

A System Dynamics and Network Analysis of the interactions between factors affecting the implementation of Integrated Project Delivery in New Zealand



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Dedication

This thesis is dedicated to my family, who have supported me throughout my academic journey, from my bachelor's degree to my PhD.

A huge thank you to my father, mother, and siblings for all their direct and indirect support, which allowed me to fulfil my academic and career goals.

Personal Statement

The PhD journey was a significant knowledge-acquisition experience that enabled me to delve deeper into the academic field and gain a comprehensive understanding of the research. Special thanks to my main supervisor and mentor, Dr. Mahesh Babu Purushothaman, for his unwavering support and guidance throughout. Truly, this research project would not have been possible without Dr Mahesh's presence.

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Abstract

Integrated Project Delivery (IPD) is a collaborative approach that unites people, systems, business structures, and practices to reduce waste and enhance sustainability in construction projects. IPD aims to improve schedule, quality, cost, and safety while promoting positive collaboration based on mutual respect and trust. Despite the abundance of literature on IPD, a comprehensive analysis of the interactions between factors and their implementation has yet to be conducted. This study aimed to fill that gap by identifying the interactions between factors that hinder the implementation of IPD through three data collection methods: systematic literature review (SLR), semi-structured interviews (SSI), and a system-wide survey questionnaire. From the literature, 127 factors to IPD were identified, and their interactions were deduced using deductive reasoning. The identified factors and their interactions were structured to identify IPD implementation challenges in New Zealand (NZ) through eighteen experts within the construction industry. For validation, the findings obtained from the experts were triangulated with the wider NZ construction sector. The factors were grouped according to their themes, including Legal, Financial, Technological, Organisational, Collaboration, and Governmental. VOSviewer software was used to identify the most frequently repeated factors in the existing literature, and their interactions were identified through manual coding and visualised using Vensim software. Additionally, NVivo software was used for infographics related to the results. Furthermore, the SPSS software was used for validating the results through identification of the statistically significant interactions; 88 out of 142 interactions passed the t-test through their p-values. Various analysis methods, including degree of centrality, eigenvector centrality, and causal chain analysis, were employed to identify the critical factors and chains influencing the implementation of IPD in NZ. IPD factors specific to NZ were identified to aid in better comprehension of the impact of the identified critical factors. The NZ-specific factors included a lack of factual information about outcomes from IPD, a limited number of contractors and consultants, federal vs local council model policy and governance conflicts, industry opting for traditional models, experienced professionals' mindset, a history of liquidation of contractors resisting risks, subcontractors taking main contractor roles, and project size. The validated results revealed resistance to change, lack of technology use, lack of IPD awareness, lack of industry standardisation, and client's resistance to change as the most critical factors. Additionally, through causal chain analysis, the critical chains of factors were identified; the heaviest chains in terms of centrality weightages were deemed critical. Finally, the results were simplified in the form of a framework for easier dissemination of the findings. This research provides valuable insights regarding the interactions between the factors of IPD, which will aid researchers and practitioners in implementing sustainable construction practices in NZ.

List of Abbreviations and Acronyms

IPD: Integrated Project Delivery

DC: Degree of Centrality

EC: Eigenvector Centrality

SD: System Dynamics

NA: Network Analysis

CCA: Causal Chain Analysis

RII: Relative Importance Index

BIM: Building Information Modelling

SLR: Systematic Literature Review

SSI: Semi-Structured Interviews

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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, nor material which to a substantial extent has been submitted for the award of any other degree or diploma at a university or other institution of higher learning. In accordance with the School of Future Environments, this thesis does not exceed 80,000 words (excluding bibliographies and appendices).

Signed:

Date: 6/10/2025

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Co-authorship Contributions within this Thesis

The following manuscripts within this Thesis are either published, under review, or unsubmitted:

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Chapter 1- Introduction

1.1 Chapter introduction

This chapter is structured into several subheadings that guide the reader through its content. In the 1.2 background section, the focus is on the construction industry, emphasising the critical importance of selecting the appropriate project delivery method and its implications for project success. Following this, section 1.3 discusses the significant challenges currently facing the New Zealand construction industry. Next, section 1.4 details the project delivery methods by examining the various approaches employed in the construction sector, offering insights into their distinctive features and applications. Following this, in section 1.5, the Integrated Project Delivery (IPD) approach is introduced, detailing its innovative framework and the collaborative spirit that distinguishes it from traditional methods. Moving forward, in section 1.6, a clear articulation of the core problem the research seeks to address is presented, setting the stage for a deeper investigation. The research aim is then detailed in section 1.7, outlining the study's overarching goals and the contributions it intends to make to the field. This is followed by an enumeration of the specific objectives in section 1.8, which guide the research endeavour and clarify what is to be achieved. The pivotal research questions steering the inquiry and focusing the analysis are then presented in section 1.9, with section 1.10 presenting the scope of this research, and section 1.11 providing an overview of the methodology for this study. The chapter then proceeds to a comprehensive analysis in section 1.12, which compares IPD with other project delivery approaches. It employs various metrics to illustrate the superior benefits of IPD in contrast to more common methods. Next, section 1.13 describes the structure of this thesis, guiding readers with the subsequent chapters. Finally, in section 1.14, the chapter concludes with a concise summary that encapsulates the main points discussed, providing a clear recap of the key themes and findings highlighted throughout the chapter.

1.2 Background

The construction industry is a major benefactor to any country's economy. The effect of this contribution greatly depends on the successful and efficient delivery of construction projects. One of the critical success factors in any construction project is the managerial decision of the project delivery method (Oyetunji & Anderson, 2006). The selection of a project delivery method has a direct impact on key performance indicators like cost, execution, quality, safety, and schedule (El-Sayegh, 2008). Construction project success knowledge has evolved during the recent decades alongside the changes and developments in project delivery models (Moradi, 2021). The term "project delivery method" refers to the process adopted by various stakeholders to execute and complete a project, encompassing the roles, responsibilities, and relationships between participants, as well as the sequence in which the project must be completed (Gad et al., 2015). When choosing a project delivery method, many owners rely on predefined criteria and methods to assist in decision-making. These methods and criteria are

not comprehensive and may not be sufficiently applicable in today's construction industry, as traditional project management practices have not kept pace with rapid changes, such as technological advancements and greener practices (Pishdad & Beliveau, 2010). The various types of project delivery methods are presented next.

1.3 Issues with the New Zealand construction industry

In 2025, the New Zealand construction industry ranked 6th among the top 10 sectors by value added nationally, contributing 6.4% of the GDP, or \$ 18.084 billion (Stats NZ, 2025). The performance of the construction industry is an important driver of growth in the New Zealand economy (Seadon & Tookey, 2019). However, the New Zealand construction industry has been suffering from low productivity rates, quality issues, low organisational flexibility, high enterprise failure rates, increased transaction costs, and unpredictability around project delivery (Chang-Richards et al., 2019). These risks are associated with high labour turnover, labour productivity, as well as skills shortage experienced in the sector (Chang-Richards et al., 2014). Additionally, Deloitte's (2018) findings showed that the cost inflation for new builds in New Zealand had run well above that of Australia and other Organisation for Economic Co-operation and Development (OECD) countries. Moreover, Fitchett and Jacob (2022) identified that construction costs in New Zealand had risen rapidly and were higher compared to those in other countries, such as Australia, Canada, and the United States of America. Figure 1 compares the construction costs between New Zealand, Australia, Canada, and the United States of America.



Figure 1: Comparison of construction costs for new builds between New Zealand and other countries (Fitchett & Jacob, 2022)

Therefore, the New Zealand construction industry needs to improve its productivity by adopting newer, more efficient project management methods and effectively utilising labour and other resources (Ghodrati et al., 2018). Unlike traditional project management, the IPD model manages the project as a temporary production system, giving equal importance to both designing the process and the product (Ghosh & Burghart, 2021). IPD increases project implementation productivity and reduces the cost impact on a construction project, thus improving profit (Adamtey, 2019). Further, Deloitte (2021) revealed that the productivity of the New Zealand construction industry decreased to its lowest level in 10 years in 2020 (-15%), as shown in Figure 2.

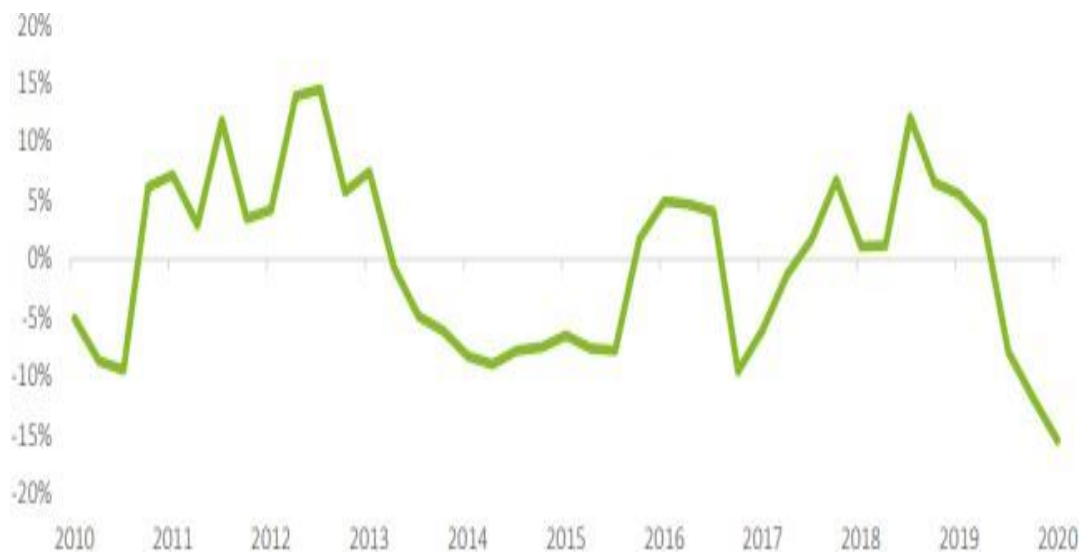


Figure 2: New Zealand construction industry productivity shown as output per hour worked (Deloitte, 2021)

Additionally, the New Zealand statistics, reported by MBIE (2023), revealed that delays were the most frequently mentioned challenge in the construction sector. The New Zealand construction industry suffers from increased costs, low productivity, delays in project completion, and poor quality; thus, it would benefit from the increased implementation of IPD. The investigation of interactions between factors in this current study will aid in understanding their impact on the implementation of IPD in the New Zealand construction industry. Using analytical methods, the researcher will be able to identify trends, recognise themes, and draw conclusions from the interactions. This study will make an original contribution to knowledge, as it is the first to investigate the interactions between factors influencing the implementation of IPD in the New Zealand construction industry. This research will benefit the New Zealand construction industry by understanding the interactions between factors that affect the implementation of IPD in New Zealand, and aid in increasing its adoption. This, in turn, will help the New Zealand construction industry improve project delivery, quality, and reduce costs. In terms of theoretical benefits, this research will be beneficial to New Zealand society, as the construction industry is a significant driver of the national economy. The next section looks at the commonly used project delivery methods.

1.4 Project delivery methods

The traditional project delivery methods used in the construction industry are detailed below:

1.4.1 Design Bid Build

The Design Bid Build (DBB) method was regarded as the most popular project delivery method up to the year 1990, where construction professionals were accrediting and regulating its features throughout almost all construction projects (Friedlander, 1998). In the DBB method, the owner issues two separate contracts, one with the consultant for the design phase of the project and one with the

contractor for project execution (Hale et al., 2009). The multiple DBB method is used if the owner wants to segregate the project into packages and contracts with a separate designer and contractor for each package. Additionally, the multiple prime contractors' method is used if the owner contracts with one consultant for the design phase; however, assigns multiple contractors for the construction contracts. The advantages of the multiple prime contractors' method are cost savings and schedule compression. In contrast, the disadvantages are coordination and management difficulties (El-Sayegh, 2008). The Design-Build method is presented next.

1.4.2 Design Build

With the progression of the 20th century, the complexity of buildings increased, signalling the need for more coordination between project stakeholders, which in turn required alternative delivery systems. This led to the formation of the Design-Build (DB) project delivery method, where the owner had a single contract with both the consultant and contractor. The DB project delivery method is often used because clients prefer to minimise risk as much as possible, as a single entity is responsible for both design and execution (Mafakheri et al., 2007). In addition to avoiding conflicts, as noted in the DBB method, the client's contract administration and site representation risks and costs are reduced, as the contractor is responsible for project coordination (Zhong et al., 2022). The DB method facilitates a collaborative construction effort, as the designer and the constructor work as a single entity. Furthermore, the DB method enables a fast-track alternative, allowing a portion of the construction to commence while the design stage is ongoing. Therefore, this provides cost and time savings to the client (Okere, 2018). In recent years, variations to the standard DB method have been introduced to accommodate diverse construction settings. These variations include bridging, novation, DB package deals, direct DB, develop and construct, the turnkey method, and build-operate-transfer (Xia et al., 2011). The Construction Manager at Risk is another commonly used method of project delivery.

1.4.3 Construction Manager at Risk

The Construction Manager at Risk (CMR) is a derivative of the Construction Manager (CM) method. In the CM approach, the owner hires both a design firm and a construction firm early in the project's preconstruction phase. The CM would then advise the owner on issues regarding design and managing construction activities. While the CM method leads to a high level of collaboration between project participants, it also requires high owner involvement, which necessitates the need for a competent owner (Gould, 2012). In comparison, the CMR method consists of the CM taking responsibility for both project coordination and execution, thereby acting as a general contractor. The CMR method is associated with a guaranteed maximum price, which is advantageous to owners (Akpan et al., 2014). It also leads to a decreased change order and increased cost certainty, as well as an enhancement in product and service quality as compared with the DBB model (Carpenter & Bausman, 2016). The Concurrent Engineering project delivery received recognition in the late 1980s.

1.4.4 Concurrent Engineering

Concurrent Engineering (CE) originated in the late 1980s to describe a systematic method for concurrently designing both the product and its downstream production and support processes (Evbomwan & Anumba, 1995). CE was proposed to minimise the product development time, in addition to enhancing the quality of the final product. (Prasad, 1996). CE can be defined as ‘A systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is designed to prompt developers from the outset to consider all elements of the product life cycle, from conception through disposal, including quality, cost, schedule, and user requirements (Love et al., 1998). CE has significant potential in construction. Its capacity to provide a practical framework for integrating and enhancing the construction process is widely acknowledged in the industry (Egan, 1998). The project nature of the construction industry signals a need for CE to be considered at both the project and organizational levels; however, the challenges include the linkages between organisational support structures and project-level support requirements (Anumba et al., 2007). The next section looks at the various types of collaborative project delivery methods.

1.4.5 Collaborative delivery methods

Prior studies have addressed success in construction projects with the implementation of collaborative delivery models (Moradi & Kahkonen, 2022). Alliancing, Partnering, and Lean Project Delivery are some types of collaborative delivery models. They are discussed further below.

1.4.5.1 Alliancing

The Alliance project delivery method was introduced in the early 1990s for high-risk oil and gas projects in the North Sea, aiming to establish a more collaborative work environment and share project risks more evenly among project teams (Walker & Hampson, 2003). Alliancing is a project delivery method that enables the owner and other project participants to work together as an integrated and collaborative team, with trust and certainty, to manage risks jointly and share the project's results in the end (Ahmed & El-Sayegh, 2021). An essential feature of the Alliancing method is the selection of a consortium, which is achieved based on performance criteria rather than price competition (Walker & Hampson, 2003). In this regard, the arrangement of the Alliance team members is a significant decision (Raisbeck et al., 2010). The Alliance project delivery method falls under the umbrella of collaborative contracting methods and can be described as multi-party contracts that are developed and executed by key project participants. To govern risk and reward allocation among project participants, the Alliance model is governed by a ‘3 limb’ compensation model, which involves a 100% open-book policy among Alliance participants. Additionally, in the Alliance model, there is a fee to cover corporate overheads and normal profit. In theory, a gain-share, pain-share regime rewards outstanding

performance, and any losses resulting from poor performance are shared equally among all Alliance participants (Raisbeck et al., 2010). Partnering is another form of collaborative contracting.

1.4.5.2 Partnering

The traditional partnering method was substantially established in the United States in the 1990s and has been widely adopted by state and federal agencies, yielding considerable benefits (Hannon & Zhang, 2017). Partnering is a project delivery method used by two organisations with mutual goals to reach determined business objectives. It involves an agreed-upon method to resolve disputes with the intention of continuous improvement (Lahdenpera, 2012). Partnering aids in delivering shared project goals through building relationships of mutual trust (Abudayyeh, 1994). The partnering method became necessary in the construction industry as stakeholders looked for more collaborative ways of working. With construction stakeholders becoming frustrated by the disputative nature of the industry, the partnering method represented an opportunity for owners, designers, contractors, subcontractors, and suppliers to maximise their abilities in a cooperative arena (Warne, 1994). Partnering aligns each project participant's business objectives by employing team-building strategies and promoting an early understanding of the project's specific challenges. After two decades of use, the results of partnering have generally been positive (AASHTO, 2018). Lean Project Delivery is a modern type of collaborative contracting.

1.4.5.3 Lean Project Delivery

Lean Project Delivery (LPD) is an innovative project delivery method designed to foster greater collaboration and improved performance in construction projects. LPD has been frequently mentioned under collaborative delivery models (Engebo et al. 2020). LPD has developed from a management approach focused on the construction stage to an alternative method of project delivery that utilises lean concepts and principles to guide contracting, design, and supply chain management (CURT, 2007). The LPD method is based on three fundamental goals: delivering a product, maximising value, and minimising waste (Ballard, 2000). Additionally, the LPD method consists of four phases. The first phase, the project definition phase, involves determining the client's needs and value. The second phase, the lean design phase, is where decisions regarding product and process are made in conjunction to create a conceptual design. Additionally, the third phase, the lean supply phase, involves transforming the conceptual design to detailed engineering documents. Finally, the last phase, the lean assembly phase, commences with the delivery of materials, tools, labour, and other components required for the project (Ghosh & Robson, 2015). The topic of this research project, Integrated Project Delivery, is introduced next.

1.5 Integrated Project Delivery

Integrated Project Delivery (IPD) falls under the umbrella of collaborative contracting methods. IPD

has been attracting growing attention across academia and the construction industry (Mesa et al., 2016). The American Institute of Architects describes IPD as a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increase value to the owner, reduce waste, and maximise efficiency through all stages of design, fabrication, and construction (Architects, 2007). Additionally, NASFA, COAA, APPA, AGC, and AIA (2010) state an alternate definition of IPD as a project delivery system. Their definition mentions that IPD occurs when integrated practices are applied to more traditional delivery systems such as DBB, CMR, and DB. IPD as a separate delivery system occurs if the owner decides to sign a multi-party contract with the consultant, contractor, and other key project participants. IPD involves the early involvement of all key participants and aims to minimise waste in construction projects, leading to improvements in cost, schedule, and quality (Matthews & Howell, 2005), while promoting collaboration through mutual respect and trust (Pishdad-Bozorgi & Beliveau, 2016). While substantial literature is available on the factors to IPD implementation, the interactions The next section details the problem statement.

1.6 Problem statement

Several articles have detailed the factors of IPD implementation. However, the interactions between the factors affecting the implementation of IPD have never been studied before. The problem lies in the lack of knowledge about the interactions between the factors affecting IPD. This research aims to solve this problem by analysing the New Zealand construction industry. The research aim is presented next.

1.7 Research aim

This research aims to identify the influencing factors of IPD and their interactions in the global and New Zealand construction industry to determine the critical factors and chains to develop a research framework that mimics the interactions of IPD factors to reflect the industry thinking in New Zealand, which will aid industry practitioners, stakeholders, researchers, and academics. The research objectives and questions are detailed in the following sections.

1.8 Research Objectives

This research aims to achieve five objectives related to the interactions between factors influencing the implementation of IPD in New Zealand. The research objectives are designed to be achieved in a step-by-step, systematic manner. The research objectives for this study are:

1.8.1 Research Objective 1

To identify the influencing factors of IPD that hinder its implementation in the global construction

industry.

1.8.2 Research Objective 2

To identify the influencing factors of IPD that hinder its implementation in the New Zealand construction industry.

1.8.3 Research Objective 3

To determine the interactions between the influencing factors that impact IPD implementation in New Zealand.

1.8.4 Research Objective 4

To determine the critical factors and chains affecting the implementation of IPD in New Zealand.

1.8.5 Research Objective 5

To develop a framework that mimics the interactions of IPD factors to reflect the industry thinking in New Zealand.

1.9 Research Questions

This research comprises five questions that will facilitate a comprehensive investigation into the interactions of factors influencing the implementation of IPD in New Zealand. The research questions are designed using a step-by-step approach to achieve a thorough understanding of the phenomenon under study. The research questions are:

1.9.1 Research Question 1

What are the influencing factors of IPD that hinder its implementation in the global construction industry?

1.9.2 Research Question 2

What are the influencing factors of IPD that hinder its implementation in the New Zealand construction industry?

1.9.3 Research Question 3

What are the interactions between factors that influence the application of IPD in the New Zealand construction industry?

1.9.4 Research Question 4

What are the critical factors and the critical chains of factors that hinder the implementation of IPD in New Zealand?

1.9.5 Research Question 5

What framework mimics the interactions of IPD factors to reflect the industry thinking in New Zealand?

1.10 Scope of research

The geographical scope of this research is primarily New Zealand; however, the findings may be relevant to other countries and regions with similar economies and construction-sector issues. The population group being studied is the New Zealand construction industry. The methodological scope is limited to a mixed-methods approach, with suitable data collection and analysis methods for both qualitative and quantitative approaches.

1.11 Overview of research methodology

A mixed-methods approach was used to address the research questions. A systematic literature review was conducted to identify the factors of IPD in the literature, and their interactions were deduced using deductive reasoning. This was followed by semi-structured interviews with experts in the New Zealand construction industry; the questions were structured to ensure they covered all factors and their interactions identified from the literature. Finally, the findings were triangulated with the broader New Zealand construction sector through a survey. A System Dynamics approach was used to construct the interactions between the factors of IPD using a causal loop diagram. Subsequently, Network Analysis was used to analyse the IPD factor network using centrality techniques: degree centrality and eigenvector centrality, to identify the critical factors. Additionally, causal chain analysis was used to identify the critical chains. To identify the statistically significant interactions obtained from the survey, the t-test was used, and the interactions were ranked using the relative importance index method. A framework comprising all statistically significant interactions was developed to facilitate the dissemination of the findings.

1.12 Metrics comparison between project delivery methods

The IPD model was compared with other project delivery models in terms of cost, project quality, schedule growth, productivity, project delivery, communication, and change management. The individual metric comparisons are detailed below:

1.12.1 Cost impact/savings on a project

One of the core benefits of IPD over other project delivery methods is the reduced cost and savings on a project (Bilbo et al., 2015). Adamtey (2019) compared the cost growth between DB and IPD projects, both of which are transmission control building facilities, and revealed that the DB project

had a cost growth of 3.2%, amounting to approximately \$1,589,400, while the cost growth in the IPD project was negative 1.6%, resulting in savings of \$1,170,000. Bilbo et al. (2015) compared the cost savings between IPD and CMR projects and found a 10.27% reduction in the initial budget for the IPD project. In contrast, for the CMR project, the cost reduction was only 3.13 percent. Additionally, the IPD project had a significantly lower number of issued requests for information documents (RFI) as compared to the CMR project. Furthermore, Mesa et al. (2016) compared the cost savings among DBB, DB, CMR, and IPD projects and found that the IPD project performed better than the others. Moreover, Trach et al. (2018) compared IPD with other project delivery methods in terms of the cost of making changes in a construction project. They found that IPD resulted in a 33 percent cost savings. Lastly, in a recent study, Kelly and Ilozor (2022) found that, at the 90 percent confidence level, lower levels of cost growth were observed in IPD projects compared to other projects. The comparison in terms of project quality is presented next.

1.12.2 Project quality

El-Asmar and Hanna (2012) compared IPD with DBB, DB, and CMR project delivery methods, and revealed that in the quality metric, which included the functionality of major building systems, the number of deficiency issues, the number and cost of punch list items, and the cost of warranty and latent defects, the IPD method performed better than others. Further, El Asmar et al. (2013) compared data from 35 projects to differentiate between IPD and non-IPD project delivery methods. Enhancement in project quality with IPD projects was one of the metrics they mentioned. Additionally, Iwanski (2013) researched the performance of IPD and non-IPD methods from the subcontractor's perspective and found that improved quality was one of the four metrics in which IPD projects performed better. Lastly, Mesa et al. (2016) revealed that on a project quality index of 1-10, DBB scored 5, DB scored 6, CMR scored 7, and IPD scored 8. Schedule growth is a common issue in construction projects.

1.12.3 Schedule growth

El Asmar et al. (2013), Iwanski (2013), and Mesa et al. (2016) compared IPD projects with other projects and identified a lower schedule growth in IPD projects. In recent studies, Adamtey (2019) and Kelly and Ilozor (2022) reconfirmed the results, revealing in their research that IPD projects performed better than other projects in terms of schedule growth. IPD increases productivity in construction projects (Bilbo et al., 2015; Adamtey, 2019).

1.12.4 Productivity

Iwanski (2013) revealed that because all key stakeholders in IPD are involved in the initial design phase, this leads to better communication and collaboration between project parties, resulting in fewer reworks, resubmittals, change orders, and change order processing time, RFIs and RFI processing

time, cost growth, and schedule growth. Furthermore, in the case study comparing DB and IPD delivery methods by Adamtey (2019), the results revealed that the DB project had almost three times the number of change orders as the IPD project. IPD reduces the delivery time in construction projects (Bilbo et al., 2015; Adamtey, 2019).

1.12.5 Project delivery

In the case study comparison between DB and IPD delivery methods, the IPD project was completed 14% faster than the DB project; the DB project measured at 181 SF/day, whereas the IPD project measured at 211 SF/day (Adamtey, 2019). Additionally, in the case study comparison between IPD and CMR delivery methods, the IPD project suffered numerous delays; however, project participants noted that the schedule overrun would have been greater, but the missed days were made up for by utilising the collaborative principles of IPD (Bilbo et al., 2015). The comparison in terms of communication is shown next.

1.12.6 Communication

El Asmar et al. (2013) and Iwanski (2013) identified communication as one of the metrics in which IPD projects performed better than other projects. Additionally, Hanna (2016) analysed 32 projects and concluded there was statistical evidence of better performance by IPD projects compared to non-IPD projects in terms of communication. Finally, the comparison in terms of the change management metric is presented next.

1.12.7 Change management

El Asmar et al. (2013), Iwanski (2013), and Hanna (2016) all concluded that IPD projects performed better than non-IPD projects in relation to the change management metric.

1.13 Structure of thesis

The thesis comprises six Chapters, which are followed by the references and appendices. The Introduction is followed by Chapter 2: Literature Review. This is followed by Chapter 3: Methodology, which presents a detailed description of the data collection and analysis processes. The Results are presented in Chapter 4, which presents the findings from all data collection methods. This is followed by Chapter 5: Discussion, which critically examines the findings. Finally, Chapter 6 concludes the thesis, providing an overview of the findings and recommendations on how the research may be beneficial.

1.14 Chapter summary

This chapter presents a general overview of the construction industry and emphasizes the importance of selecting appropriate project delivery methods. It discusses key issues facing the New Zealand construction sector and introduces common project delivery methods along with their limitations. The chapter then explores collaborative delivery approaches, particularly IPD, as potential solutions to the challenges inherent in traditional methods. This discussion leads to the formulation of the problem statement and the presentation of the research aim, objectives, and questions. The scope of the research and a brief overview of the methodology are outlined. A comprehensive comparison of IPD with other project delivery methods is provided, focusing on project metrics to demonstrate the advantages of IPD. The chapter concludes by outlining the structure of the thesis and providing a summary to guide readers.

Chapter 2- Literature review

2.1 Chapter introduction

This chapter is structured around several key subheadings. Section 2.2 discusses the importance of the global construction industry, specifically its relevance within the New Zealand context. Section 2.3 examines the needs of the construction industry, emphasising both project support systems and the role of social responsibility in construction. Section 2.4 outlines the historical development of IPD, tracing the origins of this project delivery method. Moving to section 2.5, the IPD model is introduced, providing definitions as interpreted by various academics. Section 2.6 explores the distinctive characteristics of the IPD model, highlighting its differences from other project delivery methods. In section 2.7, the discussion shifts to the factors influencing the implementation of IPD, identifying key themes that impact its adoption and effectiveness. Section 2.8 addresses the research gap, highlighting areas in the literature and knowledge that remain underexplored, thereby underscoring the relevance of this study. Finally, section 2.9 presents a summary of the chapter, encapsulating the sequence of literature discussed throughout.

2.2 Construction industry

Construction is a major industry worldwide accounting for a sizeable proportion of the gross domestic product (GDP) of most countries such as Australia (9.76%) (Australian Bureau of Statistics, 2022), New Zealand (5.08%) (Stats NZ, 2022), Canada (7.25%) (Statistics Canada, 2022) and USA (7.05%) (Bureau of Economic Analysis, 2022). The importance of the global construction industry is related not only to its size but also to its role in economic development. The construction industry constructs facilities that accommodate a wide variety of human activities, as well as the infrastructure that connects these facilities into an increasingly complex network. The facilities are required to produce all other goods and services, ranging from those needed by other producers to those required by the ultimate consumers (Crosthwaite, 2000). The extensive projects in housing, industry, transportation, and urban development that followed the emergence of modern construction materials formed the backdrop of the modern construction industry. In the USA, aside from the construction of buildings, the railway and highway projects, along with dams and irrigation projects, gave US firms a great competitive advantage in the international construction sector (Ngowi et al., 2005). The importance of the construction industry in a country's GDP changes as its economic development advances. The share of construction spending in a country's GDP grows during less-developed-country status, peaks during newly-industrialising-country status, and declines as countries move to advanced-industrialised-country status (Crosthwaite, 2000). Construction companies, particularly those from developed countries, are adopting internationalisation strategies that enable them to take advantage of the global market (Horta et al., 2013). American firms, such as Turner Construction, and British firms, such as Mace Group, have branches in the Middle East that offer lower operating costs while providing more work and opportunities. There are several ways by which construction companies enter the

international market (Ngowi et al., 2005):

- Economic booms, such as the one resulting from the sale of oil.
- Bilateral and multilateral agreements, the purpose of which is to set up protocols that allow firms of the participating countries to enter the markets of each other.
- Participation in large international projects, such as the Suez Canal, the New Hong Kong Airport, and the Three Gorges Dam in China.

To achieve a competitive position in the globalised construction market, construction companies are increasingly interested in cross-country performance comparisons (Horta et al., 2013). As construction companies must continually enhance their productivity to remain competitive, they are compelled to revise their vision, considering the company's internal circumstances, their competitors' strategies, and the evolving economic context. Construction companies attempt to implement systematic methods of performance measurement to achieve sustainable growth, profitability, and competitive advantage (Horta et al., 2013).

In New Zealand, the construction industry accounts for approximately 10% of direct fixed employment in the economy, comprising mainly small and micro firms, with a few large organisations (Seadon & Tookey, 2019). Additionally, the New Zealand construction industry is the basis of planned, designed, built, operated, and managed infrastructure in the sector (Stats NZ, 2022). However, the New Zealand construction industry has been facing issues such as increased costs, low productivity rates, quality concerns, and unpredictability in project delivery (Chang-Richards et al., 2019). Similarly, over the past few decades (Quinlan, 2012), the New Zealand construction sector has evolved into a complex subcontracting environment with a diverse workforce across multiple sites, spanning various skill levels (Lamm et al., 2017). IPD is a project delivery method that involves collaboration and integration among project parties, with the project's success as the primary goal (Hardin & McCool, 2015). The next section will investigate the needs of the construction industry.

2.3 Needs of the construction industry

The needs of the construction industry worldwide, as identified by previous studies, can be examined to determine how the global construction sector could be improved. There have been suggestions in the past that it is not fair to study the construction industries in developing countries with methods used for analysing the construction industries of developed countries, because to make a practical impact in the developing countries, there is a need for research on all aspects of construction (Ofori, 2019). Some areas have been identified after nearly six decades of studies on the construction industries in developing countries, where it is possible to view theories from a different position that can contribute to knowledge. They are:

- Project support systems: The operating environment of the project has a direct impact on the project; hence, it should be studied. The project performance parameters for developing countries should be restructured to conduct a fair analysis of the construction sector. The new parameters

should include affordability, reliability, and employment creation. Affordable housing is crucial in developing countries, where the lack of housing is most pronounced. Furthermore, only durable and reliable materials should be used for projects in developing countries, as resources are limited. Durability is defined as the ability of a building and its components to perform their required functions over a specified period (Lewry & Crewdson, 1994). The four approaches to measuring durability in materials include: Benchmark tests: Accelerated tests designed with a pass or fail criterion defined using historical data on a material's performance within a certain environment; Reference materials/comparative tests: Reference materials are used in many accelerated tests to calibrate either the equipment or the materials being tested; Environmental and stress testing: This testing describes either the attempts to simulate and accelerate the entire service environment or attempts to stress the material by intensifying the environmental factor(s) to which it is susceptible; and Site testing: This covers exposure site testing or in situ monitoring of buildings (Lewry & Crewdson, 1994). The assessment at the pre-design stage should encompass the long-term performance of the project and its critical components, considering that the project will be built in a developing country (Ofori, 2019). Several identified causes of failure in construction projects in developing countries include political interference, delays in payment, bureaucracy, corruption, poor supervision, lack of commitment by project leaders, lack of adequate planning, starting more projects than the government can fund, and changes in government. Additionally, considering the socio-economic context, the society should be involved in the planning and development stages, as they will be directly affected by the built facility (Damoah & Kumi, 2018).

- Social responsibility in construction: The idea of social safeguarding, monitoring, restricting, and penalising the opportunistic behaviour of the construction party, which may harm society's interests (Wang et al., 2016), should be established, taking into consideration the social impact of the project constructed in a developing country. Social impact refers to the consequences for human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs, and generally cope as members of society (ICGP, 2003). The population living near the project is most at risk, as they will be directly affected by the construction process, including damage to nearby houses, road blockages that can be the only source of travel, and changes to their daily routine due to the construction. Social structures and governance systems should be utilised in design and project management. Furthermore, considering the difficulties in applying regulations in developing countries due to lawlessness, the governance of projects should be paramount to safeguard them. In situations where it is problematic to enforce rules and regulations, the ability to work together, to problem solve, to communicate clearly, and to approach problem-solving from a systems perspective, along with the technical ability and experience of the project parties, becomes crucial to ensure the smooth running of the project (Ofori, 2019). The historical development of IPD is detailed next.

2.4 Historical development of Integrated Project Delivery

Traditional project delivery methods suffer from inefficient communication and subpar performance due to conflictive relationships (Abdirad & Dossick, 2019). The improvement of the adversarial nature of the construction industry was the incentive for the formation of IPD, which alters the conventional relationship between contracting parties through collaboration and integration. Initially, in the US, while the Design-Build delivery method was popular, project alliancing—a collaborative approach that linked the incentives and goals of the project parties to enhance results—was gaining popularity elsewhere. The development of project alliancing led to the formation of IPD in the US (Moynihan & Harsh, 2016). IPD emerged in 2005 as a new form of relational contracting (Thomsen et al., 2009). The American Institute of Architects (AIA) (2010) defines IPD as a project delivery method characterised by a contractual agreement among the owner, design professional, and builder, where risk and reward are shared, and stakeholder success is contingent upon project success. A significant advantage of IPD as a project delivery method is the fact that it can best utilise building information modelling (BIM). If IPD is linked with BIM, a look-ahead approach is used that aims to significantly reduce the cost of design changes through early collaboration (Abdirad & Dossick, 2019). The next section looks at how various academics and entities define IPD.

2.5 Integrated Project Delivery

IPD is slowly gaining recognition as a popular choice of project delivery. The American Institute of Architects initially described IPD as a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increases value to the owner, reduces waste, and maximises efficiency through all stages of design, fabrication, and construction (AIA, 2007). Table 1 below outlines the definitions of IPD provided by various authors.

Table 1: Definitions of Integrated Project Delivery by various authors

Author(s), Year	Integrated Project Delivery Definition
Azhar et al. (2015)	A project delivery method where project parties, such as the owner, architect, and contractor, work as a single team in the preconstruction stage and collaborate to develop and validate project goals for successful project delivery.
Bilbo et al. (2015)	The practice of early collaboration and shared responsibility throughout a project, with the primary focus on the project's success, rather than individual roles and outcomes.
Bozorgi and Beliveau (2016)	An organisation that uses a project delivery method that is governed by collaboration, trust, and where the operating system is based on integration.
Choi et al. (2019)	The promotion of team integration throughout the design and construction stages based on a contractual arrangement among project stakeholders.

Author(s), Year	Integrated Project Delivery Definition
Ghassemi and Becerik-Gerber (2011)	The integration of expertise of the project teams at the inception stage of a project to ensure that overall design decisions meet the requirements of all project parties.
Hardin and McCool (2015)	A project delivery method where a single contract is used for a project, entered by the owner, architect, main contractor, and key subcontractors.
Kahvandi et al. (2019)	A project implementation approach which creates directions for change to enhance contracts, planning, cooperation, communication, and abolish lag of the construction industry relative to other industries.
Keen and Fish (2012)	A project delivery method where the multi-party contract is the basis through which the contractor focuses on the project, establishing compensation on total project performance rather than individual performance.
Kenig (2011)	A project delivery method where the focus is on collaboration through a multi-party agreement.
Lahdenpera (2012)	A project delivery method that features a collaborative multi-party agreement, early involvement of key stakeholders, transparent financial records, shared risks and rewards, liability waivers among key participants, and jointly developed project goals.

The common consensus among all these definitions is that IPD involves collaboration and integration among project parties, where the project's success is the primary goal. The greatest advantage of IPD over other project delivery methods is the ideology of involving all key participants in the project's early stages (Hardin & McCool, 2015). By holding all project parties responsible, IPD fosters a high degree of communication and cultivates collaboration among project participants, as it can lead to additional profits for all parties involved. The aim of IPD is to minimise waste in construction projects, which leads to improvement in cost, schedule, and quality (Matthews & Howell, 2011), and address the trust issues in the construction industry by attempting to promote a positive collaboration based on mutual respect and trust (Pishdad-Bozorgi & Beliveau, 2016). The purpose of IPD is to construct a building more quickly and at a lower cost (Thomsen, 2008). This is accomplished through collaboration and shared goals of all project participants in the IPD process (Thomsen & Thompsen, 2008). In IPD, generally, the client issues a request for proposal (RFP) for design and construction services (NASFA et al., 2010). The architect and main contractor are nominated through a qualification-based selection process, during which the client assesses the responses based on project experience, management plans, and other required criteria. In the next stage, the client, along with the nominated main contractor and architect, prepares additional RFPs to include other subcontractors (Alleman et al., 2017). Once the IPD team is selected, the main contractor, architect, and subcontractors enter a multi-party contract (AIA, 2007). Figure 3 shows the IPD selection process in a flowchart.

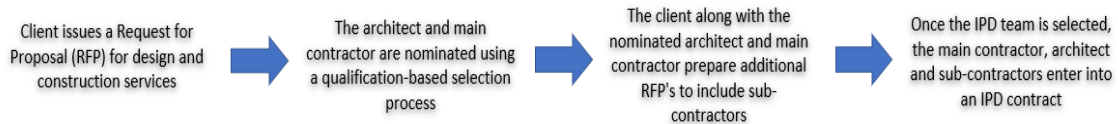


Figure 3: The IPD selection process (AIA, 2007)

The IPD selection process commences with the client issuing a Request for Proposal (RFP) for design and construction services. Through a qualification-based selection process, the architect and main contractor are selected. Together, the client, the architect, and the main contractor prepare additional RFPs to include subcontractors. Finally, all parties enter an IPD contract. There is zero percent of design development during the selection of the key team members (Adamtey, 2019). The usage of IPD as a project delivery method improves project performance significantly; metrics such as communication management, cost management, scheduling, and quality are improved immensely (El Asmar et al., 2016; Ahmad et al., 2019): refer to section **1.12 Metrics comparison between project delivery methods**. Additionally, a catalyst in the usage of IPD as a project delivery method is the application of Building Information Modelling (BIM). In BIM technology, a precise virtual model of a facility is digitally constructed (Costin et al., 2018). The BIM model can be used for the planning, design, construction, and operation of the facility, which is helpful for architects, engineers, and constructors as it aids in visualising what is to be built. This helps to identify any potential design, construction, and operational problems (Azhar, 2011). BIM encourages collaboration and integration of the roles of all project parties, making it an essential requirement for IPD (AIA, 2007). If BIM is used in IPD, construction can commence once the model is developed to the required level of detail (Adamtey, 2019). This differs from the traditional DBB project delivery method, where construction commences only after the design is completed and the bid is awarded to the contractor. Historical forms of IPD, such as alliancing and partnering agreements, can be applied without the use of BIM. These forms are identified by the early involvement of contractors, risk and reward sharing, and the absence of a tender stage (Durdyev et al., 2019). Figure 4 below presents the similarities and differences between IPD and Alliancing.

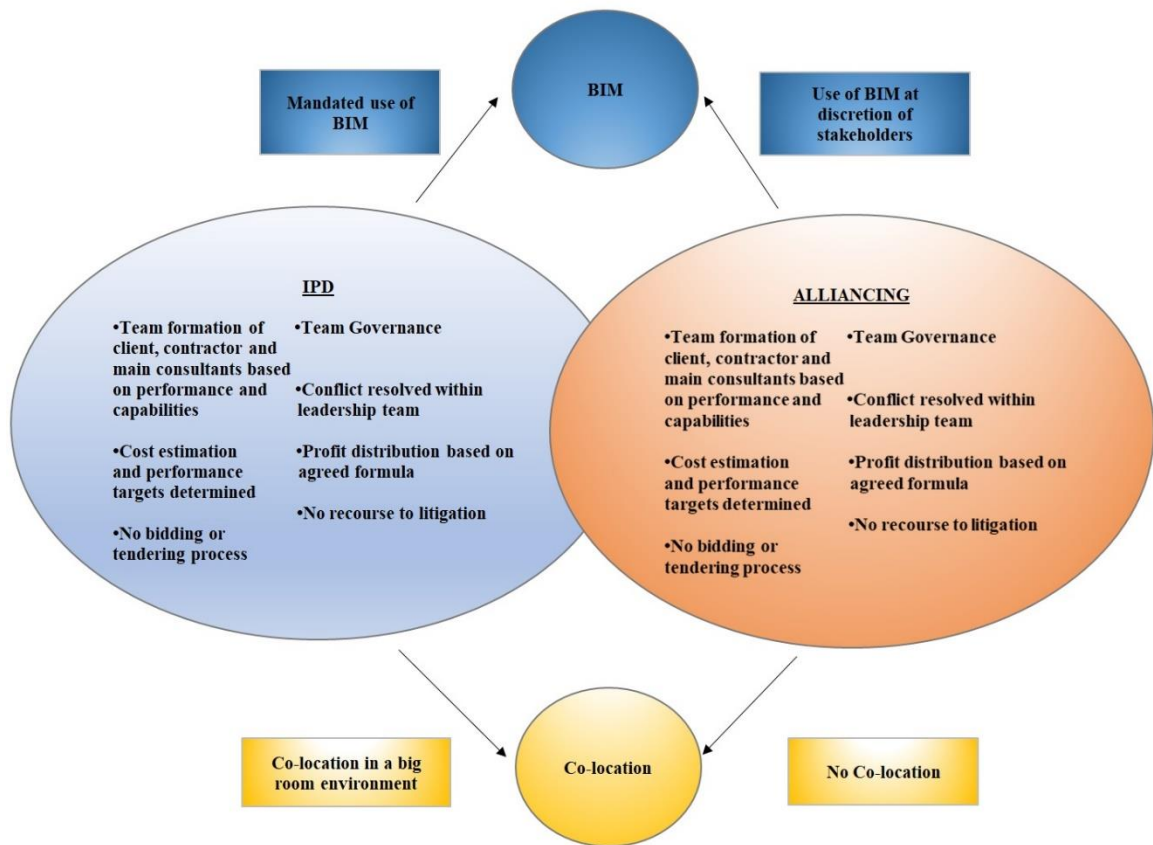


Figure 4: Similarities and differences between IPD and Alliancing

The common features of both Alliancing and IPD include team formation based on performance and capabilities, team governance, determination of cost estimation and performance targets, conflict resolution within the leadership team, profit distribution based on an agreed-upon formula, no recourse to litigation, and no tendering process. The differences between them are BIM usage and co-location. IPD mandates BIM usage and allows co-location in a big room environment, whereas Alliancing does not mandate BIM usage; it is at the discretion of stakeholders and does not involve the co-location of participants. The latest forms of IPD are highly collaborative in nature, adopting the big room concept as a shared space where team members work (Merschbrock et al., 2018). The big room concept aims to enhance coordination, cooperation, and communication among project participants from different disciplines (Temel et al., 2019). It is a physical space organisation that utilises technology while maintaining central human and interpersonal relationships. Big room is a design and coordination office located at construction sites, where all stakeholders are involved early on and are directly involved in the management and control of a project. The team members work together, enhancing team performance, fostering interaction, expediting decision-making, and minimising project costs, thereby facilitating better communication (Temel et al., 2019). Moreover, with the growth of BIM, modern forms of IPD are defined in integration with BIM, information and communication technologies, and web-based management systems (Fischer et al., 2017; Rowlinson, 2017). Modern

forms of IPD facilitate seamless data exchange among project participants (Niemann, 2017). The modern forms of IPD, in combination with BIM, enhance a wide range of potential outcomes in design and construction, including cost/profit, safety, productivity, relationships, scheduling, and return on investment (Azhar et al., 2015). IPD depends on open pricing techniques and fiscal transparency among project participants (Ahmad et al., 2019). Furthermore, project stakeholders, such as the designer and the contractor, generally evaluate and calculate their profit and shared risks based on the difference between actual and target costs (AIA, 2007). In IPD, cost estimation is significant for the remuneration arrangement, which defines precise risk and reward percentages (Love et al., 2011). Therefore, precise cost estimation is essential for the successful delivery of IPD projects (Ebrahimi & Dowlatabadi, 2018). Moreover, target value design (TVD) is considered a part of IPD, requiring quick cycles of proposals and cost evaluations (Alves et al., 2017). TVD, an emerging practice in the construction industry, is essentially a management strategy that aims to eliminate waste and deliver value through a design-to-cost method (Neto et al., 2018). In IPD, the total risk is equivalent to that of traditional project delivery methods, and the client is required to guarantee the direct project costs (Ghassemi & Becerik-Gerber, 2011). Therefore, IPD is heavily dependent on cost estimation at the project feasibility stage to develop a dependable business case for decision-making purposes (Allison et al., 2017). A significant feature of IPD as a project delivery method is its reimbursement system for assigning gain/pain ratios among project parties (Fischer et al., 2017). This feature of IPD requires a cooperative contracting relationship between project parties, as the individual success of the project participants is tied to the success in achieving the project objectives (Ahmad et al., 2019). All project parties in IPD are required to agree upon an appropriate remuneration scheme that determines the proportions of cost overrun, cost underrun, and any other price in the total budget under the agreed cost (Pishdad-Bozorgi et al., 2013). The cost scheme must comprise direct, indirect, and overhead costs, capturing the risk-reward proportions in proportion to the degree of achievement during project delivery (Pishdad-Bozorgi et al., 2013). Three components can be defined in IPD:

- Component 1 represents the payment of project costs, which considers all project implementation costs
- Component 2 represents the overhead costs for all project parties in addition to the profit
- Component 3 represents the pain/gain ratios (Zhang & Li, 2014)

Project parties who are exposed to a greater degree of uncertainty must be remunerated for the risks against a higher profit-at-risk percentage (Elghaish et al., 2020). There are several benefits of coupling BIM, IPD, and lean-based techniques (Dossick et al., 2013). Integrating BIM, IPD, and lean techniques, such as TVD, enhances the quality of design and construction deliverables, leading to notable improvements in project scheduling and cost reduction. Additionally, this integration emphasises the importance of implementing TVD with BIM and IPD to facilitate subcontractor involvement in the design stage, thereby ensuring the design is completed within the owner's budget (Nguyen & Akhavian, 2019). However, there are some major obstacles in integrating IPD with BIM and TVD. The

lack of collaboration between various stakeholders, like designers and quantity surveyors, in developing 5D BIM models is a significant challenge (Vigneault et al., 2019). Further, linking cost estimation programmes and BIM design platforms remains an obstacle (Nassar, 2011). For example, even though the pricing format is not considered in BIM models, it is required by quantity surveyors to modify the bill of quantities (Wu et al., 2014). The use of single-point estimates obtained from the BIM model may result in a greater risk for IPD arrangements (Elghaish et al., 2020). There is also some doubt regarding the information obtained from BIM models- the information is not entirely precise. The model does not hold everything that needs to be known about the building; thus, the BIM is not as robust (McCuen et al., 2011). Additionally, the integration between scheduling and cost estimation is a manual task that involves a complex process (Sunil et al., 2017). Importantly, there is no single platform that can proceed with the entire cost estimation without depending on other supporting tools (Cho et al., 2012). Table 2 details the US projects that implemented the IPD model.

Table 2: US projects that implemented the IPD model (IPDA, 2025)

Project Name	Client	Contractor	Architect	Project Cost	Project Location
Autodesk AEC Solutions Division Headquarters	Autodesk Inc	Tocci Building Companies	KlingStubbins	\$13,338,000	Waltham, Massachusetts, USA
Sutter Fairfield MOB	Sutter Health	Boldt	HGA	\$19,462,103 (construction only)	Fairfield, California, USA
Cardinal Glennon Children's	SSM Health Care	Alberici	Christner Inc	\$45,572,449 (construction only)	St. Louis, Missouri, USA
St. Clare Health Centre	SSM Health Care	Alberici	HGA	\$157,247,000	Fenton, Missouri, USA
Encircle Health	NAACC Building Co. LLC and ThedaCare	O. J. Boldt Construction	HGA	\$38,594,048	Appleton, Wisconsin, USA
Walter Cronkite School	City of Phoenix	Sundt Construction	HDR Architecture, Inc. and Ehrlich Architects	\$72,099,244	Phoenix, Arizona, USA
Cathedral Hill Hospital	Sutter Health	HerreroBoldt – A Joint Venture	SmithGroup	\$1,028,533,446	San Francisco, CA, USA

Project Name	Client	Contractor	Architect	Project Cost	Project Location
MERCY Master Plan Facility Remodel	Mercy Health Partners Regional Medical Center	Donley's Inc.	Array Healthcare Facilities Solutions, Inc.	\$19,425,447	Lorain, Ohio, USA
Lawrence & Schiller Remodel	Lawrence & Schiller	Mark Luke Construction	RSArchitects	\$500,000	Sioux Falls, South Dakota, USA
SpawGlass Austin Regional Office	SpawGlass Real Estate	SpawGlass Contractors	Barnes Gromatzky Kosarek	\$2,800,000	Austin, Texas, USA
Edith Green Wendell Wyatt Federal Building Modernisation	General Services Administration	Howard S Wright	SERA Architects	\$123,151,653	Portland, Oregon, USA
USCF Mission Bay Medical Center	USCF	DPR	Stantec (Anshen + Allen at project start)	\$1,500,000,000	San Francisco, CA, USA

2.6 Characteristics of Integrated Project Delivery

IPD is built on collaboration, which, in turn, depends on mutual trust and respect (Othman & Youssef, 2020). The foundation of IPD is the development of collaborative, integrated, and productive project teams, where everyone involved in the project mutually agrees on targets and dedicates themselves to making decisions that are best for the project outcomes, rather than focusing on individual objectives (Fischer et al., 2017). This integration is encouraged by the alignment of business interests through the adoption of behavioural, contractual, and operational components (Fischer et al., 2017). In an integrated project, all project parties benefit and are rewarded by receiving incentives tied to achieving project objectives. Furthermore, in integrated projects, innovative ideas are encouraged and freely exchanged among all project parties (Othman & Youssef, 2021). Additionally, ideas are considered and reviewed by all project parties; the best ones are collectively adopted for the project. Importantly, key participants are involved from the earliest stages, where their combined expertise significantly impacts the decisions made. The goals in integrated projects are established early, agreed upon, and taken into consideration by all project parties. A precise and deep understanding of project parties is given importance in a culture that encourages innovation and exceptional performance. Projects that adopt the IPD delivery method are aware that intensified planning aids in increasing efficiency and savings

during the execution stage. Moreover, apart from reducing design effort, the IPD delivery method improves design results and shortens the expensive construction process. IPD prioritises the team performance, which is based on open and honest communication among all project parties. In IPD, team responsibilities are clearly defined within a no-blame culture, which facilitates the discovery and resolution of disputes. Technology plays a crucial role in maximising functionality and sharing information among project parties (Othman & Youssef, 2021). Lastly, leadership in IPD projects is allocated to the team member who is most competent to lead the team in achieving the project goals (AIA, 2007). The specific characteristics of IPD are discussed below:

A multi-party contract: IPD requires relational contracting in the development of a construction project to promote collaboration and coordination among all project participants, ensuring project success (Mesa et al., 2019; Pishdad-Bozorgi & Beliveau, 2016). This type of contract serves as the vehicle that enables these goals to be achieved successfully without being complicated by separate contracts that create conflicting motives. The IPD system uses a multiparty agreement. This agreement is a single contract signed by the owner, architect, contractors, and other key participants, covering the design, construction, and commissioning of a project. The early involvement of key participants is an important characteristic of IPD (Mesa et al., 2019).

Early involvement of key participants: Key project parties in IPD, at least the owner, designer, constructor, and design consultant, are involved in the earliest design stage to develop a better understanding of the project (Mesa et al., 2019). The early involvement in IPD also aims to align and unite the main project parties, who have diverse interests and objectives to form an integrated team that works together in a collaborative way (Pishdad-Bozorgi & Beliveau, 2016). Identifying the correct participants and determining the right timing for their involvement is significant, as their participation can contribute to the project outcomes (Fischer et al., 2017). The contrasting viewpoints and early inputs from different knowledge areas can benefit projects by enhancing the constructability of the design, improving productivity, and leading to better price control and fewer surprises (Fischer et al., 2017). However, the project participants must be open to a great amount of ambiguity and alternative interpretations (Cohen, 2010). IPD involves collaboration (Mesa et al., 2019).

Collaborative decision-making and control: IPD teams work together to develop and validate project goals, leading to better design decisions and improved constructability, which ultimately contribute to the project's success (Mesa et al., 2019). Due to the integration of the main project parties, they can resolve the issue of fragmentation between the design and construction professionals that results in inefficient designs, increased errors and disputes, higher costs and incompetent work practices, and expensive alterations in the construction stage. IPD projects generally adopt a decision flow system that targets reaching decisions unanimously, enabling all team members to have a say in decisions, with the owner possessing more authority through the owner's directions (Fischer et al., 2017). IPD involves sharing the risks and rewards among the project parties (Mesa et al., 2019).

Shared risks and rewards: In IPD, relational contracts support and promote different approaches,

including partnering, alliancing, joint ventures, public-private partnerships, and better risk-sharing mechanisms. Relational contracting can be defined around five main components: commitment, trust, cooperation and communication, common goals and objectives, and a win-win philosophy (Mesa et al., 2019). In IPD, individual profit is put at risk and is proportionate to the overall project performance, as compensations are tied to the achievement of project objectives (AIA, 2014). Although the payment of direct costs is assured by the owner, profit is adjusted by comparing the total project direct costs with an agreed target. If direct costs exceed the target, the amount over the target is deducted from the profit of the entire team. Conversely, if costs are under the target, the savings are split between the owner and the IPD team (Fischer et al., 2017). By binding individual success to the success of other project parties, shared risk and reward can persuade team members to act more cooperatively to guarantee project success (AIA, 2014). Liability waivers among key participants are a significant characteristic of IPD (Mesa et al., 2019).

Liability waivers among key participants: In a true IPD arrangement, the main IPD team members relinquish their right to sue each other (Pishdad-Bozorgi & Beliveau, 2016; Fischer et al., 2017). This further highlights the concept of trust required by IPD and the participants' readiness to collaboratively solve any issues that may arise. These all explain why mutual trust and respect serve as key features of IPD and, why a preceding trust-based relationship among the prospective participants is important. Once trust is present, an individual is willing to accept shared risks knowing that the other party is capable and has a mutually positive intention to work in the best interest of the project (Pishdad-Bozorgi & Beliveau, 2016). Jointly developed project goals are an important characteristic of IPD (Mesa et al., 2019).

Jointly developed project goals: Shared financial risks and rewards enforced by IPD have a positive effect on collaboration and trust (Pishdad-Bozorgi & Beliveau, 2016). If parties are aware that success depends on the performance of other team members and the overall project outcome, they become more attentive to the project goals and act more collectively and collaboratively to ensure the project's success (Pishdad-Bozorgi & Beliveau, 2016). Additionally, jointly developed project goals unify the key project parties in working collaboratively towards the same objectives (Ahmad et al., 2019). IPD involves fiscal transparency (Ahmad et al., 2019).

