI 29	2.6	2.6
BI 30	1.4	1.5
BI 31	2.2	3.25
BI 32	3	2.4
BI 33	2.6	3.4
BI 34	4	2.6
BI 35	1.5	2.5
BI 36	2	1
Overall Score	**2.89**	**2.87**

Based on the indicator averages presented above, both companies obtained a similar score for their business innovation. Regarding the score for the indicators in this category, with the exception of a few indicators, the scores were very close for these indicators. The breakdown and background of these scores have been previously discussed in sections 4.3.4 and 4.5.4 of this thesis.

Figure 4.16: Comparison of the Indicator Averages for CS1 and CS2 on their Business Innovation Score



Through responding to the interview's open-ended questions (Appendix 3, analysed in sections 4.3.5 and 4.5.5), the respondents collectively confirmed the findings of this tool under the business innovation score category (sections 2.10, 4.3.4 and 4.5.4) and found them useful for their companies to use. This led to the validation of the findings from stage 1 of this research. These findings were part of the method (section 3.7.1) and source (section 3.7.2) triangulation method used during this thesis and helped validate the findings from the three stages of this research.

4.7 Concluding Summary - The Overall Scores

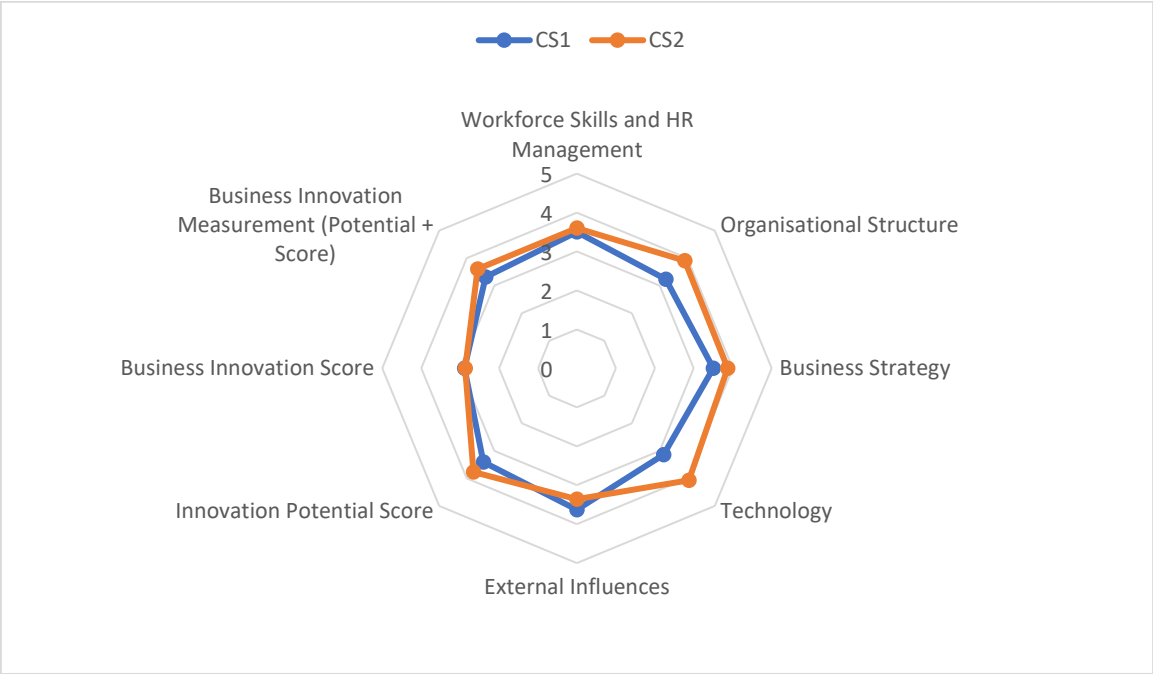
In this chapter, two construction companies within the New Zealand construction industry were studied in an attempt to embed and test the developed business innovation measurement tool within the industry. This allowed for further development of the tool, and also allowed for the

fulfilment of the aim and objectives of this thesis. By comparing the overall score for each of the five categories under innovation potential, as well as the business innovation score for each of the 2 case studies, the following results are achieved:

Table 4.40: Comparison of the Category Scores for CS1 and CS2

	CS1	**CS2**
Workforce Skills and HR Management	3.5	3.6
Organisational Structure	3.24	3.91
Business Strategy	3.5	3.87
Technology	3.14	4.06
External Influences	3.63	3.36
Innovation Potential Score	**3.4**	**3.76**
Business Innovation Score	**2.89**	**2.87**
Overall Score - Business Innovation Measurement (Potential + Score)	**3.32**	**3.61**

Figure 4.17: Comparison of the Category Scores for CS1 and CS2



As indicated in the above table, the innovation potential score for CS1 is 3.4, while it is 3.76 for CS2. This score was achieved by finding the average (descriptive statistics analysis) for the five category scores under the innovation potential. It could be concluded that due to the higher score for innovation potential, CS2 has a higher potential for innovation in the coming years, and therefore, more innovations can be expected from CS2 in the coming years.

Also, as seen in the above table, the business innovation score for CS1 is 2.89, and it is 2.87 for CS2. This score is achieved by finding the average (descriptive statistics analysis) for all the indicators in the business innovation score category of the tool. This score was very close for both companies. This score represents the business-innovation-related matters that took place, mainly during the past 1 year, as the observation period. The detailed analysis for the scores obtained for each of the indicators in this category has previously been presented in sections 4.3.4, 4.5.4 and 4.6.2 of this thesis.

Eventually, the final score for innovation is 3.32 for CS1, and it is 3.61 for CS2. These scores can be used to compare the business innovation (potential + score) of construction companies within New Zealand. This comparison can be done either individually for each company or collectively for the industry at the national level or regional clusters. As a result, and based on the responses provided by the respondents, it can be concluded that CS2 is overall more innovative than CS1. However, it should be noted that the majority of the difference between CS1 and CS2 lies in the stronger potential of CS2 and not necessarily in its actual innovation output. This can be further studied, and relevant issues can be diagnosed in a longitudinal study during the coming years. Both companies require this tool as a platform for planning, monitoring, documenting, and eventually measuring their innovation-related indicators for the improvement of their innovation environment and output.

The case studies highlight the shortages negatively affecting construction companies' innovation capability. The results also indicate vast potential within the construction

companies, but the difference between the innovation potential score and the business innovation score demonstrates that this potential is yet to be realised.

Overall, the findings from the case studies confirmed and validated the practicality of the innovation measurement tool. These results form a critical input for the triangulation process, where alignment with the theoretical foundations (Stage 1) and external expert validation (Stage 3) strengthen the credibility and validity of the tool and its diagnostic capacity.

These results also demonstrated the comprehensiveness and diagnostic capability of the developed innovation measurement tool for effectively measuring innovation within medium and large construction organisations in New Zealand, which was the aim of this research. The results that were found and analysed during CS1 and CS2 (sections 4.3, 4.5 and 4.6) are also part of the recommendations and strategic insights for improving innovation measurement practices within New Zealand construction organisations, based on the findings from the tool's implementation (objective 5).

Chapter 4 of this thesis helped and contributed to the achievement of every objective of this research, but particularly to the fulfilment of objective 3 of the research. This objective was achieved by implementing and testing the diagnostic tool developed in stage 1 of this research, through case studies with selected medium or large construction organisations in New Zealand. Chapter 4 also addressed sub-question 4 of the research. This endeavour assessed the tool's practicality and functionality in real-world settings. These findings were further discussed with construction industry experts during Stage 3 of the research. Their feedback, presented in Chapter 5, was used to validate and further refine the findings from the case studies in stage 2 and the literature review in stage 1.

Chapter Five: Evaluating the Validity of the Innovation Measurement Tool for New Zealand Construction Organisations - Analysis of the Responses Provided by the Construction Industry Experts

5.1 Introduction

Innovation is necessary for better outcomes in the construction industry (Er, 2020). Innovation is used to improve performance. Innovation is also considered a possible path for increasing profit margins. The construction industry is in high need of innovation. Additionally, continuous organisational success and further development can be achieved through innovations (Akunyumu et al., 2021). There is a positive relation between innovation and the contribution of construction companies to economic growth. Innovation is necessary to increase productivity and progress within the construction industry. In addition, the successful development and application of innovation can have great benefits for construction companies (Oladinrin et al., 2023).

This research attempted to comprehend what is required for an organisation to be more innovative. During the first stage of this research, a tool for measuring innovation was developed. The tool attempts to measure both the potential for innovation and the actual innovation of the construction organisations. The results obtained in the first stage of the research were used for the second study, conducting case studies on construction organisations in an attempt to test and further develop the tool. The following chapter presents the results obtained during the third stage of this research.

As previously mentioned in the methodology chapter (section 3.6), the third stage of the research includes interviews with construction industry experts (CIEs) in an attempt to validate the research and fulfil the triangulation method engaged for the validation of the findings of the research. In line with this, 5 experts were shortlisted and selected amongst the experts who could contribute towards the validation and further improvement of the innovation measurement tool. These people were a combination of measurement tool development experts, innovation experts, senior construction industry experts aware of the organisational culture, and experts in organisational training, and the like. The third stage of this research directly addresses objective 4 of this research and further contributes to objectives 2 and 5 of the research.

During the third stage of this research, an interview protocol was followed. The CIEs were first introduced to the tool. This stage included a flexible and semi-structured approach where discussion was allowed to go ahead according to the needs of the respondent to be familiarised with the tool. This is while the researcher, as the facilitator of the interview, guided the discussion to avoid steering away from the topic. The focus of the discussions was on the

understanding and further improvement of the innovation measurement tool. The interviewees were asked to share their views on the tool and its indicators and questions.

The interviews were then followed by a number of questions in an attempt to validate and further improve the tool. The questions were in line with objectives 2, 4 and 5 of the research. These questions are presented in Appendix 4 of the research.

5.2 The Construction Industry Experts (CIEs)

The 5 construction industry experts (CIEs) were all professionals in their field.

Construction Industry Expert 1, which is referred to as CIE1 in this research, is a highly experienced university lecturer and construction industry expert with a strong international background in disaster reconstruction, project delivery, contract negotiation, and commercial management across both public and private sectors. He was chosen as a Construction Industry Expert (CIE) due to the following traits:

Table 5.1: Characteristics which Justified the Selection of Construction Industry Expert 1 (CIE1)

Highest Education	PhD in civil engineering (procurement and contractual arrangements for post-disaster reconstruction) Post-doc on construction productivity
Academic Roles	University lecturer; designed and delivered courses
Government Role	Emergency management advisor, Ministry of Civil Defence, Wellington; involved in Christchurch earthquake post-disaster response
International Consultancy	Engineering and project management consultant in multiple countries on disaster reconstruction projects, contract negotiation and management, tendering and procurement, project risk management, and commercial project management, quantity surveyor
Construction Management Experience	Contract negotiation, procurement, and project risk management in NZ and internationally
Major Corporate Role	Business and contract manager and procurement engineer; helped establish large companies; involved in multiple significant projects
Current Roles	General manager – commercial and residential developer

Construction industry expert 2, who is referred to as CIE2 in this research, says he has the challenge of bringing ideas to life as his passion. During the past 20 years, he has been actively involved in industrial R&D, research commercialisation, and innovation management, relishing the opportunity to lead teams and projects to deliver innovation outcomes in New Zealand and Europe in areas ranging from marine biology to avionics. His traits and expertise were the criteria for choosing him as an expert for helping further refine and validate the business innovation measurement tool developed in this research:

Table 5.2: Characteristics which Justified the Selection of Construction Industry Expert 2 (CIE2)

Highest Education	PhD in physics
Years of Experience	20+ years in industrial R&D, research commercialisation, and innovation management
Geographic Scope	New Zealand and Europe
Sector Experience	Public and private sectors
Fields of Work	Industrial R&D, innovation, marine biology, avionics,
Key Roles	Product owner at a S&P500 company - digital innovation lead - innovation lead at New Zealand transport agency
Other Professional Roles	Research & Design Director - Sector Strategist at Callaghan Innovation
Professional Focus	Leading teams and delivering innovative outcomes, contributing to NZ's innovation ecosystem

Construction industry expert 3, which is referred to as CIE3 in this research, is a highly respected professional in the field of innovation management and has the following specialities, which were the basis for selecting him as a Construction Industry Expert (CIE) on innovation:

Table 5.3: Characteristics which Justified the Selection of Construction Industry Expert 3 (CIE3)

Highest Education	PhD in mechanical engineering
Research Focus	Strategic system and process innovation in manufacturing small market enterprises
Sector Experience	Public and private sectors
Specialties	Innovation management, new product development, environmental management, technology management, manufacturing strategy, engineering education
Key Roles	Head of Innovation Impact - Innovation Project Manager - Innovation Strategy Analyst - Innovation and Strategy Consultant - Chairperson - Director

Construction industry expert 4, who is referred to as CIE4 in this research, is an Innovation Consultant, Board Director, and Organisational leader. She mentions that where design meets business, innovation happens. She believes that she brings value, networks, and action to this space. CIE4 is a New Zealand-based innovation consultant with a range of corporate, government and start-up clients. The following criteria were the basis for her being selected as a Construction Industry Expert (CIE):

Table 5.4: Characteristics which Justified the Selection of Construction Industry Expert 4 (CIE4)

Highest Education	Master of Architecture (MArch)
Innovation Consulting Focus	Innovation at the intersection of design and business; clients include corporates, government, and start-ups
Governance Experience	Board and advisory roles at multiple large organisations – Organisational leader
Innovation Sector Focus	Innovative construction, prefabrication and added-value timber manufacturing
Professional Leadership	Chief executive officer (CEO), national councillor and chair, advisory committee member

Entrepreneurial Experience	Founder/Co-founder of multiple strong and large organisations
Current Roles	Innovation consultant, board director

Construction industry expert 5, which is referred to as CIE5 in this research, is a construction professional with a PhD in construction management and over 12 years of diverse industry experience in engineering, estimating, project delivery, research, and technical compliance roles. These were the criteria that justified his selection as a CIE for this research.

Table 5.5: Characteristics which Justified the Selection of Construction Industry Expert 5 (CIE5)

Highest Education	PhD in Construction Management
Years of Experience	15 years
Research Focus	Productivity in road pavement maintenance & rehabilitation projects: perspectives of New Zealand roading contractors on the constraints and improvement
Professional Roles	Site engineer, estimator, project manager, project engineer, technical & compliance manager at multiple medium and large construction firms in New Zealand

5.3 Analysis of the Responses from Construction Industry Experts (CIEs) for the Interview Questions

What follows is the result of the analysis of the responses given to the interview questions by the CIEs. These questions are provided in Appendix 4 of this research. Additionally, further comments provided by the interview respondents, other than question responses, are presented to further strengthen the feedback process on the innovation measurement tool. This tool was developed during stage 1 and has been industry tested in stage 2 of this research:

5.3.1 Question 1. What did you think about the tool? How did you find it?

In-depth analysis of the results obtained from the 5 construction industry experts supports the relevance and the practicality of the innovation measurement tool developed for the New

Zealand construction industry. CIE1 supports the tool and expresses that the results being demonstrated in a visualised format are, in fact, very useful. He believes that the results are easy to understand and that they would greatly help the manager and make them think about the potential strengths and the areas needing improvement within the company. He supports the fact that the tool is finding the gaps, and with the possibility of having longitudinal studies within the companies, impact and improvement could happen for the innovation of the companies and the company's overall benefit. This is in line with the emphasis of previous literature (section 1.1) on the importance of innovation and its measurement for the construction industry.

CIE2 believes that the tool is, from particular aspects, similar to what the New Zealand Inland Revenue Department has adopted for its tax incentive program on research and development. This aspect is exceptionally bold around the distinction they make between core R&D activity, which is planned, intentional R&D, and is performed to resolve uncertainty on one side and to support activities that are not directly resolving uncertainty but are necessary to turn the R&D into something useful. This definition is similar to the definitions engaged in the innovation measurement tool developed for follow-on activities (section 2.10.11) during this research. Literature states that follow-on activities are important for innovation success, although they are not considered in the definition of an innovation activity (OECD/Eurostat, 2018). CIE2 also expressed that he found the tool to be good. He believes that overall, the categories are well thought out and comprehensive.

CIE3 stated that the tool has the potential to be quite useful. With the aim of allowing a wide range of people from different backgrounds, departments and different organisational levels, to understand the definitions used in the tool, CIE3 recommends that while being implemented, the tool can be specifically designed for the needs of each of the companies that are using it.

CIE4 believes that the tool has the potential to be used in the industry. She believes the backbone and the structure of the tool are great. She also believes that there should be a suitable approach adopted to help promote the tool and to be able to accurately collect data. She believes that the accuracy of the input data will determine the accuracy of the output results.

CIE5 believes that the tool is very good. He believes that to achieve a reliable answer, there might be a need for everyone in the company to fill in the questions or at least people from different levels of the organisational structure will be required to respond by filling in the tool.

The insights provided by the Construction Industry Experts (CIEs) in response to this question serve as a critical validation point for the findings from Stage 1 (literature review) and Stage 2 (case studies). The experts' perspectives demonstrate a clear convergence with earlier findings. Through this convergence, the validation reinforces the consistency and robustness of the patterns identified in both the literature and case studies, contributing to a richer triangulated understanding of innovation measurement in New Zealand construction organisations.

5.3.2 Question 2. Can you review and confirm the significance of the identified items for measuring innovation in the construction industry?

Addressing question 2, CIE1 believes that the tool can measure innovation inside the construction companies. He added that the tool includes some general features of a good company that should have also been pointed out. It also includes some of the indicators that support the innovation to go forward. These are the traits required by a company to create new

things. The tool seems to be a sound innovation measurement instrument. The items and questions are related to innovation and are in line with the objectives. CIE1 also added that since the construction industry is very slow and doing poorly in innovation, there is a need to support innovation in the construction industry. This confirms the previous literature (Adafin et al., 2022; Construction Sector Accord, 2023; Ying et al., 2022), which has emphasised the weaknesses of the construction industry on innovation (discussed in sections 1.2.2 and 1.2.3). The need for supporting innovation has also been emphasised in previous literature by Chen and Chang-Richards (2022), emphasising on the significance of understanding the practical needs and motivations behind innovation adoption in New Zealand's construction industry (section 1.2.1). It is extremely important to highlight the items of the tool to further support innovation.

CIE2 believes that having clearly defined and useful definitions will allow for the collection of consistent answers. This matter was addressed during this research to reach a standard definition for innovation and to encompass a vast range of definitions from the extant literature. Therefore, the definition given by the Oslo manual 2018 (OECD/Eurostat, 2018, p. 246) was chosen (section 2.3). To also reach clearly defined and useful definitions for the tool items, a process of expert-informed thematic categorisation (Naeem et al., 2023; Braun & Clarke, 2021; Terry & Hayfield, 2021) was engaged. This process was presented in chapter 3 (section 3.4.1) of this research. During this process (section 3.4.1.4), carefully chosen names and definitions were assigned to each of the indicators.

CIE2 also believes that the results will demonstrate the areas in which the company is not performing well. Also, since the tool allows many people to participate in data collection, this will facilitate the development of industry benchmarks. This will create competition among different companies. The results will also provide a means to make a comparison between companies and find the strengths and weaknesses of each company. In this scenario, since it will be extremely rare for any company to have the highest score in all the indicators, then the areas that the company requires focus will be highlighted, and this will be the outcome of the case studies on each company. CIE2 eventually reviewed and confirmed the significance of the identified items for measuring innovation in the construction industry. He believes the tool has identified most of the significant categories.

CIE3 agrees that using this tool will allow data on innovation within the construction industry to be more standardised and generalisable to the data from other industries. He believes the developed tool is really good and is necessary. Due to the unique definitions and language engaged in the construction industry, and the difference between the terminology in the industry and academia, there is special attention required to develop a tool that addresses precise terminology (discussed in CIE2's response for this interview question). This will allow the tool to not only be used internally inside the companies, but also to be used for collecting industry-wide data and benchmarking. CIE3 went on to add that the tool is good, and the fact that the tool covers items from different angles is also good.

Similar to the other respondents, CIE4 believes that the tool is relevant to the New Zealand construction industry. There is a need to focus on the way the questions are tailored to specific companies. She believes that the structure of the tool is great and that it can make an impact on the understanding of the respondents. This also helps with the accuracy of the responses. She extremely emphasises the importance of the accuracy of the data being presented by the respondents.

CIE5 also confirms that the tool is quite comprehensive and useful for the measurement of innovation in the construction industry.

The validation provided by the Construction Industry Experts (CIEs) on the significance of the identified items for measuring innovation demonstrates a clear triangulation convergence across the three stages of this research. Their confirmation aligns with the indicators established in Stage 1 (literature review) and the practical insights derived from Stage 2 (case studies), reinforcing the robustness and relevance of these items within the New Zealand construction industry context. This convergence strengthens the credibility of the innovation measurement framework by showing consistency between theoretical foundations, empirical case evidence, and expert industry validation.

5.3.3 Question 3. Is there anything missing that you could think of?

Following the interview protocol (section 3.6) for the open-ended interviews from the construction industry experts, the respondents were asked to see if they could add anything which is not already mentioned in the tool to further refine and strengthen it.

The first item being addressed by CIE1 was problem-solving skills (section 2.9.48) and the emphasis it needs. He believes that since most companies are more reactive than proactive, when they find a problem, they intend to look for ways to solve the problem. This indeed will lead to innovation and is the normal way of making changes in the construction companies. It is worth mentioning that it was pointed out to CIEs during the interview that this indicator was covered under the category of innovation potential Technology (fourth category out of five categories in the innovation potential section of the tool), as the indicator coded Tech2 and named: Problem-solving techniques. This indicator was also discussed in section 2.9.48 of chapter 2. Developing problem-solving techniques is extremely necessary for promoting creativity and innovation (Adeoye & Jimoh, 2023). According to research, problem-solving techniques are extremely valued by employers and can be further improved by adopting different methods, such as brainstorming, root cause analysis, and learning (Aliu & Aigbavboa, 2020; Adeoye & Jimoh, 2023). Therefore, the fact that CIE1 also exceptionally emphasised this indicator confirms and validates its importance. CIE1 went on to add that more focus should be given to technologies like digital technology and automation technology. These are hot topics and can be focused on as a response to today's technological trends. These traits are previously highlighted in the tool as indicators Tech7, described in section 2.9.14, named digital technologies, and indicator Tech5, described in section 2.9.47, named presence of technology (automation technology was one of the technological innovations discussed in section 2.9.47).

CIE2 believes that to further improve the tool, there could be more focus on the details of the leadership. For example, to see if the board members are balanced? Are they experienced? Is their experience just around the construction industry, or are they familiar with other industries as well? Such studies could be performed in later stages to further expand research. Leadership was discussed within the indicator titled upper management support (section 2.9.68) that was coded as indicator Org2 under the second category of innovation potential indicators titled Organisational Structure. Section 2.9.68 emphasised the importance of company leadership and upper management on the innovations of the company (Duarte & Picchi, 2021; Barham et al., 2020; Prokop & Hájek, 2023; Aftab et al., 2022; Hijal-Moghrabi et al., 2020; Rajan et al., 2021).

CIE3 believes that there could be more focus on the budget. Exceptionally, a specific budget for innovation. This is indeed focused on the Business Innovation Score category and can be

even further improved, especially when tailoring a tool for any specific company. For instance, data on the increase in sales (section 2.10.2), or the increase in profits (section 2.10.3) of the company or the profit margin (section 2.10.3) have previously been addressed in chapter 2, addressing stage 1 of the research. Additionally, section 2.10.12 specifically discusses planned innovation activities and expenditures of the company under study. Organisational innovation budget-related indicators were also focused on the innovation potential section of the tool under the fifth category of indicators, as external influences. A number of innovation budget indicators that were during stage 1 of the research were found to be significant and influential for the innovation of the construction companies were external grants (section 2.9.19, coded as Ext20), finances (section 2.9.23, coded as Ext13), high costs (section 2.9.26, coded as Ext8), subsidies (section 2.9.61, coded as Ext19), and tax (section 2.9.65, coded as Ext15). These indicators were also collectively confirmed and validated to be significant for innovation of the construction companies during stage 2 of the research.

CIE3 also emphasised the need to focus on customers. He added that there is a need to understand the customer's needs and pain points. This matter is addressed in stage 1 of the research under the external influences category through multiple indicators and especially through the client's understanding (section 2.9.4, coded as Ext5), and market demand (section 2.9.42, coded as Ext10).

CIE4 recommends that while the tool is being implemented in different companies, tailoring wording specifically to the knowledge level of the employees of that company, and with some examples in the description section, might help particular companies. She stated that "A lot of people in construction companies are not word people, so give really specific examples of what -each indicator- it might look like"

CIE5 believes that when using the tool inside the companies, sometimes we could make the wording specific to that company. This will allow people from different levels of knowledge and experience to be able to participate. He believes the current wording can be eased for less professional employees. He believes that the tool can be further extended to include project-level studies as well. This is part of the attempt to tailor the tools to specific companies and even specific departments, which can be part of the plan to further improve the tool in the future.

The Construction Industry Experts (CIEs) largely confirmed that no significant items were missing from the developed innovation measurement tool, demonstrating triangulation convergence across Stage 1 (literature review) and Stage 2 (case studies). This alignment reinforces that the indicators comprehensively capture the dimensions of innovation measurement relevant to the New Zealand construction industry. This, in turn, validates both the theoretical foundation and the empirical findings of the earlier stages of this research.

5.3.4 Question 4. Would diagnostic be useful? Are the results useful?

In response to question 4, all the construction industry experts who were interviewed were very positive about the results and believed that the results are useful. CIE1 believed that using a mobile app would further ease the use of the tool and would help with the usefulness of the results as well. CIE2 and CIE3 also endorsed the usefulness of the tool. CIE3 further explained that in the long term, the results should set the foundation for further improvement of the company indicators.

Regarding the diagnostic capability of the tool, CIE4 states that the tool has the capability to be used inside companies, which she states, “you've been doing with a few companies”, and the results can be reflected to them. CIE4 also believes that the tool would be useful for New Zealand context.

CIE5 believes the results are very useful, and since they are a visual format, they can be easily understood. The decision makers can easily see and recognise the areas that require further improvement.

Previously in this research, the summary of weaknesses of existing innovation measurement frameworks, tools, and models was presented (section 2.6). It was discussed that there is a gap in innovation measurement literature (section 2.7), and it was found that there is a need for a comprehensive innovation measurement tool for the construction industry (section 2.8). This tool allows for diagnosing innovation-related matters within the construction industry. Through these sections, it was understood that due to the lack of a diagnostic tool for innovation, the study of innovation is negatively affected.

The positive responses from all Construction Industry Experts (CIEs) regarding the diagnostic function and the usefulness of the results demonstrate clear triangulation convergence across the three stages of this research. Their endorsement aligns with the literature review in Stage 1, which highlighted the absence of effective diagnostic tools for innovation measurement (sections 2.6–2.8), and with Stage 2 case study findings that underscored the practical need for a comprehensive and accessible framework. This convergence validates the tool’s capacity to fill the identified gap, confirming that its diagnostic insights are not only relevant but also practical for supporting decision makers in recognising and addressing areas requiring improvement.

5.3.5 Question 5. Would it be useful for a/your company to use this tool?

All 5 CIEs believed that the tool is very useful for construction companies to use. CIE1 believes that this tool could help and benefit companies, especially bigger companies with more resources, to innovate. This matter was previously emphasised in this thesis (section 1.5), and it was mentioned that the focus of this study is on Medium (20 to 49 FTE employees) and large (50 or more FTE employees) construction organisations. It was also emphasised that the reason for this focus is that medium and large companies have a fair foundation and resources to focus on innovation. Therefore, this emphasis by CIE1 on the need for resources for innovation and the availability of these resources in larger construction organisations, once again validates and confirms the decision to focus on medium and large construction organisations for the scope of this research.

CIE2 and CIE3 also believe the tool is useful for the companies, and CIE3 believes that the tool can demonstrate a self-reflection for the companies. CIE4 believes that the tool can test the innovation capability of the companies, and CIE5 also believes that the tool is useful for the companies.

The unanimous agreement among all five Construction Industry Experts (CIEs) on the usefulness of the tool for construction companies demonstrates clear triangulation convergence across the three stages of this research. Their validation aligns with Stage 1 findings, which identified the need for a structured approach to measure and enhance innovation capability, and with Stage 2 case study evidence that highlighted the practical applicability of the tool within real-world organisational contexts. This convergence reinforces the tool’s relevance and

confirms its potential to support companies - particularly those with greater resources - in assessing, reflecting on, and improving their innovation capability.

5.3.6 Question 6. How would you simplify this tool?

In order to simplify this tool and its application, CIE1 suggested making a software from the tool. During stage 1 of this research, digital technologies (section 2.9.14, coded as Tech7) and the presence of technology (section 2.9.47, coded as Tech5) were previously found critical for facilitating and supporting the innovations of a company. CIE1 believes this will encourage participation from a wider audience. The participants could just download the software app and even answer the questions at their convenience. CIE2 believes that to simplify the tool, the tool can be applied in a multi-tiered approach where you first just have a high-level self-assessment, followed by a more detailed guided assessment, followed by a hands-on kind of consulting engagement to raise the level. This will depend on what each needs and the requirements are, and which departments are the ones requiring focus. CIE3 believes that the tool can embed fewer questions. This problem can be addressed by tailoring the tool based on the characteristics of the company under study. CIE4 also believes that the wording can be more specific to suit the needs of the companies. This suggestion is also endorsed by CIE5, where he believes that tailoring the tool to the specific needs of companies can help the response process. This is while the standardised nature of the tool should not be sacrificed. He believes that the tool is really comprehensive, and some items might not be required for small companies and can be taken out of the tool. Indeed, the tool is developed in such a way that allows the results to be published even if the respondent passes on some of the responses.

These insights highlight promising directions for future research, including the development of a digital version of the tool, testing of tiered application models, and further investigation into tailored and sector-specific adaptations, all while maintaining the tool's core standardisation for consistency and comparability across companies.

5.3.7 Question 7. Do you have any further feedback?

All of the respondents were happy with the comments that they had provided for during the interviews and did not think that they needed to make any further comments in response to this question.

5.3.8 Question 8. How would you recommend this tool be implemented in the companies?

In response to question 8, CIE1 further emphasised the need and the benefits of developing a software or a mobile app (application) to facilitate the response process. He believes this will also allow the catchment of further data and more input from the respondents. This app can also allow the decision makers to see the results in real time and as data is being developed. CIE1 also believes that the government (section 2.9.25, coded as Ext18) can potentially support the implementation of this tool into the industry. This can be facilitated through the Ministry

of Housing and Urban Development or the Ministry of Business, Innovation and Employment. The impact that the governments can have on the support for innovation has previously been emphasised and found influential for innovation in stage 1 of this research (section 2.9.25).

CIE2 believes that while implementing this tool, the biggest source of value is construction industry-wide benchmarking information. These benchmarks are developed as the tool is executed with more and more construction companies. One company-specific approach while undertaking any case studies is to give the respondents an open-ended qualitative description of each of these indicators. In the next stage, the respondents will be asked to either self-rate without a scale or eventually self-rate with a scale. This will allow the development of a specific scale for the particular company from the open-ended answers that the respondents give. This method will allow the development of a tool which is familiar to the next participating employees inside the company. The tool and the scale will be further calibrated as the research stage continues, and the company's specific language will be mirrored back to the employees. The possibility of following this process is the unique potential of this innovation measurement tool. Eventually, the benchmarked data will be very beneficial for the use of decision makers, either inside each company or for the industry in general, and that is another unique value of this tool. Further into the company improvement scheme, once the decision makers are aware of the gaps inside the company, special focus and attention can be given to the needs of the company. The benefit of this tool is also that it allows for the development of standardised data through the already developed definitions. This eases the use of the tool by other facilitators who are helping to engage the tool within the companies. CIE2 further believes that even artificial intelligence and chatbots can be incorporated into the data collection process. This will facilitate the process of self-assessment. To conclude, CIE2 approves that these items are relevant and tailoring the tool to the specific needs of the companies can be part of the tool implementation stage for the construction companies.

CIE3 believes that to gain a good response from the implementation of this tool within the companies, the tool needs to be tailored to suit the specific companies' needs and level of communication, which is the norm in the company. At the same time, standardised reporting and generalisability of the responses are also important. Therefore, making sure that the definitions are clarified and that the interpretation of the questions is uniform throughout the investigations is important. Also, there is a need to have follow-up procedures to make sure that the identified company gaps are addressed to have improvement in these indicators in the long term. There needs to be actions, and more innovations need to be produced and measured from the pipeline. Once the company is studied and gaps are identified, there needs to be actions planned and implemented to achieve more innovations. CIE3 also emphasised that to have commitment from the companies to improve their innovation, they need to be convinced that they need to use this tool. They need to see the value of using this tool, and the tool's assessment is a good method to achieve this. Once the decision makers see the gaps and learn how to overcome them, they can plan actions to be more innovative. The impact of decision makers and upper management on the innovation of the company is important and has been extensively discussed previously in stage 1 of this thesis (section 2.9.68, coded as Org2). Additionally, the impact of understanding the innovation activities (section 2.10.9) and the innovation projects (section 2.10.10) of the company was found to be influential for the measurement of innovation.

On the topic of the implementation of the tool, CIE4 believes that companies want to know how they are performing compared to their peers. Therefore, CIE4 recommends benchmarking of data, which allows construction companies that work under a similar sector of the industry to compare themselves with their competitors and peers. For further improvement in implementation, in future iterations, she also promotes the idea of tailoring the wording of the

tool's indicators more specifically to the needs of each sector of the industry. As an example for the architecture companies, more focus is required on their creativity (section 2.9.12) abilities. CIE4 also supports and promotes the idea of commercialising the tool.