Fiscal transparency: The key players in IPD, such as the contractor, designer, and owner, keep an open book (NASFA et al., 2010). Contingencies are made visible through the sharing of information on expenses and revenues. Fiscal transparency serves as a key element that fosters collaboration and trust among project parties (Ahmad et al., 2019). Intensified planning and design are important characteristics of IPD (NASFA et al., 2010).

Intensified planning and design: There is more focus on enhancing the quality of designs and plans in IPD (NASFA et al., 2010). Improvements in early designs and plans facilitate the identification of errors at a less costly stage compared to the construction stage, where alterations to scope or design have a direct impact on project cost and duration (Hanif et al., 2016). Along with improvements in

project cost and duration, intensifying project planning and design enhances project quality and the likelihood of meeting jointly developed project goals (NASFA et al., 2010).

However, the IPD contract also has some limitations (Sherif et al., 2022). These include a large capital investment, required level of expertise, balanced metrics, and conclusive insurance. Project participants, such as the owner, consultant, and contractor, need to have approximately equal capital investment in the project to accept sharing the risks. Additionally, all project parties must comprise staff members who are competent in various aspects of the project. The single contract approach requires balanced metrics for design, construction, cost, and schedule to achieve the project goals. Furthermore, IPD contracts require a substantial amount of insurance, as all risks are shared between the parties involved in the project (Sherif et al., 2022). Table 3 presents a comparison of the characteristics of the traditional construction industry with those of IPD.

Table 3: Comparison of characteristics of the traditional construction industry with IPD

Comparison between the characteristics of traditional construction and IPD		
Characteristic	Traditional	IPD
Contract type	Traditional contracts often contain vague clauses, which can result in an overall project duration that is longer. The separation of design and construction is often seen as adversarial.	IPD requires relational contracting in the development of a construction project to promote collaboration and coordination among all project participants, ensuring project success. The type of contract used is known as a multi-party contract.
Collaboration	Traditional construction is often characterised by adversarial relationships, and the concept of collaboration is rare.	IPD teams collaborate on developing and validating project goals, leading to better design decisions and constructability, which ultimately contribute to the project's success.
Involvement of key stakeholders	Not all stakeholders are given priority in traditional construction. For example, subcontractors are not included in the early project discussions.	Key project parties in IPD are involved in the earliest design stage to develop a better understanding of the project.
Risk and reward sharing	The concept of risk and reward sharing among the key stakeholders does not exist in traditional construction.	Relational contracting is based on identifying mutual benefits and 'win-win' scenarios through more cooperative relationships between the contracting parties.
Project goals	In traditional construction, every stakeholder is concerned only with their own project goals. They are focused on 'I' instead of 'We'.	Project goals are jointly developed between the project parties.
Liability waivers	The concept of liability waivers among the key stakeholders does not exist in traditional construction.	The main IPD team members relinquish their right to sue each other.

The primary difference between traditional construction and IPD lies in the concept of collaboration among project parties. From the very beginning of the contract stage, there is a separation of design and construction services in traditional construction, whereas IPD promotes collaboration and coordination through the usage of a multi-party contract. Through collaboration and the early involvement of key stakeholders, project parties in IPD share risk and reward, jointly develop project goals, and agree on liability waivers. The factors that impact the implementation of IPD are detailed next.

2.7 Factors in the Implementation of Integrated Project Delivery

The implementation of IPD has experienced drawbacks (Kahvandi et al., 2019). Identifying the drawbacks is the first step in attempting to resolve them. A prior study indicated that cognitive social capital factors, such as shared vision, structural social capital factors, including social interactions, and relational social capital factors, including trust, partially mediate the relationship between relational contracting norms and the effectiveness of IPD teamwork. Based on the findings, the IPD factors can be grouped under the following themes and discussed:

2.7.1 Managerial

Shared vision (cognitive social capital): The cognitive dimension of social capital refers to the shared representations, interpretations, and systems of meaning among project participants (Nahapiet & Ghoshal, 1998). A shared vision provides a bonding mechanism that facilitates the integration of resources among contracting parties (Tsai & Ghoshal, 1998). As the IPD model can only be successfully implemented if the contracting parties share and apply common values and goals (AIA, 2007), it can be inferred that a shared vision positively impacts the effectiveness of IPD teamwork (Zhang et al., 2020). Project parties mutually share the vision of helping one another resolve difficulties and reach consensus on what is important for the project. Additionally, the project parties share the same goal of learning from one another and hold similar values. Furthermore, aligning objectives and recognising mutual benefits help build consensus and a willingness to help others to preserve relationships. The social interactions are discussed next.

Social interactions (structural social capital): The structural dimension of social capital refers to people and what they do (Harpham et al., 2002); it also refers to the overall pattern of connections between actors in social activities- that is, whom the actors can reach and how they interact with each other (Burt, 1992). By establishing a series of procedures to enhance social interactions, regardless of frequency or quality, relational contracting norms strengthen network ties (Tsai & Ghoshal, 1998). In the IPD model, social interactions are enhanced through a series of working arrangements, such as co-location, kick-off meetings, and regular team meetings, to facilitate informal communication and the development of interpersonal relationships (Bygballe et al., 2015). Social interactions facilitate collective practices and foster a mutually beneficial atmosphere in which project parties are willing to

share knowledge and fully leverage their advantages (Harpham et al., 2002). However, social interactions do not have a major positive effect on the effectiveness of IPD teamwork. As social interaction mainly reflects the intensity and density of the social network, a possible explanation for this phenomenon is that frequent social interactions without essential information exchange may lead to more conflicts among team members and increase unnecessary management costs. Trust is discussed next.

Trust (relational social capital): In the relational dimension of social capital, trust has proven to have a causal relationship with solidarity, mutuality, and flexibility (Gupta et al., 2011). Prior studies have identified trust as one of the critical factors that affect resource exchange and teamwork (Argiolas et al., 2008). In project management, the level of trust between team members is a factor that determines whether decisions are made in the best interest of the project, and whether the team members are willing to take risks for the sake of project goals (Wang et al., 2018). As IPD is built on teamwork (AIA, 2007), which is based on trust, it can be inferred that trust has a positive impact on the effectiveness of IPD teamwork. The project participants are required to fulfil their responsibilities and overcome egotism, which is essential for establishing initial trust among the project participants. Additionally, the project parties are encouraged to partake in behaviours that benefit the relationship between participants and take collective responsibility, which further builds trust among the team. Project parties do not take advantage of each other, even if the opportunity arises, and always rely on each other. Additionally, project parties consistently uphold their commitments to one another and are honest and responsible in their dealings.

Furthermore, stakeholder engagement was identified as another key influencer of IPD. A group of researchers discussed in their study the role of stakeholder influence in project delivery, specifically integrated project delivery (Aaltonen et al., 2019). A study on the influence of stakeholder engagement in Finnish integrated project deliveries concluded that the early integration of designers, contractors, clients, and other pertinent stakeholders through collaborative contractual, organisational, and technical arrangements has been one of the foundations of the Finnish integrated project deliveries (Hietajarvi et al., 2017). Wider and inclusive stakeholder engagement requires incentives and performance metrics that ensure the voices of stakeholders are heard and valued (Kivila et al., 2017). The formation of a strong, collaborative project identity is one way to overcome silos and boundaries among stakeholders, ensuring identification with and commitment to the project (Aaltonen et al., 2019). Engaging stakeholders in a value-adding manner is not only a matter of introducing new tools and processes for stakeholder management, but also a question of fostering a deep cultural change that warrants new attitudes, mentalities, and values toward stakeholder engagement. Specifically, the roles of the project manager and the client's representatives are significant in endorsing the new, open ways of sharing information and building transparent dialogues with various stakeholders (Aaltonen et al., 2019). Additionally, it was found that high-level BIM applications strengthen positive relationships (Zhang et al., 2020).

2.7.2 Technical

Level of BIM application: As an emerging way of integrating and utilising project life cycle data, BIM has revolutionised the construction industry by enhancing project teamwork (Kent & Becerik-Gerber, 2010). BIM plays a crucial role in the IPD collaboration process, enabling the involvement of all project parties from the design phase through to project handover (Aminu Umar et al., 2015). It is important to note that BIM application requires an implementation strategy to ensure that contracting parties fulfil their required responsibilities (Arayici et al., 2011). Prior studies also suggest that BIM implementation enhances teamwork and fosters significantly more trust among project participants by reducing information asymmetry and uncertainty, thereby enabling transactions to be more flexible and transparent (Singh et al., 2011). Through the implementation of BIM, opportunistic behaviours caused by asymmetry are avoided; therefore, the cost of initial trust among project parties is lower, and team members are more likely to trust one another (Zhang et al., 2020). Thus, it is essential to recognise that BIM implementation in construction projects is not limited to only functional and technical levels; instead, it is an approach to management that may impact the teamwork process (Kent & Becerik-Gerber, 2010).

Another study was conducted on the IPD influencers that have an impact on trust-building attributes (Pishdad-Bozorgi & Beliveau, 2016). The findings can be grouped under the following theme and discussed:

2.7.3 Environmental

Peer performance evaluation and feedback, fair and equitable agreements, work-related interaction (co-location), information sharing, a collaborative mindset and culture, transparency, mutual respect, mutual confidence in each other's competencies, and Lean were identified as the IPD influencers that have an impact on the development of trust among the project parties. Peer performance assessment and feedback are effective ways to build and maintain trust within a team, and a well-constructed IPD agreement, which shares the risks and incentives equally among the project parties, supports the establishment of mutual trust. Conversely, a poorly designed contract diminishes trust. Trust is established when project parties are open and honest in their dealings, and treating people with politeness fosters relationships and trust. Additionally, trust is created when individual team members have mutual confidence in each other's capabilities, based on successful past relationships. Trust is established if promises are fulfilled and is diminished if there is a lack of dependability. Moreover, lean visualises a project as a network of reliable commitments. Lean construction features, such as reliable promising, Target Value Design (TVD), and Last Planner System (LPS), build trust. Additionally, co-location facilitates communication and interaction, thereby helping to build relationships that can potentially develop into trust. It is also relevant to note that trust is connected to information sharing, and withholding information leads to suspicion, defensive behaviours, and, eventually, a dysfunctional team. Additionally, relational contracts, such as IPD, require the project

parties to have a cooperative culture. This form of contracting is specifically designed to produce a collaborative and trusting atmosphere. Without a change in the traditional mindset and culture, the IPD contractual and operational tools cannot be constructive. Even though true collaboration occurs when trust exists, parties can also choose to collaborate intentionally when they are unfamiliar with each other, and there is no prior trust due to a lack of a previous relationship (Pishdad-Bozorgi & Beliveau, 2016).

Moreover, a comprehensive list of drawbacks in IPD implementation in the Iranian construction industry was prepared using a questionnaire survey (Kahvandi et al., 2019). Additionally, another study on the barriers of IPD implementation in the Indian construction industry was conducted (Roy et al., 2018). The results from both studies are presented in Table 4 below.

Table 4: IPD implementation factors in the Iranian and Indian construction industries

(Kahvandi et al., 2019; Roy et al., 2018)

Theme	Factor
Managerial	<ul style="list-style-type: none"> •Inconsistency in project management •Lack of sufficient knowledge among investors about successful new contractual systems all over the world •Lack of holding training courses for investors about defining and stating the advantages of successful new contractual systems all over the world •Lack of a proper definition of teamwork culture among project key stakeholders •Poor matrix structure in project-based organisations •Poor information sharing among different phases of the project •The challenge of selecting a compensator for financial losses
Environmental	<ul style="list-style-type: none"> •Lack of motivation for investors to use modern contracts, such as the IPD approach •Lack of control and strong management of the employer •Lack of proper orientation for the future and not paying attention to future development, particularly in governmental projects •Lack of familiarity of contractors with the IPD approach •Lack of conditions for the insurance to cover the entire project in the country, according to the new contractual systems •Lack of conditions for the insurance to cover the responsibilities according to the new contractual systems for the contractor •Non-participation of governmental agencies in construction, according to the governing rules in the governmental contracts
Contractual	<ul style="list-style-type: none"> •Lack of mutual trust among project key stakeholders regarding managerial and financial issues •Lack of appropriate policies and current construction contractual strategies •Lack of appropriate policies and current construction contractual strategies •Lack of identical contracts among subcontractors, such as the IPD approach •Lack of a proper definition of the responsibilities of each of the parties to the contract •Tendency to use conventional contractual methods and resistance to new ideas

Theme	Factor
Technical	<ul style="list-style-type: none"> • Early definition of target goals without a fully developed design • Integration of information and knowledge management systems • Lack of integrated collaboration among key stakeholders, due to a lack of the necessary technology • Lack of sufficient knowledge about design, construction, and maintenance among employer agents • Unestablished/unclear BIM standards and practices
Legal	<ul style="list-style-type: none"> • Criteria for selection of agencies: value-based versus cost-based • Need for a new legal framework
Financial	<ul style="list-style-type: none"> • Difference in the accounting of costs and profit among the client, consulting, and contracting firms • Equitable distribution of opportunities for gain and potential for loss among stakeholders
Cultural	<ul style="list-style-type: none"> • Awareness and willingness about IPD among owners • Contract language reflecting scars of prior battle • Inexperience with each other and IPD • Mutual respect and trust
Other	<ul style="list-style-type: none"> • Early involvement of subcontractors • Requirement of a competent and risk-tolerant client • Subjectivity in measuring quality

The themes presented in Table 4 that have not been covered can be discussed individually:

2.7.4 Contractual

Contractual challenges were the most significant in the Iranian construction industry (Kahvandi et al., 2019). This is because, alongside inappropriate contractual strategies, issues such as the absence of similar IPD contracts and a lack of mutual respect among stakeholders were prevalent in the Iranian construction industry. As a result, contractual challenges hinder IPD implementation.

2.7.5 Legal

Regarding legal barriers, the current tendering rules in India are stringent for all projects financed through public funds: the contract is awarded to the lowest responsive and responsible bidder. As the criteria for selecting parties in IPD are supposed to be value-based rather than cost-based, it is not compliant with the current rules.

2.7.6 Financial

Regarding financial barriers, there is a difference in the accounting practices of costs and profit between designers and contractors in India. The designers include profit in hourly rates, while the contractors consider profit as a percent of the cost. Thus, integrating these two types of accounting practices into a single, unified method for calculating cost and profit is a significant challenge.

2.7.7 Cultural

Regarding cultural barriers, there is a significant amount of mistrust among parties in the Indian construction industry due to prior experiences of opportunistic behaviour. Additionally, inexperience with each other and IPD, contractual language reflecting scars of prior battle, and the lack of IPD awareness and willingness among owners were additional issues identified.

2.7.8 Other

Regarding other barriers, subcontractors in the Indian construction industry are not reliable or sufficiently competent to make a worthwhile contribution to the IPD process; instead, they attempt to exploit the IPD system of collaborative decision-making and the free flow of information to engage in opportunistic behaviour (Roy et al., 2018). The research gap is introduced next.

2.8 Research Gap

While recent studies on IPD have identified the factors that hinder its implementation (Arar et al., 2025; Sherif et al., 2022), no comprehensive study of the interactions among factors affecting IPD implementation in New Zealand has been conducted. There has been only a single brief study in which a group of researchers investigated the application of IPD in public-sector projects within the New Zealand construction industry (Naismith et al., 2016). The limited number of studies on IPD adoption in New Zealand may suggest that IPD is not well-suited to the New Zealand construction industry; however, this reasoning is not significant, given that the New Zealand government has frequently used Alliancing, another collaborative project delivery model, in its projects. While there are a few differences between the Alliancing model and IPD, particularly BIM use and co-location, such as in IPD, both project delivery models fall under the same category of collaborative contracting. Thus, it is reasonable to establish that IPD implementation is possible in New Zealand.

Section *1.12 Metrics comparison between project delivery methods* identifies the superiority of the IPD model over the commonly used project delivery models in comparison studies conducted by researchers worldwide based on a number of performance metrics, including cost, quality, schedule, productivity, project delivery, communication, and change management. Since the benefits of the IPD model are apparent, it is reasonable to establish that the New Zealand construction industry would benefit from its implementation, considering the challenges it faces, as discussed in Section *1.3 Issues with the New Zealand construction industry*.

Considering that IPD is relatively uncommon in the global construction industry and that the New Zealand construction industry largely follows the traditional project delivery method, except for large-scale government projects, the factors of IPD identified in the literature may be relevant in the New Zealand context as well. In fact, since the New Zealand construction industry is largely traditional compared to the construction industries of other first-world countries, additional factors that are specific to New Zealand may hold prevalence in terms of IPD implementation in the country.

Given the issues facing the New Zealand construction sector and the advantages offered by the IPD model, a study is warranted to identify the interactions among factors that affect IPD implementation in New Zealand.

Despite the growing interest in IPD within the construction industry, a significant gap remains in understanding the specific influencing factors and their interactions, particularly within the context of New Zealand's construction sector. Existing literature often overlooks the critical factors and their relationships that drive successful IPD implementation. This lack of comprehensive analysis hinders the development of a robust research framework that accurately reflects the unique dynamics of IPD in New Zealand. Addressing this gap is essential for providing valuable insights and guidance to industry practitioners, stakeholders, researchers, and academics alike. It is important to note that the factors do not operate in isolation; instead, they interact with one another, which amplifies their impact on the implementation of IPD. The investigation of interactions between factors in this current study will aid in understanding the impact of factors affecting the application of IPD in the New Zealand construction industry. This research aims to identify the influencing factors of IPD and their interactions in the global and New Zealand construction industry to determine the critical factors and chains to develop a research framework that mimics the interactions of IPD factors to reflect the industry thinking in New Zealand, which will aid industry practitioners, stakeholders, researchers, and academics. The chapter summary is provided next.

2.9 Chapter summary

This chapter begins by highlighting the global importance of the construction industry, then narrows its focus to New Zealand. This was followed by an examination of the construction industry's needs regarding project support systems and social responsibility. Following this, the IPD model was introduced, beginning with its historical development, its academic definition, and its global implementation. The characteristics of IPD were discussed next, followed by the factors that impact its implementation. Finally, the research gap was introduced to identify the knowledge gap and explain how this study aims to fill it.

Chapter 3- Methodology

3.1 Chapter introduction

This chapter is divided into several subheadings that outline the study's design. It commences from section 3.2, which presents the breakdown of philosophical approaches, methods, and the appropriate framework for conducting this research, along with the quality control criteria that were adhered to. In section 3.2.1, the ontological position is discussed, where different types of ontological positions are explored, including the one selected for this research. This is followed by section 3.2.2, which addresses the epistemological position, providing an overview of the various epistemological positions and detailing the one chosen for this research. Section 3.2.3 focuses on the theoretical framework, discussing the various types of theoretical frameworks commonly used in research and identifying the framework selected for this study. Next, in section 3.2.4, the methodological position is discussed, presenting the various methodological approaches and indicating the one selected for this research. In section 3.2.5, the methods used for data collection, analysis, and presentation of results for each research question are examined. Section 3.2.6 discusses the framework deemed appropriate for investigating the interactions between the factors of IPD. Following that, section 3.2.7 addresses quality control, detailing the quality criteria adhered to in terms of reliability, validation, credibility, and transferability. Finally, section 3.2.8 provides a summary of the chosen approaches by displaying the research onion and including a table that outlines how the data were collected, analysed, and presented for each research question. The chapter concludes with section 3.3, which offers a detailed summary of the chapter's content.

3.2 Design of the Study

The framework for this research process contained four elements: epistemology, theoretical framework, methodology, and methods (Crotty, 1998). The ontological position is a precursor to the epistemological position, which facilitates an understanding of what reality is (Cohen et al., 2002).

3.2.1 Ontological position

Ontology is concerned with reality and what it is constituted by. The word originated from Ancient Greek, having derived from 'on', meaning 'to exist'. In that respect, the nature of reality, or what is 'knowable', is the primary concern of Ontology (Guba, 1990). Realism and idealism are some suggestions for the ontological position.

3.2.1.1 Realism

Realism implies that reality, or social phenomena, has an existence that is independent of the human observer (Blaikie, 2007). Realism considers social entities to be like physical entities in the natural world, to the extent that they exist independently of the way we perceive and label them, or even our

awareness of them. Furthermore, realism posits that there is a single, objective reality that is observable without the influence of the observer (Saunders et al., 2009).

3.2.1.2 Idealism

Idealism refers to the concept that society is based on ideas, such as how humans comprehend and perceive things to be, and how humans construct reality as it is (Ylonen & Aven, 2023). Additionally, idealism assumes that reality has a cognitive influence, and engagement influences both the observer and the object (Burrell & Morgan, 1979). The main position of idealism is that anything real is a possible, if not an actual, object of thought. If something is real, then it can be represented in a mental state; it can be thought about, understood, and cognised (Lane, 2018).

Ontologically, the interactions between the factors of IPD are subjective and require the engagement of participants, which influences both the observer and the participant. Thus, the ontological position will be idealism. The epistemological position is discussed next.

3.2.2 Epistemological position

The area of philosophy that focuses on understanding reality and the nature of knowledge is known as epistemology (Grant & Giddings, 2002). Objectivism, constructivism, subjectivism, and pragmatism are some suggestions for the epistemological position.

3.2.2.1 Objectivism

Objectivism is based on the theory that reality exists independently of human consciousness and the methods that lead to discovering objective truth (Crotty, 1998). In this, researchers consider the participant as an object (Grant & Giddings, 2002). In objectivism, the researcher is independent with no control over the results (Polit & Hungler, 1999).

3.2.2.2 Constructivism

Constructivism is based on the theory that cognitive meaning is constructed instead of discovered, and separate meanings have been constructed for the same aspect by different researchers (Crotty, 1998). In this, the researcher captures the participants' intersubjectivity (Grand & Giddings, 2002). In constructivism, the researcher engages with participants, and knowledge is gained through the interaction process (Polit & Hungler, 1999).

3.2.2.3 Subjectivism

Subjectivism revolves around the theory that our experience constitutes reality, rather than a shared or external objective truth (Richardson & Bowden, 1983). In subjectivism, there are two pathways: the radical researcher-researched relationship and the post-structuralist researcher-researched relationship

(Grand & Giddings, 2002). The methodology for this study will employ a qualitative approach. As knowledge will be acquired through qualitative analysis, the epistemological position for this study will be constructive. The next paragraph will discuss the theoretical framework and the chosen methodological approach for this study.

3.2.2.4 Pragmatism

Pragmatism revolves around the ideology that knowledge is based on experience. The way humans view the world is influenced by experiences in the social world. The knowledge that an individual creates from experience is considered distinctive because of the set of biological, behavioural, and environmental forces that constitute a human being. Additionally, most knowledge is socially created and shared from the collective experiences of people. Furthermore, this knowledge cannot be considered reality, as it is created for the purpose of enhancing human livelihood (Morgan, 2014). Pragmatism is premised on the idea that research can steer clear of metaphysical debates about the nature of truth and reality, focusing instead on 'practical understandings' of concrete, real-world issues (Patton, 2005).

As the study will involve mixed methods, pragmatism will be the chosen epistemological position. The next section discusses the suitable theoretical framework for this research study.

3.2.3 Theoretical framework

The theoretical framework is the approach to acquiring knowledge. Some common types include interpretivism, radical/critical theory, and post-positivism.

3.2.3.1 Interpretivism

The constructivist epistemological position is linked to interpretivism (Meredith, 1998). Interpretivism emphasises the importance of interpretation and observation in the pursuit of knowledge. At the same time, the linked constructionism emphasises that knowledge is firmly constructed by participants, rather than passively received from them (Ritchie et al., 2013). Moreover, the researcher is focused on gaining knowledge from the participants' experiences through their perspectives (Ritchie et al., 2013).

3.2.3.2 Radical/Critical

In the radical/critical approach, the participants are viewed as fellow researchers, and the framework revolves around reciprocity, participation, and power sharing (Grant & Giddings, 2002).

3.2.3.3 Post-positivism

The post-positivism framework balances both positivism and interpretivism frameworks. It prioritises researching issues in the context of including the experiences of the majority and declaring results

based on that which the majority deems acceptable (Wildemuth, 1993). Furthermore, this framework posits that knowledge is not absolute and prioritises a thorough comprehension of the research study using multiple methods (Guba, 1990). This tends to reduce the personal biases of the researcher and the participants as the subject is studied from various angles (Phillips, 1990).

The post-positivism framework is ideally suited for mixed methods research and, therefore, will be the chosen theoretical framework for this research. The next section discusses the appropriate methodological position for this study.

3.2.4 Methodological position

Some suggestions for methodological positions that can be used in conjunction with the post-positivism theoretical framework include the scientific method and mixed methods.

3.2.4.1 Scientific method

The Scientific method is based on theory construction, the generation of testable hypotheses, their empirical testing, and the revision of the theory if the hypothesis is rejected (Flowerdew, 2019). A significant requirement of this method is the ability to structure the inquiry process as a whole and to identify specific research problems to be addressed at each stage of investigation (Haig, 2014).

3.2.4.2 Mixed methods

Mixed methods is a research approach where researchers collect and analyse both qualitative and quantitative data within the same study (Shorten & Smith, 2017). Mixed methods research draws on the probable strengths of both approaches, which enables researchers to explore multiple perspectives and uncover relationships that exist between the research questions (Creswell, 2009). Using mixed methods affects not only measurement but all stages of the research (Brewer & Hunter, 1989). Further, the mixed methods procedure allows a pragmatic perspective in the research (Morgan, 2014).

This research will investigate the interactions between factors influencing the application of IPD in the New Zealand construction industry through both qualitative and quantitative approaches; hence, a mixed methods approach is the most suitable methodological position. The next section outlines the methods, including data collection, analysis, and the presentation of results for each research question.

3.2.5 Methods

The methods in a research design are pertinent to the techniques used for data collection, analysis, and presentation. As the philosophical approach, or methodology, was discussed in the previous sections, the methods relate to the practical approach for carrying out the research study. This section explains how each research question was addressed using appropriate data collection and analysis methods. Further, the presentation of results using software tools for each research question is also detailed. The methods

for *1.9.1 Research Question 1* are detailed below.

3.2.5.1 Data Collection

As Research Question 1 involves identifying the factors of IPD in the global construction industry, a thorough literature review was required, which involved articles relevant to IPD, articles mentioning factors related to its implementation, English-language articles, and articles that ideally included country-specific IPD data. For these reasons, the systematic literature review was deemed the most suitable method for data collection.

Systematic Literature Review

A systematic literature review (SLR) is a significant feature of academic research. Fundamentally, knowledge advancement must be built on the prior existing work. To push the knowledge frontier, we must first understand where it lies. By reviewing the relevant literature, the depth and breadth of the current body of work will be identified, and gaps will be recognised and explored. By summarising, analysing, and synthesising a group of related literature, a particular hypothesis will be tested, and/or new theories could be developed. Additionally, we can evaluate the validity and quality of existing work against specific criteria to identify weaknesses, inconsistencies, and contradictions (Xiao & Watson, 2017).

An SLR was conducted to identify all existing factors affecting IPD in the literature. The step-by-step procedure is detailed below.

Step 1: Establishing the Rationale: The rationale for this study was established to identify the objectives of the SLR. The rationale of the study is that, though numerous articles have detailed the factors of IPD, the interactions between these factors remain a research gap.

Step 2: Determining the Objective: The objective of this study was to identify and rank key IPD factors based on their interactions in the literature.

Step 3: Determining the Inclusion and Exclusion criteria: The inclusion and exclusion criteria are as shown below in Table 5:

Table 5: SLR inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Articles mentioning factors to Integrated Project Delivery	Non-integrated Project Delivery and construction-related articles
English language papers	Articles without mention of factors to Integrated Project Delivery
Articles published between the years 2009 and 2023	Non-English language papers
	Articles published before the year 2009
	Systematic literature reviews

Step 4: Selection of Databases to Identify Articles: Three databases — namely, Scopus, Emerald, and ScienceDirect — were used to identify articles that mention barriers to IPD.

Step 5: Determining the Search String: Table 6 shows the search string for each database.

Table 6: SLR search string

Search engine	Search string
Scopus	“Integrated Project Delivery” AND “Barriers” OR “Challenges” OR “Obstacles” published from 2009 to 2023
Emerald	“Integrated Project Delivery” AND “Challenges” published from 2009 to 2023
ScienceDirect	“Integrated Project Delivery” AND “Challenges” published from 2009 to 2023

Step 6: Selection of Articles: The total number of articles selected was 128, of which 66 had either explicitly or implicitly mentioned factors.

Step 7: Identification of Factors: Two hundred twenty-two factors were found from the 66 articles selected. Ninety-five of the 222 factors were related to others; hence, those factors were combined, and 127 were identified through this review. Figure 5 shows the PRISMA chart for the SLR process.

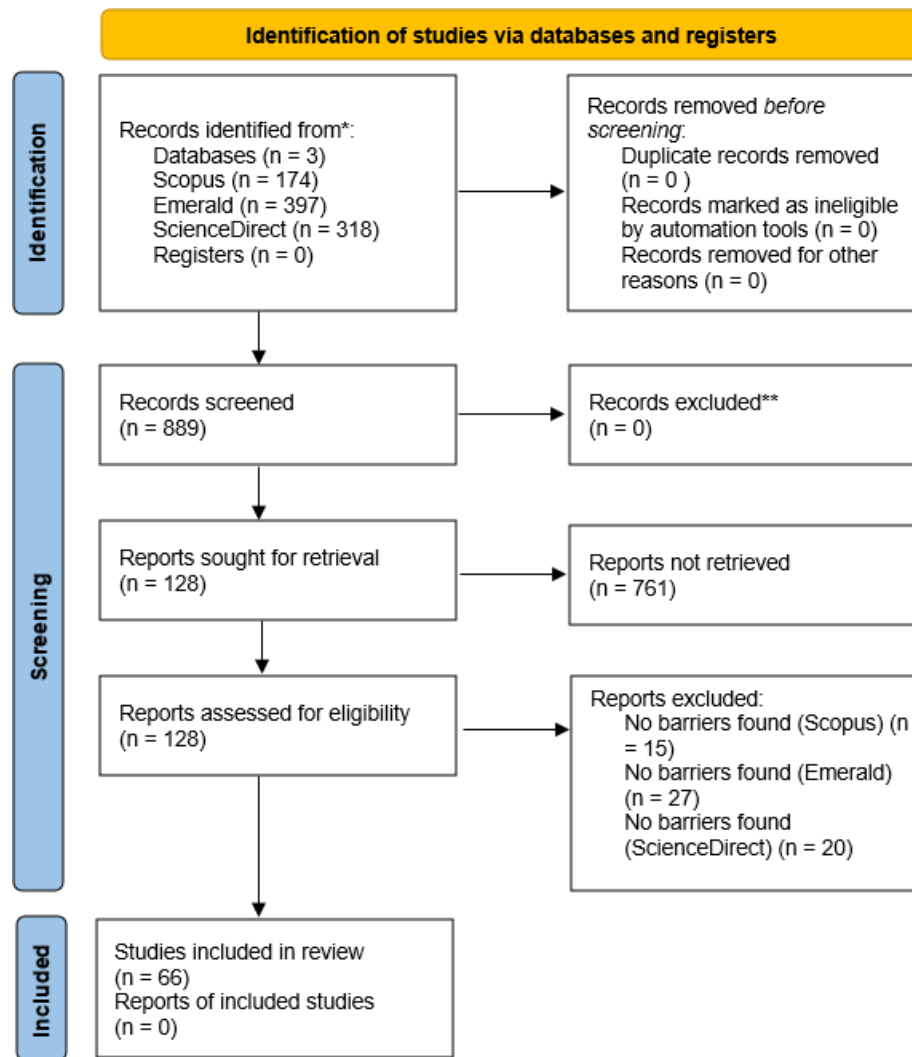


Figure 5: PRISMA chart for the SLR process.

The next section looks at the data analysis for Research Question 1.

3.2.5.2 Data Analysis

The data analysis was performed using the following steps:

1. Factor identification: To investigate the issues that impact the implementation of IPD in the global construction industry, it was necessary to identify the individual factors. For this purpose, each article was read twice to identify the factors influencing IPD. The identified factors were grouped into themes, including Collaboration and Communication (CC), Cultural/Organisational (CO), Financial (F), Governmental/Political (GP), Legal (L), and Technological (T).
2. Determining relevance: As 127 factors of IPD were found from the SLR, it was necessary to determine the relevance of every factor. For this reason, using VOSviewer's text mining functionality, all factors were uploaded to the software in a text document to visualise their co-occurrence. This visualisation displayed connectivity between keywords; however, it fell short of expectations and could not reveal all the factors, interactions, and polarity.

3. Interrelations and polarity: As the VOSviewer result fell short of expectations, the researcher decided to manually identify the interrelations and polarity between the factors. For this reason, each of the 66 articles was studied to identify interrelations and the polarity of the interaction between factors, i.e., whether it was positive (*factor A causes factor B to increase*) or negative (*factor A causes factor B to decrease*). The polarity was explicit in some articles and implicit in others. The researcher used deductive reasoning to identify the polarity in the implicit cases.
4. Organising identified interrelations and polarity: For ease of comprehension and to preserve the findings, a matrix was created in an Excel workbook that contained all factors obtained from the SLR. The factors were placed in the matrix's x- and y-directions. For identified interactions, polarity was assigned to the intersecting cells in the Excel workbook.
5. For visualisation of the findings, the System Dynamics (SD) approach was used, and the identified interrelations and polarities between the factors were modelled into a Causal Loop Diagram (CLD) using Vensim software.
6. To study the relationships between the identified factors of IPD, through the Network Analysis (NA) approach, Degree of Centrality (DC) and Eigenvector Centrality (EC) were computed for each factor in the network.
7. For identification of the critical factors, a comparison table was drawn where factors from every analysis: factor frequency, DC, and EC were listed. The factors that appeared in every analysis were deemed as first-level critical factors. The factors that appeared in both DC and EC analyses were deemed as second-level critical factors. The next section looks at SD in detail.

System Dynamics

System Dynamics (SD), first revealed by Forrester (1961), is a methodology for analysing the evolution of complex systems over time, driven by networks of causal relationships among their constituent elements (Ruiz et al., 2025). The primary focus of SD is to understand how the elements in a system interact with one another. It revolves around a computer simulation technique that utilises a feedback approach in analysing the behaviour over time of a complex and dynamic system (Sapiri et al., 2017). A computer simulation model is developed to assist management in making constructive decisions. SD provides a method for designing policies to improve the behaviour of complex, dynamic systems. It is worth noting that many SD models involve interactions between people and their surrounding environment. In the literature, many people are concerned with how things change over time. As SD is a growing field, it is increasingly viewed as an ideal approach for addressing multiple feedback loops and nonlinear systems that span various intellectual disciplines (Sapiri et al., 2017). Forrester's methodology provides a foundation for creating computer models that can do what humans cannot, such as analysing a structure logically and identifying the interactions and modes of behaviour

of complex social systems. This provides a framework in which strategies can be tested, and trade-offs can be evaluated (Bala et al., 2017). SD has been considerably used in the fields of construction management and energy to assess the impact of various policies and scenarios (Xu & Zou, 2021). SD can be used for management strategies in construction projects (Iqbal et al., 2016), infrastructure planning policies (Castelblanco et al., 2024), and carbon emission policies in the construction sector (Eker et al., 2018). In the context of socio-technical systems, SD offers valuable insights into the way alternative factors interact over time to influence the course of change (Ruiz et al., 2025). For the visualisation of the interrelations and polarities between the factors of IPD, and for a comprehensive understanding of the relationships between these factors, SD was used in this research. Causal Loop Diagrams (CLD) are a key tool in SD.

Causal Loop Diagram

A CLD is a well-utilised approach to systems mapping, with roots dating back to the 1970s, and a strong connection to system dynamics (Barbrook-Johnson & Penn, 2022). CLDS represent a system in three basic elements- boxes, connections, and feedback loops. The boxes, or nodes, represent variables in the system. The connections, or edges, represent the causal influence from one node to another. The connections can be either positive (both nodes increase or decrease together) or negative (nodes change in opposite directions; if one node increases, the other decreases). It is like Fuzzy Cognitive Mapping or Participatory Systems Mapping. Feedback loops make CLDS unique, both in the construction of the map and in its visualisation. Additionally, loops are made notable using curved arrows to create circles. Furthermore, the loops are color-coded or annotated with small arrows and “+” or “-” symbols to indicate whether they are reinforcing (positive) or balancing (negative) feedback loops. The feedback loops normally focus around ‘a core system engine’, a set of nodes that are the core of the system. The nodes in the core system engine are often visualised more eminently than other nodes in the map. The feedback loops provide significant insight into the system's dynamics. It is normal to use the maps to prioritise the identified critical nodes to distinguish them from individual nodes; the identified feedback loops in the system are brought together to analyse how they might arise. The emphasis on feedback loops identifies CLDs as a disciplined approach to examining a system. A CLD focuses on feedback as a significant component and organising structure for complex systems, enabling the inclusion of all kinds of concepts and variables. This implies that a CLD can assist with the production of focused maps, enabling the visualisation of the interconnected nature of systems. CLDs are considered stepping stones to simulation methods, such as system dynamics, due to their focus on feedback and strict use of variables for nodes in the map. NA is a complementary method to SD (Schoenenberger & Schenker-Wicki, 2014).

Network Analysis

Network Analysis (NA) was first identified in 1932, where a social network was mapped using 'sociometry', a technique for eliciting and graphically representing individuals' subjective feelings toward one another (Borgatti et al., 2009). The theory of networks facilitates the development of explanations in a wide range of disciplines, including psychology, economics, and management consulting. In management consulting, network analysis is often applied in the context of knowledge management, where the objective is to help organisations better exploit the knowledge and capabilities distributed across their members. A key task of NA has been to invent graph-theoretic properties that characterise structures, positions, dyadic properties, and the overall shape of ties. At the node level of analysis, the most widely studied concept is centrality: a family of node-level properties relating to the structural importance or prominence of a node in the network (Borgatti et al., 2009). Schoenenberger and Schenker-Wicki (2014) believe that the centrality measures used in NA are a valuable complement to the analysis techniques employed in SD. Centrality analyses can serve as a first screening tool for large SD models to identify potential levers within the model. By representing an SD model as a directed network, we limit ourselves to its structural complexity and neglect its dynamic complexity that emerges from nonlinear relations and accumulations (Oliva, 2004). One of the core assumptions of SD is that system behaviour arises from its underlying system structure; thus, unwanted system behaviour can be altered by changing the system structure. Therefore, having better tools available to understand and simplify structural complexity allows for a more efficient policy design process (Oliva, 2004). In NA, centrality is a frequently used method to determine which vertex holds a critical position in a network (Laghridat & Essalih, 2023). Centrality measures answer the question "who (or which) is the most important vertex in the network?". The answer to this question depends on the power that a vertex has in terms of the number of direct and indirect connections. The study of centrality determines the role of a vertex within a network, as well as its influence on the flow and sharing of information (Rochat, 2009). To understand the criticality of factors based on connections within the network, centrality methods — Degree Centrality (DC) and Eigenvector Centrality (EC) were employed to identify the critical factors in the network.

Degree Centrality

DC is one of the most used centrality measurements in network analysis as it aids in measuring the activity of transfer and communication within a network (Freeman, 1978). The number of direct connections of a vertex is a valuable measure of centrality as the results are easy to interpret and communicate (Landherr et al., 2010). DC is a suitable centrality measurement to indicate the influence of individual vertices within a network (Lee et al., 2010). DC is a local centrality calculated from a node's immediate neighbourhood links (Bamakan et al., 2019). It is the most straightforward centrality measure to compute, and the DC for a node is its degree (Golbeck, 2015). Typically, the numbers are converted to a 0-1 scale, and the node with the highest number of links in the network has a DC of 1.

The centrality of other nodes will be a fraction of their degree compared to that of the most popular node. As this study involved investigating how the factors of IPD influence each other, which can be determined through the links between each individual factor, DC was an appropriate centrality technique for this research. EC goes beyond degree centrality to identify the importance of each node within a network (Tortosa et al., 2017).

Eigenvector Centrality

Eigenvector Centrality (EC) measures a node's significance while considering the significance of its neighbours (Golbeck, 2013). EC suggests a node is more central as it is connected to important nodes (Bonacich, 2007). EC is a suitable measure of network centrality (Bonacich, 1972). In contrast to DC, which weights every contact equally, the eigenvector weights contacts according to their centralities. EC can also be seen as a weighted sum of not only direct connections but also indirect connections of every length. Thus, it considers the entire pattern in the network (Bonacich, 2007). Using the power iteration method, each node within the network is assigned a value; the higher the value, the greater the level of influence within the network (Meghanathan, 2015). EC suggests that links from important nodes are worth more than those from unimportant nodes. In the beginning, all nodes start equal, but nodes with more edges gain importance as the calculation progresses based on the significance of the nodes to which they are linked. A node will have a higher score if it is connected to high-valued nodes compared with equal connections to low-valued nodes. This research followed Meghanathan (2015) in calculating the EC. All factors to IPD were arranged in a matrix based on their incoming nodes to compute the EC. The matrix was multiplied by a column vector of unit 1, and the total incoming nodes of each factor were listed. Then, the normalised value was calculated (the square root of the sum of squares of node values). The node value of each factor was divided by the normalised value, resulting in the eigenvalue of each factor. The iterations were repeated until the normalised value stabilised (Meghanathan, 2015). Additionally, Bihari and Pandia's (2015) findings show that EC is more suitable than other centrality measures for identifying the most prominent vertex in a network. In comparison to DC, EC is parameter-free, computationally fast, and independent of prior assumptions (Maharani et al., 2014). Moreover, Agryzkov et al. (2017) believe that EC is the most suitable centrality measure for identifying the most and least influential vertices in a network. Finally, Iacobucci et al. (2017) noted that EC enables a comprehensive understanding of a network by identifying the first, second, and subsequent eigenvectors. The first eigenvector is associated with the largest eigenvalue, which captures the most significant amount of variance in a network. Moreover, subsequent eigenvectors provide further insight into the network's structure. For example, the first eigenvector is likely to reflect volumes and strengths of connections among the vertices. In contrast, the second or third eigenvector can delineate those in separate groups within the network that behave in somewhat equivalent manners, or other elements of network structure that can be informative in comprehending the vertices and the patterns that link them. As this research aimed to identify the critical factors of IPD in New Zealand based on their interactions with other factors, EC was an appropriate centrality

technique for this research, as it identified the most influential factors within the network. The next section looks at how the results were presented.

3.2.5.3 Presentation of Results

VOSViewer software was used to visualise the frequency of the identified factors of IPD. Additionally, the identified interactions between factors and their polarities were visualised in a CLD using Vensim software. The software programs can be studied in more detail below.

VOSViewer

VOSviewer is a software tool for creating maps based on network data and for visualising and exploring these maps (Eck & Waltman, 2015). The functionality of VOSviewer consists of:

- Map creation using network data: A map can be created based on an available network. However, creating a network is also possible. VOSviewer can be used to construct networks of scientific journals, publications, researchers, research organisations, countries, keywords or terms. Objects in these networks can be joined by bibliographic coupling, co-authorship, co-occurrence, citation, or co-citation links. Bibliographic database files and reference manager files can be provided as input to the software for constructing a network.
- Visualisation and exploration of maps: The software provides three visualisation features: network visualisation, overlay visualisation, and density visualisation. Additionally, the zooming and scrolling commands allow maps to be explored fully.

Although the primary use of VOSviewer is to analyse bibliometric networks, the software can also be used to create, visualise, and explore maps based on any type of network data (Eck & Waltman, 2015). To determine the relevance of the factors obtained from the SLR, and for identification of the key factors, which were offered through repetition in literature, VOSviewer was a suitable choice of software for this research. Vensim software is discussed next.

Vensim

Vensim software, commonly used for CLDs, is one of the software tools that employs SD to model and provide solutions to a proposed problem (Koushali et al., 2015). Vensim employs an objective modelling method that enables the software to model complex problems more straightforwardly than other programming languages. Models built using Vensim are significantly simpler than those constructed using traditional programming languages (Koushali et al., 2015; Goncalves & Giorgetti, 2013). The physical and conceptual attributes of the model are defined using the analytical functions of Vensim. The results are presented visually and examined for sensitivity, which aids in various decision-making capabilities (Koushali et al., 2015). Vensim models are either built as CLDs or

diagrams of stocks and rates. Stocks are represented by rectangles (box variables), and rates are represented by arrows on double solid lines signalling into a box (rate in) or out of a box (rate out). Additionally, the arrows have valves presented as two opposing triangles, the purpose of which is to control the rates of flow into and out of the box. Finally, clouds at the ends represent sources or sinks of a quantity being transported into or out of a box. Figure 6 shows a sample stock and rate diagram.



Figure 6: Sample stock and rate in Vensim

Due to the ease of modelling and the software's features, such as coloured arrows that aid in differentiating between positive and negative polarities of the IPD factors, Vensim was a suitable software choice for this research. The methods for **1.9.2 Research Question 2** are detailed next.

Research Question 2 investigated the influencing factors that hinder the implementation of IPD in New Zealand. For this purpose, a qualitative approach was warranted to gather data through open-ended, thought-provoking, and detailed questions that would aid in identifying New Zealand-specific factors that impact IPD implementation. The data collection method is described in detail below.

3.2.5.4 Data Collection (Qualitative)

Numerous qualitative methods exist that aid researchers in collecting qualitative data. The most common approaches that are often used by researchers include:

Semi-structured interviews

Semi-structured interviews are widely used in qualitative research to understand the reasons people act in specific ways by exploring participants' perceptions, experiences, and attitudes. Additionally, they are used to generate ideas for developing or changing practice. They can be used for data collection or as an informal evaluation tool. One of the advantages of using semi-structured interviews is the richness of data they yield (Harvey-Jordan & Long, 2001). During an interview, a subject is free to talk as openly as they wish, and the frankness of opinions can get to the heart of the matter. Semi-structured interviews employ a series of open-ended questions based on the topic areas the researcher wants to cover, allowing various themes or subtopics to emerge. Themes are generally identified by the researcher prior to the interview. Still, the interview schedule framework should be sufficiently flexible to allow themes that develop throughout the discussions to be explored (Harvey-Jordan & Long, 2001). Focus groups are another option for collecting qualitative data.

Focus groups

Focus groups are a form of group interview that utilises the communication between research participants to generate data. Although group interviews are commonly used as a suitable method to collect data from several people simultaneously, focus groups explicitly utilise group interaction as part of their methodology (Kitzinger, 1995). Focus groups share many similarities with less structured interviews, and they involve more than simply collecting data from multiple participants simultaneously. A focus group is a group discussion on a particular topic organised for research purposes. This discussion is guided, monitored, and recorded by a researcher (Gill et al., 2008). Observation is another option for collecting qualitative data.

Observation

Observation is one of the oldest research approaches in qualitative research. This method involves collecting data using the researcher's senses, especially by looking and listening in a systematic and meaningful manner (McKechnie, 2008). Furthermore, the method necessitates a lengthy engagement and continuous observations in the field (Lincoln & Guba, 1985), as well as the researcher's capability, which is often filtered by bias and the lens through which knowledge is perceived (Kvale, 1995).

To investigate the interactions of factors affecting the implementation of IPD in New Zealand, the researcher was required to interact with construction professionals in a friendly manner, which would enable thought-provoking and detailed discussions in a relaxed atmosphere. For these reasons, semi-structured interviews were deemed as a suitable data collection method for this study, where meetings could be scheduled at the convenience of the interviewees. Table 7 details the profiles of the interviewees who were selected for an interview.

Table 7: Interviewee profiles

Interviewee code	Designation	Years of experience
C1	Project Manager	20+
C2	Building Services Engineer	30+
C3	Technical Director	30+
C4	Technical Director	20+
C5	Lean Coordinator	10+
C6	Construction Manager	10+
C7	Commercial Manager	30+
C8	Commercial Manager	25+
C9	Construction Manager	10+
C10	Quality Manager	25+
C11	Project Delivery Manager	20+
C12	Project Director	30+
C13	BIM Coordinator	10+

Interviewee code	Designation	Years of experience
C14	Quality Lead	10+
C15	Project Manager	15+
C16	Project Manager	20+
C17	BIM Coordinator	10+
C18	Project Planner	10+

The sampling techniques used to recruit the participants are presented next.

Sampling techniques

To recruit the participants, both purposive and snowball sampling techniques were used. These are discussed in more detail below.

Purposive sampling

Purposive sampling, also known as judgment sampling, is the deliberate choice of a participant due to the qualities they possess. It is a non-random technique that does not require underlying theories or a fixed number of participants. The researcher determines the necessary criteria and sets out to find participants who can and are willing to provide information based on their experience and knowledge (Bernard, 2002). Purposive sampling is typically employed in qualitative research to identify and select information-rich samples, thereby maximising the efficient use of available resources (Patton, 2002). The reasons for adopting the purposive sampling technique are that, according to the research aims and objectives, a specified group of participants may hold different and significant views and therefore need to be included in the sample (Trost, 1986). The process involves identifying and selecting individuals or groups knowledgeable about a phenomenon (Creswell & Plano Clark, 2011). The availability and willingness of participants to communicate experiences and opinions articulately and reflectively are significant (Spradley, 1979). The criteria to recruit participants were:

- Previous experience or actively engaged in applying IPD as a project delivery method.
- Previous experience with IPD-related project delivery methods, such as alliancing or collaborative contracting

As the recruitment criteria for this research was specific to construction professionals with IPD experience and/or knowledge, the purposive sampling technique was suitable for this research. The snowball sampling technique was another method used to recruit participants for a semi-structured interview.

Snowball sampling

Snowball sampling or chain-referral sampling of a population initiates with a convenience sample of an initial subject, which then serves as a ‘seed’ through which the wave 1 participant is recruited. In turn,

the wave 1 participant recruits the wave 2 participant. The sample consequently grows wave by wave like a snowball (Heckathorn, 2015). Snowball sampling may generate biased results because participants with extensive social connections can refer others who share similar characteristics to those of the initial participant (Erickson, 1979). The snowball sampling technique is useful if the population of interest is difficult to reach (Oisin, 2007). The snowball sampling technique is not as uncontrolled as its name may imply; the researcher is heavily involved in developing and managing the origin and progress of the sample. Additionally, the researcher aims to ensure that the chain of referrals aligns with the research study's objectives (Alkassim et al., 2016). As there was a limited presence of construction professionals with IPD experience and/or knowledge in New Zealand, the snowballing sampling technique was appropriate for this research, as the selected participants were able to refer other participants who had relevant credentials. The interview protocol and procedure are described next.

Interview procedure and protocol

The SLR results were used to frame the open-ended questions regarding themes, factors, and relationships. The aim was to gather as much information as possible using open-ended questions targeted at experts in the New Zealand construction industry. The SSI formed the qualitative component of this study. Ethics approval was required prior to the commencement of data collection. An application was prepared, and the researcher was briefed on privacy and the code of conduct to be adhered to during data collection. *Appendix 11- Ethics Approval* shows the ethics approval for this research study; the ethics approval number is 23/270. A selection criterion was used to recruit participants; initially, purposive sampling was employed, followed by snowball sampling. Short-listed construction professionals were approached through their public profiles, and upon initial interest, a formal email containing the participant information sheet, invitation letter, and the required consent forms was sent. *Appendix 3- Interview Invitation* displays the invitation sent via email, *Appendix 12- Participant Information Sheet for Interviews* displays the information sheet, *Appendix 13- Consent Form for Interviews* and *Appendix 14- Consent Form for Interviews by videoconference* display the consent forms, and *Appendix 2- Interview Questions* details the questions. The researcher made sure that the appropriate consent forms were signed prior to the interview. A date and time were set, and the interviews were conducted online using Microsoft Teams. The interviews began with the researcher recording the consent and providing the interviewees with general information, including the total number of questions and the expected duration of the interview (45-60 minutes). The interviewees were given 5 minutes to review the questions before the interview began. Upon commencement, the researcher selected the 'record and transcribe' feature of the application, and the interviews were transcribed using the in-built transcription feature. The conversation that followed was friendly, and the researcher ensured that the interviewees felt relaxed. The semi-structured interviews consisted of 24 open-ended questions, and the researcher ensured that ample time was allocated for the interviewees to provide detailed explanations. Upon finishing the explanation given by the

interviewees, the researcher tried to extract more information by asking questions such as, 'Would you like to add anything else?'. Additionally, where the researcher felt that insufficient information was provided for a particular concept, further sub-questions were asked about the phenomenon in question. A total of 18 semi-structured interviews were conducted. The data analysis for Research Question 2 is presented below.

3.2.5.5 Data Analysis

Upon completion of the semi-structured interviews, the analysis was performed through manual coding. The transcripts were read twice, and colour codes were used to identify the IPD factors. The transcription feature of Microsoft Teams was used to create transcripts of each interview, which were then uploaded to the NVivo software. The results from the manual coding were replicated using the text analysis feature of NVivo, and the factors were coded according to their themes. This feature of NVivo aided in the presentation of infographics, which detailed the frequency of the factors revealed by the interviewees. The presentation of results is discussed next.

3.2.5.6 Presentation of Results

NVivo software was used to aid with the visualisation of the factors of IPD identified from the interviews. The interview transcripts were uploaded to the software, and the factors were coded for each interviewee. NVivo helped determine the frequency of the coded factors, as well as distinguish between the number of factors revealed by each interviewee. Further, interviewee-specific infographics were presented, showcasing the impact of the interview through the number of factors coded. NVivo can be studied in more detail below.

NVivo

NVivo has numerous advantages and can significantly enhance the quality of research. Furthermore, the software significantly reduces manual work, allowing the researcher more time to identify trends, recognize themes, and draw conclusions (Hilal & Alabri, 2013). Dalkin et al. (2020) reported that NVivo software is a powerful qualitative analysis tool that can code and analyse various types of data, including text, video, and audio. It is also an effective tool for conducting qualitative research. With NVivo, it is possible to manage, access, and analyse qualitative data while maintaining a comprehensive perspective on all the data, without losing its richness or closeness to the original data, which is critical for qualitative research (Bazeley & Richards, 2000). NVivo is designed to approach qualitative analysis as researchers do. A project may start simply with a question or a purpose. NVivo will store those initial ideas in rich text documents, allowing you to edit them as they evolve, and link your notes to other files as you progress. These first ideas can be explored in a visual model. Researchers typically generate initial concepts, ideas, or categories. NVivo will store these at nodes

that can be explored, organised, or changed. Researchers may create data documents and edit them during a project or import documents that have already been prepared (such as transcripts of interviews). Further, documents can be edited or imported into the NVivo project in a rich text format. Also, data outside the project can be represented in editable, codable proxy documents. Moreover, interpreting a document and storing the ideas that emerge from it requires annotating, memoing, coding, and reflecting on coding (Bazeley & Richards, 2000). As NVivo enables documents to be imported and subsequently analysed, with the presentation of results in the form of various infographics, it was a suitable choice of software for this research. The methods for **1.9.3 Research Question 3** are detailed next.

1.9.3 Research Question 3 was pertinent to identifying the interactions between the factors that influence the application of IPD in New Zealand. This research question was addressed through both qualitative and quantitative approaches. The results obtained from the semi-structured interviews were triangulated using a system-wide survey questionnaire to investigate whether the wider New Zealand construction industry agreed with the experts. The data collection, analysis, and presentation of results for both qualitative and quantitative approaches are detailed below. The data collection is described in detail below.

3.2.5.7 Data Collection (Qualitative)

Likewise, to Research Question 2, semi-structured interviews were used to identify the interactions between the factors of IPD.

Semi-structured interviews

Likewise, to Research Question 2, the semi-structured interviews were an appropriate data collection approach, enabling thought-provoking and detailed discussions in a relaxed atmosphere. The results from the qualitative semi-structured interviews were triangulated with a quantitative approach. The data collection for the quantitative approach is detailed next.

3.2.5.8 Data Collection (Quantitative)

Triangulation is a combination of techniques that are used to enhance accuracy, improve judgments, and validate data through cross-verification from multiple sources (Smith, 1975). A single method is unlikely to yield a comprehensive account of the phenomenon under investigation; therefore, two or more methods are employed to utilise different intellectual tools on the task at hand. The assumption is that various perspectives can be generated, which will provide a fuller and more informative picture of what is happening: such fuller pictures will be more rounded, nuanced, and valid than those produced by a single method (Torrance, 2012). The quantitative methods detailed below were considered.

Survey

A survey design refers to the data collection method used in conducting survey research (Glasow, 2005). The two primary features of survey research are the use of predefined samples and well-structured instruments. Researchers often opt for a survey design in studies that aim to draw statistical inferences (Bihu, 2021). Survey research places importance on measuring the causality between dependent and independent variables (Cresswell, 2014). Survey research requires methods that prioritise research practices leading to quantitative analysis, such as questionnaires, structured interviews, or data from published statistics that are founded in the positivistic paradigm (Gabble, 1994). Researchers use statistical techniques to analyse the reported data from respondents and use the data for generalisations in the wider context. Most surveys use structured instruments, such as questionnaires with standardised questions, to aid in analysis (Glasow, 2005). The survey research findings should include the positive consequences of multiple interactions between the involved parties. Impactful survey design is achieved by considering inputs from targeted respondents, users of the study findings, and expatriates carrying out the respective surveys (Glasow, 2005). The advantage of questionnaires in surveys is that they enable the generation of data that is both cost-effective and efficient. Furthermore, questionnaire surveys enable the instruments to be easily piloted, implemented, analysed, and the findings shared with stakeholders. Due to these reasons, questionnaire surveys are a popular data collection tool in academic research (Regmi et al., 2016). The process of conducting a questionnaire survey consists of several phases: defining the research aim, identifying the target population, determining the sample size and data collection technique, structuring the questionnaire, piloting it before wider dissemination, implementing the survey, and finally analysing the data (Burgess, 2001). A case study is another option for collecting quantitative data.

Case study

A case study is defined as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, where the boundaries between the phenomenon and its context are not clearly defined, and in which multiple sources of evidence are used (Yin, 2004). A case study is therefore contextualised as a detailed investigation, commonly with data collected over a period, of one or more organisations, or groups within organisations, with a view to providing an analysis of the context and processes involved in the phenomenon under study (Hartley, 1994). The experimental method is another option for collecting quantitative data.

Experimental

Experimental research methods have a long history across various disciplines. Experiments are notable because they are the most effective way to establish causation; this makes them a powerful tool if researchers need to demonstrate cause-and-effect relationships (Stoner et al., 2023). Experimental research is a technique used in quantitative research to assess whether an activity or material affects participant outcomes. The researcher measures the effect by assigning a single set of actions to one

group, known as the intervention, and denying the set of actions to the other group. Experimental research involves a hypothesis and a variable that can be measured, calculated, and compared in a controlled environment. The purpose of experimental research is to discover a correlation and a relationship between the dependent variable and the independent variable. The data in an experimental study must be measured, and the method is also known as intervention research or group comparison research (Ghanad, 2023).

As the purpose of the quantitative approach was to validate the findings with the broader construction sector in New Zealand, the survey questionnaire was deemed the most appropriate method due to its ease of distribution, cost-effectiveness, and widespread use. The calculation to identify the appropriate sample size for the survey questionnaire is discussed next.

Sample size

For large populations, Cochran (1963) developed an equation to yield a representative sample for proportions. Equation 1 shows the formula used to calculate the sample size required for the survey questionnaire.

Equation 1: Formula for sample size

$$n_0 = \frac{z^2 pq}{e^2} \quad (1)$$

where n_0 is the sample size, z^2 is the abscissa of the normal curve that cuts off an area α at the tails ($1 - \alpha$ equals the desired confidence level, e.g., 95%), e is the margin of error, p is the estimated proportion of an attribute that is present in the population, and q is $1-p$. The value for Z is found in statistical tables, which contain the area under the normal curve. The confidence level was set at 95 percent, and the margin of error was specified as 7 percent. Additionally, the z -value associated with a 95 percent confidence level was found to be 1.96 (Hazra, 2017). Lastly, for p , the estimated proportion of the NZ construction industry that was familiar with IPD, as there are no in-depth prior studies on IPD in NZ, other OECD countries with relevant IPD data were considered. In Canada, the 2023 metrics revealed that out of 493 major construction projects, at least 106 projects employed the IPD model (IPDA, 2023; Natural Resources Canada, 2023). Thus, p was considered as 21.5 percent. Therefore, solving for n_0 :

$$n_0 = \frac{1.96^2 * 0.215(1 - 0.215)}{0.07^2}, \quad n_0 = 132.32$$

The minimum number of survey responses required was set as 132. The survey procedure is detailed next.

Procedure

For triangulation purposes, a system-wide survey questionnaire followed the semi-structured interviews. In comparison to the semi-structured interviews, the survey questionnaire targeted the New Zealand construction industry to investigate whether the sector agrees with the opinions of the experts. The original survey, created as part of the initial ethics application, had to be amended based on the results from the qualitative, semi-structured interviews. For this reason, an amended survey was submitted to the ethics committee for approval. *Appendix 17- Ethics Approval for Amended Survey Questionnaire* shows the ethics approval. Upon approval, a survey questionnaire was generated by using Qualtrics through the website, 'www.qualtrics.com'. For easy comprehension, all identified interactions were listed and rewritten. For example, 'lack of promotion of IPD causes an increase in the lack of IPD awareness of stakeholders' was rewritten as 'stakeholders lack IPD awareness because it is not promoted enough'. The survey was designed using a 6-point Likert scale, with response choices of: Strongly Agree, Somewhat Agree, Neither Agree nor Disagree, Somewhat Disagree, Strongly Disagree, and I don't know. The survey was first piloted with three experts who had participated in the previously conducted interviews. The purpose of the pilot was to ensure that the experts agree with the field language used, as the survey was targeted at a general audience who may not be familiar with IPD. *Appendix 15- Participant Information Sheet for Pilot Survey* shows the information sheet, and *Appendix 16- Consent Form for Pilot Survey* shows the consent form. Upon confirmation received from the three experts that the survey questionnaire should be distributed, the researcher created a link for the survey. *Appendix 18- Survey Questionnaire* shows the final survey questionnaire that was distributed. The survey was anonymous, and neither the researcher nor the respondents knew each other's identities. A formal invitation, posted as a flyer containing the survey link, was shared on professional networking sites. Further, the flyer was distributed to professional bodies pertinent to the construction industry in New Zealand. The professional bodies selected were:

- 1) Engineering New Zealand
- 2) New Zealand Institute of Building
- 3) Civil Contractors
- 4) Society of Construction Law New Zealand

The aim was to gather as many responses as possible to reflect the industry thinking. A total of 137 survey responses were collected. The demographics of the survey respondents are discussed next.

Demographics

The demographics of the respondents, including gender, profession, age range, and years of work experience in the construction industry, are presented in Table 25 in *Appendix 7- Survey Demographics*. The results comprised of 111 males and 26 females, which is in line with the gender

proportion of the NZ construction industry. This reveals that the construction industry in New Zealand, like almost every other country, is male-dominated. Apart from the gender grouping, the two most common age ranges of respondents were the age group '26-35' with 54 respondents, and '36-45' with 43 respondents. This reveals that the younger population primarily dominates the New Zealand construction industry. Furthermore, regarding the professions, several respondents did not answer the question, with 18 fully completed survey sheets not mentioning any profession. However, from the fully completed responses, it was noted that 'quantity surveyor' was the most repeated response, with 8 responses, followed by 'project engineer' with 6 responses, 'design engineer' with 5 responses, 'construction manager', 'project coordinator', 'design manager', 'consultant', and 'site engineer' each with four responses. The next in succession were 'project manager', 'BIM modeller', and 'BIM manager', each with three responses. It should be noted that some professions were synonymous, such as 'site engineer' and 'field engineer'; 'company owner' and 'construction company owner'. The data analysis for Research Question 3 is presented in detail below.

3.2.5.9 Data Analysis

From the semi-structured interviews, the interactions between the factors of IPD were identified using manual coding. The researcher employed deductive reasoning to identify interactions that were not immediately apparent. The interactions were categorised as either positive (+) or negative (-), with (+) indicating that factor A caused factor B to increase, and (-) indicating that factor A caused factor B to decrease. This procedure was completed for each of the 18 interviewees, and the results were recorded in an Excel workbook. The network was visualised using Vensim. Sample transcription coding is shown below:

C2: 'I believe that that it is relatively lowly implemented; the reason for that is because there is not a particularly good proven track record within the construction industry in New Zealand. And I think because of that, there is a reluctance from the likes of clients and or constructors or any stakeholder.'

Using deductive reasoning, it was concluded that the lack of familiarity with the IPD approach (LoF) among contractors causes resistance to change from stakeholders (RtC) to increase.

Likewise, to the analysis for Research Question 1, SD and NA approaches were used. The interactions between the factors of IPD were visualised using a CLD, and the network was analysed using centrality techniques, DC, and EC. Additionally, for the quantitative approach, the relative importance index (RII) method and statistical tests were used to analyse the survey responses. The RII method and statistical tests are detailed below.

Relative Importance Index

The RII is a statistical method to determine the ranking of different factors (Hossen et al., 2015). The

RII is used to describe the relative importance of specific causes and effects based on the likelihood of occurrence and the magnitude of effect, using a Likert scale. The higher the RII value, the greater the phenomenon's impact. Equation 2 shows the formula used to determine the RII values.

Equation 2: Formula for RII

$$RII = \frac{\Sigma W}{A * N} \quad (2)$$

Where W was the sum of the scores answered by each respondent on a scale of 1 to 5, with 1 indicating 'Strongly Agree', the highest score, and 5 indicating 'Strongly Disagree', the lowest score. A was the highest score, and N was the total number of the sample. According to Akadiri (2011), five important levels are transformed from RI values: high (H) ($0.8 \leq RI \leq 1$), high-medium (H-M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$). The statistical tests used for analysis are described next.

Statistical tests

The applicability of statistical tests depends on the types of data available. If sample population distributions are measured and replicated, then overall population tests are applicable, such as the unpaired t-test or a non-parametric distribution test (Conover, 1980). However, if paired samples are available, then suitable methods include the paired t-test, regression analysis, or the non-parametric sign test. Stochastic models, which cause a distribution for comparison with each observation, also initiate statistical problems (Dent & Blackie, 1979). Generally, the mean of the generated distribution is used, although more complex alternatives are available (Reynolds et al., 1981). Many statistical tests are available (McCarl, 1984); however, simple and easily understood tests are often preferred. Typically, the two-tailed significance testing approach is adopted, allowing for deviations in either the positive or negative direction (Mayer & Butler, 1993). For the validation of survey responses, this research employed two-tailed significance testing using SPSS software. The features of SPSS software are discussed in the following section.

SPSS software

The Statistical Package for the Social Sciences (SPSS) is a versatile software that supports a variety of analyses, transformations, and output formats. The software facilitates the collection of statistics, ranging from simple descriptive numbers to complex analyses of multivariate matrices. The software facilitates efficient data comprehension and enables researchers to test hypotheses that were previously considered too complex. Furthermore, the software helps save time and reduces the likelihood of errors in the data analysis process (Alili & Krstev, 2019). The presentation of results for Research Question 3 is discussed next.

3.2.5.10 Presentation of Results

The interactions between the factors of IPD were presented in the form of a CLD using Vensim. The methods for *1.9.4 Research Question 4* are outlined next.

Research Question 4 involved the identification of the critical factors as well as the critical chains of factors that impact IPD implementation in New Zealand. Likewise, to Research Question 3, the critical factors and their relationships were identified through both data collection approaches: qualitative and quantitative.

3.2.5.11 Data Collection (Qualitative)

Semi-structured interviews were used for the qualitative approach.

Semi-structured interviews

Likewise, to Research Questions 2 and 3, semi-structured interviews were used for the qualitative component for Research Question 4. The quantitative data collection approach is discussed next.

3.2.5.12 Data Collection (Quantitative)

Likewise, to Research Question 3, the system-wide survey questionnaire was used for the quantitative approach.

Survey

Likewise, to Research Question 3, the survey questionnaire was used. The data analysis for Research Question 4 is discussed next.

3.2.5.13 Data Analysis

According to the results of *3.2.5.9 Data Analysis*, for the qualitative approach, the factors were grouped in a comparison table, with the factors listed in order of their DC and EC values. Additionally, the SLR and SSI frequencies of the factors were included in the comparison table, along with the DC and EC values. The purpose was to compare the relevance of a factor in the literature with its perceived relevance by the expert interviewees. The factors that appeared in every analysis (DC, EC, SII, and SLR) were deemed the most critical factors. Additionally, the factors that appeared in every analysis except for the SLR were deemed the next-level critical factors in the New Zealand context. Next, the triangulated survey results were analysed using the same methodology. The statistically significant interactions were used to inform the logic model, which was sketched using Vensim, like the logic model developed from the semi-structured interviews conducted. A difference

from the prior analysis, however, was that for eigenvector computation, the RII values were used instead of a unit value of 1 to detail the interaction values between factors. This was because many responses (137) were received from the survey questionnaire, and thus, the interaction values between factors could be deemed reliable. This contrasts with the semi-structured interviews conducted, during which only 18 professionals participated in the data collection. Next, the factors were grouped in a comparison table, with the factors listed as per their DC and EC values, along with the SLR frequency. The factors that appeared in every analysis (DC, EC, and SLR) were deemed the most critical validated factors. The factors that appeared in both DC and EC analyses, however, not in the SLR, were deemed the next level validated critical factors in New Zealand. Moreover, the aim was to identify the critical chains of factors as well. For this purpose, Causal Chain Analysis (CCA) was employed. CCA is explained further below.

Causal Chain Analysis

CCA involves developing a logic model and using it to anchor subsequent analysis, aiming to provide empirical evidence for parts of the causal chain and information about contextual modifiers (Kneale et al., 2018). CCA maps essential linking elements, usually at the business-unit level of analysis (Cascio & Boudreau, 2008). CCA describes an approach that utilises various methods to theorise and test how interventions influence outcomes. Logic models are graphical representations of programme theory that depict intervention components, mechanisms, outputs, and outcomes as a sequential chain of events- these form the basis of CCA (Kneale et al., 2018). The interactions between the factors can be studied in more detail through CCA, and the sum of the DC and EC values of the factors can aid in identifying the heaviest chains, which are deemed critical. The Vensim model was used as the logic model and analysed to identify possible causal chains that impact IPD implementation in NZ. The presentation of results for Research Question 4 is discussed next.

3.2.5.14 Presentation of Results

The interactions between the factors of IPD were presented in the form of a CLD using Vensim. The critical factors and their chains were presented in a tabulated format. The next section looks at the framework selection for this research.

3.2.6 Framework

The final research question for this study, as mentioned in *1.9.5 Research Question 5*, investigates the most suitable type of framework for identifying factors and their interactions. Before answering the Research Question, it is important to understand the concept of a framework and its relevance in a research study. Frameworks are essential research tools that are critically important for structuring empirical inquiry and theoretical development in the environmental social sciences, governance research and practice, the sustainability sciences, and fields of social-ecological systems research, in

tandem with the associated disciplines of those fields (Binder et al., 2013). The approved interactions between the factors of IPD, as obtained from the survey questionnaire, were used to construct the framework. The conceptual framework is described next.

3.2.6.1 Conceptual Framework

A conceptual framework is a structure that can ideally explain the natural progression of the phenomenon under study (Camp, 2001). The researcher's approach to exploring the research problem is presented through the conceptual framework, which offers an integrated view of the phenomenon under study (Liehr & Smith, 1999). From a statistical perspective, the conceptual framework describes the relationship between the main variables of a study (Grant & Osanloo, 2014). A conceptual framework can be presented in either graphical or narrative form, illustrating the key variables to be studied and the presumed relationships between them (Miles & Huberman, 1994). As this research investigates the factors of IPD and their interactions, the conceptual framework is the ideal choice of framework for this study. The three types of a conceptual framework are descriptive, explanatory, and predictive. These are explained below:

Descriptive Framework

A descriptive framework systematically describes a phenomenon, identifying its characteristics, trends, and frequencies. It aims to summarise or represent the data in a concise manner. Additionally, the focus of the descriptive framework is at the measurable level, rather than the construct level (Shmueli, 2010). However, the descriptive framework does not investigate causality or cause-and-effect relationships. The explanatory framework investigates causality.

Explanatory Framework

The explanatory framework combines theory with data to test hypotheses and explain behaviour. The explanatory framework helps identify the key parameters that explain the observed patterns in the data (Panovska-Griffiths et al., 2021). The explanatory framework is a multi-variable construct used to make sense of complex events by assigning new meaning to complex phenomena, separating out individual components of an event, and unifying these components into a coherent model. The model is then used for its intended purpose (Davidoff, 2019). The explanatory framework explains why a phenomenon occurs, uncovers causal relationships, and explores the relationships between variables. The predictive framework is described next.

Predictive Framework

The predictive framework forecasts future occurrences by using patterns and trends based on

established causal relationships. It is a process of applying a statistical model or a data mining algorithm to data for the purpose of predicting new and future observations (Geisser, 1993). As the interactions between the factors of IPD in New Zealand have not been identified prior to this study, the predictive framework is not relevant for this research study.

This research used both descriptive and explanatory frameworks. The descriptive framework was initially used to identify the factors of IPD and their interactions in the New Zealand context, as well as to determine the frequency of those interactions as revealed by the expert interviewees. Next, the explanatory framework was employed to model the interactions between the factors of IPD into a causal loop diagram and comprehend the causality through the causal chain analysis method. The next section details the quality control criteria for this research.

3.2.7 Quality control

Addressing quality in mixed methods research is essential for several reasons. First, researchers need criteria to ensure that their studies, as well as the manuscripts they assess, are justifiable and transparent (Collins et al., 2012). This is especially relevant in the field of mixed methods, as some critical principles are still unfamiliar to many scholars (Tashakkori & Teddlie, 2010). Second, for learning purposes, the criteria can be beneficial for new researchers. Third, the literature on the quality of mixed methods aids in consolidating the narrative about the unique features of this type of research (Creswell, 2015). Indeed, since mixed methods research involves the integration of quantitative and qualitative components, there is a case for using specific criteria to evaluate the quality of this type of research method. Reliability is an essential component of quality control in a research study.

3.2.7.1 Reliability

Reliability depends on the ability to present organised data and ideas to promote understanding (Walliman, 2017). One of the main requirements of any research is the reliability of the data and findings. Reliability deals with the consistency, dependability, and replicability of the results obtained from a particular research study (Nunan, 1999). Obtaining results from a quantitative approach is rather straightforward because the data is in numerical form; however, obtaining results from a qualitative approach is somewhat difficult because the data is in narrative form and subjective (Zohrabi, 2013). Instead of obtaining the same results, it is better to think about the consistency and dependability of the data. The purpose is to agree that, based on the data collection methods, the findings and results are consistent and dependable (Lincoln & Guba, 1985). The dependability of a research study can be ensured using three techniques: the investigator's position, triangulation, and audit trail (Merriam, 1998).

- The investigator's position: The researcher needs to explain explicitly the different processes

and phases of the inquiry.

All aspects of the study have been detailed, including the rationale and the design of the study.

- Triangulation: The researcher should use alternative procedures for data collection, and the data should be obtained from different sources.

The results from the semi-structured interviews were triangulated with a system-wide survey questionnaire. The interviews were targeted at experts, whereas the survey questionnaire was targeted at the NZ construction industry.

- Audit trail: The researcher should describe in detail how the data is collected, analysed, and how the results are obtained.

The data collection, analysis, and presentation of results have been thoroughly explained for each research question. Validation is another essential component of quality control in a research study.

3.2.7.2 Validation

Validity in research is “the extent of the legitimate generalisability of the results of an experiment” (Walliman, 2017). The validity of research depends on a robust ethical design that uses the same protocol across all settings and is carried out in real-world settings, providing data that represent the influence on sought variables (Denzin, 1978). Carter et al. (2014) believe that triangulation is a strategy to achieve validation in research. Further, Golafshani (2003) emphasised that reliability, validity, and triangulation reflect the multiple ways of establishing the truth. The validity of the current research was ensured by:

- The interviewees were knowledgeable about collaborative project delivery models, such as IPD
- Establishing the same semi-structured interview protocol with every interviewee
- The interview questions were structured to ensure all factor themes were covered
- In-depth analysis of the factor network diagram, considering results from every analysis
- Triangulation of the results obtained from the expert interviewees with the wider NZ construction industry
- Using statistical tests to ensure the validity of the results

Credibility is another essential component of quality control in a research study.

3.2.7.3 Credibility

Credibility is the confidence that can be placed in the truth of the research findings. It determines whether the research findings accurately represent the information derived from the participants' original data and accurately reflect their original views (Korstjens & Moser, 2017). Credibility is equivalent to internal validity in quantitative research and is concerned with the feature of real-world value. Tactics to ensure credibility include prolonged engagement, persistent observation, triangulation, and member check (Lincoln & Guba, 1985). The credibility of the current research was ensured by:

- Prolonged discussion with expert interviewees: The hour-long interviews consisted of open-ended questions, and the interviewees were encouraged to provide as many details as possible
- Triangulation: The interactions between the factors of IPD revealed by the expert interviewees were triangulated with the wider NZ construction industry

Transferability is another essential component of quality control in a research study.

3.2.7.4 Transferability

Transferability refers to the extent to which research findings can be applied to alternative contexts or situations (Riazi et al., 2023). In qualitative research, transferability refers to the extent to which the results can be applied to other contexts or settings with different respondents (Korstjens & Moser, 2017). Qualitative researchers aim to provide comprehensive and nuanced depictions of the study's environment, participants, and procedures to enhance the potential for transferability. By providing thorough and comprehensive explanations, researchers enable readers to assess the applicability of the findings to similar situations, thereby enhancing the study's transferability (Ahmed, 2024).

Transferability in the current research was ensured by:

- Thick descriptions: The research context, participant details, and chosen methods have been discussed thoroughly to allow readers to evaluate the similarities between their context and the current research study
- Sampling methods and participant selection criteria: The sampling methods used and the criteria for participant selection have been explained to assist readers in determining whether the findings might be applicable or transferable to similar populations or settings

The next section provides an overview of the chosen approaches for this research study.

3.2.8 Summary of chosen approaches

The research onion and a summary of how the research questions were answered are presented below.

3.2.8.1 Research onion

A research onion is used to provide a structured and layered framework for designing a research methodology, aiding researchers through decisions from wide philosophical choices to data collection techniques. The onion is designed in a manner that allows the outer layers to describe the philosophical choices pertinent to the study's methodology, with the inner layers detailing the selection of specific methods for the study. The research onion ensures coherence in the research design, providing a systematic approach that aids critical decisions to be made in the correct order. Figure 7 reveals the research onion for this study.

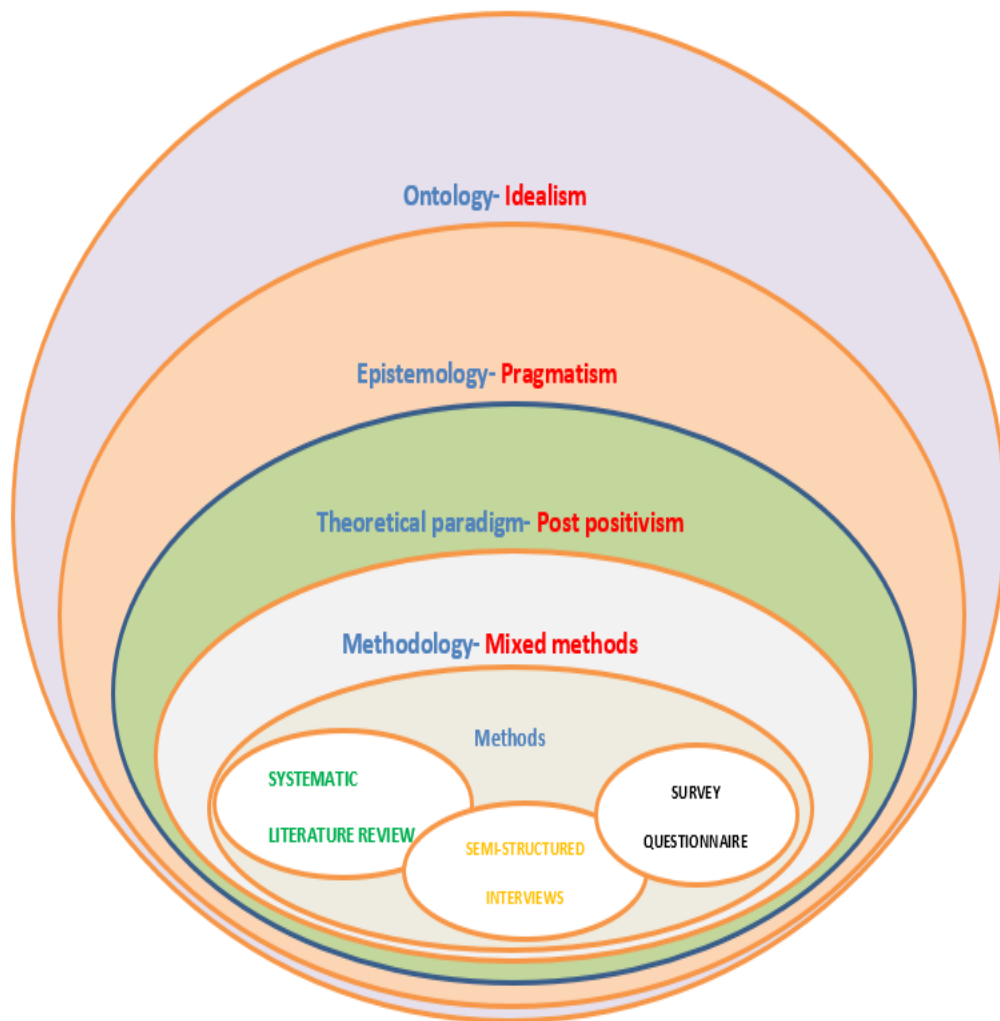


Figure 7: Research onion

3.2.8.2 Summary of how Research Questions were answered

Table 8 details the way data was collected, analysed, and how the results were presented for each Research Question.

Table 8: Summary of how Research Questions were answered

Research Question	Data Collection	Data Analysis	Presentation of Results
What are the influencing factors of IPD that hinder its implementation in the global construction industry?	Systematic Literature Review	Frequency Analysis + Degree Centrality + Eigenvector Centrality	VOSviewer + Vensim
What are the influencing factors of IPD that hinder its implementation in the New Zealand construction industry?	Semi-Structured Interviews	Thematic and narrative analyses	NVivo
What are the interactions between factors that influence the application of IPD in the New Zealand construction industry?	Semi-Structured Interviews + Survey Questionnaire	Manual coding + Degree Centrality + Eigenvector Centrality	Vensim
What are the critical factors and the critical chains of factors that hinder the implementation of IPD in New Zealand?	Semi-Structured Interviews + Survey Questionnaire	Degree Centrality + Eigenvector Centrality + Causal Chain Analysis + Relative Importance Index + T-test (P-values) using SPSS software	Vensim + Tabulated results for Critical Factors and Chains
What framework mimics the interactions of IPD factors to reflect the industry thinking in New Zealand?	Semi-Structured Interviews + Survey Questionnaire	No specific analysis since the data was captured from the validated interactions between the factors of IPD through the survey	Framework

A Systematic Literature Review (SLR) was conducted to identify the factors of IPD in the global context, followed by Semi-Structured Interviews (SSI) with construction professionals in the New Zealand (NZ) construction industry. The interview transcripts were used to identify the factors of IPD, along with their interactions in the NZ context. For validation, the results were triangulated using a system-wide survey questionnaire. SD was used to model the interactions into a CLD, and NA

techniques, DC and EC, were used to identify the critical factors. Additionally, CCA was employed to identify the critical chains. The chapter summary is outlined next.

3.3 Chapter summary

This chapter detailed the methodology and the design of the study for this research. The ontological position for this study was idealism, the epistemological position was pragmatism, the theoretical framework was post-positivism, and the methodological position was mixed methods. Using the SLR method, the global factors to the implementation of IPD were identified and used to frame the open-ended questions for data collection in the New Zealand construction industry. The data collection method consisted of both qualitative and quantitative approaches. The qualitative approach consisted of eighteen semi-structured interviews with professionals in the New Zealand construction industry, who were recruited using purposive and snowballing sampling methods. The factors of IPD and their interactions were identified using manual coding. For validation, the results from the qualitative semi-structured interviews were triangulated with a system-wide survey questionnaire to investigate if the broader workforce of the New Zealand construction industry agreed with the views of the experts. The sample size formula yielded a requirement of a minimum of thirty-six responses from the survey questionnaire; however, 137 responses were received. VOSviewer software was used to identify the frequency of the factors of IPD identified from the literature, and NVivo software was used to identify the frequency of the factors of IPD identified from the semi-structured interviews. Using the SD approach, the interactions of factors of IPD were modelled into a CLD using Vensim software, and the network was analysed using NA techniques: DC and EC. Additionally, CCA was employed to identify the critical chains of the factors of IPD. The results from the survey questionnaire were analysed using the RII method and the t-test. The t-test was performed using SPSS software, which enabled the identification of statistically significant interactions through the resulting p-values. The framework for this study was based on the conceptual framework, as it was the most suitable choice for investigating the interactions between factors. In particular, the descriptive and explanatory frameworks, which are subtypes of the conceptual framework, were used for this research. Finally, the quality control criteria for this research consisted of reliability, validation, credibility, and transferability.

Chapter 4- Results

4.1 Chapter introduction

The results were obtained through various data collection methods, including systematic literature review (SLR), semi-structured interviews (SSI), and a system-wide survey questionnaire. The primary objective was to identify the factors of IPD along with their interactions and then employ analysis methods to rank the critical factors within this network. While the SLR results provided a global perspective, the insights from the SSI and the system-wide survey questionnaire were specifically focused on New Zealand. The SLR findings informed the development of open-ended questions used in the SSI. Subsequently, these results were triangulated with the data gathered from the system-wide survey questionnaire. This chapter corresponds with the Research Questions and is organised into several sections: section 4.2 presents the results for Research Question 1, section 4.3 covers the results for Research Question 2, section 4.4 discusses the results for Research Question 3, section 4.5 outlines the results for Research Question 4, and section 4.6 details the results for Research Question 5. Finally, section 4.7 offers a summary of the way the results were obtained and presented in a systematic manner.

4.2 Results for Research Question 1

Aside from using the SLR results to frame the open-ended questions, another aim of the SLR process was to identify the critical factors of IPD and their interactions in the literature. The purpose was to determine the prevalence of the global factors of IPD and their interactions in the New Zealand context. *1.9.1 Research Question 1* was answered through the procedure detailed below:

The SLR process resulted in 66 articles from 2009 to 2023. Figure 8 illustrates the year-wise distribution of the 66 articles, and Figure 9 categorises the articles by country/region. These articles were from 26 countries spread over five continents, which shows that IPD is researched globally.

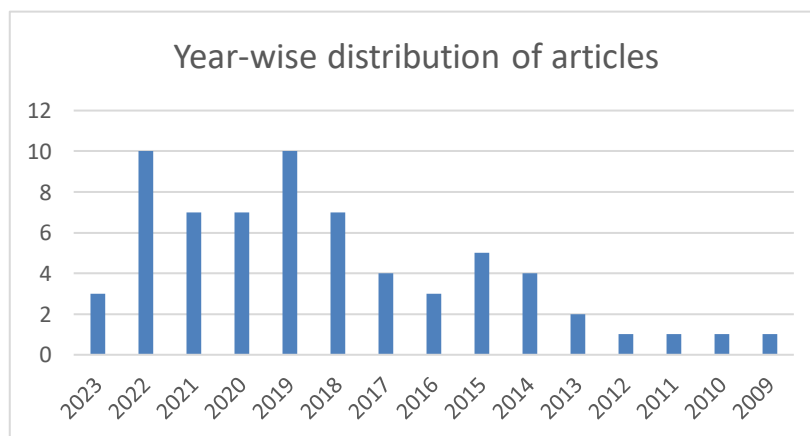


Figure 8: Year-wise distribution of articles

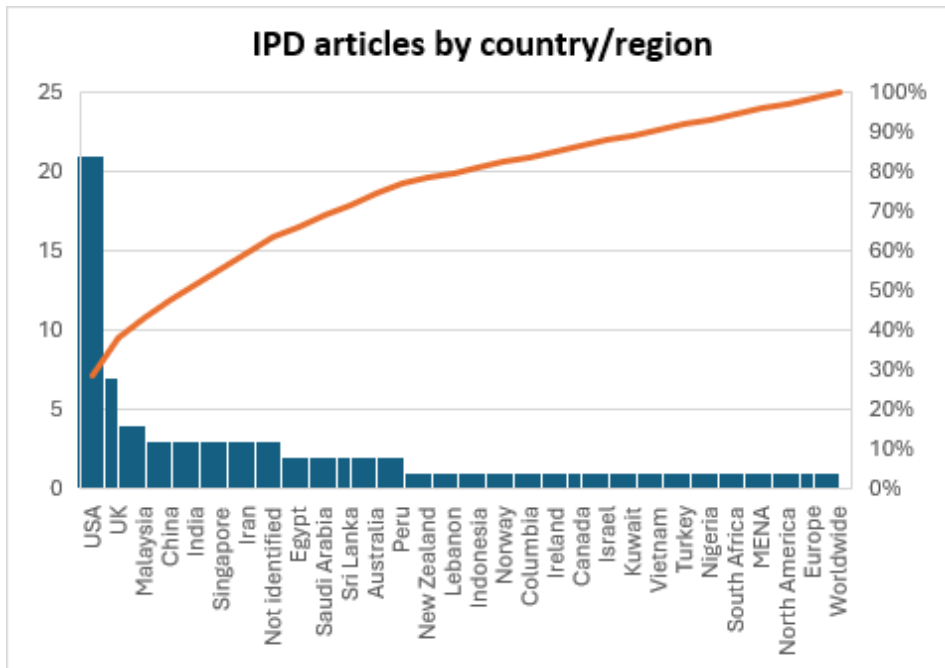


Figure 9: IPD articles by country/region

It is evident from Figure 9 that most IPD factor-related articles were based in the USA (21). The UK is in second place with seven articles, and Malaysia has four. China, India, Iran, and Singapore each have three articles, while the country/region could not be identified from three articles. Australia, Egypt, Peru, Saudi Arabia, and Sri Lanka contributed two. Canada, Colombia, Indonesia, Ireland, Israel, Kuwait, Lebanon, New Zealand, Norway, Nigeria, South Africa, Turkey, and Vietnam each contributed one article. The three articles were not based on any specific country; instead, they mentioned regions —Europe, MENA, and North America. Finally, one research article was based on a worldwide study. It can be concluded that the adoption of IPD is gaining popularity worldwide; however, a higher number of articles originate from the USA or the UK.

Two hundred twenty-two factors were found from the 66 articles selected. Ninety-five of the 222 factors were related to others; hence, those factors were combined, and 127 were identified through this review. Figure 10 displays all 127 factors, while Table 9 provides a detailed breakdown of the factors, including themes, sample author references, and the total number of authors who identified each factor.

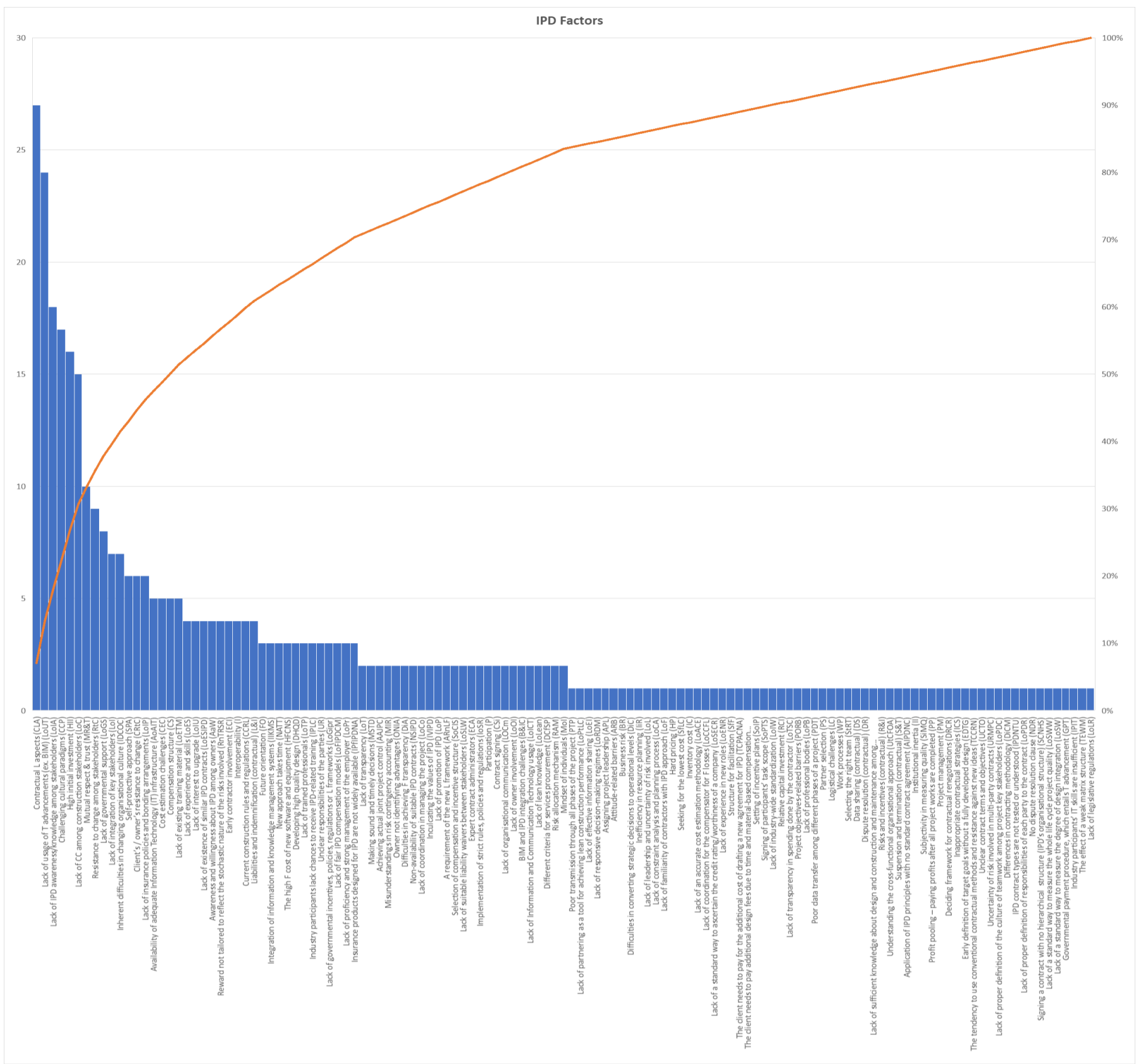


Figure 10: IPD factors obtained from SLR

Table 9: IPD factors

Factor	Factor theme	Sample Author References	Author Frequency
Lack of CC among construction stakeholders (LoC)	CC	Durdyev et al. (2019), Ma et al. (2022)	15
Mutual respect & trust (MR&T)	CC	Roy et al. (2018)	10
Lack of integration of key stakeholders (LoI)	CC	Kahvandi et al. (2019), Osman et al. (2017)	7
Self-protective approach (SPA)	CC	Sherif et al. (2022), Sherif and Abotaleb (2023)	6
Lack of transparency (LoT)	CC	Charlesraj and Gupta (2019), Hettiaarachchige et al. (2022)	2
Achieving actual joint project control (AAJPC)	CC	Rodrigues and Lindhard (2021)	2
Poor transmission through all phases of the project (PTP)	CC	Hettiaarachchige et al. (2022)	1
Lack of IPD awareness/knowledge among stakeholders (LoIA)	CO	Forero et al. (2015), Alqahtani et al. (2022)	18
Challenging cultural paradigms (CCP)	CO	Naismith et al. (2016), Dalui et al. (2021)	17
Resistance to change among stakeholders (RtC)	CO	Li and Ma (2017), Karasu et al. (2022)	9
Inherent difficulties in changing organisational culture (IDCOC)	CO	Zhang et al. (2018), Zuber et al. (2019)	7
Client's / owner's resistance to change (CRtC)	CO	Naismith et al. (2016), Govender et al. (2018)	6
Lack of existing training material (LoETM)	CO	Hettiaarachchige et al. (2022)	5
Awareness and willingness about IPD among owners (AaW)	CO	Khanna et al. (2021), Jadidoleslami et al. (2022)	4
Early contractor involvement (ECI)	CO	Sherif et al. (2022), Ma et al. (2022)	4
Lack of experience and skills (LoES)	CO	Khanna et al. (2021)	4
Lack of interest to upgrade (LoIU)	CO	Khanna et al. (2021)	4

Factor	Factor theme	Sample Author References	Author Frequency
Interoperability (I)	CO	Azhar et al. (2015), Ghassemi and Becerik-Gerber (2011)	4
The new approach takes time (NATT)	CO	Charlesraj and Gupta (2019)	3
Future orientation (FO)	CO	Sherif and Abotaleb (2023), Sherif et al. (2022)	3
Integration of information and knowledge management systems (IIKMS)	CO	Charlesraj and Gupta (2019), Roy et al. (2018)	3
Lack of proficiency and strong management of the employer (LoPr)	CO	Kahvandi et al. (2018)	3
Industry participants lack chances to receive IPD-related training (IPLC)	CO	Ma et al. (2022)	3
Lack of trained professionals (LoTP)	CO	Naismith et al. (2016)	3
Developing high-quality design (DHQD)	CO	Ebrahimi and Dowlatabadi (2019)	3
Unclear responsibilities of the parties (UR)	CO	Hettiaarachchige et al. (2022)	3
Owner not identifying advantages (ONIA)	CO	Govender et al. (2018), Karasu et al. (2022)	2
Participation (P)	CO	Chalesraj and Gupta (2019), Sherif and Abotaleb (2023)	2
Making sound and timely decisions (MSTD)	CO	Ebrahimi and Dowlatabadi (2019)	2
Risk allocation mechanism (RAM)	CO	Azhar et al. (2015)	2
Different criteria for services procurement (DCfSP)	CO	Azhar et al. (2015)	2
Mindset of individuals (MoI)	CO	Khanna et al. (2021)	2
Lack of lean knowledge (LoLean)	CO	Tillmann et al. (2012)	2
Lack of owner involvement (LoOI)	CO	Gomez et al. (2018)	2
Lack of organisational communication (LOCm)	CO	Hettiaarachchige et al. (2022)	2
Lack of promotion of IPD (LoP)	CO	Forero et al. (2015), McDonnell (2015)	2

Factor	Factor theme	Sample Author References	Author Frequency
Inculcating the values of IPD (IVIPD)	CO	Korb et al. (2016)	2
Lack of coordination in managing the project (LoCo)	CO	Kahvandi et al. (2018), Psomas and Alzraiee (2020)	2
Lack of partnering as a tool for achieving lean construction performance (LoPtLC)	CO	Sari et al. (2023)	1
Lack of effective information sharing (LoEI)	CO	Elghaish et al. (2020)	1
Lack of responsive decision-making regimes (LoRDM)	CO	Elghaish et al. (2020)	1
Assigning project leadership (APL)	CO	Naismith et al. (2016)	1
Attitude-related barriers (ARB)	CO	Evans et al. (2021)	1
Business risk (BR)	CO	Naismith et al. (2016)	1
Difficulties in converting strategic decisions to operational levels (DiC)	CO	Zhang et al. (2020)	1
Inefficiency in resource planning (IiR)	CO	Hettiaarachchige et al. (2022)	1
Lack of leadership and uncertainty of risk involved (LoL)	CO	Naismith et al. (2016)	1
Lack of constraint analysis and planning process (LoCA)	CO	Gomez et al. (2018)	1
Lack of familiarity of contractors with the IPD approach (LoF)	CO	Kahvandi et al. (2018)	1
Lack of a standard way to measure the degree of design integration (LoSW)	CO	Ma et al. (2022)	1
Lack of a standard way to measure the whole life cycle project quality (LoSWW)	CO	Ma et al. (2022)	1
Lack of proper definition of responsibilities of each party to the contract (LoPDR)	CO	Kahvandi et al. (2018)	1
Lack of proper definition of the culture of teamwork among project key stakeholders (LoPDC)	CO	Kahvandi et al. (2018)	1
Lack of sufficient knowledge about design, construction, and maintenance among representatives of the employer (LoSK)	CO	Kahvandi et al. (2018)	1

Factor	Factor theme	Sample Author References	Author Frequency
Logistical challenges (LC)	CO	Dossick et al. (2013)	1
Partner selection (PS)	CO	Su et al. (2021)	1
Poor data transfer among different phases of a project (PDT)	CO	Kahvandi et al. (2018)	1
Project objectives-related barriers (PORB)	CO	Evans et al. (2021)	1
Signing of participants' task scope (SoPTS)	CO	Su et al. (2021)	1
Setting of incentive plans (SoIP)	CO	Su et al. (2021)	1
Structure for facilitation (SfF)	CO	Bilbo et al. (2014)	1
The effect of a weak matrix structure (TEWM)	CO	Kahvandi et al. (2018)	1
An early definition of target goals without a fully developed design (EDTG)	CO	Roy et al. (2018)	1
Project management (PM)	CO	Azhar et al. (2015)	1
Subjectivity in measuring quality (SiMQ)	CO	Roy et al. (2018)	1
Work processes (WP)	CO	Azhar et al. (2013)	1
Lack of industry-wide standardisation (LoIW)	CO	Kent and Gerber (2010)	1
Lack of experience in new roles (LoENR)	CO	Abdirad and Dossick (2019)	1
Selecting the right team (StRT)	CO	Ebrahimi and Dowlatabadi (2019)	1
Understanding the cross-functional organisational approach (UtCFOA)	CO	Laurent and Leicht (2019)	1
Institutional inertia (II)	CO	Rowlinson (2017)	1
High initial investment (HII)	F	Evans et al. (2021), Hettiaarachchige et al. (2022)	16
Compensation structure (CS)	F	Hettiaarachchige et al. (2022)	5
Cost estimation challenges (CEC)	F	Elghaish and Abrishami (2020), Seed (2014)	5
Reward not tailored to reflect the stochastic nature of the risks involved (RnTRSR)	F	Ma et al. (2023)	4
Insurance products designed for IPD are not widely available (IPfIPDNA)	F	Ma et al. (2022), Kent and Gerber (2010)	3
The high F cost of new software and equipment (HFCNS)	F	Hettiaarachchige et al. (2022)	3

Factor	Factor theme	Sample Author References	Author Frequency
Lack of fair IPD compensation models (LoFIPDCM)	F	Elghaish et al. (2020)	3
Misunderstandings in risk contingency accounting (MIR)	F	Elghaish et al. (2020)	2
Difficulties in achieving F transparency (DiA)	F	Rodrigues and Lindhard (2021)	2
Hard pricing (HP)	F	Elghaish et al. (2020)	1
Seeking for the lowest cost (SfLC)	F	Zhang et al. (2018)	1
Inventory cost (IC)	F	Hettiaarachchige et al. (2022)	1
Lack of an accurate cost estimation methodology (LoACE)	F	Elghaish et al. (2020)	1
Lack of coordination for the compensator for F losses (LoCCFL)	F	Kahvandi et al. (2019)	1
Lack of a standard way to ascertain the credit rating/worthiness of a company (LoSECR)	F	Ma et al. (2022)	1
The client needs to pay for the additional cost of drafting a new agreement for IPD (TCPACNA)	F	Ma et al. (2022)	1
The client needs to pay additional design fees due to time and material-based compensation (TCPAFTM)	F	Ma et al. (2022)	1
Relative capital investment (RCI)	F	Sherif and Abotaleb (2023)	1
Profit pooling – paying profits after all project works are completed (PP)	F	Elghaish et al. (2020)	1
Lack of transparency in spending done by the contractor (LoTSC)	F	Charlesraj and Gupta (2019)	1
Lack of governmental support (LoGS)	GP	McDonnell (2015), Evans et al. (2021)	8
Lack of professional bodies (LoPB)	GP	Li and Ma (2017)	1
Contractual L aspects (CLA)	L	Ibidapo et al. (2017), Alinezhad et al. (2020)	27
Lack of insurance policies and bonding arrangements (LoIP)	L	Ahmed et al. (2021), Bilbo et al. (2014)	6
Current construction rules and regulations (CCRL)	L	Li and Ma (2017)	4

Factor	Factor theme	Sample Author References	Author Frequency
Liabilities and indemnification (contractual) (L&I)	L	Ahmed et al. (2021)	4
Lack of existence of similar IPD contracts (LoESIPD)	L	Hettiaarachchige et al. (2022), Bilbo et al. (2014)	4
Lack of governmental incentives, policies, regulations or L frameworks (LoGipr)	L	Evans and Farrell (2022)	3
Lack of suitable liability waivers between stakeholders (LoSLW)	L	Elghaish et al. (2020)	2
Expert contract administrators (ECA)	L	Sherif et al. (2022), Sherif and Abotaleb (2023)	2
Non-availability of suitable IPD contracts (NSIPD)	L	Khanna et al. (2021)	2
Implementation of strict rules, policies and regulations (IoSR)	L	Sherif and Abotaleb (2023), Sherif et al. (2022)	2
Contract signing (CSi)	L	Su et al. (2021)	2
A requirement of the new L framework (ARnLF)	L	Hettiaarachchige et al. (2022), Roy et al. (2018)	2
Selection of compensation and incentive structure (SoCIS)	L	Sherif et al. (2022), Ghassemi and Becerik-Gerber (2011)	2
Lack of legislative regulations (LoLR)	L	Zhang et al. (2018), Ma et al. (2022)	1
Data sharing (contractual) (DS)	L	Ahmed et al. (2021)	1
Dispute resolution (contractual) (DR)	L	Ahmed et al. (2021)	1
Risks and incentives (contractual) (R&I)	L	Ahmed et al. (2021)	1
Suspension and termination (contractual) (S&T)	L	Ahmed et al. (2021)	1
Application of IPD principles with no standard contract agreement (AIPDNC)	L	Gomez et al. (2018)	1
Deciding framework for contractual renegotiations (DRCR)	L	Naismith et al. (2016)	1
Inappropriate contractual strategies (ICS)	L	Hettiaarachchige et al. (2022)	1
The tendency to use conventional contractual methods and resistance against new ideas (TCCRN)	L	Kahvandi et al. (2018)	1
Unclear contract terms and objectives (UCTO)	L	Zhang et al. (2018)	1

Factor	Factor theme	Sample Author References	Author Frequency
Uncertainty of risk involved in multi-party contracts (URMPC)	L	Naismith et al. (2016)	1
Differences in contracting methodology (DiCM)	L	Mulholland and Clevenger (2018)	1
IPD contract types are not tested or understood (IPDNTU)	L	Charlesraj and Gupta (2019)	1
No dispute resolution clause (NDR)	L	Charlesraj and Gupta (2019)	1
Signing a contract with no hierarchical structure (IPD's organisational structure) (SCNHS)	L	Buk'hail and Al-Sabah (2022)	1
Lack of usage of T advancements (ex. BIM) (LoUT)	T	Ebekozien et al. (2022), Rosayuru et al. (2022)	24
Availability of adequate Information Technology (IT) infrastructure (AoAIT)	T	Naismith et al. (2016), Osman et al. (2017)	5
Lack of Information and Communication Technology usage (LoICT)	T	Azhar et al. (2015)	2
BIM and IPD integration challenges (B&IC)	T	Elghaish and Abrishami (2020)	2
Governmental payment procedure, which entails T advancement (GPT)	T	Alqahtani et al. (2022)	1
Industry participants' IT skills are insufficient (IPIT)	T	Ma et al. (2022)	1

CC contains seven factors, the most frequently cited being the lack of CC among construction stakeholders (15 author references) and the importance of mutual respect and trust between stakeholders (10 author references). CO contains sixty-four factors, with the most frequently cited being a lack of IPD awareness/knowledge among stakeholders (18 author references), challenging cultural paradigms (17 author references), and resistance to change (9 author references). F contains twenty factors, with the most repetitive being high initial investment (16 author references), cost estimation challenges (5 author references), compensation structure (5 author references), and reward not tailored to reflect the stochastic nature of the risks involved (4 author references). GP contains two factors: lack of governmental support (8 author references) and lack of professional bodies (1 author reference). L contains twenty-eight factors, the most repetitive being contractual L aspects (27 author references) and the lack of insurance policies and bonding arrangements (6 author references). T contains six factors, with the most repetitive being the lack of usage of T advancements (e.g., BIM) (24 author references) and the availability of adequate IT infrastructure (5 author references). Using the

text mining functionality of VOSviewer, all factors were uploaded to the software in a text document to visualise the co-occurrence of factors. The factors with the highest frequency are shown below in Figure 11.

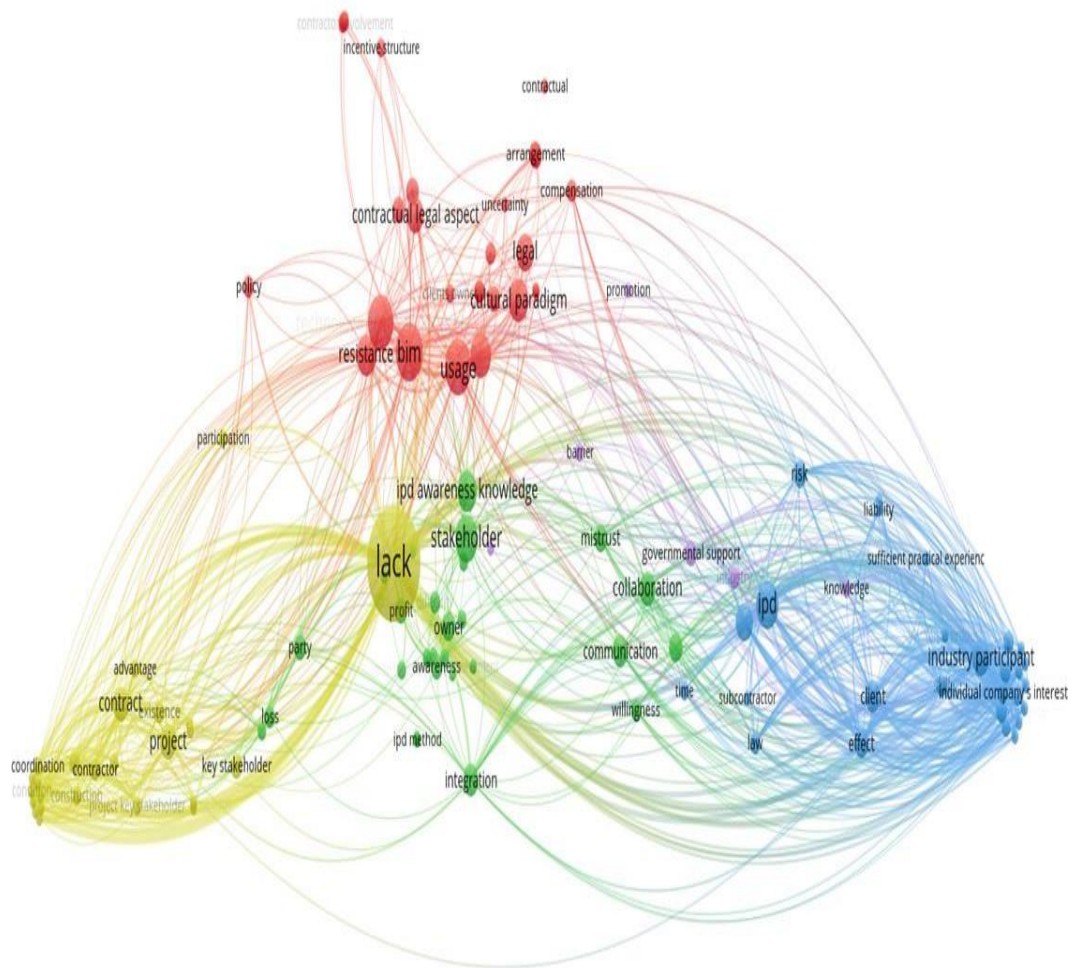


Figure 11: Key factors to IPD implementation shown in VOSViewer

The VOSviewer identifies and connects the most common factors to IPD from the 222 factors found in the SLR. The results from VOSviewer categorise the factors into five colour categories, indicating the connections between them. Additionally, the link between factors reveals the strength of the relationship; the thicker the connection, the stronger the relationship between those factors. The factors in red are contractor involvement, incentive structure, contractual aspects, arrangement, compensation, uncertainty, policy, cultural paradigm, resistance, BIM, and usage. The factors in yellow are lack, project, key stakeholder, advantage, contract, existence, coordination, and contractor. The factors in green represent IPD awareness/knowledge, stakeholder, mistrust, collaboration, communication, ownership, IPD method, integration, and willingness. The factors in blue are risk, liability, time, law, client effect, sufficient practical experience, industry participation, and the individual company's interest. The factors in purple are governmental support, industry, knowledge, and promotion. It is also pertinent to note that the larger the font of a factor, the greater its significance. The factors in the red colour category can be categorised into cultural paradigms, resistance, either due to contractual aspects, financial matters, such as compensation or incentive structure, or BIM usage requirements. The factors in yellow can be categorised as a lack of essential requirements, such as coordination between key stakeholders and competent contractors. Lack is the largest factor of all the displayed factors. The factors in blue can be categorised into a lack of sufficient practical experience regarding IPD, individual interests of project stakeholders, and risk and liability being major factors in capturing a client's interest in implementing IPD. The green factors can be categorised as a lack of IPD awareness and collaboration issues, specifically, a lack of communication and mistrust between project parties. Finally, the factors in purple can be categorised into a lack of governmental support and a lack of promotion of IPD.