CIE5 restated that to get good responses from the case studies, there is a need to tailor the tool for the specific company and perhaps the specific department under investigation. The tool can even be responded to collectively by people from different departments to achieve the most reliable results. Once the data is gathered, there needs to be a strategy in place to address the shortcomings and to aim for more innovation to happen inside the company. To be innovative, it is important to implement a strategy within the organisational to support team expectations for having an innovative culture. Business and organisational strategy-related indicators were categorised under the second category of indicators (out of five) from the innovation potential section of the tool and were found to be significant for the innovations of a company. More specifically, 2 indicators directly address the companies' innovation strategy (section 2.9.59, strategic plan coded as BS1 and section 2.9.60, strategy communication coded as BS2).

CIE5 believes the changes and achievements need to be measured again after a period of time to see the results of the strategies set. This will further strengthen the power of the tool to improve the innovative capability of the companies and will further convince the decision makers to use this tool. CIE5 also mentioned that during the implementation of the tool inside the companies, workshops can be very useful to help the collection of data and to disseminate the requirements of a company to innovate. This is in line with the two indicators of knowledge management (section 2.9.37, coded under Org7) and strategy communication (section 2.9.60, coded under BS2), which were found to be influential for innovation in stage 1 of this research.

The recommendations from the Construction Industry Experts (CIEs) on how the tool should be implemented in companies demonstrate clear triangulation convergence across all three stages of this research. Their emphasis on developing digital applications, leveraging government support, tailoring the tool to company-specific needs, and embedding implementation strategies aligns closely with stage 1 findings that are crucial for fostering innovation. These suggestions also converge with stage 2 case study evidence, which highlighted the importance of the tool's practical adaptability for innovation improvement. This convergence validates the tool's design and reinforces its capacity to be effectively implemented in practice, ensuring that it not only measures innovation but also actively supports companies in embedding strategies that improve their innovative capability.

5.3.9 Question 9. What follow-up procedures would you recommend to further improve the practicality of the tool?

In order to further improve the practicality of the tool, CIE1 believes the tool should be presented to other markets, like the government (section 2.9.25, coded under Ext18). CIE1 strongly believes that the government should enforce any company with more than 300 employees to use this tool. Also, any construction company that involves public interests and/or has a turnover of more than $100 million every year should be obligated to use the tool.

CIE2 believes that measuring innovation on its own cannot be the terminal goal and should be seen as an instrumental goal to reach better outcomes. This is in line with what was previously mentioned in section 1.1 of this research, stating that innovation in the construction industry brings multiple benefits, including competitive advantage, improved performance and productivity, increased quality, better addressed consumer needs, further organisational

improvement, sustainability and efficiency. Innovation also helps with better project management, communication, and design accuracy, while it improves value and decision-making processes in organisations. Innovation also drives growth (section 1.1).

Similar to his response to question 8 during stage 3 of research, CIE2 believes that the biggest source of value for this tool is the benchmarking of the indicators for the industry and defining the standards as the data is collected and more data is accumulated. He also believes that this tool can be used to measure data on the project level, program level or organisational level. This will allow the results and the lessons learned to be transferred from one project to another. This is in line with the significance of knowledge sharing and knowledge management (section 2.9.37, coded as Org7) practices of the companies as found in stage 1 of this research. The application of knowledge management techniques could help support technological innovations and sustainable performance within construction firms (Khan et al., 2024). Additionally, effective knowledge management paves the way for a culture supporting continuous learning and innovative thinking in construction firms (Sergeeva & Duryan, 2021).

Also, according to CIE2, the best practices can be identified and repeated in future projects. CIE2 greatly believes that using consistent and generalisable definitions greatly helps with the benchmarking of data. Finally, CIE2 emphasises that, as a follow-up procedure, companies could be introduced to other service providers to help them improve their score on the indicators that have been identified as needing help and attention.

Based on the comments by CIE3, companies should be studied in longitudinal studies. He believes that to improve the practicality of the tool, there should be actions in place to help the companies achieve higher scores. CIE3 emphasises that there should be special attention to strengthen these scores, and this matter requires actions other than business as usual. This statement confirms the significance of innovation activities (section 2.10.9) and innovation projects (section 2.10.10) for innovation that were highlighted during stage 1 of this research.

CIE4 believes that the main issue to focus on is the way the tool is being communicated to the respondents. There needs to be special attention to the specific way that each of the companies is being addressed with the tool. Therefore, the way that the definitions of the tool are presented and communicated needs to be tailored to the special characteristics of the company. CIE4, similar to other CIEs, believes that benchmarking the data as they are developed and allowing the participating companies to compare their results with other companies through industrial averages can be very beneficial for the practicality of the tool. She also stated that companies want to know how they're performing compared to their peers.

CIE5 emphasised that the outcomes need to be measured in a longitudinal study to see the changes in a periodic way to investigate whether the company has been innovative and whether the performance and productivity of the company have improved.

By reviewing the CIEs' responses to the question on follow-up procedures to further improve the practicality of the tool, it is noticeable that the CIEs demonstrated clear confidence in the developed tool’s strength by offering targeted recommendations for its ongoing enhancement. Their responses validated and reinforced the findings from Stage 1 and Stage 2, creating a strong triangulation across the thesis. This convergence underscores that expert validation has confirmed the tool’s foundation while advancing its practicality and relevance for industry application.

5.4 General Comments on the Validation of the Business Innovation Measurement Tool

During the CIE interviews, the respondents made a number of comments that were found to be constructive towards the improvement of the business innovation measurement tool. These comments were analysed using NVivo and are presented in the following section. All of these comments were taken into consideration, and some of these were implemented into the improvement of the final version of the tool.

CIE1 strongly approved the implementation of a definition for business innovation where both new and improved are engaged. This definition was mentioned on the first page of the tool: "A business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm" (OECD/Eurostat, 2018, p.20). CIE1 also endorses that innovation without previous intention is also considered an innovation. CIE1 also strongly believes that having problem-solving techniques (section 2.9.48, coded under Tech2) amongst employees is important for being an innovative company. He also supports having an indicator on Autonomy (section 2.9.2, coded under WF&HR7) and suggested having *"self-driven"* in the explanation section of this indicator. This was added to the final version of the tool as part of continuous improvement of the tool under the WF&HR7 indicator.

CIE1 also mentioned that the issue of fragmentation (section 2.9.24, coded under Ext6) is very important in the studies related to innovation. Many of the construction companies in New Zealand are small, and this results in them working in fragments, which leads to many issues in the industry. These companies usually do not have the budget, the willingness, or even the time to innovate. CIE1 strongly believes that the size of the company affects its innovation capability (discussed under 1.5, scope of the research). Small and medium-sized companies are more reactive rather than proactive. These small and medium-sized companies just want to put bread on the table and are usually overloaded. They lack a long-term strategy (section 2.9.59) and can only focus on short-term goals (section 2.9.40). These issues are exacerbated while these construction companies are operating under a fragmented type of industry where information is not shared amongst them. Many of the innovations are not passed on from one employee or company to the other (sections 2.9.37 and 2.9.39). These matters were approved by the respondent.

CIE1 also believes that trade associations could have played a decisive role in the communication and interaction amongst employees (section 2.9.37), but this has not been the case. These matters could be discussed under the Government (section 2.9.25) support indicator, which is under the external influences category of indicators. Other indicators were also discussed and endorsed by CIE1 including but were not limited to high costs (section 2.9.26), market demand (section 2.9.42), competition (section 2.9.8), finances (section 2.9.23), jurisdiction (section 2.9.36), infrastructure (section 2.9.29), subsidies (section 2.9.61), external grants (section 2.9.19), contracts (section 2.9.10), tender process (section 2.9.67), and environmental barriers (section 2.9.18). He also agrees that these indicators could play the role of a driver or a barrier. These indicators have previously been discussed under the External Influences category (fifth category of innovation potential section) of this thesis and have been embedded into the tool.

Research indicates that risk-averse behaviour can negatively impact innovation (Ribeirinho et al., 2020) and reduce the likelihood of adopting new technologies and systems (Zhang et al., 2024b) in the construction industry. CIE2 commented that the indicator referring to risk taking (section 2.9.44, Not fearing from risking) can be referred to as risk appetite. CIE2 mentioned that boards of directors, from a governance perspective, are increasingly being encouraged to provide risk appetite statements. So, for instance, a lot of companies are currently doing risk management plans, and it is only just now starting to evolve into a risk appetite statement. According to CIE2, risk management plans seek to identify the risks and quantify how big the impact of the risk is and how big the likelihood of the risk is. Then, based on that classification, they prioritise those risks in terms of managing them. But what they do not say is, to what extent are we willing to take that risk? A risk appetite statement is a formal declaration of how much they fear taking a risk. As part of continuous improvement of the tool, risk appetite was embedded into the final version of the innovation measurement tool inside the explanation for the indicator WF&HR 12, described in section 2.9.44, Not fearing from risking.

CIE3 recommended further emphasis on the different types of technology to further strengthen the technology category (category three under the innovation potential section of the tool). CIE4 had a similar perspective and thinks that being more specific while addressing technology could help further strengthen the tool. She believes that digital technology (section 2.9.14, coded under Tech7) and the integration of digital tools should receive further attention. She reiterated that the construction industry is very poor at technology uptake. So, technology can receive further attention while tailoring the tool for specific companies.

Technology has already received attention, and in this research has been embedded into a separate category of its own while developing the business innovation measurement tool. This is also in line with the existing literature on innovation (sections 2.9.14 and 2.9.47), and the relation between technology and innovation has largely been discussed in the third category of the indicators named *Technology*.

Further attention can also be given in the next iterations of the tool and as part of future research. Additionally, by building the knowledge database while collecting industry-wide data from many companies, and later by defining the industry benchmarks, it is possible to tailor the tool for specific companies and embed further indicators that specifically address the technological needs of that sector of the industry.

5.5 Concluding Summary

This chapter presented the final stage (3) of the research, which evaluated the validity of the innovation measurement tool for New Zealand construction organisations through the perspectives of five Construction Industry Experts (CIEs). Their collective insights validated the tool's relevance, comprehensiveness, and practicality, and offered constructive recommendations for refinement and wider application of the tool. Chapter 5 also addressed objective 4 and sub-question 5 of this research.

The experts collectively confirmed that the tool effectively captures both innovation potential and actual innovation performance within construction firms. They emphasised its usefulness for diagnosing innovation-related gaps, its practicality for supporting benchmarking across the industry, and its capability for providing decision makers with actionable insights for improvement. Their responses demonstrated clear triangulation convergence with findings

from Stage 1 (literature review) and Stage 2 (case studies), and reinforced the tool's theoretical foundation, empirical robustness, and industry relevance.

While the tool was strongly endorsed, the experts also proposed enhancements. These suggestions included the development of a digital platform, a tiered application model, and tailored wording for different organisational levels. They stressed the importance of ongoing refinement through longitudinal studies, benchmarking, and collaboration with government agencies as an attempt to ensure the tool remains practical, adaptable, and impactful for medium and large construction organisations.

Overall, the results of this chapter confirm that the innovation measurement tool is not only a valid instrument for assessing innovation but also a catalyst for embedding strategies that can strengthen the innovative capability of New Zealand's construction industry.

As mentioned in this chapter, based on the results obtained from the construction industry experts, it can be concluded that:

- In-depth analysis of the results obtained from the construction industry experts supports the relevance and the practicality of the innovation measurement tool developed for the New Zealand construction industry.
- All of the respondents reviewed and confirmed the significance of the identified items for measuring innovation in the construction industry.
- All of the construction industry experts who were interviewed were very positive about the results and believed that the results are useful.
- All of the interviewed CIEs believed that the tool is very useful for construction companies to use.

As previously indicated (section 3.6), for the third stage of the research, to form the third angle of a triangulation approach, five interviews were conducted with construction industry experts who had previous experience relevant to the research. This allowed for the validation and further refinement of the business innovation measurement tool that was developed in stage 1 of this research and was industry tested and refined during stage 2 of the research. By reaching a point of saturation on the data that was being given by the respondents, based on the criteria mentioned in the methodology chapter (section 3.14), eventually the tool was validated, and the interviews were considered sufficient. This third stage, which validated the findings of this research, developed the confidence for the final publication of the Business Innovation Measurement Tool, tailored for New Zealand's Medium and Large construction companies.

Chapter Six: Discussion

6.1 Introduction

This thesis presents the process that was followed for measuring innovation in New Zealand construction organisations: developing a measurement tool for medium and large companies. The main aim of this research was to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand. This tool facilitates the identification and enhancement of innovation capabilities, addressing the current gaps in innovation measurement practices within the construction industry.

As a result of conducting this research, the aim and objectives were achieved (section 1.3). It is expected that by implementing the developed tool in construction companies, there will be a better understanding of the requirements for innovation, and more innovations will happen in the coming years. During this research, an understanding of the current literature on innovation measurement in construction was achieved. A holistic and diagnostic tool was developed for measuring innovation within the New Zealand construction organisations. The tool was tested within the New Zealand construction organisations. The validity of the measurement tool was evaluated. In the previous chapters of this thesis, information on innovation measurement, diagnostics and advice for improving the innovation measurement indicators within the New Zealand construction organisations was provided to some extent. This is further addressed in this chapter and the final (Conclusion) chapter. As a result, innovation and the measurement of innovation within the New Zealand construction organisations will be improved.

This developed tool is made up of two major sections. The first section measured the potential of innovation in the company, and this was done by measuring the 5 categories that are presented below:

- Workforce Skills and HR Management consisting of 16 indicators
- Organisational Structure consisting of 9 indicators
- Business Strategy consisting of 9 indicators
- Technology consisting of 7 indicators
- External Influences consisting of 27 indicators.

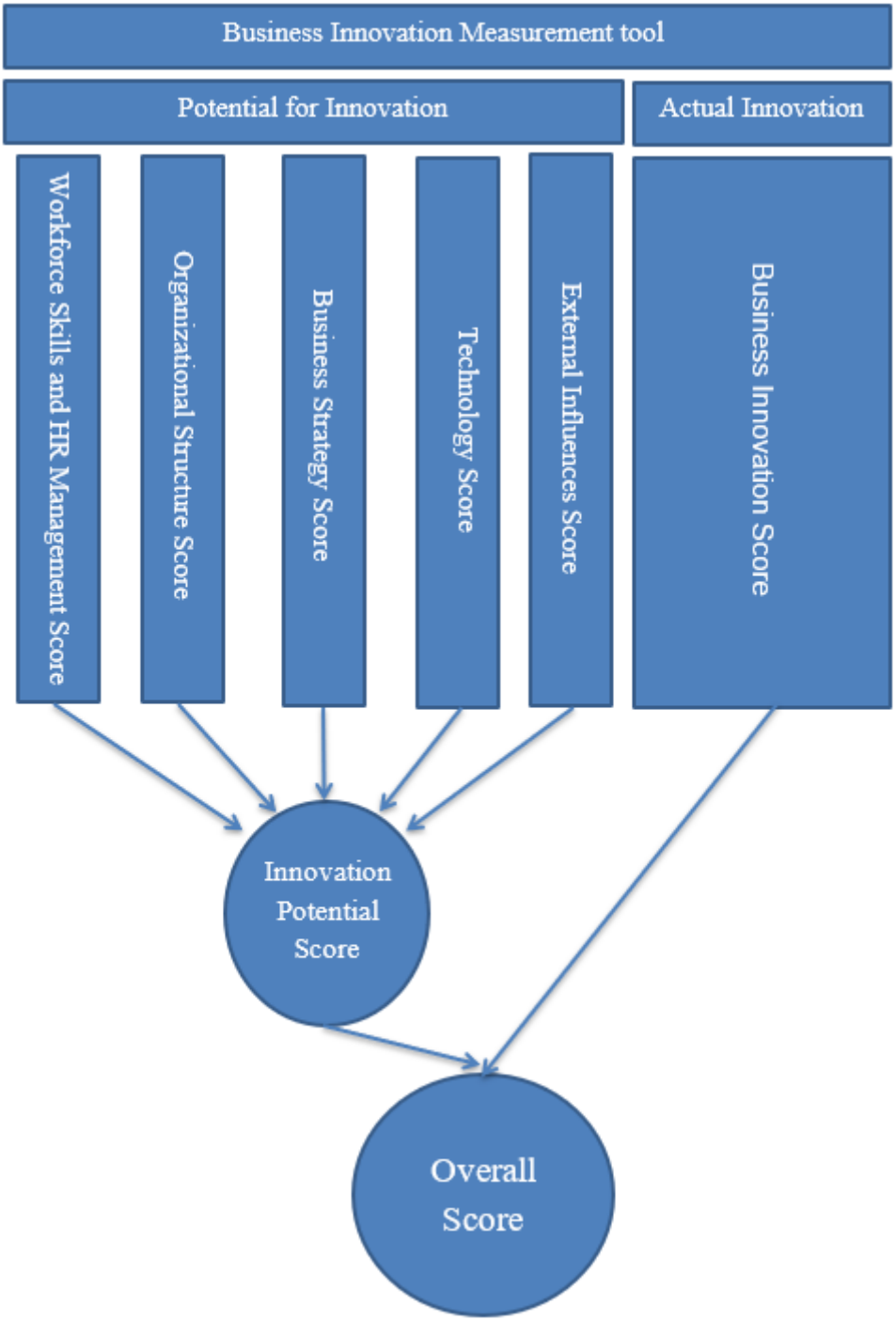
In chapter 4 (sections 4.3.2 and 4.5.2), the results for each company are presented separately for each indicator, and the mean scores for these 5 categories form the Innovation Potential Score for the company. Through this research (sections 4.3.5 and 4.5.5), it was found that the indicators that make up these categories were found to be valid and that the respondents agreed on the importance and usefulness of the indicators. During the interviews with the construction industry experts (CIEs), the respondents reviewed and confirmed the significance (section 5.3.2) of the identified items for measuring innovation in the construction industry.

The innovation measurement tool is followed by presenting 36 questions that collectively measure the actual innovation of the case company under investigation. This score is known as the Business Innovation Score of the company. Finally, the Overall Score of the company is

produced as the average of potential and actual scores measured through answering the questions of the Business Innovation Measurement (Potential + Score) of the company. These sets of questions were later followed by two sets of questions on the General Resources of the company, and on the Demographic Questions. These sets of data can be helpful in better understanding the company under investigation, but it needs to be mentioned that these data were not used for the achievement of the objectives of this research and therefore were only collected but were not analysed in any way. This data was not part of the purposeful sampling criteria (section 3.10) for the sample selection during this research. Through this research (sections 4.3.5 and 4.5.5), it was found that these indicators were valid and that the respondents agreed on the importance and usefulness of the indicators. During the interviews with the CIEs, the respondents reviewed and confirmed the significance (section 5.3.2) of these identified items for measuring innovation in the construction industry.

The following figure is a graphical representation of the Business Innovation Measurement Tool, which was developed in this research and depicts the basis for the achievement of the Overall Score:

Figure 6.1: Business Innovation Measurement Tool



The developed tool has the capability of instantly generating results once the scores are entered for the questions. These scores are based on the answers provided by the respondents. Not only could the results be analysed and the company gaps and flaws, and even capabilities and potentials can be discussed individually for each company, but also the results for each company could be compared with other companies either for each indicator or collectively for a chosen set of indicators or even categories. This analysis can help diagnose the deficiencies and help the companies improve. Additionally, the industry averages/benchmarks can be populated and used as a basis for the support and improvement of innovation within the New

Zealand construction industry. This Business Innovation Measurement (Potential + Score) tool is presented in Appendix 2 of this thesis. This tool was initially developed in stage one of this research and further refined, improved and validated through the second and third stages of this thesis. The three stages of this research have previously been presented extensively in the relevant chapters 2, 4 and 5, respectively.

6.2 Research Discussion

In this section of Chapter 6, the results and achievements of the research will be discussed. Key findings in relation to the research topic are further discussed. Additionally, the research results are interpreted, assessed and compared to the existing research that has been presented earlier in this thesis (stage 1, presented in chapter 2). How the research contributed towards the achievement of the research aims and objectives is discussed.

As previously mentioned in section 1.3.1, this research aims to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand. To achieve this aim, the research pursued 5 objectives. These objectives were presented in section 1.3.2 of the thesis. The mentioned objectives were fulfilled by conducting the methodology adopted in this research. This process was described in Chapter 3 of the thesis.

6.2.1 Discussion of the Results from the Responses to the Tool's Indicators (Innovation Potential)

As previously explained in Chapter 3, this research adopted a three-stage sequential exploratory mixed methods design (section 3.3) for the aim of triangulation (section 3.7). The first stage of research (section 3.4, presented in chapter 2) contributed towards understanding the literature on innovation measurement in construction. Additionally, in this stage, an attempt was made to gather a number of indicators and questions using previously published research. These materials were used to develop a tool for measuring innovation in the construction organisations. During the second stage of this research (section 3.5, presented in chapter 4), this tool was tested on two case study companies, each with 5 respondents, totalling 10 respondents. This allowed for gaining feedback from respondents, refining, and further developing the tool. For the third stage of this research (section 3.6, presented in chapter 2), the tool was eventually shared with the construction industry experts to gain their feedback, further develop the tool and validate the findings of stages 1 and 2 of this research by completing the third side of the triangulation method.

As stated in Table 4.40, CS2 scored a higher score in all but one of the Innovation Potential categories. This is while both companies had a very close score for their Business Innovation Score. These scores were extensively discussed in sections 4.3, 4.5 and 4.6 of this thesis. The three-stage research proved to be a good choice as it allowed for the collection of sufficient data around the matters relating to the development of the tool. It also allowed for the diagnosis of the issues that needed attention and the matters that represent the strength factors of the companies that were under investigation.

The results of the three stages of this research led to the development of a comprehensive list of indicators that allow measurement of innovation in medium and large construction companies of New Zealand. Previous publications on innovation, as presented in chapters 1 and 2, each tend to focus on several indicators in isolation from other important indicators. Therefore, the contribution made by this thesis to the field of research is the comprehensiveness of the tool that was developed.

6.2.1.1 Innovation Potential - Workforce Skills and HR Management

In the workforce skills and HR management category, CS1 achieved an overall score of 3.5 (section 4.3.2.1) while CS2 scored 3.6 (section 4.5.2.1). CS2 achieved a high score for Cognitive abilities (section 2.9.9), Commitment (section 2.9.6), and Partnerships (section 2.9.46). This is while CS1's score was negatively affected by Autonomy (section 2.9.2), R&D capability (section 12.9.53), Creativity (section 2.9.12), External involvement (section 2.9.20) and Innovation non-resistance (section 2.9.33). It can be concluded that, consistent with the findings from the first stage, literature review (section 2.9) of this research, these indicators play an important role in the innovative capability of the construction companies.

During the three stages of the research, it was found and validated that the 16 indicators that make up the Workforce Skills and HR Management category of the innovation potential and eventually the overall innovation score, were in fact significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.9) and supports the initial findings by the research that were presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for diagnosing the potential of the construction companies to innovate [by using their workforce skills and HR management category's capabilities]. They stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the indicators of Cognitive abilities (section 2.9.9), Adaptability and flexibility (section 2.9.1), Social skills (section 2.9.), Systems skills (section 2.9.64), Entrepreneurialism (section 2.9.17), Creativity (section 2.9.12), Autonomy (section 2.9.2), Collaboration (section 2.9.5), Partnerships (section 2.9.46), Commitment (section 2.9.6), Innovation non-resistance (section 2.9.33), Not fearing from risking (section 2.9.44), Employee performance (section 2.9.15), External involvement (section 2.9.20), R&D capability (section 2.9.53), and Communication (section 2.9.7) are in line with the previous literature presented in chapter 2 (sections stated respectively). These indicators were previously presented in Table 2.13 of this thesis, together with their sources in extant literature.

6.2.1.2 Innovation Potential: Organisational Structure

On the organisational structure category, CS1 achieved an overall score of 3.24 (section 4.3.2.2) while CS2 scored 3.91 (section 4.5.2.2). CS2's high score was mainly due to its high scores for Organisational support (section 2.9.45), Upper management support (section 2.9.68),

and the presence of an Innovation Champion (section 2.9.31). While CS1's lower score was mainly due to its relatively lower score for the presence of an Innovation Champion (section 2.9.31), Incentives (section 2.9.28), Lessons learned (section 2.9.39), and Career development (section 2.9.3). Achieving a higher score in the mentioned indicators would have eventually led to a better score for CS1 in its Overall Score - Business Innovation Measurement (Potential + Score). These results are in line with the previous findings of stage 1, literature review (section 2.9), indicating the importance of these indicators for innovation and its measurement.

During the three stages of the research, it was found and validated that the 9 indicators that make up the Organisational Structure category of the innovation potential and eventually the overall innovation score, were in fact significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.9) and supports the initial findings by the research that were presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for diagnosing the potential of the construction companies to innovate by using their Organisational Structure category's capabilities. They also stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the indicators of Organisational support (section 2.9.45), Upper management support (section 2.9.68), Innovation Champion (section 2.9.31), Recruitment policies (section 2.9.52), Employee recognition (section 2.9.16), Incentives (section 2.9.28), Knowledge management (section 2.9.37), Lessons learned (section 2.9.39) and Career development (section 2.9.3) are in line with the previous literature presented in chapter 2 (sections stated respectively). These indicators were previously presented in Table 2.13 of this thesis, together with their sources in extant literature.

6.2.1.3 Innovation Potential: Business Strategy

On the business strategy category, CS1 achieved an overall score of 3.5 (section 4.3.2.3) while CS2 scored 3.87 (section 4.5.2.3). This difference in the score was mainly the result of a higher score by CS2 for Strategic Plan (section 2.9.59), Strategy communication (section 2.9.60), Progress monitoring (section 2.9.50), Innovation Strategy (section 2.9.34), and In-house sourcing (section 2.9.27). While the low score for CS1 was mainly related to Strategy communication (section 2.9.60), Progress monitoring (section 2.9.50), Innovation Strategy (section 2.9.34), Multiple market focus (section 2.9.43), In-house sourcing (section 2.9.27) and Lifecycle focus (section 2.9.40). It is now evident that the previously stated literature in stage 1 of this research (section 2.9) on innovation measurement was correct in emphasising the importance of these indicators for innovation measurement.

During the three stages of the research, it was found and validated that the 9 indicators that make up the Business Strategy category of the innovation potential and eventually the overall innovation score, were in fact significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.9) and supports the initial findings by the research that was presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for diagnosing the potential

of the construction companies to innovate [by using their workforce skills and Business Strategy category's capabilities]. They also stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the indicators of Strategic Plan (section 2.9.59), Strategy communication (section 2.9.60), Progress monitoring (section 2.9.50), Innovation Strategy (section 2.9.34), Finish price focus (section 2.9.21), Quality focus (section 2.9.22), Multiple market focus (section 2.9.43), In-house sourcing (section 2.9.27) and Lifecycle focus (section 2.9.40) are in line with the previous literature presented in chapter 2 (sections stated respectively). These indicators were previously presented in Table 2.13 of this thesis, together with their sources in extant literature.

6.2.1.4 Innovation Potential: Technology

In the technology category, CS1 achieved an overall score of 3.14 (section 4.3.2.4) while CS2 scored 4.06 (section 4.5.2.4). The main reasons for this relatively high difference in the score of the two companies in this category lie in the overall perception of the managers towards technology. As previously diagnosed (section 4.3.3.4), CS1 collectively has a somewhat negative perception towards technology and especially the cost of technology. On the opposite side, CS2 welcomes technology (section 4.5.3.4). This is also reflected in CS1's 2.8 score for Innovation awareness (section 2.9.30), whereas CS2 scores 4.0 for this indicator. CS1 scored low for just about every indicator for this category, including Problem-solving techniques (section 2.9.48), Innovative designers (section 2.9.35), and Presence of technology (section 2.9.47). The score was exceptionally low for Innovation awareness (section 2.9.30), Design capabilities (section 2.9.13), Presence of technology (section 2.9.47), Technical expertise (section 2.9.66), and Digital technologies (section 2.9.14). This is while CS2 scored a high score of 4.4 for Presence of technology (section 2.9.47) and Technical Expertise (section 2.9.66). These matters reflect the potential of CS2 for innovation. It can be concluded that, consistent with the findings from the first stage, literature review (section 2.9) of this research, these indicators play an important role in the innovative capability of the construction companies.

During the research, it was found and validated that the 7 indicators that make up the Technology category of the innovation potential and eventually the overall innovation score, were in fact significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.9) and supports the initial findings by the research that were presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for diagnosing the potential of the construction companies to innovate [by using their Technology category's capabilities]. They additionally stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the indicators of Innovation awareness (section 2.9.30), Problem-solving techniques (section 2.9.48), Innovative designers (section 2.9.35), Design capabilities (section 2.9.13), Presence of technology (section 2.9.47), Technical expertise (section 2.9.66), Digital technologies (section 2.9.14) are in line with the previous literature presented in chapter 2

(sections stated respectively). These indicators were previously presented in Table 2.13 of this thesis, together with their sources in extant literature.

6.2.1.5 Innovation Potential: External Influences

On the external influences category, CS1 achieved an overall score of 3.63 (section 4.3.2.5) while CS2 scored 3.36 (section 4.5.2.5). This is the only category out of the five categories of the innovation potential section where CS1 achieved a higher score. This is due to findings that CS1 has been handling the outside company influences better. It should be noted that CS1 is a relatively smaller company operating in the prefabrication sector of the construction industry. This is while CS2 is a larger company, operates mostly as a main contractor, and deals with a different nature of the outside organisational world. To have a better insight, it is evident that the labour market (section 2.9.38) has had a negative impact on CS2. CS2 is not happy with the level of expertise that the contractors (section 2.9.11) have been demonstrating. The Fragmentation (section 2.9.24) of the construction industry has had an unpleasant effect on CS2. To add to this matter, Project-baseness (section 2.9.51) of the construction industry is not something that has been helpful with the goals of CS2. The current high costs (section 2.9.26) in the market are negatively affecting CS2's projects. Their clients (section 2.9.4) have not been demanding innovation (section 2.9.32). Interestingly, both companies are unhappy with Markets for finance (section 2.9.23), Regulatory and enforcement framework / Jurisdiction conditions (section 2.9.36), Tax system Infrastructure (section 2.9.65), Macroeconomic policy (inflation, exchange rates, consumer demand etc.) (section 2.9.41), Government support for innovation (section 2.9.25), public support through subsidies (section 2.9.61), Rewards, awards, grants, funds etc (section 2.9.19) and Current forms of contract (section 2.9.10). It seems like CS1 is dealing with the tender process (section 2.9.67) much better. It is worth noting that CS1 is enjoying lower competition (section 2.9.8) from rivals in its sector, and although competition is a leading indicator for innovation, CS1 has greater leverage when negotiating prices with clients. In the other company, CS2 needs to bid lower in the tenders, and its tender processes (section 2.9.67) might negatively affect its ability to innovate. The society (section 2.9.57) has had the same impact on both companies, and it is neither positive nor negative (Neutral towards positive). When compared to CS2, CS1 has had a relatively negative experience around social responsibility (section 2.9.55), Natural and environmental sustainability (section 2.9.63) conditions and changes, and around the extent that CS1's response to environmental changes (section 2.9.54) affects CS1's innovations (idea generation). This is while environmental (section 2.9.18) factors have created a lower barrier for innovation in CS1 than for CS2. This means that CS2's innovations are more affected by environmental factors than CS1's. These results are in line with the previous findings of stage 1, literature review (section 2.9), indicating the importance of these indicators for innovation and its measurement.

During the three stages of the research, it was found and validated that the 27 indicators that make up the External Influences category of the innovation potential and eventually the overall innovation score, were in fact significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.9) and supports the initial findings by the research that were presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for diagnosing the potential of the construction companies to innovate [by using their External Influences category's

capabilities]. They also stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the indicators of Product markets (section 2.9.49), Labour market (section 2.9.38), Contractor's expertise (section 2.9.11), Innovation demand (section 2.9.32), Client's understanding (section 2.9.4), Fragmentation (section 2.9.24), Project-baseness (section 2.9.51), High costs (section 2.9.26), Suppliers (section 2.9.62), Market demand (section 2.9.42), Competition (section 2.9.8), Standards (section 2.9.58), Finances (section 2.9.23), Jurisdiction (section 2.9.36), Tax (section 2.9.65), Infrastructure (section 2.9.29), Macroeconomy (section 2.9.41), Government (section 2.9.25), Subsidies (section 2.9.61), External grants (section 2.9.19), Contracts (section 2.9.10), Tender process (section 2.9.67), Society (section 2.9.57), Social responsibility (section 2.9.55), Sustainability (section 2.9.63), Response to Environment (section 2.9.54), Environmental barriers (section 2.9.18) are in line with the previous literature presented in chapter 2 (sections stated respectively). These indicators were previously presented in Table 2.13 of this thesis, together with their sources in extant literature.

6.2.2 Discussion of the results for the Business Innovation Score (Actual Innovation)

On the business innovation score category, CS1 achieved an overall score of 2.89 (section 4.3.4 and 4.6.2) while CS2 scored 2.87 (section 4.5.4 and 4.6.2). It is quite interesting to see the score for the output of innovation being the same for both companies. The respondents from CS1 were quite positive about the innovation output in their company. This is while during the interview, the respondents from CS1 highlighted many factors that need focus in order to see improvement in the innovation potential of CS1.

On the other hand, the respondents in CS2 were very confident in the innovation potential of their company and contrary to that, they were not happy with the level of innovations that were happening in CS2. They mentioned many factors, and mainly, the lack of a measurement tool and documentation were the reasons for the respondents from CS2 giving low scores to the indicators of business innovation.