In all literature related to IPD factors, the factors have been divided into themes such as L, F, CO, CC, T, and GP:

- In the CC theme, the most significant barriers are the lack of CC among construction stakeholders and mutual respect and trust between them—for IPD to be implemented, key construction stakeholders must improve on CC and trust.
- In the CO theme, the key factors are challenging cultural paradigms, lack of IPD awareness/knowledge among stakeholders, and resistance to change. These three key factors in CO are interconnected in the sense that, because of a lack of IPD knowledge, key construction stakeholders are resistant to change from their traditional practices, which challenges cultural paradigms.
- In the F theme, the notable factors are high initial investment, compensation structure, and cost estimation challenges. This indicates that key project stakeholders must be prepared for the costs

required to implement IPD and develop mutual trust among themselves through fair compensation models and profit-sharing arrangements.

- The GP theme has two factors: lack of governmental support and lack of professional bodies. The limitation is obvious, as governments must step in to increase the implementation of IPD. Creating professional bodies that oversee the IPD process would be a good start.
- The L theme has contractual aspects and a lack of insurance policies and bonding arrangements as noteworthy factors. It is pertinent to note that different countries have different L requirements. As such, countries should accommodate IPD in contracts and encourage its implementation through insurance policies and bonding arrangements.
- Finally, the T theme lacks usage of T advancements (ex., BIM), and the availability of adequate IT infrastructure is a significant factor. For IPD to be successfully implemented, organisations must upgrade their IT infrastructure and use the latest technology.

This SLR aimed to detail the factors of IPD and display the connectivity between factors. The results of SLR are shown in Table 9, and the connectivity between factors is offered through the VOSviewer visualisation diagram in Figure 11.

The results from VOSviewer show the key factors and how they are linked through different colour codes. However, they do not show the polarity. Each paper was studied to determine the polarity between factors, and the polarity between factors was identified using deductive reasoning. Figure 12 shows the interactions between the key factors, including polarity.

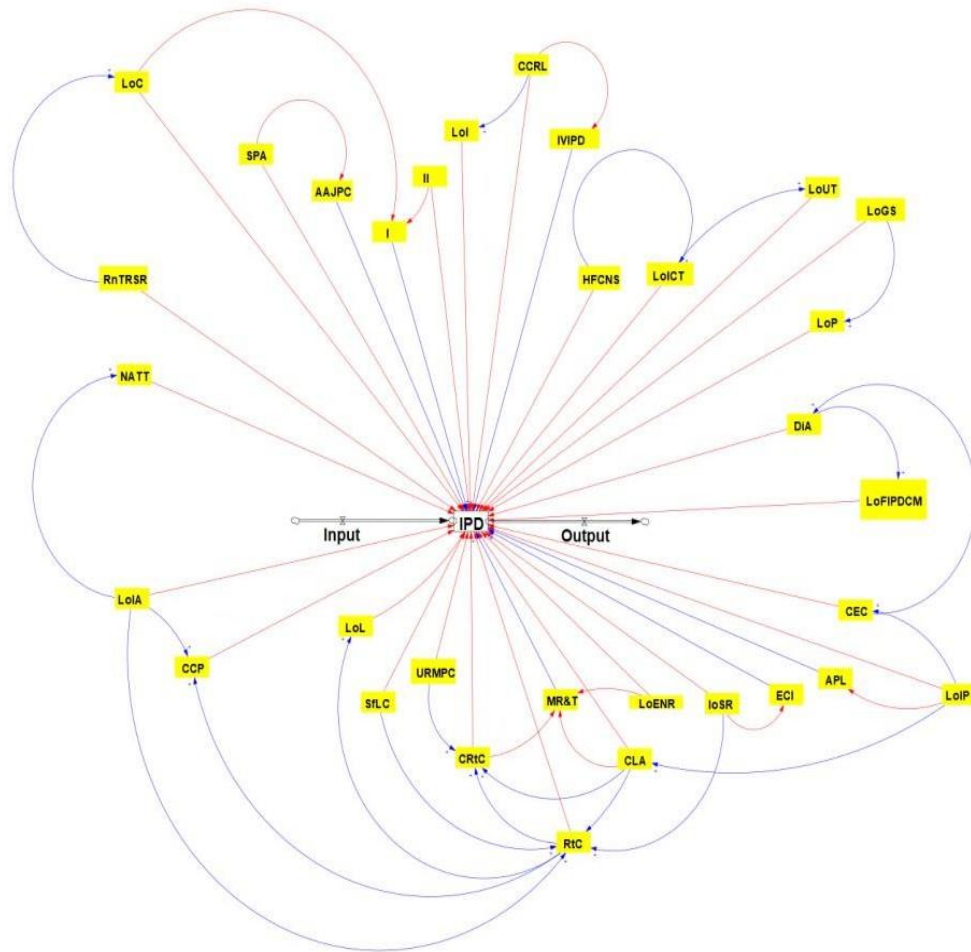


Figure 12: Interactions between key factors to IPD implementation shown in Vensim

The inclusion of polarity provides a clearer picture of the interactions between key factors and IPD, which was missing from the VOSviewer result. Blue arrows indicate a positive (+) relationship, i.e., *factor A causes factor B to increase*. On the other hand, red arrows indicate a negative (-) relationship, i.e., *factor A causes factor B to decrease*. It is worth noting some differences in the wording of factors between the VOSviewer result and the Vensim diagram. For example, ‘coordination’ in VOSviewer and interoperability or ‘I’ in the Vensim diagram. This is because different authors used alternate terminologies to identify the factors.

It is essential to use analysis methods to determine the importance of each factor in the network. Table 21 in *Appendix 1- Analyses of the factors of IPD identified from the literature* groups the factors in terms of nodes, degree centrality, and eigenvector centrality.

4.2.1 Critical factors

With reference to *Degree Centrality*, DC was one of the analysis methods to identify the critical factors in the literature. DC is a measure of local centrality calculated from a vertex's immediate neighbourhood links (Bamakan et al., 2019). It is the most straightforward centrality measure to compute, and the DC for a node is simply its degree (Golbeck, 2015). Typically, the numbers are converted to a 0-1 scale, and the node with the highest degree in the network will have a degree centrality of 1. The centrality of other nodes will be a fraction of their degree compared to that of the most popular node. RtC has the highest number of nodes and thus has a DC of 1. The critical factors with a higher DC compared to others are 1) RtC, (2) CLA, (3) CRtC, (4) LoIA, (5) LoIP, and (6) MR&T. The disadvantage of this analysis is that more than one node often has the same degree, and thus, it is impossible to rank the nodes uniquely.

From the Vensim figure, each factor can be distinguished based on the total number of nodes rendered or received. RtC is the most prominent factor among all factors as it has the highest number of nodes. LoIA, SfLC, IoSR, and CLA impact it. RtC impacts other factors, namely CCP, CRtC, and LoL. CLA is another notable factor with four nodes. However, the higher outgoing number suggests that it impacts other factors, such as CRtC, RtC and MR&T. It can be noted that CLA is impacted by LoIP, which can be broken down to the reasoning that a lack of insurance policies and bonding arrangements causes complications with contractual legal aspects for an IPD contract. CRtC is another prominent factor with four nodes. However, the higher incoming node number suggests that other factors impact it. CLA, RtC, and URMPC impact CRtC. However, it can be noted from the Vensim figure that CRtC impacts MR&T- the client's resistance to change reduces mutual respect and trust among the project stakeholders. MR&T, LoIA, and LoIP are notable factors with three nodes. A significant difference is that LoIA and LoIP have three outgoing nodes, whereas MR&T has three incoming nodes. This can be clearly explained as the lack of insurance policies, bonding arrangements, and IPD awareness among stakeholders impacts other factors. However, other factors impact MR&T, causing mutual respect and trust among stakeholders to decrease. LoIA impacts NATT, CCP, and RtC. LoIP impacts APL, CLA, and CEC. CLA, CRtC, and LoENR impact MR&T. CCP, CEC, DiA, I, IoSR, LoC, and LoICT all consist of two (2) nodes. CEC, DiA, LoC, and LoICT are the only factors in equilibrium as influence rendered equals influence received. CCP and I each comprised two incoming nodes, suggesting that other factors also impact them, while IoSR consists of two outgoing nodes, signalling its influence on other factors. APL, AAJPC, CCRL, ECI, HFCNS, II, IVIPD, LoL, LoI, LoGS, LoFIPDCM, LoENR, LoP, LoUT, NATT, RnTRSR, SfLC, SPA, URMPC all consist of one (1) node. APL, AAJPC, ECI, IVIPD, LoL, LoI, LoFIPDCM, LoP, LoUT, and NATT all have one incoming node- signalling that other factors impact them. On the other hand, CCRL, HFCNS, II, LoENR, LoGS, RnTRSR, SfLC, SPA and URMPC have one outgoing node, indicating they impact other factors.

The critical factors to IPD based on interactions (3 or more nodes) are (1) RtC, (2) CLA, (3) CRtC, (4) LoIA, (5) LoIP, and (6) MR&T. Each critical factor can be analysed to determine how they

interact with other factors. From the Vensim figure, we can see that the lack of insurance policies increases the impact of contractual legal aspects, increasing stakeholder resistance. Similarly, the implementation of strict rules and policies increases resistance from stakeholders. Also, the lack of IPD awareness increases resistance among stakeholders. Moreover, seeking the lowest cost is another reason stakeholders resist the use of IPD. Resistance among stakeholders creates challenging cultural paradigms that hinder the implementation of IPD. Additionally, resistance among stakeholders makes clients hesitant to use IPD and makes it challenging to acquire leadership for an IPD project. Moreover, the client's resistance to change hinders IPD implementation and reduces mutual respect and trust among stakeholders.

CLA associated with IPD contracts can cause resistance from both the client and project stakeholders, thereby lowering their mutual trust. The contractual legal aspects of IPD, resistance from stakeholders, and the uncertainty of risk involved in multi-party contractual arrangements all contribute towards increasing the client's resistance to change. The lack of IPD awareness increases challenging cultural paradigms, resistance, and time for stakeholders to adjust to the new approach. The lack of insurance policies and bonding arrangements complicates contractual legal aspects and challenges the estimation of IPD costs. It also causes difficulties in assigning project leadership, as there is much risk involved in the absence of appropriate insurance policies. Contractual legal aspects, the client's resistance to change, and lack of experience in new roles cause stakeholders to lose mutual respect and trust. Eigenvector centrality extends beyond degree centrality, enabling further analysis to distinguish between nodes in a network.

With reference to *Eigenvector Centrality*, EC was another method used for the identification of the critical factors. The main principle of EC is that links from important nodes are worth more than links from unimportant nodes. To compute the values, all nodes start equal, but nodes with more edges gain importance as the calculation progresses based on the significance of the nodes to which they are connected. After many iterations, the values stabilise, resulting in the final values for eigenvector centrality. To compute the EC, all factors of IPD were arranged in a matrix. (Figure 13). The factors were listed according to their incoming nodes, and the matrix was multiplied by a column vector of unit 1 (Meghanathan, 2015). Then, the normalised value was calculated (the square root of the sum of squares of node values). The node value of each factor was divided by the normalised value, resulting in the eigenvalue of each factor. For example, in the first iteration, the eigenvalue for RtC is 0.53 (4/7.55). The iterations must be repeated until the normalised value stabilises (Meghanathan, 2015). However, in this case, the fifth iteration resulted in null values. Therefore, the calculations were stopped after the fourth iteration, and the factors were ranked according to their appearance in the iterations; that is, factors appearing in the fourth iteration were ranked higher than those appearing in the third iteration. This is because the repeated presence of a factor signifies its importance within the network (Meghanathan, 2015). Figure 13 details the EC computation.

	RC	CLA	CRC	LoA	LoP	MR&T	CCP	LoC	I	LoSR	LoICT	CEC	DIA	LoUT	LoI	LoGS	EI	LoPPDCM	SPA	LoP	IVPD	APL	SIC	URMPC	HFCNS	LoL	RnTISR	AAPC	NATT	CCRL	LoENR	II	Column vector of unit 1	Nodes	Square	Eigenvalue	Nodes	Square	Eigenvalue	Nodes	Square	Eigenvalue	Nodes	Square	Eigenvalue	Nodes	Square	Eigenvalue											
RC	1																																1	4	16	0.53	0.13	0.0169	0.11																				
CLA		1																															1	1	1	0.13																							
CRC			1																														1	3	9	0.04	0.066	0.4356	0.56	0.11	0.012	0.18																	
LoA				1																													1																										
LoP					1																													1																									
MR&T						1																												1	3	9	0.04	0.53	0.2809	0.45	0.56	0.31	0.93	0.18	0.032	0.71													
CCP							1																											1	2	4	0.26	0.53	0.2809	0.45	0.11	0.012	0.18																
LoC								1																										1	1	1	0.13																						
I									1																									1	2	4	0.26	0.13	0.0169	0.11																			
LoSR										1																								1																									
LoICT											1																								1	1	1	0.13																					
CEC												1																							1	1	1	0.13	0.13	0.0169	0.11																		
DIA													1																						1	1	1	0.13	0.13	0.0169	0.11	0.11	0.012	0.18															
LoUT														1																					1	1	1	0.13	0.13	0.0169	0.11																		
LoI															1																				1	1	1	0.13																					
LoGS																1																			1	1	1	0.13																					
EI																	1																		1	1	1	0.13																					
LoPPDCM																		1																	1	1	1	0.13	0.13	0.0169	0.11	0.11	0.012	0.18	0.18	0.032	0.71												
SPA																			1																1	1	1	0.13																					
LoP																				1															1	1	1	0.13																					
IVPD																					1														1	1	1	0.13																					
APL																						1													1	1	1	0.13																					
SIC																							1												1																								
URMPC																							1												1																								
HFCNS																							1												1																								
LoL																								1											1	1	1	0.13	0.53	0.2809	0.45	0.11	0.012	0.18															
RnTISR																								1											1																								
AAPC																									1											1	1	1	0.13																				
NATT																										1										1	1	1	0.13																				
CCRL																										1										1																							
LoENR																										1										1																							
II																										1										1																							

Figure 13: Eigenvector centrality computation

The results from the calculations revealed that the most influencing factors based on interrelations in the network, in descending order, are (1) MR&T and LoFIPDCM; (2) CRtC, CCP, DiA and LoL; (3) I, CEC, RtC, and LoUT. The results can be interpreted by analysing the connections of the identified factors.

- MR&T and LoFIPDCM (eigenvalue 0.71 in the four iterations)
 - Of the three incoming connections of MR&T, CRtC and CLA are notable as they are important in the factor network. CRtC and CLA are jointly ranked second in the degree centrality analysis, while CRtC is also jointly ranked second in the eigenvector centrality analysis. The fact that MR&T is impacted by both makes it clear why it is the joint most significant factor in the network.
 - Even though LoFIPDCM only has a single connection, because of an incoming node from DiA, it has resulted in being the joint most crucial factor in the eigenvector centrality analysis. This is because the connections and branches resulting from DiA are noteworthy. DiA is connected to CEC, which in turn is connected to LoIP. The fact that LoIP is connected to CLA, which has connections to MR&T, CRtC and RtC, proves that indirect connections to highly influential factors can be considered significant.

- CRtC, CCP, DiA and LoL (eigenvalue 0.18 in the third iteration)
 - CRtC is impacted by three factors, two of which are influential in the network- CLA and RtC. This, combined with the fact that it impacts MR&T, which is an influencing factor, explains why CRtC is a significant factor.
 - CCP is impacted by RtC, which is an influencing factor. This relationship deems CCP necessary.
 - DiA has important connections, as previously discussed.
 - LoL, likewise to CCP, is impacted by RtC.

- I, CEC, RtC and LoUT (eigenvalue 0.11 in the second iteration)
 - Two factors impact I. Of the two factors, LoC is slightly important within the network.
 - CEC has important connections such as DiA. However, computations revealed that its significance remained within two iterations.
 - RtC has the most connections. However, not every connection is significant; hence, RtC did not move past two iterations.
 - LoUT is impacted by LoICT, and while it is not highly ranked, it is still an essential factor within the network. This relationship deemed LoUT relevant, yet not highly critical, as it did not move past two iterations.

To identify the critical factors, the results from all analyses were compared. The next section presents the comparison.

4.2.2 Comparison of top factors

Table 10 compares the top factors of IPD from various analyses, including frequency, DC, and EC.

Table 10: Comparison between the top factors of IPD as per various analyses

Factor	Degree of centrality	Degree centrality rank	Factor	Eigenvector centrality	Eigenvector centrality rank	Factor	Frequency	Frequency rank
RtC	1	1	MR&T	0.71 (4 Iterations)	1	CLA	27	1
CLA	0.57	2	LoFIPDCM	0.71 (4 Iterations)	1	LoUT	24	2
CRtC	0.57	2	CRtC	0.18 (3 Iterations)	2	LoIA	18	3
MR&T	0.43	3 - 5	CCP	0.18 (3 Iterations)	2	CCP	17	4
LoIP	0.43		DiA	0.18 (3 Iterations)	2	HII	16	5
LoIA	0.43		LoL	0.18 (3 Iterations)	2	LoC	15	6
CCP	0.29	6-12	RtC	0.11 (2 Iterations)	3-6	MR&T	10	7
DiA	0.29		CEC	0.11 (2 Iterations)		RtC	9	8
I	0.29		LoUT	0.11 (2 Iterations)		LoGS	8	9
CEC	0.29		I	0.11 (2 Iterations)		LoI	7	10
LoICT	0.29					IDCOC	7	10
IoSR	0.29							
LoC	0.29							

The results from the SLR were used to frame the open-ended questions for the SSI. The questions were structured to ensure that they cover all identified factors of IPD from the comprehensive review of literature. The aim was to investigate the factors of IPD specific to New Zealand, the impact of the factors identified from the SLR, and the identification of new factors that were not found in the literature. The results from the SSI, which answer **1.9.2 Research Question 2**, are presented next.

4.3 Results for Research Question 2

Eighteen SSI were conducted with professionals in the New Zealand construction industry to answer Research Question 2. The interviewees were coded using the terminology ‘C’ for privacy reasons: for example, C1 represented interviewee 1. The interviewee profiles are shown in **3.2.5.4 Data Collection (Qualitative)**. Through manual coding, the researcher identified the factors affecting the implementation of IPD in the New Zealand construction industry. Figure 14 visualises the proportion of factors coded in each interview.

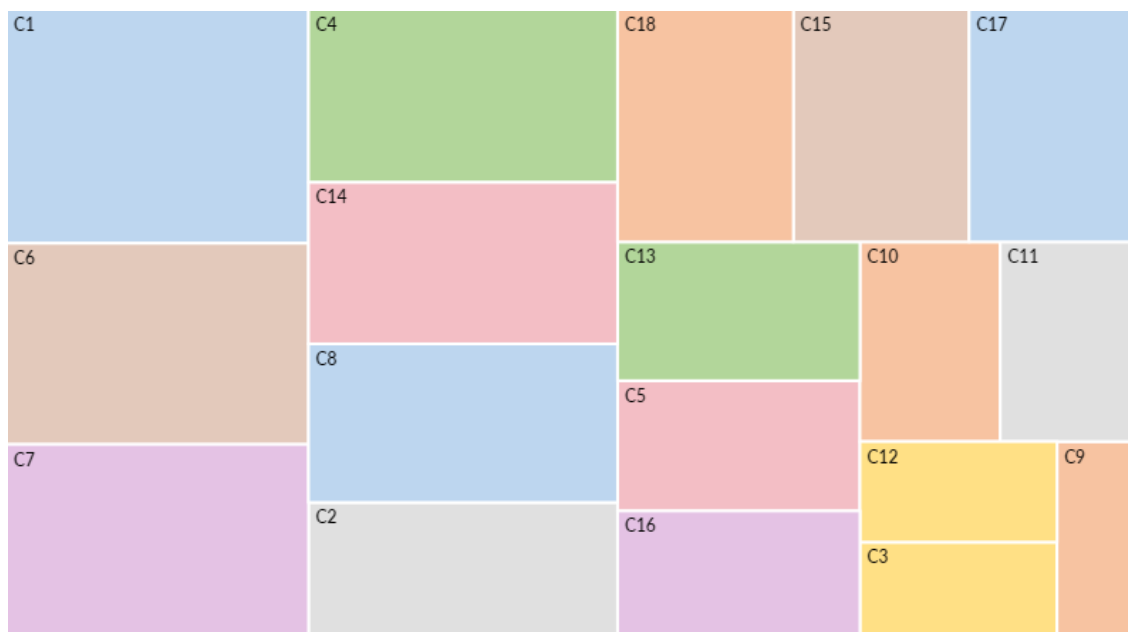


Figure 14: Proportion of factors coded by each interviewee

It is notable that interviewees C1, C6, and C7 identified the largest number of factors, while interviewees C3, C9, and C12 identified the fewest. Figure 15 shows the grouping of the most frequently repeated factors by theme among all interviewees—the larger the space occupied by a factor, the higher its frequency. LoIA has the highest frequency:50, followed by LoC:43, RtC:42, CLA:36, CRtC:33, HII:31, LoUT and LoGS:28, MR&T:27, SPA:25, LoI:20, PORB:19, LoIW:16, CCP:15, LoF:14, B&IC:13, IoSR:12, IVIPD:11, LoIP and LoPr:10. The remaining factors shown in Figure 15 have a frequency of less than 10.

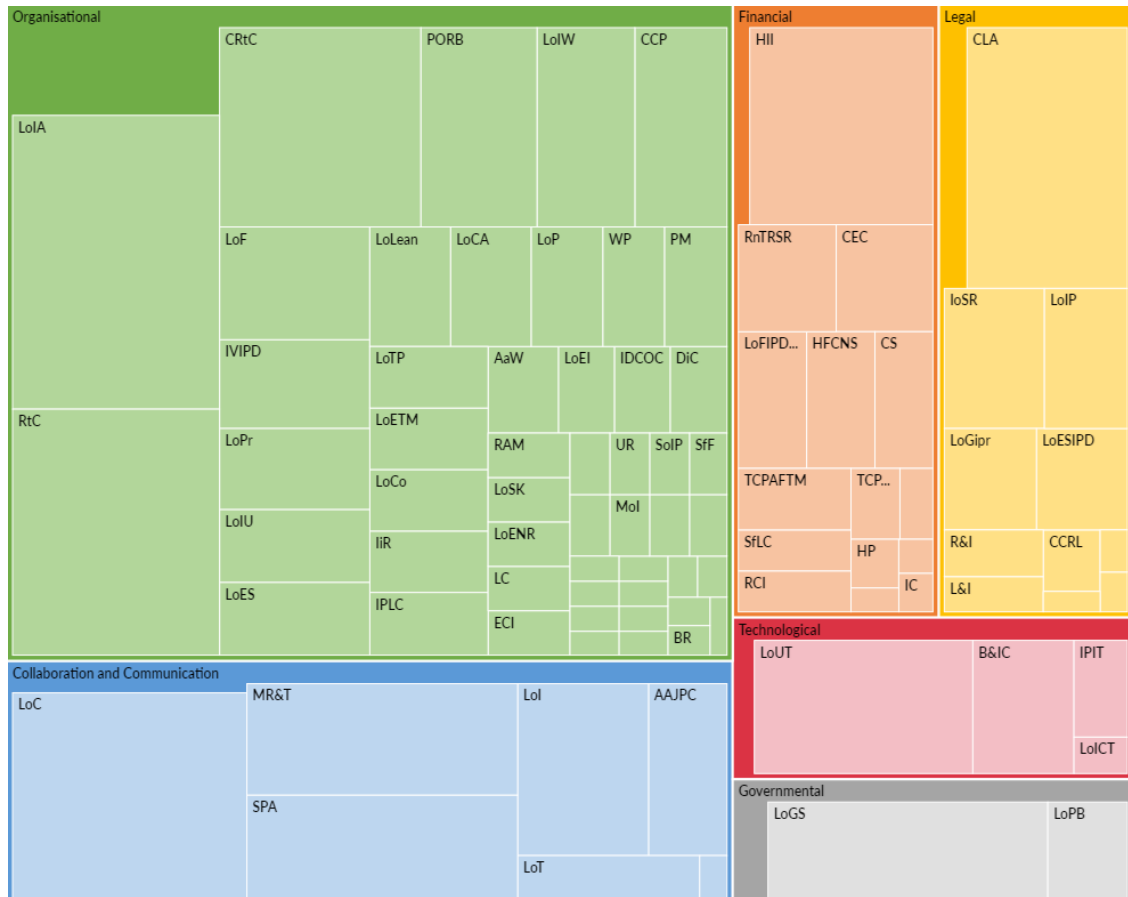


Figure 15: Factors as per their themes

The next stage involved identifying the interactions between the factors of IPD as revealed by the expert interviewees. This process answered **1.9.3 Research Question 3**.

4.4 Results for Research Question 3

Research Question 3 involved identifying the interactions between the factors of IPD from the SSI initially and then validating the findings with the broader New Zealand construction industry. Hence, section 4.4.1 presents the interactions between the factors of IPD, and section 4.4.2 presents the validated interactions.

4.4.1 Interactions between the factors of IPD

Through manual coding, the researcher identified the factors and their interactions affecting the implementation of IPD. The interactions were categorised as either positive (+) or negative (-), with (+) indicating that factor A caused factor B to increase, and (-) indicating that factor A caused factor B to decrease. This procedure was completed for each of the eighteen interviewees, and the results were visualised using Vensim. Sample transcription coding is shown below:

C2: “I believe that that it is relatively lowly implemented; the reason for that is because there is not a particularly good proven track record within the construction industry in New Zealand. And I think because of that there is a reluctance from the likes of clients and or constructors or any stakeholder.”

Using deductive reasoning, it was concluded that the lack of familiarity of contractors with IPD approach (LoF) causes resistance to change from stakeholders (RtC) to increase. *Appendix 4- Interactions of factors* details all identified interactions. The results from all interviews are discussed below.

Interviewee C1 was an experienced project manager with previous work experience in the United States. They mentioned a total of 38 factors and 18 interactions. They believed that the New Zealand construction industry significantly lacks the requirements for successful IPD implementation. They identified the challenges of BIM implementation and compared the current level of BIM implementation in New Zealand to that of San Francisco 20 years ago. Interviewee C1 identified that the lack of leadership, combined with contractors' unfamiliarity with the IPD approach, causes difficulties in converting strategic decisions into operational levels. Additionally, they believe that the lack of government support is a reason for the absence of professional bodies associated with IPD in New Zealand; the lack of trained professionals is a reason for the lack of required skills and experience; and a weak organisational matrix structure is the cause of unclear responsibilities among stakeholders. Other interactions included the practice of setting target goals without a fully developed design, causing difficulties with the development of a high-quality design; the lack of proficiency by the employer, resulting in a lack of sound and timely decision-making; and the strict rules associated with IPD, causing clients not to identify any advantages with implementing IPD. Moreover, the interactions involving financial aspects included misunderstandings in risk contingency accounting, which pose challenges in cost estimation, as well as risks and incentives associated with IPD contracts that hinder the selection of adequate compensation and incentive structures. Additionally, the organisational interactions of factors included the lack of IPD promotion, which hinders awareness among clients as well as stakeholders; the unwillingness of clients increases their resistance to change. Furthermore, the lack of IPD awareness limits the interest shown by stakeholders in upgrading to newer delivery models, such as IPD, and this lack of awareness also impacts collaboration between stakeholders, which in turn causes a lack of integration among key stakeholders. Lastly, interviewee C1 revealed that contractual legal aspects associated with IPD increase resistance from stakeholders, and this resistance, in turn, causes resistance from the client as well. Out of the factors that interact with others, the lack of promotion of IPD was the only factor with the most interactions, namely, two. It is worth noting that all the interacting factors encompass all themes except collaboration and technological themes.

Interviewee C2 was a highly experienced building services engineer with over 30 years of experience in the New Zealand construction industry. They were employed by a top-tier construction firm and

possessed extensive knowledge of collaborative project delivery models, including IPD. Interviewee C2 mentioned a total of 28 factors and 14 interactions. Resistance to change and the client's resistance to change have the most interactions, at four (4), followed by a lack of IPD awareness at three (3), and a lack of technology use, a lack of familiarity among contractors with IPD, and a lack of integration between key stakeholders, each at two (2). A notable point is that no factor from the governmental theme interacts with any other factor. The interactions identified by them included the lack of IPD awareness, which caused unfamiliarity among contractors with the IPD approach, as well as increased resistance from both clients and stakeholders. Moreover, the lack of technology use was referred to as increasing resistance among stakeholders and causing challenges in integrating BIM and IPD. Other factors that contributed to growing resistance from stakeholders included the high initial investment requirement and the unfamiliarity of contractors with the IPD approach. Furthermore, they identified that the lack of constraint analysis and planning process, along with the high cost associated with new software, increases the client's resistance to change; however, they believed that increased awareness of IPD among clients aids in reducing resistance from them. From the collaborative factors, they identified that the integration of key stakeholders is impacted by the lack of collaboration between the project participants, as well as the self-protective approach taken by them. Finally, they identified that contractual legal aspects pose risks and incentive issues regarding IPD, and the lack of leadership makes it difficult to translate strategic decisions into operational levels.

Interviewee C3 was a technical director with one of New Zealand's leading contracting firms, and they were involved in a significant project. They also had over 30 years of experience in different countries and were familiar with IPD. Interviewee C3 identified a total of 20 factors. They revealed a couple of interactions, such as challenging cultural paradigms, that reduce the mutual respect and trust among stakeholders. Additionally, the lack of efficient information sharing causes difficulties in converting strategic decisions into operational levels, along with poor data transfer. All the interacting factors are from collaboration and organisational themes. Other factors mentioned by them included factors from the organisational theme, such as inherent difficulties in changing organisational culture, mindset of individuals, the lack of coordination between stakeholders, lack of familiarity of contractors with the IPD approach, lack of responsive decision-making regimes, lack of organisational communication, inefficient resource planning, assigning project leadership, work processes, and understanding the cross-functional organisational approach. Factors from the financial theme included high economic costs associated with new software, high initial investment, and relatively high capital investment requirements of IPD. Lastly, factors related to the legal theme included contractual legal aspects regarding IPD, as well as the lack of insurance policies and bonding arrangements necessary. Additionally, the lack of constraint analysis and the planning process also reduces efficiency in resource planning.

Interviewee C4 was a technical director with one of New Zealand's leading consulting firms, and they were also involved in a major project. They had over 20 years of experience in Australia and New

Zealand and were also familiar with IPD. Interviewee C4 identified a total of 38 factors and 15 interactions between IPD factors. The most prominent factors, each with 2 nodes, were the lack of technology use, contractual legal aspects, lack of insurance policies, mutual respect and trust, and lack of constraint analysis. The fact that a lack of technology use, inadequate insurance policies, and a lack of mutual respect and trust have two incoming nodes suggests that other factors also impact them. In contrast, contractual legal aspects and lack of constraint analysis each have 2 outgoing nodes, which is indicative of the fact that they, in turn, influence other factors. Interviewee C4 revealed that challenging cultural paradigms, along with the lack of constraint analysis and planning process, cause difficulties in project management, which then reduces the mutual respect and trust among stakeholders. Additionally, the compensation structure of IPD contracts also lowers the trust component between stakeholders. Interviewee C4 also believed that the lack of government support is responsible for the unavailability of professional bodies associated with IPD in New Zealand, and the absence of IPD contracts is a significant reason why contractors are unfamiliar with the IPD process. Also, they identified that contractual legal aspects pose risks and incentive issues regarding IPD, in addition to the difficulty of acquiring insurance policies. The issue of hard pricing also makes it difficult to obtain relevant insurance policies. Regarding technological issues, interviewee C4 noted that the lack of an appropriate information technology infrastructure makes the implementation of modern technology difficult. Moreover, they believed that the lack of collaboration between stakeholders hinders the implementation of technology, which leads to issues with BIM and IPD integration. Finally, they revealed that the mindset of stakeholders makes it harder to change an organisation's culture, and the lack of experience and skills hinders the implementation of lean principles, which ultimately impacts the implementation of IPD. It is pertinent to note that all interacting factors cover all themes.

Interviewee C5 was a lean coordinator and was working with a major contractor in New Zealand on a significant infrastructure project. They had over 10 years of experience and were familiar with collaborative project delivery models, such as IPD. Interviewee C15 revealed a total of 22 factors and 13 interactions. The lack of technology use has the greatest number of interactions - 4 (2 incoming and 2 outgoing), followed by the lack of IPD awareness, which has 3 outgoing interactions. This implies that the lack of IPD awareness impacts other factors, while the lack of technology use is in equilibrium; it affects other factors and is also impacted. Interviewee C5 revealed that the lack of opportunities for industry participants to receive IPD-related training, combined with the scarcity of existing training materials and a lack of IPD awareness among stakeholders, all contribute to the underutilisation of technological advancements. They also noted that the lack of utilisation of technological advancements results in challenges with BIM and IPD integration. Regarding the collaboration factors, interviewee C5 believed that the lack of integration between key project participants caused transparency issues among stakeholders; the lack of collaboration among stakeholders led to integration problems between key parties; and the self-protective approach taken by stakeholders made joint project control difficult.

Additionally, they revealed that the lack of IPD awareness reduces collaboration levels between stakeholders, as well as causing industry-wide standardisation issues. Regarding challenging cultural paradigms, they believed that not only did they cause resistance from stakeholders, but they also had an impact on their collaboration levels. Additionally, interviewee C5 noted that the contractual legal aspects associated with IPD not only posed challenges to cost estimation but also eroded the trust component among stakeholders. Finally, they thought that one of the reasons for resistance to IPD from stakeholders was that their IT skills were insufficient. It can be noted that factors from all themes, except the governmental theme, interact with one another.

Interviewee C6 was a construction manager with a reputed contractor in New Zealand. They had over 10 years of experience and possessed a strong educational background relevant to the construction industry. They were aware of lean construction principles and IPD. Interviewee C6 identified a total of 38 factors and 19 interactions with resistance from stakeholders and the client, which emerged as the factors with the largest number of nodes, each having 4 incoming nodes. This suggests that resistance to change, as well as the client's resistance to change, is often the result of numerous preceding factors that influence them. Interviewee C6 revealed that the additional fees the client is required to pay for an IPD agreement, along with the extra costs due to time and material constraints, are a major reason why clients resist IPD uptake. Also, seeking for the lowest price and the fact that the reward may not match the risks involved were other reasons why clients resist the IPD model. In addition, they believed that the current construction rules and regulations increase caution taken by stakeholders, which not only reduces the trust component among project participants but also lowers their interest in upgrading to IPD. Interviewee C6 mentioned that the lack of promotion of IPD was a reason for the unavailability of IPD contracts; the lack of IPD awareness among stakeholders caused issues with coordination; and the lack of government support resulted in a lack of government incentives, policies, and regulations pertinent to IPD. Importantly, they revealed that the high initial investment requirement caused resistance from stakeholders, contractual legal aspects associated with IPD, the high financial cost of new software, and logistical challenges linked with using the IPD model. Further interactions revealed a lack of constraint analysis, which increases inefficiency in resource planning; a lack of integration between key participants due to low collaboration levels among project stakeholders; and the underutilisation of technology because of the high costs of required software. Lastly, interviewee C6 mentioned that the high initial investment requirement was a reason for the lack of insurance policies and bonding arrangements pertinent to IPD, and the lack of knowledge among client representatives was the reason for the challenges in integrating BIM and IPD. It is also noteworthy to mention that all interacting factors cover all themes.

Interviewee C7 was an experienced commercial manager with a tier 1 contractor in the Auckland region of New Zealand and was familiar with collaborative project delivery models such as IPD. Interviewee C7 identified a total of 30 factors and 23 interactions, with a lack of IPD awareness, mutual respect, and trust, as well as a lack of governmental support, having the largest number of

nodes, each with 4 nodes. The lack of IPD awareness has 4 outgoing nodes, and mutual respect and trust have 4 incoming nodes, while the lack of governmental support has a combination of 2 outgoing and 2 incoming nodes. It can be inferred that interviewee C7 believes that the lack of IPD awareness exacerbates several other factors, while many factors contribute to a decrease in mutual respect and trust among stakeholders. Additionally, while the lack of governmental support affects other factors, it is also affected itself. The lack of industry standardisation, resistance to change, and achieving actual joint project control are the next-level critical factors, with each having 3 nodes. Resistance to change has 3 incoming nodes, suggesting that it is only impacted by other factors. In contrast, the lack of industry standardisation and achieving actual joint project control consists of 2 incoming nodes and 1 outgoing node, indicating that although they impact other factors, they are more susceptible to being affected. Interviewee C7 revealed that achieving joint project control, a lack of IPD awareness, and a lack of interest from stakeholders to upgrade all contributed to resistance from stakeholders. Additionally, they revealed that contractual legal aspects of IPD, along with the high initial investment requirement of IPD, were reasons for the lack of governmental support. However, they identified that the lack of government support resulted in a shortage of professional bodies associated with IPD, as well as a lack of government policies, incentives, and regulations. Additionally, they noted that the lack of government support, along with contractual legal aspects, a lack of IPD awareness, and a lack of collaboration among stakeholders all contributed to the reduction of trust among project participants. Moreover, interviewee C7 believed that the compensation structure of IPD, along with the self-protective approach taken by stakeholders, as well as IPD's unawareness, all contribute to the lack of collaboration between project participants. Further discussions about collaborative factors revealed that the compensation structure of IPD and the lack of employer proficiency both made achieving joint project control difficult. Additionally, they believed that the lack of collaboration among stakeholders led to transparency issues between them. Interviewee C7 thought that the lack of IPD contracts led to unfamiliarity among contractors with the IPD model, which created challenging cultural paradigms. Additionally, the shortage of trained professionals contributed to the lack of IPD standardisation, which in turn led to the absence of professional bodies in the country. They also mentioned that logistical challenges associated with the IPD model were a reason for the lack of industry-wide standardisation, and the limited use of technology meant that problems would arise between BIM and IPD integration. Finally, interviewee C7 revealed the obvious- IPD unawareness meant that IPD principles were not getting implemented in New Zealand. It is worth noting that all interacting factors cover all themes.

Interviewee C8 was also an experienced commercial manager with 25+ years of experience in the construction industry. Unlike interviewee C7, they were on the consultant's team. Interviewee C8 identified a total of 25 factors and 20 interactions, with the lack of collaboration and the client's resistance to change having the largest number of nodes, each with 4 nodes. While the client's resistance to change has only 4 incoming nodes, the lack of collaboration has 3 incoming nodes and 1 outgoing node, implying that the factor is more susceptible to being impacted by other factors, despite

having 1 outgoing node. A client's resistance to change is influenced by several factors. The lack of technology use is a critical factor at the next level, with 3 nodes - 2 outgoing and 1 incoming, suggesting that it is more likely to impact other factors. Additionally, all interactions encompass factors from all themes. Interviewee C8 identified that the high initial investment requirement of IPD, the lack of transparency in spending by the contractor, industry standardisation, and project objectives-related barriers all contribute to the client's resistance to change. Additionally, they believed that the lack of IPD awareness, industry standardisation, and a fair compensation model all contribute to increased resistance from stakeholders. Moreover, they revealed that contractual legal aspects associated with IPD, the lack of a fair compensation model, and IPD unawareness all hinder collaboration between the project stakeholders. The lack of cooperation between project participants hinders integration among key stakeholders, resulting in a lack of interest from project participants in adopting IPD. Interviewee C8 mentioned that the project participants are also uninterested in upgrading to IPD if there are skill shortages among the workforce. Also, they believed that there was a lack of governmental support, as the risks involved did not compensate for the possible rewards of IPD. The lack of governmental support resulted in a corresponding lack of professional bodies associated with IPD in New Zealand. Regarding technology use, interviewee C8 noted that the high financial cost of software was a significant factor contributing to the limited adoption of technology, which not only caused challenges in BIM and IPD integration but also led to problems with cost estimation. Finally, they revealed that the lack of lean knowledge among stakeholders resulted in a lack of implementation of IPD principles, and that the high initial investment was the reason for the limited availability of insurance policies for IPD.

Interviewee C9 was a relatively young construction manager with a tier 1 contractor in New Zealand. They were still relatively experienced, with over 10 years of work experience in the construction industry and a strong understanding of IPD. Compared to previous interviewees, they revealed a lot fewer interactions. Interviewee C9 identified 13 factors and a few interactions (6), including the lack of promotion of IPD, which leads to a lack of familiarity among contractors with the IPD approach, and the absence of IPD contracts. Aside from the lack of collaboration causing a lack of integration among key stakeholders, interviewee C9 believes that the risks associated with IPD contracts do not match the rewards offered. This not only impacts the client's resistance to change but also causes a lack of governmental support. Additionally, the fact that the government seeks the lowest possible cost further reduces the appeal of IPD. The lack of IPD promotion, reward not tailored to reflect IPD risks, and the lack of governmental support were the most prominent factors, each having 2 nodes. While the reward is not tailored to reflect IPD risks and the lack of IPD promotion has 2 outgoing nodes, the lack of governmental support consists of 2 incoming nodes, suggesting that other factors influence this factor. Further, they revealed that the lack of IPD promotion was responsible for the lack of IPD contracts and unfamiliarity among contractors. Lastly, interviewee C9 also agreed that low collaboration levels among the project participants impacted the integration between the key stakeholders. Other factors

identified by interviewee C9 included the self-protective approach of stakeholders, the employer's lack of proficiency, issues with mutual respect and trust among project participants, and a lack of awareness of IPD.

Interviewee C10 was a quality manager with over 25 years of experience in the construction industry. They were also employed with a tier 1 contractor and had experience with IPD-related collaborative project delivery models, such as alliancing. Interviewee C10 revealed a total of 17 factors and 11 interactions. They believe that mutual respect and trust, resistance to change, and the lack of industry-wide standardisation are significant factors in IPD implementation. Resistance to change, mutual respect, and trust are influenced by incoming nodes, indicating that several factors impact these aspects. The lack of industry standardisation has 1 incoming node; however, its 2 outgoing nodes reveal that the factor impacts other factors. Interviewee C10 further identified that resistance to change from stakeholders was mainly due to IPD unawareness, a lack of industry-wide standardisation, and unfamiliarity among contractors with the IPD model. Furthermore, they believed that resistance from clients was primarily due to the strict rules associated with IPD and the lack of industry standardisation. Interestingly, they also revealed that the resistance from clients, along with the lack of efficient information sharing, were reasons for the lack of industry standardisation. Mutual respect and trust were identified as critical factors by them, which they believed were impacted by the contractual legal aspects of IPD, the lack of transparency between stakeholders, and the absence of a fair compensation model. Interviewee C10 further revealed that high initial investment, lack of government support, rewards not tailored to reflect the risks associated with IPD, a self-protective approach by stakeholders, and the lack of IPD contracts were additional factors that hindered the implementation of IPD in New Zealand.

Interviewee C11 was a project delivery manager with over 20 years of experience in the construction industry. They had prior experience with the alliancing model and were able to answer the questions on IPD factors, as both models have many similarities. Interviewee C11 identified a total of 17 factors and 9 interactions. They believed that resistance to change from stakeholders is the most critical factor affecting IPD implementation in New Zealand, with several factors contributing to its increase. They determined that a high initial investment, a lack of lean knowledge, a lack of industry standardisation, a focus on the lowest cost, and a self-protective approach by stakeholders all contributed to increased resistance from stakeholders. They also revealed that the contractual legal aspects of IPD, along with the high initial investment requirement, both reduce the mutual respect and trust component among the project stakeholders. Finally, they believed that IPD unawareness increased resistance from the client, and collaboration issues between stakeholders made it challenging to achieve joint project control. Other factors mentioned by interviewee C11 included a lack of technology use, governmental support, employer proficiency, and integration between key stakeholders. Lastly, they revealed that liabilities and indemnification issues with IPD contracts were also a factor.

Interviewee C12 was an experienced project director with over 30 years of experience in the construction industry. They had prior working experience with a variety of project delivery models, including IPD. Interviewee C12 revealed a total of 16 factors and 6 interactions. It is worth noting that all identified factors encompassed every theme, except for the technological theme, and the interacting factors covered all themes except for the financial and technological ones. It is also interesting to note that only inculcating IPD values was identified as the prominent factor with 2 incoming nodes. They revealed that IPD unawareness hinders the implementation of IPD values. Additionally, they mentioned that the lack of governmental support also impacted the implementation of IPD values. This suggests that the lack of governmental support, combined with insufficient awareness of IPD, hinders IPD implementation in New Zealand. Among the organisational themes, interviewee C12 revealed that the lack of experience and skills available causes challenging cultural paradigms, and the business risk associated with IPD impacts resistance from clients. Regarding the collaboration theme, they identified that the lack of collaboration between stakeholders led to transparency issues among them, and the contractual legal aspects of IPD caused stakeholders to be more self-protective. Other factors revealed by them included the lack of a fair compensation model, the need for trained professionals, challenges in cost estimation, high initial investment, and the strict rules associated with IPD.

Interviewee C13 was a BIM coordinator with a tier 1 contractor in the Wellington region of New Zealand. They had over 10 years of work experience in the construction industry and were familiar with collaborative project delivery models, including IPD. Interviewee C13 identified a total of 23 factors and 9 interactions. The identified factors represent all themes, and the interactions cover every theme except the legal theme. The lack of collaboration between stakeholders was the most crucial factor in this network, with a total of 3 nodes. Resistance to change and the lack of technology use were critical factors at the next level, with 2 nodes each, signalling their importance. Interestingly, the lack of technology use was the only factor in equilibrium with 1 incoming and 1 outgoing node. Interviewee C13 further revealed that unawareness of IPD increases resistance and leads to collaboration issues among stakeholders; these collaboration issues, in turn, reduce coordination between them and also affect the integration between key stakeholders. Additionally, they mentioned that the lack of experience in new roles also makes stakeholders resistant. Regarding the technological theme, interviewee C13 identified that the high financial cost of new software is a reason for the limited use of technology in New Zealand, which contributes to the challenges of BIM and IPD integration. Furthermore, they revealed that the absence of professional bodies associated with IPD in New Zealand is a contributing factor to the lack of IPD promotion. Finally, they noted that the self-protective approach of stakeholders undermines mutual respect and trust among them. Factors that impacted IPD in New Zealand but had no interactions included contractual legal aspects, issues with inculcating IPD values, absence of early contractor involvement, insufficient IT skills of industry participants, lack of training professionals, proficiency of the employer, transparency between stakeholders, efficient information sharing, lean knowledge, and a standard way to measure the degree

of design integration.

Interviewee C14 was a quality lead with a tier 1 contractor in the Auckland region of New Zealand. They had over 10 years of experience and were familiar with collaborative project delivery models, including IPD. Interviewee C14 identified a total of 29 factors and 23 interactions, with resistance to change being the most prevalent factor, 7 total nodes (5 incoming and 2 outgoing nodes). The lack of governmental support is a critical factor at the next level, with 6 total nodes (5 outgoing and 1 incoming node). This is indicative of the fact that while resistance from stakeholders is influenced by other factors, the lack of governmental support exacerbates the impact of these factors, causing them to intensify. Mutual respect and trust are next in line, with a total of 5 incoming nodes. As previously identified by other interviewees, trust is impacted by several other factors. Also, all identified factors and interactions cover all themes. They revealed that the lack of experience and skills among stakeholders, limited lean knowledge, inadequate integration between the main parties, governmental support, and the high initial investment requirement all contributed to resistance from the project stakeholders. Moreover, they believed that the lack of governmental support, limited knowledge, inadequate training of professionals, contractual legal aspects, and the self-protective approach of stakeholders hindered the trust component between project participants. Furthermore, interviewee C14 believed that the lack of governmental support was the reason for the lack of government incentives, policies, and regulations regarding IPD, technology use, and industry standardisation in New Zealand. Also, they noted that the lack of IPD awareness led to collaboration issues among stakeholders, made it challenging to establish a sufficient risk allocation mechanism, and was also a contributing factor to the lack of governmental support and industry standardisation in New Zealand. They were also of the opinion that challenging cultural paradigms and resistance from stakeholders were reasons for the lack of technology use in New Zealand. Regarding the legal factors, interviewee C14 revealed that the additional costs clients incur due to time and material constraints complicate the contractual aspects of IPD implementation, and the implementation of strict rules associated with IPD makes joint project control difficult. They also thought that resistance from stakeholders increased clients' resistance to IPD. Lastly, interviewee C14 identified the lack of experience in new roles pertinent to IPD, a fair IPD compensation model, transparency in spending done by the contractor, professional bodies, insurance policies, training material, BIM, and IPD integration challenges, and project management difficulties as additional factors that impacted IPD implementation in New Zealand.

Interviewee C15 was a project manager with a reputable consulting firm in Auckland. They had over 15 years of experience in the construction industry and were familiar with IPD. Interviewee C15 identified a total of 25 factors and 10 interactions, with the lack of governmental support being the most prominent factor, comprising 3 total nodes (2 outgoing and 1 incoming). This is again suggestive of the fact that although other factors may influence the lack of governmental support, they are more likely to amplify its impact on IPD implementation. IPD unawareness and the lack of collaboration are next-level critical factors, with each having 2 total nodes. A notable point is that each consists of one

outgoing and one incoming node, indicating that they are in a state of equilibrium within the factor network. Also, the identified factors cover all themes. However, the interacting factors do not cover the legal theme. Interviewee C15 revealed that the high initial investment associated with IPD was a reason why governments weren't interested in it. Furthermore, they noted that the lack of governmental support resulted in a shortage of incentives, policies, regulations, and training materials that would have facilitated the promotion of IPD. Additionally, they believed that since smaller projects don't require the IPD model, project-objective-related barriers were a reason for the lack of industry-wide standardisation in New Zealand, which then increased the initial investment requirement due to stakeholders' unfamiliarity with the IPD model. Other organisational factor interactions mentioned by them included the lack of opportunities for industry participants to receive IPD training, which causes unawareness and leads to a lack of interest in upgrading to IPD. Regarding collaborative factor interactions, interviewee C15 revealed that IPD unawareness led to collaboration issues between stakeholders, which then led to integration problems between the main parties. They also mentioned that the self-protective approach of stakeholders made it challenging to achieve joint project control. Other factors to IPD in the New Zealand context mentioned by them included contractual legal aspects, lack of coordination between stakeholders, lack of suitable insurance policies, issues with inculcating IPD values, cost estimation challenges, lack of technology use and proficiency from the employer, inefficiency in resource planning, implementation of strict rules associated with IPD, and the inadequate IT skills of project stakeholders. Finally, the collaboration factors revealed by them included a lack of transparency between stakeholders and issues with mutual respect and trust among them.

Interviewee C16 was a project manager with over 20 years of experience in the construction industry. They were employed with a reputable consultancy firm in Auckland and had experience with collaborative delivery models, such as alliancing. Interviewee C16 identified a total of 17 factors and 7 interactions with clients' resistance to change and IPD unawareness being the most prevalent factors, each consisting of 3 total nodes. While IPD unawareness consists of 2 outgoing and 1 incoming node, the client's resistance to change only has incoming nodes. This suggests that the lack of IPD awareness is more likely to impact other factors, and the client's resistance to change increases in severity due to factors such as the high initial investment requirement of IPD, project objectives-related barriers, and IPD unawareness among stakeholders. The identified factors encompass all themes; however, the interacting factors don't include any from the legal and governmental themes. Further, they believed that the lack of technology use was a notable factor in the New Zealand context as well. Project objectives, related barriers, and IPD unawareness likewise impacted them. They thought that the lack of chances for industry participants to receive IPD training was a significant reason for their unawareness. Lastly, they also mentioned that the collaboration issues between project stakeholders led to integration problems between the main parties. Interviewee C16 revealed that the lack of insurance policies, current construction rules and regulations, contractual legal aspects, lack of lean knowledge

among stakeholders, challenging cultural paradigms, resistance to change, lack of experience and skills, as well as governmental support, and unclear contract terms and objectives were other factors to IPD implementation in New Zealand.

Interviewee C17 was a BIM coordinator with over 10 years of experience in the construction industry. They were employed by a notable contractor in the Auckland region and were familiar with IPD. Interviewee C17 revealed a total of 18 factors and 10 interactions, with IPD unawareness being the most prevalent factor, 4 total nodes. The fact that IPD unawareness has 4 outgoing nodes reveals that it impacts other factors, increasing their severity. Mutual respect and trust, and resistance to change are next-level critical factors, with each having 2 incoming nodes, suggesting that the factors are impacted by other factors. Interviewee C17 further revealed that unawareness of IPD and project objectives-related barriers increases resistance from project stakeholders. Furthermore, they mentioned that contractual legal aspects and the lack of governmental support caused trust issues between the project stakeholders. Moreover, they believed that IPD unawareness was responsible for the lack of governmental support, clients' resistance, and collaboration issues between the stakeholders, which in turn led to a lack of integration between them. They also mentioned that the lack of existing training material contributed to the limited use of technology, and the contractual legal aspects of IPD presented challenges in cost estimation. Interviewee C17 mentioned that the lack of opportunities for stakeholders to receive IPD training, the limited experience and skills among project participants, project management difficulties, the implementation of strict rules pertinent to IPD, high initial investment, and the absence of industry-wide standardisation were additional factors affecting IPD implementation in New Zealand.

Interviewee C18 was a project planner with over 10 years of experience in the construction industry. They were employed with a tier 1 contractor in the Auckland region and were familiar with collaborative project delivery models, including IPD. Interviewee C18 identified 23 factors and 18 interactions. They identified resistance to change as the most prevalent factor, with a total of 5 incoming nodes. Several factors, including the contractual legal aspects of IPD, IPD unawareness among stakeholders, the compensation structure of IPD, stakeholders' lack of experience in new roles pertinent to the IPD model, and the self-protective approach of project participants, contribute to increased resistance from stakeholders. The lack of governmental support, collaboration, and challenging cultural paradigms are the next-level critical factors, with each consisting of 3 total nodes. The lack of governmental support and challenging cultural paradigms only consist of 3 outgoing nodes, indicating that they impact other factors, while the lack of collaboration consists of 2 incoming and 2 outgoing nodes. They mentioned that IPD unawareness among stakeholders and challenging cultural paradigms impacted the collaboration levels between stakeholders. The lack of collaboration, in turn, affected the trust component between project participants, as well as making the use of modern technology difficult. Moreover, they believed that the lack of governmental support made the use of modern technology difficult and hindered the implementation of government policies, incentives, and

regulations. Also, they noted that the lack of governmental support meant that IPD wasn't being promoted sufficiently, resulting in a shortage of training materials available for stakeholders. Furthermore, interviewee C18 revealed that the self-protective approach of stakeholders made joint project control difficult, as well as lowering the trust component among the project stakeholders. Lastly, they mentioned that the lack of constraint analysis and planning processes makes it challenging to have a proper structure for IPD facilitation, and challenging cultural paradigms lower the interest in upgrading to IPD among stakeholders. Finally, interviewee C18 mentioned that high initial investment, project objectives-related barriers, a lack of lean knowledge among stakeholders, and issues with future orientation and the setting of incentive plans were additional factors affecting IPD implementation in New Zealand.

Figure 16 illustrates the consolidated Vensim model, which encompasses all factors and interactions identified by all interviewees (See *Appendix 19- Individual interviewee interactions* for individual interviewee interactions). The blue and red arrows shown represent the polarity between factors, with blue indicating a positive relationship while red signaling a negative relationship. It can be noted that the factors situated far right do not interact with other factors and only impact IPD, with blue arrows indicating a positive influence (i.e., an increase in IPD implementation) and red arrows indicating a negative influence (i.e., a decrease in IPD implementation). It is relevant to note that all factors have a link to IPD, whether they interact with other factors or not. It is also significant to note the prevalence of a colour code for individual factors, such as blue for RtC (resistance to change) and red for MR&T (mutual respect and trust). A lot of factors cause RtC to increase, hence the blue arrows, while a lot of factors cause MR&T to decrease, hence the red arrows. It is important to note that some interactions are synonymous, such as the lack of constraint analysis and planning processes (LoCA) causing difficulties in project management (PM) or LoCA causing difficulties in having a proper structure for facilitation (SfF). The reason for this is that interviewees used alternative wordings to define a phenomenon.

4.4.1.1 Grouping of all factors as per analysis methods

Table 11 analyses all factors of IPD using degree centrality, eigenvector centrality, SLR, and SSI frequencies. To investigate the interactions between the factors of IPD, centrality methods, such as degree and eigenvector centralities, are appropriate methods for network analysis. *Degree Centrality* and *Eigenvector Centrality* explain why degree and eigenvector centralities are appropriate methods for network analysis. Additionally, SSI frequency highlights the relevance of IPD factors in the New Zealand context, while SLR frequency underscores the significance of IPD factors globally. The factors that appeared in every analysis were deemed critical.

Table 11: Analysis of the factors of IPD

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
Lack of collaboration among construction stakeholders (LoC)	15	15	6	6	12	0.52	0.0545
Lack of integration of key stakeholders (LoI)	7	11	2	3	5	0.21	0.024
Lack of transparency (LoT)	2	4	2	1	3	0.13	0.0348
Self-protective approach (SPA)	6	10	2	6	8	0.34	0
Poor transmission through all phases of the project (PTP)	1	0	0	0	0	0	0
Mutual respect & trust (MR&T)	10	11	13	0	13	0.56	0.244
Achieving actual joint project control (AAJPC)	2	6	5	1	6	0.26	0.024
Challenging cultural paradigms (CCP)	17	7	2	6	8	0.34	0.0555
Lack of IPD awareness/knowledge among stakeholders (LoIA)	18	15	2	12	14	0.60	0.0655
Resistance to change among stakeholders (RtC)	9	12	21	2	23	1	0.434
Inherent difficulties in changing organisational culture (IDCOC)	7	1	1	0	1	0.04	0
Client's / owner's resistance to change (CRtC)	6	11	14	2	16	0.69	0.449
Awareness and willingness about IPD among owners (AaW)	4	1	2	0	2	0.08	0.273
Early contractor involvement (ECI)	4	0	0	0	0	0	0
Interoperability (I)	4	0	0	0	0	0	0
Participation (P)	2	0	0	0	0	0	0
Lack of partnering as a tool for achieving lean construction performance (LoPtLC)	1	0	0	0	0	0	0
Owner not identifying advantages (ONIA)	2	1	1	0	1	0.04	0
Lack of effective information sharing (LoEI)	1	2	0	3	3	0.13	0
Lack of responsive decision-making regimes (LoRDM)	1	0	0	0	0	0	0

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
Lack of coordination in managing the project (LoCo)	2	2	2	0	2	0.08	0.0536
Future orientation (FO)	3	0	0	0	0	0	0
Integration of information and knowledge management systems (IIKMS)	3	0	0	0	0	0	0
Inculcating the values of IPD (IVIPD)	2	3	3	0	3	0.13	0.0825
Lack of promotion of IPD (LoP)	2	6	2	6	8	0.34	0.139
Assigning project leadership (APL)	1	0	0	0	0	0	0
Attitude-related barriers (ARB)	1	0	0	0	0	0	0
Business risk (BR)	1	1	0	1	1	0.04	0
Difficulties in converting strategic decisions to operational levels (DiC)	1	2	4	0	4	0.17	0.0555
Inefficiency in resource planning (IiR)	1	2	1	0	1	0.04	0
Industry participants lack chances to receive IPD-related training (IPLC)	3	3	0	2	2	0.08	0
Lack of leadership and uncertainty of risk involved (LoL)	1	1	0	1	1	0.04	0
Lack of trained professionals (LoTP)	3	3	0	3	3	0.13	0
Lack of existing training material (LoETM)	5	4	2	1	3	0.13	0.118
Lack of organisational communication (LOCm)	2	1	0	1	1	0.04	0
Lack of owner involvement (LoOI)	2	0	0	0	0	0	0
Lack of constraint analysis and planning process (LoCA)	1	4	0	4	4	0.17	0
Lack of proficiency and strong management of the employer (LoPr)	3	2	0	2	2	0.08	0
Lack of familiarity of contractors with the IPD approach (LoF)	1	6	3	3	6	0.26	0.124
Lack of a standard way to measure the degree of design integration (LoSW)	1	0	0	0	0	0	0
Lack of a standard way to measure the whole life cycle project quality (LoSWW)	1	0	0	0	0	0	0
Lack of proper definition of responsibilities of each party to the contract (LoPDR)	1	0	0	0	0	0	0
Lack of proper definition of the culture of teamwork among project key stakeholders (LoPDC)	1	0	0	0	0	0	0
Lack of sufficient knowledge about design, construction, and maintenance among representatives of the employer (LoSK)	1	1	0	1	1	0.04	0
Lack of experience and skills	4	5	1	4	5	0.21	0

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
(LoES)							
Lack of interest to upgrade (LoIU)	4	6	5	1	6	0.26	0.0655
Lack of lean knowledge (LoLean)	2	4	1	3	4	0.17	0
Logistical challenges (LC)	1	2	0	2	2	0.08	0
Mindset of individuals (MoI)	2	1	0	1	1	0.04	0
Partner selection (PS)	1	0	0	0	0	0	0
Poor data transfer among different phases of a project (PDT)	1	1	1	0	1	0.04	0
Project objectives-related barriers (PORB)	1	4	0	4	4	0.17	0
Signing of participants' task scope (SoPTS)	1	0	0	0	0	0	0
Setting of incentive plans (SoIP)	1	0	0	0	0	0	0
Structure for facilitation (SfF)	1	1	1	0	1	0.04	0
The effect of a weak matrix structure (TEWM)	1	1	0	1	1	0.04	0
Unclear responsibilities of the parties (UR)	3	1	1	0	1	0.04	0
Different criteria for services procurement (DCfSP)	2	0	0	0	0	0	0
Early definition of target goals without a fully developed design (EDTG)	1	1	0	1	1	0.04	0
Project management difficulties (PM)	1	1	2	1	3	0.13	0.0251
Risk allocation mechanism (RAM)	2	1	1	0	1	0.04	0.0297
Subjectivity in measuring quality (SiMQ)	1	0	0	0	0	0	0
Work processes (WP)	1	0	0	0	0	0	0
Developing high-quality design (DHQD)	3	1	1	0	1	0.04	0
Lack of industry-wide standardisation (LoIW)	1	7	7	4	11	0.47	0.29
Lack of experience in new roles (LoENR)	1	2	0	1	1	0.04	0
Making sound and timely decisions (MSTD)	2	1	1	0	1	0.04	0
New approach takes time (NATT)	3	0	0	0	0	0	0
Selecting the right team (StRT)	1	0	0	0	0	0	0
Understanding the cross-functional organisational approach (UtCFOA)	1	0	0	0	0	0	0
Lack of factual information about outcomes from IPD in NZ (LoFI)	0	1	0	0	0	0	0
Limited number of contractors and consultants (LCC)	0	1	0	0	0	0	0
Institutional inertia (II)	1	0	0	0	0	0	0
Industry opting for traditional models (IoTM)	0	1	0	0	0	0	0
Experienced professionals' mindset (EPM)	0	1	0	0	0	0	0
History of liquidation of contractors resisting risks (HLC)	0	1	0	0	0	0	0
Subcontractors taking main	0	1	0	0	0	0	0

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
contractor roles (StMCR)							
Project size (Psz)	0	1	0	0	0	0	0
High initial investment (HII)	16	7	2	5	7	0.3	0.187
Profit pooling – paying profits after all project works are completed (PP)	1	0	0	0	0	0	0
Insurance products designed for IPD are not widely available (IPfIPDNA)	3	0	0	0	0	0	0
Lack of fair IPD compensation models (LoFIPDCM)	3	3	0	3	3	0.13	0
Compensation structure (CS)	5	3	0	4	4	0.17	0
Hard pricing (HP)	1	1	0	1	1	0.04	0
Seeking the lowest cost (SfLC)	1	3	0	3	3	0.13	0
Inventory cost (IC)	1	0	0	0	0	0	0
Lack of an accurate cost estimation methodology (LoACE)	1	0	0	0	0	0	0
Lack of coordination for the compensator for F losses (LoCCFL)	1	0	0	0	0	0	0
Lack of a standard way to ascertain the credit rating/worthiness of a company (LoSECR)	1	0	0	0	0	0	0
Misunderstandings in risk contingency accounting (MIR)	2	1	0	1	1	0.04	0
The high F cost of new software and equipment (HFCNS)	3	4	0	3	3	0.13	0
The client needs to pay for the additional cost of drafting a new agreement for IPD (TCPACNA)	1	1	0	1	1	0.04	0
The client needs to pay additional design fees due to time and material-based compensation (TCPAFTM)	1	2	0	2	2	0.08	0
Cost estimation challenges (CEC)	5	4	3	0	3	0.13	0.176
Reward not tailored to reflect the stochastic nature of the risks involved (RnTRSR)	4	3	0	2	2	0.08	0
Difficulties in achieving F transparency (DiA)	2	0	0	0	0	0	0
Relative capital investment (RCI)	1	0	0	0	0	0	0
Lack of transparency in spending done by the contractor (LoTSC)	1	1	0	1	1	0.04	0
Lack of governmental support (LoGS)	8	11	5	10	15	0.65	0.116
Lack of professional bodies (LoPB)	1	5	2	1	3	0.13	0.187
Contractual L aspects (CLA)	27	13	1	8	9	0.39	0
Lack of insurance policies and bonding arrangements (LoIP)	6	3	3	0	3	0.13	0.0866
Lack of existence of similar IPD contracts (LoESIPD)	4	3	1	1	2	0.08	0.0655
Lack of legislative regulations (LoLR)	1	0	0	0	0	0	0
A requirement of the new L	2	0	0	0	0	0	0

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
framework (ARnLF)							
Data sharing (contractual) (DS)	1	0	0	0	0	0	0
Dispute resolution (contractual) (DR)	1	0	0	0	0	0	0
Liabilities and indemnification (contractual) (L&I)	4	0	0	0	0	0	0
Risks and incentives (contractual) (R&I)	1	3	1	1	2	0.08	0
Selection of compensation and incentive structure (SoCIS)	2	1	1	0	1	0.04	0
Suspension and termination (contractual) (S&T)	1	0	0	0	0	0	0
Application of IPD principles with no standard contract agreement (AIPDNC)	1	0	0	0	0	0	0
Lack of suitable liability waivers between stakeholders (LoSLW)	2	0	0	0	0	0	0
Expert contract administrators (ECA)	2	0	0	0	0	0	0
Implementation of strict rules, policies, and regulations (IoSR)	2	3	0	3	3	0.13	0
Contract signing (CSi)	2	0	0	0	0	0	0
Deciding framework for contractual renegotiations (DRCR)	1	0	0	0	0	0	0
Inappropriate contractual strategies (ICS)	1	0	0	0	0	0	0
Non-availability of suitable IPD contracts (NSIPD)	2	1	1	0	1	0.04	0.0655
The tendency to use conventional contractual methods and resistance against new ideas (TCCRN)	1	0	0	0	0	0	0
Unclear contract terms and objectives (UCTO)	1	0	0	0	0	0	0
Uncertainty of risk involved in multiparty contracts (URMPC)	1	0	0	0	0	0	0
Current construction rules and regulations (CCRL)	4	1	0	1	1	0.04	0
Differences in contracting methodology (DiCM)	1	0	0	0	0	0	0
IPD contract types are not tested or understood (IPDNTU)	1	0	0	0	0	0	0
Lack of governmental incentives, policies, regulations, or L frameworks (LoGipr)	3	5	1	0	1	0.04	0.0532
No dispute resolution clause (NDR)	1	0	0	0	0	0	0
Signing a contract with no hierarchical structure (IPD's organisational structure) (SCNHS)	1	0	0	0	0	0	0
Federal vs local council model policy and governance conflicts (FvLCM)	0	2	0	0	0	0	0
Lack of usage of technological advancements (ex., BIM) (LoUT)	24	11	10	2	12	0.52	0.385

Factor	SLR Frequency	SSI frequency	IN	ON	TN	DC	EC
Availability of adequate Information Technology (IT) infrastructure (AoAIT)	5	0	0	0	0	0	0
Governmental payment procedure, which entails T advancement (GPT)	1	0	0	0	0	0	0
Industry participants' IT skills are insufficient (IPIT)	1	1	0	1	1	0.04	0
Lack of Information and Communication Technology usage (LoICT)	2	1	0	1	1	0.04	0
BIM and IPD integration challenges (B&IC)	2	7	2	0	2	0.08	0.176

- IN= Incoming nodes; ON= Outgoing nodes; TN= Total nodes

The validated interactions obtained from the system-wide survey questionnaire are presented next.

4.4.2 Validated interactions between the factors of IPD

The results from the semi-structured interviews were validated using a system-wide survey questionnaire. The purpose was to investigate whether the wider construction sector of New Zealand agreed with the viewpoints of the experts. *Procedure* details the survey process. One hundred thirty-seven responses were collected. The survey was anonymous, but the demographics section captured relevant data pertinent to the respondents. *Demographics* details the demographics of the survey respondents. Table 12 presents the results of the system-wide survey conducted. The survey comprised a total of 142 interactions, which were identified from the prior interviews; these interactions were grouped according to their themes. The L theme consisted of 16 interactions; the T theme consisted of 15 interactions; the GP theme consisted of 14 interactions; the F theme consisted of 19 interactions; the CC theme consisted of 23 interactions; and the CO theme consisted of 55 interactions. Subsequently, section 4.4.2.1 details the analysis of the results.

Table 12: Survey results

Theme	Qs No.	SA	SoA	NAND	SoD	SD	IDK/NR
L	1	37	48	11	7	2	32
	2	27	61	14	4	0	31
	3	32	56	9	5	1	34
	4	14	60	10	10	5	38
	5	24	67	5	5	2	34
	6	34	66	6	1	3	27
	7	9	65	21	5	2	35
	8	4	39	15	16	6	57
	9	2	42	40	4	2	47
	10	5	58	24	10	5	35

Theme	Qs No.	SA	SoA	NAND	SoD	SD	IDK/NR
	11	2	52	28	12	7	36
	12	12	69	16	9	4	27
	13	17	70	9	11	3	27
	14	0	26	18	21	7	65
	15	1	22	23	25	2	64
	16	21	59	10	3	2	42
T	1	12	66	23	14	1	21
	2	10	71	29	8	1	18
	3	20	94	9	6	0	8
	4	4	67	24	24	2	16
	5	6	71	34	14	1	11
	6	8	61	38	14	3	13
	7	13	64	14	14	1	31
	8	12	65	17	13	1	29
	9	12	69	16	13	2	25
	10	23	77	9	4	1	23
	11	27	88	8	2	2	10
	12	44	78	3	1	1	10
	13	49	75	4	2	0	7
	14	34	77	16	2	1	7
	15	37	70	15	2	2	11
GP	1	5	53	15	5	1	58
	2	20	52	11	1	2	51
	3	2	41	17	13	3	61
	4	3	65	17	3	1	48
	5	3	58	18	7	1	50
	6	4	62	13	5	0	53
	7	1	52	16	5	1	62
	8	1	46	24	9	1	56
	9	4	53	22	7	1	50
	10	4	58	19	5	1	50
	11	2	30	11	31	10	53
	12	3	47	21	10	3	53
	13	3	56	21	7	1	49
	14	5	58	23	4	2	45
F	1	45	70	5	2	1	14
	2	34	78	7	3	0	15
	3	35	77	9	5	0	11
	4	49	71	4	1	1	11
	5	7	74	18	2	1	35
	6	6	72	19	3	1	36
	7	9	71	14	4	2	37

Theme	Qs No.	SA	SoA	NAND	SoD	SD	IDK/NR
	8	20	84	17	1	2	13
	9	25	96	4	1	0	11
	10	23	60	15	11	5	23
	11	5	78	13	5	1	35
	12	36	80	6	2	0	13
	13	17	80	19	2	2	17
	14	12	82	16	5	2	20
	15	14	80	22	7	2	12
	16	28	93	3	2	0	11
	17	11	89	9	2	1	25
	18	10	81	20	5	3	18
	19	9	84	23	2	1	18
CC	1	6	78	18	10	5	20
	2	8	75	20	10	5	19
	3	5	24	4	34	64	6
	4	15	79	15	6	2	20
	5	8	66	23	6	2	32
	6	11	75	20	11	1	19
	7	7	82	21	8	1	18
	8	10	91	16	5	1	14
	9	13	83	17	12	0	12
	10	29	73	15	8	1	11
	11	17	75	18	15	0	12
	12	20	93	11	2	0	11
	13	21	91	11	1	1	12
	14	6	78	19	17	1	16
	15	4	30	5	36	58	4
	16	12	104	9	2	0	10
	17	10	87	19	4	1	16
	18	14	97	12	1	0	13
	19	13	94	14	1	0	15
	20	19	107	3	0	0	8
	21	12	87	15	7	0	16
	22	4	69	11	7	1	45
	23	6	90	16	12	0	13
CO	1	19	82	5	5	1	25
	2	25	94	4	2	0	12
	3	26	93	3	3	0	12
	4	18	89	13	3	0	14
	5	20	91	11	1	0	14
	6	28	86	10	0	0	13
	7	30	89	4	0	0	14

Theme	Qs No.	SA	SoA	NAND	SoD	SD	IDK/NR
	8	33	86	4	0	0	14
	9	7	73	21	3	1	32
	10	29	73	15	8	1	11
	11	27	74	15	4	1	16
	12	29	77	14	1	1	15
	13	31	82	11	2	0	11
	14	7	69	9	4	2	46
	15	22	82	15	3	1	14
	16	25	80	14	2	0	16
	17	24	77	14	2	1	19
	18	13	81	23	3	1	16
	19	17	87	13	3	2	15
	20	23	90	12	1	1	10
	21	25	88	12	2	0	10
	22	12	84	20	3	1	17
	23	20	86	9	5	1	16
	24	25	89	11	0	0	12
	25	28	90	4	2	0	13
	26	14	77	13	4	2	27
	27	10	81	15	3	2	26
	28	8	75	20	5	2	27
	29	22	88	16	1	2	8
	30	23	92	13	0	0	9
	31	17	86	11	0	0	23
	32	17	97	8	0	1	14
	33	10	79	10	1	0	37
	34	18	88	11	5	0	15
	35	10	75	9	0	0	43
	36	16	85	8	0	0	28
	37	20	97	7	0	0	13
	38	15	79	7	0	0	36
	39	13	80	13	13	2	16
	40	26	97	5	0	0	9
	41	12	64	11	0	1	49
	42	24	88	7	2	0	16
	43	10	69	14	24	1	19
	44	19	93	9	2	1	13
	45	14	99	6	1	2	15
	46	14	86	15	2	2	18
	47	15	87	16	0	2	17
	48	5	71	21	1	2	37
	49	4	70	9	0	3	51
	50	9	89	19	2	1	17

Theme	Qs No.	SA	SoA	NAND	SoD	SD	IDK/NR
	51	10	86	17	3	2	19
	52	9	79	25	6	1	17
	53	5	80	13	0	1	38
	54	23	75	20	2	1	16
	55	25	87	9	1	1	14

- **Qs No.= Question Number, SA= Strongly Agree, SoA= Somewhat Agree, NAND= Neither Agree Nor Disagree, SoD= Somewhat Disagree, SD= Strongly Disagree, IDK/NR= I don't know/ No response**

4.4.2.1 Analysis of results

The analysis of the system-wide survey was conducted using RII and the t-test. The RII was used to identify the highest-ranked interactions from the broader New Zealand construction industry's perspective. The responses (SA, SoA, NAND, SoD, SD) of each interaction were assigned a score and counted. The sum of the responses was divided by the sample size to achieve the RII score of individual interactions. Additionally, the t-test was used to identify the statistically significant interactions. The t-test was conducted using the SPSS software. The responses from every interaction were copied to the software and analysed using its built-in feature, with the resulting p-value of each interaction determining whether the responses received for a particular interaction occurred by chance or not. Interactions with a high RII value yet failing the t-test were discarded, as the responses could not be deemed reliable and were likely to have occurred by chance. The next section discusses the RII analysis.

Relative Importance Index

Relative Importance Index discusses RII in detail. The RII is a statistical method to determine the ranking of different factors; the higher the RII value, the greater the impact of the factor. To calculate the RII, the responses of individual interactions were assigned scores, with SA receiving a score of 5, SoA receiving a score of 4, NAND receiving a score of 3, SoD receiving a score of 2, and SD receiving a score of 1. Additionally, unanswered responses and responses of 'I don't know' were excluded from the sample size. The survey results of each interaction were copied into an Excel spreadsheet, and the sum of the responses was divided by the sample size for that interaction to obtain the RII value. Next, the RII values were assigned to each interaction, and the interactions were grouped according to their themes. Table 13 details all interactions used in the survey questionnaire, grouped by RII values.

Table 13: Survey factor interactions detailed as per their RII values

Survey question number	Interaction	RII value
1	Lack of IPD contracts causes unfamiliarity among contractors (LoESIPD, LoF)	0.811
2	Lack of promotion causes unavailability of suitable IPD contracts (LoP, NSIPD)	0.809
3	Stakeholders hesitate to use IPD because of strict contractual clauses (CLA, RtC)	0.819
4	Risks associated with IPD contracts make it difficult to estimate project costs (MIR, CEC)	0.741
5	IPD's strict contractual clauses increase the risk taken by stakeholders (CLA, R&I)	0.786
6	IPD's strict contractual conditions make stakeholders overly cautious (CLA, SPA)	0.832
7	IPD's strict contractual conditions make joint project control difficult (CLA, AAJPC)	0.745
8	IPD contractual arrangement complications cause challenges in obtaining insurance coverage (CLA, LoIP)	0.649
9	IPD's contractual conditions reduce governmental support (CLA, LoGS)	0.684
10	IPD's contractual conditions reduce mutual respect and trust among stakeholders (CLA, MR&T)	0.688
11	IPD's contractual conditions reduce collaboration between stakeholders (CLA, LoC)	0.657
12	Clients do not see advantages in IPD because of its strict contractual conditions (IoSR, ONIA)	0.731
13	Clients resist using IPD because of strict contractual conditions (IoSR, CRtC)	0.758
14	There is a lack of insurance policies due to IPD's high initial investment (HII, LoIP)	0.563
15	Insurance companies do not offer policies due to complicated IPD pricing models (HP, LoIP)	0.586
16	Lack of governmental support causes insufficient regulations and legal frameworks to aid IPD (LoGS, LoGipr)	0.789
17	Clients resist technology due to high software costs (HFCNS, CRtC)	0.72
18	Technology is not used adequately, as new software costs are high (HFCNS, LoUT)	0.736
19	Cost estimation becomes challenging without the use of technology (LoUT, CEC)	0.796
20	Project objectives-related barriers hinder technology use (PORB, LoUT)	0.677
21	Resistance among stakeholders hinders technology use (RtC, LoUT)	0.706
22	Challenging cultural paradigms hinder technology use (CCP, LoUT)	0.691
23	Lack of existing IPD training material hinders technology use (LoETM, LoUT)	0.747
24	Lack of IPD awareness among stakeholders hinders	0.737

	technology use (LoIA, LoUT)	
25	Stakeholders' lack of opportunities to receive IPD training hinders technology use (IPLC, LoUT)	0.735
26	Incompetency among the clients' representatives causes BIM and IPD integration challenges (LoSK, B&IC)	0.805
27	Without technological support, stakeholders hesitate to use IPD (LoUT, RtC)	0.82
28	BIM and IPD integrate well with technological support (LoUT, B&IC)	0.848
29	Using technology successfully is more complicated without the proper tools and resources (LoICT, LoUT)	0.869
30	Effective and productive use of technology relies on the collaboration of stakeholders (LoC, LoUT)	0.816
31	Stakeholders are reluctant to use IPD when they lack IT skills (IPIT, RtC)	0.819
32	Governments are reluctant to use IPD because of the reward-risk mismatch (RnTRSR, LoGS)	0.741
33	The lack of governmental support for IPD is due to the high initial investment (HII, LoGS)	0.8
34	The lack of governmental support necessitates a higher initial investment for IPD (LoGS, HII)	0.659
35	IPD is not promoted enough because of the lack of governmental support (LoGS, LoP)	0.723
36	IPD is not promoted due to the lack of relevant professional bodies (LoPB, LoP)	0.726
37	There are inadequate professional bodies for IPD because it is not standardised (LoIW, LoPB)	0.757
38	Professional bodies do not promote IPD due to lack of governmental support (LoGS, LoPB)	0.722
39	IPD stakeholders lack mutual respect and trust due to inadequate governmental support (LoGS, MR&T)	0.693
40	IPD principles are not put into practice due to insufficient government support (LoGS, IVIPD)	0.721
41	IPD is not standardised due to the lack of governmental support (LoGS, LoIW)	0.735
42	The lack of government support has prevented the adoption of technology in IPD (LoGS, LoUT)	0.555
43	Insufficient governmental support has led to a lack of training material on IPD (LoGS, LoETM)	0.696
44	Stakeholders are hesitant to implement IPD because of the lack of governmental support (LoGS, RtC)	0.712
45	There is less governmental support for IPD because of unawareness among stakeholders (LoIA, LoGS)	0.722
46	Stakeholders are hesitant to use IPD due to high initial investment (HII, RtC)	0.86
47	Stakeholders are hesitant to use IPD because of the compensation structure (CS, RtC)	0.834
48	Stakeholders hesitate to use IPD because of other low-cost project delivery alternatives (SfLC, RtC)	0.825

49	Clients resist using IPD because of the high initial investment (HII, CRtC)	0.872
50	Clients hesitate to use IPD because of the extra costs of creating a new agreement (TCPACNA, CRtC)	0.766
51	Clients hesitate to use IPD because of the additional costs required to draft a new agreement (TCPACNA, CRtC)	0.764
52	Clients hesitate to use IPD because of the additional design fees requirement (TCPAFTM, CRtC)	0.769
53	Clients are hesitant to use IPD because the reward offered does not reflect the risks taken (RnTRSR, CRtC)	0.788
54	Clients are hesitant to use IPD if the contractor's spending lacks transparency (LoTSC, CRtC)	0.83
55	There is a high investment requirement for IPD because it is not standardised (LoIW, HII)	0.755
56	Added design cost for the client complicates the IPD's contractual conditions (TCPAFTM, CLA)	0.758
57	Stakeholders disagree over compensation based on risks taken in an IPD contract (R&I, SoCIS)	0.841
58	Achieving joint project control is difficult due to IPD's compensation structure (CS, AAJPC)	0.778
59	The compensation structure of IPD reduces mutual respect and trust among stakeholders (CS, MR&T)	0.765
60	Lack of mutual respect and trust among IPD stakeholders is due to high initial investment (HII, MR&T)	0.747
61	Seeking lower costs causes clients to resist using IPD (SfLC, CRtC)	0.833
62	Misunderstandings in risk contingency accounting increases cost estimation challenges (MIR, CEC)	0.783
63	The high cost of new software and equipment required for IPD makes stakeholders hesitant (HFCNS, RtC)	0.753
64	There is a lack of collaboration between stakeholders due to IPD's compensation structure (CS, LoC)	0.771
65	Challenging cultural paradigms reduces mutual respect and trust among stakeholders (CCP, MR&T)	0.715
66	Challenging cultural paradigms hinder collaboration between stakeholders (CCP, LoC)	0.72
67	Stakeholders unfamiliar with IPD do not understand the importance of collaboration (LoIA, LoC)	0.406
68	Stakeholders' self-interest reduces mutual respect and trust among them (SPA, MR&T)	0.765
69	Stakeholders' self-interest hinders incentives to consider IPD (SPA, LoIU)	0.737
70	Stakeholders' self-interest reduces collaboration between them (SPA, LoC)	0.747
71	Stakeholders' self-interest causes resistance to use IPD (SPA, RtC)	0.745
72	Stakeholders resist using IPD if the main parties are not integrated together (LoI, RtC)	0.769
73	Key parties' integration gets affected when stakeholders do not collaborate (LoC, LoI)	0.755
74	Key parties' integration gets affected when stakeholders are self-protective (SPA, LoI)	0.742
75	Key parties' integration gets affected when stakeholders are not transparent (LoT, LoI)	0.753

76	Mutual respect and trust decreases when stakeholders do not collaborate (LoC, MR&T)	0.816
77	Mutual respect and trust decreases when stakeholders are not transparent (LoT, MR&T)	0.808
78	Unavailability of trained professionals reduces mutual respect and trust between stakeholders (LoTP, MR&T)	0.719
79	Stakeholders unfamiliar with IPD do not understand the importance of collaboration (LoIA, LoC)	0.425
80	Transparency decreases among stakeholders when they do not collaborate (LoC, LoT)	0.804
81	Joint project control becomes difficult because of self-interest among stakeholders (SPA, AAJPC)	0.754
82	Joint project control becomes difficult when stakeholders do not collaborate (LoC, AAJPC)	0.8
83	Achieving joint project control becomes difficult if the client is not proficient (LoPr, AAJPC)	0.796
84	Managing the project becomes difficult when stakeholders do not collaborate (LoC, LoCo)	0.817
85	The incentive for stakeholders to use IPD decreases when the main parties are not united (LoI, LoIU)	0.771
86	Lack of lean knowledge among stakeholders reduces mutual respect and trust (LoLean, MR&T)	0.737
87	Difficulties in project management reduce mutual respect and trust among stakeholders (PM, MR&T)	0.743
88	Target goals for IPD implementation are difficult to set without high-quality design (EDTG, DHQD)	0.809
89	Lack of IPD promotion reduces awareness and willingness among clients (LoP, AaW)	0.827
90	Lack of IPD promotion reduces awareness among stakeholders (LoP, LoIA)	0.828
91	The lack of promotion causes a shortage of IPD contracts (LoP, LoESIPD)	0.798
92	The lack of promotion causes unfamiliarity among contractors with IPD (LoP, LoF)	0.811
93	Stakeholders are not interested in upgrading to IPD because of unawareness (LoIA, LoIU)	0.835
94	Stakeholders' unfamiliarity with IPD causes resistance (LoF, RtC)	0.842
95	Stakeholders resist using IPD because of unawareness (LoIA, RtC)	0.847
96	Stakeholders resist using IPD because of logistical challenges (LC, RtC)	0.754
97	Stakeholders resist IPD because they are not interested in upgrading from other delivery models (LoIU, RtC)	0.792
98	Stakeholders resist using IPD because of its lack of standardisation (LoIW, RtC)	0.808
99	Stakeholders resist upgrading to IPD because of the lack of experience and skills (LoES, RtC)	0.816
100	Stakeholders resist using IPD because of unfamiliarity among contractors (LoF, RtC)	0.823
101	Stakeholders resist using IPD because of their lack of lean knowledge (LoLean, RtC)	0.756
102	Stakeholders are hesitant to use IPD because of their limited experience in new roles (LoENR, RtC)	0.796

103	Stakeholders resist using IPD because they lack the required experience and skills (LoES, RtC)	0.8
104	Stakeholders lack IPD awareness because they are not trained (LoTP, LoIA)	0.805
105	Stakeholders resist using IPD because of project objectives-related barriers (PORB, RtC)	0.768
106	Stakeholders do not upgrade to IPD because of challenging cultural paradigms (CCP, LoIU)	0.786
107	Clients are hesitant to use IPD when stakeholders resist change (RtC, CRtC)	0.809
108	Clients resist using IPD if there is unawareness among stakeholders (LoIA, CRtC)	0.814
109	Clients hesitate to use IPD because of project objectives-related barriers (PORB, CRtC)	0.771
110	Clients resist using IPD because of its lack of standardisation (LoIW, CRtC)	0.796
111	Clients resist using IPD because of unawareness among stakeholders (LoIA, CRtC)	0.816
112	Clients resist using IPD because of business risk (BR, CRtC)	0.827
113	Target goals for IPD implementation are difficult to set without high-quality design (EDTG, DHQD)	0.776
114	Converting strategic decisions to operational levels is difficult because of unfamiliarity among contractors (LoF, DiC)	0.769
115	Converting strategic decisions to operational levels is difficult because of low organisational communication (LOCm, DiC)	0.745
116	A weak organisational matrix causes unclear responsibilities of the stakeholders (TEWM, UR)	0.793
117	Making sound and timely decisions becomes difficult if the client is not proficient (LoPr, MSTD)	0.815
118	Converting strategic decisions to operational levels is difficult in the absence of leadership (LoL, DiC)	0.81
119	The lack of trained professionals causes a shortage of IPD experience in the market (LoTP, LoES)	0.809
120	The lack of constraint analysis and planning process causes resistance among clients (LoCA, CRtC)	0.78
121	Unawareness among stakeholders causes contractors to be unfamiliar with IPD (LoIA, LoF)	0.795
122	Lack of constraint analysis causes inefficiency in resource planning (LoCA, IiR)	0.802
123	Lack of information sharing causes converting strategic decisions to operational levels difficult (LoEI, DiC)	0.814
124	Lack of information sharing hinders data transfer in projects (LoEI, PDT)	0.82
125	Lack of constraint analysis and planning process causes difficulties in project management (LoCA, PM)	0.815
126	Difficulties in project management arise because of challenging cultural paradigms (CCP, PM)	0.747
127	Mindset of individuals causes difficulties in changing organisational culture (MoI, IDCOC)	0.832

128	There is a lack of lean knowledge among stakeholders because of inexperience (LoES, LoLean)	0.795
129	IPD is not standardised because of unawareness among stakeholders (LoIA, LoIW)	0.823
130	Coordination issues exist because of IPD unawareness among stakeholders (LoIA, LoCo)	0.703
131	Stakeholders fail to implement IPD principles due to lack of awareness (LoIA, IVIPD)	0.804
132	Challenging cultural paradigms contribute towards stakeholders resisting IPD (CCP, RtC)	0.8
133	Contractors' lack of familiarity with IPD develops challenging cultural paradigms (LoF, CCP)	0.781
134	IPD is not standardised because of the unavailability of trained professionals (LoTP, LoIW)	0.786
135	IPD is not standardised because of logistical challenges (LC, LoIW)	0.744
136	The lack of lean knowledge among stakeholders makes IPD implementation difficult (LoLean, IVIPD)	0.767
137	IPD is not standardised because of the lack of information sharing among stakeholders (LoEI, LoIW)	0.77
138	Lack of experience among stakeholders causes challenging cultural paradigms (LoES, CCP)	0.767
139	IPD is not standardised because of project objectives-related barriers (PORB, LoIW)	0.748
140	Lack of constraint analysis and planning hinders effective IPD implementation (LoCA, SfF)	0.77
141	Training material on IPD is currently unavailable due to a lack of promotion (LoP, LoETM)	0.793
142	IPD unawareness increases the risk allocation mechanism among stakeholders (LoIA, RAM)	0.817

The next section details the t-test analysis, which was another type of analysis used for the system-wide survey questionnaire.

T-test

For the survey results, the t-test was used to identify the statistically significant interactions. The purpose was to identify statistically significant interactions using p-values obtained through t-tests

performed with SPSS software. The values 1-5, which represent the answer choices ranging from "strongly disagree" to "strongly agree," were used as test values in the test. The test value was selected to be the median value of the individual interactions. For identification, a null hypothesis was formulated, and the corresponding p-values helped determine whether the results obtained were due to chance or not. The rule followed was that if the p-value was less than 0.05, the result was considered statistically significant, as it was unlikely to have occurred by chance. Conversely, for p-values greater than 0.05, the interaction was deemed statistically insignificant (i.e., it occurred by chance) and was discarded. Table 26 in *Appendix 8- P-values from T-test* details the p-values obtained from the t-test for all interactions. The next section presents the statistically significant interactions obtained through the t-test.

Statistically significant interactions

Table 14 presents the statistically significant interactions, along with their polarity as determined by the survey results, grouped by theme.

Table 14: Statistically significant interactions simplified using factor codes

Theme	Factor A	Factor B	Polarity
L	MIR	CEC	+
	CLA	SPA	+
	CLA	AAJPC	-
	CLA	LoIP	+
	CLA	LoGS	+
	CLA	MR&T	-
	CLA	LoC	+
	IoSR	ONIA	+
	IoSR	CRtC	+
T	HFCNS	CRtC	+
	HFCNS	LoUT	+
	PORB	LoUT	+
	RtC	LoUT	+
	CCP	LoUT	+
	LoETM	LoUT	+
	LoIA	LoUT	+
	IPLC	LoUT	+
	LoUT	B&IC	+
	LoICT	LoUT	+
G	RnTRSR	LoGS	+
	LoGS	HII	+
	LoGS	LoP	+
	LoPB	LoP	+
	LoIW	LoPB	+
	LoGS	LoPB	+
	LoGS	MR&T	-
	LoGS	IVIPD	-
	LoGS	LoIW	+

Theme	Factor A	Factor B	Polarity
	LoGS	LoETM	+
	LoGS	RtC	+
	LoIA	LoGS	+
F	HII	RtC	+
	CS	RtC	+
	SfLC	RtC	+
	HII	CRtC	+
	TCPACNA	CRtC	+
	TCPAFTM	CRtC	+
	LoTSC	CRtC	+
	LoIW	HII	+
	TCPAFTM	CLA	+
	R&I	SoCIS	+
	CS	MR&T	-
	HII	MR&T	-
	SfLC	CRtC	+
	HFCNS	RtC	+
	CS	LoC	+
	CC	CCP	MR&T
CCP		LoC	+
SPA		MR&T	-
SPA		LoIU	+
SPA		LoC	+
SPA		RtC	+
LoI		RtC	+
LoC		LoI	+
LoT		LoI	+
LoTP		MR&T	-
SPA		AAJPC	-
LoC		LoCo	+
LoI		LoIU	+
LoLean		MR&T	-
PM		MR&T	-
CO	LoP	AaW	-
	LoP	LoIA	+
	LoIA	LoIU	+
	LoF	RtC	+
	LoIA	RtC	+
	LC	RtC	+
	LoLean	RtC	+
	PORB	RtC	+
	PORB	CRtC	+
	LoIA	CRtC	+
	BR	CRtC	+
	EDTG	DHQD	+
	LoF	DiC	+
	LOCm	DiC	+
	LoPr	MSTD	+
	LoEI	PDT	+
	LoCA	PM	+
	CCP	PM	+
MoI	IDCOC	+	
LoIA	LoIW	+	

Theme	Factor A	Factor B	Polarity
	LoIA	LoCo	+
	LC	LoIW	+
	LoLean	IVIPD	-
	LoEI	LoIW	+
	LoES	CCP	+
	PORB	LoIW	+
	LoCA	SfF	-

Following this, the next stage of the research involved identifying the critical factors and their interrelated chains that impact IPD implementation in New Zealand. This process answered **1.9.4 Research Question 4**.

4.5 Results for Research Question 4

Likewise, to Research Question 3, in Research Question 4, the critical factors were identified through centrality methods, DC, and EC, frequency analyses, SSI, and SLR. The factors that appeared in every analysis were deemed critical. Additionally, critical chains were identified from the interactions between the factors. Section 4.5.1 outlines the critical factors, Section 4.5.2 details the validated critical factors, Section 4.5.3 outlines the critical chains, and Section 4.5.4 outlines the validated critical chains.

4.5.1 Critical factors

The factors with the highest degree and eigenvector centralities are listed in Table 15. *Degree Centrality* explains degree centrality in detail, and *Eigenvector Centrality* explains eigenvector centrality in detail. For eigenvector centrality computation, all factors to IPD were arranged in a matrix based on their incoming nodes. The matrix was multiplied by a column vector of unit 1, and the total incoming nodes of each factor were listed (Meghanathan, 2015). Then, the normalised value was calculated (the square root of the sum of squares of node values). The node value of each factor was divided by the normalised value, resulting in the eigenvalue of each factor. The iterations were repeated until the normalised value stabilised (Meghanathan, 2015). After eight iterations, the normalised value stabilised, and the final eigenvalues of each factor were noted. Table 23 in *Appendix 5- Eigenvector Centrality computation* details the eigenvector centrality calculation. Table 15 compares the top 10 factors from DC, EC, and frequency analyses. The factors identified in the literature, as determined by the SLR frequency analysis, are global IPD factors. On the other hand, the factors listed in the SSI frequency and both centrality analyses are specific to New Zealand.

4.5.1.1 Comparison of top factors

Table 15: Comparison of IPD factors as per various analyses

Factor	Degree of centrality	Degree of centrality rank	Factor	Eigenvector centrality	Eigenvector centrality rank	Factor	SSI frequency	SSI frequency rank	Factor	SLR frequency	SLR frequency rank
RtC	1	1	CRtC	0.449	1	LoC	15	1	CLA	27	1
CRtC	0.69	2	RtC	0.434	2	LoIA	15	1	LoUT	24	2
LoGS	0.65	3	LoUT	0.385	3	CLA	13	2	LoIA	18	3
LoIA	0.6	4	LoIW	0.29	4	RtC	12	3	CCP	17	4
MR&T	0.56	5	AaW	0.273	5	LoI	11	4	HII	16	5
LoC	0.52	6	MR&T	0.244	6	MR&T	11	4	LoC	15	6
LoUT	0.52	6	HII	0.187	7	CRtC	11	4	MR&T	10	7
LoIW	0.47	7	LoPB	0.187	7	LoGS	11	4	RtC	9	8
CLA	0.39	8	B&IC	0.176	8	LoUT	11	4	LoGS	8	9
CCP	0.34	9	CEC	0.176	8	LoIW	7	5	LoI	7	10
SPA	0.34	9	LoP	0.139	9	CCP	7	5	IDCOC	7	10
LoP	0.34	9	LoF	0.124	10	HII	7	5			
HII	0.30	10				B&IC	7	5			

The next section details the grouping of factors obtained from the statistically significant interactions.

4.5.2.2 Grouping of factors from all statistically significant interactions as per various analyses

Table 16 details the individual factors from the Vensim model, grouped by node, along with their degree and eigenvector centralities.

Table 16: Analysis of the factors of IPD

Factor	SLR Frequency	IN	ON	TN	DC	EC
MIR	2	0	1	1	0.08	0
CEC	5	1	0	1	0.08	0
CLA	27	1	6	7	0.54	0
SPA	6	1	5	6	0.46	0
AAJPC	2	2	0	2	0.15	0
LoIP	6	1	0	1	0.08	0
LoGS	8	3	8	11	0.85	0.141
MR&T	10	9	0	9	0.69	0.215
LoC	15	4	2	6	0.46	0
IoSR	2	0	2	2	0.15	0
ONIA	2	1	0	1	0.08	0
CRtC	6	10	0	10	0.77	0.332
HFCNS	3	0	3	3	0.23	0
LoUT	24	8	1	9	0.69	0.465
PORB	1	0	4	4	0.31	0
RtC	9	12	1	13	1	0.405
CCP	17	1	4	5	0.38	0
LoETM	5	1	1	2	0.15	0.0682
LoIA	18	1	7	8	0.62	0.207
IPLC	3	0	1	1	0.08	0
B&IC	2	1	0	1	0.08	0.353
LoICT	2	0	1	1	0.08	0
RnTRSR	4	0	1	1	0.08	0
HII	16	2	3	5	0.38	0.194
LoP	2	2	2	4	0.31	0.218
LoPB	1	2	1	3	0.23	0.2
LoIW	1	5	2	7	0.54	0.233
IVIPD	2	2	0	2	0.15	0.0706
CS	5	0	3	3	0.23	0
SfLC	1	0	2	2	0.15	0
TCPACNA	1	0	1	1	0.08	0
TCPAFTM	1	0	2	2	0.15	0
LoTSC	1	0	1	1	0.08	0
R&I	1	0	1	1	0.08	0
SoCIS	2	1	0	1	0.08	0

Factor	SLR Frequency	IN	ON	TN	DC	EC
LoIU	4	3	0	3	0.23	0.163
LoI	7	2	2	4	0.31	0
LoT	2	0	1	1	0.08	0
LoTP	3	0	1	1	0.08	0
LoCo	2	2	0	2	0.15	0.137
LoLean	2	0	3	3	0.23	0
PM	1	2	1	3	0.23	0
AaW	4	1	0	1	0.08	0.206
LoF	1	0	2	2	0.15	0
LC	1	0	2	2	0.15	0
BR	1	0	1	1	0.08	0
EDTG	1	0	1	1	0.08	0
DHQD	3	1	0	1	0.08	0
DiC	1	2	0	2	0.15	0
LOCm	2	0	1	1	0.08	0
LoPr	3	0	1	1	0.08	0
MSTD	2	1	0	1	0.08	0
LoEI	1	0	2	2	0.15	0
PDT	1	1	0	1	0.08	0
LoCA	1	0	2	2	0.15	0
MoI	2	0	1	1	0.08	0
IDCOC	7	1	0	1	0.08	0
LoES	4	0	1	1	0.08	0
SfF	1	1	0	1	0.08	0

The factors with the highest degree and eigenvector centralities are listed in Table 17, along with their frequencies in the literature. *Degree Centrality* explains degree centrality in detail, and *Eigenvector Centrality* explains eigenvector centrality in detail. The RII values of the statistically significant interactions were used to compute the eigenvector centrality. This is in contrast to the SSI results, where a unit value of 1 was used for every interaction. This is because the SSI process had a small number of participants (18) compared to the survey respondents (137), hence the survey results were deemed more reliable. Table 27 in *Appendix 9- Eigenvector Centrality computation* details the eigenvector centrality computation.

4.5.2.3 Comparison of top factors

Table 17 categorises the top-ranked factors according to SLR, degree centrality, and eigenvector centrality analyses.

Table 17: Comparison of IPD factors using various analyses

Factor	Degree of centrality	Degree centrality rank	Factor	Eigenvector centrality	Eigenvector centrality rank	Factor	SLR Frequency	Frequency rank
RiC	1	1	LoUT	0.465	1	CLA	27	1
LoGS	0.85	2	RiC	0.405	2	LoUT	24	2
CRiC	0.77	3	B&IC	0.353	3	LoIA	18	3
MR&T	0.69	4	CRiC	0.332	4	CCP	17	4
LoUT	0.69	4	LoIW	0.233	5	HII	16	5
LoIA	0.62	6	LoP	0.218	6	LoC	15	6
LoIW	0.54	7	MR&T	0.215	7	MR&T	10	7
CLA	0.54	7	LoIA	0.207	8	RiC	9	8
LoC	0.46	9	AaW	0.206	9	LoGS	8	9
SPA	0.46	9	LoPB	0.2	10	LoI	7	10
						IDCOC	7	10

The next section looks at the critical chains. Section 4.5.3 presents the results of the causal chains inferred from the interactions between factors reported by the interviewees, as well as the most critical chains categorised according to the analysis methods. Section 4.5.4 presents the results of the causal chains inferred from the validated interactions between factors reported by the broader New Zealand construction industry, as well as the most critical chains categorised according to the analysis methods.

4.5.3 Critical chains

Causal Chain Analysis explains causal chain analysis in detail. The Vensim model, constructed from the interactions revealed by the expert interviewees, served as the logic model and was analysed to identify possible causal chains that impact IPD implementation in New Zealand. Table 24 in *Appendix 6- Causal Chain Analysis* details the analysis of the identified critical chains in terms of chain length, weight, degree centrality weight, and eigenvector centrality weight.

Table 24: Causal Chain Analysis reveals that 24 factors, namely, TCPAFTM, CCRL, IPLC, CS, LoCA, PORB, HFCNS, IoSR, LoFIPDCM, LoPB, SfLC, LoESIPD, LoTP, RnTRSR, LoTSC, BR, TCPACNA, HII, IPIT, LC, LoP, LoPr, LoEI, and LoENR, start a causal chain, and all chains apart from 41, 44, and 45 end with either B&IC or CEC. This highlights that BIM and IPD integration, as well as cost estimation challenges, often result from a series of preceding factors. Chains 41, 44, and 45 end with LoPB, MR&T, and LoIU, respectively. The chain weight was calculated using the polarity between the factors in the chain; for example, a positive relationship had a score of (+1), while a negative relationship had a score of (-1). Similarly, the chain degree and eigenvector centrality weight were calculated by substituting the factor value instead of (+/-1).

The longest chain starts with TCPAFTM, which signals that the additional design fees paid by the client due to time and material-based compensation are the root cause of the problem, as they lead to complications with contractual legal aspects, prompting the self-protective approach taken by stakeholders. This leads to a lack of collaboration and integration among stakeholders, resulting in a lack of interest, which in turn causes resistance from both stakeholders and the client. As clients refuse to adopt IPD, this leads to a lack of industry-wide standardisation of IPD, which in turn causes a high initial investment for new IPD projects. The significant investment causes resistance from the government in publicly funded projects, as they often seek the lowest cost. This leads to a lack of professional bodies being established in New Zealand, as there is limited support for IPD, which in turn reduces promotion and awareness among contractors. This unfamiliarity causes challenging cultural paradigms as the project parties resist IPD requirements, such as the use of modern technology. Ultimately, the lack of technology use causes challenges in cost estimation, as well as difficulties with BIM and IPD integration.

It is significant to note that while chains 1 and 2, commencing with TCPAFTM, have the most factors (18), they are not the strongest in terms of eigenvector centrality weightage. Chains 5 and 6, beginning

with IPLC, and chains 19 and 20, starting with LoPB, are the heaviest, with an eigenvalue of 2.694. This can serve as the basis of an argument that the lack of opportunities for industry participants to receive IPD training, combined with the absence of professional bodies associated with IPD, are crucial factors that impact IPD implementation in New Zealand.

Table 18 examines the most critical chains identified through the causal chain analysis.

Table 18: Critical chains of IPD factors

Factors in the chain	Number of factors in the chain	Chain weight	Chain centrality weight (degree centrality)	Chain centrality weight (eigenvector centrality)
TCPAFTM-CLA-SPA-LoC-LoI-LoIU- RtC- CRtC-LoIW-HII-LoGS-LoPB- LoP-LoIA- LoF-CCP-LoUT-B&IC	18	17	7.1739	2.576
TCPAFTM-CLA-SPA-LoC-LoI-LoIU- RtC- CRtC-LoIW-HII-LoGS-LoPB- LoP-LoIA- LoF-CCP-LoUT-CEC	18	17	7.1739	2.576
IPLC-LoIA-LoF-CCP-LoC-LoI-LoIU- RtC- CRtC-LoIW-HII-LoGS-LoPB- LoP-LoETM- LoUT-B&IC	17	16	6.5652	2.694
IPLC-LoIA-LoF-CCP-LoC-LoI-LoIU- RtC- CRtC-LoIW-HII-LoGS-LoPB- LoP-LoETM- LoUT-CEC	17	16	6.5652	2.694
LoPB-LoP-LoIA-LoF-CCP-LoC-LoI- LoIU-RtC-CRtC-LoIW-HII-LoGS- LoETM-LoUT- B&IC	16	15	6.4782	2.694
LoPB-LoP-LoIA-LoF-CCP-LoC-LoI- LoIU-RtC-CRtC-LoIW-HII-LoGS- LoETM-LoUT- CEC	16	15	6.4782	2.694

Section 4.5.4 examines the critical chains derived from the validated survey results.

4.5.4 Validated critical chains

Table 28 in *Appendix 10- Causal Chain Analysis* details the critical chains based on all statistically significant survey interactions. *Table 28: Causal Chain Analysis* reveals that 27 factors start a causal chain. This contrasts with the prior analysis in 4.5.3 *Critical chains*, where 24 factors were identified that initiated a causal chain. Although the number of causal chains identified in this analysis is fewer than those in Section 4.4.3, more factors have been identified in the validated results that initiate a causal chain. LoGS and LoP have been identified as the factors that cause the heaviest causal chains in terms of degree centrality. This can be reasoned down that the broader workforce of the New Zealand construction industry believes that the lack of governmental support, along with the lack of promotion of IPD, are significant factors that cause a ripple effect. Additionally, LoIW causes the heaviest chain

in terms of eigenvector centrality. This can be the basis of an argument that the lack of industry-wide standardisation of IPD in New Zealand is a notable factor and thus should be given ample consideration. The wider workforce of the New Zealand construction industry is of the opinion that the lack of industry-wide standardisation hinders the formation of professional bodies associated with IPD, which leads to a lack of promotion of IPD. This causes IPD unawareness among stakeholders, which doesn't help in acquiring support from the government regarding IPD implementation. The lack of government support leads to resistance from project stakeholders in adopting essential requirements for IPD implementation, such as the use of modern technology. Ultimately, the lack of technology use leads to issues with BIM and IPD integration. Table 19 details the validated critical chains.

Table 19: Validated critical chains of IPD factors

Factors in the chain	Number of factors in the chain	Chain weight	Chain centrality weight (degree centrality)	Chain centrality weight (eigenvector centrality)
LoGS - LoP - LoIA - LoIW - HII - RtC - LoUT - B&IC	8	7	4.38	1.863
LoP - LoIA - LoGS - LoIW - HII - RtC - LoUT - B&IC	8	7	4.38	1.863
LoIW - LoPB - LoP - LoIA - LoGS - RtC - LoUT - B&IC	8	7	4.23	1.869
CLA - LoGS - LoP - LoIA - LoIW - HII - RtC - LoUT	8	7	4.23	1.398
CLA - LoGS - LoPB - LoP - LoIA - RtC - LoUT - B&IC	8	7	4.23	1.636
LoIA - LoGS - LoIW - HII - RtC - LoUT - B&IC	7	6	4.08	1.645
RnTRSR - LoGS - LoPB - LoP - LoIA - RtC - LoUT - B&IC	8	7	3.77	1.636

The next section discusses the results for *1.9.5 Research Question 5*.

4.6 Results for Research Question 5

The *Statistically significant interactions* identified from the system-wide survey questionnaire can be used to answer Research Question 5. The validated factors of IPD can be identified from *Table 16: Analysis of the factors of IPD* and the validated critical factors can be identified from *Table 17: Comparison of IPD factors using various analyses*. A framework was developed that details the results comprehensively, with validated factors grouped by theme, the validated critical factors highlighted, and the interactions of each factor are clearly presented. The framework can be used as a standalone guide for industry practitioners, stakeholders, academics, and researchers. Figure 18 illustrates the framework, presenting the findings of this research study.

4.7 Chapter summary

This chapter presented the results from all data collection methods: SLR, SSI, and the system-wide survey questionnaire. *1.9.1 Research Question 1* identified the critical factors from the SLR, which consisted of RtC, MR&T, and CCP that appeared in every analysis; and because of the interlink effect, CEC, CRtC, DiA, and I were deemed critical as well due to their presence among the top factors in both centrality analyses. *1.9.2 Research Question 2* identified the factors of IPD in the New Zealand context, with the results presented using infographics generated from NVivo software. *1.9.3 Research Question 3* examined the interactions between the factors of IPD in the New Zealand context, with the results presented in the form of CLDs using Vensim software. The identified interactions from the SSI were modelled into a CLD, and the network was analysed using centrality techniques: DC and EC. Further, CCA was employed to identify the critical chains. The SSI results were validated using the system-wide survey questionnaire, the results of which were analysed using the RII method and the t-test. *1.9.4 Research Question 4* involved identifying the critical factors of IPD and their interrelated chains in the New Zealand context. The SSI results were grouped into a comparison table consisting of DC, EC, SSI frequency, and SLR frequency. The factors that appeared in every analysis were deemed critical; the factors that appeared in every analysis except the SLR were deemed as next-level critical factors in the New Zealand context. RtC, HII, MR&T, and LoUT were identified as the critical factors; and CRtC and LoIW were identified as the next-level critical factors. Through CCA, it was found that twenty-four factors start a causal chain; 45 causal chains were found, out of which six were deemed critical. For validation, the results were triangulated with the system-wide survey questionnaire. Out of 142 interactions identified from the SSI, eighty-eight were deemed statistically significant. The statistically significant interactions were again modelled into a CLD using Vensim software, and the network was analysed using DC, EC, and CCA. The factors were again grouped into a comparison table consisting of DC, EC, and SLR frequency, and the factors that appeared in every analysis were deemed critical. The factors that appeared in every analysis except the SLR frequency were deemed as next-level critical factors in the New Zealand context. LoIA, RtC, MR&T, and LoUT were identified as the critical factors; and CRtC, along with LoIW, were identified as the next-level critical factors. Through CCA, it was found that 27 factors start a causal chain; out of 30 chains, 7 were deemed critical. *1.9.5 Research Question 5* provided an appropriate framework detailing the validated interactions between the factors of IPD. The framework was intended to be a standalone guide for industry practitioners, stakeholders, researchers, and academics alike, that can be used to refer to the findings of this research study.

Chapter 5- Discussion

5.1 Chapter introduction

This section discusses the results of the critical factors of IPD obtained from the literature, as well as the critical factors of IPD and their interactions in the New Zealand context. Aligned with the Research Questions, the chapter unfolds systematically. In section 5.2, the discussion for Research Question 1 is presented, followed by section 5.3, which delves into Research Question 2. Section 5.4 is dedicated to the discussion regarding Research Question 3, while section 5.5 addresses Research Question 4. Section 5.6 presents the discussion for Research Question 5. Section 5.7 synthesises the results of all Research Objectives to explain the process of the development of the framework, while section 5.8 compares the results with recent studies on IPD. Finally, section 5.9 provides a summary of the chapter.

5.2 Discussion for Research Question 1

With reference to Section 4.2 *Results for Research Question 1* that answers 1.9.1 *Research Question 1*, the comparison table, *Table 10: Comparison between the top factors of IPD as per various analyses*, shows that MR&T, RtC, and CCP are the only critical factors that appear in all types of analyses. Despite the frequency ranking, which indicates the number of authors who identified it as a factor of IPD, the factors that appear in degree centrality and eigenvector centrality analyses should be considered critical and studied in more detail due to the interlink effect. Hence, it is vital to consider the factors CRtC, DiA, I, and CEC that appear in these two analyses.