When analysing the score of the two companies in this category, it is interesting to see that both companies achieved a similar score for many of the questions/indicators (section 4.6.2). They achieved different scores for BI 5, which means that CS1's increase in sales due to innovations (section 2.10.2) is less than CS2's. The same is correct for an increase in profits (BI 6, section 2.10.3). This is while CS1's market share of the firm's product innovations out of all sales in the market for similar products is higher than for CS2 (BI 8, section 2.10.4). Interestingly, the respondents of CS2 were unhappy and gave a low score to the distribution and logistics (BI 10, section 2.10.5) of their company. This is while CS1 scored a relatively better score for this indicator. Also, CS1's business process innovations resulted in a higher increase in sales when compared to CS2 (BI 15, section 2.10.5). It was found during the case studies that during the past year, the Research and experimental development (R&D) activities (BI 20, section 2.10.9) and Engineering, design, and other creative work activities (BI 21, section 2.10.9) of CS2 were higher during the past year than CS1. Also, Employee training activities (BI 24, section 2.10.9) were higher in CS2. But interestingly, software development and database activities (BI 25, section 2.10.9) and activities related to acquisition or lease of

tangible assets (BI 26, section 2.10.9) were higher for CS1 than CS2 during the past year as the observation year.

Other outstanding scores were the number of ongoing innovation projects at the end of the past year (BI 31, section 2.10.10), where CS2 had a higher number of projects. Also, Follow-on activities like follow-on marketing/promotions/sales/advertising/fairs/distribution, etc. (BI 32, section 2.10.11), where CS1 was more successful than CS2 in this indicator. CS2 was more successful in other follow-on activities like follow-on training related to the use of innovations during the past year / familiarising users with a firm's innovations (BI 33, section 2.10.11). While CS1 performed better at after-sales services/maintenance/operations management/utility improvement/installation/updating/repair services/guarantee/return schemes/information services/communication, etc. (BI 34, section 2.10.11). CS2 has a higher planned annual innovation expenditure for the next two years (BI 35, section 2.10.12), while the expenditure planned accounts for a higher percentage of CS1's total expenses (BI 36, section 2.10.12) when comparing this percentage to CS2's figures. This indicates that even if larger companies invest a lower percentage of their expenses/capital on innovation, in reality, they have an upper hand in their capital power to innovate or invest in innovation.

During the research, it was found and validated that the 36 questions that make up the Business Innovation Score and eventually the overall innovation score of the construction companies were, in fact, significant for the measurement of innovation in the construction industry. This is in line with the findings of the literature (section 2.10) and supports the initial findings by the research that were presented in chapter 2. The respondents during the case studies (sections 4.3.5 and 4.5.5) and the CIEs during their interviews (section 5.3) stated that these indicators are useful and relevant for measuring innovation in the construction industry. The respondents stated that using these indicators would be useful for measuring the innovations of the construction companies [by using their Business Innovation Score (Actual Innovation) category's questions]. They also stated that these indicators are useful for their company's use and that the results are consistent with the reality of their companies.

Therefore, it can be concluded that the results achieved from the three stages of this research indicates that the 36 questions of the Business Innovation Score (Actual Innovation) category are in line with the previous literature presented in chapter 2 (section 2.10). The sources for these indicators from the extant literature were previously presented in Table 2.14 of this thesis.

6.2.3 Discussion of the Findings from the Case Studies

Using the developed business innovation measurement tool during the two case studies (stage 2 of research presented in chapter 4) proved to be very useful. It allowed for the diagnosis of the potentials and deficiencies of the study cases. The tool allowed for not only the collection of quantitative data from the respondents, but it also initiated discussions that were found crucial for the analysis of the company characteristics. Discussions took place both during the time that the case company's interviewees were responding to the tool's questions and further during the responses that the interviewees provided for the interview questions. These results are presented and analysed in-depth in this thesis (sections 4.3.3, 4.3.4, 4.3.5, 4.5.3, 4.5.4, 4.5.5). What follows is the discussion of the findings from these case studies. These findings directly address objective 3 and contribute towards the fulfilment of objectives 2 and 5 of this research.

6.2.3.1 Discussion of the Findings from Case Study 1

Through the diagnosis of the results from case studies (stage 2 of research presented in chapter 4), during section 4.3.3.1 (Diagnostic Insights - Workforce Skills and HR Management), it was found that CS1 uses employees from different levels of knowledge and expertise. At CS1, there are employees who took on the role of innovation champion, and this shows more potential towards the indicators of this category than others. The dominant mindset at CS1 is that if they are going to use extremely qualified, then they will have to pay more, and this is not what they have in their strategies. CS1 also has some processes going on to manage communications, workforce skills and human resources. Also, CS1 has admitted to having problems aligning the employees into a common direction when aiming for a common goal. It was also found that there is high consent over employee performance (cost reduction, productivity, effectiveness). There is the belief that they have invested in this regard, and this is the result of the previous attention received.

CS1's employees believed that there is a low potential for research and development in the company. It was evident that CS1 depends highly on external sources for knowledge and innovative ideas. They also prefer to use external resources for the Research and Development of the company.

Confirming the findings from stage 1 of the research (as indicated here in the section numbers from chapter 2), in section 4.3.3.2 of the research (Diagnostic Insights - Organisational Structure), it seemed as if CS1 has a good approach towards their organisational structure. It was additionally found that there is still room for improvement in this category of indicators. One of the problems is the limited amount of budget that they have, and this is a matter which definitely relates to the size of the company. During the CS1 process, it was found that there is a focus required for matters relating to knowledge management (section 2.9.37) and lessons learned (section 2.9.39) from the organisational structure category. It was also found that there have been good incentives (section 2.9.28) programs within CS1. In regard to other knowledge management practices, CS1 implements knowledge management (section 2.9.37) practices as well. CS1 has created an operational manual in an attempt to develop a structure and improve the organisational system and structure. This will allow for a common understanding of the organisational structure, goals, and strategies. Eventually, this will lead to more systematic innovations within the company. It was also found that CS1 needs to invest more in matters related to communication (section 2.9.7). Similarly, there is a high trust amongst the employees towards the management of the company and exceptionally towards the CEO (section 2.9.68).

Extending the findings from stage 1 of the research (as indicated here in the section numbers from chapter 2) in section 4.3.3.3 of the research (Diagnostic Insights - Business Strategy), it was understood that within CS1 there is also a good strategy in place and that collaboration (section 2.9.5) exists towards having a common understanding and to improve the business strategy of the company. There is also the belief that the strategic plan (section 2.9.59) is well established but is not being communicated (section 2.9.60) well enough to the employees. Also, the CEO of the company demonstrates a long-term strategic perspective towards the strategy of the company (section 2.9.59). Regarding the quality of the houses built by CS1, it was found that the company has a huge focus on quality (section 2.9.22). Regarding the strategic plan (section 2.9.59) of the company, it is evident that there is a high focus on it inside CS1.

Reinforcing the findings from stage 1 of the research (as indicated here in the section numbers from chapter 2) in section 4.3.3.4 of the research (Diagnostic Insights - Technology), it was

evident that there is the belief inside CS1 that since CS1 is made up of a small team, this is making harder to find resources and finances (section 2.9.23), including human resources to pursue technological advances. This is while there are employees in the company who are extremely qualified. It is a norm in CS1 to look for innovative solutions and use different tools for problems and matters. Additionally, if any employee has proposed any solution that has led to cost reductions or the minimisation of time for the project, there could be bonuses given to that employee as an incentive (section 2.9.28) to motivate future suggestions. Unfortunately, it was found that the manufacturing team is not comprised of skilled labour (section 2.9.64). Therefore, any attempt to have the manufacturing team achieve a technical task is most likely going to end in failure. It was further found that there is a belief that technology is the foundation of innovation, and if someone can get it right, it will lead to profit. In CS1, there is the belief that the profit gained through technology can be used to further support technology, innovation, and the development of the company. There is also the emphasis that the finished price should not be the focus (section 2.9.21) of the company, and good quality (section 2.9.22), healthy, fast, and sustainable (section 2.9.63) housing should be the main focus of the company.

The CEO of CS1 believes that the company is still low in the technology sector, but they are deliberately low. He is aware that the company needs to improve in this category. It was found that the company is a recent set-up and that the high cost (section 2.9.26) of technology is the reason they have decided not to invest too much in technology. Additionally, findings indicate that they have a strategy to keep the tasks manual and that technology is deliberately kept low in the company.

Converging with the findings from stage 1 of the research (as indicated here in the section numbers from chapter 2), in section 4.3.3.5 of the research (Diagnostic Insights – External Influences), it was evident that the overall attitude of the employees towards the external factors was positive. So, it could be seen that CS1 has been able to handle the impacts of the external factors to a great extent. As a result, external factors won't affect the company's performance or the innovation of the company. Based on the findings, market demand (section 2.9.42) is not affecting the company CS1, but the competition (section 2.9.8) in the market has definitely affected the company. Additionally, it was found that in recent years, the company has been affected by the impact of COVID-19.

Confirming the findings from stage 1 of the research (as indicated here in the section numbers from chapter 2) further results from section 4.3.3.5 of the research (Diagnostic Insights - External Influences), revealed that there is unsatisfactory in the company with the markets for finance (section 2.9.23), the government support towards innovation (section 2.9.25), public support through subsidies (section 2.9.61) and external grants as in rewards, awards, grants, funds etc (section 2.9.19). On the other side, in addition to the above-mentioned, the employees were happy with the following indicators and gave them a score of 4 indicating that the impact if these indicators on the company and its innovation are positive: Contractor's expertise (section 2.9.11), Innovation demand: Market/owner/client demand for innovation (section 2.9.32), Fragmentation: Fragmented nature of the construction industry (section 2.9.24), High costs: Affecting High cost of projects (section 2.9.26), Suppliers: Goods and services suppliers (section 2.9.62), Market demand: Structure of market demand (section 2.9.42), Competition: Competition in the market (section 2.9.8), Tender process (section 2.9.67), Society: Society's attitude towards innovation (section 2.9.57), Social responsibility (section 2.9.55), Sustainability: Natural and environmental sustainability conditions and changes (section 2.9.63), and Response to Environment: Natural and environmental sustainability conditions and changes (section 2.9.54).

Corroborating the findings identified in Stage 1 of the research (as indicated here in the section numbers from chapter 2), there was also satisfaction around the impact of Standards/Codes (industry-wide co-ordination) (section 2.9.58) on the company's innovation capabilities and the company's overall performance. As previously mentioned in section 4.3.3.5 of the research (Diagnostic Insights - External Influences), there seems to be a constructive approach in place within CS1 for the management of the impact of external factors on the company. This means that the company and its plans are not affected by the outside-company factors. This leads to the success of the company, its plans and consequently, its innovations. External factors have not only not impacted the company, but in many cases, they have worked in favour of CS1 and its plans. As a result, it is understood that the indicators that are mentioned under category 5 of the innovation measurement tool (External Influences) have been working in favour of the innovations of CS1.

During the first case study, CS1, the following information was also found and presented in section 4.3.4 (Diagnostic Insights – Business Innovation Score for CS1): Data suggest that the company's innovative goods during the last year were "moderate to high" (BI 1, Table 4.8, and section 2.10.1**)**. The analysis identifies that the company's innovative services (BI 2, Table 4.8 and section 2.10.1**)** during the last year were "moderate to high" but closer to the "high" range. Research found that the company had produced "6 to 8" innovations during the past year (BI 3, Table 4.8 and section 2.10.1**)**. It was also understood that 41% to 60% of the company's sales are related to product innovations (BI 4, Table 4.8, and section 2.10.2**)** that have taken place inside the company. Data also suggest that 21% to 40%, somewhere around the 30% mark, was the impact of the company's product innovations on an increase in sales (BI 5, Table 4.8, and section 2.10.2**)**. The importance of these indicators for innovation and their measurement has been previously emphasised in their respective sections during stage 1 of this research (as indicated here in the section numbers from chapter 2).

Diagnosing the insights from CS1 (section 4.3.4) also revealed that the company's product innovations accounted for an increase in the profits of 21% to 40% (BI 6, Table 4.8, and section 2.10.3**)**. It was also understood that 21% to 40% was the average profit margin for CS1's product innovations (BI 7, Table 4.8, and section 2.10.3**)**. Based on the findings from CS1, it was concluded that amongst all similar products, CS1 has been able to achieve 21% to 40% of the market share (BI 8, Table 4.8, and section 2.10.4**)**. Further analysis of the responses in section 4.3.4 indicates that the respondents gave the average score of 3.15 to the set of indicators under sections 2.10.5 (Innovation outcomes: Processes, BI 9 to BI 15, Table 4.9) and 2.10.6 (Operational costs and process innovations BI 16, Table 4.9). The analysis also identifies that the business process innovations of CS1 resulted in 41% to 60% increase in sales (BI 15, Table 4.9, and section 2.10.5**)**. Findings also revealed that the business process innovations of CS1 resulted in 21% to 40% reduction in operational cost (per unit of output / per operation) (BI 16, Table 4.9, and section 2.10.6**)**. Further, during section 4.3.4, it was found that CS1 has been "Moderate" for Novelty, Innovativeness, and Economic impact (BI 17, BI 18, BI 19, Table 4.10, and section 2.10.7**)**. Based on the findings in section 4.3.4, it was also concluded that CS1 has been "An innovative firm" and "An innovation-active firm" during the past one year (Question e, Table 4.11, and section 2.10.8**)**. CS2 achieved an average score of 3.05, which is *"Moderate"* for its Innovation Activities set of indicators (BI 20 to BI 27, Table 4.12, and section 2.10.9). Further, it was found that in CS1, "2 to 5" innovation projects were undertaken during the past year (BI 28, Table 4.13, and section 2.10.10**)**. Another finding was that in CS1, "1 to 2" innovation projects were completed during the past year (BI 29, Table 4.13, and section 2.10.10**)**. Data also suggest that in CS1, "0" projects were ceased before completion during the past year (BI 30, Table 4.13, and section 2.10.10**)**. Further, it was found that in CS1, "1 to 2" innovation projects were ongoing at the end of the past year (BI 31, Table 4.13, and section

2.10.10**)**. The analysis in section 4.3.4 identified that in CS1, the pursuit of Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc., was "moderate" during the past year (BI 32, Table 4.14, and section 2.10.11**)**. The importance of these indicators for innovation and their measurement has been previously highlighted in their respective sections during stage 1 of this research (as indicated here in the section numbers from chapter 2).

Research found that in CS1, follow-on training and familiarising of the users with CS1's innovations was "low" during the past year (BI 33, Table 4.14, and section 2.10.11**)**. This indeed needs improvement as it will allow for innovation, further performance of the company and lead to more benefits and further profits. It was also understood that in CS1, After-sales services/maintenance/operations management/utility improvement/installation/updating/repair services/guarantee/return schemes/information services/communication, etc, follow-on activities were "highly" practised in CS1 during the past year (BI 34, Table 4.14, and section 2.10.11**)**. Data also suggest that CS1 is planning to conduct innovation activities during the next two years (Question i, Table 4.15, and section 2.10.12). Findings also revealed that CS1 is planning to spend $100k to $500k annually during the next two years on innovation (BI 35, Table 4.16, and section 2.10.12**)**. Based on the findings, it was also concluded that CS1 is planning to invest 20% to 40% of its expenditure on innovation during the next two years (BI 36, Table 4.16, and section 2.10.12**)**. Another finding was that there will be a rise in the total expenditure on innovation during the next two years compared to this year (Question i, Table 4.17, and section 2.10.12). The score of 2.89 for CS1 in the business innovation score (section 4.5.4) category of the innovation measurement tool is an outcome of these indicator scores and supports the evidence established in Stage 1 of the research (as indicated here in the section numbers from chapter 2).

The respondents also provided feedback (section 4.3.5, Analysis of the responses from CS1 for the Interview Questions) regarding the business innovation measurement tool. They believed the questions of the tool were easy to understand. The following is a discussion around their feedback on the tool (section 4.3.5, Question 1): the respondents mentioned that the tool is pretty easy and handy and has all the relevant questions and information required for the organisation. Based on the respondents' comments (section 4.3.5, Question 1), it was found that the hard work done to develop this tool is evident. Additionally, it was found that the results and the spider diagrams are a good reflection of the responses provided by the respondent. Data also suggest that this tool could help the company and might lead to the company achieving a better score in the indicators. Further, it was found that the tool could eventually lead to being more innovative and, as a result, more successful.

The analysis of the interviews (section 4.3.5, Question 2) identifies that the tool was comprehensive, and it covers everything. This question found that the tool could demonstrate how CS1 can improve the innovations of the company. It was also understood that the tool demonstrates the areas where CS1 is lacking. Data in the responses provided for section 4.3.5, Question 2, suggest that the tool does allow for an understanding of separate responses in a comprehensive way.

Respondents from CS1 (section 4.3.5, Question 3) added that the results of the innovation measurement tool are accurate and can be very useful for the benefit of CS1. Answers to this interview question 3 revealed that diagrams are a better way of illustrating the results as they demonstrate what the reader is looking for. Based on these findings from interview question 3, it was also concluded that the tool could help the leadership if the company move from management to more of a leader type. Another finding was that the results are useful to understand and see the factual information from inside the company. The respondents

mentioned that the tool also helps to understand the areas that is required or desired to work on for further improvement.

Data from the responses to question 3 (section 4.3.5) also suggest that the use of the tool is to see the gaps or the strengths. Hence, to fix where the attention is required. Respondents also support the usefulness of the tool and say that the tool is 100% beneficial. They believe the tool allows the whole company to focus on the right areas and understand where each staff member is placed on the same scale. Responses to question 3 further indicated that the tool has the ability to demonstrate the different perspectives of the management, labour force and other employees. This, in turn, allows to focus on the right department.

Based on the responses to question 4 (section 4.3.5), it was found that the tool could potentially be useful for CS1, but it is required to have a review once a year to see the gaps and strengths. Then the results could be compared with the previous years to see how the scores and other matters have changed. The analysis identifies that the tool allows for the catchment of data from different backgrounds.

Answers to Question 4 (section 4.3.5) found that the tool allows for the catchment of data from different perspectives, especially as a mix of practical and academic perspectives. The respondents endorsed that the results are as expected and that they were not surprised by the results. In response to Question 5 (section 4.3.5), they also believed that the tool itself was surprising and that the outcome was very accurate. They believed that the outcome results are relevant, and the tool results demonstrate the required information. It was found from the responses to question 5 (section 4.3.5) that the tool is a good scale to measure the innovation of the company. In response to Question 6 (section 4.3.5), respondents believed that the tool was comprehensive and covered everything. They believed that the tool was simple enough. In response to Question 7 (section 4.3.5), interviewees liked the fact that the diagnostics were available very early in the process. One interviewee stated that, together with the board members, he looks forward to hearing more about the diagnostics and the analysis of the responses. He thinks there is potential for further collaborations in research or implementation of the tool inside the company CS1.

This is the end of the discussion of the results obtained from the first case study (CS1). What follows is the discussion of the results obtained during the second case study (CS2).

6.2.3.2 Discussion of the Findings from Case Study 2

Through the diagnosis of the results from case studies (stage 2 of research presented in chapter 4), it was found that CS2 is one of the leaders for the use of digital modelling (section 2.9.47 Presence of technology) in construction projects. CS2 has a dedicated engineering, design and innovation team (section 2.9.13 Design capabilities). CS2 has an innovation manager and technicians who work alongside the innovation manager (section 2.9.31 Innovation Champion). CS2 benefits from an in-house design team (section 2.9.13 Design capabilities) consisting of registered architects and registered engineers. These people have an eye on innovation and value engineering. Many of CS2's innovations come from product and business processes (section 2.10.5) rather than the actual product (section 2.10.1) itself. CS2 continuously tries to use new material or new technologies (section 2.9.47 Presence of technology). These findings echoed the findings previously highlighted in Stage 1 of the research (as indicated here in the section numbers from Chapter 2).

Research found that CS2 focuses on delivery and client satisfaction. CS2 has potential for innovation, but it will take time to showcase since CS2 is still a young company. Innovation will require more from the demand side, and as the demand increases (section 2.9.32 Innovation demand), CS2 will also adapt accordingly. CS2 needs improvement in the area of capturing and documenting the ideas (section 2.9.37 Knowledge management). Innovation has been slow in the construction industry, and the traditional methods of building have been practised in the same way for a long time. These findings reinforced the insights derived from Stage 1 (as indicated here in the section numbers from Chapter 2).

Within CS2, the organisational structure identifies the methods that are utilised for capturing and documenting employees' skills (section 2.9.37 Knowledge management). The construction industry is very heavily documented (section 2.9.58 Standards), and this is because the liabilities are large, huge in fact, for quite a period of time, which is 10 years after completion of a project. This means that the trail of documentation (for example, on quality) has to be retained, and that products must be built in accordance with the specification, and regulatory consents and authority requirements (section 2.9.58 Standards). This excessive documentation process negatively affects innovation. To reduce this effect, there is a need to have more new ideas in the business and invest time in them. There is also a need for improvement in the systems, procedures, and policies, and CS2 is currently working on these improvements. CS2 currently has 150 employees, 128 of whom are based on site. This means that only 22 people are working in the office, and only one-third of the office employees would be dedicated or have part-time roles in implementing innovation and upgrading their policies and procedures. This is not enough. In order to improve on this gap, there is a need to build a balance sheet. CS2 has a full-time engineering and design team (section 2.9.31 Innovation Champion) with three employees. They work on drone technology, digital twinning, etc. For CS2, innovation has to have a benefit (sections 2.10.2 to 2.10.6), like adding to the efficiency or bringing in margin profits. The CEO of CS2 believes that in the business, there are three key things: *"brand, people, and money"*. If any task, including innovation, is not doing any of those three, then it is not worth pursuing. On a typical construction project for CS2, 45% is labour and 55% is materials of the project cost. If any innovation could change the labour productivity by 10%, that would result in 4.5% of savings on the cost of the project (section 2.10.6). This is the long-term approach for CS2. CS2 will soon be launching its *"Engineering and Design"* business, which will be run alongside the construction business. CS2 is also making attempts to commercialise (sections 2.10.2 up to 2.10.6) its construction technology (section 2.9.47). For CS2, the project is the shop front, and it is not the office. CS2 is pushing to be a technology company that is building buildings. CS2 is engaging an external partner (section 2.9.46 Partnerships) to help CS2 regarding follow-on activities (section 2.10.11), and the relationship between CS2 and the society (section 2.9.57). These findings are consistent with the findings presented in Stage 1 of the research (as indicated here in the section numbers from Chapter 2). These findings are in agreement with the Stage 1 findings cited in Chapter 2 (as indicated here in the section numbers from Chapter 2).

Within CS2, 80% of the project engagement is through *"early contractor involvement"* or *"design and build"* service models (section 2.9.10 Contracts). And so, when CS2 are engaged at that point, they are able to innovate. The other 20% that are build-only do not contain much innovation since everything is predefined for the construction stage and the company just does what the plans have told them to do. Therefore, the first two mentioned procurement methods allow for more innovations to happen (section 2.9.10 Contracts). For CS2, innovation will allow to have a bigger chunk of the market (section 2.10.4 Market share and product innovations). These findings are in agreement with this research's Stage 1 findings cited in Chapter 2 (as indicated here in the section numbers from Chapter 2).

Through benefiting from the indicators of the innovation measurement tool for data collection, the results of the case studies allowed us to see the potential for innovation in the construction industry. This is contradictory to the existing perception about the industry that the construction projects have always been built using the same methods and that there is not much room for innovation (section 1.2.2). The innovation measurement approach must consider measuring the benefit of innovations for the client. An innovative solution might generate the cost saving (section 2.10.6) of 2% but since in terms of sales (sections 2.10.2, 2.10.4 and 2.10.5) there are different departments and business units like engineering or design, it could be harder to measure. Innovation might not be directly revenue-generating (section 2.10.3). CS2 is not selling Engineering, Design and Innovation (EDI), but this capability within the business supports CS2's projects, and the projects contribute towards revenues and profits (section 2.10.3). But what portion of the EDI was engaged, and how much revenue it created, and how much profit, is hard to measure. In regard to follow-on activities (section 2.10.11), the topic is relevant to *"facilities management and lifecycle management of the project"*. In CS2, this is managed by *"BIM modelling"* and involves having every element of a building modelled and having all the data required for the maintenance of each element of the building. So, as an example, if a light bulb requires changing, there won't be the need to first check the bulb since all the data, like its product code, is already inside the BIM model. Another problem that CS2 is facing with the follow-on activities (section 2.10.11) is the complexity that exists because of all the different parties that are involved in the after-sales aspect. These findings are echoing the findings previously highlighted in Stage 1 of this research (as indicated here in the section numbers from Chapter 2).

CS2 achieved a higher score for its Innovation Potential (section 4.6.1) than its Business Innovation score (section 4.6.2). CS2-Int5 believes this comparison reflects the facts inside the company. To document the innovations that happen, a developed innovation measurement tool was necessary. Additionally, there is a need to define more projects on innovation and proceed with innovations as projects (section 2.10.10). There is a dedicated specialised team for innovation (section 2.9.31 Innovation Champion), and a lot of ideas happen inside the company. There seem to exist areas that require further attention, for example, communication (section 2.9.7) and idea catchment aspects of innovation. Therefore, innovation is not measured correctly or analysed appropriately, and its impact and added value are not understood. CS2-Int5 believes there is a high potential in the company for innovation, but it is not actualised. Also, due to this gap inside the company, innovations and future development plans are not appropriately analysed and prioritised to allow focus on the areas that will have the highest benefits down the line.

During the interviews, it was also noticed that CS2-Int5 had a very unique view towards some issues. He did not in any way look at the construction industry as a product-producing industry. In line with the abovementioned, CS2-Int4 gave a very low score to the question addressing the impact of innovations on the operational costs: BI16 (section 2.10.6). He explains that this is because CS2 is not mapping it and not capturing this data yet (section 2.9.37). CS2 also has not realised how they can commercialise (sections 2.10.2 up to 2.10.6) what they are doing in the construction technology (section 2.9.47) space. Therefore, one of the things that he, as the CEO, is doing is interviewing external parties (section 2.9.20) to come in and help with this matter. This will include an assessment of what the company is currently doing in this area and an assessment of what the market (section 2.9.42) can sustain. This is because he believes that the market requires an increase in knowledge (section 2.9.37) around what can be done with innovations. Altogether, he believes that innovation has the potential to reduce operational costs (section 2.10.6), but this amount will not be massive. These findings further justify the unexpected result for CS2 on the Business Innovation Score category (Table 4.40) and reaffirm

the Stage 1 findings outlined in Chapter 2 (as indicated here in the section numbers from Chapter 2).

During the case studies, a number of findings were achieved that gave a deeper insight into the innovation potential and actual innovations of CS2. By discussing these findings, it becomes possible to investigate the strengths and weaknesses of CS2 for innovation. The case study allowed us to understand that there is a positive feeling from the employees towards the workforce skills and HR management (category 1 out of 5 in the innovation potential score of the tool) of the company. These results were previously reflected in the respondents' given scores (section 4.5.2.1). This positivity increases the potential for innovation within the company. There is the belief that there are employees in CS2 who are very good at entrepreneurialism (section 2.9.17). Other employees are also open to change. There is also a sense that the younger generation is more eager to pick work up quicker and develop them.

CS2 employees were found to be open to innovation and not resisting (section 2.9.33) it but the uptake of innovation needs improvement. The employees who work on the construction site mainly follow instructions and have their minds set on just finishing the tasks. This matter indicates the need for a strong *"change management"*. This does not mean that there is resistance towards innovation from these workers; rather, it is a matter of innovation uptake. This matter is mainly with the older workers, as younger workers are better at innovation uptake. This understanding, in turn, highlights the need for *"continual improvement"* or, in other words, Career development: Training, skills and career development opportunities (section 2.9.3). It was also found during the case studies that not fearing from risking (section 2.9.44) needs focus inside the company. The employees outlined that *"innovation comes by fear"*. This can be in the form of the fear of change, fear of the outcome and fear of the potential downside. These findings reflect the insights previously highlighted in Stage 1 (as indicated here in the section numbers from Chapter 2).

According to the findings from the responses, in the organisational structure category (category 2 out of 5 in the innovation potential score of the tool), there seems to be a negative view towards the available incentives (section 2.9.28 and 2.9.16) for innovation in the company. The respondents were positive towards the potential of the company to innovate and expressed a number of innovations. There is a good focus towards career development (section 2.9.3) in CS2. The company often does a great deal of off-site training with the staff. This training includes all the employees, including the management. CS2 also values the history and culture of NZ. They invited a number of people from the Māori community and engaged them in the training program for the employees. Regarding incentives (section 2.9.28 and 2.9.16), it was found that there are differences in the responses, and it is necessary to look into the underlying cause of this difference. These issues were reflected in the eventual score of CS2 on the Business Innovation Score category (Table 4.40) and are consistent with the findings presented in Stage 1 (as indicated here in the section numbers from Chapter 2).

Regarding the business strategy (category 3 out of 5 in the innovation potential score of the tool), it was found that this is taken seriously in CS2, although the company is still unclear about where it is heading. This state is believed by respondents to be a result of indicators external to the company (section 4.5.2.5). Inside CS2, there is the belief that innovation covers a wide range of matters, not just limited to drone deployment and digital twins. Innovation includes commercial contracts (section 2.9.10), mental state of the employees (section 2.9.9) and the process of dealing with the customer (section 2.9.4). Innovation additionally includes the public, people's wellness and diversity and social procurement (section 2.9.57). Since CS2 is looking for incremental improvements, there is the belief that innovation should be right

through the business and everything CS2 does. These findings are reinforcing the insights derived from Stage 1 of the research (as indicated here in the section numbers from Chapter 2).

CS2 also has a lifecycle focus (section 2.9.40) and emphasises the benefit versus return of investing in projects from a lifecycle perspective. There is also the belief that the company could further improve on the business strategy category, and this could be done through monitoring and documenting (section 2.9.37) the developments as the products (sections 2.10.1 to 2.10.4) are in use. This allows the comparison of the actual outcome versus the expected outcome. The achieved documentation results could be used as a basis for future plans. These indicators from the tool (as indicated here in their section numbers from chapter 2) were discussed in their respective sections during stage 1 of the research.

CS2 also has a focus on technology (category 4 out of 5 in the innovation potential score of the tool) and sees the investments made in technology as overhead costs and long-term investments. Numerous technologies have been adopted in the CS2 projects. The respondents highlighted that external parties (section 2.9.20) are involved in delivering innovation and construction technology (section 2.9.47) in the company.

During the case study, it was found that external influences (category 5 out of 5 in the innovation potential score of the tool) have had a great impact on CS2. This was reflected in the low score that CS2 obtained for this category of questions (section 4.5.2.5) and through the feedback that was given by the respondents (section 4.5.3.5). There is a belief towards the New Zealand construction industry that it is *"on its knees and in a very, very bad state"*. The belief in CS2 is that costs are very expensive (section 2.9.26), the developments are very slow, and the industry is very poor. Also, there is a lot of border (sections 2.9.36 and 2.9.58) for the work. There is no authority (section 2.9.25) to comprehend and put the industry together. Further, there is a lot of talk but little action in the industry, and there is little investment in research and development (section 2.9.53), and the businesses are very small. The employees also think that it is only going to get worse in the Auckland Market over the next 5 to 7 years. The impact of these statements was reflected in the low score of CS2 in the External Influences category (sections 4.5.2.5 and 4.5.3.5) and validates the Stage 1 findings noted in the relevant sections of Chapter 2 (as indicated here in the section numbers from Chapter 2)

Also, by carefully analysing and discussing the data collected from the respondents for the business innovation score (section 4.5.4) category of the innovation measurement tool, a number of key points were found. It was understood that the company's innovative goods (BI 1, Table 4.24, and section 2.10.1) during the last year were *"moderate to high"*. Data also suggest that the company's innovative services (BI 2, Table 4.24 and section 2.10.1) during the last year were *"high"*. Further, it was found that the company had produced *"6 to 8"* innovations (BI 3, Table 4.24 and section 2.10.1) during the past year. The analysis identifies that 21% to 40% of the company's sales are related to product innovations (BI 4, Table 4.24, and section 2.10.2) that have taken place inside the company. Research found that 41% to 60%, somewhere around the 50% mark, was the impact of the company's product innovations on an increase in sales (BI 5, Table 4.24, and section 2.10.2). It was also understood that the company's product innovations accounted for an increase in the profits of 41% to 60% (BI 6, Table 4.24, and section 2.10.3). Data also suggest that 21% to 40% was the average profit margin (BI 7, Table 4.24, and section 2.10.3) for CS2's product innovations. Findings also revealed that amongst all similar products, CS2 has been able to achieve 0% to 20% of the market share (BI 8, Table 4.24, and section 2.10.4). Probably around 17.5% based on the average obtained. The importance of these indicators for innovation and their measurement has been previously emphasised in their respective sections during stage 1 of this research (as indicated here in the section numbers from chapter 2).