5.2.1 MR&T (DC rank= 3, EC rank= 1, SLR frequency rank= 7)

In the construction industry, segregated organisational structures often result in hostile relationships, defensive behaviour, and inefficient performance (Kadefors, 2004). Trust represents a mutual confidence between interrelated parties when the nature of the exchange could potentially expose them to some degree of vulnerability (Coleman, 1990). Trust is more significant in large, complex projects and unified, multidisciplinary environments due to a larger network of interdependencies and a greater need for project participants to depend on each other's actions (Swan et al., 2002). One of the most critical drivers of change in the construction industry is the lack of trust (Duke et al., 2010). Interpersonal mistrust leads to guarded behaviours and deteriorated conflicts, which result from individuals pursuing and protecting their interests. In such cases, it is challenging to achieve a collective purpose. Additionally, lack of trust reduces efficiency and team productivity (Ashcraft, 2011). Notably, a sufficient level of trust reduces exchange costs in business relationships (Wood & McDermott, 1999). Mutual respect and trust can be divided into goodwill and competence trust (Zhang et al., 2018). Goodwill trust has a positive impact on collaboration, while competence trust

exhibits a U-shaped effect. Goodwill trust occurs when project stakeholders prioritise their common interests instead of pursuing their own interests. On the other hand, competence trust can be defined as being confident in partners' capabilities to complete a project. Competence and trust are essential for joint decision-making (Zhang et al., 2018). Pishdad-Bozorgi and J. Beliveau (2016) believe that the lack of mutual trust among project stakeholders regarding financial and management issues leads to an increase in changes, disputes, and claims, resulting in additional costs for the projects. Mutual respect and trust was identified as a critical factor based on the results of all analyses. Indeed, the characteristics of the IPD model necessitate that all project participants have a high level of trust among themselves. Resistance to change is discussed next.

5.2.2 RtC (DC rank= 1, EC rank= 3, SLR frequency rank= 8)

Jadidoleslami et al. (2022) defined resistance to change as the necessity of moving away from traditional management towards implementing modern management, particularly creating integration in management. Resistance to change can come from the project stakeholders or the client. Nonetheless, the tendency to use traditional contracts causes resistance to new ideas (O'Connor, 2009). Rached et al. (2014) think that organisations and people are resistant to new ideas. Porwal and Hewage (2013) believe that one of the significant challenges to IPD is resistance to change. Abanda et al. (2015), Olawumi et al. (2018), and Evans and Farrell (2020) each found that resistance to change from conventional construction practices is a significant factor in implementing IPD. The resistance to change among construction stakeholders is a key barrier to implementing innovative project delivery models, such as IPD. Resistance to change has negatively impacted the skills, knowledge, and experience of project stakeholders in the construction industry. Hence, for the construction industry to experience increased implementation of the IPD model, a significant change in stakeholders' attitudes and perceptions is warranted (Evans et al., 2021). Additionally, Ma et al. (2022) believe that the changes from traditional project delivery methods to IPD may create barriers due to resistance from diverse areas. However, some of these components and changes have been implemented by industry practitioners with experience in integration from previous projects. Although the changes required to adopt IPD may create barriers to implementation, practitioners' perceptions of these barriers may vary according to the degree of integration experience they have accumulated (Ma et al., 2022). Sherif and Abotaleb (2022) mentioned the concept of personal resistance to change, i.e., stakeholders depend on the types of contracts they trust and are reluctant to change. Bhonde et al. (2020) noted that resistance to change can stem from greater involvement in project management, while Boodai (2014) believed that resistance to change can originate from cultural issues. Moreover, Ghassemi and Becerik-Gerber (2011) identified that resistance can also stem from reluctance to cross-disciplinary input during the early design stage. Additionally, Lines et al. (2015) believe that overcoming resistance to change is linked to factors such as education and leadership. Finally, Fischer et al. (2017) suggested that the concept of co-location in IPD implementation may be a cause of resistance due to expenses and practical considerations. Resistance to change is a renowned critical factor of IPD in the global context

as the adversarial nature of the construction industry makes it challenging for the project stakeholders to invest in each other for the sake of the project. Challenging cultural paradigms are discussed next.

5.2.3 CCP (DC rank= 6, EC rank= 2, SLR frequency rank= 4)

Challenging cultural paradigms arise because several construction companies are unwilling to adopt an alternative approach, there is limited information about the process, and there is inadequate industry support (Ebekozi, 2022). Additionally, Alinezhad et al. (2020) identified CCP as one of the significant barriers to IPD implementation, reasoning that varying cultural issues in individual countries hinder its implementation. Ghassemi and Becerik-Gerber (2011) revealed that integrating project personnel, IPD training, and trust-building activities and tools can be undertaken to overcome cultural barriers. Challenging cultural paradigms was identified as a critical factor based on the results of all analyses. It is relevant in the global context, as large-scale projects where IPD may be implemented typically consist of personnel from various backgrounds, and the differences in beliefs, work processes, and behavioural expectations lead to the development of cultural issues. The client's resistance to change is discussed next.

5.2.4 CRtC (DC rank= 2, EC rank= 2)

In IPD projects, the owner diligently and continuously participates throughout the project to identify the value and prioritise the alternatives. The owner is, in fact, an essential contributor, rather than simply a service buyer (Cheng & Johnson, 2016). An IPD owner should have 5 key characteristics: clarity, commitment, engagement, leadership, and integrity (Fischer et al., 2017). The IPD owner must be able to define what they want and what the IPD team must achieve. IPD owners should express commitment to IPD and a willingness to support the process with training and resources. IPD owners should be empowered and fully engaged with the project team. Additionally, there is a need for leadership in IPD owners. The more leadership an IPD owner takes, the better value and the more success is driven into the project. Further, the quality of integrity is important in IPD owners. The IPD owner needs to create a space and environment that fosters trust-based relationships (Fischer et al., 2017). Moreover, when selecting team members, IPD owners must consider an individual's past performance and experience, competency, collaborative ability, commitment to the IPD principles, and, most importantly, the presence of a good pre-existing business relationship among the team members (Pishdad-Bozorgi & Beliveau, 2016). The client's resistance to change makes IPD implementation unlikely, and this is particularly significant in the NZ context, given its highest EC value. Risk will never be shared among the project stakeholders without the client's willingness. In IPD, the client is a key factor in ensuring project success (Li & Ma, 2007). Govender et al. (2018) identified clients' not seeing the advantages of IPD as a significant barrier to its implementation. Karasu et al. (2023) also concluded that clients and owners play a key role in transitioning to a more collaborative

approach. Additionally, without the owner's willingness, risk will not be shared among the project parties. In the IPD context, the involved owner is a key factor in determining project success. Moreover, the owner decides on the project delivery model to be used, payment options, and selection of the project parties. Therefore, if the owner does not want to implement IPD, little can be done. Improving the level of awareness of the potential benefits of IPD adoption may increase owners' willingness, which can be achieved through continuous professional development programs conducted by professional bodies in the built environment (Li & Ma, 2007). The client's resistance to change is a critical factor of IPD implementation, as the model cannot be implemented without their approval and consent. The difficulties in achieving financial transparency are discussed next.

5.2.5 DiA (DC rank= 7, EC rank= 2)

Difficulties in achieving financial transparency reduce collaboration and trust among project stakeholders (Ahmad et al., 2019). Establishing elements of sharing risks, rewards, and financial transparency can take time (Rodrigues & Lindhard, 2021). To increase financial transparency among project stakeholders, contractual documents should be adapted and signed at an early stage, and cost estimates should be carried out as an iterative process with the project's central concept frozen at an early stage to enhance understanding and minimise risks (Rodrigues & Lindhard, 2021). DiA was identified as a critical factor based on its presence in both centrality analyses and should be given importance. The factor causes issues with collaboration and diminishes trust between the project stakeholders due to fears of uneven profit distribution, which makes IPD implementation unlikely. Interoperability is discussed next.

5.2.6 I (DC rank= 8, EC rank= 3)

The factors of interoperability or coordination between stakeholders include tasks, interdependence, human differences, environment, contract type, and time constraints (Zhang et al., 2018). Moreover, when stakeholders perceive greater equity in information sharing, they become more open to increased coordination, which in turn enhances collaboration (Zhang et al., 2018). Additionally, Azhar et al. (2014) revealed in their research that the need for more effective interoperability is a major hurdle to inter-organisational integration. Further, as inter-organisational integration significantly contributes to implementing multi-party contracts in IPD projects, the interoperability issue must be addressed. Interoperability was identified as a critical factor based on its presence in both centrality analyses; it plays a part in the level of collaboration required for an IPD project. Cost estimation challenges are discussed next.

5.2.7 CEC (DC rank= 9, EC rank= 4)

IPD lacks an accurate cost estimation methodology at the front end of a project when little information

is available (Elghaish et al., 2010). Additionally, several financial management challenges are associated with integrating BIM with IPD (Elghaish & Abrishami, 2020). Some solutions have been proposed in the literature to overcome these challenges. These include utilising 5D BIM with Monte Carlo simulation, mathematical models developed through detailed 5D BIM models, and a novel mechanism for managing cost savings by distinguishing between saved resources at the organisational level and the daily task level, which increases trust among stakeholders (Elghaish et al., 2010). The challenge associated with cost estimation was identified as a critical factor due to its presence in both centrality analyses. The factor is of considerable significance as IPD will face implementation challenges in the absence of an accurate cost estimate that can prepare the stakeholders in advance regarding their financial commitments. The next section discusses the results for **1.9.2 Research Question 2**.

5.3 Discussion for Research Question 2

Research Question 2 investigates the influencing factors of IPD in the New Zealand context. Therefore, the validated critical factors from **4.5.2.3 Comparison of top factors** can be studied in more detail. **Table 17: Comparison of IPD factors using various analyses** identifies RtC, MR&T, LoUT, and LoIA as the factors that were highly rated in every analysis. Additionally, LoIW and CRtC appeared in both degree centrality and eigenvector centrality analyses; hence, they should be considered critical due to the interlink effect. RtC, MR&T, LoUT, LoIA, LoIW, and CRtC are discussed below:

5.3.1 RtC (DC rank=1, EC rank=2, SLR frequency rank=8)

RtC has been discussed previously in the section **5.2.2 RtC (DC rank= 1, EC rank= 3, SLR frequency rank= 8)**.

5.3.2 MR&T (DC rank=4, EC rank=7, SLR frequency rank=7)

MR&T has been discussed previously in the section **5.2.1 MR&T (DC rank= 3, EC rank= 1, SLR frequency rank= 7)**. The lack of technology use is discussed next.

5.3.3 LoUT (DC rank=4, EC rank=1, SLR frequency rank=2)

Several organisations and bodies have recognised the effective implementation of IPD through the use of technology (AIA, 2007; AIA and AGC, 2011; NASFA et al., 2010). However, the lack of technology use is a critical factor to IPD. Kent and Becerik-Gerber (2010) identified that the industry's use of technology and BIM is not advanced enough to support IPD. Evans and Farrell (2020) reconfirmed the findings, revealing that current technology use is not satisfactory. Eastman et al. (2011) believe that there is no extensive BIM-based cost management platform that can perform all cost-

related procedures. The combination of BIM and IPD enables a level of collaboration that enhances productivity and minimises errors, in addition to allowing for the exploration of new, innovative concepts (Khanna et al., 2021). Porwal and Hewage (2013) revealed that IPD may be most effective in facilitating the use of BIM in construction projects. Moreover, IPD with BIM and ICT enhances the utilisation of technology while also changing the whole design and construction process. Also, professional leaders in the AEC industry are getting more aware of the potential of integrating emerging digital technologies such as cloud computing, BIM, blockchain, and mixed realities with tried-and-true workflow procedures, resulting in notable productivity gains and reductions in RFIs, field disputes, waste, and project timelines (Khanna et al., 2021). However, Ahmed and Sobuz (2019) revealed that two key roadblocks to widespread adoption of IPD in developing countries are the lack of standard BIM contract agreements and problems with using BIM as a collaborative framework. The lack of technology use is a critical factor in the New Zealand context, as not only is the current level of technology implementation far behind that of other developed countries, but technology use is also an essential requirement for implementing IPD. The lack of IPD awareness among stakeholders is discussed next.

5.3.4 LoIA (DC rank=6, EC rank=8, SLR frequency rank=3)

Kahvandi et al. (2019) identified the lack of IPD awareness as the primary barrier to its implementation in their research. Additionally, Forero et al. (2015) also believe that one of the primary barriers to IPD implementation is the lack of awareness and knowledge among the stakeholders. Alqahtani et al. (2022) studied the barriers to IPD implementation in Saudi Arabia and identified that the Saudi construction sector was largely conscientious and pragmatic in nature, and the dearth of awareness made IPD implementation challenging. An approach to increasing IPD awareness among project participants involves training them several months prior to the project's commencement, which enhances cooperation and mutual trust among them (Kahvandi et al., 2019). The lack of IPD awareness among stakeholders is a critical factor in New Zealand, as a large proportion of the construction workforce isn't familiar with it. This unfamiliarity is also a reason for resistance to change from not only the project stakeholders but also the client.

5.3.5 CRtC (DC rank=3, EC rank=4)

CRtC has been discussed previously in the section *5.2.4 CRtC (DC rank= 2, EC rank= 2)*. The lack of industry-wide standardisation is discussed next.

5.3.6 LoIW (DC rank=7, EC rank=5)

The construction industry is traditionally conservative and largely risk-averse, with recognised project delivery models and contractual frameworks that may not be easily adapted to the collaborative nature

of IPD (Agupugo, 2023). The lack of industry standardisation is a significant factor in the NZ context, even though it wasn't among the critical factors in the SLR results. Kent and Gerber (2010) emphasised the importance of BIM adoption for successful IPD adoption. They revealed that the absence of standard BIM contract documents and issues arising from the use of BIM as a collaborative framework are two major factors hindering the implementation of IPD. Additionally, Kraatz et al. (2014) also identified the lack of industry standardisation as a factor in IPD implementation. As the construction industry continues to face increasing pressure to enhance safety, reduce costs, and meet environmental and regulatory requirements, the adoption of IPD could play a critical role in helping to achieve these objectives (Akpe et al., 2024). The successful implementation of IPD in the construction industry requires a strategic approach, including the establishment of clear contractual frameworks, fostering a culture of collaboration, investing in training, promoting technology adoption, encouraging early stakeholder involvement, and aligning IPD with project-specific goals and industry standards (Ekechukwu & Simpa, 2024). Akpe et al. (2024) emphasised on the establishment of clear contractual frameworks that meet IPD objectives. They further indicated that this can be achieved by developing agreements that outline shared goals, integrate decision-making processes, and establish mechanisms for resolving conflicts. The lack of industry-wide standardisation is a critical factor in New Zealand, even though it wasn't among the critical factors identified in the literature. The factor is of utmost importance and has a role to play in the impact of other identified critical factors as well. The impact of the critical factors can be better understood by examining the New Zealand-specific factors identified during the SSI process. These factors were not identified in the prior SLR conducted.

5.3.7 NZ-specific factors

The SSI process revealed LoFI, LCC, FvLCM, IoTM, EPM, HLC, StMCR, and Psz are the New Zealand-specific factors that are discussed below.

5.3.7.1 Lack of factual information about outcomes from IPD in NZ (LoFI)

The fact that RtC is one of the top factors influencing IPD in NZ is expected, as there are no documented case studies of successful IPD-delivered construction projects. Interviewee C10 quotes, 'What have we got in terms of? Uh. Factual information about outcomes from IPD in New Zealand?' Furthermore, the roles of LoIW and MR&T are also evident. IPD has not received industry recognition in NZ due to LoFI, which reduces the level of trust from the industry. The limited number of contractors and consultants doesn't help the IPD cause.

5.3.7.2 Limited number of contractors and consultants (LCC)

Due to NZ being a relatively small country, the limited number of construction professionals doesn't help the IPD cause, especially if most of the workforce lacks IPD awareness. Interviewee C16 quotes, 'And the fact that there are a limited number of both consultants and contractors and client

organisations.’ The impact of MR&T can be deduced since LCC implies that most contractors and consultants may have prior working experience with each other. If the parties do not have the proper MR&T required, it will be difficult to enter an IPD agreement. The fact that NZ has a complicated governance structure makes IPD implementation challenging.

5.3.7.3 Federal vs local council model policy and governance conflicts (FvLCM)

One of the unique challenges in NZ compared to other countries is the complicated governance structure that is pertinent to the construction industry. There are three governing bodies- federal, regional, and local. The main issue is that each has its own rules, which can cause immense confusion regarding legality and thus cause resistance. RtC and CRtC have been identified as critical factors to IPD in NZ, and it is not surprising to see why. Interviewee C4 quotes that, ‘the only thing real difference between New Zealand and other countries is the state versus local Council model or the state being the federal.’ Further, interviewee C14 reconfirmed the use of a regional council code in NZ, as quoted, ‘Let's go with something that's New Zealand-based. Like a Regional Council code and stuff. So when the alliance was formed, they would form to a certain spec and certain code. That's how you get billed.’ The NZ construction industry prefers traditional project delivery models over newer, untried ones.

5.3.7.4 Industry opting for traditional models (IoTM)

This can also be reasoned to RtC. The construction sector in NZ is not interested in untried project delivery models. Interviewee C18 quotes, ‘So compared to, for example, other countries, New Zealand. Has a lot to improve. And more the views. Basically, most are still more traditional compared to for example other developed countries.’ Additionally, the NZ construction industry lags in terms of technology adoption. The current BIM usage is comparable to that in San Francisco 20 years ago, as mentioned by interviewee C1. The impact of LoUT is clear: New Zealand is trailing other developed countries in terms of technology use. Also, interviewee C17 believes that the NZ construction industry is still in a learning phase concerning IPD. It was found out that resistance in NZ is mainly from the experienced professionals.

5.3.7.5 Experienced professionals’ mindset (EPM)

One of the primary reasons for the prominence of RtC in NZ is that older, experienced professionals are often resistant to change. Younger professionals are more interested in modern approaches, but they are not heard enough, as not much can be done if a director or chief executive is opposed to change. Interviewee C2 quotes, ‘My opinion, my personal opinion is, is the younger generation are often more receptive to change processes, and the older generation are often seen believing that that's always been done this way.’ Moreover, interviewee C1 also stated that the most significant influence on collaboration levels in NZ is from the client. CRtC plays an important role here, as collaborative delivery models like IPD will not be implemented if the client resists change. Also, there is a history of liquidation of contractors in NZ.

5.3.7.6 History of liquidation of contractors resisting risks (HLC)

Another prominent NZ-specific factor is that many contractors have gone into liquidation, thus increasing the caution taken by contractors. The increased caution results in resistance, which places RtC and CRtC into perspective. New project delivery approaches are deemed risky. Interviewee C6 quotes, ‘I think contractors have become more aware due to probably the number of main contractors that have gone into liquidations.’ Another relevant factor is that many subcontractors are taking main contractor roles.

5.3.7.7 Subcontractors taking main contractor roles (StMCR)

The surge in the number of contractors going into liquidation has led to a significant number of subcontractors taking on main contractor roles. The smaller firms cannot cope with the financial requirements of IPD and are thus resistant. This can be resonated to RtC. Interviewee C7 quotes, ‘Umm, I think the New Zealand context has a particular challenge in that contractors who were normally quite you know are moving from second tier to become what is our essentially our first tier or our subcontractors picking up more head contractor roles.’ Lastly, project size is another NZ-specific factor.

5.3.7.8 Project size (Psz)

Smaller-sized projects are quite prominent in NZ and hence IPD is not seen as a feasible choice of project delivery option. Interviewee C17 quotes, ‘Most of the projects we work on on daily basis, they are very small in scale which doesn't require the IPD model.’ This can again be resonated to RtC.

The next section discusses the results for *1.9.3 Research Question 3*.

5.4 Discussion for Research Question 3

Research Question 3 investigates the interactions between factors that impact IPD implementation in New Zealand. Thus, the validated interactions (*Statistically significant interactions*) of the validated critical factors from *5.3 Discussion for Research Question 2* can be analysed to study their impact in detail in the New Zealand context. Table 20 details the validated interactions of the validated critical factors RtC, LoUT, LoIA, MR&T, LoIW, and CRtC.

Table 20: Validated interactions of the validated factors

Validated Critical Factors	Validated Interactions	Polarity
RtC	RtC, LoUT	+
	LoGS, RtC	+
	HII, RtC	+
	CS, RtC	+
	SfLC, RtC	+
	HFCNS, RtC	+

Validated Critical Factors	Validated Interactions	Polarity
	LoF, RtC	+
	LoIA, RtC	+
	LC, RtC	+
	LoLean, RtC	+
	PORB, RtC	+
	SPA, RtC	+
	LoI, RtC	+
LoUT	HFCNS, LoUT	+
	PORB, LoUT	+
	RtC, LoUT	+
	CCP, LoUT	+
	LoETM, LoUT	+
	LoIA, LoUT	+
	IPLC, LoUT	+
	LoICT, LoUT	+
	LoUT, B&IC	+
LoIA	LoIA, LoUT	+
	LoIA, LoGS	+
	LoP, LoIA	+
	LoIA, LoIU	+
	LoIA, RtC	+
	LoIA, CRtC	+
	LoIA, LoIW	+
	LoIA, LoCo	+
MR&T	LoGS, MR&T	-
	CS, MR&T	-
	HII, MR&T	-
	CCP, MR&T	-
	SPA, MR&T	-
	LoTP, MR&T	-
	LoLean, MR&T	-
	PM, MR&T	-
	CLA, MR&T	-
LoIW	LoGS, LoIW	+
	LoIW, HII	+
	LoIA, LoIW	+
	LC, LoIW	+
	LoEI, LoIW	+
	PORB, LoIW	+
CRtC	IoSR, CRtC	+
	HFCNS, CRtC	+
	HII, CRtC	+
	TCPACNA, CRtC	+

Validated Critical Factors	Validated Interactions	Polarity
	TCPAFTM, CRtC	+
	LoTSC, CRtC	+
	PORB, CRtC	+
	LoIA, CRtC	+
	BR, CRtC	+
	SfLC, CRtC	+

The validated critical factors are discussed in the context of their validated interactions below:

5.4.1 RtC

Resistance to change in New Zealand is among the critical factors, and its interactions range across all themes, except for the legal theme. RtC is primarily influenced by several other factors; however, it poses challenges to the adoption of technology. RtC is influenced by the lack of governmental support, the high initial investment requirement of IPD, the compensation structure of IPD, the high financial cost associated with new software and technology use, seeking the lowest cost, the lack of IPD awareness among stakeholders, the lack of familiarity with IPD among contractors, logistical challenges, the lack of lean knowledge among project stakeholders, project objectives-related barriers, the self-protective approach of stakeholders, and finally, the lack of integration among the key project parties. The lack of technology use is discussed next.

5.4.2 LoUT

The lack of technology use is among the critical factors in New Zealand. Its interactions consist of factors from the financial, organisational, and technological themes. The high financial cost of new software and technology is a reason for the lack of technology uptake in New Zealand; organisational factors that hinder technology uptake include project objectives related barriers, resistance to change from stakeholders, challenging cultural paradigms, the lack of IPD awareness, the lack of existing training material associated with IPD, and the lack of chances available for industry participants to receive IPD training. Lastly, the technological factors that influence technology uptake in New Zealand include the lack of suitable IT infrastructure and the challenges of integrating BIM and IPD when technology is not utilised effectively. The lack of IPD awareness is discussed next.

5.4.3 LoIA

The lack of IPD awareness among stakeholders is a critical factor in New Zealand, and its interactions consist of factors from the governmental, technological, and organisational themes. LoIA is influenced by the lack of promotion of IPD; all other interactions consist of LoIA influencing other factors. From the technological perspective, LoIA poses difficulties in technology adoption, and from the governmental perspective, LoIA is a reason for the lack of governmental support. Interactions with

organisational factors include the lack of interest in upgrading to IPD, resistance to change from stakeholders, clients' resistance to change, the lack of industry-wide standardisation, and the lack of coordination among project participants. Mutual respect and trust are discussed next.

5.4.4 MR&T

Mutual respect and trust are another critical factor in New Zealand. Its interactions consist of factors from all themes except for the technological theme. MR&T is only impacted by factors, and the governmental factor consists of the lack of governmental support. The self-protective approach of stakeholders encompasses the collaboration theme, while contractual and legal aspects comprise the legal theme. The factors from the financial theme consist of the compensation structure and the high initial investment requirement of IPD. Finally, factors from the organisational theme include the lack of trained professionals, challenging cultural paradigms, the absence of lean knowledge among stakeholders, and difficulties with project management. The lack of industry-wide standardisation is discussed next.

5.4.5 LoIW

The lack of industry-wide standardisation wasn't among the critical factors in the literature, but it is of considerable importance in New Zealand. Its interactions consist of factors from the governmental, financial, and organisational themes. LoIW increases the high initial investment requirement of IPD; its all other interactions consist of LoIW getting influenced by other factors. From the governmental theme, LoIW is influenced by the lack of governmental support. From the organisational theme, LoIW is influenced by the lack of IPD awareness among stakeholders, logistical challenges, inefficient information sharing, and project objectives-related barriers. The client's resistance to change is discussed next.

5.4.6 CRtC

Like LoIW, the client's resistance to change was not among the critical factors identified in the literature; however, it is important in the New Zealand context. Its interactions include factors from the legal, financial, and organisational themes. Like MR&T, CRtC is only impacted by other factors. From the legal theme, the implementation of strict rules and regulations associated with IPD contracts cause CRtC to increase. From the financial theme, the high cost of new software, the high initial investment requirement of IPD, the extra fees that need to be paid by the client for an IPD contract, and due to time and material constraints, the lack of transparency in spending done by the contractor, and seeking for the lowest cost cause CRtC to increase. Finally, the factors from the organisational theme that influence CRtC include project objectives-related barriers, the lack of IPD awareness among stakeholders, and business risk.

5.4.7 Consistent interactions obtained from all data collection methods

The interactions of the validated critical factors of IPD identified in the literature, as mentioned by the expert interviewees, and subsequently validated by the broader workforce of the New Zealand construction industry, should be given considerable importance. The consistent interactions are detailed below:

5.4.7.1 SfLC, RtC (+)

The factor, seeking the lowest cost, can cause increased resistance from project stakeholders, and this can be considered a significant interaction between the factors of IPD. While other individual factors, such as the lack of governmental support and the client's resistance to change exist, resistance can be considered from decision makers, like government officials, regarding IPD implementation in public projects, or even clients, who are generally the ones who bear the costs of the high initial investment requirement of IPD. Resistance from stakeholders can refer to investors who must bear the responsibility of meeting the financial requirements of IPD. It can be agreed that the resistance to change is a global factor relevant not only in New Zealand but also in the broader global construction industry.

5.4.7.2 LoICT, LoUT (+)

The lack of adequate IT usage in projects and firms is a reason for the slow adoption of technology, which is essential for successful IPD implementation. This interaction reveals that organisations and projects interested in the IPD model need to adhere to a developed IT infrastructure that can support the latest technology. It is also worth noting that, in addition to the high initial investment requirement of IPD, high costs are associated with the development of IT infrastructure and the adoption of new software. This interaction highlights the significance of IT infrastructure development and the adoption of modern technology for effective IPD implementation.

5.4.7.3 LoIA, RtC (+)

The lack of IPD awareness increases the resistance from the stakeholders. This is one of the most common interactions between factors that is particularly relevant in the New Zealand context, as the general construction workforce is not familiar with the IPD model. It is also significant in the global context, proven by the fact that both resistance to change and IPD unawareness are frequently mentioned in IPD literature. Importantly, this interaction highlights the need to educate the global workforce on IPD principles. Traditional project delivery models like DBB will continue to be preferred over a superior project delivery model, such as IPD, if the awareness component is not increased among the global workforce.

5.4.7.4 CLA, MR&T (-)

The contractual legal aspects associated with the IPD model lower the trust component among the project stakeholders. This interaction should not be surprising, as participants are bound to have trust issues if clauses such as relinquishing the right to sue one another, a characteristic of the IPD model, are implemented. This interaction is a prevalent issue with IPD implementation, as the global construction industry is renowned for being risk-averse. Other legal issues, such as the sharing of risks and rewards among project participants, are another reason why trust issues exist between them regarding IPD implementation. The contractual aspects of IPD deem the model risky, and not everyone is willing to take on such a risk. The next section outlines the discussion of the results for **1.9.4 Research Question 4**.

5.5 Discussion for Research Question 4

Research Question 4 examines the critical factors and their chains that influence the implementation of IPD in New Zealand. As section 5.3 Discussion for Research Question 2 has already discussed the validated critical factors that impact the implementation of IPD in New Zealand, this section will discuss the critical chains and how they impact the implementation of IPD in New Zealand. The most critical, validated chains of factors that impact the implementation of IPD have been detailed in **4.5.4 Validated critical chains**, and they are discussed below:

5.5.1 LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT-B&IC (DC weight=4.38, EC weight=1.863)

This chain of factors is the joint highest in terms of DC weightage and the joint second-highest in terms of EC weightage. The lack of governmental support hinders the promotion of IPD as a project delivery model, resulting in a lack of awareness among stakeholders in the construction industry. The lack of IPD awareness implies that IPD is not standardised within the New Zealand construction industry, which has an impact on the initial investment requirement of IPD. The high investment requirement leads to resistance from stakeholders, who resist the adoption of essential IPD requirements, such as the use of technology. Ultimately, the lack of technology use leads to issues with BIM and IPD integration.

5.5.2 LoP-LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC (DC weight=4.38, EC weight=1.863)

This chain of factors is the joint highest in terms of DC weightage and the joint second-highest in terms of EC weightage. This chain of factors is like 5.5.1 LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT-B&IC (DC weight=4.38, EC weight=1.863), except for the positioning of the first three factors in the chain. While 5.4.1 commences with the lack of governmental support, this chain initiates from the lack of promotion of IPD, which causes unawareness among stakeholders, leading to a lack of governmental support for IPD as a project delivery model. The subsequent factors are like those in 5.4.1; the lack of governmental support leads to a lack of industry standardisation of IPD in New

Zealand, which in turn impacts the initial investment requirement of IPD. The high investment causes resistance from stakeholders, leading to a lack of technology uptake, which ultimately results in issues with BIM and IPD integration.

5.5.3 LoIW-LoPB-LoP-LoIA-LoGS-RtC-LoUT-B&IC (DC weight=4.23, EC weight=1.869)

This chain of factors is the joint second-highest in terms of DC weightage, but the sole-highest in terms of EC weightage, so it should be considered most critical. This chain of factors begins with the lack of industry standardisation of IPD, which leads to a lack of professional bodies associated with IPD establishing themselves in New Zealand. The lack of professional bodies in New Zealand causes issues with the promotion of IPD, as there is no governing body overseeing the process. The lack of promotion leads to a lack of awareness among stakeholders, resulting in insufficient governmental support for IPD. The lack of governmental support influences stakeholder resistance, which leads to a lack of technology adoption and ultimately causes issues with BIM and IPD integration.

5.5.4 CLA-LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT (DC weight=4.23, EC weight=1.398)

This chain of factors is the joint second-highest in terms of DC weightage. Although it is not among the highest in terms of EC weightage, it remains a critical chain nonetheless and warrants discussion. This chain initiates from the contractual legal aspects of IPD, which is one of the reasons why the government resists its uptake in New Zealand. The lack of governmental support leads to issues with promoting IPD, resulting in a lack of awareness among the construction workforce. This leads to a lack of industry standardisation, which impacts the initial investment requirement of IPD. The high investment requirement causes resistance from project participants, resulting in a lack of technology adoption.

5.5.5 CLA-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC (DC weight=4.23, EC weight=1.636)

This chain of factors is also the joint second-highest in terms of DC weightage. It is also not among the highest in terms of EC weightage; however, it is among the critical chains nonetheless and should be discussed. This chain begins with the contractual legal aspects of IPD, which influences the lack of governmental support for IPD in New Zealand. The lack of governmental support is a reason why professional bodies associated with IPD aren't getting established in New Zealand. The lack of professional bodies contributes to the underpromotion of IPD, resulting in a lack of awareness among stakeholders. This leads to resistance from stakeholders, which in turn influences the limited use of technology and ultimately causes challenges with BIM and IPD integration.

5.5.6 LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC (DC weight=4.08, EC weight=1.645)

This chain is not among the highest either DC or EC weightages. It is still among the critical chains identified and thus warrants discussion. The chain begins with a lack of IPD awareness among

stakeholders, which in turn influences the lack of governmental support in New Zealand. The lack of governmental support is a reason for the lack of IPD standardisation in New Zealand, which impacts the initial investment requirement for IPD. The high initial investment requirement causes resistance from stakeholders, which in turn influences the slow uptake of technology, ultimately leading to challenges in BIM and IPD integration.

5.5.7 RnTRSR-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC (DC weight=3.77, EC weight=1.636)

This chain is also not among the highest either DC or EC weightages. As it is among the critical chains identified, it warrants discussion. The idea that the rewards associated with the IPD model do not adequately reflect the significance of the risks undertaken initiates this chain, which contributes to the lack of governmental support for the IPD model in New Zealand. The lack of governmental support is a reason why professional bodies associated with IPD aren't getting established in the country, and the lack of professional bodies contributes to the underpromotion of IPD, resulting in a lack of awareness among stakeholders. This leads to resistance from stakeholders, which in turn influences the limited use of technology and ultimately causes challenges with BIM and IPD integration. The next section details the discussion of the results for *1.9.5 Research Question 5*.

5.6 Discussion for Research Question 5

Research Question 5 seeks to identify an appropriate framework that mimics the interactions of the IPD factors to reflect industry thinking in New Zealand. The conceptual framework was used for this research study. In particular, the descriptive and explanatory frameworks, which are subtypes of the conceptual framework, were used for this research study. They are discussed in *3.2.6 Framework*, and the resulting framework is presented in *4.6 Results for Research Question 5*. All validated factors of IPD and their interactions, identified from the survey questionnaire, were used to construct the framework. The framework consisted of 59 validated factors and 88 validated interactions between these factors. The framework was intended to be a standalone guide that industry practitioners, stakeholders, researchers, and academics alike can refer to access the findings of this research study. To restate, the conceptual framework is a network of interlinked concepts that are combined to provide a comprehensive understanding of the phenomenon under study. The conceptual framework facilitates the explanation of variables and their presumed relationships through the use of arrows, providing a graphical representation. For this study, the factors of IPD and their interactions were modelled into a causal loop diagram using Vensim software. Thus, the conceptual framework was the most appropriate framework for this research.

The descriptive framework systematically describes a phenomenon, identifying its characteristics, trends, and frequencies. As the interactions between the factors of IPD were the phenomenon under study in this research, which involved identifying not only the frequency of the factors but also their interactions, the descriptive framework was suitable for this research.

The explanatory framework extends beyond the descriptive framework to explain why a phenomenon occurs, uncover causal relationships, and examine the relationships between variables. As the interactions and polarity between the factors of IPD were investigated in detail through the cause-and-effect approach of causal chain analysis, the explanatory framework was also suitable for this research. A third subtype of the conceptual framework, the predictive framework, was not utilised in this research as it was deemed irrelevant. The predictive framework aims to forecast future trends by leveraging established causal relationships. As this research investigates the causality between the factors of IPD in New Zealand for the first time, the predictive framework was not appropriate for this research. It is worthwhile to note that future research on IPD implementation in New Zealand may find the results of this study beneficial and may utilise the predictive framework in their own studies. The next section outlines the chapter summary.

5.7 Discussion on Framework development

For Research Objective 1, challenging cultural paradigms, difficulties in achieving financial transparency, interoperability, and cost estimation challenges, were identified as critical solely in the literature. For Research Objective 2, the lack of IPD awareness was the most frequent factor revealed by the interviewees, which was followed by the lack of collaboration, resistance to change, contractual legal aspects, client's resistance to change, high initial investment, lack of technology use, lack of governmental support, mutual respect and trust, self-protective approach, lack of integration, project objectives-related barriers, lack of industry standardisation, challenging cultural paradigms, lack of familiarity of contractors, BIM and IPD integration challenges, implementation of strict rules and regulations, lack of inculcating the values of IPD, lack of insurance policies, and the lack of proficiency from the employer. For Research Objective 3, the interactions between the factors of IPD, the most frequent interactions (identified by 5 or more interviewees) were the lack of collaboration increasing the lack of integration between stakeholders, the lack of IPD awareness increasing the lack of collaboration between stakeholders, the lack of IPD awareness increasing resistance from stakeholders, contractual legal aspects decreasing the mutual respect and trust among stakeholders, lack of technology use increasing BIM and IPD integration challenges, and the lack of governmental support increasing the lack of governmental policies and incentives for IPD implementation. For Research Objective 4, resistance to change, mutual respect and trust, and the client's resistance to change, the lack of industry standardisation, the lack of IPD awareness, and the lack of technology use were identified as critical in New Zealand. Regarding the critical chains, the lack of IPD promotion and governmental support cause the heaviest chains in Degree Centrality weightage, and the lack of industry standardisation initiates the heaviest chain in Eigenvector Centrality weightage. For Research Objective 5, the statistically significant interactions, derived from the survey results through the t-test, using p-values, and ranked using the RII method, were used to create the framework, a simplified version of the Vensim diagram, for easier dissemination of the results.

5.8 Comparison of Findings with Recent Literature on IPD

Recent published studies on IPD that investigated factors to its implementation in established platforms include Arar et al. (2025) and Sherif et al. (2022). Both studies identified resistance to change, contractual and legal aspects, and a lack of technology use as common factors affecting IPD implementation. While other prominent factors identified in this research, such as high initial investment, lack of IPD awareness, client's resistance to change, and lack of government support, were not identified by Sherif et al. (2022), Arar et al. (2025) identified them as notable factors. However, a key difference between the findings is the significance of the factor: lack of industry standardisation in the New Zealand context. Neither Arar et al. (2025) nor Sherif et al. (2022) identified it as a factor. In addition, the New Zealand-specific factors identified in the section **5.3.7 NZ-specific factors**, reveal the unique implementation issues in the country compared to recent research.

5.9 Chapter summary

This chapter discussed the results obtained from each Research Question in a systematic manner. The results from **1.9.1 Research Question 1** were discussed initially. The critical factors obtained from the literature, MR&T, RtC, CCP, CRtC, DiA, I, and CEC were discussed individually. This was followed by a discussion of the results from **1.9.2 Research Question 2**. The validated critical factors obtained from Section **4.5.2.3 Comparison of top factors**: RtC, MR&T, LoUT, LoIA, CRtC, and LoIW were discussed individually; to assess their impact in the New Zealand context, the **5.3.7 NZ-specific factors**, which were identified during the SSI process: LoFI, LCC, FvLCM, IoTM, EPM, HLC, StMCR, and Psz, were discussed. Next, the results from **1.9.3 Research Question 3** were discussed. The validated critical factors —RtC, MR&T, LoUT, LoIA, CRtC, and LoIW— were discussed in the context of their validated interactions. A discussion was also emphasised for the interactions between the factors of IPD identified from all data collection methods in **5.4.7 Consistent interactions obtained from all data collection methods**. This was followed by a discussion on the results from **1.9.4 Research Question 4**, which examined both the critical factors and their chains. As the critical factors had been discussed in the prior sections, the validated chains were the topic for discussion. Based on **Appendix 10- Causal Chain Analysis**, the seven most critical chains in terms of DC and EC weightages were discussed: (1) LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT-B&IC, (2) LoP-LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC, (3) LoIW-LoPB-LoP-LoIA-LoGS-RtC-LoUT-B&IC, (4) CLA-LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT, (5) CLA-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC, (6) LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC, and (7) RnTRSR-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC. Following this, the choice of framework for this research study, as per **1.9.5 Research Question 5**, the conceptual framework and its subtypes, the descriptive and explanatory frameworks, were discussed as to why they were appropriate for this research study. Next, the findings obtained from all research objectives were integrated and positioned within the broader body of existing knowledge. Finally, the findings were compared and contrasted with recent studies on IPD.

Chapter 6- Conclusion

6.1 Chapter introduction

This chapter provides an overview of the research study's background, its application, and its contributions to both practical and theoretical knowledge. It commences with an overview in section 6.2, followed by sections 6.3 and 6.4, which delve into the Research Questions and Findings. In section 6.5, the focus shifts to the contribution to knowledge, explaining how this research can be applied. Section 6.6 provides recommendations while section 6.7 discusses the limitations of the study. Section 6.8 presents the concluding remarks. Finally, section 6.9 wraps up the chapter with a summary.

6.2 Overview

The factors in the implementation of IPD are well-documented and recognised in the literature. Additionally, industry practitioners and researchers familiar with the IPD model are aware of the requirements necessary for its implementation. However, a significant gap in research is the understanding of the interactions between the factors of IPD. A thorough investigation of the factor network has not been conducted. It is noteworthy to mention that factors of IPD do not operate in isolation; instead, they interact with one another, thus increasing their impact on its implementation. This research investigated the interactions between the factors of IPD using three data collection methods: an SLR, which was followed by 18 qualitative semi-structured interviews, the results of which were triangulated with 137 quantitative survey responses from the wider NZ construction industry. The SLR was used to detail a comprehensive list of the factors of IPD, and the semi-structured interviews were designed to cover all of them. Using the System Dynamics approach, the factors and their interactions were modelled into a causal loop diagram using Vensim. Using centrality techniques in Network Analysis, degree centrality and eigenvector centrality were employed to identify the critical factors. Furthermore, using causal chain analysis, the sum of the centrality values of the factors helped identify the heaviest chains, which were deemed critical. From the triangulated survey responses, using the Relative Importance Index method, all 142 interactions were assigned a value. Furthermore, using the statistical t-test, 88 interactions were found to be statistically significant, and all these interactions were re-modelled into a causal loop diagram using Vensim. Next, the centrality computation procedure was repeated, and the validated critical factors were identified. Finally, using causal chain analysis, the validated chains of factors with the highest centrality values were deemed critical. The next section examines how the Research Questions were formulated.

6.3 Research Questions

The research questions were framed to enable a step-by-step approach to identifying the interactions

between factors affecting the implementation of IPD in New Zealand. The first step was to identify the factors of IPD from the literature. Thus, **1.9.1 Research Question 1** was designed to investigate all factors of IPD globally through a thorough Systematic Literature Review. A challenge was the repetition and synonyms of identified factors. For this reason, the researcher analysed the initial 222 identified factors of IPD and discarded the synonyms, thereby reducing the identified factors of IPD in the global construction industry to 127. Following on, **1.9.2 Research Question 2** was designed to identify the factors of IPD in the New Zealand context specifically. The aim was to investigate the factors of IPD globally that were relevant in New Zealand. Additionally, identifying specific New Zealand factors not previously identified in the Systematic Literature Review that affect IPD implementation was also significant. The next step was to identify the interactions between the factors that impact IPD implementation in New Zealand; thus, **1.9.3 Research Question 3** was created. Following this, the next sequence involved distinguishing between the factors; therefore, **1.9.4 Research Question 4** aimed to identify the critical factors of IPD, as well as the critical chains of factors. Finally, **1.9.5 Research Question 5** examined a specific framework that can be used to identify the interactions between the factors of IPD in New Zealand. The next section looks at the Research Findings.

6.4 Research Findings

The factors that appeared in every type of analysis done were deemed critical. The critical factors from **1.9.1 Research Question 1** were resistance to change, mutual respect and trust, and challenging cultural paradigms. The factors that appeared in both degree centrality and eigenvector centrality analyses, but not in the frequency analysis, were deemed as second-level critical factors. It is relevant to note that the SLR interactions were based on deductive reasoning, and different articles used alternate wordings to identify a factor. The second-level critical factors identified from Research Question 1 included the client's resistance to change, difficulties in achieving financial transparency, cost estimation challenges, and interoperability issues. **1.9.2 Research Question 2** and **1.9.3 Research Question 3** investigated the factors of IPD in the New Zealand context; the validated critical factors identified through the system-wide survey questionnaire were resistance to change, lack of technology use, and lack of awareness of IPD; these factors consistently ranked among the top factors in every analysis and were also part of the critical chains identified. The validated second-level critical factors were the lack of industry-wide standardisation, the client's resistance to change, and mutual respect and trust. The lack of industry-wide standardisation and clients' resistance to change were evident in every analysis, except for the frequency analysis obtained from the literature. This can serve as the basis of an argument that, although the lack of industry standardisation and clients' resistance to change aren't among the critical factors in the literature, they are of significance in the New Zealand context. Furthermore, mutual respect and trust was evident in every analysis, except for the critical chains identified. This can be the basis of an argument that, although mutual respect and trust interacts with other factors, it is not among the most critical factors identified. **1.9.4 Research Question 4**

investigated the critical chains of the factors of IPD in New Zealand. The validated critical chain of factors with the highest degree centrality and eigenvector centrality weightages that impact the implementation of IPD in New Zealand are:

- LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT-B&IC
- LoP-LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC
- LoIW-LoPB-LoP-LoIA-LoGS-RtC-LoUT-B&IC
- CLA-LoGS-LoP-LoIA-LoIW-HII-RtC-LoUT
- CLA-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC
- LoIA-LoGS-LoIW-HII-RtC-LoUT-B&IC
- RnTRSR-LoGS-LoPB-LoP-LoIA-RtC-LoUT-B&IC

Finally, *1.9.5 Research Question 5* identified a specific framework that mimics the interactions of the factors of IPD. The framework is presented in *4.6 Results for Research Question 5*. The next section examines how this research contributes to the body of knowledge.

6.5 Contribution to knowledge and usefulness of the research

The interactions between the factors of IPD implementation are a gap in research, and this research adds to this knowledge. IPD as a project delivery model has been studied briefly in the New Zealand context. This research contributes to the knowledge base by providing an in-depth understanding of the factors, critical factors, and their interactions. Further, through detailed analysis techniques, this research also identifies the critical chains of factors that impact IPD implementation in New Zealand. Aside from the New Zealand context, the detailed systematic literature review conducted in this research also identified the interactions between the factors of IPD in the current literature. How each beneficiary can benefit through this research is detailed below:

- Industry practitioners

Industry practitioners will become aware of the critical factors and how they impact or are impacted by other factors. As they have first-hand experience in project execution, they will benefit from this knowledge, which will enable them to anticipate the expected challenges. Thus, they could work out possible solutions beforehand.

- Stakeholders

Stakeholders in the construction industry, when presented with the opportunity to adopt the IPD project delivery method, will be aware of the interplay between factors and the potential challenges. Unlike industry practitioners, stakeholders may not be directly involved in project execution; however,

this knowledge will enable them to make critical management decisions, not only at the inception stage of the project but also during the construction process.

- Client/Owner

The client or owner is the decision maker for a construction project. They hold the final decision in the selection of the delivery model for a particular project. The findings of this research will guide them in understanding the various factors that impact the client's resistance, as well as the challenges that can be anticipated when adopting the IPD model.

- Project manager

The project manager holds ultimate responsibility for the successful completion of a construction project and is often responsible for reporting to higher management, which includes directors and the client. This research will guide project managers through the interplay between the factors of IPD, how they impact one another, and how they, in turn, are impacted by other factors. As the identified factors encompass a broad range of themes, project managers interested in implementing IPD will be well-equipped to address the potential challenges associated with the IPD model.

- Construction manager

The construction manager holds the utmost responsibility for executing work in a construction project and is second only to the project manager in terms of assigned authority. The findings of this research will aid construction managers in addressing practical issues related to the implementation of IPD. Although construction managers are primarily responsible for site works, the identified interactions between the factors of IPD will equip them well if they are ever presented with the opportunity to work in an IPD-administered project.

- Researchers

As the interactions between the factors of IPD have been conducted for the first time, researchers can build on this vast area of study. The results of this study can be further investigated to solidify the findings, and alternative analysis approaches can be employed. Additionally, as the present study investigates the interactions between the factors of IPD in New Zealand, researchers can conduct comparative studies in individual countries to identify country-specific interactions between the factors of IPD. Moreover, the results of this study may be applicable to countries with similar economies to New Zealand.

- Academics

Academics in the construction field interested in teaching about collaborative contracting, such as IPD, and the factors that hinder its implementation, can also benefit from this study. The findings can be incorporated into teaching curricula not only at the tertiary or university level, but also at trade schools, where applicants learn about practical and on-the-job issues. The next section discusses the recommendations.

6.6 Recommendations

Through the framework presented, industry practitioners can become aware of how factors interact to impact IPD implementation in New Zealand. Practical implementation strategies should be developed based on the findings. For example, a solution-oriented framework should be designed to address not only the critical factors identified but also the significant factors that initiate the identified critical chains. The lack of government support and the lack of IPD promotion are prominent in New Zealand, as they drive the heaviest causal chains; this makes a compelling case that the government has a major role to play for any chance of IPD adoption in the country. The identification of a lack of industry standardisation as both a critical factor and the sole factor driving the heaviest chain in terms of Eigenvector Centrality weightage should signal its importance in New Zealand. IPD is relatively uncommon in New Zealand, and private contractors in the country are unlikely to be willing to risk its adoption for their projects. For these reasons, the role of the New Zealand government is pivotal, as the most plausible pathway for IPD uptake in the country is through public-sector projects. Additionally, future studies can investigate IPD factor interactions in other developed countries and employ alternative data-collection and analysis methods. Additionally, the identified critical factors and chains can be further studied to validate the study's findings. Future studies should also propose solutions to mitigate the effects of these factors and their interactions and to increase IPD implementation, ultimately leading to sustainable construction in New Zealand. The next section discusses the limitations of this research.

6.7 Limitations of the research

The lack of knowledge of IPD within the New Zealand construction industry needs to be acknowledged. Although the researcher aimed to gather accurate research findings, some factors were beyond their control. These include the limited involvement of some interviewees with IPD-administered projects. Although valuable insights were obtained from the semi-structured interview process, a relevant point to note is that some interviewees, who were experienced with collaborative contracting methods such as Alliancing, had IPD knowledge but had limited IPD experience. Additionally, no government officials were interviewed. The interviewees were almost entirely

comprised of the actual construction workforce, including consultants, contractors, engineers, and managers. The lack of data from a decision maker within the New Zealand government, who has the authority to select IPD as the project delivery method in public projects, is a limitation of the research findings. Further, there may have been interviewee bias. The initial data collection was entirely based on qualitative semi-structured interviews; therefore, the research findings are entirely dependent on the views of the expert interviewees. If there is a bias from any of the interviewees, then the findings may not be genuinely authentic. Lastly, as data collection commenced with the SLR, it is essential to acknowledge the limitations of the SLR process. The SLR limitations include the risks of bias, such as selection bias, publication bias, attrition bias, and selective outcome reporting. However, the SLR process adopted in this research overcomes these limitations. The next section provides the concluding remarks.

6.8 Concluding remarks

This research provides a comprehensive understanding of the interactions between the factors of IPD. For the first time, the interactions between the factors of IPD were investigated using System Dynamics and Network Analysis. The choice of analysis methods — degree centrality, eigenvector centrality, and causal chain analysis — have been used in conjunction for the first time to investigate the IPD factor network. This research provides valuable insights into the interactions between the factors of IPD and how they influence each other within the factor network that hinders its implementation in New Zealand. Despite some limitations of this research, the findings can be useful for industry practitioners, stakeholders, researchers, and academics alike. The next section outlines the chapter summary.

6.9 Chapter summary

This chapter begins with an overview of the current research study, followed by the formulation of research questions that were developed systematically to achieve the research aim. Next, the findings were discussed, which consisted of the critical factors and their chains that impact the implementation of IPD in New Zealand. This was followed by a discussion on how the present study contributes to knowledge and the utility of the research. The beneficiaries who could benefit from the findings of this research included industry practitioners, stakeholders in the construction industry, researchers, and academics. Following this, generic and specific recommendations, along with ideas for future studies, were discussed. Penultimately, the limitations of this research were discussed, which included limited IPD involvement of some interviewees, the absence of government officials in the interviews, and potential bias among interviewees. Lastly, the chapter concludes with a brief discussion on the novelty of this research.

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Appendix 1- Analyses of the factors of IPD identified from the literature

Table 21: Analyses of the factors of IPD identified from the literature

Factor	Incoming Nodes	Outgoing Nodes	Total Nodes	Frequency (Identified by no. of authors)	Degree of Centrality	Eigenvector Centrality
RtC	4	3	7	9	1	0.11 (2 Iterations)
CLA	1	3	4	27	0.57	0.13 (1 Iteration)
CRtC	3	1	4	6	0.57	0.18 (3 Iterations)
LoIA	0	3	3	18	0.43	0
LoIP	0	3	3	6	0.43	0
MR&T	3	0	3	10	0.43	0.71 (4 Iterations)
CCP	2	0	2	17	0.29	0.18 (3 Iterations)
LoC	1	1	2	15	0.29	0.13 (1 Iteration)
I	2	0	2	4	0.29	0.11 (2 Iterations)
IoSR	0	2	2	2	0.29	0
LoICT	1	1	2	2	0.29	0.13 (1 Iteration)
CEC	1	1	2	5	0.29	0.11 (2 Iterations)
DiA	1	1	2	2	0.29	0.18 (3 Iterations)
LoUT	1	0	1	24	0.14	0.11 (2 Iterations)
LoI	1	0	1	7	0.14	0.13 (1 Iteration)
LoGS	0	1	1	8	0.14	0
ECI	1	0	1	4	0.14	0.13 (1 Iteration)
LoFIPDCM	1	0	1	3	0.14	0.71 (4 Iterations)
SPA	0	1	1	6	0.14	0
LoP	1	0	1	2	0.14	0.13 (1 Iteration)
IVIPD	1	0	1	2	0.14	0.13 (1 Iteration)
APL	1	0	1	1	0.14	0.13 (1 Iteration)
SfLC	0	1	1	1	0.14	0
URMPC	0	1	1	1	0.14	0
HFCNS	0	1	1	3	0.14	0
LoL	1	0	1	1	0.14	0.18 (3 Iterations)
RnTRSR	0	1	1	4	0.14	0
AAJPC	1	0	1	2	0.14	0.13 (1 Iteration)
NATT	1	0	1	3	0.14	0.13 (1 Iteration)
CCRL	0	1	1	4	0.14	0
LoENR	0	1	1	1	0.14	0
II	0	1	1	1	0.14	0

Appendix 2- Interview Questions

1. Kindly detail your knowledge about IPD. Do you consider it to be a superior project delivery method to other methods? Why?
2. Please elaborate on your experience and role in an IPD administered construction project.
3. In your experience, how would you describe the current level of IPD implementation in New Zealand?
4. In your opinion, how does the role of stakeholders influence the adoption of IPD in the New Zealand construction industry?
5. In your experience, do legal requirements such as insurance policies and bonding arrangements cause complications with job costing and accounting for an IPD contract? If yes, what affect does it have in New Zealand? (Legal)
6. What is the relationship between cultural paradigms and resistance to change from project participants for IPD implementation? Please explain in the New Zealand context. (Cultural/Organisational)
7. In your experience, do contractual legal aspects and implementation of strict rules and regulations have an affect on resistance to change from stakeholders for IPD implementation? If yes, what affect does it have in New Zealand? (Legal)
8. How would you describe the relationship between contractual legal aspects and trust among project participants for IPD implementation? Please explain in the New Zealand context. (Legal)
9. In your experience, is IPD awareness/knowledge a factor that may affect resistance to change from stakeholders for IPD implementation? If yes, what is the impact in the New Zealand context? (Cultural/Organisational)
10. What is the relationship between cultural paradigms and the usage of technological advancements such as BIM for IPD implementation in New Zealand? (Cultural)
11. In your experience, is the usage of technological advancements such as BIM a factor that may affect resistance to change from stakeholders for IPD implementation? How would you describe this relationship in the New Zealand context? (Technological)
12. What significance would you place on collaboration for IPD implementation? How would you describe the current level of collaboration in the New Zealand construction industry? (Collaboration)
13. How would you describe the relationship between the continuation of individual interests and trust among project participants for IPD implementation? Please explain in the New Zealand context (Collaboration)
14. How would you describe the relationship between IPD awareness/knowledge and collaboration between project participants for IPD implementation in New Zealand? (Cultural)
15. In your opinion, can financial decisions have an impact on resistance to change from the project participants for an IPD contract? If yes, please explain this relationship in the New Zealand context (Financial)
16. Do you consider that differences in financial matters between project participants may affect equitable distribution of opportunities for gain and potential for loss among stakeholders for an IPD contract? If yes, please explain in the New Zealand context (Financial)

17. What is the relationship between governmental support and mistrust among project participants for IPD implementation? Please explain this relationship in the New Zealand context (Governmental)
18. In your experience, does knowledge of lean methodology affect resistance to change from project stakeholders for IPD implementation in New Zealand? Please explain (Cultural)
19. In your experience, does governmental support have an impact on resistance to change from project stakeholders for IPD implementation in New Zealand? Please explain (Governmental)
20. How would you describe the relationship between the contractual requirements of IPD and governmental support for IPD implementation? Please explain in the New Zealand context. (Legal)
21. What is the relationship between the presence of professional bodies and resistance to change from project stakeholders for IPD implementation in New Zealand? (Governmental)
22. What is the relationship between governmental support and the presence of professional bodies for IPD implementation in New Zealand? (Governmental)
23. Please describe the relationship between governmental support and the usage of technological advancements such as BIM for IPD implementation in New Zealand. (Governmental)
24. What is the relationship between BIM and IPD integration framework with cost estimation for IPD implementation? Please describe this relationship in the New Zealand context. (Technological)

Appendix 3- Interview Invitation



Dear Participant,

Re: Invitation to participate in a research project- Interaction of factors, stakeholders and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand construction industry; AUTEK approval no. 23/270

The purpose of this letter is to invite you to participate in a research study. The participant information sheet enclosed provides details of this study, which you need to read before deciding to take part in this study.