Further analysis of the responses in section 4.5.4 indicates that the respondents gave the average score of 2.8 to the set of indicators under sections 2.10.5 (Innovation outcomes: Processes, BI 9 to BI 15, Table 4.25) and 2.10.6 (Operational costs and process innovations BI 16, Table 4.25). Based on the findings, it was concluded that the business process innovations of CS2 resulted in 21% to 40% increase in sales (BI 15, Table 4.25, and section 2.10.5). Another finding was that the business process innovations of CS2 resulted in 0% to 20% reduction in operational cost (per unit of output / per operation) (BI 16, Table 4.25, and section 2.10.6). Somewhere around the 16% mark, based on the average results provided. Data also suggest that CS2 has been *"Moderate"* for Novelty, Innovativeness, and Economic impact (BI 17, BI 18, BI 19, Table 4.26, and section 2.10.7). Further, it was found that CS2 has been *"An innovative firm"* and *"An innovation-active firm"* during the past one year (Question e, Table 4.27, and section 2.10.8). CS2 achieved an average score of 3.28, which is *"Moderate"* for its Innovation Activities set of indicators (BI 20 to BI 27, Table 4.28, and section 2.10.9). The analysis identifies that in CS2, *"2 to 5"* innovation projects were undertaken during the past year (BI 28, Table 4.29, and section 2.10.10). Research found that in CS2, "1 to 2" innovation projects were completed during the past year (BI 29, Table 4.29, and section 2.10.10). It was additionally understood that in CS2, *"0"* projects were ceased before completion during the past year (BI 30, Table 4.29, and section 2.10.10). Data also suggest that in CS2, "2 to 5" innovation projects were ongoing at the end of the past year (BI 31, Table 4.29, and section 2.10.10). The importance of these indicators for innovation and their measurement has been previously highlighted in their respective sections during stage 1 of this research (as indicated here in the section numbers from chapter 2).

Findings also revealed that in CS2, the pursuit of Follow-on marketing/promotions/sales/advertising/fairs/distribution, etc. (BI 32, Table 4.30, and section 2.10.11) was *"Low"* during the past year. Based on the findings, it was also concluded that in CS2, follow-on training and familiarising of the users with CS2's innovations (BI 33, Table 4.30, and section 2.10.11) were *"Moderate"* during the past year. This indeed needs improvement as it allows for the further performance of the company and leads to more benefits and further profits. Another finding was that in CS2, After-sales services/maintenance/operations management/utility improvement/installation/updating/repair services/guarantee/return schemes/information services/communication, etc. (BI 34, Table 4.30, and section 2.10.11) follow-on activities were "Low" practised in CS2 during the past year. Data also suggest that CS2 is planning to conduct innovation activities during the next two years on innovation (Question i, Table 4.31, and section 2.10.12). Further, it was found that CS2 is planning to spend $500k to $1 million annually during the next two years (BI 35, Table 4.32, and section 2.10.12). The analysis identifies that CS2 is planning to invest 0% to 20% of its expenditure on innovation during the next two years (BI 36, Table 4.32, and section 2.10.12). Research found that there will be a rise in the total expenditure on innovation during the next two years compared to this year (Question i, Table 4.33, and section 2.10.12). The score of 2.87 for CS2 in the business innovation score (section 4.5.4) category of the innovation measurement tool is an outcome of these indicator scores and supports the evidence established in Stage 1 of the research (as indicated here in the section numbers from Chapter 2).

The case study respondents also provided further feedback (section 4.5.5 Analysis of the responses from CS2 for the Interview Questions) regarding the business innovation measurement tool. They believed the tool was very useful. The following is a discussion around their feedback on the tool (section 4.5.5, Question 1): The respondents mentioned that the tool can help to get the companies thinking about where they sit on this innovation spectrum. Collected data additionally suggests that the tool is good, and it is generating some interesting data. Further, it was found that there were many questions in the tool, but they are categorised

well in a structured way. The analysis of case study interview responses identifies that the questions are applicable to the firm. Interviews found that the spider diagram is useful and is a means of understanding the *"wellness"* of the company in areas based on the tool's categories. It was understood that the tool is seen as *"thought-provoking,"* and it is interesting to see innovation as a project and measure its output.

Collected data (section 4.5.5, Question 2) further suggests that the tool is *"specific and broad at the same time"*. Findings revealed that the tool covers everything in broad terms. Based on the findings, it was concluded that the tool could be further tailored to be project-level based rather than organisational-level based. Another finding was that the tool could be tailored to address the specific sector of the construction industry that each company is operating under.

Analysed data (section 4.5.5, Question 3) suggests diagnostics could definitely be useful. It will allow one to see the areas that require improvement. The aim is to make sure everyone understands the plan. And since in big companies, managing innovation is hard, this tool can help. Diagnostics allows to see the trends and understand the benefits of innovation. Diagnostics would allow one to see the strength areas regarding innovation and also allow for managing the procurement process and defining governmental policies. This will allow to direct the innovation measurement tool's data to specific issues where we feel innovation could provide solutions, with more benefits. Diagnostics will allow the chance to see the results of different people in the company merged together and compared. Further (section 4.5.5, Question 3), it was found that even with support for innovation from the senior management level, there is a need to create the right system structure so that the support filters down to everybody, and this is where this developed innovation measurement tool could support innovation.

Analysis (section 4.5.5, Question 4) identified that the results could be compared between different organisational and project levels to find differences in perspectives and to fill the gaps. Responses to Question 4 in section 4.5.5 additionally stated that the tool could gather the information from all the employees and improve the employees' understanding of what is going to be done around innovation. Further, it was stated that the tool could clarify information on the employees' perceptions and clear misconceptions. Responses to Question 4 in section 4.5.5 found that the collection of the data is on one side, and the interpretation of it is another. Since the tool collects a lot of information, it could be well used and benefited from. It was acknowledged that a lot of effort must have been put into the process of developing this tool. Data suggested that the implementation of the tool could potentially engage the younger employees with the leadership panel as well, and this is desired by the young employees. Findings further revealed that the tool definitely highlights the need to understand what the requirements are to become innovative.

Based on the interviewee statements (section 4.5.5, Question 5), it was found that, through using the tool, it is possible to understand the potential for innovation in the construction industry. Another finding was that the implementation of the tool for the case study allowed us to see the reality in the company: there is the belief that the innovation potential in the company is good, but there is still room for improvement in the output sector. Interviewees (section 4.5.5, Question 6) suggested having fewer technical terms, shorter questions, possibly dividing the tool into multiple tools or giving it to respondents in multiple sessions. Embedding the tool into an online platform was also suggested. These suggestions can be explored in further studies or future iterations of the tool. Eventually (section 4.5.5, Question 7) it was stated by the respondents that the tool is good work and that it is important for the industry.

This is the end of the discussion of the results obtained from the second case study (CS2), and as a result, both of the case studies. What follows is the discussion of the results obtained during the interviews with the CIEs.

6.2.4 Discussion of the Findings from the Interviews with the Construction Industry Experts (CIEs)

As previously mentioned in the methodology chapter (section 3.6), the third stage of the research included semi-structured interviews with construction industry experts in an attempt to fulfil the third side of the triangulation method engaged for the validation of the findings of this research. In line with this, 5 experts were shortlisted and selected amongst the experts who could contribute towards the validation and further improvement of the innovation measurement tool. These people were a combination of measurement tool development experts, innovation experts, senior construction industry experts aware of the organisational culture, experts in organisational training, and the like. The third stage of this research directly addresses objective 4 of this research and further contributes to objectives 2 and 5 of the research. The following results were obtained during the interviews with the CIEs:

During the CIE interviews, the relevance and the validity of the innovation measurement tool developed for the New Zealand construction industry were evaluated. CIEs supported the tool and expressed that the results being demonstrated in a visualised format are, in fact, very useful. It was stated that the results are easy to understand and that they would greatly help the managers and make them think about the organisation's areas of potential and the areas needing improvement within the company. It was endorsed that the tool is finding the gaps, and with the engagement of longitudinal studies within companies, impact and improvement could happen for the innovation and benefit of the companies.

It is believed that the tool is, in particular aspects, similar to what the New Zealand Inland Revenue Department has adopted for its tax incentive program on research and development. This aspect is exceptionally bold around the distinction they make between core R&D activity (which is planned, intentional R&D and is to resolve uncertainty) on one hand and supporting activities (which are not themselves resolving the uncertainty but are necessary in order to turn the R&D into something useful) on the other hand. This definition is similar to the definitions engaged in the innovation measurement tool developed during this research (section 2.10.9 Innovation activities and section 2.10.11 Follow-on innovation activities).

It was mentioned that overall, the categories of the tool are well thought out and comprehensive. There is the belief that the tool is very good and that in order to achieve a reliable answer, there might be the need for everyone in the company to fill in the questions, or at least people from different levels of the organisational structure will be required to respond by filling in the tool. During the CIE interviews, the tool was reviewed, and the significance of the identified items for measuring innovation in the construction industry was confirmed. CIEs believed that the tool could measure innovation inside the construction companies. They added that the tool includes some general features of a good company that should have been pointed out. It includes some of the indicators that support the innovation to go forward. These are the traits required by a company in order to create new things. The tool seems to be a sound innovation measurement instrument. The items and questions are related to innovation.

It was stated by CIEs that since the construction industry is very slow and doing really poorly in innovation, there is a need to support innovation in the construction industry. To further

support innovation, it is exceptionally important to highlight the importance of addressing the items of the tool.

It was endorsed that the developed tool allows for more practical usage and to be used as a guide for individual businesses on how to optimise the matters relating to innovation. CIEs endorsed that having clearly defined and useful definitions allows for the collection of consistent answers. The results demonstrate the areas in which the company is not performing well, and since the tool allows for many people to participate in the data collection, this facilitates the development of industry benchmarks. This sets up a competition amongst different companies. The analysis of the obtained data identified that another benefit of the tool that was pointed out by CIEs was that the results allow for a comparison between companies, to find the strengths and weaknesses of each company. In this scenario, since it is extremely rare for any company to have the highest score in all of the indicators, the areas that the company requires focus are highlighted, and this is the outcome of the case studies on each company.

There was endorsement from the CIEs that using this tool will allow the data on innovation within the construction industry to be more standardised and generalisable to the data from other industries. It is believed that this tool is really good, and it is necessary. Due to the unique definitions and language engaged in the construction industry, and the difference between the terminology in the industry and academia, special attention is required to develop a tool that addresses precise terminology. This will allow the tool to not only be used internally inside the companies, but also to be used for collecting industry-wide data and benchmarking. The CIEs reiterated that the tool is good, and the fact that the tool covers items from different angles is also good.

The CIEs expressed that the tool is relevant to the New Zealand construction industry. There is a need to focus on the way the questions are tailored to the specific companies. There is also the belief that the structure of the tool is great and that it can make an impact on the understanding of the respondents. This helps with the accuracy of the responses. The importance of the accuracy of the data being presented by the respondents was extremely emphasised. CIEs also confirmed that the tool is quite comprehensive and useful for measuring innovation in construction organisations.

All the construction industry experts who were interviewed were very positive about the results and believed that the results are useful. It is believed by CIEs that using a mobile app would further ease the use of the tool and would help with the usefulness of the results. CIEs further explained that in the long term, the results should set the foundation for further improvement of the company indicators. They also emphasised that the results are very useful and since they are in a visual format, they can be easily understood. The decision makers can easily see and recognise the areas that require further improvement. All of the 5 CIEs believed that the tool is very useful for construction companies to use. There is the belief that this tool could help and benefit companies, especially big companies with more resources, to innovate. Additionally, the tool is useful for companies and can demonstrate a self-reflection for them. The tool can test the innovation capability of the companies. CIEs suggested making software from the tool. This will encourage participation from a wider audience. The participants could just download the software app and even answer the questions at their convenience. CIEs further emphasised the benefits of developing software or a mobile app (application) to facilitate the response process. This will also allow the catchment of further data and more input from the respondents. This app can allow the decision makers to see the results in real time and as data is being developed.

Based on the findings of the research, CIEs believe that the government can potentially support the implementation of this tool in the industry. This can be facilitated through the Ministry of Housing and Urban Development (MHUD) or the Ministry of Business, Innovation and Employment (MBIE). CIEs believe that while implementing this tool, the biggest source of value is the construction industry-wide benchmarking information. These benchmarks are developed as the tool is executed with more and more construction companies. The benchmarked data will be very beneficial for the use of decision makers, either inside each company or for the industry in general, and that is the unique value of this tool. Further into the company improvement scheme, once the decision makers are aware of the gaps inside the company, special focus and attention can be given to the needs of the company. The other benefit of this tool is that it allows for the development of standardised data through the already developed definitions. This facilitates the use of the tool by other facilitators who are helping to engage the tool within the companies.

CIEs further believe that even artificial intelligence and chatbots can be incorporated into the data collection process. This will facilitate the process of self-assessment. To conclude, CIEs approve that these items are relevant and tailoring the tool to the specific needs of the companies can be part of the tool implementation stage for the construction companies. It is emphasised by the CIEs that once the decision makers see the gaps and learn how to overcome them, they can plan actions to be more innovative.

It was stated by the CIEs that once the data is gathered, there needs to be a strategy in place to address the shortcomings and to aim for more innovation to happen inside the company. The changes and achievements need to be measured after a period of time to see the results of the set strategies. This will further strengthen the power of the tool to improve the innovative capability of the companies, and it will further convince the decision makers to use this tool. CIEs mentioned that during the implementation of the tool inside the companies, workshops can be very useful to help the collection of data and to disseminate the requirements of a company to innovate. The analysis of the findings reveals that in order to further improve the practicality of the tool, CIEs believe the tool should be presented to other markets, like the government. They strongly believe that the government should enforce any company with more than 300 employees to use this tool. Also, any construction company that involves public interests and/or has a turnover of more than $100 million every year should be obligated to use the tool.

CIEs believe that measuring innovation in itself cannot be the terminal goal and should be seen as an instrumental goal to reach better outcomes. They also added that this tool can be used to measure data on the project level, program level, or organisational level. This will allow the results and the lessons learned to be transferred from one project to another. This is in line with the knowledge sharing and knowledge management (section 2.9.37) practices of the companies. Additionally, best practices can be identified and repeated in future projects. CIEs greatly believe that using consistent and generalisable definitions greatly helps with the benchmarking of data. CIEs emphasise that, as a follow-up procedure, the companies could be introduced to other service providers to help them improve their score on the indicators that have been identified as needing help and attention. CIEs believe that to improve the practicality of the tool, there should be actions in place to help the companies achieve higher scores. There should be special attention to strengthen these scores, and this matter requires actions other than business as usual. The companies should be studied in different periodic studies.

During the research, CIEs believe that the main issues to focus on are the way the tool is being communicated to the respondents. There needs to be special attention to the specific way that each of the companies is being addressed with the tool. Therefore, the tool needs to be tailored

to the special company in the way definitions are presented and in the way it is communicated. CIEs believe that benchmarking the data as they are developed and allowing the participating companies to compare their results with other companies through industrial averages can be very beneficial for the practicality of the tool. They stated that companies are eager to know how they're performing compared to their peers. CIEs emphasised that the outcomes need to be measured in a longitudinal study to see the changes in a periodic way, to investigate whether the company has been innovative or whether the performance or productivity of the company improved.

During the CIE interviews, the respondents made a number of comments that were found to be constructive towards the improvement of the business innovation measurement tool. All of these comments were taken into consideration, and some of these were implemented into the improvement of the final version of the tool.

It was stated that Fragmentation (section 2.9.24) is very important in the studies related to innovation. Many of the construction companies in New Zealand are small, and this results in them working in fragments, which leads to many issues in the industry. These companies usually do not have the budget, the willingness, or even the time to innovate. It was revealed in research that CIEs strongly believe that the size of the company affects its innovation capability. Small and medium-sized companies are more reactive rather than proactive. These small and medium-sized companies just want to put bread on the Table and are usually overloaded. They lack a long-term strategy (section 2.9.59) and can only focus on short-term (section 2.9.40) goals. These issues are exacerbated while these construction companies are operating under a fragmented type of industry where information is not shared amongst them (section 2.9.37). Many of the innovations are not passed on from one employee or company to the other. These matters were approved by the respondents. These findings are in line with the decision to focus on medium and large companies for this research.

CIEs believe that trade associations could have played a decisive role in communication and interaction amongst employees, but this has not been the case.

Many of the business innovation measurement tool's indicators were discussed in detail and endorsed by CIEs during the interviews, and they agreed that these indicators could play the role of a driver or a barrier. CIEs reiterated that the construction industry is very poor at technology uptake. Therefore, technology (section 2.9.47) can receive further attention while implementing the tool within the construction companies. This matter has already received attention while developing the Business Innovation Measurement Tool and has been embedded into a separate category of its own. Additionally, by building the knowledge database while collecting industry-wide data from many companies, and later by defining the industry benchmarks, it is possible to tailor the tool for specific companies and embed further indicators that specifically address the technological needs of that sector of the industry.

As mentioned before, during this research, all the construction industry experts who were interviewed were very positive about the results and believed that the results are useful. In-depth analysis of the results obtained from the construction industry experts supports the relevance and the practicality of the innovation measurement tool developed for the New Zealand construction organisations. Research demonstrated that all of the respondents reviewed and confirmed the significance of the identified items for measuring innovation in the construction organisations. Data suggest that all of the interviewed CIEs believed that the tool is very useful for construction organisations to use.

6.3 Concluding Summary

This chapter discussed the results that were obtained during this thesis. Initially, the results that were obtained from the responses to the tool's indicators during the case studies of the two construction companies were discussed. This section had a focus on comparing the results of the two study cases as well as highlighting the areas that made the differences in the scores of the two case studies. This discussion was categorised based on the 6 (5 Innovation Potential + 1 Actual Innovation) different categories of the tool questions. The discussion chapter was later followed by the discussion of the further data obtained from the respondents during the case studies. These data were collected during the communications that took place during the interviews with the respondents of the case studies. These data were categorised separately for the two study cases and consisted of the discussions around the analysis of the results of the quantitative data gathered from the responses to the tool's questions and discussions around the analysis of the results of the further qualitative communications during the filling of the tool's questions. These further talks gave an in-depth insight into the innovation-related characteristics of the companies that were investigated and demonstrated the diagnostic capability of the tool. Additionally, in this chapter, the results of the analysis of the responses to the case study interview questions were discussed. These questions are presented in Appendix 3 of this thesis. Eventually, the data collected from the interviews with CIEs during the third stage of this research were discussed. These questions are presented in Appendix 4 of this thesis.

The strength and credibility of the findings presented within this chapter are reinforced by their consistency across multiple data sources and methods. By drawing on insights from the literature review (stage 1), case study investigations (stage 2), and expert validation (stage 3), the research benefits from methodological and source triangulation, which enhances the robustness of the results. The convergence of evidence from these diverse sources not only confirms the reliability of the identified innovation indicators but also strengthens the overall validity of the developed Business Innovation Measurement Tool. This multi-method approach provides a solid foundation for the conclusions drawn and the recommendations proposed in the following chapter.

Chapter Seven: Conclusion and Recommendations

7.1 Introduction

The aim of this research was to develop a comprehensive diagnostic tool to effectively measure innovation within medium and large construction organisations in New Zealand. This research addressed the identified gap in existing innovation measurement practices, as the absence of a framework that captures both Innovation Potential and Business Innovation Score within the context of the New Zealand construction industry. Guided by the research aim and objectives, this research was conducted through a sequential exploratory mixed-methods design, consisting of a literature review, case studies, and expert evaluations to ensure the tool's practicality, relevance, and validity.

This chapter concludes this thesis by presenting a synthesis of the research findings and demonstrating how the research aim and objectives were achieved. It outlines the contributions of the study to theory, practice, and methodology. This is followed by implications for the construction industry and policy development. Recommendations for industry practitioners, policymakers, and future research are then presented. The chapter concludes with a discussion of the limitations of the research and a final concluding summary on the significance of the study.

7.2 Summary of the Research

7.2.1 Restatement of the Research Problem

Innovation is widely acknowledged as an important driver for productivity, performance, competitiveness, and long-term sustainability in the construction industry (Akunyumu et al., 2021; Chen & Chang-Richards, 2022; Ponta et al., 2021). It supports improved project outcomes, enhanced quality, better resource utilisation, and greater responsiveness to client needs (Adafin et al., 2022; Er, 2020; Lo & Kam, 2021). Despite its importance, the construction industry has traditionally been characterised as a weak innovator due to factors such as its project-based nature, high degree of fragmentation, reliance on multiple stakeholders, and resistance to change (Akunyumu et al., 2021; Er, 2020; Chen & Chang-Richards, 2022; Ribeirinho et al., 2020). These characteristics are the reason behind great challenges for the measurement and management of innovation activities.

As previously discussed in sections 2.5 and 2.6, existing innovation measurement frameworks, including widely recognised global models, are mostly designed for manufacturing or general economic sectors. While they are valuable in those contexts, these frameworks often overlook the unique characteristics of the construction industry, particularly the dynamic, project-driven environment and the influence of external factors. As a result, the indicators used in these

frameworks may not fully capture the drivers, enablers, and barriers of innovation that are specific to the construction organisations.

In section 2.7 of the thesis, it was highlighted that in New Zealand, these limitations are further exacerbated due to the absence of a comprehensive, context-specific tool capable of measuring innovation in medium and large construction organisations. Without such a tool, organisations lack the means to systematically evaluate their Innovation Potential, which is the internal and external factors influencing their capacity to innovate, and their Business Innovation Score, which is the outcomes achieved through innovation activities. This gap restricts the ability of firms to benchmark their innovation performance, identify strengths and weaknesses, and implement targeted strategies for their improvement. It also limits the capacity of policymakers and industry bodies to establish baselines, monitor progress, and design initiatives that encourage innovation in the New Zealand construction industry.

Section 2.8 discussed that to address this problem, it was required to develop a diagnostic tool specifically tailored to the characteristics, challenges, and opportunities of New Zealand's construction industry. Such a tool needs to integrate relevant global best practices with the indicators that are adapted to the local context. This process enables accurate measurement, meaningful benchmarking, and the promotion of innovation capability across the construction industry of New Zealand.

7.2.2 Summary of the Methodology

This research utilised a sequential exploratory mixed methods design for the development of a comprehensive, context-specific and validated diagnostic tool to measure the innovation of medium and large organisations inside the New Zealand construction industry. The methodology consists of three main stages:

Stage 1 was conducted by a comprehensive review of extant global and New Zealand-specific literature to identify existing innovation measurement tools, frameworks, and models and to extract relevant indicators which are applicable to the New Zealand construction industry. The literature review also enabled categorisation of innovation indicators into two main components: Innovation Potential and Business Innovation Score.

Stage 2 was conducted through case studies on selected medium and large organisations within the New Zealand construction industry. The developed tool from Stage 1 was tested in each company to measure their innovation and to collect data on the relevance and applicability of the identified indicators in real-world settings.

Stage 3 of this research involved the evaluation and validation of the developed innovation measurement tool by Construction Industry Experts (CIEs). Experts assessed the developed innovation measurement tool for significance, completeness, practicality, and suitability for the New Zealand context. Their feedback was used to further refine and finalise the tool.

This staged design allowed for triangulation across sources for data collection (literature, case studies, and expert evaluations), which improved the robustness and credibility of the research outcomes. This methodology ensured that the final tool was theoretically grounded, empirically tested, and validated for both industry relevance and academic rigour.

7.2.3 Summary of Key Findings

This research produced numerous important findings through integrating results from the literature review, case studies, and Construction Industry Expert (CIE) evaluations.

From Stage 1 (Literature Review), the analysis understood that extant innovation measurement frameworks, while valuable within other sectors, do not fully address the distinctive characteristics of the construction industry, especially in the New Zealand context. The review enabled the categorisation of innovation measurement into two primary categories, Innovation Potential and Business Innovation Score, with the identification of specific indicators under each category. Five categories were developed for Innovation Potential: Workforce Skills and HR Management, Organisational Structure, Business Strategy, Technology, and External Influences. This stage of the research provided the theoretical foundation and set of indicators for the development of the diagnostic tool.

From Stage 2 (Case Studies), the implementation of the tool within selected medium and large construction organisations represented its ability to capture a comprehensive understanding of innovation capability. Results indicated varying performance across companies and in different categories, with certain strengths in some areas and more significant weaknesses in others. The findings also highlighted the influence of contextual factors on innovation capability.

From Stage 3 (CIE Evaluations), expert feedback confirmed the relevance and completeness of the tool's indicators and structure. Experts validated the tool's suitability for application in the New Zealand construction industry and emphasised its potential for supporting organisational improvement, benchmarking and informed decision making. They also recommended that the tool be supported and promoted for use across the construction industry and integrated into broader industry initiatives.

Across all stages of this research, strong convergence was observed between the literature, empirical results from the case studies, and expert evaluations. The case study findings aligned with the thesis's literature and confirmed that innovation in the construction industry is influenced by the factors and conditions that were previously presented in the thesis during stage 1 (Chapter 2). Similarly, expert insights strengthened the thesis's literature (stage 1 presented in Chapter 2) and case study's empirical evidence (stage 2, presented in Chapter 4) by validating the tool's ability to measure both Innovation Potential and Business Innovation Score in a manner that is practical, theoretically grounded, and specific to the construction industry's context. This convergence significantly increases the credibility and applicability of the outcomes of this research.

7.3 Achievement of Research Aim and Objectives

This research achieved the aim of developing a comprehensive and diagnostic tool for effectively measuring innovation within New Zealand's Medium and Large construction organisations. The path for this aim was a staged mixed-methods approach, combining evidence from the literature, case studies, and expert evaluations. The following outlines how each of the research objectives was achieved, with supporting evidence from the findings:

7.3.1 Objective 1

This objective was achieved through conducting an extensive literature review (Chapter 2) that examined global and New Zealand-specific innovation measurement frameworks, tools, and models. The review identified the limitations of existing frameworks in addressing the unique characteristics of the construction industry. It also resulted in the categorisation of innovation indicators into Innovation Potential and Business Innovation Score, forming the theoretical foundation of the diagnostic tool that was identified as a research gap.

7.3.2 Objective 2

This objective was achieved through the design of a diagnostic tool that integrates global best practices with indicators adapted for the New Zealand construction context. The tool includes two primary components: Innovation Potential (five categories) and Business Innovation Score. It was developed based on insights from the literature review (Stage 1), refined through empirical evidence from the case studies (Stage 2), and additionally further refined and validated through expert feedback.

7.3.3 Objective 3

This objective was achieved in Stage 2 of this research (Chapter 4) by applying the tool within medium and large New Zealand construction organisations. The case studies demonstrated the tool's ability to capture a comprehensive profile of innovation capability, reveal category-specific strengths and weaknesses, and provide empirical evidence of its functionality in practice.

7.3.4 Objective 4

This objective was achieved through Stage 3 (Chapter 5), where CIEs evaluated the tool's clarity, completeness, practicality, and suitability for the New Zealand context. Their feedback confirmed the validity of the indicators and the usefulness of the tool. Additionally, the triangulation of their insights with the case study findings and literature enhanced the robustness of the tool.

7.3.5 Objective 5

This objective was achieved through the integration and synthesis of findings from all stages of this research. The analysis identified specific areas for improvement within organisations, as well as strategies to enhance innovation capability across the construction industry. Recommendations for improving innovation measurement, which are presented throughout the thesis and are specifically summarised in Section 7.7 of this chapter, include the adoption of

the tool for regular assessment, the use of results to inform strategic planning, and the incorporation of innovation measurement into broader industry and policy frameworks.

By delivering recommendations based on evidence, this research provides actionable guidance for construction organisations which are seeking to improve their innovation capability, for policymakers who are aiming to encourage innovation within the construction industry, and for industry bodies which are interested in establishing consistent benchmarks.

Through the systematic fulfilment of these five objectives, this research successfully met its primary aim and developed a comprehensive, validated, and context-specific diagnostic tool for measuring innovation in medium and large construction organisations in New Zealand. The staged approach of this research ensured that the tool is theoretically grounded, empirically tested, and practically relevant, resulting in a valuable contribution to both academic knowledge and industry practice.

7.4 Achievement of Research Question and Sub-Questions

This research addresses the primary research question of how a diagnostic tool can be developed to effectively measure innovation within medium and large construction organisations in New Zealand, addressing the unique characteristics and challenges of the construction industry. For the achievement of this question, 6 sub-questions were developed in section 1.3.3 of this research. Through achieving these sub-questions, the primary question of this research was answered. The details of this process are presented in their respective chapters and briefly summarised as follows:

7.4.1 Sub-Question 1

Chapter 2 addresses sub-question 1 of this research (section 1.3.3). It provides an extensive review of the already existing innovation measurement frameworks, tools, and models, such as the Innovation Process Model, Simons' Levers of Control, the InnovationOne Framework, and the Oslo Manual 2018. Each of the presented frameworks are critically evaluated, with their strengths and weaknesses highlighted and summarised in dedicated tables. This analysis reveals that while some models focus on culture, strategy, or performance metrics, they usually fall short in addressing the construction industry's project-based nature, fragmentation, and reliance on external collaboration. The summary of weaknesses in Section 2.6 clearly identifies the existing gaps which prevent these frameworks from being effectively applied into New Zealand's medium and large construction organisations

7.4.2 Sub-Question 2

Chapter 2 addresses sub-question 2 of this research (section 1.3.3). It establishes the theoretical foundation required for a context-specific tool by identifying the indicators that affect innovation potential and actual innovation. Section 2.9 systematically categorises attributes such as autonomy, career development, collaboration, creativity, and knowledge management, showing how these shape organisational potential for innovation. Section 2.10 introduces the

Business Innovation Score, which complements innovation potential by measuring the actual outcomes, such as product, process, and innovation projects. Together, these sections provide a dual framework, Innovation Potential and Business Innovation Score, which demonstrate how innovation can be effectively measured inside New Zealand's construction organisations through a comprehensive set of indicators and methods

7.4.3 Sub-Question 3

Chapter 2 also addresses sub-question 3 of this research (section 1.3.3). While the practical testing of the tool is addressed in later chapters, Chapter 2 lays the required foundation through demonstrating the necessity and relevance of a comprehensive diagnostic tool tailored to the specific needs of New Zealand's construction context. The gaps identified in global frameworks within this chapter, combined with the detailed list of indicators specific to New Zealand's industry environment, strongly establish the rationale for a tool that can be both functional and practical. The summary of findings is presented in this section (Section 2.11), consolidating this by showing how the literature review directly led to the development of a diagnostic tool structured around the existing realities of the construction sector, ensuring that the developed tool would be applicable in practice.

7.4.4 Sub-Question 4

Chapter 4 directly addresses sub-question 4 (section 1.3.3) through implementing the tool inside two New Zealand construction organisations and reporting the achieved results, thereby demonstrating real-world practicality and functionality. Chapter 4 explains Stage 2 of this research, as the tool's application through a multiple-case study design, demonstrating how the tool practically functions in actual organisational contexts. Chapter 4 then presents the study process used in this practice of tool application, such as responses to the Innovation Potential questionnaire and its analysis, Business Innovation Score and its analysis, and analysis of interview question responses for the 2 case study companies, representing the practicality and functionality of the developed tool inside construction companies. The chapter then compares the 2 companies across indicators and categories (Innovation Potential and Business Innovation Score) and closes with an overall-scores summary, evidencing that the tool is capable of yielding beneficial and usable diagnostics, can support benchmarking, and further produce actionable insights when applied operationally within medium and large construction companies of New Zealand.

7.4.5 Sub-Question 5

Chapter 5 also addresses sub-question 5 of this research (section 1.3.3). Chapter 5 fulfils this question through conducting Stage 3 of the research as expert validation: in-depth interviews with construction industry experts (CIEs) structured around questions which investigate the significance of the indicators of the tool, the usefulness of diagnostics, applicability of the the tool within organisations, ways of simplifying it and its implementation, thereby testing the validity of the tool and reliability of results. Experts consistently affirmed the relevance of the tool's indicators and, through conducting extended interviews, responses converged to saturation, resulting in evidence that the sample and findings were sufficient and repeatable. Chapter 5 embeds these results within an explicit triangulation technique and recognised quality criteria (construct, internal and external validity; reliability and replicability), and it triangulates multiple forms of evidence (literature foundations, Likert responses from case

studies, interview narratives, and expert evaluations) to corroborate the indicators of the developed tool. Together, these design choices and findings demonstrate that the tool is both valid and reliable for medium and large-sized construction companies within New Zealand.

7.4.6 Sub-Question 6

This thesis responds to sub-question 6 by demonstrating, through all three of its stages, how innovation measurement could be used as actionable insights within organisations and the wider industry. Stage 1 of the research established the diagnostic framework by identifying and categorising the indicators of Innovation Potential and the Business Innovation Score, and ensured that the foundations of the tool were strong, theoretically grounded and comprehensive. Stage 2 applied the tool within two medium and large New Zealand construction case study companies, and provided practical and diagnostic outcomes which exposed organisational strengths, weaknesses, and benchmarking opportunities. Stage 2 also offered insights into how measurement can guide innovation improvement strategies. Stage 3 refined and validated the tool with the help of construction industry experts, confirming the tool's relevance and applicability across different organisational settings and ensured that the results are reliable for informing practice. Chapter 7, and specifically Section 7.7, consolidated these findings and contributions through emphasising that the tool not only fills a research gap in the field of innovation measurement within the New Zealand construction industry, but also provides strategic direction. Organisations are encouraged to use the tool as part of their continuous assessment, industry stakeholders are advised to embed the innovation measurement tool into their planning and capability-building, and policymakers are guided to integrate the tool into their sector-wide strategies. In this way, this thesis shows that the strategic insights gained are centred and focused on using measurement not just as a one-off activity but as an ongoing process which supports organisational decision-making, industry benchmarking, and long-term improvement in innovation and especially its measurement practices.

7.5 Contributions to Knowledge

7.5.1 Theoretical Contributions

This research makes several theoretical contributions to the body of knowledge on innovation measurement, particularly in the context of the construction industry. Firstly, it addresses a significant gap in the literature by developing a comprehensive diagnostic tool that measures both Innovation Potential and Business Innovation Score within medium and large construction organisations in New Zealand. Although existing frameworks provide valuable insights and guidance, they are mainly designed for manufacturing or broader economic sectors and do not adequately consider the unique characteristics of the construction industry.

Categorising innovation measurement into the two complementary dimensions of Innovation Potential and Business Innovation Score provides a conceptual framework that distinguishes between the drivers of innovation capability and the outcomes achieved. This theoretical distinction, which is based on the literature and validated through empirical research and expert evaluation, offers a more detailed understanding of innovation measurement in construction organisations and can be adapted to other project-based industries facing similar challenges.

Furthermore, the identification and organisation of indicators within Innovation Potential's five categories improves the existing theoretical models by clearly collecting organisational, human, technological, and external factors. This integrated approach reflects the multifaceted nature of innovation potential in the construction industry and advances existing theoretical perspectives, which usually address these elements in isolation.

This research additionally contributes to the theoretical understanding of context-specific innovation measurement by demonstrating how global best practices can be adapted to align with local industry conditions. This provides a framework for tailoring innovation measurement tools to the unique and special needs of different sectors and national contexts, and consequently broadening the applicability and relevance of innovation measurement theory beyond its conventional domains.

7.5.2 Practical Contributions

This research provides useful and practical contributions to the New Zealand construction industry through the development of a validated, context-specific diagnostic tool to measure innovation inside medium and large construction organisations. This tool offers a structured and systematic method for assessing not just Innovation Potential (the organisational capacity and enabling factors for innovation) but also Business Innovation Score (the outcomes achieved through innovation activities).

By applying this tool to organisations, they can create a detailed profile of their innovation capability across five categories of Innovation Potential. This enables companies to identify their strengths, find weak areas in need of improvement, and develop targeted strategies for strengthening their innovation capability. The ability to measure not just enablers, drivers, barriers, but also the outcomes of innovation, ensures that improvement initiatives are based on a comprehensive understanding of organisational performance.

This tool further presents a consistent framework for benchmarking innovation capability within and across organisations. This, in turn, facilitates internal performance monitoring over time and external comparisons with industry peers and competitors. It also supports competitive positioning and continuous improvement. The tool's adaptability allows it to be applied in different organisational contexts within the New Zealand construction industry. This adaptability indicates the tool's relevance to a range of companies with different structures and market focuses within the defined scope of research.

At an industry level, this tool offers value to policymakers, industry bodies, and government agencies through developing reliable and standardised data about the companies' and industry's performance regarding innovation. This data can be used to monitor existing industry trends, evaluate the effectiveness of innovation policies, and design targeted interventions to strengthen innovation capability across the industry. In this way, the tool has the potential to inform not only the decision makers within organisations, but also broader strategic planners within the New Zealand construction industry.

7.5.3 Methodological Contributions

This research makes a number of methodological contributions to the field of innovation measurement, especially within the construction industry. The sequential exploratory mixed methods design adopted for this research represents a systematic and rigorous approach to develop and validate a context-specific diagnostic tool. By integrating findings from the literature review (Stage 1), case studies (Stage 2), and CIEs evaluations (Stage 3), the research methodology ensured that the tool was not only theoretically grounded but empirically tested as well. This multi-stage process provided a platform for a robust triangulation, while it improved the credibility and reliability of this research's outcomes.

An important methodological innovation is the categorisation of indicators into the two complementary categories of Innovation Potential and Business Innovation Score. This categorisation, which was achieved through a structured innovation measurement framework, offers a more balanced and comprehensive tool for measuring innovation capability by capturing not just the enabling factors but the resulting performance outcomes as well. Within Innovation Potential, the five-category structure was derived from a combination of theoretical synthesis and empirical validation, and is a representation of a refined and construction-industry-specific achievement in the categorisation of innovation indicators.

The tool's validation process is also a contributor to methodological novelty. The evaluation by CIEs went beyond traditional face-value assessment, as it consisted of detailed feedback on the relevance of the indicators, their usefulness, completeness, and practical applicability in the New Zealand construction industry. This iterative process for refinement, which is guided by both industry and academic perspectives, ensured the methodological robustness of the final tool and further provided a replicable model for developing innovation measurement tools for other sectors or contexts.

Overall, the methodological approach adopted during this research demonstrates the value of combining extant literature reviews' outcomes with case study application and expert validation to produce measurement tools that are context-specific, comprehensive, and applicable within real-world industry settings.

In comparison with the previous frameworks, tools, and models for measuring innovation, which were discussed in section 2.5 of this thesis, the tool developed during this thesis offers originality and novelty, and adds its unique contribution and usefulness to the field of innovation measurement. The following table summarises these characteristics:

Table 7.1: Originality and Novelty, Contribution and Usefulness of the Developed Innovation Measurement Tool

Originality and Novelty	Contribution and Usefulness
A context-specific diagnostic tool for medium & large New Zealand construction organisations (rather than manufacturing-oriented, generic tools).	Fills the documented gap by giving firms and policymakers a suitable way to evaluate innovation in NZ construction.
Dual-component measurement that separates Innovation Potential (enablers) from Business Innovation Score (outcomes).	Offers a balanced view of capability vs. realised results, improving diagnosis and planning.

A five-category structure for Innovation Potential (Workforce & HR Management, Organisational Structure, Business Strategy, Technology, External Influences).	Gives clear action domains for targeted improvement programs in firms.
Three-tiered scoring (Indicator, Respondent, Category) designed for construction settings.	Enables granular + holistic diagnosis of innovation performance.
A micro / meso / macro dashboard that visualises indicator, category, and organisation-level results.	Makes results interpretable and actionable for managers and boards.
Transparent equal-weighting and simple 5-point scales (no complex normalisation).	Improves usability, comparability, and adoption across companies.
Adaptation of global best practices to a national/sector context.	Advances theory on context-specific measurement and shows how to tailor frameworks to local conditions.
Sequential, mixed-methods development Tool development + embedding in case study + CIE validation	Delivers a validated, credible tool and a replicable method for other sectors.
Sector-wide benchmarking orientation (within/across organisations; policy use).	Supports internal tracking, external comparison, and policy interventions based on standardised data.
Construction-specific indicator set reflecting drivers, enablers, and barriers often missed by generic models.	Produces more valid measures of innovation in project-based, fragmented construction contexts.

7.6 Implications

7.6.1 Implications for Industry

This research offers important implications for the New Zealand construction industry at both organisational and industry levels. For construction companies, the developed diagnostic tool provides a reliable and structured means of measuring innovation capability. This happens through the simultaneous measurement of Innovation Potential and Business Innovation Score. By identifying strengths and weaknesses across the five categories of Innovation Potential, organisations can prioritise targeted initiatives to improve their performance, allocate resources more effectively and even align the company's innovation activities with strategic objectives.

The tool's ability to present a comprehensive innovation profile further allows companies to benchmark their performance internally in longitudinal studies and externally against peers and competitors which are operating under the same industry. This ability of the tool facilitates continuous improvement and supports competitive advantage for companies operating in domestic or international markets. By embedding regular use of the tool into their organisational processes, companies could track the impact of their innovation programmes, adjust their strategies in response to changing market conditions, and foster a culture of continuous innovation within themselves.

For government agencies and policymakers, the tool provides a mechanism based on evidence for measuring and benchmarking the state of innovation within the construction industry.

Gathered data from the tool's application can support policy development and further allow targeted interventions, which are aimed at improving innovation capability across the construction industry. This includes the design of support initiatives, funding programmes, and regulatory changes that support innovation adoption and diffusion. The tool can further be used to monitor the effectiveness of the government's innovation strategies over time, and can even help ensure that public investment in innovation delivers tangible and measurable outcomes.

By delivering valuable and actionable insights to both industry practitioners and policymakers, this research contributes to building a more innovative, productive, and competitive construction industry for New Zealand.

7.6.2 Implications for Academia

The findings of this research advance academic understanding about innovation measurement in multiple important ways. Firstly, the research extends the body of knowledge by introducing a sector-specific framework for measuring innovation in medium and large construction organisations based on both theory and empirical evidence. The categorisation of innovation measurement into Innovation Potential and Business Innovation Score offers a conceptual distinction which allows researchers to analyse innovation from both capability-making and performance-outcome perspectives. This dual approach addresses a gap in extant literature, in which innovation measurement often focuses disproportionately on either inputs or outputs, instead of integrating both dimensions.

The identification and organisation of Innovation Potential into five interrelated categories develops a theoretically robust and practically relevant structure which can be applied to further research. This categorisation improves academic discourse through integrating organisational, human, technological, and external factors into a unified measurement framework that reflects the complex realities of innovation in project-based industries.

In addition, this research demonstrates the significant value of a staged mixed-methods design for tool development and validation. Through combining literature review, case studies, and CIE evaluations, the research offers a replicable methodological model for future research in the field of innovation measurement. This triangulated approach ensures theoretical robustness, empirical relevance, and practical applicability, which makes it adaptable to other sectors and national contexts.

Finally, this research contributes to the academic discussion on the contextualisation of innovation measurement frameworks. It shows how global best practices can be adapted to meet the unique and special conditions of a specific industry and geographical location, consequently encouraging further studies which tailor innovation measurement tools to the distinct needs of different industries.

7.7 Recommendations

7.7.1 Recommendations for Industry Practice

The diagnostic tool developed in this research can be integrated into the business processes of medium and large construction organisations as a central component of their strategic management and frameworks for continuous improvement. Companies are encouraged to adopt the tool as part of their regular performance monitoring and use it to measure both Innovation Potential and Business Innovation Score at set intervals, such as annually or biannually. Regular application of the tool will allow organisations to track progress over time, measure the effectiveness of their innovation programmes, and identify possible gaps which need attention.

To maximise impact, companies can integrate the tool into their strategic planning cycles. This would contribute towards the innovation measurement outcomes, to directly support proper resource allocation, workforce development, and decisions on investments in technology. Cross-functional teams, including senior management, project managers, and innovation champions, should be involved with administering and interpreting the results obtained from the tool's implementation. This will result in fostering a shared commitment to helping improve innovation capability inside the New Zealand construction industry.

Benchmarking should be a key element of the tool's usage. Companies can compare their innovation performance with that of other industry peers and consequently identify areas where they are behind the industry benchmarks. They can then adopt best practices from high or even better-performing organisations. This could contribute to building a more competitive and innovation-oriented construction industry.

In addition, the government's involvement is very important for supporting the widespread adoption of innovation measurement. Government agencies such as the Ministry of Business, Innovation and Employment (MBIE) can support and even promote the tool as an industry standard. They could provide incentives for adoption, such as the organisation's access to funding programmes, recognition schemes, or preferential treatment in public procurement processes for the companies which demonstrate strong innovation capability or even focus. Awareness campaigns led by the government and training initiatives can further assist organisations in effectively using the tool and interpreting its results.

Through a collaborative approach between industry and the government, this tool could become an integral mechanism of support for the improvement of innovation capability. This support mechanism could support sustainable growth and further strengthen the overall competitiveness of New Zealand's construction industry.

7.7.2 Recommendations for Policymakers

Policymakers have a critical role in promoting and facilitating the adoption of standardised innovation measurement practices within New Zealand's construction industry. The diagnostic tool developed in this research provides a validated and context-specific framework, which can be used as the basis for innovation benchmarking across the construction industry. Through

promoting its consistent use, policymakers could achieve reliable and comparable data which supports evidence-based decision-making and consequently long-term strategic planning.

One recommendation is to integrate innovation measurement into existing industry performance monitoring systems, which are managed by agencies such as the Ministry of Business, Innovation and Employment (MBIE). This can possibly involve the establishment of industry-wide reporting requirements for innovation capability and performance, through the use of the developed innovation measurement tool, as the standard measurement framework. Such requirements would guarantee that innovation is systematically monitored and that progress can be tracked over time at both organisational and sectoral levels.

Incentive-based policies can further support innovation adoption. These could possibly include making eligibility for certain government funding programmes or public procurement contracts dependent on companies showing active engagement in innovation measurement and improvement activities. Recognition schemes, awards, or public rankings based on innovation performance can further motivate organisations to prioritise innovation capability development.

Additionally, policymakers can support capacity building through funding training programmes, workshops, and guidance materials, which help companies apply the tool effectively. Partnerships with industry bodies and professional associations can be utilised for increasing awareness and providing ongoing support for implementation.

Through embedding innovation measurement into national construction policy and performance frameworks, policymakers can help create a culture of continuous improvement, encourage knowledge sharing, and strengthen the New Zealand construction industry to compete more effectively in both domestic and global markets.

7.7.3 Recommendations for Future Research

Future research can build on the outcomes of this study by extending the application of the diagnostic tool beyond medium and large construction organisations in New Zealand to other sectors and industry contexts. Testing the tool on small construction firms, as well as in related project-based industries such as engineering, architecture or infrastructure development, can provide valuable insights into its adaptability and generalisability. Such studies could potentially identify any sector-specific modifications needed to maintain accuracy and relevance.

Another area for future research is the refinement and expansion of the tool's indicators. Although the current tool includes a comprehensive set of indicators under Innovation Potential and Business Innovation Score, further empirical studies can explore additional indicators that can help capture emerging trends in innovation, such as digital transformation, sustainability-driven innovation, and collaborative innovation networks.

Longitudinal studies can investigate how indicator relevance evolves over time in response to technological, regulatory, market or other possibly impactful changes. It is recommended to conduct this research with as many of the construction companies as possible. This will facilitate the industry benchmarks to be defined, and companies can compare their scores with

the industry benchmarks and see where they stand compared to other companies. This would help the companies stay competitive and thrive in the future.

Additionally, research can investigate the integration of the developed diagnostic tool with other organisational performance measurement systems. This will enable a more holistic evaluation of business performance, which links innovation capability with productivity, profitability, and sustainability outcomes. Studies exploring the relation between the developed tool's results and actual organisational performance indicators can further strengthen its value as a decision-making tool.

The current tool was developed with a focus on organisational-level studies inside medium and large construction companies. However, it has the potential to be further improved and extended to cover project-level and industry-level applications. Future research can adapt the framework to measure innovation capability at the scale of individual projects, which will enable more detailed insights into how innovation emerges and is implemented within specific project environments. Similarly, scaling the tool for industry-level studies can provide policymakers and industry bodies with a broader view of sector-wide innovation trends, challenges, and opportunities, consequently supporting better targeted interventions and strategic planning.

Finally, international research through applying and comparing the tool in other national contexts can develop a deeper understanding of how geographical, cultural, and policy environments are influencing innovation capability in the construction industry. Such work will contribute to the development of not only globally adaptable, but also locally relevant, innovation measurement frameworks. This, in turn, will provide opportunities for extending and refining the current tool through future research.

7.8 Concluding Summary

This research has addressed a significant and critical gap in the measurement of innovation within New Zealand's medium and large construction organisations. This gap was addressed through developing, validating, and presenting a comprehensive diagnostic tool that captures both Innovation Potential and Business Innovation Score. Through its theoretically grounded and empirically tested indicators, the tool provides a practical means for organisations to measure and improve their innovation capability, while additionally presenting policymakers and industry bodies with a standardised mechanism for monitoring sector-wide innovation performance.

By continuously measuring the construction companies using this developed tool, organisations will continually improve and refresh their approaches to innovation management strategies to adapt to approaches that will lead to more innovations and better outcomes through innovations. This is highly emphasised considering the challenging competition that exists in the current construction industry environment as a result of ever-changing technological achievements.

The measurement guidelines developed in this thesis align with the need to carry out innovation measurement in a consistent manner, such that the results from different tool users can be easily

comparable. This will lead to enhancing the innovativeness of the construction companies and the effectiveness of the policymakers and regulatory bodies. This will eventually lead to the improvement of the indicators of innovation measurement within the construction organisations of New Zealand.

The sequential exploratory mixed methods design adopted for this research ensured that the tool reflects both global best practices and the unique characteristics of the New Zealand construction industry. By comprehending findings from the literature, empirical evidence from case studies, and validation from CIEs, this research delivers an innovation measurement framework that is context-specific, robust, and adaptable.

The potential impact of this research extends beyond the immediate scope of the New Zealand construction industry. The framework and methodology of this research can be applied to other project-based industries and adapted for use in different national contexts. This adaptation, in turn, will further contribute to the broader improvement of innovation measurement theory and practice. Eventually, the adoption of this tool has the potential to drive sustained improvements in innovation capability, strengthen industry competitiveness and support the long-term growth and resilience of the New Zealand construction industry.

7.9 Limitations of the Research

While this research makes a significant contribution to innovation measurement within the construction industry, a number of limitations need to be acknowledged. These limitations do not diminish the credibility of the findings but rather define the scope within which they should be interpreted.

From a methodological perspective, the tool was developed and validated through a sequential exploratory mixed methods design, which involved literature review, case studies, and Construction Industry Expert (CIE) evaluations. While this process ensured theoretical grounding and practical relevance, the case study sample size was limited to medium and large construction organisations in New Zealand. This may possibly affect the generalisability of the findings to small firms, other industries or different national contexts without further adaptation and testing.

In terms of contextual limitations, this research was conducted within the specific regulatory, economic, and market conditions of New Zealand's construction industry. Factors such as local government policies, industry practices, and market size may influence the applicability of the tool in other countries or sectors. Additionally, the focus on organisational-level measurement means that the tool does not directly assess innovation at the project-level or across broader industry-level, although it could be adapted for these purposes in future research.

Regarding scope, the tool captures innovation capability and performance at a specific point in time. While it provides valuable benchmarking and diagnostic insights, it does not account for longitudinal changes unless applied repeatedly over time. Furthermore, while the tool addresses a comprehensive set of innovation indicators, it may not fully capture emerging innovation dimensions such as those driven by rapidly evolving technologies or shifting societal expectations.

Acknowledging these limitations provides a clear basis for interpreting the findings and highlights

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Appendix 1: Ethics

---------- Forwarded message ---------
From: <humanethics@massey.ac.nz>
Date: Tue, 9 Jun 2020 at 10:42
Subject: Human Ethics Notification - 4000022772
To: <H.SadeghzadehFasaghandis.1@uni.massey.ac.nz>, <M.B.Jelodar@massey.ac.nz>, <S.Wilkinson@massey.ac.nz>
Cc: <humanethics@massey.ac.nz>

HoU Review Group

Ethics Notification Number: 4000022772
Title: Improving the Value of Innovation in the New Zealand Construction Industry

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz. "

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that

the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter, please login to the RIMS system, and under the Reporting section, View Reports you will find a link to run the LR Report.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

Appendix 2: Business Innovation Measurement Tool (Potential and Score) + Sample Responses

- The following tool, consisting of a set of questions, will measure the “Potential for Innovation” and the "Business Innovation" of your company.

- During this study: “observation period” is defined as the “past one year”.

- A "business innovation" is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.

- A "product innovation" is a new or improved good or service that differs significantly from the firm’s previous goods or services and that has been introduced on the market. Minor variations of the same product is not considered an innovation.

- A "business process innovation" is a new or improved business process for one or more business functions that differs significantly from the firm’s previous business processes and that has been brought into use by the firm. Business process innovations concern the different functions of a firm.

- "Innovation activities" include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm.

- Many innovation-active firms organise their innovation activities as "innovation projects", defined as a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes.

- Other than innovation activities, firms can also conduct "follow-on activities", but within the observation period. These follow-on activities can be critical for the success of an innovation, but they are not included in the definition of an innovation activity.

Potential: Workforce Skills and HR Management

The main objective of this section is to find information about the Workforce Skills and HR Management of your firm.

To what extent do you find the following traits present within your organisation?

			Very low	Low	Average	High	Very High	Score 1-5
WF&HR 1	Cognitive abilities	Cognitive abilities, in particular idea generation and reasoning abilities of the workforce				✓		4
WF&HR 2	Adaptability and flexibility	Adaptability and flexibility towards change			✓			3
WF&HR 3	Social skills	Social skills, to work with people to achieve goals			✓			3
WF&HR 4	Systems skills	Systems skills, to understand, monitor, and improve sociotechnical systems				✓		4
WF&HR 5	Entrepreneurialism	Entrepreneurialism					✓	5
WF&HR 6	Creativity	Creativity				✓		4
WF&HR 7	Autonomy	Autonomy - Self Driven				✓		4
WF&HR 8	Collaboration	Collaboration amongst departments and employees			✓			3
WF&HR 9	Partnerships	Collaboration with partners				✓		4
WF&HR 10	Commitment	Commitment from employees towards tasks and duties				✓		4
WF&HR 11	Innovation non-resistance	Employees not showing resistance towards innovative practices			✓			3
WF&HR 12	Not fearing from risking	Not fearing from risking on innovation - Not showing Risk Averse Behaviour - Risk Appetite			✓			3

WF&HR 13	Employee performance	Employee performance (cost reduction, productivity, effectiveness)			✓			3
WF&HR 14	External involvement	External network involvement			✓			3
WF&HR 15	R&D capability	R&D capability		✓				2
WF&HR 16	Communication	Communication			✓			3
			AVERAGE SCORE					3.44

Potential: Organisational Structure

The main objective of this section is to find information about the Policies and Organisational Structure of your firm in relation to innovation.

To what extent do you find the following traits present within your organisation?

			Very low	**Low**	**Average**	**High**	**Very High**	**Score 1-5**
Org 1	Organisational support	Organisational structure supporting Innovation - Innovation Infrastructure				✓		**4**
Org 2	Upper management support	Upper management and decision maker's support for innovations				✓		4
Org 3	Innovation Champion	How do you rate the contribution of the Innovation Champion (someone directly tasked with managing the innovation practices within the company) within your company?				✓		4
Org 4	Recruitment policies	Employee recruitment policies that seek creative skills for innovativeness			✓			3

Org 5	Employee recognition	Performance appraisals, promotion, and employee recognition			✓			3
Org 6	Incentives	Incentives for employee performance in suggesting ideas for innovation or in developing innovations			✓			3
Org 7	Knowledge management	Knowledge management processes					✓	5
Org 8	Lessons learned	Management of lessons learned			✓			4
Org 9	Career development	Training, skills, and career development opportunities			✓			4
			AVERAGE SCORE					3.78

Potential: Business Strategy

The main objective of this section is to find information about the Business Strategy of your firm.

			Very poor(ly)	Poor(ly)	Neutral	Strong(ly)	Very strong(ly)	Score 1-5
BS 1	Strategic Plan	How do you rate your company's strategic plan?					✓	5
BS 2	Strategy communication	How well are your company's strategic plans communicated to the employees?					✓	5
BS 3	Progress monitoring	How strong is the progress monitoring system of your company's strategic plan towards achieving company plans?					✓	5
BS 4	Innovation Strategy	How well does your company's strategic plans address innovations?				✓		4

BS 5	Finish price focus	To what extent does your company's strategic plan focus on the price of the finished product?			✓			3
BS 6	Quality focus	To what extent does your company's strategic plan focus on the quality features of the finished product?			✓			3
BS 7	Multiple market focus	To what extent does your company's strategic plan focus on multiple markets simultaneously?				✓		4
BS 8	In-house sourcing	To what extent does your company fulfil its requirements in-house (products, processes, technology, plans etc.)				✓		4
BS 9	Lifecycle focus	To what extent does your company's strategic plan have a lifecycle perspective?				✓		4
			AVERAGE SCORE					4.1111

Potential: Technology								
The main objective of this section is to find information about the Technology of your firm.								
To what extent are the following factors present in your organisational interactions?								
			Very low	**Low**	**Average**	**High**	**Very High**	**Score 1-5**
Tech 1	Innovation awareness	Awareness about innovative tools, methods, and practices amongst the employees					✓	5
Tech 2	Problem-solving techniques	Use of problem-solving techniques amongst employees				✓		4

Tech 3	Innovative designers	Designer's understanding of innovations (Architects, structural, mechanical, electrical engineers)				✓		4
Tech 4	Design capabilities	Design capabilities			✓			3
Tech 5	Presence of technology	Presence of Technology				✓		4
Tech 6	Technical expertise	Technical expertise in emerging technologies				✓		4
Tech 7	Digital technologies	Digital technologies, platforms, and analytics				✓		4
			AVERAGE SCORE					4

Potential: External Influences

The main objective of this section is to find information about the External Influences on your firm.

To what extent and how each of the following items contributed to innovation within your company?

			Strongly negative	**Negative**	**Neutral**	**Positive**	**Strongly Positive**	**Score 1-5**
Ext 1	Product markets	Proximity to product markets				✓		4
Ext 2	Labour market	Labour market conditions		✓				2
Ext 3	Contractor's expertise	Contractor's expertise				✓		4
Ext 4	Innovation demand	Market/owner/client demand for innovation				✓		4
Ext 5	Client's understanding	Client's understanding about their needs, desires and requirements.		✓				2

Ext 6	Fragmentation	Fragmented nature of the construction industry		✓				2
Ext 7	Project-baseness	Temporary/project-base nature of the construction projects		✓				2
Ext 8	High costs	Affecting High cost of projects				✓		4
Ext 9	Suppliers	Goods and services suppliers				✓		4
Ext 10	Market demand	Structure of market demand		✓				2
Ext 11	Competition	Competition in the market				✓		4
Ext 12	Standards	Standards/Codes (industry-wide co-ordination)				✓		4
Ext 13	Finances	Markets for finance				✓		4
Ext 14	Jurisdiction	Regulatory and enforcement framework / Jurisdiction conditions				✓		4
Ext 15	Tax	Tax system		✓				2
Ext 16	Infrastructure	Infrastructure services				✓		4
Ext 17	Macroeconomy	Macroeconomic policy (inflation, exchange rates, consumer demand etc.)					✓	5
Ext 18	Government	Government support				✓		4
Ext 19	Subsidies	Public support through subsidies			✓			3
Ext 20	External grants	Rewards, awards, grants, funds etc				✓		4
Ext 21	Contracts	Current forms of contract				✓		4

Ext 22	Tender process	Tendering process				✓		4
Ext 23	Society	Society's attitude towards innovation (citizen attitudes to IP, entrepreneurship or new technologies)		✓				2
Ext 24	Social responsibility	Social responsibility					✓	5
Ext 25	Sustainability	Natural and environmental sustainability conditions and changes					✓	5
Ext 26	Response to Environment	To what extent does your company's response to environmental changes affect your company's innovations (idea generation)?					✓	5
Ext 27	Environmental barriers	To what extent do environmental factors create a barrier to the innovations of your company?			✓			3
			AVERAGE SCORE					3.56

Business Innovation Score (Tailored for the construction Industry)

The following section of the tool, consisting of a set of questions, will measure the Business Innovation of your company. During this study: "observation period" is defined as the "past one year" except as noted specifically for a question.

a) Business Innovations

Please indicate the name of your business innovations. If your company has numerous innovations, please indicate the most important ones only. Minor variations of the same product is not considered an innovation.

b) Products Innovation:

Please answer the following 8 questions:

		Very Low	Low	Moderate	High	Very High	Score 1-5	
BI 1	Overall, how do you rate your company's produced "innovative goods" during the past year?				✓		4	
BI 2	Overall how do you rate your company's produced "innovative services" during the past year?				✓		4	
		1 to 5	**6 to 10**	**11 to 15**	**16 to 20**	**20+**		
BI 3	Please indicate the number of product innovations during the observation period		✓				2	
		0% to 20%	**21% to 40%**	**41% to 60%**	**61& to 80%**	**81% to 100%**		
BI 4	Inside your company, what share of the total sales in the previous three years do you estimate is due to product innovations?				✓		4	
BI 5	To what extent did your company's product innovations result in an increase in sales?				✓		4	
BI 6	To what extent did your company's product innovations result in an increase in profits?			✓			3	
BI 7	What was your average profit margin for your company's product innovations?			✓			3	
BI 8	What is the market share of the firm's product innovations out of all sales in the market for similar products?						-	

c) Business Process Innovation Measurement (Outcomes Measurement):

How do you rate your company's developments, during the past year, in relation to the following "innovative processes"?								
		Very Low	**Low**	**Moderate**	**High**	**Very High**	**Score 1-5**	**Name of Innovation(s)**
BI 9	Production of goods or services			✓				**3**
BI 10	Distribution and logistics			✓				3
BI 11	Marketing and sales			✓				3
BI 12	Information and communication systems			✓				3
BI 13	Administration and management				✓			4
BI 14	Product and business process development			✓				3
Please answer the following questions regarding your company's business process innovations:								
		0% to 20%	**21% to %40**	**41% to 60%**	**61% to 80%**	**81% to 100%**	**Score 1-5**	
BI 15	To what extent did your company's business process innovations result in an increase in sales?					✓	4	
BI 16	To what extent did your company's business process innovations –directly or indirectly – led to a reduction in operational cost (per unit of output / per operation)?	✓					1	
d) Innovation novelty and impacts assessments The basic requirement for an innovation is that it must be significantly different from the firm's previous products or business processes. How do you rate the ……. of the innovations / most important innovation of your company during the past year?								
		Very Low	**Low**	**Moderate**	**High**	**Very High**	**Score 1-5**	**DON'T KNOW**

BI 17	Novelty			✓			3		
BI 18	Innovativeness				✓		4		
BI 19	Economic impact			✓			3		

e) Innovation and business profiling

The innovation status of a firm is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. Under which business profile would you place your company?

Tick one in each row please:

An innovative firm: reports one or more innovations within the past year.	✓	A non-innovative firm: reports no innovations within the past year.	
An innovation-active firm: was engaged at some time during the past year in one or more activities to develop or implement new or improved products or business processes for an intended use.	✓	The firm is not engaged in innovation activities and has not introduced any innovations in the observation period.	

f) Innovation Activities

Innovation activities include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm.

To what extent during the past year has your company undertaken any of the following activities?								
		Very Low	**Low**	**Moderate**	**High**	**Very High**	**Score 1-5**	**Was the activity conducted for innovation purposes? (Yes/No)**
BI 20	Research and experimental development (R&D) activities				✓		**4**	
BI 21	Engineering, design, and other creative work activities				✓		**4**	
BI 22	Marketing and brand equity activities			✓			**3**	
BI 23	Intellectual Property (IP) related activities		✓				**2**	
BI 24	Employee training activities			✓			3	
BI 25	Software development and database activities		✓				2	
BI 26	Activities related to the acquisition or lease of tangible assets	✓					1	
BI 27	Innovation management activities.			✓			3	

g) Data on innovation projects:

Many innovation-active firms organise their innovation activities as innovation projects, defined as a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes.

For your company, please indicate:

Does your company organise your innovation activities on a project basis?	Yes	No
	✓	

		0	1 to 2	2 to 5	5 to 10	10+	Score 1-5	Not relevant
BI 28	The number of innovation projects undertaken during the past year?				✓		**4**	
BI 29	The number of innovation projects completed during the past year?			✓			**3**	
BI 30	The number of innovation projects ceased before completion during the past year.	✓					**1**	
BI 31	The number of ongoing innovation projects at the end of the past year.				✓		**4**	

h) Follow-on activities:

Other than innovation activities, firms can also conduct follow-on activities, but within the observation period. These follow-on activities can be critical for the success of an innovation, but they are not included in the definition of an innovation activity.

To what level does your company pursue any of the "follow-on" activities for their innovation projects?

		Very Low	Low	Moderate	High	Very High	Score 1-5	Description of Activity
BI 32	Follow-on marketing/promotions/sale/advertising/fairs/distribution etc.			✓			3	
BI 33	Follow-on training related to the use of innovations during the past year / familiarising users with a firm's innovations,			✓			3	
BI 34	After-sales services/maintenance/operations management/utility improvement/installation/updating/repair		✓				2	

	services/guarantee/return schemes/information services/communication etc.							
i) Planned innovation activities and expenditures								
	Data on a firm's future plans for innovation activities can provide information about the possible development of innovation in an economy or industry in the near future.							
	Data on planned innovation activities can also help assess the likely impact of recent changes in the innovation environment of firms.							
Please answer the following four questions:								
		Yes	**No**	**Don't Know**			**Score 1-5**	**Don't Know**
	Does your company plan to conduct any innovation activities during the next two years?	✓						
		Less than $100k	**$100k to 500k**	**$500k to $1M**	**$1M to $5M**	**More than $5M**		**Don't Know**
BI 35	Could you please indicate your company's planned annual innovation expenditures during the next two years?			✓				
		0% to 20%	**20% to 40%**	**40% to 60%**	**60% to 80%**	**80% to 100%**		**Don't Know**
BI 36	What percentage of your company's expenditures is on innovation during the next two years?	✓						
					Rise	**Stay the same**	**Fall**	**Don't Know**
How is your company's total expenditure on innovation expected to change during the next two years compared to the year in which data are being collected (nowcasting, which is the year after the reference year)?					✓			

Potential for Innovation in the Construction Industry

General Resources

	Response	Comments
The main objective of this section is to find information about the general resources of your firm.		
1. Number of employees in the company you work for (FTE):		
a. Zero-employees / Self-employed		
b. 1-5 employees		
c. 6-19 employees		
d. 20-49 employees		
e. 50+ employees ✓		
2. Please indicate the volume of turnover of your company:		
a) less than $1 million		
b) $1million to $10 million		
c) $10 million to $100 million		
d) $100 million to $1 billion ✓		
e) more than $1 billion		
3) Please indicate the volume of assets owned by your company:		
(This includes tangible fixed assets, intangible fixed assets, goodwill and current assets, regulatory licence to exploit resources etc.)		
a) less than $1 million		

b) $1million to $10 million		
c) $10 million to $100 million ✓		
d) $100 million to $1 billion		
e) more than $1 billion		
4) Please indicate the age of your company		
a) less than 1 year		
b) 1 to 5 years		
c) 5 to 10 years		
d) 10 to 20 years ✓ **2013**		
e) more than 20 years		
5) Please indicate the profit margin of your company		
a) less than %20 ✓		
b) %20 to %40		
c) %40 to %60		
d) %60 to %80		
e) more than %80		
6) Please indicate the equity ratio of your company (debt vs equity)		
a) less than %20 ✓		
b) %20 to %40		
c) %40 to %60		
d) %60 to %80		
e) more than %80		
7) Please indicate whether your company is:		
a) Stand-alone ✓ b) Part of an organisation		
a) National ✓ b) Multinational		
The country your head office is based in: …Christchurch….		