You are not obliged to take part in this study. If you decide to participate, you may withdraw from the study at any time without any disadvantage to yourself and without any obligation to give a reason.

If you decide to take part in this study, please complete the consent forms and email them back to me.

Should you wish to receive a summary of the research findings, please let me know. The findings will be posted to a link which you can bookmark accordingly.

Please do not hesitate to contact me should you require further information.

Yours sincerely

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Approved by the Auckland University of Technology Ethics Committee on 26/10/2023, AUTEK Reference number 23/270.

Appendix 4- Interactions of factors

Table 22: Interactions of the factors of IPD identified from the interviews

Interactions of Factors	Polarity	Identified by number of interviewees
LoC, LoI	+	10
LoIA, LoC	+	9
LoIA, RtC	+	7
CLA, MR&T	-	6
LoUT, B&IC	+	6
LoGS, LoGipr	+	5
LoGS, LoPB	+	4
HII, RtC	+	4
SPA, MR&T	-	4
LoIA, CRtC	+	4
CLA, RtC	+	3
HFCNS, LoUT	+	3
LoGS, MR&T	-	3
SPA, AAJPC	-	3
LoIW, RtC	+	3
CRtC, AaW	-	2
LoP, LoIA	+	2
RtC, CRtC	+	2
LoIA, LoIU	+	2
CLA, R&I	+	2
LoCA, IIR	+	2
LoC, LoUT	+	2
LoESIPD, LoF	+	2
LoIA, LoIW	+	2
CLA, CEC	+	2
CCP, LoC	+	2
LoIA, LoUT	+	2
LoETM, LoUT	+	2
RnTRSR, CRtC	+	2
LoC, LoT	+	2
LoC, MR&T	-	2
LoIA, IVIPD	-	2
PORB, CRtC	+	2
LoIW, CRtC	+	2
HII, CRtC	+	2
RnTRSR, LoGS	+	2
SPA, RtC	+	2
LoLean, RtC	+	2
LoENR, RtC	+	2
CCP, LoUT	+	2

Interactions of Factors	Polarity	Identified by number of interviewees
LoF, RtC	+	2
RtC, LoUT	+	2
LoGS, LoUT	+	2
LoIA, LoGS	+	2
IPLC, LoIA	+	2
HII, LoIP	+	2
HII, LoGS	+	2
R&I, SoCIS	+	1
EDTG, DHQD	+	1
IoSR, ONIA	+	1
LoP, AaW	-	1
LoF, DiC	+	1
LOCm, DiC	+	1
TEWM, UR	+	1
MIR, CEC	+	1
LoPr, MSTD	-	1
LoL, DiC	+	1
LoTP, LoES	+	1
LoCA, CRtC	+	1
LoIA, LoF	+	1
HFCNS, CRtC	+	1
SPA, LoI	+	1
CCP, MR&T	-	1
LoEI, DiC	+	1
LoEI, PDT	+	1
CLA, LoIP	+	1
CCP, PM	+	1
MoI, IDCOC	+	1
LoICT, LoUT	+	1
CS, MR&T	-	1
LoCA, PM	+	1
PM, MR&T	-	1
LoES, LoLean	+	1
CCP, RtC	+	1
LoI, LoT	+	1
IPIT, RtC	+	1
IPLC, LoUT	+	1
LC, RtC	+	1
CCRL, SPA	+	1
SfLC, CRtC	+	1
TCPACNA, CRtC	+	1
TCPAFTM, CRtC	+	1
LoIA, LoCo	+	1
LoSK, B&IC	+	1

Interactions of Factors	Polarity	Identified by number of interviewees
HFCNS, RtC	+	1
SPA, LoIU	+	1
LoP, NSIPD	+	1
LoF, CCP	+	1
LoIA, MR&T	-	1
AAJPC, RtC	+	1
HP, LoIP	+	1
SPA, LoC	+	1
CLA, LoGS	+	1
CS, AAJPC	-	1
CS, LoC	+	1
LoC, AAJPC	-	1
LoIU, RtC	+	1
LoTP, LoIW	+	1
LoIW, LoPB	+	1
LC, LoIW	+	1
LoPr, AAJPC	-	1
LoFIPDCM, RtC	+	1
LoI, LoIU	+	1
LoES, LoIU	+	1
CLA, LoC	+	1
LoTSC, CRtC	+	1
LoFIPDCM, LoC	+	1
LoLean, IVIPD	-	1
LoUT, CEC	+	1
LoP, LoESIPD	+	1
LoP, LoF	+	1
SfLC, LoGS	+	1
CRtC, LoIW	+	1
IoSR, CRtC	+	1
LoT, MR&T	-	1
LoEI, LoIW	+	1
LoC, AAJPC	-	1
LoGS, HII	+	1
SfLC, RtC	+	1
HII, MR&T	-	1
BR, CRtC	+	1
LoES, CCP	+	1
CLA, SPA	+	1
LoGS, IVIPD	-	1
LoC, LoCo	+	1
LoPB, LoP	+	1
LoES, RtC	+	1
LoI, RtC	+	1

Interactions of Factors	Polarity	Identified by number of interviewees
TCPAFTM, CLA	+	1
IoSR, AAJPC	-	1
LoGS, LoIW	+	1
LoLean, MR&T	-	1
LoTP, MR&T	-	1
LoIA, RAM	+	1
LoGS, RtC	+	1
PORB, LoIW	+	1
LoIW, HII	+	1
LoGS, LoETM	+	1
PORB, LoUT	+	1
PORB, RtC	+	1
LoCA, SfF	-	1
CCP, LoIU	+	1
CS, RtC	+	1
LoGS, LoP	+	1
LoP, LoETM	+	1
LoFIPDCM, MR&T	-	1

Appendix 5- Eigenvector Centrality computation

Table 23: Eigenvector Centrality computation

Factor	Nodes	Square	EV 1	Nodes	Square	EV 2	Nodes	Square	EV 3	Nodes	Square	EV 4	Nodes	Square	EV 5	Nodes	Square	EV 6	Nodes	Square	EV 7	Nodes	Square	EV 8
LoC	6	36	0.174	0.203	0.0412	0.0875	0.0875	0.00765	0.0435	0.1242	0.0154	0.0636	0.0888	0.00788	0.0431	0.109	0.0118	0.0509	0.114	0.0129	0.0525	0.119	0.0141	0.0545
LoI	2	4	0.058	0.232	0.0538	0.1	0.1	0.01	0.0497	0.0435	0.00189	0.0223	0.0636	0.00404	0.0308	0.0431	0.00185	0.0201	0.0509	0.00259	0.0234	0.0525	0.00275	0.024
LoT	2	4	0.058	0.232	0.0538	0.1	0.1875	0.035	0.0932	0.0932	0.00868	0.0477	0.0859	0.00737	0.0416	0.0739	0.00546	0.0345	0.071	0.00504	0.0327	0.0759	0.00576	0.0348
SPA	2	4	0.058	0.029	0.000841	0.0125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PTP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MR&T	13	169	0.377	0.725	0.525	0.312	0.525	0.275	0.261	0.484	0.234	0.248	0.487	0.237	0.236	0.512	0.262	0.239	0.533	0.284	0.245	0.534	0.285	0.244
AAJPC	5	25	0.145	0.232	0.0538	0.1	0.1	0.01	0.0497	0.0435	0.00189	0.0223	0.0636	0.00404	0.0308	0.0431	0.00185	0.0201	0.0509	0.00259	0.0234	0.0525	0.00275	0.024
CCP	2	4	0.058	0.116	0.0134	0.05	0.0625	0.0039	0.031	0.0684	0.00467	0.035	0.0984	0.00968	0.0477	0.113	0.0127	0.0528	0.119	0.0141	0.0548	0.121	0.0146	0.0555
LoIA	2	4	0.058	0.058	0.00336	0.025	0.0875	0.00765	0.0435	0.105	0.011	0.0538	0.127	0.0161	0.0616	0.132	0.0174	0.0616	0.141	0.0198	0.0649	0.143	0.0204	0.0655
RTC	21	441	0.609	1.102	1.214	0.475	0.949	0.9	0.472	0.825	0.68	0.423	0.865	0.748	0.419	0.943	0.889	0.44	0.942	0.887	0.434	0.947	0.896	0.434
IDCOC	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRtC	14	196	0.406	0.928	0.861	0.4	0.912	0.831	0.453	0.918	0.842	0.47	0.942	0.887	0.457	0.979	0.958	0.457	0.985	0.97	0.453	0.98	0.96	0.449
AaW	2	4	0.058	0.464	0.215	0.2	0.4875	0.237	0.242	0.558	0.311	0.286	0.597	0.356	0.289	0.589	0.346	0.275	0.598	0.357	0.275	0.596	0.355	0.273
ECI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPtLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ONIA	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoRDM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCo	2	4	0.058	0.232	0.0538	0.1	0.1125	0.0126	0.0559	0.087	0.00756	0.0446	0.117	0.0136	0.0567	0.104	0.0108	0.0485	0.112	0.0125	0.0516	0.117	0.0136	0.0536
FO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IIKMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IVIPD	3	9	0.087	0.232	0.0538	0.1	0.1	0.01	0.0497	0.13	0.0169	0.0666	0.157	0.0246	0.0762	0.168	0.0282	0.0785	0.18	0.0324	0.0829	0.18	0.0324	0.0825
LoP	2	4	0.058	0.203	0.0412	0.0875	0.212	0.0449	0.105	0.248	0.0615	0.127	0.272	0.0739	0.132	0.302	0.0912	0.141	0.311	0.0967	0.143	0.305	0.093	0.139
APL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DiC	4	16	0.116	0.087	0.00756	0.0375	0.0625	0.0039	0.031	0.0684	0.00467	0.035	0.0984	0.00968	0.0477	0.113	0.0127	0.0528	0.119	0.0141	0.0548	0.121	0.0146	0.0555
IIR	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IPLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoETM	2	4	0.058	0.203	0.0412	0.0875	0.15	0.0225	0.0746	0.192	0.0368	0.0984	0.231	0.0533	0.112	0.239	0.0571	0.111	0.26	0.0676	0.119	0.259	0.067	0.118
LOCm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoOI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoF	3	9	0.087	0.145	0.021	0.0625	0.1375	0.0189	0.0684	0.192	0.0368	0.0984	0.234	0.0547	0.113	0.255	0.065	0.119	0.264	0.0696	0.121	0.272	0.0739	0.124
LoSW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoSWW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPDR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPDC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoSK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoES	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIU	5	25	0.145	0.261	0.0681	0.112	0.1875	0.0351	0.0932	0.124	0.0153	0.0635	0.11	0.0121	0.0533	0.14	0.0196	0.0654	0.134	0.0179	0.0617	0.143	0.0204	0.0655
LoLean	1	1	0.029	0.029	0.000841	0.0125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PDT	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PORB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SoPTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SoIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfF	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEWM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UR	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DCfSP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDTG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PM	2	4	0.058	0.058	0.00336	0.025	0.05	0.0025	0.0248	0.031	0.000961	0.0158	0.035	0.00122	0.0169	0.0477	0.00227	0.0222	0.0528	0.00278	0.0243	0.0548	0.003	0.0251
RAM	1	1	0.029	0.058	0.00336	0.025	0.025	0.000625	0.0124	0.0435	0.00189	0.0223	0.0538	0.00289	0.0261	0.0616	0.00379	0.0287	0.0616	0.00379	0.0283	0.0649	0.00421	0.0297
SiMQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DHGD	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIW	7	49	0.203																					

Factor	Nodes	Square	EV 1	Nodes	Square	EV 2	Nodes	Square	EV 3	Nodes	Square	EV 4	Nodes	Square	EV 5	Nodes	Square	EV 6	Nodes	Square	EV 7	Nodes	Square	EV 8
HII	2	4	0.058	0.348	0.121	0.15	0.3245	0.105	0.161	0.329	0.108	0.168	0.402	0.161	0.195	0.411	0.168	0.192	0.411	0.168	0.189	0.409	0.167	0.187
PP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IPfPDNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoFIPDCM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoACE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCCFL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoSECR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MIR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HFCNS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPACNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPAFTM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CEC	3	9	0.087	0.319	0.101	0.137	0.475	0.225	0.236	0.391	0.152	0.2	0.385	0.148	0.186	0.377	0.142	0.176	0.369	0.136	0.17	0.384	0.147	0.176
RnTRSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DiA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RCI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoGS	5	25	0.145	0.145	0.021	0.0625	0.175	0.0306	0.087	0.204	0.0416	0.104	0.221	0.0488	0.107	0.256	0.0655	0.119	0.253	0.064	0.116	0.253	0.064	0.116
LoPB	2	4	0.058	0.348	0.121	0.15	0.3245	0.105	0.161	0.329	0.108	0.168	0.402	0.161	0.195	0.411	0.168	0.192	0.411	0.168	0.189	0.409	0.167	0.187
CLA	1	1	0.029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIP	3	9	0.087	0.087	0.00756	0.0375	0.15	0.0225	0.0746	0.161	0.0259	0.0825	0.168	0.0282	0.0815	0.195	0.038	0.0911	0.192	0.0368	0.0884	0.189	0.0357	0.0866
LoESIPD	1	1	0.029	0.058	0.00336	0.025	0.0875	0.00765	0.0435	0.105	0.011	0.0538	0.127	0.0161	0.0616	0.132	0.0174	0.0616	0.141	0.0198	0.0649	0.143	0.0204	0.0655
LoLR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARnLF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L&I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R&I	1	1	0.029	0.029	0.000841	0.0125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SoCIS	1	1	0.029	0.029	0.000841	0.0125	0.0125	0.000156	0.00621	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S&T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIPDNC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoSLW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IoSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CSi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRCR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NSIPD	1	1	0.029	0.058	0.00336	0.025	0.0875	0.00765	0.0435	0.105	0.011	0.0538	0.127	0.0161	0.0616	0.132	0.0174	0.0616	0.141	0.0198	0.0649	0.143	0.0204	0.0655
TCCRN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UCTO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
URMPC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCRL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DiCM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IPDNTU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoGipr	1	1	0.029	0.145	0.021	0.0625	0.0625	0.0039	0.031	0.087	0.00756	0.0446	0.104	0.0108	0.0504	0.107	0.0114	0.05	0.119	0.0141	0.0548	0.116	0.0134	0.0532
NDR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCNHS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoUT	10	100	0.29	1.102	1.214	0.475	0.7875	0.62	0.391	0.751	0.564	0.385	0.777	0.603	0.377	0.79	0.624	0.369	0.835	0.697	0.384	0.841	0.707	0.385
AoAIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GPT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IPIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoICT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B&IC	2	4	0.058	0.29	0.0841	0.125	0.475	0.225	0.236	0.391	0.152	0.2	0.385	0.148	0.186	0.377	0.142	0.176	0.369	0.136	0.17	0.384	0.147	0.176
LoFI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FvLCM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IoTM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EPM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
StMCR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psz	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NV=34.45			NV=2.32			NV=2.01			NV=1.95			NV=2.06			NV=2.14			NV=2.18			NV=2.18	

Appendix 6- Causal Chain Analysis

Table 24: Causal Chain Analysis

Chain length no.	Factors in chain	No. of factors in chain	Chain weight	Chain centrality weight (Degree centrality)	Chain centrality weight (Eigenvector centrality)
1	TCPAFTM-CLA-SPA-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-B&IC	18	17	7.1739	2.576
2	TCPAFTM-CLA-SPA-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-CEC	18	17	7.1739	2.576
3	CCRL-SPA-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-B&IC	17	16	6.7391	2.576
4	CCRL-SPA-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-CEC	17	16	6.7391	2.576
5	IPLC-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoETM-LoUT-B&IC	17	16	6.5652	2.694
6	IPLC-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoETM-LoUT-CEC	17	16	6.5652	2.694
7	CS-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-B&IC	16	15	6.5217	2.576
8	CS-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-CEC	16	15	6.5217	2.576
9	LoCA-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.5217	2.576
10	LoCA-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.5217	2.576
11	PORB-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.5217	2.576
12	PORB-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.5217	2.576
13	HFCNS-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.4782	2.576
14	HFCNS-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.4782	2.576
15	IoSR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.4782	2.576
16	IoSR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.4782	2.576
17	LoFIPDCM-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-B&IC	16	15	6.4782	2.576
18	LoFIPDCM-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoUT-CEC	16	15	6.4782	2.576
19	LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoETM-LoUT-B&IC	16	15	6.4782	2.694
20	LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoETM-LoUT-CEC	16	15	6.4782	2.694
21	LoTP-LoES-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoUT-B&IC	16	15	6.4782	2.552
22	LoTP-LoES-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoUT-CEC	16	15	6.4782	2.552
23	SfLC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.4782	2.576
24	SfLC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.4782	2.576
25	LoESIPD-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoUT-B&IC	16	15	6.4347	2.6415
26	LoESIPD-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoUT-CEC	16	15	6.4347	2.6415

Chain length no.	Factors in chain	No. of factors in chain	Chain weight	Chain centrality weight (Degree centrality)	Chain centrality weight (Eigenvector centrality)
27	RnTRSR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.4347	2.576
28	RnTRSR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.4347	2.576
29	BR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.3913	2.576
30	BR-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.3913	2.576
31	TCPACNA-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	16	15	6.3913	2.576
32	TCPACNA-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	16	15	6.3913	2.576
33	LoTSC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	15	14	6.2608	2.389
34	LoTSC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	15	14	6.2608	2.389
35	HII-LoGS-RtC-CRtC-LoIW-LoPB-LoP-LoIA-LoF-CCP-LoC-LoUT-B&IC	13	12	5.8695	2.4865
36	HII-LoGS-RtC-CRtC-LoIW-LoPB-LoP-LoIA-LoF-CCP-LoC-LoUT-CEC	13	12	5.8695	2.4865
37	LC-RtC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoUT-B&IC	13	12	5.826	2.2995
38	LC-RtC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoUT-B&IC	13	12	5.826	2.2995
39	IPIT-RtC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoUT-B&IC	13	12	5.7826	2.2995
40	IPIT-RtC-CRtC-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoUT-CEC	13	12	5.7826	2.2995
41	LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-CRtC-LoIW-HII-LoGS-LoPB	13	12	5.6956	2.004
42	LoEI-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-B&IC	14	13	5.6521	1.94
43	LoEI-LoIW-HII-LoGS-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU-RtC-LoUT-CEC	14	13	5.6521	1.94
44	LoPr-AAJPC-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoT-MR&T	16	11	5.6086	2.1147
45	LoENR-RtC-CRtC-LoIW-HII-LoGS-LoPB-LoP-LoIA-LoF-CCP-LoC-LoI-LoIU	14	13	5.6086	2.1255

Appendix 7- Survey Demographics

Table 25: Survey Demographics

No.	Profession	Gender	Age range	Years of experience
1	Project manager	M	26-35	5 - 10 years
2	Project planner	M	36-45	5 - 10 years
3	Project engineer	M	46-55	30+ years
4	Construction manager	M	46-55	20 - 30 years
5	BIM manager	M	26-35	5 - 10 years
6	Project engineer	M	26-35	5 - 10 years
7	Design manager	M	36-45	10 - 20 years
8	Senior project manager	M	46-55	20 - 30 years
9	Project manager	M	26-35	10 - 20 years
10	Civil engineer	M	26-35	5 - 10 years
11	Quantity surveyor	M	36-45	10 - 20 years
12	Senior quantity surveyor	F	26-35	5 - 10 years
13	Construction manager	M	56+	30+ years
14	Project director	M	56+	30+ years
15	Electrical engineer	M	36-45	10 - 20 years
16	Design engineer	M	26-35	5 - 10 years
17	Design manager	M	36-45	10 - 20 years
18	Quantity surveyor	M	26-35	5 - 10 years
19	N/A	M	36-45	10 - 20 years
20	N/A	M	36-45	10 - 20 years
21	N/A	M	26-35	5 - 10 years
22	Construction manager	M	36-45	10 - 20 years
23	N/A	F	26-35	5 - 10 years
24	Estimator	F	26-35	5 - 10 years
25	N/A	M	36-45	10 - 20 years
26	Senior project manager	M	46-55	30+ years
27	Commercial manager	M	56+	30+ years
28	Commercial	M	46-55	30+ years
29	Systems director	M	36-45	20 - 30 years
30	Design manager	F	36-45	10 - 20 years
31	Design manager	M	36-45	10 - 20 years
32	Quality lead	M	26-35	5 - 10 years
33	Estimator	M	26-35	5 - 10 years
34	Company director	M	56+	30+ years
35	Managing director/ Construction manager	M	46-55	30+ years
36	Digital delivery manager	F	36-45	10 - 20 years
37	Consultant	M	46-55	20 - 30 years
38	Construction engineer	M	26-35	5 - 10 years
39	N/A	M	26-35	5 - 10 years

No.	Profession	Gender	Age range	Years of experience
40	Design engineer	M	26-35	5 - 10 years
41	Project engineer	M	26-35	5 - 10 years
42	N/A	M	26-35	5 - 10 years
43	BIM manager	F	36-45	10 - 20 years
44	N/A	M	26-35	5 - 10 years
45	Commercial manager	M	36-45	20 - 30 years
46	N/A	M	26-35	5 - 10 years
47	Mechanical engineer	M	36-45	10 - 20 years
48	Designer	M	26-35	5 - 10 years
49	Quality lead	M	36-45	10 - 20 years
50	N/A	F	20-25	0 - 5 years
51	Civil engineer	M	26-35	5 - 10 years
52	Contractor	M	36-45	10 - 20 years
53	BIM modeller	M	20-25	0 - 5 years
54	Lecturer	F	36-45	10 - 20 years
55	N/A	M	26-35	5 - 10 years
56	N/A	M	26-35	5 - 10 years
57	Construction manager	M	36-45	10 - 20 years
58	N/A	M	20-25	0 - 5 years
59	Quantity surveyor	M	26-35	5 - 10 years
60	Quantity surveyor	F	26-35	5 - 10 years
61	BIM modeller	M	20-25	0 - 5 years
62	Director	M	46-55	20 - 30 years
63	Research assistant	M	26-35	0 - 5 years
64	Manager	M	36-45	10 - 20 years
65	BIM lead	F	36-45	10 - 20 years
66	Site engineer	M	20-25	0 - 5 years
67	BIM lead	M	26-35	5 - 10 years
68	Graduate engineer	M	20-25	0 - 5 years
69	Quantity surveyor	M	26-35	5 - 10 years
70	Director of construction company	M	46-55	30+ years
71	Mechanical design engineer	M	26-35	5 - 10 years
72	Construction engineer	M	26-35	5 - 10 years
73	Quantity surveyor	M	26-35	5 - 10 years
74	BIM manager	M	36-45	10 - 20 years
75	CAD operator	M	20-25	0 - 5 years
76	N/A	F	26-35	5 - 10 years
77	N/A	M	20-25	5 - 10 years
78	Consultant	F	36-45	10 - 20 years
79	Design engineer	M	26-35	5 - 10 years
80	Project engineer	M	26-35	5 - 10 years
81	Commercial	M	36-45	10 - 20 years

No.	Profession	Gender	Age range	Years of experience
82	Site engineer	M	20-25	0 - 5 years
83	BIM	M	26-35	5 - 10 years
84	Design engineer	F	26-35	5 - 10 years
85	Design engineer	M	26-35	5 - 10 years
86	BIM modeller	M	20-25	0 - 5 years
87	Quantity surveyor	F	36-45	10 - 20 years
88	Site engineer	M	20-25	0 - 5 years
89	Health and safety coordinator	M	26-35	5 - 10 years
90	Legal aid	M	36-45	10 - 20 years
91	Project manager	M	46-55	20 - 30 years
92	Office manager	F	36-45	10 - 20 years
93	N/A	M	26-35	5 - 10 years
94	N/A	M	20-25	0 - 5 years
95	Engineering manager	F	36-45	10 - 20 years
96	Project coordinator	M	26-35	5 - 10 years
97	Site engineer	M	20-25	0 - 5 years
98	Project delivery manager	M	36-45	10 - 20 years
99	Graduate engineer	M	20-25	0 - 5 years
100	Business consultant	M	36-45	10 - 20 years
101	N/A	M	20-25	0 - 5 years
102	Project coordinator	M	26-35	5 - 10 years
103	Architect	F	36-45	10 - 20 years
104	Project coordinator	M	26-35	5 - 10 years
105	Director	M	46-55	20 - 30 years
106	Graduate architect	F	20-25	0 - 5 years
107	Consultant	M	46-55	20 - 30 years
108	Construction company owner	M	46-55	20 - 30 years
109	Field engineer	M	26-35	0 - 5 years
110	Project BIM manager	F	36-45	10 - 20 years
111	Project engineer	M	26-35	0 - 5 years
112	Research officer	M	26-35	0 - 5 years
113	Health and safety officer	M	36-45	10 - 20 years
114	Lecturer	F	36-45	0 - 5 years
115	Graduate quantity surveyor	M	20-25	0 - 5 years
116	Designer	M	26-35	0 - 5 years
117	Manager	M	36-45	10 - 20 years
118	Consultant	F	46-55	20 - 30 years
119	Land surveyor	M	26-35	5 - 10 years
120	Electrical engineer	M	26-35	0 - 5 years
121	Quality inspector	M	26-35	5 - 10 years
122	Research officer	F	26-35	0 - 5 years

No.	Profession	Gender	Age range	Years of experience
123	Company owner	M	46-55	20 - 30 years
124	Graduate quantity surveyor	F	20-25	0 - 5 years
125	Project engineer	M	26-35	5 - 10 years
126	Company owner	M	46-55	20 - 30 years
127	Land surveyor	M	36-45	10 - 20 years
128	Lead designer	F	36-45	10 - 20 years
129	Project coordinator	M	20-25	0 - 5 years
130	Quantity surveyor	M	26-35	5 - 10 years
131	Lecturer/Assistant professor	F	36-45	5 - 10 years
132	Structural designer	M	36-45	10 - 20 years
133	Research coordinator	F	26-35	0 - 5 years
134	Cost controller	M	36-45	10 - 20 years
135	Junior quantity surveyor	M	20-25	0 - 5 years
136	Research engagement lead	M	36-45	0 - 5 years
137	Digital delivery lead	M	36-45	10 - 20 years

Appendix 8- P-values from T-test

Table 26: P-values from the t-test

Interrelation	1	2	3	4	5	Mean	Median
1	<0.001	<0.001	<0.001	0.539	<0.001	4.0571	4
2	<0.001	<0.001	<0.001	0.51	<0.001	4.0472	4
3	<0.001	<0.001	<0.001	0.234	<0.001	4.0971	4
4	<0.001	<0.001	<0.001	0.003	<0.001	3.6869	4
5	<0.001	<0.001	<0.001	0.716	<0.001	4.0291	4
6	<0.001	<0.001	<0.001	0.043	<0.001	4.1545	4
7	<0.001	<0.001	<0.001	<0.001	<0.001	3.7255	4
8	<0.001	<0.001	0.051	<0.001	<0.001	3.2375	4
9	<0.001	<0.001	<0.001	<0.001	<0.001	3.4222	3
10	<0.001	<0.001	<0.001	<0.001	<0.001	3.4706	4
11	<0.001	<0.001	0.003	<0.001	<0.001	3.2871	4
12	<0.001	<0.001	<0.001	<0.001	<0.001	3.6909	4
13	<0.001	<0.001	<0.001	0.019	<0.001	3.7909	4
14	<0.001	<0.001	0.302	<0.001	<0.001	2.875	3
15	<0.001	<0.001	0.519	<0.001	<0.001	2.9315	3
16	<0.001	<0.001	<0.001	0.899	<0.001	3.9895	4
17	<0.001	<0.001	<0.001	<0.001	<0.001	3.6379	4
18	<0.001	<0.001	<0.001	<0.001	<0.001	3.6807	4
19	<0.001	<0.001	<0.001	0.787	<0.001	3.9845	4
20	<0.001	<0.001	<0.001	<0.001	<0.001	3.3884	4
21	<0.001	<0.001	<0.001	<0.001	<0.001	3.5317	4
22	<0.001	<0.001	<0.001	<0.001	<0.001	3.4597	4
23	<0.001	<0.001	<0.001	<0.001	<0.001	3.6981	4
24	<0.001	<0.001	<0.001	<0.001	<0.001	3.6852	4
25	<0.001	<0.001	<0.001	<0.001	<0.001	3.6786	4
26	<0.001	<0.001	<0.001	0.693	<0.001	4.0263	4
27	<0.001	<0.001	<0.001	0.251	<0.001	4.0709	4
28	<0.001	<0.001	<0.001	<0.001	<0.001	4.2835	4
29	<0.001	<0.001	<0.001	<0.001	<0.001	4.3154	4
30	<0.001	<0.001	<0.001	0.18	<0.001	4.0846	4
31	<0.001	<0.001	<0.001	0.175	<0.001	4.0952	4
32	<0.001	<0.001	<0.001	<0.001	<0.001	3.7089	4
33	<0.001	<0.001	<0.001	0.892	<0.001	4.0116	4
34	<0.001	<0.001	0.002	<0.001	<0.001	3.3421	4
35	<0.001	<0.001	<0.001	<0.001	<0.001	3.7416	4
36	<0.001	<0.001	<0.001	<0.001	<0.001	3.6322	4
37	<0.001	<0.001	<0.001	0.001	<0.001	3.7738	4
38	<0.001	<0.001	<0.001	<0.001	<0.001	3.6133	4
39	<0.001	<0.001	<0.001	<0.001	<0.001	3.4568	4
40	<0.001	<0.001	<0.001	<0.001	<0.001	3.5977	4
41	<0.001	<0.001	<0.001	<0.001	<0.001	3.6782	4
42	<0.001	<0.001	0.104	<0.001	<0.001	2.7976	3
43	<0.001	<0.001	<0.001	<0.001	<0.001	3.4405	4
44	<0.001	<0.001	<0.001	<0.001	<0.001	3.6023	4
45	<0.001	<0.001	<0.001	<0.001	<0.001	3.6522	4
46	<0.001	<0.001	<0.001	<0.001	<0.001	4.2683	4
47	<0.001	<0.001	<0.001	0.004	<0.001	4.1721	4
48	<0.001	<0.001	<0.001	0.045	<0.001	4.1270	4
49	<0.001	<0.001	<0.001	<0.001	<0.001	4.3254	4
50	<0.001	<0.001	<0.001	0.005	<0.001	3.8235	4

Interrelation	1	2	3	4	5	Mean	Median
51	<0.001	<0.001	<0.001	<0.001	<0.001	3.7822	4
52	<0.001	<0.001	<0.001	0.011	<0.001	3.81	4
53	<0.001	<0.001	<0.001	0.517	<0.001	3.9597	4
54	<0.001	<0.001	<0.001	<0.001	<0.001	4.1508	4
55	<0.001	<0.001	<0.001	0.009	<0.001	3.7456	4
56	<0.001	<0.001	<0.001	0.002	<0.001	3.7941	4
57	<0.001	<0.001	<0.001	<0.001	<0.001	4.2097	4
58	<0.001	<0.001	<0.001	0.102	<0.001	3.8917	4
59	<0.001	<0.001	<0.001	0.013	<0.001	3.8291	4
60	<0.001	<0.001	<0.001	0.002	<0.001	3.7760	4
61	<0.001	<0.001	<0.001	<0.001	<0.001	4.1667	4
62	<0.001	<0.001	<0.001	0.414	<0.001	3.9554	4
63	<0.001	<0.001	<0.001	<0.001	<0.001	3.7563	4
64	<0.001	<0.001	<0.001	0.002	<0.001	3.8235	4
65	<0.001	<0.001	<0.001	<0.001	<0.001	3.5983	4
66	<0.001	<0.001	<0.001	<0.001	<0.001	3.6017	4
67	<0.001	0.837	<0.001	<0.001	<0.001	2.0229	2
68	<0.001	<0.001	<0.001	0.026	<0.001	3.8376	4
69	<0.001	<0.001	<0.001	<0.001	<0.001	3.6857	4
70	<0.001	<0.001	<0.001	<0.001	<0.001	3.7034	4
71	<0.001	<0.001	<0.001	<0.001	<0.001	3.7227	4
72	<0.001	<0.001	<0.001	0.01	<0.001	3.8455	4
73	<0.001	<0.001	<0.001	0.001	<0.001	3.776	4
74	<0.001	<0.001	<0.001	0.59	<0.001	3.9603	4
75	<0.001	<0.001	<0.001	0.002	<0.001	3.7680	4
76	<0.001	<0.001	<0.001	0.426	<0.001	4.0397	4
77	<0.001	<0.001	<0.001	0.458	<0.001	4.04	4
78	<0.001	<0.001	<0.001	<0.001	<0.001	3.562	4
79	<0.001	0.248	<0.001	<0.001	<0.001	2.1278	2
80	<0.001	<0.001	<0.001	0.854	<0.001	3.9921	4
81	<0.001	<0.001	<0.001	0.006	<0.001	3.8347	4
82	<0.001	<0.001	<0.001	1	<0.001	4	4
83	<0.001	<0.001	<0.001	0.592	<0.001	3.9754	4
84	<0.001	<0.001	<0.001	<0.001	<0.001	4.124	4
85	<0.001	<0.001	<0.001	0.021	<0.001	3.8595	4
86	<0.001	<0.001	<0.001	<0.001	<0.001	3.7283	4
87	<0.001	<0.001	<0.001	<0.001	<0.001	3.7258	4
88	<0.001	<0.001	<0.001	0.891	<0.001	4.0089	4
89	<0.001	<0.001	<0.001	0.005	<0.001	4.1360	4
90	<0.001	<0.001	<0.001	0.005	<0.001	4.144	4
91	<0.001	<0.001	<0.001	0.880	<0.001	3.9919	4
92	<0.001	<0.001	<0.001	0.238	<0.001	4.0569	4
93	<0.001	<0.001	<0.001	0.003	<0.001	4.1452	4
94	<0.001	<0.001	<0.001	<0.001	<0.001	4.2114	4
95	<0.001	<0.001	<0.001	<0.001	<0.001	4.2358	4
96	<0.001	<0.001	<0.001	<0.001	<0.001	3.7714	4
97	<0.001	<0.001	<0.001	0.59	<0.001	3.9603	4
98	<0.001	<0.001	<0.001	0.903	<0.001	4.0083	4
99	<0.001	<0.001	<0.001	0.183	<0.001	4.0820	4
100	<0.001	<0.001	<0.001	0.023	<0.001	4.1270	4
101	<0.001	<0.001	<0.001	0.023	<0.001	3.8242	4
102	<0.001	<0.001	<0.001	0.794	<0.001	3.9837	4
103	<0.001	<0.001	<0.001	0.309	<0.001	4.0579	4
104	<0.001	<0.001	<0.001	0.688	<0.001	4.0254	4

Interrelation	1	2	3	4	5	Mean	Median
105	<0.001	<0.001	<0.001	0.011	<0.001	3.8430	4
106	<0.001	<0.001	<0.001	0.304	<0.001	3.9344	4
107	<0.001	<0.001	<0.001	0.389	<0.001	4.0472	4
108	<0.001	<0.001	<0.001	0.181	<0.001	4.0709	4
109	<0.001	<0.001	<0.001	0.019	<0.001	3.8583	4
110	<0.001	<0.001	<0.001	0.794	<0.001	3.9835	4
111	<0.001	<0.001	<0.001	0.019	<0.001	4.112	4
112	<0.001	<0.001	<0.001	0.001	<0.001	4.1613	4
113	<0.001	<0.001	<0.001	0.096	<0.001	3.8818	4
114	<0.001	<0.001	<0.001	0.021	<0.001	3.8468	4
115	<0.001	<0.001	<0.001	<0.001	<0.001	3.7455	4
116	<0.001	<0.001	<0.001	0.619	<0.001	3.9690	4
117	<0.001	<0.001	<0.001	0.096	<0.001	4.0781	4
118	<0.001	<0.001	<0.001	0.259	<0.001	4.0526	4
119	<0.001	<0.001	<0.001	0.305	<0.001	4.0488	4
120	<0.001	<0.001	<0.001	0.685	<0.001	3.98	4
121	<0.001	<0.001	<0.001	0.67	<0.001	3.9754	4
122	<0.001	<0.001	<0.001	0.82	<0.001	4.0106	4
123	<0.001	<0.001	<0.001	0.103	<0.001	4.0734	4
124	<0.001	<0.001	<0.001	0.012	<0.001	4.1048	4
125	<0.001	<0.001	<0.001	0.088	<0.001	4.0792	4
126	<0.001	<0.001	<0.001	<0.001	<0.001	3.7355	4
127	<0.001	<0.001	<0.001	<0.001	<0.001	4.1641	4
128	<0.001	<0.001	<0.001	0.726	<0.001	3.9773	4
129	<0.001	<0.001	<0.001	0.037	<0.001	4.1074	4
130	<0.001	<0.001	<0.001	<0.001	<0.001	3.5169	4
131	<0.001	<0.001	<0.001	0.657	<0.001	4.0242	4
132	<0.001	<0.001	<0.001	1	<0.001	4	4
133	<0.001	<0.001	<0.001	0.139	<0.001	3.9076	4
134	<0.001	<0.001	<0.001	0.26	<0.001	3.9333	4
135	<0.001	<0.001	<0.001	<0.001	<0.001	3.76	4
136	<0.001	<0.001	<0.001	0.026	<0.001	3.8372	4
137	<0.001	<0.001	<0.001	0.011	<0.001	3.8583	4
138	<0.001	<0.001	<0.001	0.011	<0.001	3.8390	4
139	<0.001	<0.001	<0.001	<0.001	<0.001	3.7417	4
140	<0.001	<0.001	<0.001	0.034	<0.001	3.8889	4
141	<0.001	<0.001	<0.001	0.608	<0.001	4.9669	4
142	<0.001	<0.001	<0.001	0.109	<0.001	4.0894	4

Appendix 9- Eigenvector Centrality computation

Table 27: Eigenvector Centrality computation

Factor	Nodes	Square	EV1	Nodes	Square	EV2	Nodes	Square	EV3	Nodes	Square	EV4	Nodes	Square	EV5	Nodes	Square	EV6
MIR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CEC	0.741	0.549	0.0432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLA	0.758	0.574	0.0442	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPA	0.832	0.692	0.0485	0.0367	0.00134	0.0412	0	0	0	0	0	0	0	0	0	0	0	0
AAJPC	1.499	2.247	0.0874	0.0694	0.00481	0.0779	0.031	0.00096	0.0303	0	0	0	0	0	0	0	0	0
LoIP	0.649	0.421	0.0378	0.0286	0.000817	0.0321	0	0	0	0	0	0	0	0	0	0	0	0
LoGS	2.147	4.609	0.125	0.0651	0.00423	0.0731	0.0566	0.0032	0.0554	0.0989	0.00978	0.113	0.174	0.0302	0.0282	0.0147	0.000216	0.0506
MR&T	6.572	43.191	0.383	0.315	0.0992	0.353	0.318	0.101	0.311	0.154	0.0237	0.177	0.183	0.0334	0.0312	0.0491	0.00241	0.169
LoC	2.895	8.381	0.168	0.0974	0.00948	0.109	0.0307	0.00094	0.03	0	0	0	0	0	0	0	0	0
IoSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ONIA	0.731	0.534	0.0426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRtC	7.962	63.393	0.464	0.111	0.0123	0.124	0.307	0.0942	0.3	0.246	0.0605	0.282	0.32	0.102	0.0953	0.0511	0.00261	0.176
HFCNS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoUT	5.898	34.786	0.344	0.486	0.236	0.546	0.371	0.137	0.363	0.481	0.231	0.552	0.495	0.245	0.228	0.138	0.019	0.475
PORB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RtC	9.465	89.586	0.552	0.304	0.0924	0.341	0.497	0.247	0.487	0.35	0.1225	0.402	0.426	0.181	0.169	0.0714	0.00509	0.246
CCP	0.767	0.588	0.0447	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoETM	0.696	0.484	0.0406	0.087	0.00756	0.0977	0.0508	0.00258	0.0498	0.0385	0.00148	0.0442	0.0786	0.00617	0.00576	0.0196	0.000384	0.0675
LoIA	0.828	0.685	0.0483	0.0699	0.00488	0.0785	0.14	0.0196	0.137	0.211	0.0445	0.242	0.148	0.0219	0.0204	0.0266	0.000707	0.0917
IPLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B&C	0.848	0.719	0.0494	0.291	0.0846	0.326	0.463	0.214	0.453	0.307	0.0942	0.352	0.468	0.219	0.204	0.193	0.0372	0.665
LoICT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RnTRSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HII	1.414	1.999	0.0824	0.249	0.062	0.279	0.159	0.0252	0.155	0.123	0.0151	0.141	0.206	0.0424	0.0396	0.0746	0.00556	0.257
LoP	1.449	2.099	0.0845	0.152	0.0231	0.17	0.262	0.0686	0.256	0.156	0.0243	0.179	0.186	0.0345	0.0322	0.0513	0.00263	0.176
LoPB	1.479	2.187	0.0862	0.258	0.0665	0.289	0.164	0.0268	0.16	0.127	0.0161	0.145	0.214	0.0457	0.0427	0.0765	0.00585	0.263
IVIPD	1.488	2.214	0.0868	0.09	0.0081	0.101	0.0527	0.00277	0.0516	0.0399	0.00159	0.0458	0.0814	0.00662	0.00618	0.0203	0.000412	0.07
LoIW	3.82	14.592	0.222	0.131	0.0171	0.147	0.118	0.0139	0.115	0.153	0.0234	0.175	0.282	0.0795	0.0742	0.0375	0.0014	0.129
CS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPACNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPAFTM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R&I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SoCIS	0.841	0.707	0.049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIU	2.343	5.489	0.136	0.143	0.0204	0.16	0.204	0.0416	0.2	0.176	0.0309	0.202	0.222	0.0492	0.0459	0.017	0.000289	0.0586
LoI	1.508	2.274	0.0879	0.126	0.0158	0.141	0.0822	0.00675	0.0805	0.0226	0.00051	0.0259	0	0	0	0	0	0
LoT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCo	1.52	2.31	0.0886	0.171	0.0292	0.192	0.144	0.0207	0.141	0.12	0.0144	0.137	0.17	0.0289	0.027	0.0143	0.000204	0.0493
LoLean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PM	1.562	2.439	0.0911	0.0333	0.0011	0.0374	0	0	0	0	0	0	0	0	0	0	0	0
AaW	0.827	0.683	0.0482	0.0698	0.00487	0.0784	0.14	0.0196	0.137	0.211	0.0445	0.242	0.148	0.0219	0.0204	0.0266	0.000707	0.0917
LoF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDTG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DHQD	0.776	0.602	0.0452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DiC	1.514	2.292	0.0883	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOCm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSTD	0.815	0.664	0.0475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PDT	0.82	0.672	0.0478	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDCOC	0.832	0.692	0.0485	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfF	0.77	0.592	0.0449	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		NV=17.14			NV=0.89			NV=1.02			NV=0.87			NV=1.07			NV=0.29	

Factor	Nodes	Square	EV7	Nodes	Square	EV8	Nodes	Square	EV9	Nodes	Square	EV10	Nodes	Square	EV11	Nodes	Square	EV12
MIR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AAJPC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoGS	0.0662	0.00438	0.0817	0.129	0.0166	0.141	0.182	0.0331	0.159	0.101	0.0102	0.0935	0.111	0.0123	0.104	0.15	0.0225	0.141
MR&T	0.227	0.0515	0.28	0.176	0.0309	0.193	0.226	0.051	0.198	0.282	0.0795	0.261	0.279	0.0778	0.263	0.228	0.0519	0.215
LoC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IoSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ONIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRtC	0.298	0.0888	0.367	0.285	0.0812	0.313	0.357	0.127	0.313	0.316	0.0998	0.292	0.375	0.14	0.353	0.352	0.123	0.332
HFCNS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoUT	0.291	0.0846	0.359	0.455	0.207	0.5	0.502	0.252	0.44	0.454	0.206	0.42	0.47	0.22	0.443	0.493	0.243	0.465
PORB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RtC	0.334	0.111	0.412	0.347	0.12	0.381	0.463	0.214	0.406	0.431	0.185	0.399	0.443	0.196	0.417	0.43	0.184	0.405
CCP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoETM	0.0352	0.00123	0.0434	0.0568	0.00322	0.0624	0.0981	0.00962	0.086	0.11	0.0121	0.101	0.065	0.00422	0.0613	0.0723	0.00522	0.0682
LoIA	0.145	0.021	0.179	0.231	0.0533	0.253	0.161	0.0259	0.141	0.167	0.0278	0.154	0.221	0.0488	0.208	0.22	0.0484	0.207
IPLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B&IC	0.402	0.161	0.496	0.304	0.0924	0.334	0.424	0.179	0.371	0.373	0.139	0.345	0.356	0.126	0.335	0.375	0.14	0.353
LoICT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RnTRSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HII	0.13	0.0169	0.16	0.158	0.0249	0.173	0.264	0.0696	0.231	0.31	0.0961	0.287	0.223	0.0497	0.21	0.206	0.0424	0.194
LoP	0.227	0.0515	0.28	0.178	0.0316	0.195	0.231	0.0533	0.202	0.288	0.0829	0.267	0.282	0.0795	0.266	0.232	0.0538	0.218
LoPB	0.134	0.0179	0.165	0.163	0.0265	0.179	0.273	0.0745	0.239	0.32	0.102	0.296	0.229	0.0524	0.216	0.213	0.0453	0.2
IVIPD	0.0364	0.00132	0.0449	0.0589	0.00346	0.0647	0.101	0.0102	0.0885	0.114	0.0129	0.105	0.0674	0.00454	0.0635	0.0749	0.00561	0.0706
LoIW	0.112	0.0125	0.138	0.207	0.0428	0.227	0.311	0.0967	0.272	0.232	0.0538	0.214	0.195	0.038	0.183	0.247	0.061	0.233
CS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfLC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPACNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCPAFTM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R&I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SoCIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoIU	0.0765	0.00585	0.0944	0.149	0.0222	0.163	0.211	0.0445	0.185	0.117	0.0136	0.108	0.128	0.0163	0.12	0.173	0.0299	0.163
LoI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoTP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCo	0.0644	0.00414	0.0795	0.125	0.0156	0.137	0.177	0.0313	0.155	0.0991	0.00982	0.0917	0.108	0.0116	0.101	0.146	0.0213	0.137
LoLean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AaW	0.145	0.021	0.179	0.231	0.0533	0.253	0.161	0.0259	0.141	0.167	0.0278	0.154	0.22	0.0484	0.207	0.219	0.0479	0.206
LoF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDTG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DHGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DiC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOCm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoPr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MSTD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PDT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDCOC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LoES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SfF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NV=0.81			NV=0.91			NV=1.14			NV=1.08			NV=1.06			NV=1.06		

Appendix 10- Causal Chain Analysis

Table 28: Causal Chain Analysis

Chain length no.	Factors in chain	No. of factors in chain	Chain weight	Chain centrality weight (Degree centrality)	Chain centrality weight (Eigenvector centrality)
1	CLA - LoGS - LoP - LoIA - LoIW - HII - RtC - LoUT	8	7	4.23	1.398
2	CLA - LoGS - LoPB - LoP - LoIA - RtC - LoUT - B&IC	8	7	4.23	1.636
3	SPA - LoC - LoI - RtC - LoUT - B&IC	6	5	2.92	0.87
4	LoGS - LoP - LoIA - LoIW - HII - RtC - LoUT - B&IC	8	7	4.38	1.863
5	LoC - LoI - RtC - LoUT - B&IC	5	4	2.46	0.87
6	HFCNS - RtC - LoUT - B&IC	4	3	1.92	0.87
7	PORB - LoIW - LoPB - LoP - LoIA - LoGS - RtC - LoUT	8	7	3.85	1.404
8	RtC - LoUT - B&IC	3	2	1.69	0.87
9	CCP - LoC - LoI - RtC - LoUT - B&IC	6	5	2.85	0.87
10	LoETM - LoUT - B&IC	3	2	0.85	0.533
11	LoIA - LoGS - LoIW - HII - RtC - LoUT - B&IC	7	6	4.08	1.645
12	IPLC - LoUT - B&IC	3	2	0.77	0.465
13	LoICT - LoUT - B&IC	3	2	0.77	0.465
14	RnTRSR - LoGS - LoP - LoIA - LoIW - HII - RtC - LoUT	8	7	3.77	1.398
15	RnTRSR - LoGS - LoPB - LoP - LoIA - RtC - LoUT - B&IC	8	7	3.77	1.636

Chain length no.	Factors in chain	No. of factors in chain	Chain weight	Chain centrality weight (Degree centrality)	Chain centrality weight (Eigenvector centrality)
16	HII - RtC - LoUT - B&IC	4	3	2.08	1.064
17	LoP - LoIA - LoGS - LoIW - HII - RtC - LoUT - B&IC	8	7	4.38	1.863
18	LoPB - LoP - LoIA - LoGS - HII - RtC - LoUT - B&IC	8	7	4.08	1.83
19	LoIW - LoPB - LoP - LoIA - LoGS - RtC - LoUT - B&IC	8	7	4.23	1.869
20	CS - LoC - LoI - RtC - LoUT - B&IC	6	5	2.69	0.87
21	SfLC - RtC - LoUT - B&IC	4	3	1.85	0.87
22	TCPAFTM - CLA - LoGS - LoP - LoIA - RtC - LoUT - B&IC	8	7	4.15	1.436
23	TCPAFTM - CLA - LoGS - LoIW - HII - RtC - LoUT - B&IC	8	7	4.15	1.438
24	LoI - RtC - LoUT - B&IC	4	3	2	0.87
25	LoT - LoI - RtC - LoUT - B&IC	5	4	2.08	0.87
26	LoLean - RtC - LoUT - B&IC	4	3	1.92	0.87
27	LoF - RtC - LoUT - B&IC	4	3	1.85	0.87
28	LC - LoIW - LoPB - LoP - LoIA - LoGS - RtC - LoUT	8	7	3.69	1.404
29	LoEI - LoIW - LoPB - LoP - LoIA - LoGS - RtC - LoUT	8	7	3.69	1.404
30	LoES - CCP - LoC - LoI - RtC - LoUT - B&IC	7	6	2.92	0.87

Appendix 11- Ethics Approval



Auckland University of Technology Ethics Committee (AUTECH)

26 October 2023
Mahesh Babu
Faculty of Design and Creative Technologies

Dear Mahesh

Re Ethics Application: **23/270 Interaction of factors, stakeholders and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand construction industry.**

Thank you for your responses to AUTECH's conditions.

Your ethics application has been approved for three years until 26 October 2026.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the [Auckland University of Technology Code of Conduct for Research](#) and as approved by AUTECH.
2. All public facing documents must have the AUTECH approval number and be of a high standard of spelling and grammar. Dates on the Information Sheet(s) and Consent Form(s) must be consistent.
3. Any amendments to the project must be approved by AUTECH prior to being implemented.
4. A progress report is due annually on the anniversary of the approval date.
5. A final report is due at the expiration of the approval period, or, upon completion of project.
6. Any serious or adverse events must be reported to AUTECH, this includes unforeseen issues that might affect continued ethical acceptability of the project.
7. AUTECH grants ethical approval only. You are responsible for obtaining management permission for access from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

The application number and title need to be referenced on all correspondence related to this project.

All forms are available online <http://www.aut.ac.nz/research/researchethics>

For any enquiries, please contact ethics@aut.ac.nz

(This is a computer-generated letter for which no signature is required)

The AUTECH Secretariat

Auckland University of Technology Ethics Committee

Cc: saad.binasad@aut.ac.nz; Mani Poshdar

Appendix 12- Participant Information Sheet for Interviews

The logo for Auckland University of Technology (AUT) is displayed in white, bold, sans-serif capital letters on a black rectangular background.

TE WĀNANGA ARONUI
O TĀMAKI MAKĀU RAU

Date Information Sheet Produced

13/07/2023

Project Title

Interaction of factors, stakeholders and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand Construction Industry.

Kia Ora

I, Saad Bin Asad am a PhD candidate at Auckland University of Technology and would like to invite you to participate in my research. This research study aims to look into the implementation of Integrated Project Delivery (IPD) in the New Zealand construction industry, and the factors affecting its implementation.

What is the purpose of this research?

IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increase value to the owner, reduce waste, and maximise efficiency through all stages of design, fabrication, and construction. However, there are several barriers to the implementation of IPD. This research aims to narrow down the barriers from the global context to New Zealand context. The research interviews will be conducted at a suitable time between 8 AM and 8 PM as per your convenience. The findings of this research may be used for academic publications and presentations. This research will be beneficial for the New Zealand construction industry to promote IPD as a project delivery method which will aid in reducing cost, schedule delays and enhancing productivity.

How was I identified and why am I being invited to participate in this research?

There are specific criteria to select the target population for this research study- participants with knowledge of IPD or interested in the usage of IPD as a project delivery method. Your experience and familiarity matches the research criteria, and the researcher obtained your reference through your public profile and professional bodies. This Participant Information Sheet has been sent to you via email.

How do I agree to participate in this research?

Should you decide to participate in this research study, you would need to complete a Consent Form and email back to the researcher. Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

What will happen in this research?

If you agree to participate, you will be invited to take part in a single interview with me. You can choose to do this online via Zoom, over the phone, or in person, at a private setting. The interview will be a conversation about your experiences with IPD and what are the barriers in its implementation in your opinion. During the interview, I will be asking you a set of questions and give you plenty of time to provide your responses. You are welcome to bring a support person with you to the interview. If you do not wish to answer a particular question or continue with the interview, you will be free to stop at any time without giving a reason. You will also be offered an opportunity to review the audio recording transcripts of your interview.

What are the discomforts and risks?

As this research is on a general topic which would be conveyed in a simple and friendly conversation, no discomforts and risks are anticipated.

How will these discomforts and risks be alleviated?

It is not anticipated that any discomforts would occur.

What are the benefits?

The outcome of this research will be shared with the participants- which will enable them to understand the barriers to IPD in the New Zealand context comprehensively, and thus prepare solutions. The benefit to me would be the award of a doctoral degree.

How will my privacy be protected?

The interviews will be audio recorded and will be transcribed verbatim (word-for-word). For privacy protection, no real names or other identifiable information will be used in the transcriptions. Your identity will never be revealed in any publications or presentations arising from this study. Apart from the researchers, no one else will have access to your information. Finally, all data, including Consent Forms, will be kept secure on AUT premises and destroyed ten years after completion of the study.

What are the costs of participating in this research?

No costs are involved. I only require around 30-60 minutes of your time. As a token of appreciation, snacks, refreshments, or gift vouchers would be given to you.

What opportunity do I have to consider this invitation?

You will have 1 month to consider this invitation.

Will I receive feedback on the results of this research?

Yes, a summary of results would be posted to the following link which you can bookmark accordingly:

https://drive.google.com/drive/folders/1MZ8UZcuAdOpqz9xtmYtC_xKbkYNwS5Q?usp=sharing

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor,

Dr Mahesh Babu, Mahesh.babu@aut.ac.nz.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEK,

ethics@aut.ac.nz, (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Saad Bin Asad, Email: saad.binasad@aut.ac.nz.

Project Supervisor Contact Details:

Dr Mahesh Babu, Mahesh.babu@aut.ac.nz.

Approved by the Auckland University of Technology Ethics Committee on 26/10/2023, AUTEK Reference number 23/270.

Appendix 13- Consent Form for Interviews



AUT

TE WĀNANGA ARONUI
O TĀMAKI MAKĀU RAU

For use when interviews are involved.

Project title: Interaction of factors, stakeholders, and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand Construction Industry.

Project Supervisor: **Mahesh Babu, Mani Poshdar**

Researcher: **Saad Bin Asad**

- I have read and understood the information provided about this research project in the Information Sheet dated 13/07/2023.
- I have had an opportunity to ask questions and to have them answered.
- I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- I agree to take part in this research.
- I wish to receive a summary of the research findings (please tick one): Yes No

Participant's signature:

.....

.....