Is your company publicly listed on the stock exchange? a)Yes b)No ✓					
8) Please indicate the type of customers/clients (main/majority) your company has been dealing with:					
a) Government (Business to Government) ✓					
b) Other businesses (Business to Business)					
c) Individual Consumer (Business to Consumer)					
d) other: Please indicate …….					
9) If your company deals with the governmental sector (B2G), please indicate the level of government:					
a) National ✓					
b) Regional ✓					
c) Local					
10) Please indicate the type of financing for the innovation activities of your company:					
a) Internal ✓					
b) Equity					
c) Debt					
d) Mixed					
e) Financial transfers					
f) other: please specify ……..					
	a) less than %20	**b) %20 to %40**	**c) %40 to %60**	**d) %60 to %80**	**e) More than %80**
11) What percentage of your company's employees have tertiary education?		**✓ %25**			
12) What percentage of your company's employees have job-specific tertiary education?					**✓ %100**

13) What percentage of your company's employees have vocational training relevant to their duties?					**✓ %100**
14) What is the average tenure of your employees in their positions?	**Less than 2 years**	**2 to 4 years**	**4 to 6 years**	**6 to 8 years**	**More than 8 years**
			✓		

Potential for Innovation in the Construction Industry		
Demographic Questions		
	Response	**Comments**
The main objective of this section is to find general information about "you":		
1. Please indicate your role in the construction industry:		
a. Consulting		
b. Contracting		
c. Owner/Client/Principal	Owner	
d. Others (please specify) …….		
2. Under which sector have you mainly operated in?		
a. Public sector		

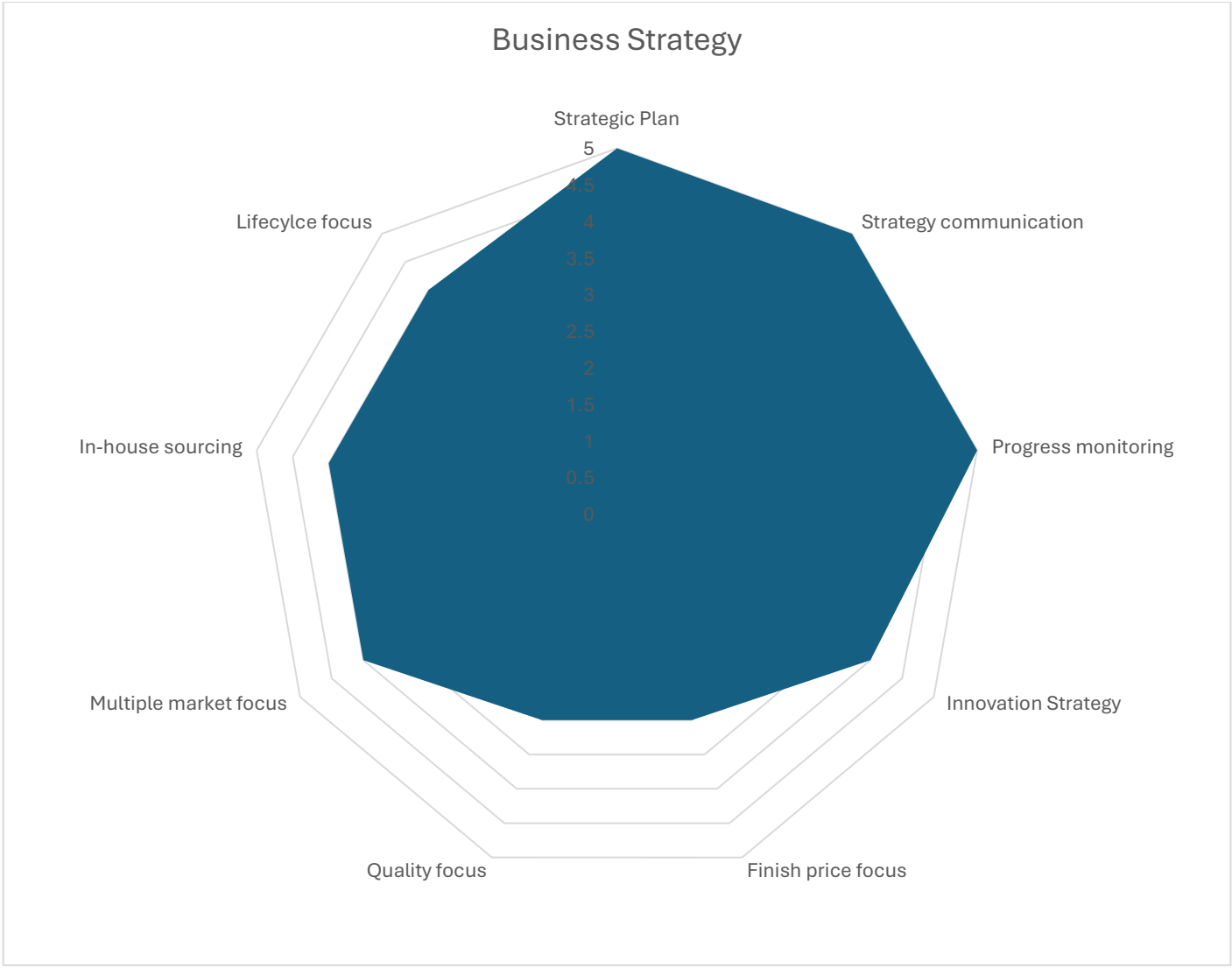
b. Private sector	✓	
c. PPP		
d. Others (please specify) …….		
3. What type of construction work are you dominantly involved in?		
a. Residential		
b. Industrial		
c. Commercial	✓	
d. Civil engineering and/or infrastructure		
e. Others (please specify) …….		
4. What is your profession in the construction industry?		
a. Architect		
b. Engineer	✓	
c. Planner		
d. Quantity Surveyor		
e. Project Manager		
f. Others (please specify) ….....		
5. Designation of respondent:		
a. CEO	✓	
b. Board Member		
c. Project Manager		
d. Others (please specify) …….		

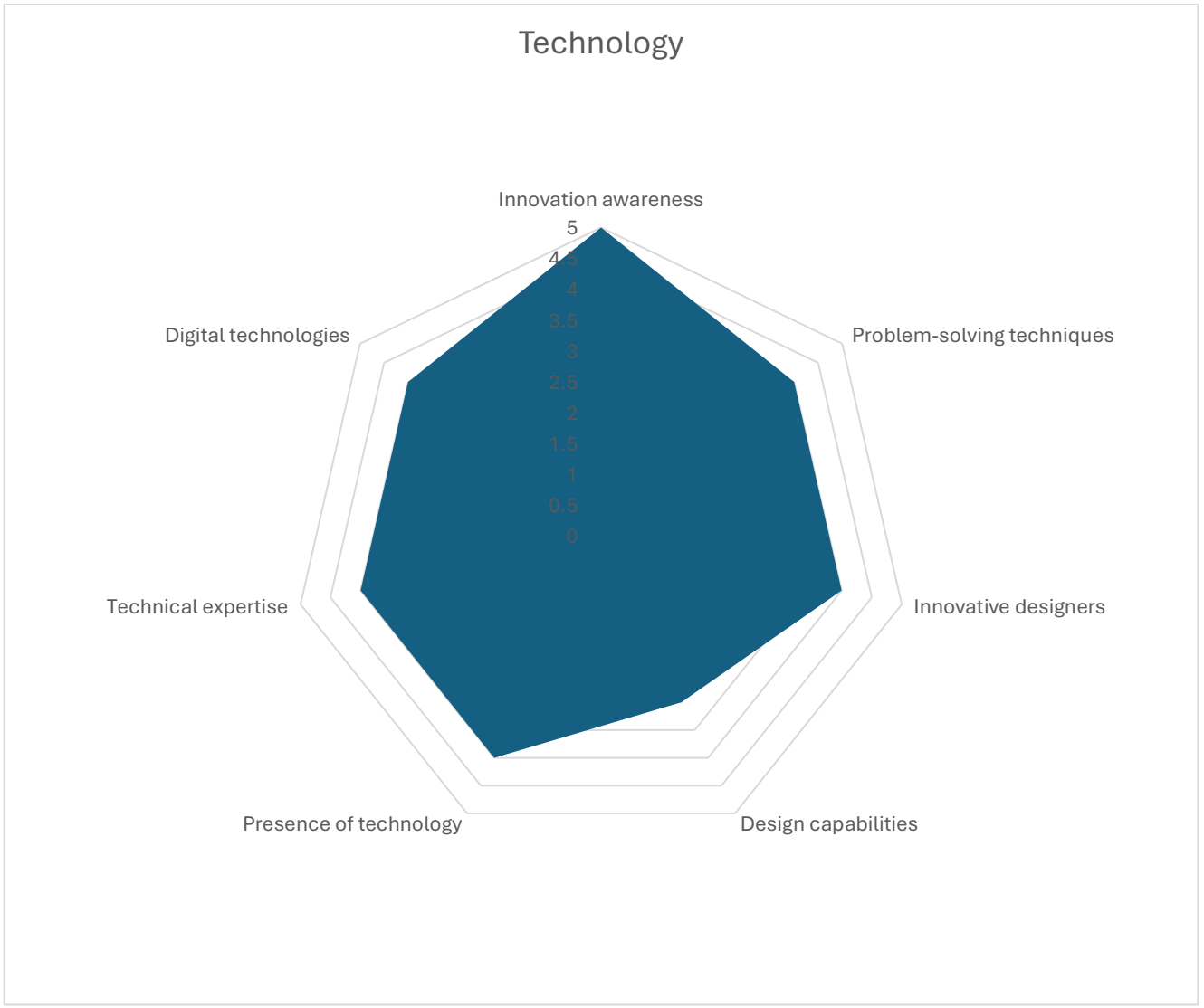
6. Highest academic qualification of respondent:		
Qualification name: ……	H3 certificate in Engineering and The school of life	
Qualification level according to NZQA: ……		
7. Do you have any professional qualification or membership:		
Yes		
No	✓	
Please specify: ……		
8. Years of experience of respondent in construction works:		
a. 0-5 years		
b. 6-10 years		
c. 11-15 years		
d. 16-20 years		
e. Over 20 years (please specify) …….	40	
9. Years of involvement of respondent in management:		
a. 0-5 years		
b. 6-10 years		
c. 11-15 years		
d. 16-20 years	✓	
e. Over 20 years (please specify) …….		

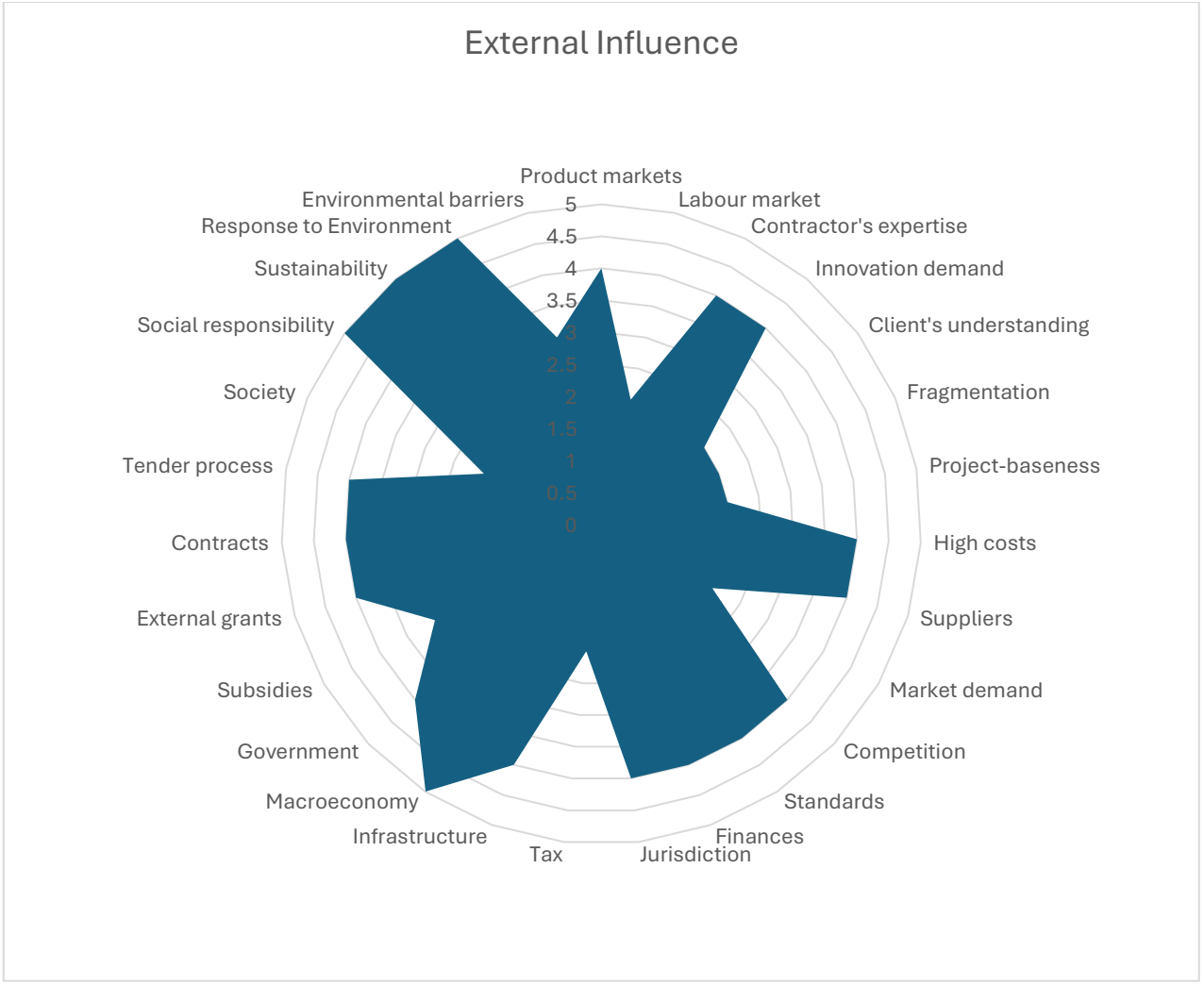
11. Please indicate your age range:		
a. 21 to 29		
b. 30 to 39		
c. 40 to 49		
d. 50 to 59	✓	
e. 60+		

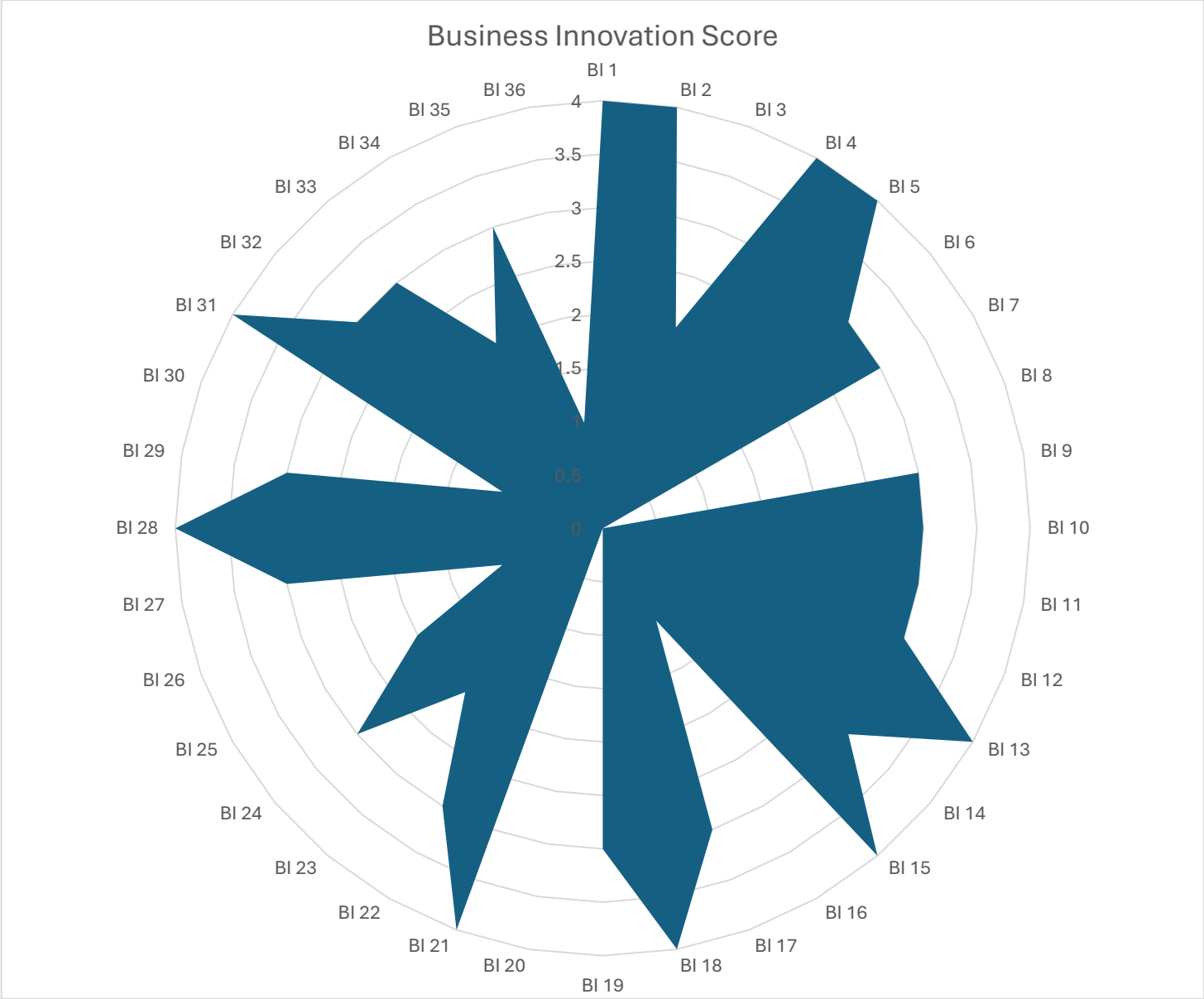
Result Diagrams

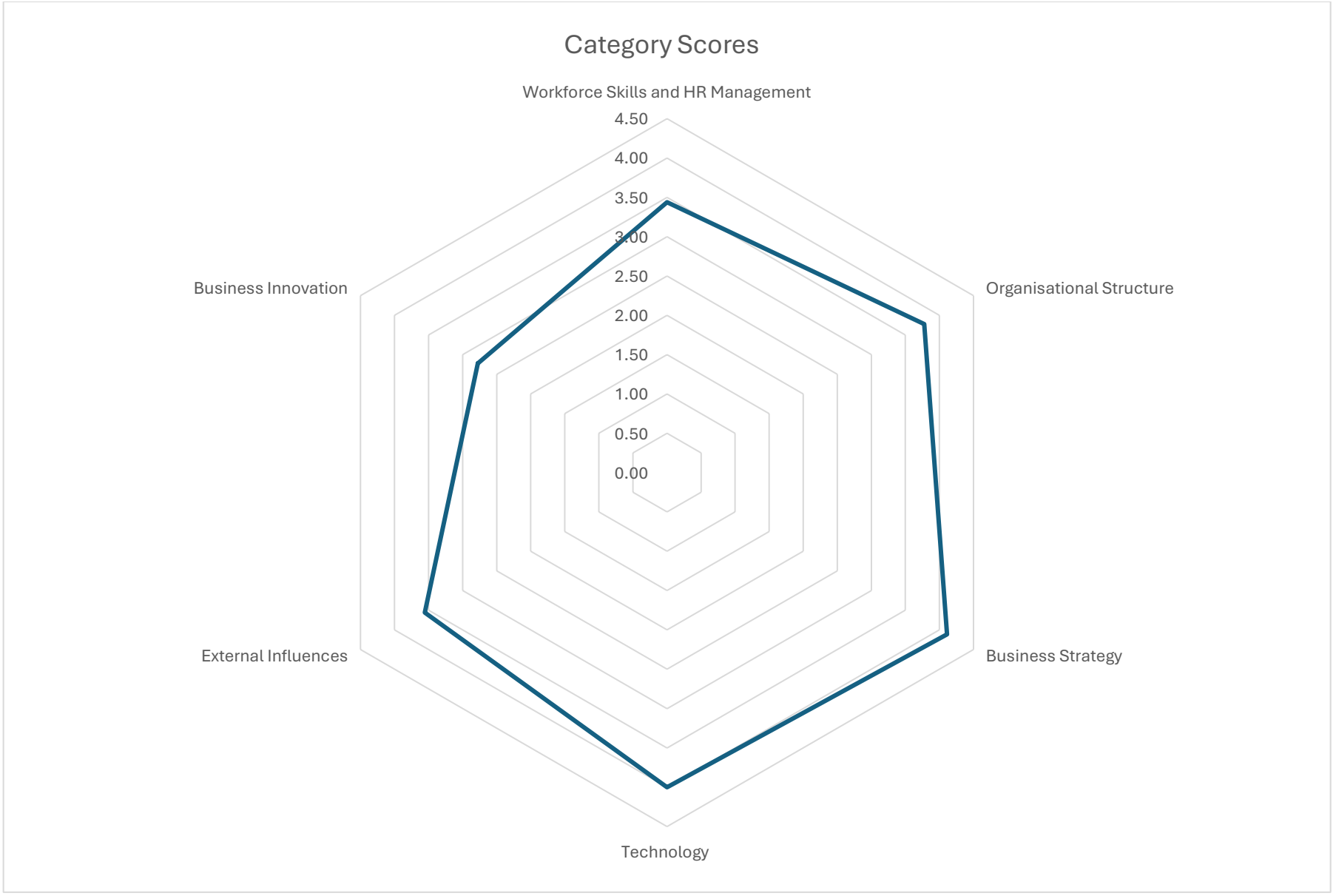
Organisational Structure
Organisational support
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Upper management support
Innovation Champion
Recruitment policies
Employee recognition
Incentives
Knowledge management
Lessons learned
Career development


Business Strategy
Strategic Plan
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Strategy communication
Progress monitoring
Innovation Strategy
Finish price focus
Quality focus
Multiple market focus
In-house sourcing
Lifecylce focus

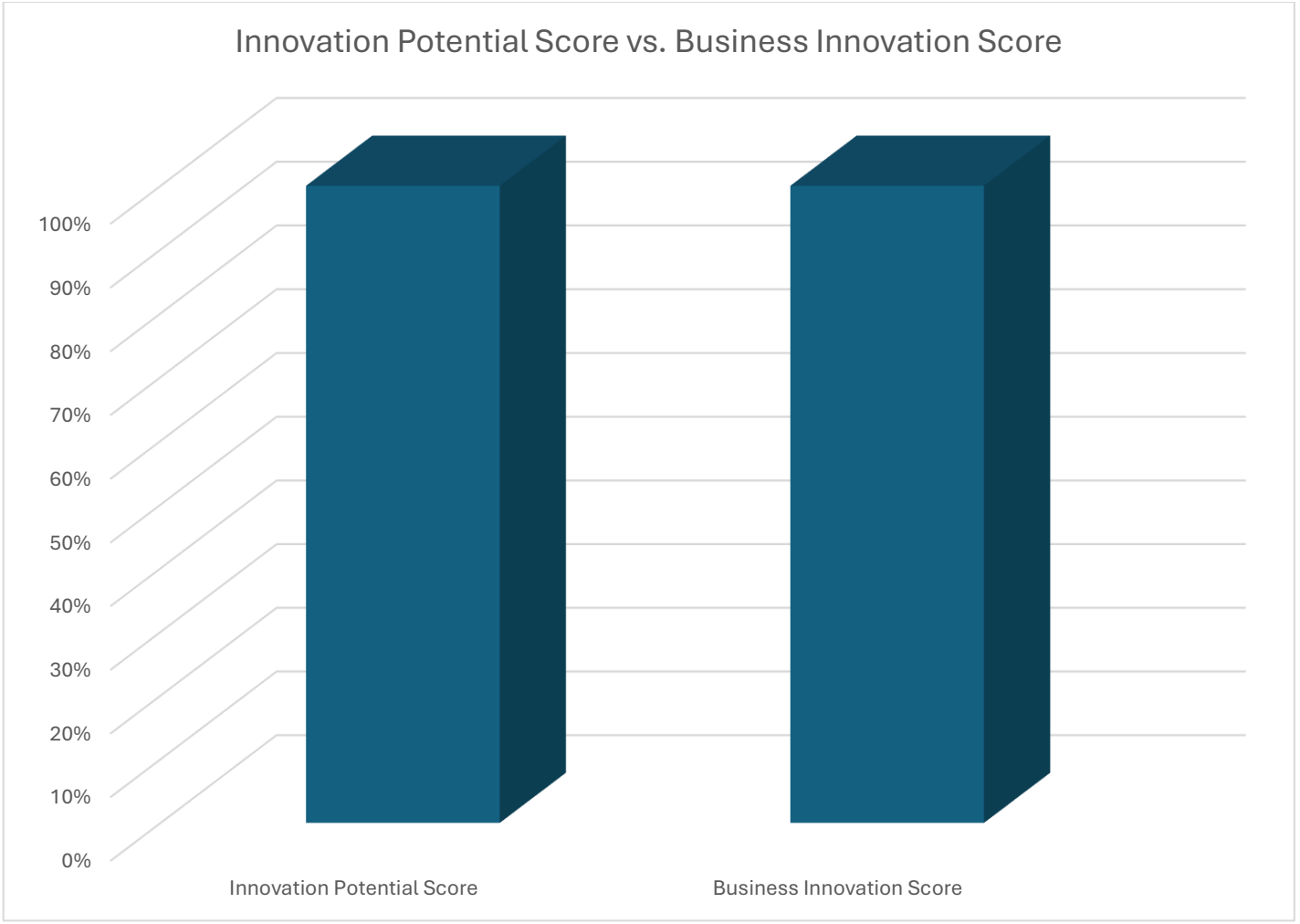

Technology
Innovation awareness
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Problem-solving techniques
Innovative designers
Design capabilities
Presence of technology
Technical expertise
Digital technologies


External Influence
Product markets
Labour market
Contractor's expertise
Innovation demand
Client's understanding
Fragmentation
Project-baseness
High costs
Suppliers
Market demand
Competition
Standards
Finances
Jurisdiction
Tax
Infrastructure
Macroeconomy
Government
Subsidies
External grants
Contracts
Tender process
Society
Social responsibility
Sustainability
Response to Environment
Environmental barriers
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0


Business Innovation Score
BI 1
BI 2
BI 3
BI 4
BI 5
BI 6
BI 7
BI 8
BI 9
BI 10
BI 11
BI 12
BI 13
BI 14
BI 15
BI 16
BI 17
BI 18
BI 19
BI 20
BI 21
BI 22
BI 23
BI 24
BI 25
BI 26
BI 27
BI 28
BI 29
BI 30
BI 31
BI 32
BI 33
BI 34
BI 35
BI 36
4
3.5
3
2.5
2
1.5
1
0.5
0


Category Scores
Workforce Skills and HR Management
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Organisational Structure
Business Strategy
Technology
External Influences
Business Innovation

Category Scores	Workforce Skills and HR Management	**3.44**
	Organisational Structure	**3.78**
	Business Strategy	**4.11**
	Technology	**4.00**
	External Influences	**3.56**
	Business Innovation	**2.78**
	Innovation Potential Score	**3.68**
	Business Innovation Score	**2.78**
Overall Score		**3.37**


Innovation Potential Score vs. Business Innovation Score
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Innovation Potential Score
Business Innovation Score

Appendix 3: Interview Questions with the Respondents from the Case Study Companies

What did you think about the tool? How did you find it?

Is there anything missing that you could think of?

Would diagnostic be useful? Are the results useful?

Would it be useful for your company to use this tool?

Are the results what you would expect? Are you surprised?

How would you simplify this tool?

Do you have any further feedback?

Appendix 4: Interview Questions with the Construction Industry Experts

What did you think about the tool? How did you find it?
Can you review and confirm the significance of the identified items for measuring innovation in the construction industry?
Is there anything missing that you could think of?
Would diagnostic be useful? Are the results useful?
Would it be useful for a/your company to use this tool?
How would you simplify this tool?
Do you have any further feedback?

Follow-up questions

How would you recommend this tool to be implemented in the companies.
What follow-up procedures would you recommend to further improve the practicality of the tool?

Are the results what you would expect? Are you surprised?

Appendix 5: Stage 2 (Case Study) Invitation to Participate in A Research Interview – Cover Letter

INVITATION TO PARTICIPATE IN A RESEARCH INTERVIEW

RESEARCH TITLE (Thesis title was later amended):
IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

Hi,

I am a student at Massey University undertaking a Ph.D. research on the abovementioned topic. I would like to invite you to participate in an interview as part of my research.

I aim to investigate which industry attributes are necessary for a construction company to innovate. The mentioned research also investigates the things that allow the measurement of business innovation within the construction companies. Also, the current state of innovation potential and business innovation of your company will be measured. The purpose of this interview is to obtain your opinion on how to improve this tool.

The interview time is estimated to between 20 to 30 minutes. The reason for your selection as a potential respondent is because of you and your company operating under the construction industry. If you are interested in participating in this interview, please do not hesitate to contact me. Thank you very much in advance for your time and valuable assistance in this research.

Researchers:

- PhD Student: Hossein Sadeghzadeh Fasaghandis
  Email: H.Sadeghzadeh@massey.ac.nz Mob: [redacted]
- Supervisor: Professor Suzanne Wilkinson
  Email: S.Wilkinson@massey.ac.nz
- Co-Supervisor: Dr Mostafa Babaeian Jelodar
  Email: M.B.Jelodar@massey.ac.nz

All researchers are from the School of Built Environment at Massey University.

Yours sincerely
Hossein Sadeghzadeh

Appendix 6: Stage 2 (Case Study) Information Sheet to Participate in A Research Interview

INFORMATION SHEET TO PARTICIPATE IN A RESEARCH INTERVIEW

RESEARCH TITLE (Thesis title was later amended):
IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

Hi,

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The tool consists of questions about the following information:

- General demographic question,
- General resources of the company,
- Workforce skills and human resources management,
- Organisational structure,
- Business strategy,
- Technology,
- External influences,
- Business Innovation of the company.

Data obtained from the interview will be treated with strict confidence, anonymously and used for academic purposes only. Your voluntary contribution to answering the questions would be

most appreciated. You may stop participating in this research at any time. Please answer the questions as accurately as you can. This significantly influences the quality of the data, the results, and thus, the entire research.

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact: (Research Ethics) at

Email: humanethics@massey.ac.nz

Ethics Notification Number: 4000022772

Please provide your email address if you wish to have a summary of the research findings.

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question,
- withdraw from the study (within one week after the interview),
- ask any questions about the study at any time during participation,
- understand that your name will not be used unless you give permission to the researcher,
- be given access to a summary of the project findings when it is concluded.
- Completion and return of the questionnaire/interview implies consent. You have the right to decline to answer any particular question.

As the individual interviews will be recorded, you have the right to:

- ask for the recorder to be turned off at any time during the interview.

Researchers:

- PhD Student: Hossein Sadeghzadeh Fasaghandis
  Email: H.Sadeghzadeh@massey.ac.nz Mob: [redacted]
- Supervisor: Professor Suzanne Wilkinson
  Email: S.Wilkinson@massey.ac.nz
- Co-Supervisor: Dr Mostafa Babaeian Jelodar
  Email: M.B.Jelodar@massey.ac.nz

All researchers are from the School of Built Environment at Massey University. Please feel free to contact the researcher and/or supervisor(s) if you have any questions about the project.

Thank you very much in advance for your time and valuable assistance in this research.

Yours sincerely
Hossein Sadeghzadeh

Appendix 7: Stage 2 (Case Study) Research Consent Form

RESEARCH TITLE (Thesis title was later amended):
IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read, or have had read to me in my first language, and I understand the Information Sheet attached as Appendix I. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time.

1. I agree/do not agree to the interview being sound recorded.
2. I wish/do not wish to have my recordings returned to me.
3. I agree to participate in this study under the conditions set out in the Information Sheet.

Declaration by Participant:

By signing below, it will be understood that you have consented to participate in the project.

I _____ hereby consent to take part in this study.

Signature: _____ Date: _____

Email: _____

Appendix 8: Stage 3 (CIE Interviews) Invitation to Participate in A Research Interview – Cover Letter

INVITATION TO PARTICIPATE IN A RESEARCH INTERVIEW

RESEARCH TITLE (Thesis title was later amended):
IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

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I aim to investigate which industry attributes are necessary for a construction company to innovate. The mentioned research also investigates the things that allow the measurement of business innovation within the construction companies. The purpose of this interview is to obtain your opinion on how to improve this tool and to validate the tool. The reason for your selection is your previous relevant experience.

The interview time is estimated to be between 30 to 45 minutes. The reason for your selection is your previous relevant experience. If you are interested in participating in this interview, please do not hesitate to contact me. Thank you very much in advance for your time and valuable assistance in this research.

Researchers:

- PhD Student: Hossein Sadeghzadeh Fasaghandis
  Email: H.Sadeghzadeh@massey.ac.nz Mob: [redacted]
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All researchers are from the School of Built Environment at Massey University.

Yours sincerely
Hossein Sadeghzadeh

Appendix 9: Stage 3 (CIE Interviews) Information Sheet to Participate in A Research Interview

INFORMATION SHEET TO PARTICIPATE IN A RESEARCH INTERVIEW

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IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

Hi,

I am a student at Massey University undertaking a Ph.D. research entitled: "Improving the Value of Innovation in the NZ Construction Industry". I would like to invite you to participate in an interview as part of my research. I aim to investigate which industry attributes are necessary for a construction company to innovate. The mentioned research also investigates the measures that allow the measurement of business innovation within the construction companies. The purpose of this interview is to obtain your opinion on how to improve this tool. The interview time is estimated to be between 30 to 45 minutes. The reason for your selection is your previous relevant experience.

The tool consists of questions about the following information:

- General demographic question,
- General resources of the company,
- Workforce skills and human resources management,
- Organisational structure,
- Business strategy,
- Technology,
- External influences,
- Business Innovation of the company.

Data obtained from the interview will be treated with strict confidence, anonymously and used for academic purposes only. Your voluntary contribution to answering the questions would be most appreciated. You may stop participating in this research at any time. Please answer the

questions as accurately as you can. This significantly influences the quality of the data, the results, and thus, the entire research.

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact: (Research Ethics) at

Email: humanethics@massey.ac.nz

Ethics Notification Number: 4000022772

Please provide your email address if you wish to have a summary of the research findings.

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question,
- withdraw from the study (within one week after the interview),
- ask any questions about the study at any time during participation,
- understand that your name will not be used unless you give permission to the researcher,
- be given access to a summary of the project findings when it is concluded.
- Completion and return of the questionnaire/interview implies consent. You have the right to decline to answer any particular question.

As the individual interviews will be recorded, you have the right to:

- ask for the recorder to be turned off at any time during the interview.

Researchers:

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All researchers are from the School of Built Environment at Massey University. Please feel free to contact the researcher and/or supervisor(s) if you have any questions about the project.

Thank you very much in advance for your time and valuable assistance in this research.

Yours sincerely
Hossein Sadeghzadeh

Appendix 10: Stage 3 (CIE Interviews) Research Consent Form

RESEARCH TITLE (Thesis title was later amended):
IMPROVING THE VALUE OF INNOVATION IN THE NZ CONSTRUCTION INDUSTRY

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read, or have had read to me in my first language, and I understand the Information Sheet attached as Appendix I. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time.

1. I agree/do not agree to the interview being sound recorded.
2. I wish/do not wish to have my recordings returned to me.
3. I agree to participate in this study under the conditions set out in the Information Sheet.

Declaration by Participant:

By signing below, it will be understood that you have consented to participate in the project.

I _____ hereby consent to take part in this study.

Signature: _____ Date: _____

Email: _____

Appendix 11: Sample Transcript of Interviews with Case Study Participants During Stage 2 of Research

Confidentiality and Anonymisation Note

All interview data presented in this appendix have been fully anonymised to protect participant confidentiality. Names of individuals, organisations, projects, and any potentially identifying information have been removed or generalised. The transcript is reproduced verbatim in content, with only formatting standardisation applied. This material is included solely to provide transparency and to contribute to an audit trail for the qualitative analysis conducted in this research, in accordance with the approved ethics protocol.

Interviewee (0:10)
Do you want something to drink or anything?

Facilitator (0:12)
No, I'm alright.

Facilitator (0:16)
The first page is the information sheet. It gives definitions of what we are trying to measure. As mentioned, innovation is assessed using two merged tools: Innovation Potential and Business Innovation.
The first sections measure a number of variables which, based on the results, allow us to understand the company's potential to innovate. The later sections focus more on outputs. We then compare these two aspects to see whether the potential is higher or lower than the output and whether there is room for improvement.
There are also several definitions used throughout the research. The observation period is the past one year. If there was a client or a project from a couple of years back, I would appreciate it if those are not taken into account, as the aim is to measure the present rather than the past.
If you would like, you can skim through it to get a general idea so that we are on the same page.

Interviewee (1:29)
Okay, common sense.

Facilitator (1:39)
Just go through and tick any of the boxes. Any time you do not know something, generally put a blank. If you are not one hundred per cent sure, or if something sits in between, it does not need to be exact - you can just tick it.

Interviewee (2:52)
It's been a long day so far, so my eyes are a little sore.

Facilitator (2:56)
Some people feel that way. That number of pages covers the Innovation Potential section.

Thank you - that's the first tool finished.
Now the next two pages are about innovations within the company. The previous sections focused on potential, and these sections help us understand outputs. We try to do some diagnostics before moving to the next part.

Interviewee (11:04)
Okay, thank you. Some of these are tricky.

Facilitator (13:45)
I understand - some of them might not be directly related to your subject.

Interviewee (13:48)
If some of it is, that's alright.

Facilitator (21:00)
Thank you for your patience. The next section covers the general resources of the company. This part is about the company - what the company should be - and there are several pages about yourself and where you fit in.

Interviewee
We are going to try to finish this.

Facilitator (25:51)
Thank you, and thank you for your patience.
Would you like to see the initial results?

Interviewee (25:56)
Yeah.

Facilitator (26:00)
These are initial results only, as some of them show preliminary information. The most consistent area appears to be technology, and I think the highest score you gave was for technology.
Is there a reason for that?

Interviewee (26:16)
No, we are particularly focused on it.
We know we have specific people who may not be revenue-generating but are employed for the purpose of driving technology. They may look like overhead costs, but they are an investment.
Yes, it is a long-term investment, which is brilliant, because a lot of businesses will not do it. I imagine especially private businesses, such as consultants who are not driven by stock exchange or shareholder perspectives.
It is a genuine, direct investment for the purpose of growth.

Facilitator (27:06)
Which has resulted in innovation?

Interviewee (27:09)
Definitely. Yeah. Yeah.

I mean, innovation in our industry is happening, but it is so hard to measure, isn't it?
The time and investment we have put into it is definitely above and beyond all the businesses I have come across, and it is going to pay dividends in the near future because we are staying ahead of the curve, although a lot of this innovation technology has not quite been implemented yet because it is so complex.
The discussion is not just client-driven. There is going to be a tipping point where we are already ahead. Definitely. Yeah.

Facilitator (27:56)
There are some ups and downs in the business strategy from the results. You gave a lower score for life-cycle focus, but you were happy with the strategic plan and strategy communication.
I noticed you never gave a five; four was probably the highest score. Is there a reason for not giving fives? Do you think there is room for improvement anywhere?

Interviewee (28:28)
It is subjective again, isn't it? It is a personal thing, I guess.

Facilitator (28:34)
Yeah. I mean, do you see something in the company where you think no fives are gained?

Interviewee (28:41)
Yeah, there are definitely fives gained in some areas.
We are very focused on delivery and client satisfaction. But where innovation sits at the moment - although it is a key driver for the business and a key area of development - it is almost subordinate to delivery, because at the moment it is not such a strong, specific client need.

Facilitator (29:05)
Innovation?

Interviewee (29:07)
Yeah.

Facilitator (29:19)
Multiple market focus - is that affecting innovation? The company focuses on multiple markets. Is that affecting innovation in any way?

Interviewee (29:30)
No, that was probably answered wrong, wasn't it?

Facilitator (29:32)
So let's go back. Market focus, business strategy.

Interviewee (29:38)
Definitely not. Yeah, it does not detract from it. Okay, so I would give that a five, actually.

Facilitator (29:48)
Do you think a greater focus on multiple markets has a positive impact on innovation?

Interviewee (29:54)
No, no - that is neutral actually, isn't it? Sorry. Yeah, it is neutral.

Facilitator (30:01)
So what it means is that since the company focuses on multiple places, is that benefiting innovation, or is it not affecting it at all?

Interviewee (30:12)
It is not really impacting it, in my opinion.

Facilitator (30:16)
Okay, so neutral.

Interviewee (30:38)
Yeah.

Facilitator (30:40)
Okay, good. Now, the other thing these results show is a score for Innovation Potential and, at the same time, a score for Business Innovation.
As you can see, the score you gave for the company's Innovation Potential is higher than the score for Business Innovation.
Do you think there is a lot of potential in the company that is not yet coming through?

Interviewee (30:44)
It's going to take time.

Facilitator (30:46)
Okay. What do you mean by "it's going to take time"?

Interviewee (30:56)
There has to be more demand for it in order for it to come through.
As I said, there will be a tipping point. At the moment, industry innovation is not that strong. But when other people step up to the mark and innovation becomes more common and regular, we will start reaching and exceeding that potential.

Facilitator (31:27)
So, coming to the measurement factor, this relates to our question about the use of this tool. From the results, you mentioned that the company's potential and innovations are not coming out of the pipeline, or they are not being measured.

Interviewee (31:45)
Or not being taken up.
You can develop an innovative idea or solution, and it gets to the point of execution - implementation - and then it does not come to fruition for various reasons.
So you have all the ideas. It is a supply-and-demand issue again.
We have potential, lots of ideas, lots of talented people, software development, and technology.
Sometimes it becomes a case of providing these innovative services as a by-product, to showcase what we are doing and what our capabilities are, for future work.

Facilitator (32:30)
Absolutely. So you think improvement is needed in idea capture?

Interviewee (32:38)
Yeah, because that is industry-driven.

Facilitator (32:45)
Okay. So you mean it is the same across the whole industry?

Interviewee (32:48)
Yeah.
We have been building buildings the same way for a very long time. There are new ideas and innovative ways, and slowly but surely they start being adopted.
You think, "Yeah, that worked - that was cool. We did that on that project."
Then another company does it, then others follow, and then consultants start designing that way.
At that point, it is no longer innovation, because it becomes common practice.

Facilitator (33:16)
Well, is it not? See, that's the -

Interviewee (33:19)
Preparative innovation, isn't it?

Facilitator (33:21)
Now, that is interesting for us.

Interviewee (33:27)
Because you said innovation is only innovative if it was not done last year, or if you are innovating compared to what you have done previously.

Facilitator (33:36)
It might have been implemented in a different company, but once we implement it in our company, that is innovation for us.
That is implementation. Yes. We are not innovating globally, but we are innovating internally.

Interviewee (33:48)
We are just implementing.

Facilitator (33:49)
We are just implementing.
Yeah, so we can do that in the company.

Interviewee (33:51)
So that is what the industry needs to catch up with, and then everyone will be implementing.

Facilitator (33:57)
Okay. So how can that happen in the company itself?

Interviewee (34:03)
We do a lot of design and construct ECI - early contractor involvement.
That means early contractor involvement.
You have a client with a concept, but no completed design, and they do not yet have the capability or capacity to go to tender with a full design.
So they come to a specialist with in-house design capabilities, and we come up with various solution proposals, which include innovation, and then execute and deliver them.
That is how we can move from innovating to implementing innovation.
But as with a lot of innovation, many people are trying to do it. Coming up with something that is truly innovative is not so common.
That said, we are definitely giving it a very good shot. For New Zealand, being a relatively small place, we are playing a big part.

Facilitator (35:20)
Good, good. So what did you think of the tool, and how do you see it?

Interviewee (35:27)
Yeah, good. Good.
It is generating some interesting data, isn't it?
There are all the ingredients here within the organisation, but unfortunately, as one of several stakeholders in projects, we cannot always control the implementation of innovation.
We can drive it and suggest it, which we continue to do.
I think it is definitely an industry issue.
However, with our design-and-construct model, where we control design, we have an opportunity to implement innovative ideas.
There are also budget constraints and time constraints, but normally the innovative solutions we develop have time and cost benefits.
There is also material here about life-cycle costing.
A lot of our innovation is about designing buildings in a way that minimises life-cycle costs and makes them as economical and environmentally friendly as possible.
I think that will become more and more important, especially with schools and university buildings.
It is becoming more of a client need, which will encourage further innovation.

Facilitator (36:33)
Good. So let's go to some of these questions. Is there anything missing that you can think of within the tool?

Interviewee (36:40)
Anything missing?
No, not really.
It is quite specific, but broad at the same time, if you know what I mean. It covers everything in broad terms.
It depends on what you are trying to get out of the data.

Facilitator (36:59)
It is construction-specific.

Interviewee (37:02)
Fully contractor-based.

Facilitator (37:05)
Okay, so you mean project-based?

Interviewee (37:07)
Yeah.

Facilitator (37:09)
It is more team-based or organisation-based rather than project-based. Is that what you mean?

Interviewee (37:14)
More specific to our type of construction and what we do, but -

Facilitator (37:18)
That's good. Please elaborate on that, because I tried to make it specific to construction. So you think it is not specific?

Interviewee (37:25)
No, no - it is specific to construction.
But there are various types of construction: commercial, infrastructure, subcontracted services, facilities management, and so on.
We operate in quite a specific space - design and construct, ECI, government projects, schools, and university-type work.

Facilitator (37:55)
How do you think we could further improve it?

Interviewee (38:00)
Oh, no - I do not think it needs improvement.
You are going to see various contractors, and it has to remain consistent. You cannot change it for every person you meet, because then you would get mixed results.
So I think it is appropriate for the general industry.

Facilitator (38:18)
Thank you. Would diagnostics be useful - analysing the data?

Interviewee (38:23)
Oh, yeah. Yeah, definitely.

Facilitator (38:26)
How could they be useful?

Interviewee (38:30)
We are always trying to make sure everyone understands the plan and the direction we are trying to take as a business in terms of innovation.
When there are more than one hundred people in the business, the message can sometimes get lost.
Doing this sort of research at scale within the business would help us understand that.
If you see a complete mix of results on the graphs, you might identify trends. For example, people may not fully understand the benefits of innovation or how much it contributes to turnover.

That would highlight hotspots to focus on, particularly around communication and what we are trying to achieve in the innovation space.
So yes - one hundred per cent - it is useful data.

Facilitator (39:18)
Good. Would it be useful for the organisation?

Interviewee (39:22)
Yeah, yeah, definitely.

Facilitator (39:25)
How do you think the organisation could implement this?

Interviewee (39:30)
By using the data, really, for the same reasons.
If everyone completed the survey, you could review specific areas of the innovation space and focus on improving understanding in those areas.
We already do similar things - surveys to gather opinions and identify gaps or shortfalls in understanding.
You might think something is at one hundred per cent, but the results show twenty per cent here, twenty per cent there - completely different from what you expected.
It can really turn your understanding around.

Facilitator (40:05)
Okay, that's good.
Were the results what you expected, or were you surprised?

Interviewee (40:11)
No, I was not surprised.
It was quite encouraging that the results showed there is a lot of potential for innovation in the business.
People often think construction is an industry where buildings have always been built the same way, and ask how much innovation is possible.
But there is a lot of potential there, and I really do believe it.
It is just a matter of time.

Facilitator (40:33)
Coming to this - since you are the commercial manager - there were some questions related to your field, about sales and individuals.
Would you like to add any specific items you noticed, where innovation could be measured in commercial roles?

Interviewee (40:48)
I think, historically, we do not -

Interviewee (40:55)
Yeah, it is very difficult.
In terms of sales, it is difficult, but in terms of commercial benefit to clients, it is clearer.
An innovative solution that we implement might generate a cost saving of, say, two per cent.
That is something we can measure commercially in terms of benefit to the client.

However, measuring it directly in terms of sales is quite complex.
Innovation sits across several business units, EDI - engineering, design, and innovation - and these are not directly revenue-generating. We do not sell EDI as a standalone product that people buy.
EDI - engineering, design, and innovation - supports projects, and those projects contribute to revenue and profit.
But determining what portion of that EDI support generates revenue, and how much revenue is attributable to that specific component, is very difficult.
There are arguments both ways.
Around eighty per cent of our business comes through design-and-build and ECI, which is essentially innovation. That is just how our business operates.
So yes, it is interesting. I have seen a lot of analysis around that.

Facilitator (41:55)
There absolutely is.
In the Business Innovation section, we try to measure some aspects related to the commercial side, such as what percentage of sales are influenced by innovation.

Interviewee (42:06)
Yeah. I was trying to be very direct and very specific to innovation.

Facilitator (42:11)
For example, to what extent are your company's product innovations resulting in increased sales?
Or follow-on activities - where you have sales and then after-sales activities.
How would you relate innovation to that?
Could anything be done within the company to strengthen that link?

Interviewee (42:34)
After-sales?

Facilitator (42:36)
Yes - follow-on activities.

Interviewee (42:39)
That is about moving more into facilities management and life-cycle management of projects.
That is driven largely through innovation in BIM modelling, where every element of a build is captured in a digital model, along with all maintenance-related data.
So if, for example, a light fitting needs replacing, there is no need to inspect it manually - the product code and specifications are already available in the model.
At the moment, across the industry, builders, contractors, and asset managers are all separate businesses.
That fragmentation creates an after-sales problem, which we are trying to address.

Facilitator (43:18)
Good. Do you think that needs to be measured and counted as innovation within construction?

Interviewee (43:24)
Would that be innovation in construction?

I suppose it would be, because at the moment, contractors delivering government projects are not doing this.
You do see developers who are also contractors delivering full vertical integration - from concept through to facilities management.
But in a competitive, tendered government market, that is not happening yet.
It is something we are striving towards. We have the resources and the technology, but not yet the implementation within a typical project.

Facilitator (44:10)
This is exactly the point I am trying to address.
In construction, we always focus on delivery and the physical product, while the backstage activities are undervalued.
Investments in innovation, specialists working on long-term ideas, and capabilities that may not pay off for several years are often overlooked.
The purpose of this tool is to highlight those aspects.
If this were implemented in a focus group or a one-day workshop, instead of rushing through it, each item could be discussed in more depth, supported by examples.
If measured again after a year, we might see that each department has generated new ideas, new processes have been implemented, and added value has been created.
This tool is intended to highlight areas that have historically been neglected in construction.

For example, we often treat the liability period as simply a duty, something that does not affect future projects once delivery is complete.
But does that negatively affect how the company is perceived externally - its vision and brand?
That is innovation.
Manufacturing and digital industries place strong emphasis on this, whereas construction generally does not.

To put it differently, where is the construction brand?
If you want to buy a phone, you think of companies like Apple or Samsung.
If you want to buy a car, you think of brands like Mercedes or Nissan.
Where is the equivalent global construction brand?

Interviewee (44:52)
Very interesting.
Construction might be different because it is so diverse in terms of products. You have houses, hospitals, churches, libraries - and then someone builds them, operates them, and returns to them as well.
So yes, it is interesting.
An example might be something like Westfield. They buy the land, develop it, construct it, lease it out, and then maintain it.
Westfield is a brand - a global brand.
Apart from Westfield, can we think of many other construction brands at that scale?

Facilitator (45:32)
Yes, that is right.
For example, Ramada does that for hotels. You can develop a hotel and lease it to Ramada, and they handle the operation.
So you remain the owner, and they lease it for fifteen or twenty years.

They specialise in that sector.
But we still need to develop that model further in residential, university buildings, and libraries.

Interviewee (46:05)
There is a lot of risk in construction, isn't there?
It is seen as highly specialised, and there are massive stakeholders to manage, each with associated risks.
So maybe it all just seems too hard.

Facilitator (46:23)
It is project-based.
The root cause is that every project is unique.
You bring organisational process assets from previous projects - experience, checklists, procedures - but the new project is still unique.
It might be similar, but it is never the same.

Interviewee (46:50)
Yeah.
The site is different, the ground conditions are different, it rains, or it does not rain.
You cannot get a subcontractor on site, and materials are not available.
It might be the same building on paper, but it is never the same in reality.

Facilitator (47:15)
Client perception also plays a role.
The way clients engage engineers and consultants can change everything.

Interviewee (47:25)
Yeah, yeah.
It is interesting.
We do have specialist contractors who build airports all over the world, and others who build stadiums or complex bridges.
That is interesting in itself.

Facilitator (47:50)
I assume some of this is also related to company size.
Innovation can be subjective to the size of the organisation.
Some companies, for example, large multinational firms with multi-billion-dollar innovation budgets, can replicate landmark projects.
They become brands.
If you want a skyscraper in Auckland, you might call five contractors - those become the recognised brands.

Interviewee (48:28)
Yeah, Samsung does a lot of that.

Facilitator (48:32)
They build ships as well.

Interviewee (48:35)
Yeah.
They were involved in Burj Khalifa, weren't they? At least part of it.
And they also worked on the Kuala Lumpur Tower.
They are now doing another one - I cannot remember the name.

Facilitator (49:00)
You mentioned stadium contractors.
They are specialists.
I once heard that if you want to host the Olympic Games, there are only a few contractors you can realistically call.

Interviewee (49:15)
Yes - Besix, for example.
A Belgian company.
Then there are Turkish contractors specialising in airports.
But houses? Not so much.

Facilitator (49:40)
So there is room for improvement.
That is where it starts to click.
A company might be doing a lot of work backstage, but if it improves its brand perception, it may attract more projects.
That could even shift the project pipeline in a different direction.
Five years down the line, that might influence overall business strategy.
If a company identifies a new market through branding that was previously neglected, it can have a significant impact.
If I want to buy a house and I recognise a brand, I am more likely to choose that brand.

Interviewee (50:12)
Yeah. One thing we look at a lot is the housing shortage. New Zealand clearly requires innovation to solve it.
We have delivered a lot of modular buildings in the past that could meet the needs and demands.
However, government policy creates obstacles. There is too much bureaucracy involved in getting modular housing approved in the way we would like to implement it.
That bureaucracy and red tape delay innovation.
There are people ready to implement solutions, but the regulatory process holds things back.

Facilitator (50:48)
Yeah, yeah. That is reflected in some of the questions.

Interviewee (50:54)
But in other areas, you see grants being provided for innovation and education.
So it is interesting - there is support in some places, but barriers in others.

Facilitator (51:07)
Good, good.
How would you simplify this tool?

Interviewee (51:12)
How would I simplify it?
I am a big fan of plain English.
Some questions can be interpreted subjectively depending on how a person reads or understands the scenario.
That said, I am sure you have already spent a lot of time making the questions as clear as possible, so simplifying further could be challenging.

Facilitator (51:36)
Yeah, definitely. Anything else?

Interviewee (51:40)
No, no - I think it is good.

Facilitator (51:43)
How would you rate the tool? Do you think it would be practical to use?

Interviewee (51:50)
Yes, definitely.
It would produce good data. The key is the interpretation of that data.
I have only looked at it briefly, but there is a lot of information that comes out of it.
I think it could be used extensively.
I like it - I like data.

Facilitator (52:10)
Do you work with data?

Interviewee (52:12)
A lot. Yes - a lot.
That is why I work extensively with risk management, forecasting, and opportunity management.
You might start a project expecting an eight per cent margin, but risks could reduce that to four per cent.
At the same time, there are opportunities that could increase the margin.
The challenge is converting those opportunities into real outcomes.
A big part of my role is reporting anticipated margin because it has a major influence on business performance.
We do not want to tender a project at eight per cent and then, two years later, quietly deliver four per cent.

Facilitator (53:05)
How do you manage that?

Interviewee (53:08)
We use risk and opportunity registers.
We assign dollar values to risks and opportunities, along with mitigation or realisation strategies.
We also define timelines, responsibilities, and reporting mechanisms.
That information is tracked over the life cycle of the project.

Facilitator (53:32)
Okay, interesting.
So, coming to this, do you think this tool could be engaged in companies as a process development tool?

Interviewee (53:48)
Oh, yeah. I mean, it is a tool, isn't it?
You can always change the questions or the way people respond, but so far, I think this is brilliant.
For me, I like it because it allows you to get data in many different ways.

Facilitator (54:00)
And just one last question - do you have any further feedback?

Interviewee (54:04)
I would be interested to see the outcome of your research, to be honest.
I did not go through everything in detail, but what is the overall objective?

Facilitator (54:15)
Initial results show that the construction industry - globally and in New Zealand - is perceived as not innovating and as being conservative.
We tried to understand where this perception comes from and whether it is correct.
There is contradictory research - some argue that the construction industry *is* innovating, but that innovation is not being measured.
That is what this research is trying to address.
At the same time, we identified criteria, items, and variables that define Innovation Potential.
Each of these items is drawn from existing research, and I have tried to bring them together.
The result is a combined Innovation Potential tool and a Business Innovation measurement tool.
This allows comparison between potential and output.
I see different results across different companies, which is interesting.
The aim is first to diagnose where problems exist and then to develop strategies for implementation.
If we want to change something, we need to measure it - because what cannot be measured cannot be changed.

Interviewee (55:35)
If I were tailoring the tool, I might focus it more specifically on areas of construction where innovation is occurring - for example, procurement processes, government policy, or high-rise construction.
That could generate very useful data.
If I were to use this model in my role, I would apply it to specific issues where innovation could deliver tangible benefits.

Facilitator (56:05)
Can you give a small example, so I have a lead to follow?

Interviewee (56:10)
Sure.
One issue is resource shortages - particularly skilled labour.

In areas like structural and in-situ concrete works, delivery is very risky for us.
Securing resources on a lump-sum, fixed-price basis is challenging, and risk exposure is high.
Risk communication and risk management are major issues.

I understand risk well and know how to manage and report on it at a senior level, but we currently have around twelve projects running.
The people who truly control risk are on-site.
Sometimes it is difficult to communicate risks that may materialise six months from now, because site teams are focused on today.
Different roles see risk differently.

If we could find an innovative way to manage risk openly across the business - from senior management through to site engineers - that would be extremely valuable.
A split-second decision on site can result in losses of tens or hundreds of thousands of dollars.

What I have been doing recently is sitting down with project teams for several hours to go through risk registers in detail - identifying who controls each risk, what actions are required, and how mitigation can be achieved.
We also ask teams to add risks that are not currently captured, because they are living the project and understand it better than anyone else.
That is a form of innovation in our risk management process.

However, I do not have the capacity to do this for every project.
We need a tool or process that achieves the same outcome more efficiently.
Developing a tool is not the hardest part - getting people to engage with it and see the benefit is the real challenge.
People need to understand the *why*.

A survey like this could help understand people's perceptions of risk and inform how systems and procedures are designed to manage it effectively.

Facilitator (58:05)
Are there tools already available for this?

Interviewee (58:08)
There are various ways of recording risk, but often it is just paperwork.
The challenge is not recording risk - it is getting people to buy into the process.
That is the difficult part.
It is the human side - people have different experiences, qualifications, and ways of communicating.

Facilitator (58:30)
From my own experience - before starting my PhD, I was a residential developer - I found that the construction industry is different from some other industries.
Construction sites are often isolated from the Project Management Office.
The Project Management Office tends to operate at a higher or broader level, while construction sites have their own immediate problems.
When the two come together, they do not always integrate well.

When I think about returning to industry after my PhD, one of the things I would do differently is invest more in the Project Management Office - not only making it robust and independent, but also ensuring it actively engages with construction teams.
I keep a notebook where I record ideas as they arise, because otherwise they get lost.

Taking risk management as a practical example, you mentioned four-hour discussions with site teams.
It is hard to imagine that when the site staff walked away from those sessions, they were not more aligned with your perspective.
They would have seen issues differently and felt more engaged.
If something arises later that might affect margin - whether four per cent or eight per cent - they are more likely to recognise it and act on it early.
That is how integration happens.

Interviewee (59:55)
The key thing I always say is that if you do not tell anybody about a risk, no one can help plan for it.
There is nothing more frustrating than sitting in a four-hour meeting, identifying risks and mitigation strategies, and then two months later, the risk occurs because it was not managed.
You lose the eighty thousand dollars you predicted you would lose.

Often, the issue is that the risk register sits on someone's computer.
The people on site do not know about it.
So it comes down to accountability.
You have to bring people into the process, involve them, and make them feel responsible.
Then human nature kicks in - people want to win, they want to manage risks out.

Communication is the biggest challenge.
Some people care, some do not.
But we have a lot of good people, and they are only as good as the opportunities you give them.
If you give them the opportunity to manage risk, protect margin, or seize opportunities, many of them will fight hard for it.

Facilitator (1:01:20)
Sometimes leadership styles matter here.
There is transactional leadership - give and take - and transformational leadership, which focuses on intrinsic values.
You need a mix, depending on the project and its stage.

You mentioned employees who feel a strong sense of belonging to the company.
Those people can come to you and say, for example, "Seasonally, we might not get access to this timber in March. Why don't we purchase early and stock up?"
We have all seen this on sites.
If you do not act, you end up with delays because materials are unavailable.

In Christchurch, there were instances where people were paid directly for new ideas - a transactional approach.
Someone comes up with a new way to mitigate risk and is rewarded for it.

Interviewee (1:02:45)
Yes.
We have KPI systems and performance-related pay, particularly for project teams.
But increasingly, it is about giving people direct opportunities to contribute.
Even if it is not explicitly transactional, it is embedded in project delivery.

If people do not realise that something they did on site improved the margin by one per cent, they might feel frustrated later.
But if they know in advance what they can influence, they feel responsible and empowered.
Giving people the ability to control outcomes makes a big difference.

It is especially rewarding when teams are receptive and engaged.
You can tell when people genuinely care and want to contribute.

Facilitator (1:03:55)
I am really glad we had this discussion today.
I learned a lot.
From a tool perspective, these conversations and the engagement itself give a strong sense of what is happening in the industry.

Interviewee (1:04:10)
Yes.
This organisation is particularly good at encouraging this sort of engagement.
It is hard work, but that is the nature of construction.

Facilitator (1:04:25)
You mentioned earlier that you worked in a different sector before and had exposure to other industries.

Interviewee (1:04:35)
Yeah.
I have worked quite a bit overseas - in the UK, in the Middle East, in Dubai for about seven years, then some time in Malaysia, and then here for the last couple of years.
You see a lot of different project types, people, and cultures.
That helps you understand how people work and how projects are delivered in different contexts.
So that experience is valuable.

It has always been construction for me - always contracting.

Appendix 12: Sample Transcript of Interviews with CIEs During Stage 3 of Research

Confidentiality and Anonymisation Note

All interview data presented in this appendix have been fully anonymised to protect participant confidentiality. Names of individuals, organisations, projects, and any potentially identifying information have been removed or generalised. The transcript is reproduced verbatim in content, with only formatting standardisation applied. This material is included solely to provide transparency and to contribute to an audit trail for the qualitative analysis conducted in this research, in accordance with the approved ethics protocol.

Interviewee (0:00):
You have my permission to record this.

Facilitator (0:05):
I will put this closer to you.

Interviewee (0:07):
Yeah, that's fine. Because that's what you're interested in. Sorry. Yeah. It looks like it's rising above the background.

Facilitator (0:15):
So yeah, as long as it's going up and down, we should be fine. Okay.

Interviewee (0:21):
Now that's good. So do you think,

Facilitator (0:28):
Yeah. Thank you for participating in these interviews. Now, the Business Innovation Measurement Tool consists of two major categories. The first one is under the category of potential.

Interviewee (0:42):
Innovation potential. Are you measuring the potential of the organisation? Correct? Yep. Okay, the organisation and where they currently set the score?

Facilitator (0:53):
Definitely. Yeah, we give them a score for different issues.

Facilitator (1:12):
But at the same time, the research gap we have tried to fill is that, of course, I want to go into facts. Construction is always categorised as an industry that doesn't innovate, you know, while,

Interviewee (1:22):
It has, it has low productivity.

Facilitator:
That's part of it.

Interviewee:
It has low productivity. And it's often used as a proxy to say that it's an industry that doesn't innovate. But productivity isn't solely a measure of innovation. So the two can be used interchangeably. Yeah. Anyway, carry on.

Facilitator (1:46):
Like this, as we go on, I know that you've been selected as a subject matter expert. And I see that you are pretty knowledgeable in this area. So you're quite right. In fact, we believe that there is a lot of innovation happening in the construction industry, but it's not really documented. So that's also one problem that exists. But how do we really measure it? So my research initially indicated that there is no comprehensive tool that measures innovation forecast. There are some things that measure innovation, for example, for the manufacturing industry, but it's not really, really fully relevant to the construction industry.

Interviewee (2:37):
And when you say you're measuring the innovation potential, why would someone be interested in just an innovation measure? You engage in innovation in order to get better outcomes. So is your innovation potential measure a measure of the potential to improve your outcomes? Or is it simply a measure of areas that you could innovate in, but you leave the dotted line to the outcomes to the company? Because if I can achieve reduced costs, increased safety, increased speed to market, and increased market share, it's presumably because I've done something different. It's presumably because of innovation, but I don't care. I don't care whether it's through innovation, whether it's through market forces, whether it's through, you know, whatever. That's the only thing I'm interested in. So I'm not interested in innovation, per se. I'm interested in reduced costs, increased safety, and increasing the speed to market. Yep. Yep. I think it's still recording.

Facilitator (4:02):
Look, you're quite right. In fact, we have the category of innovation outcomes. We want to improve that. We want to improve safety, we want to improve productivity, and we want to improve speed to market. Yes, we want to reduce costs. And there's lots of research out there that indicates that innovation could potentially lead to each feature that we want to improve on innovation, but how are we going to improve innovation that we can't measure? So that's the gap. You can't improve anything that you can’t measure.

Interviewee:
Yep.

Facilitator:
Now, there are some measures out, some scales, well, they're not fully, totally new scales, but they are measuring scales, and they are somehow claiming to be the innovation measurement tool. One, they're not comprehensive. They are cluster research, which looks at some aspects. They can be categorised into three major categories and leading indicators, lagging indicators. For example, Callaghan measures innovation. I've talked to some other people as

well. So they think they should measure R&D, and then they're pretty firm in this idea that R&D measurement is the measurement of innovation.

Interviewee (5:36):
So the ministerial notice that gives power to Callaghan Innovation to disburse taxpayer money, restricts their operations to R&D and actually prevents them from branching out into innovation. So it's not their belief. It's their constraint.

Facilitator (5:59):
You might have experience with Callaghan as well. So you might have made this decision. Yeah. Well, I thought. And they firmly, in fact, noted that, well, to measure innovation, we measure R&D, budget for R&D, which is based on the Frascati Manual, shows innovation. That's it. But they wouldn't even question, so I understand that, you know, that no, there's a background. Yes. Now, my research shows that, yes, the governments see R&D as an indicator of innovation. And that's what they want to see. Yeah. So the budget that goes into R&D for them is the indicator of innovation. And that's how they see, you know, R&D might or might not lead to innovation. And at the same time, there's serendipitous innovation, where you might have an innovation happening in the company, and you might not have planned for it.

Interviewee (7:06):
Might not have arisen out of R&D. So, R&D is neither necessary nor sufficient to generate better outcomes through innovation. So yeah, so,

Facilitator (7:18):
I call these leading indicators.

Interviewee (7:21):
Well, so the framework I'm used to dealing with is “inputs, outputs and outcomes”, right, which are generally “leading, current, and lagging” indicators. It's not always quite like that, but more or less correlated. So what are you putting into the system? How much are you spending on R&D? What's coming out? Things like patents, things like new products, etc. But ultimately, I don't care about any of that. What are the outcomes? Faster speed to market, reduced costs, improved bottom line, improved safety, increased market share, you know. So for business and commercial companies, it's shareholder value. For government departments, and Kāinga Ora currently, as the largest construction department, has the largest single construction budget in New Zealand, so there are, you know, lots of players in the space. But right now, their outcomes are actually not purely commercial drivers. So they have things like, you can read this online, I think it's called the Building Momentum report from Kāinga Ora, it outlines their six key outcome metrics, and includes diversification of the construction industry, more inclusion of Māori and Pasifika in the construction industry, it includes health outcomes and community outcomes from their projects, none of which would reflect in a commercial enterprise’s shareholder value. So even just the outcome measures aren’t uniform across the construction sector. And that's important to know, because essentially, whatever you're doing seeks to optimise outcomes. And you need to understand that what you're optimising for will change depending on the client, the customer. So anyway,

Facilitator (9:31):
What you're defining as outcomes is pretty much close to what we use as a word in research, drivers.

Interviewee (9:41):
Drivers, benefits and outcomes. Yeah, we branched off, sorry, I hijacked the conversation because you started talking about leading indicators. So we're using R&D spend as a leading indicator.

Facilitator:
Yep. That's one of them.

Interviewee:
Potentially a misguided one, but one that Callaghan Innovation uses as its leading indicator for innovation.

Facilitator (10:13):
Yeah. Well, the Oslo Manual is more recent. Yep. Have you read it?

Interviewee (10:22):
Yes, yes. Yes. Out of the OECD work.

Facilitator (10:25):
How do you see the Oslo Manual?

Interviewee (10:32):
Yeah. Look, it's an evolution, the whole point of the OECD. So you've got, firstly, the OECD Observatory for Public Sector Innovation, OPSI. It's worth having a look for its innovation framework, which looks at kind of four facets of innovation, worth looking at, if you haven't. But the primary concern is really a macroeconomic perspective, right. OECD's work comes at things from a macroeconomic perspective. And so it's much more concerned with standardisation and being able to compare apples with apples and make these long-term predictions than a practical guide for an individual business on how to optimise what you have to do. Yeah. So I found the Oslo Manual helpful. It's great for shaping my thinking. It's great for kind of having comparators, benchmarks, standards, but it is not sufficient to inform an individual business's decisions.

Facilitator (11:55):
Do you think there is a publication that does that?

Interviewee (11:58):
Look, you can look at things like Nesta (National Endowment for Science, Technology and the Arts). So Nesta is a UK outfit that looks at innovation frameworks and approaches to innovation that I think are very, very sound, very comprehensive, and very practical. And they combine, you know, all the usual buzzwords, like Lean Startup, like agile, like design thinking, and all of those things into it. And ironically, oh God, what's his name, MBR in the United Arab Emirates? Mohammed bin Rashid?

Interviewee (12:56):
Yeah, I think he's the,

Unknown Speaker (12:57):
Yeah, that's right. That's right. So there's the MBR Centre for Government Innovation, which is a government entity similar to Callaghan Innovation but a lot more well-resourced. And

while I don't agree with some of the political ideologies, that toolkit that they've put together for measuring and promoting and advancing innovation, which is partly based on NESTA, partly based on OPSI and others, I think that's a lot more, it's a lot closer. So the MBR Centre for Innovation and the Observatory of Public Sector Innovation. Thank you. Yeah. So if you look at the websites, the MBR Centre for Innovation, you will find detailed tools, manuals, matrices, and benchmarks that you can download for free and check out. I found it much more practical than the Oslo Manual.

Facilitator (14:17):
Great, that's interesting. You're quite right on the Oslo Manual. In fact, throughout the manual, it attempts to find generalisation grounds. In fact, I have adapted some of the items from the Oslo Manual because I think that there is a gap in construction. For example, we hear that construction is not innovative. But once reading through what other industries are adopting to measure innovation, we find out that many of these items exist within construction,

Interviewee (15:14):
The construction industry. Yeah.

Facilitator (15:16):
But they're not measured. For example, the construction industry doesn't really see what services are provided. For example, after-sales services, which are part of the contract - the liability period - are always done, and they need the process on a day-by-day basis, trying to be more productive, trying to be more lean during that era. And they don't really document what they did during some tasks. But if they do, that is an indicator that they're innovative. But usually, even after handover, I found that to be a possibility to show that innovation is happening. And while we highlight this in our research as a practical tool, things are going to be further widened. Now, the industry knows that they will emphasise it. Yeah. While previously, that was sort of my version of the construction industry, it usually just sees that one year as a burden, and they just want to get rid of that one year because they've already handed over. They don't want to deal with it too much. Yeah. There's not even too much emphasis on that.

Interviewee (16:56):
Have you looked at the Callaghan? I'm sure they will have told you about this, but have you looked at the Doblin's 10 Types of Innovation framework? So I mean, if you kind of prompt a construction company with that framework, they will come to that conclusion usually. I mean, I've talked to construction companies, and I said, you know, it's not just about the thing you build, it's about the service that you offer with it, including pre- and after-, you know. So what is the cost of that? What is the margin that you get from that? What is the market position that you get from there? Doblin's 10 Types of Innovation are a good way to prompt that. Not the only way.

Facilitator (17:45):
Some, that's the problem. I read through it, off the top of my head, and six are relevant for our work.

Interviewee (17:53):
Okay. Which ones? Which are irrelevant?

Facilitator (17:56):
I do remember when I read it, I said I wouldn't, as a construction company manager, I wouldn't personally adopt it.

Interviewee (18:07):
It's just the language that's problematic, right? Obviously, it's not in the language of a construction company. But if I look at the 10 Types, I use the 10 Types as part of the work with Kāinga Ora. I certainly found benefits to all ten.

Facilitator (18:25):
Just remembering one at the moment, like there was something about the delivery of products or parcels or something like that, and emphasising more on the service sector. While….

Interviewee:
The wording, you're quite right, maybe it was the word. Yeah, the wording is the challenge.

Facilitator:
It is a ground for research.

Interviewee (18:51):
Like if you're talking about channel to market, for instance. Yeah. So with the channel, it is less about the delivery of discrete units of physical things. A channel is more about how you reach your target market. So a channel could be a large government contract versus straight to homeowners versus large development companies versus, versus, versus. So, you know, how do you get to the people who pay for your thing? That's the channel. And I'm not talking about the marketing side, that's a separate issue. But how do you actually, yeah, it's kind of like that, the contractual model.

Facilitator (19:47):
Procurement. Yeah. Like, if you put it with the word procurement, that would make sense for construction.

Interviewee (19:52):
Yeah. Yeah. It's different again from the revenue model. So the revenue model is often part of the contract. But that type of contract would be your channel in this configuration. Anyway, but we're getting carried away, it's now getting quite academic. Tell me a bit more about the tool,

Facilitator (20:19):
Yep. So the first part is the potential score. We can read this. Yep. "The following set of questions will measure the potential for innovation and the business innovation of your company."

Interviewee (20:33):
So, the business innovation is your current state, and this is your potential for the future state. How does that work?

Facilitator (20:41):
So this is the potential that the company has. It could be the future, but it's only potential. It's not,

Interviewee:
Realised.

Facilitator (20:47):
No.

Interviewee:
And is this your realised potential, or is this something else?

Facilitator (20:52):
Yes. This is somewhat what you mentioned as outputs and outcomes, more like that, which is realised and has somehow shown itself. Yes, yeah. Innovation. Yeah. It's not like it's a potential.

Interviewee (21:13):
Business potential and business performance.

Facilitator (21:16):
Right. Now, the Oslo Manual, I tried to adopt this using an observation period of the past one year, unless it's somehow required to do past one year. Yeah. I found this to be relevant to the potential as well. So the Oslo Manual doesn't use it for potential; usually, it doesn't have too much.

Interviewee (21:38):
It's just your performance over the past year. It measures the efficacy of actions in the past. It's a lagging indicator. So while your potential, measured over this observation period, applies to the future.

Facilitator:
Yeah, that's right.

Interviewee:
Okay, that's fine. Okay. Yep. Yep.

Facilitator (22:11):
Well, potential for the future, not that, yes.

Interviewee (22:13):
The potential,

Facilitator (22:16):
In real life might never be.

Interviewee (22:17):
Yes.

Facilitator:
That's where the problem lies.

Interviewee:
Exactly.

Facilitator:
Yeah. So, business innovation, so we defined a couple of definitions that businesses use, so product or business process, yep, or a combination thereof?

Interviewee (22:30):
Yeah. And with product, you include product or service.

Facilitator (22:35):
Product is good. Or service.

Interviewee (22:37):
Yep. Perfect. Yep.

Facilitator (23:08):
Now, of course, you know, the business process integration now.

Interviewee (23:12):
Yes. Yep. That previous business. Yeah.

Facilitator (23:19):
Now, we also have innovation activities. I tried to,

Interviewee (23:23):
Just sorry, this is important. By "new to firm", so new to firm, new to organisation, not new to the industry or new to the world.

Facilitator (23:35):
Well, see, as we mentioned, we are measuring at the organisational level. Yep. Not industry level. So there are different studies. This is just, we need to go through many, many organisations within the industry to be able to give out statistics for the industry. Yet the questions are addressed at the firm,

Interviewee (24:00):
Yep, that's good. Now,

Facilitator (24:04):
Innovation activities include all development, financial, and commercial activities undertaken by a firm that are intended to result in an innovation. Intention for innovation.

Interviewee (24:13):
Yeah. There is a difference between innovation, the verb, and innovation, the noun. Yep. Yep. Yep. Good.

Facilitator (24:25):
Now, we also have the word "innovation projects", because we want to look and see if they do innovation as a project or if it's just random innovation. And we also have follow-on activities. Other than innovation, firms can also conduct follow-on activities. But within the

observation period, these follow-on activities can be critical for innovation, but they're not included in the definition of innovation activities.

Interviewee (24:52):
Yeah, yeah. You're starting to kind of align with the IRD definition of core work, the work that IRD has for the research and development tax incentive. And while we acknowledge there is a big difference between R&D and innovation, they have a similar distinction between core R&D activity, which is planned, intentional R&D to resolve an uncertainty, and then they've got supporting activities, which aren't themselves resolving the uncertainty, but they are necessary in order to turn the R&D into something useful. So innovation and follow-on activities, so,

Facilitator (25:48):
For the purpose of this as well, we need to define IRD.

Interviewee:
IRD is the Inland Revenue Department, our tax department. Yeah, the people that we distribute, well,

Facilitator (25:57):
We've got R&D at a different word before. Yeah.

Interviewee (26:01):
IRD has an R&D tax incentive.

Facilitator:
Yeah. So now, let's keep going. The potential has five different categories.

Interviewee (26:15):
You've given it five different categories.

Facilitator (26:19):
We started off with a number of enablers, drivers, and barriers. We then classified them into five different categories. So workforce skills and HR management is the first, right. Would you like to go through? Yeah, the company usually scores them on a Likert scale of one to five.

Interviewee (26:38):
Yep. So yep. Cool. So NESTA also has a capabilities framework. So you can do a bit of compare and contrast between that. Systems, entrepreneurialism, creativity, autonomy, collaboration, partnerships, commitment, innovation resistance, okay. So that one would be a barrier? Not, not. Yeah. Fear of failure? Is that fear of failure and poor performance? External involvement, R&D capability, not fearing risk. And so is that fear of failure? Just risk? When risk? Okay, so risk appetite?

Facilitator (27:13):
There is risk taking. Yeah, the company risk taking.

Interviewee (27:19):
Okay. So in other contexts, you'll find people referring to this as risk appetite. And boards of

directors, from a governance perspective, are increasingly being encouraged to provide risk appetite statements. So, for instance, while a lot of them do risk management plans, it's only just now starting to evolve into risk appetite statements. So a risk management plan seeks to identify the risks, seeks to quantify how big the impact is, how big the likelihood is, and then based on that classification, they prioritise those risks in terms of managing them. But what they don't say is, how willing are we to take that risk, right? And that's what a risk appetite statement is. So, risk appetite statements are a formal declaration of how much they fear taking a risk.

Facilitator (28:27):
Now, this is pretty interesting. Part of my research is on leadership in the construction industry. And I've emphasised leadership to a large extent because research does indicate the leader has a huge emphasis on the style of leadership, because it's a big issue.

Interviewee (28:44):
And there's a difference between governance and leadership. Yeah, yeah.

Facilitator (28:49):
Governance, or if you want to call it, would be important there. There are corporate, autocratic,

Interviewee (29:01):
Governance, leadership, and management distinguish themselves, in my view. Governance is about due diligence, to make sure your direction is right. Okay. Leadership is about providing the…. Governance is the *why*, leadership is the *what*, and management is the *how*, if you want to think of it easily. It's a simplification, but essentially, the board of directors are there to ensure that you are keeping with the intent of the shareholder interests and that you are doing so in a diligent manner. In other words, that you've made all your checks and balances, that you're not trading insolvently, that you're not taking undue risks, you know, all of that stuff.
The leadership is there to communicate the direction to the rest of the organisation, to engage in a two-way process by which they drive the direction and execute on the board's direction. And management is there to determine how that is done, the actual mechanics of delivering. So setting, communicating, executing. And with each one of those functions, there are different levers that they can pull to promote innovation. So the job of each of these functions is different in promoting innovation anyway. But in here, I agree with all of these, that these are very relevant and important, just knowing that different aspects of these will apply to different parts of the organisation, obviously.

Facilitator (31:22):
Oh yeah, yeah, definitely. If I want to add something, like if this tool is going to be applied within the organisation, as I was mentioning, we can have team-level studies. And during that study, we can ask the team members to measure their leader. And at the same time, we have leadership studies where we can ask the leader to measure themselves. You might be familiar, the MLQ, the Multifactor Leadership Questionnaire.

Interviewee (31:54):
No, I did not, but that's great. Yeah. Okay. And yeah.

Facilitator (31:57):
Mainly focuses on three types of leadership, which are transformational, transactional, and passive-avoidant leadership.

Interviewee (32:06):
Yes, yes. Yes. It's kind of like, yeah, laissez-faire leadership.

Facilitator (32:11):
Yeah. So there, we do distinguish between the questionnaires, which can ask the leader to rate themselves. Yeah. And at the same time, asking ways to rate the leader. And you mentioned not fearing risk and the impact of the leader on that, which can be measured.

Interviewee (32:39):
I'm just conscious that if this is how you present your tool, then just "very low, low, average, high, very high" needs some kind of definition. So if you just take your phone and scan this QR code for a second, I'll show you a maturity model assessment tool that I've developed for a different purpose. But just the camera, just use the camera. Oh,

Facilitator (33:13):
I think I need the internet for that, right? Yes, I was turning the internet back on.

Interviewee (33:19):
Okay. Okay. So, oh, okay, sorry. Let's hang on. That might help you. I want to share it, not as edits. I want to share it as a, I'll find another way to share it with you by email. But what I wanted to show you is this: in order for you to make this rating, you first need an understanding of how to calibrate those. What does "very low" mean? What does "low" mean?

Facilitator (34:14):
Right. Okay, I understand. Yep, yep, yep. The definition of "low" as in, okay.

Interviewee (34:24):
Yeah. So this is a maturity model for transport systems thinking. And so here is what "high" and "low" mean in terms of how well a project is defined in its outcome. Yeah. You'll be able to see how well connected they are to the wider ecosystem, how well they're integrated with the value chain. A high level of value chain integration means that there's a clear understanding and collaboration on the full value chain to an agreed vision, versus competition or conflict between adjacent value chain actors, which is low. And in between, there are different layers. So, a low level of social skills, what does that mean? You know, what does a low level of social skills mean?

Facilitator (35:27):
I'll come to that. In fact, I did that during the tool development.

Interviewee (35:40):
What you do. Because I'm thinking all the way to the end, where you're wanting to make this into a successful business and you want to protect a competitive advantage. I think that if you're going to embark on this, the biggest source of value that's protectable is the benchmarking information that you develop as you execute this with more and more businesses, with more and more construction businesses. And to maximise that value, I would

recommend to you that before you ask them to do any kind of rating, that they give an open-ended qualitative description of each of these things, right. And then you ask them to either self-rate without a scale, but eventually self-rate with a scale. And the reason for that is because you'll be able to develop the scale from the open-ended responses that your participants give.
So you might go to the first organisation, and you say, you know, tell me about what level your social skills are at. And they will use words, keywords, and descriptions that you record. And then you say, well, do you think it's a low level or a high level? And they'll say it. So after you do ten of those, you'll start finding words and phrases that essentially calibrate the scale for you. And other respondents will recognise that, you'll be using their language back to them. You'll be mirroring their language back to them. And that will be unique to you, because you've done the work. You've done the work of talking with construction businesses, asking them those questions.
And if someone else goes in and just takes this framework, they won't have the language. So, a patent or copyright isn't a fine-grained enough tool to protect this. A trade secret might be an avenue that you can explore, so that you don't publish these questions to more than a certain level of detail, so that only someone participating can see them. Those are avenues. But the real value that you can then sell to someone is that benchmarking data. So this is important when we get to this bit. I think that's the biggest value.

Facilitator (38:25):
That's quite interesting. So that will definitely come into this question. You know, we have some issues. First, I'll briefly outline why we haven't explained further.

Interviewee (38:36):
Explained?

Facilitator (38:38):
Because initially I had to explain this, explaining each and every one of those would help the respondent understand, but at the same time, it's taking time.

Interviewee (38:53):
Yes, I see. You want it to be faster. Yeah.

Facilitator (38:57):
By itself, it's huge. You understand innovation, and you know innovation is not a small topic.

Interviewee (39:03):
So with this one that I just showed you, the way that we overcome this is that what you've seen is a one-to-five scale on, I think, six criteria. So this is already seventy, or I don't know, seventy-one, I think, and we've got five more. So my recommendation is that as a self-assessment, as an initial self-assessment, you actually leave that out, okay. Just have a self-assessment of one to five on the five areas, with a little bit of description. And then, following on from that, you provide a service. You provide a service that then takes them through the finer-grained details.
So they've done the easy bit of, you know, one to five on five areas, it's easy. I can do that, right? I know my company. And oh, yes, this area probably needs a bit more work. I could do better here. Yeah. Now I want more. Now I want to know how to do something about it. Now we're going to look under the hood, right? And that's where you come in. And that's the service they pay for. It's a consultancy service, right?

Facilitator:
We're on the same boat.

Interviewee:
Yeah. So you shouldn't be scared, even just for your own reference, to protect yourself, to have a definition of these things. Because otherwise, you cannot scale your business, right? If the only way to have a reliable and benchmarkable assessment is through your knowledge of what an average autonomy score means, and only you can perform the assessments, and you can only perform *x* number of assessments in a year, if you want to do 1,000 or 10,000 global-scale assessments, each of which generates a few thousand dollars, then you need to be able to give this framework to somebody else, train them up, and have them be able to do that.
And the best way to do that, of course, is if people are able to do it themselves, if you can automate it. But if you can't, then at least have a documented scale. Yeah, documented. What you're building over time, you don't have to start, you know, my biggest advice, if you want to start a business, is just start it. Don't wait till everything's ready and everything's finished. Just start it, gather the data, and refine the documentation. But you have to have the plan ready. How will I get from what I'm doing now, a mechanical, manual, one-by-one process, to eventually be fully automatic, entirely scalable? What's my roadmap for that?
So for this, the roadmap should include the gathering of the open-ended responses into a framework that you can then either give to an associate, like a franchisee or whatever, or include as part of a self-assessment, automated self-assessment. A chatbot could do it, for instance. A chatbot is basically using a bit of artificial intelligence to prompt these questions in a more natural language way.
So what you might do with a client is you might sit down and say, "All right, let's talk about the level of R&D capability in your business. Tell me a little bit more about the R&D capabilities. Would you say that it is…?" You understand the conversation you're having with your client, right? Currently, you're doing that because it's in your head and you're doing it yourself, rather than just giving them a tick box. Because they might have questions, and they might already understand some stuff, so you don't want to tell them things they already know.
A chatbot can perform that same function. They start with one part of the question, they see what the response is, and based on that response, they either dig deeper or they leave it, because they can see that the person gets it. So they use it, for instance, in airline bookings. You can book your airline tickets with a chatbot. You say, "I'd like to go to Paris," and the chatbot will say, "That's great. How many people are going?" "Oh, me and my family." "How many people are in your family?" "How many of them are kids?" Right? And so if I say, "I'd like to go to Paris with myself and my adult partner on the 25th of May between the hours of…" the chatbot will say, "Okay, here are your tickets." But if you just say, "I'd like to go to Paris," then they'll ask these probing questions.
Yes, you can pay someone to develop that. It's almost a commodity product,

Facilitator (44:33):
I understand that will be in the further stages. Just to confirm, what I understood is that you and I both know that these items are relevant.

Interviewee:
Yes.

Facilitator:
Now, they might not be relevant to all companies. So we might have a small pilot study. Yep. And see which one of these are relevant, say seventeen,

Interviewee (44:54):
Yes, yes. Yes.

Facilitator (44:56):
So what we'll find out is which of these are a priority specifically for this company. Now we can have these items, very low, low, average, high, tailored specifically for that company, and then do an in-depth study and add this chatbot or face-to-face interview with the managers and see where they tick, saying that yes, we agree that we have a gap that needs to be filled. And if they already have strengths in one field, which the tool shows, and I'll show in a couple of minutes, where we can improve.

Interviewee (45:29):
Yeah. We can just quickly - can I just go through each of these, so we have a chat? Yes. So I still haven't seen anything around governance… Business strategy, yep. Okay. Technology, yeah. And external influences. And with standards, you include regulation, correct.

Facilitator (46:13):
So that would be more governance.

Interviewee (46:18):
So governance would probably, I would just put, you know, how strong is your governance, either here, but probably more in the organisational structure. Well, yeah, it could be. Your board of directors, people, to you, and they have skills and capabilities, need to have certain skills and capabilities. So you could put it under there. But otherwise,

Facilitator (46:43):
What kind of, like, what items would you put into that?

Interviewee (46:48):
Like, is your board balanced? Or is it just a bunch of, is it just a bunch of accountants? Is your board experienced, both within your core industry and adjacent industries? Is your board, yeah, yeah, that's, you know, I don't want to be too prescriptive. But your board needs to be right and be doing the right things; otherwise, the rest won't follow. Otherwise, you're either just lucky or unlucky.

Facilitator (47:30):
Let's come to this. In fact, I probably just started initially with a huge emphasis on leadership, which is sort of governance.

Interviewee (47:42):
Your CEO is your leader, and your board is the direction.

Facilitator (47:46):
Okay. Now, for example, there is research, I've done some research previously on a similar but not exactly this topic, which is the internationalisation of construction companies. There

is research that shows, for example, that board of directors' tenure, tenure, yeah, how long they've been engaged. And research shows, interestingly enough, that a mix of young…

Interviewee (48:11):
Yes, yes. Diversity is most effective,

Facilitator:
Is that what you mean?

Interviewee:
Exactly, that kind of stuff. What size construction companies are you targeting? Because obviously, if it's a one-man band,

Facilitator (48:27):
Well, there is research. To go ahead with the quantitative research, there is sometimes a mixed-methods approach. Now, what happens? I'll give you an example: productivity leads to innovation, or innovation leads to productivity. Some research shows that smaller companies might be different to larger companies. In smaller companies, they are innovating to increase productivity. At the same time, bigger companies are already probably more productive, so they have a lot of budget they can invest in innovation. While smaller companies are looking at innovation as a means of survival, bigger companies are looking at it as a means of expansion into new markets or things like that.
So what is the difference now with this emphasis? I can say I haven't differentiated explicitly. I have looked into medium and large companies. I have had case studies from medium companies and large companies, yeah, according to the New Zealand definition of company size.

Interviewee:
Yeah, that's good. That's fine.

Facilitator:
I can add both, but my potential, this is a question I would like to ask. This is more of an organisational-level study. Sometimes in construction, there is a need to do project-level studies. For example, I'm not measuring, "Did you pour this grout harder than you used to do before?" You know, "Is that better?" But that's also a gap where it needs to be done. For example, innovation happens deep down in pipes, or canals, yeah, and the manholes. But where is that documented?

Interviewee (50:19):
So I agree. With the other benchmark that I showed you, which I'll link you, I said the same thing. You can either perform this assessment at a project level, at a programme level, or at an organisational level. So for governments, they distinguish between projects and programmes. A programme is basically a collection of similar projects. The only thing that I would say is that you should never leave the assessment at the project level. You should always ask, how do you grow beyond the project to scale it? Because a project, by the time you do your thing, will be over very quickly. The ideas, how do you give that innovation longevity? How does it transfer from that project to another, and another, and another? So I think you're, yeah,

Facilitator (51:26):
So the construction industry is a project-based industry.

Interviewee (51:29):
It's a project-based industry, but the people in it persist from project to project.

Facilitator (51:34):
We call it organisational process assets, yeah, where one asset is transferred from one project to the other.

Interviewee (51:44):
Yeah.

Facilitator:
And that's what this is, in fact, what this tool is trying to emphasise. If there was a successful best practice, we can benchmark it and move it to the next project, not repeat mistakes.

Interviewee (52:00):
Yep. Yeah, that's exactly right. Okay, cool. What else have we got? So let's say I've done all of those. So what happens next?

Facilitator (52:10):
Yeah. So there, the potential finishes. That was that part.

Interviewee:
Yep. Just good.

Facilitator:
Now we go to measure actual, the actual innovation. Yeah.

Interviewee (52:19):
Do you mind if I just,

Facilitator (52:24):
But this is a mix of questions from different resources again.

Interviewee (52:29):
So new product developments, sales, yeah, yeah. So you do need to be, just in the definitions, just a bit over here. Just a definitional thing. You know, I think the Oslo Manual defines a new product or service as one that's been developed in the last three years or something like that.

Facilitator (52:59):
And specifically, sometimes it differentiates between one year and three years for specific questions, but it also recommends sticking to one year to have that standard.

Interviewee (53:10):
It really depends on the market. In pharmaceuticals, you can't have that, because there will be no drug that has gone through clinical trials that was developed in the last year and is already on the market. Right. And also, you need to define what the endpoint of development is. One

year is too long. Yeah.
So as long as you have a set of definitions that are useful, then you'll get consistent answers. If you don't, then you won't get consistent answers. So let's say you define, "What share of total sales in the previous three years do you estimate is due to products or services that have entered the market during the previous five years?" Something like that, it's up to you.

Facilitator (54:06):
What is your question?

Interviewee (54:09):
Yeah, so sales. So there's a big difference between sales from existing customers versus new customers. So I'd also look at market share and diversification in terms of your market, okay, as measures. Well, I don't know, it might come later. I don't know. But just, "Has your product and service innovation helped you increase market share and market diversification?" I think it comes later.

Facilitator (55:00):
Yeah.

Interviewee (55:07):
Okay, so this is increase in sales. Increase in sales appears twice, but one is more related to product versus business process. Okay.
Again, someone filling this in is going to ask, "What's the difference between novelty and innovativeness?"
Yeah, cool. Okay, so these provide clear definitions. So this is useful.

Business Innovation Score. Okay. That's the kind of stuff, you know, where I can quickly tell which box to tick. Good. Yeah, yeah. Great. A good input measure, "F" is a good input measure. Yep. Yes, yeah. Follow-on, right.

Facilitator (56:33):
See, here goes marketing, sales, advertising, shares. This is something, like the follow-on activities, that is usually neglected in construction. Would you agree?

Interviewee (56:44):
Well, I don't know. It just appears in a different bucket, right? If you're the CEO of a company, you still worry about that, you still think about that. It's not ignored. But to the construction manager, it's completely invisible, you know? Okay.
And these are just the demographics. And these are the same; these are consistent demographics.

Facilitator (57:48):
Yep. This one is a general resources measure, which looks into the resources of the organisation or the company. The next one is more personal to the person who's filling it out.

Interviewee (57:55):
Yeah, that's fine. This one is just a bit of a demographic. It's probably helpful to you to find out who your customers are. Yeah, that's different. Yeah. And also the credibility of, oh, yeah, yeah.

Facilitator:
Would you like to quickly look at this, if you like?

Interviewee:
Yeah, sure. Sure. Yep. Yep. So, hey.

Facilitator:
Feel free to pass if any of,

Interviewee (58:34):
you have to choose one, or any? Most of it has been covered, so,

Facilitator:
It's all right. You can think through multiple things that you have experienced.

Interviewee:
And then I have to go, I'm sorry.

Facilitator:
I'll quickly show what we see as results.

Interviewee:
Yeah, I'll be with you in a second. Right. Yeah.

Facilitator (59:32):
So thank you for,

Interviewee:
No worries.

Facilitator:
So, for example, after we fill these out, we get the results table. And here we can, what happens with the spider diagram is this: for example, you'll be working in the workforce skills and HR management category. What happens is we can see in that category what is happening,

Interviewee (59:52):
Exactly the same approach that we're using for that maturity model. You can see, first of all, where am I not doing so well, that's your incentive to do more work. And the other one is that, as many people fill this out, you can provide a bit of an industry benchmark. And everyone wants to be better than their competitors.
The good thing is, you'll always find differences. Some will be better at one thing, some will be better at another. Very few people will fill out the survey and be better than everybody else in all aspects. So they'll only be interested in the bits that they're not so good at. And that's where your business comes from.

Facilitator (1:00:37):
If I want to share some of my experience, they usually look into this figure to see if their potential is lower than their outcome. Interestingly, they would like to see the results of their outcome more than their potential.

Interviewee (1:00:48):
So this is dangerous. Just because your Business Innovation Score uses different metrics, different measures, to assess that versus the potential, you would be arbitrarily scaling these two, right? This is not a percentage of that. No. Depending on what questions you ask and how you ask them, someone might have a much higher Business Innovation Score than the innovation potential, which would seem weird, right? So I'd be careful in how you present this.

Facilitator (1:01:28):
How could we look into that? That sort of,

Interviewee (1:01:32):
So, yeah, perhaps as a percentage deviation from the industry average. So your innovation potential is 108% of the industry average. You're above average. That's great.

Facilitator (1:02:12):
Not these indicators. Oh yeah. Yeah. Yeah, that's great.

Interviewee (1:02:17):
And because of that, you could then have a narrative explaining that, hey, your potential is low, but your performance is high. It's because you've already kind of exhausted the thing. Or maybe it's a time thing. Yeah. But otherwise, this could be misleading.

Facilitator (1:02:42):
There can be longitudinal studies, where, throughout the years, benchmarks have been developed.
Going to my questions, two minutes?

Interviewee:
Okay, two minutes.

Facilitator (1:02:56):
So, just quickly, let's see. What did you think about the tool? How did you find it?

Interviewee (1:03:02):
Yeah, I found it good. I found the overall categories well thought out and comprehensive. Some minor gaps. And I found the biggest gap in the tool to be an indication of what the scores mean.

Facilitator (1:03:25):
Can you review and confirm the significance of the identified items for measuring innovation in the construction industry?

Interviewee (1:03:31):
Yes. I do believe that you have identified most of the significant categories.

Facilitator:
Okay. Within construction?

Interviewee:
Yes, of course. Yeah.

Facilitator (1:03:41):
Is there anything missing that you could think of?

Interviewee (1:03:42):
I've mentioned those during the discussion.

Facilitator (1:03:46):
Would diagnostics be useful? I mean, the spider diagrams and all that, are the results useful for the company?

Interviewee (1:03:50):
Yes. Yes.

Facilitator (1:03:53):
Would it be useful for your company to use this tool?

Interviewee (1:03:59):
I believe so. Yes.

Facilitator (1:04:02):
How would you simplify this tool?

Interviewee (1:04:04):
By having it in a kind of multi-tiered approach, where first you have just a high-level self-assessment, followed by a more detailed guided assessment, followed by a hands-on consulting engagement to raise the level.

Facilitator:
On employees, leaders, or all of them?

Interviewee:
Yeah, it depends. Each company is different. Different areas need work.

Facilitator (1:04:33):
Perfect. And how would you simplify this tool?

Interviewee (1:04:37):
Yeah, I've said that, the incremental, incremental approach.

Facilitator (1:04:40):
Do you have any further feedback?

Interviewee:
Let me think about that.

Facilitator:
Okay. I'll look forward to it,

Interviewee:
yes, of course,

Facilitator:
I appreciate it,

What follow-up procedures would you recommend to further improve the practicality of the tool?

Interviewee (1:04:50):
Yeah, like I said, I would not leave it as just an assessment. I would then, whether you provide that or somebody else provides that, doesn't matter, but have the option for a person who's completed this to do something about it, right? Yeah. You'll be in that prime position where they go, "Oh, I really want to improve this area." Okay, what do I do? You need to be ready with the answer. "Well, here's someone you can call." Okay, I'll do that with you. Or, you know, yeah.

Facilitator (1:05:31):
Wonderful. Thank you for participating.

Interviewee:
It's a pleasure,

Facilitator:
on a Saturday.

Interviewee (1:05:36):
That was very interesting.

Facilitator (1:05:40):
I'll stop this now.