Participant's name:

.....

.....

Participant's Contact Details (if appropriate):

.....

.....

.....

.....

.....

Date:

Note: *The Participant should retain a copy of this form.*

Approved by the Auckland University of Technology Ethics Committee on 26/10/2023, AUTEK Reference number 23/270.

Appendix 14- Consent Form for Interviews by videoconference

AUT

TE WĀNANGA ARONUI
O TAMAKI MAKAU RAU

Oral Consent Protocol

For use when interviews are being conducted by videoconference.

Project title: Interaction of factors, stakeholders, and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand Construction Industry.

Project Supervisor: **Mahesh Babu, Mani Poshdar**

Researcher: **Saad Bin Asad**

The participant joins the videoconference.

Do you agree to my recording your consent to participate?

If they agree, then the record function will be activated and they will be asked the following:

Have you read and understood the information provided about this research project in the Information Sheet dated 13/07/2023?

Do you have any questions about the research?

Do you understand that notes will be taken during the interviews and that the interview will also be audio- recorded and transcribed?

Do you understand that taking part in this study is voluntary (your choice) and that you may withdraw from the study at any time without being disadvantaged in any way.?

Do you understand that if you withdraw from the study then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used? However, once the findings have been produced, removal of your data may not be possible.

Do you agree to take part in this research?

Do you wish to receive a summary of the research findings? (please tick one): Yes No

Do you want me to send you a copy of the audio recording for this consent? Yes No

Please confirm your name and contact details

Participant's name:

.....
.....

Participant's Contact Details (if appropriate):

.....
.....
.....
.....

I will now turn off the recording of the Consent and then will start a separate recording for the interview.

Note: The Participant should retain a copy of this form.

Appendix 15- Participant Information Sheet for Pilot Survey



Participant Information Sheet- Pilot study for electronic questionnaire survey

Date Information Sheet Produced

29/09/2023

Project Title

Interaction of factors, stakeholders and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand Construction Industry.

Kia Ora

I, Saad Bin Asad am a PhD candidate at Auckland University of Technology and would like to invite you to participate in my research. This research study aims to look into the implementation of Integrated Project Delivery (IPD) in the New Zealand construction industry, and the factors affecting its implementation.

What is the purpose of this research?

I invite you to pilot a survey questionnaire related to IPD before wider dissemination. Further information about the pilot, including the interview afterwards is detailed below under the “What will happen in this research?” heading. The pilot survey can be accessed through this URL:

https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_dgrMsbWZRFMYM3I

IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increase value to the owner, reduce waste, and maximise efficiency through all stages of design, fabrication, and construction. However, there are several barriers to the implementation of IPD. This research aims to narrow down the barriers from the global context to the New Zealand context. The findings of this research may be used for academic publications and presentations. This research will be beneficial for the New Zealand construction industry to promote IPD as a project delivery method, which will aid in reducing cost, schedule delays and enhancing productivity.

How was I identified and why am I being invited to participate in this research?

There are specific criteria to select the target population for this research study- participants with knowledge of IPD or interested in the usage of IPD as a project delivery method. Your experience and familiarity matches the research criteria, and the researcher obtained your reference through your public profile and professional bodies. This Participant Information Sheet has been sent to you via email.

How do I agree to participate in this research?

Should you decide to participate in this research study, you must complete a Consent Form and email it back to the researcher. Your participation in this research is voluntary (it is your choice), and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. Should you choose to withdraw from the study, you will be offered the choice between having any data that is identifiable (interview data) belonging to you removed or allowing it to continue to be used. However, removing your interview data will not be possible once the actual survey commences or findings are produced. The Pilot survey data provided using the URL above cannot be removed as it is anonymous.

What will happen in this research?

If you agree to participate, the following sequence will be followed:

1. Review and complete the survey questionnaire using the link mentioned above.
2. Upon reviewing and completing the questionnaire, you will be invited for an interview by the researcher to collect your feedback.
3. The interview will focus on the entire questionnaire in detail to check if each question is



straightforward and the possible inclusion of any field language used.

What are the discomforts and risks?

As this research is on a general topic which would be conveyed in a simple and friendly conversation, no discomforts and risks are anticipated.

How will these discomforts and risks be alleviated?

It is not anticipated that any discomforts would occur.

What are the benefits?

The outcome of this research will be shared with the participants- which will enable them to understand the barriers to IPD in the New Zealand context comprehensively, and thus prepare solutions. The benefit to me would be the award of a doctoral degree.

How will my privacy be protected?

The interviews will be audio recorded and will be transcribed verbatim (word-for-word). No real names or other identifiable information will be used in the transcriptions for privacy protection. Your identity will never be revealed in any publications or presentations arising from this study. Apart from the researchers, no one else will have access to your information. Finally, all data, including Consent Forms, will be kept secure on AUT premises digitally and destroyed ten years after completion of the study.

What are the costs of participating in this research?

No costs are involved. I only require around 30-60 minutes of your time.

What opportunity do I have to consider this invitation?

You will have 1 week to consider this invitation.

Will I receive feedback on the results of this research?

Yes, a summary of results would be posted to the following link which you can bookmark accordingly:
https://drive.google.com/drive/folders/1MZ8UZcuAdOpquz9xtmYtC_xKbkYNwS5Q?usp=sharing

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, *Dr Mahesh Babu*, Mahesh.babu@aut.ac.nz.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTECH, ethics@aut.ac.nz , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Saad Bin Asad, Email: saad.binasad@autuni.ac.nz.

Project Supervisor Contact Details:

Dr Mahesh Babu, Mahesh.babu@aut.ac.nz.

Approved by the Auckland University of Technology Ethics Committee on 26/10/2023, AUTECH Reference number 23/270.

Appendix 16- Consent Form for Pilot Survey



Consent Form

For use when a pilot study for survey questions is involved

Project title: Interaction of factors, stakeholders, and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand Construction Industry.

Project Supervisor: **Mahesh Babu, Mani Poshdar**

Researcher: **Saad Bin Asad**

- I have read and understood the information provided about this research project in the Information Sheet dated 29/09/2023.
- I have had an opportunity to ask questions and to have them answered.
- I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- I agree to take part in this research.
- I wish to receive a summary of the research findings (please tick one): Yes No

Participant's signature:

Participant's name:

Participant's Contact Details (if appropriate):

.....
.....
.....
.....

Date:

Note: The Participant should retain a copy of this form.

Approved by the Auckland University of Technology Ethics Committee on 26/10/2023, AUTEK Reference number 23/270.

Appendix 17- Ethics Approval for Amended Survey Questionnaire



Auckland University of Technology Ethics Committee (AUTEC)

8 August 2024
Mahesh Babu
Faculty of Design and Creative Technologies

Dear Mahesh

Re: Ethics Application: **23/270 Interaction of factors, stakeholders and characteristics affecting the implementation of Integrated Project Delivery in the New Zealand construction industry.**

Thank you for your responses to the amendments to your ethics application.
The amendment to update the anonymous survey has been approved.

Non-Standard Conditions of Approval

1. On the flyer include the AUT logo and advice that it is student research.

Non-standard conditions do not need to be submitted to or reviewed by AUTEC unless requested but must be completed before commencing your study.

Standard Conditions of Approval

8. The research is to be undertaken in accordance with the [Auckland University of Technology Code of Conduct for Research](#) and as approved by AUTEC.
9. All public facing documents must have the AUTEC approval number and be of a high standard of spelling and grammar. Dates on the Information Sheet(s) and Consent Form(s) must be consistent.
10. Any amendments to the project must be approved by AUTEC prior to being implemented.
11. A progress report is due annually on the anniversary of the approval date.
12. A final report is due at the expiration of the approval period, or, upon completion of project.
13. Any serious or adverse events must be reported to AUTEC, this includes unforeseen issues that might affect continued ethical acceptability of the project.
14. AUTEC grants ethical approval only. You are responsible for obtaining management permission for access from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

The application number and title need to be referenced on all correspondence related to this project.

All forms are available online <http://www.aut.ac.nz/research/researchethics>

For any enquiries, please contact ethics@aut.ac.nz

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat

Auckland University of Technology Ethics Committee

Cc: saad.binasad@autuni.ac.nz; Mani Poshdar

Appendix 18- Survey Questionnaire

PhD- Survey

Survey Flow

Block: Information Sheet (3 Questions)
Standard: Block 9 (2 Questions)
Standard: DEMOGRAPHICS (5 Questions)
Standard: LEGAL (1 Question)
Standard: (1 Question)
Standard: TECHNOLOGICAL (1 Question)
Standard: (1 Question)
Standard: GOVERNMENTAL (1 Question)
Standard: (5 Questions)
Standard: ORGANISATIONAL (1 Question)
Standard: (1 Question)

Page Break

Information Sheet Kia Ora I, Saad Bin Asad am a PhD candidate at Auckland University of Technology and would like to invite you to participate in my research. This research study aims to look into the implementation of Integrated Project Delivery (IPD) in the New Zealand construction industry, and the factors affecting its implementation. This research study is anonymous, and submission of the survey implies consent. You can exit from the survey at anytime by closing the browser should you decide to change your mind. However, once the survey has been submitted, information cannot be withdrawn as the data is anonymous. What is the purpose of this research? IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increase value to the owner, reduce waste, and maximise efficiency through all stages of design, fabrication, and construction. However, there are several barriers to the implementation of IPD. This research aims to narrow down the barriers from the global context to the New Zealand context. The findings of this research may be used for academic publications and presentations. This research will be beneficial for the New Zealand construction industry to promote IPD as a project delivery method, which will aid in reducing cost, schedule delays and enhancing productivity. How was I identified and why am I being invited to participate in this research? There are specific criteria to select the target population for this research study- participants with knowledge of IPD or interested in the usage of IPD as a project delivery method. Your experience and familiarity matches the research criteria, and the researcher obtained your reference through your public profile and professional bodies. How do I agree to participate in this research? Should you decide to participate in this research study, you must answer "Yes" to the consent question. What will happen in this research? The survey questionnaire consists of statements pertaining to the interactions between factors that affect the implementation of IPD in the New Zealand construction industry. You would need to select the best possible response to each statement ranging from 'Strongly agree' to 'Strongly disagree'. If you are unsure about a particular statement, you may select 'I don't know'. What are the discomforts and risks? As this research is on a general topic which would be conveyed in a simple and friendly conversation, no discomforts and risks are anticipated. How will these discomforts and risks be alleviated? It is not anticipated that any discomforts would occur. What are the benefits? The outcome of this research will be shared with the participants- which will enable them to understand the barriers to IPD in the New Zealand context comprehensively, and thus prepare solutions. The benefit to me would be the award of a doctoral degree. How will my privacy be protected? The survey would be completed online in an anonymous manner through a link. No one, including the researcher will be able to view the identity of the person who submitted the survey. What are the costs of participating in this research? No costs are involved. I only require around 30 minutes of your time. Will I receive feedback on the results of this research? Yes, a summary of results will be posted to the following link in 2025 which you can bookmark accordingly:

https://drive.google.com/drive/folders/1MZ8UZcuAdOpquz9xtmYtC_xKbkYNwS5Q?usp=sharing What do I do if I have concerns about this research? Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Mahesh Babu, Mahesh.babu@aut.ac.nz. Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTECH, ethics@aut.ac.nz , (+649) 921 9999 ext 6038. Whom do I contact for further information about this research? Please keep this Information Sheet for your future reference. You are also able to contact the research team as follows: Researcher Contact Details: Saad Bin Asad, Email: saad.binasad@autuni.ac.nz. Project Supervisor Contact Details: Dr Mahesh Babu, Mahesh.babu@aut.ac.nz.

Kia Ora I, Saad Bin Asad am a PhD candidate at Auckland University of Technology and would like to invite you to participate in my research. This research study aims to look into the implementation of Integrated Project Delivery (IPD) in the New Zealand construction industry, and the factors affecting its implementation. This research study is anonymous, and submission of the survey implies consent. You can exit from the survey at anytime by closing the browser should you decide to change your mind. However, once the survey has been submitted, information cannot be withdrawn as the data is anonymous. What is the

purpose of this research? IPD is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance project results, increase value to the owner, reduce waste, and maximise efficiency through all stages of design, fabrication, and construction. However, there are several barriers to the implementation of IPD. This research aims to narrow down the barriers from the global context to the New Zealand context. The findings of this research may be used for academic publications and presentations. This research will be beneficial for the New Zealand construction industry to promote IPD as a project delivery method, which will aid in reducing cost, schedule delays and enhancing productivity. How was I identified and why am I being invited to participate in this research? There are specific criteria to select the target population for this research study- participants with knowledge of IPD or interested in the usage of IPD as a project delivery method. Your experience and familiarity matches the research criteria, and the researcher obtained your reference through your public profile and professional bodies. How do I agree to participate in this research? Should you decide to participate in this research study, you must answer "Yes" to the consent question. What will happen in this research? The survey questionnaire consists of statements pertaining to the interactions between factors that affect the implementation of IPD in the New Zealand construction industry. You would need to select the best possible response to each statement ranging from 'Strongly agree' to 'Strongly disagree'. If you are unsure about a particular statement, you may select 'I don't know'. What are the discomforts and risks? As this research is on a general topic which would be conveyed in a simple and friendly conversation, no discomforts and risks are anticipated. How will these discomforts and risks be alleviated? It is not anticipated that any discomforts would occur. What are the benefits? The outcome of this research will be shared with the participants- which will enable them to understand the barriers to IPD in the New Zealand context comprehensively, and thus prepare solutions. The benefit to me would be the award of a doctoral degree. How will my privacy be protected? The survey would be completed online in an anonymous manner through a link. No one, including the researcher will be able to view the identity of the person who submitted the survey. What are the costs of participating in this research? No costs are involved. I only require around 30 minutes of your time. Will I receive feedback on the results of this research? Yes, a summary of results will be posted to the following link in 2025 which you can bookmark accordingly: https://drive.google.com/drive/folders/1MZ8UZcuAdOpquz9xtmYtC_xKbkYNwS5Q?usp=sharing What do I do if I have concerns about this research? Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Mahesh Babu, Mahesh.babu@aut.ac.nz. Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTECH, ethics@aut.ac.nz , (+649) 921 9999 ext 6038. Whom do I contact for further information about this research? Please keep this Information Sheet for your future reference. You are also able to contact the research team as follows: Researcher Contact Details: Saad Bin Asad, Email: saad.binasad@autuni.ac.nz. Project Supervisor Contact Details: Dr Mahesh Babu, Mahesh.babu@aut.ac.nz.

Are you currently working or have previously worked within the New Zealand construction industry?

- YES (1)
- NO (2)

Skip To: End of Survey If Are you currently working or have previously worked within the New Zealand construction industry? = NO

End of Block: Information Sheet

Start of Block: Block 9

Have you read and understood the information provided about this research project in the Information Sheet dated 24 July 2024, and do you understand that taking part in this study is voluntary and you are unable to

withdraw information once you complete the survey because it is anonymous?

- YES (1)
- NO (2)

Skip To: End of Survey If Have you read and understood the information provided about this research project in the Informat... = NO

Do you consent to take part in this research?

- YES (1)
- NO (2)

Skip To: End of Survey If Do you consent to take part in this research? = NO

End of Block: Block 9

Start of Block: DEMOGRAPHICS

Please select your gender

- Male (1)
 - Female (2)
 - Other (3)
-

Please mention your profession and job title

Please select your years of experience in the construction industry

- 0-5 years (1)
- 5-10 years (2)
- 10-20 years (3)
- 20-30 years (4)
- 30+ years (5)

Please select your age group

- 20-25 years (1)
 - 26-35 years (2)
 - 36-45 years (3)
 - 46-55 years (4)
 - 56+ years (5)
-

Please mention your location

End of Block: DEMOGRAPHICS

Start of Block: LEGAL

This section seeks answers specific to the legal factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact.

End of Block: LEGAL

Start of Block:

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (27)	Somewhat agree (28)	Neither agree nor disagree (29)	Somewhat disagree (32)	Strongly disagree (33)	I don't know (35)
Lack of IPD contracts causes unfamiliarity among contractors (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of promotion causes unavailability of suitable IPD contracts (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders hesitate to use IPD because of strict contractual clauses (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Risks associated with IPD contracts make it difficult to estimate project costs (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's strict contractual clauses increase the risk taken by stakeholders (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's strict contractual conditions make stakeholders overly cautious (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's strict contractual conditions make joint project control difficult (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

IPD contractual arrangement complications cause challenges in obtaining insurance coverage (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's contractual conditions reduce governmental support (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's contractual conditions reduce mutual respect and trust among stakeholders (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD's contractual conditions reduce collaboration between stakeholders (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients do not see advantages in IPD because of its strict contractual conditions (16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients resist using IPD because of strict contractual conditions (17)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is a lack of insurance policies due to IPD's high initial investment (18)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Insurance companies do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

not offer policies due to complicated IPD pricing models (19)

Lack of governmental support causes insufficient regulations and legal frameworks to aid IPD (20)



End of Block:

Start of Block: TECHNOLOGICAL

This section seeks answers specific to the technological factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact

End of Block: TECHNOLOGICAL

Start of Block:

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (1)	Somewhat agree (2)	Neither agree Nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)	I don't know (6)
Clients resist technology due to high software costs (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Technology is not used adequately, as new software costs are high (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost estimation becomes challenging without the use of technology (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Project objectives-related barriers hinder technology use (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resistance among stakeholders hinders technology use (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Challenging cultural paradigms hinder technology use (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of existing IPD training material hinders technology use (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of IPD awareness among stakeholders hinders technology use (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Stakeholders' lack of opportunities to receive IPD training hinders technology use (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incompetency among the clients' representatives causes BIM and IPD integration challenges (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Without technological support, stakeholders hesitate to use IPD (16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
BIM and IPD integrate well with technological support (17)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using technology successfully is more complicated without the proper tools and resources (19)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effective and productive use of technology relies on the collaboration of stakeholders (21)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders are reluctant to use IPD when they lack IT skills (22)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

End of Block:

Start of Block: GOVERNMENTAL

This section seeks answers specific to the governmental factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact

End of Block: GOVERNMENTAL

Start of Block:

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)	I don't know (6)
Governments are reluctant to use IPD because of the reward-risk mismatch (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The lack of governmental support for IPD is due to the high initial investment (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The lack of governmental support necessitates a higher initial investment for IPD (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD is not promoted enough because of the lack of governmental support (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD is not promoted due to the lack of relevant professional bodies (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There are inadequate professional bodies for IPD because it is not standardised (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Professional bodies do not promote IPD due to lack of governmental support (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD stakeholders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

lack mutual respect and trust due to inadequate governmental support (8)

IPD principles are not put into practice due to insufficient government support (9)

IPD is not standardised due to the lack of governmental support (10)

The lack of government support has prevented the adoption of technology in IPD (11)

Insufficient governmental support has led to a lack of training material on IPD (12)

Stakeholders are hesitant to implement IPD because of the lack of governmental support (13)

There is less governmental support for IPD because of unawareness among stakeholders (14)

Page Break

FINANCIAL This section seeks answers specific to the financial factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact

Page Break

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)	I don't know (6)
Stakeholders are hesitant to use IPD due to high initial investment (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders are hesitant to use IPD because of the compensation structure (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders hesitate to use IPD because of other low-cost project delivery alternatives (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients resist using IPD because of the high initial investment (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients hesitate to use IPD because of the extra costs of creating a new agreement (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients hesitate to use IPD because of the additional costs required to draft a new agreement (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients hesitate to use IPD because of the additional design fees requirement (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients are hesitant to use IPD because the reward offered does not reflect the risks taken (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clients are hesitant to use IPD if the contractor's spending lacks transparency (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is a high investment requirement for IPD because it is	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

not standardised (11)						
Added design cost for the client complicates the IPD's contractual conditions (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders disagree over compensation based on risks taken in an IPD contract (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Achieving joint project control is difficult due to IPD's compensation structure (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The compensation structure of IPD reduces mutual respect and trust among stakeholders (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of mutual respect and trust among IPD stakeholders is due to high initial investment (16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seeking lower costs causes clients to resist using IPD (26)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Misunderstandings in risk contingency accounting increases cost estimation challenges (27)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The high cost of new software and equipment required for IPD makes stakeholders hesitant (28)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is a lack of collaboration between stakeholders due to IPD's compensation structure (29)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Page Break

COLLABORATION This section seeks answers specific to the collaboration factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact

Page Break

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)	I don't know (6)
Challenging cultural paradigms reduces mutual respect and trust among stakeholders (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Challenging cultural paradigms hinder collaboration between stakeholders (16)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders unfamiliar with IPD do not understand the importance of collaboration (17)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' self-interest reduces mutual respect and trust among them (18)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' self-interest hinders incentives to consider IPD (19)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' self-interest reduces collaboration between them (20)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' self-interest causes resistance to use IPD (21)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Stakeholders resist using IPD if the main parties are not integrated together (22)



Key parties' integration gets affected when stakeholders do not collaborate (23)



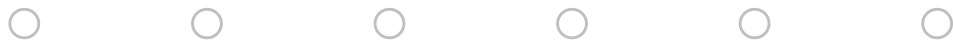
Key parties' integration gets affected when stakeholders are self-protective (24)



Key parties' integration gets affected when stakeholders are not transparent (25)



Mutual respect and trust decreases when stakeholders do not collaborate (26)



Mutual respect and trust decreases when stakeholders are not transparent (27)



Unavailability of trained professionals reduces mutual respect and trust between stakeholders (28)



Stakeholders unfamiliar with IPD do not understand the importance of collaboration (29)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transparency decreases among stakeholders when they do not collaborate (30)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Joint project control becomes difficult because of self-interest among stakeholders (31)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Joint project control becomes difficult when stakeholders do not collaborate (32)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Achieving joint project control becomes difficult if the client is not proficient (33)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Managing the project becomes difficult when stakeholders do not collaborate (34)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The incentive for stakeholders to use IPD decreases when the main parties are not united	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(35)

Lack of lean knowledge among stakeholders reduces mutual respect and trust (36)

Difficulties in project management reduce mutual respect and trust among stakeholders (37)

End of Block:

Start of Block: ORGANISATIONAL

This section seeks answers specific to the organisational factors that affect the implementation of IPD and how they interact with other factors to amplify or reduce their impact

End of Block: ORGANISATIONAL

Start of Block:

Please choose the most suitable response to each interaction ranging from "Strongly Agree" to "Strongly Disagree"

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)	I don't know (6)
Target goals for IPD implementation are difficult to set without high-quality design (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of IPD promotion reduces awareness and willingness among clients (78)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of IPD promotion reduces awareness among stakeholders (79)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The lack of promotion causes a shortage of IPD contracts (80)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The lack of promotion causes unfamiliarity among contractors with IPD (81)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders are not interested in upgrading to IPD because of unawareness (82)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' unfamiliarity with IPD causes resistance (83)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders resist using IPD because of unawareness (84)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Stakeholders resist using IPD because of logistical challenges (85)

Stakeholders resist IPD because they are not interested in upgrading from other delivery models (86)

Stakeholders resist using IPD because of its lack of standardisation (87)

Stakeholders resist upgrading to IPD because of the lack of experience and skills (88)

Stakeholders resist using IPD because of unfamiliarity among contractors (89)

Stakeholders resist using IPD because of their lack of lean knowledge (90)

Stakeholders are hesitant to use IPD because of their limited experience in new roles (91)

Stakeholders resist using IPD because they lack the required experience and skills (92)

Stakeholders lack IPD awareness

because they are not trained (93)

Stakeholders resist using IPD because of project objectives-related barriers (94)

Stakeholders do not upgrade to IPD because of challenging cultural paradigms (95)

Clients are hesitant to use IPD when stakeholders resist change (96)

Clients resist using IPD if there is unawareness among stakeholders (97)

Clients hesitate to use IPD because of project objectives-related barriers (98)

Clients resist using IPD because of its lack of standardisation (99)

Clients resist using IPD because of unawareness among stakeholders (100)

Clients resist using IPD because of business risk (101)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Target goals for IPD implementation are difficult to set without high-quality design (102)



Converting strategic decisions to operational levels is difficult because of unfamiliarity among contractors (103)



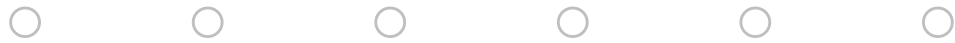
Converting strategic decisions to operational levels is difficult because of low organisational communication (104)



A weak organisational matrix causes unclear responsibilities of the stakeholders (105)



Making sound and timely decisions becomes difficult if the client is not proficient (106)



Converting strategic decisions to operational levels is difficult in the absence of leadership (107)



The lack of trained professionals causes a shortage of



IPD experience
in the market
(108)

The lack of
constraint
analysis and
planning
process causes
resistance
among clients
(109)

Unawareness
among
stakeholders
causes
contractors to
be unfamiliar
with IPD (110)

Lack of
constraint
analysis causes
inefficiency in
resource
planning (111)

Lack of
information
sharing causes
converting
strategic
decisions to
operational
levels difficult
(112)

Lack of
information
sharing hinders
data transfer in
projects (113)

Lack of
constraint
analysis and
planning
process causes
difficulties in
project
management
(114)

Difficulties in
project
management
arise because
of challenging
cultural
paradigms
(115)

Mindset of individuals causes difficulties in changing organisational culture (116)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is a lack of lean knowledge among stakeholders because of inexperience (117)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD is not standardised because of unawareness among stakeholders (118)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Coordination issues exist because of IPD unawareness among stakeholders (119)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders fail to implement IPD principles due to lack of awareness (120)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Challenging cultural paradigms contribute towards stakeholders resisting IPD (121)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contractors' lack of familiarity with IPD develops challenging cultural paradigms (122)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IPD is not standardised because of the unavailability of trained	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

professionals
(123)

IPD is not
standardised
because of
logistical
challenges
(124)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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The lack of
lean
knowledge
among
stakeholders
makes IPD
implementation
difficult (125)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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IPD is not
standardised
because of the
lack of
information
sharing among
stakeholders
(126)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Lack of
experience
among
stakeholders
causes
challenging
cultural
paradigms
(127)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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IPD is not
standardised
because of
project
objectives-
related barriers
(128)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Lack of
constraint
analysis and
planning
hinders
effective IPD
implementation
(129)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Training
material on
IPD is
currently
unavailable
due to a lack of
promotion
(130)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
-----------------------	-----------------------	-----------------------	-----------------------	-----------------------	-----------------------

IPD
unawareness
increases the
risk allocation
mechanism
among
stakeholders
(131)



End of Block:

Appendix 19- Individual interviewee interactions

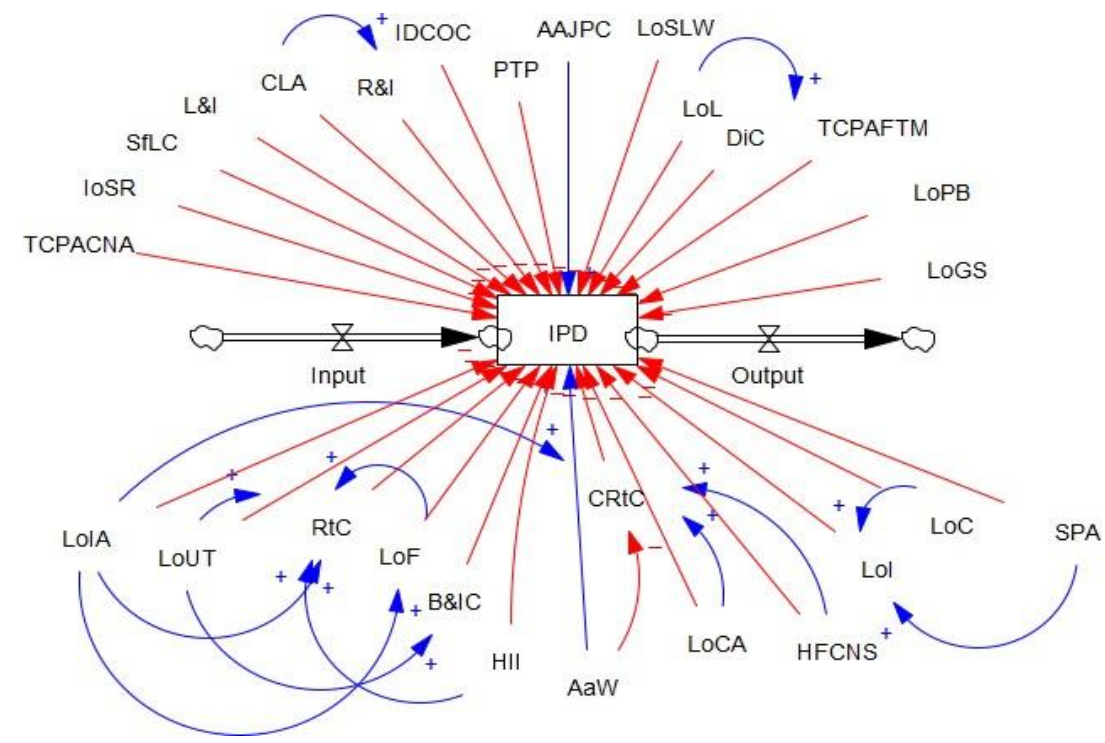


Figure 19: Interviewee C1

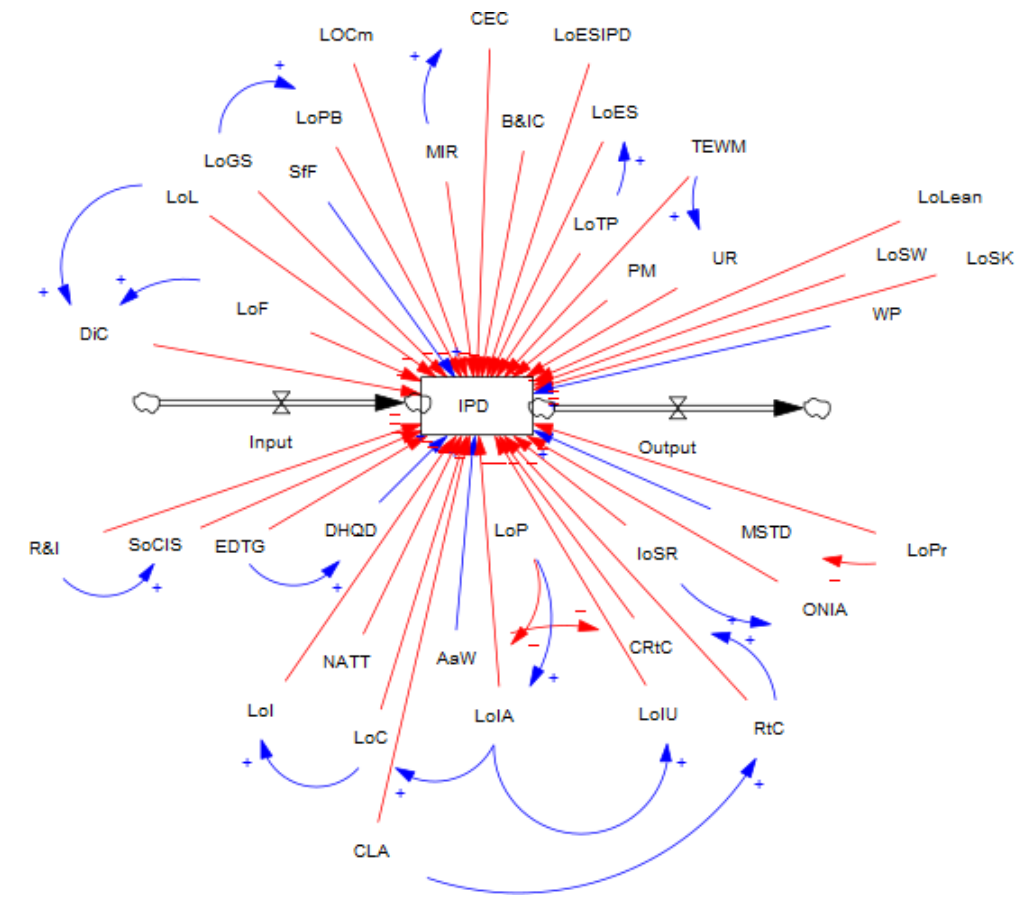


Figure 20: Interviewee C2

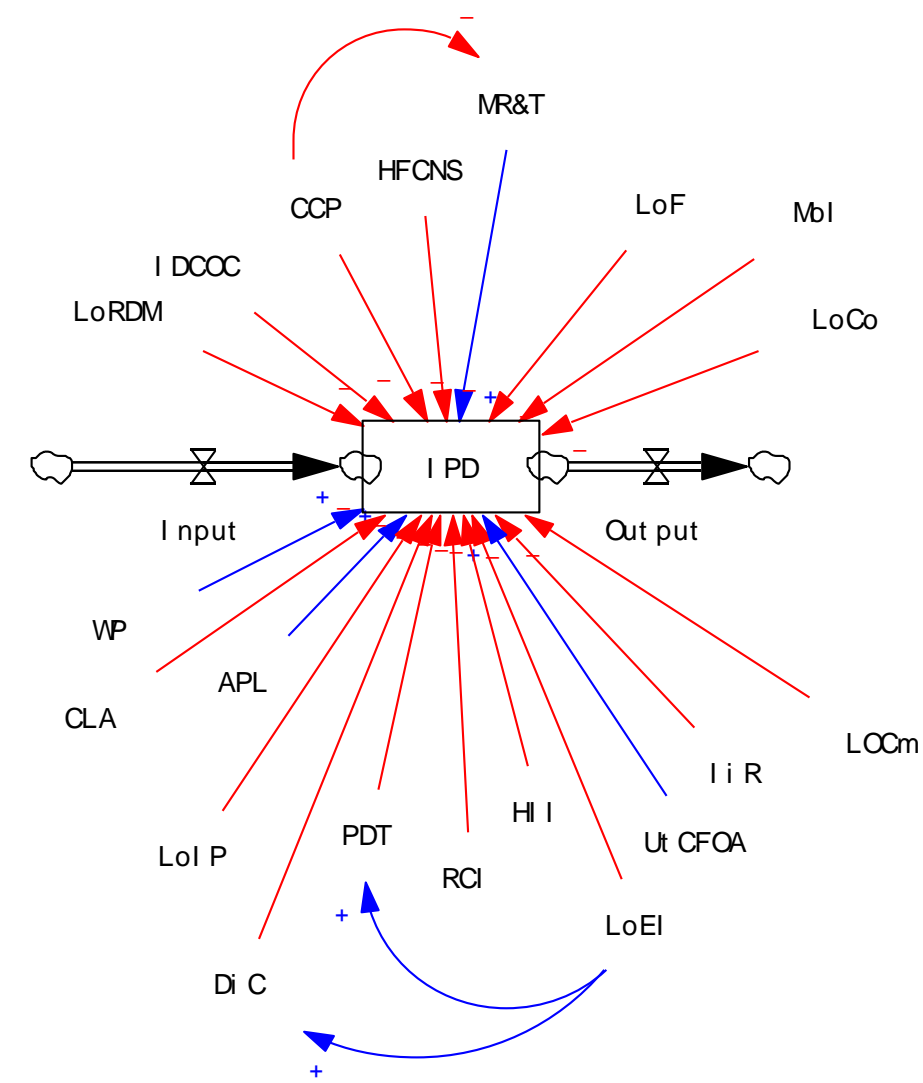


Figure 21: Interviewee C3

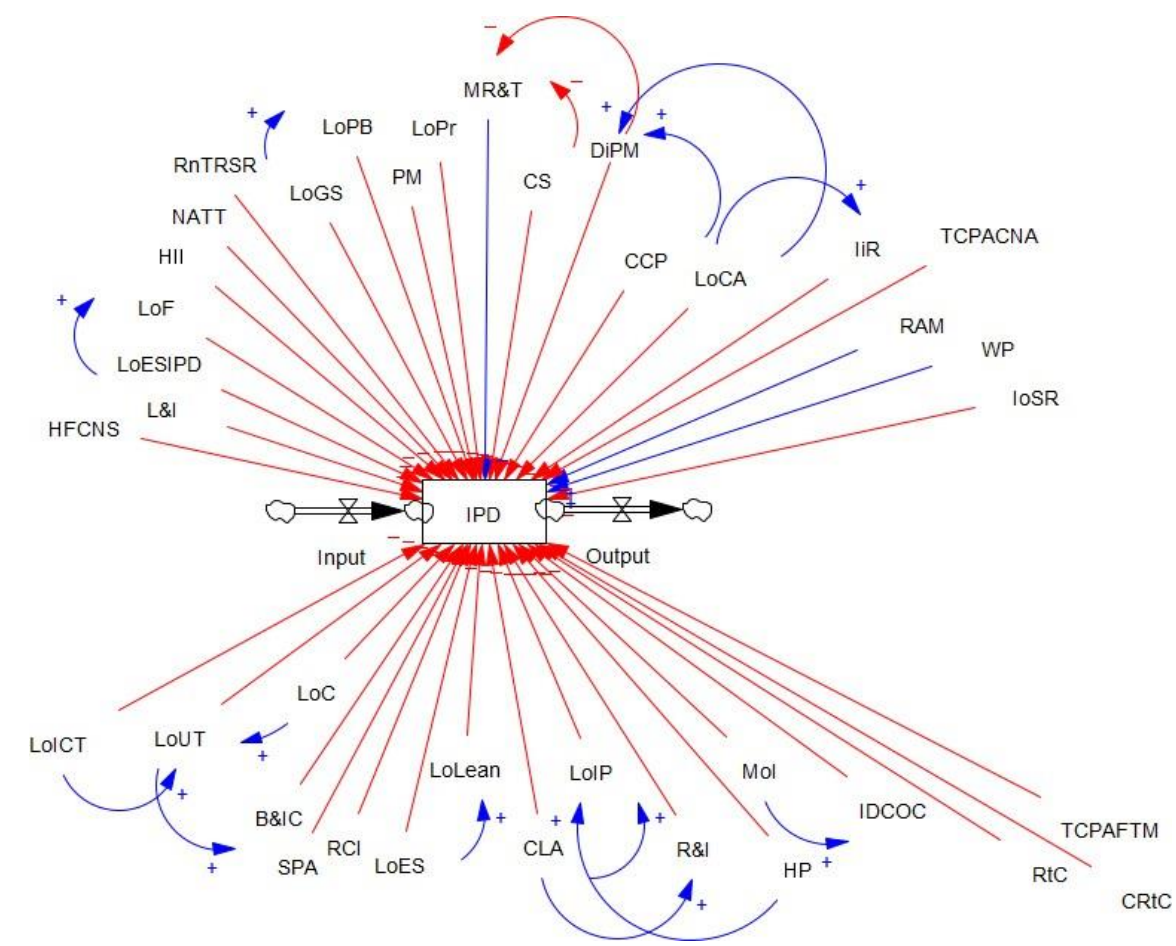


Figure 22: Interviewee C4

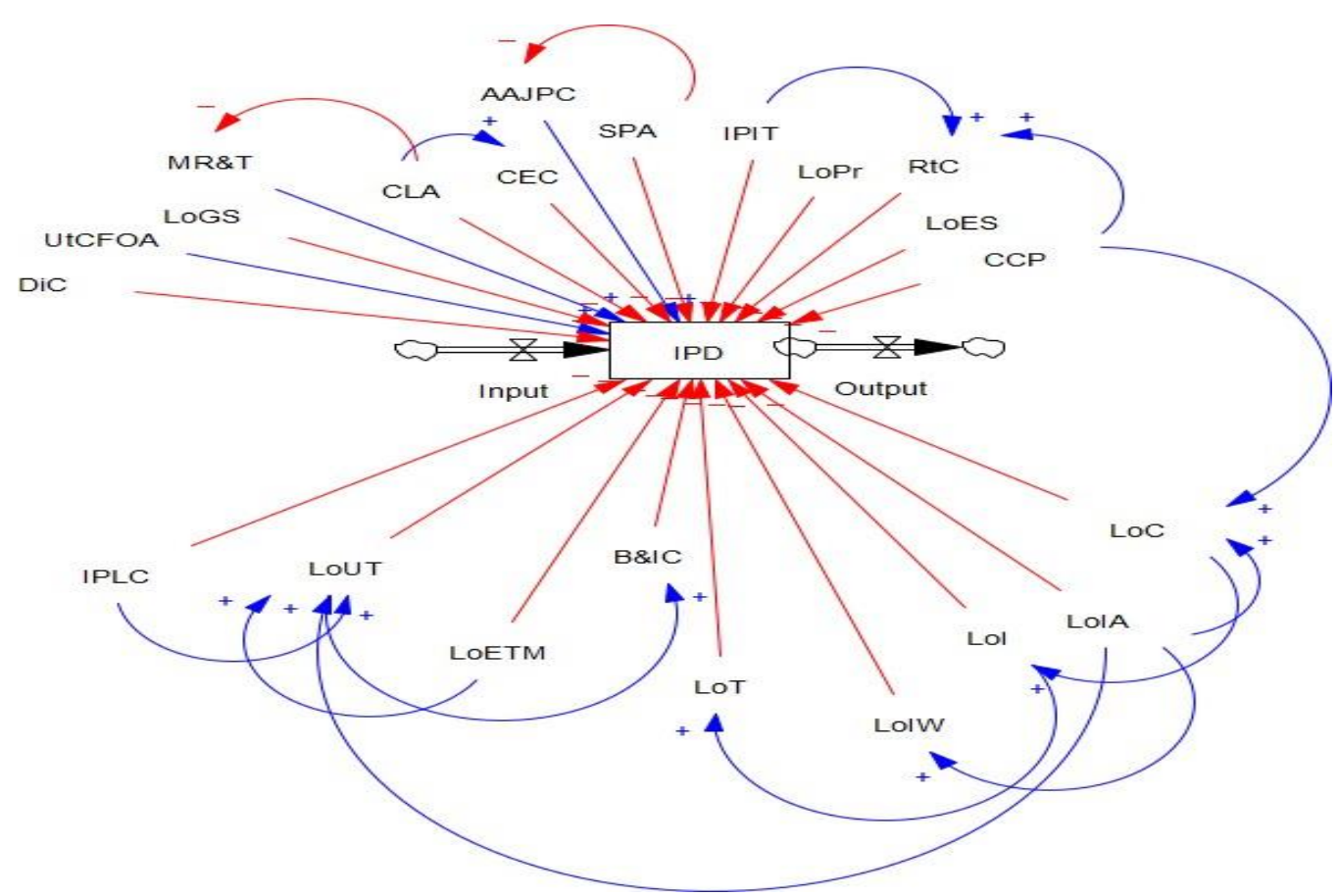


Figure 23: Interviewee C5

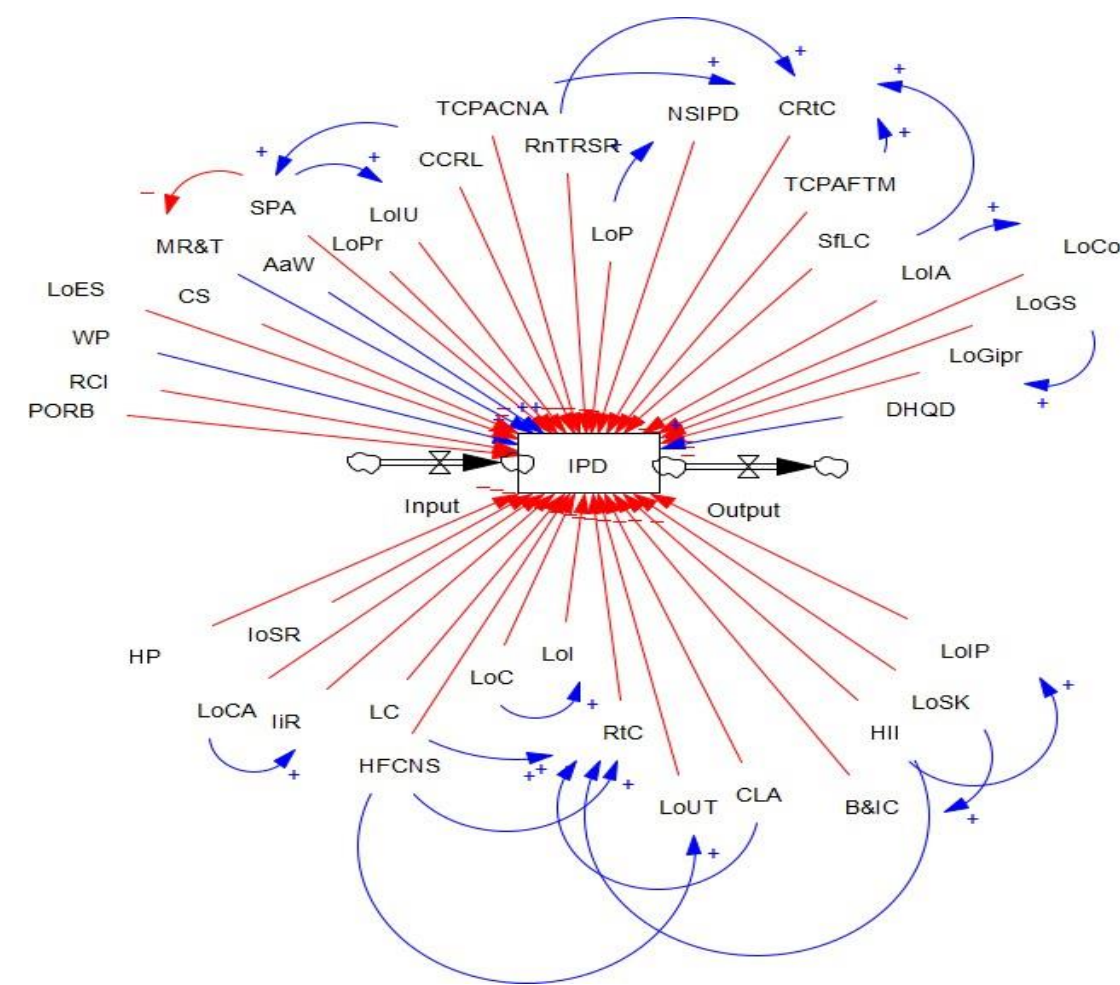


Figure 24: Interviewee C6

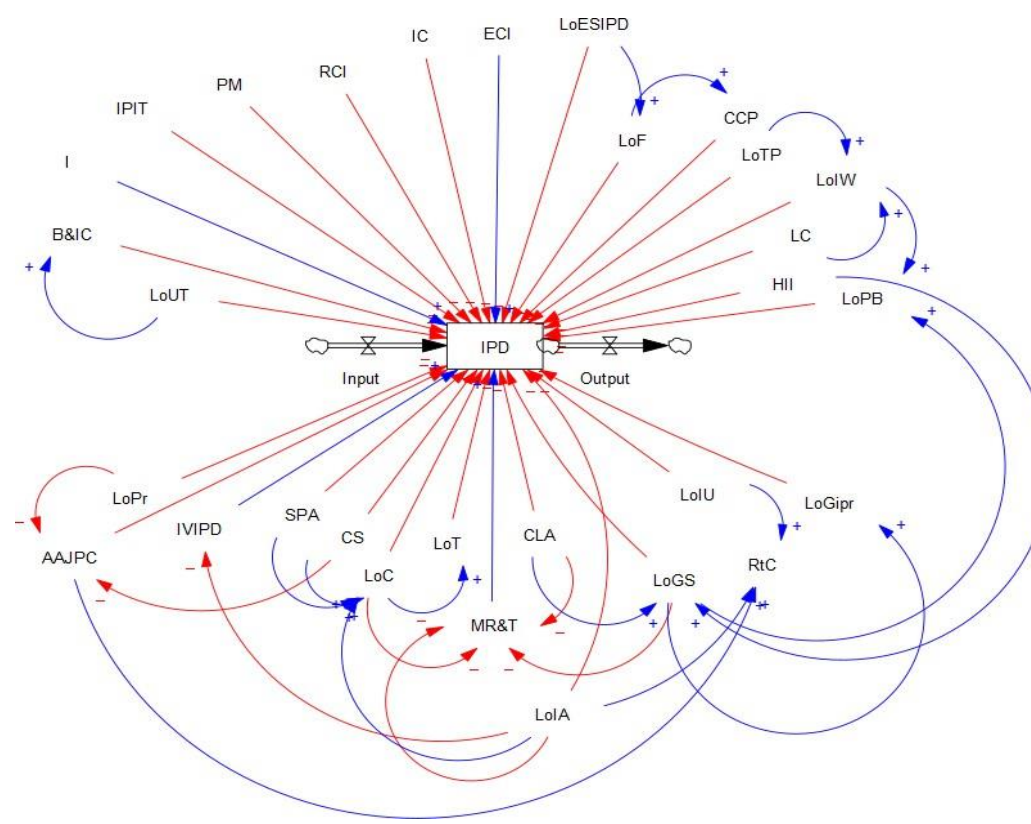


Figure 25: Interviewee C7

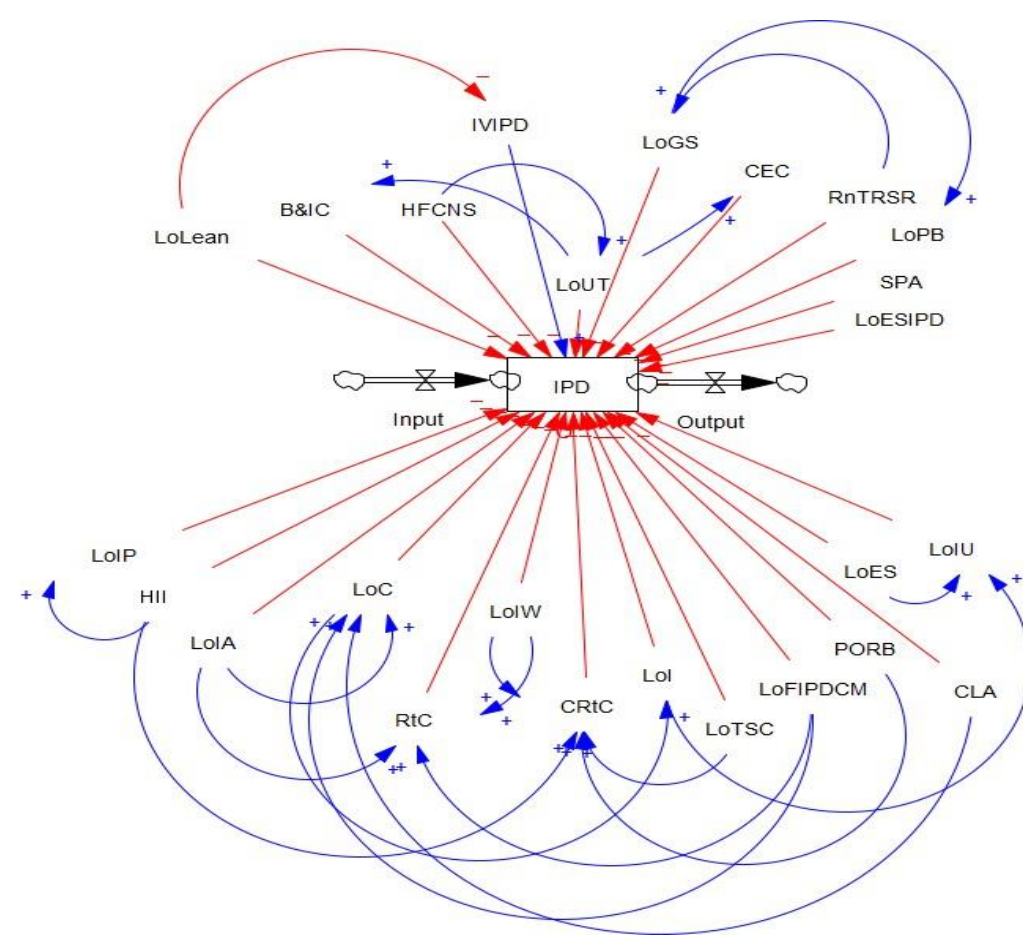


Figure 26: Interviewee C8

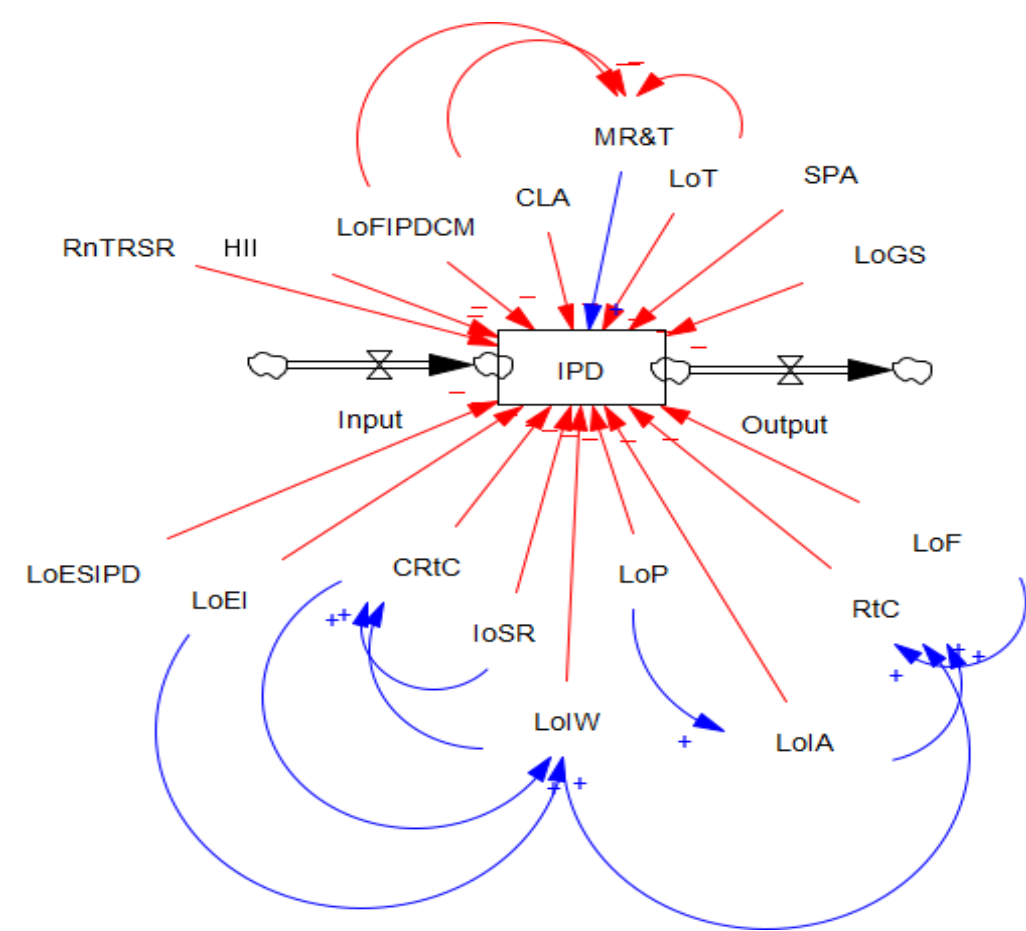


Figure 27: Interviewee C9

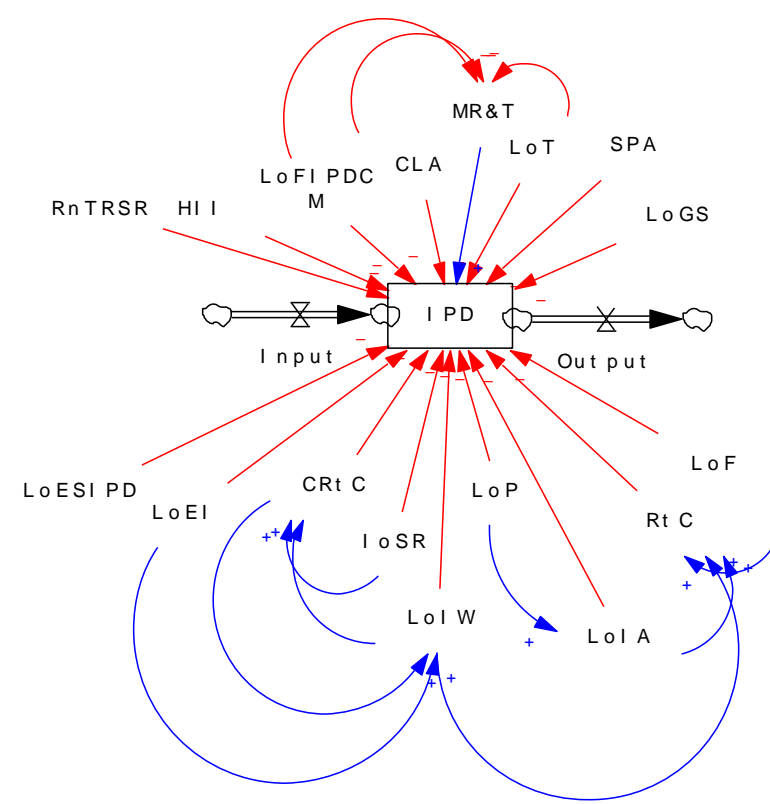


Figure 28: Interviewee C10

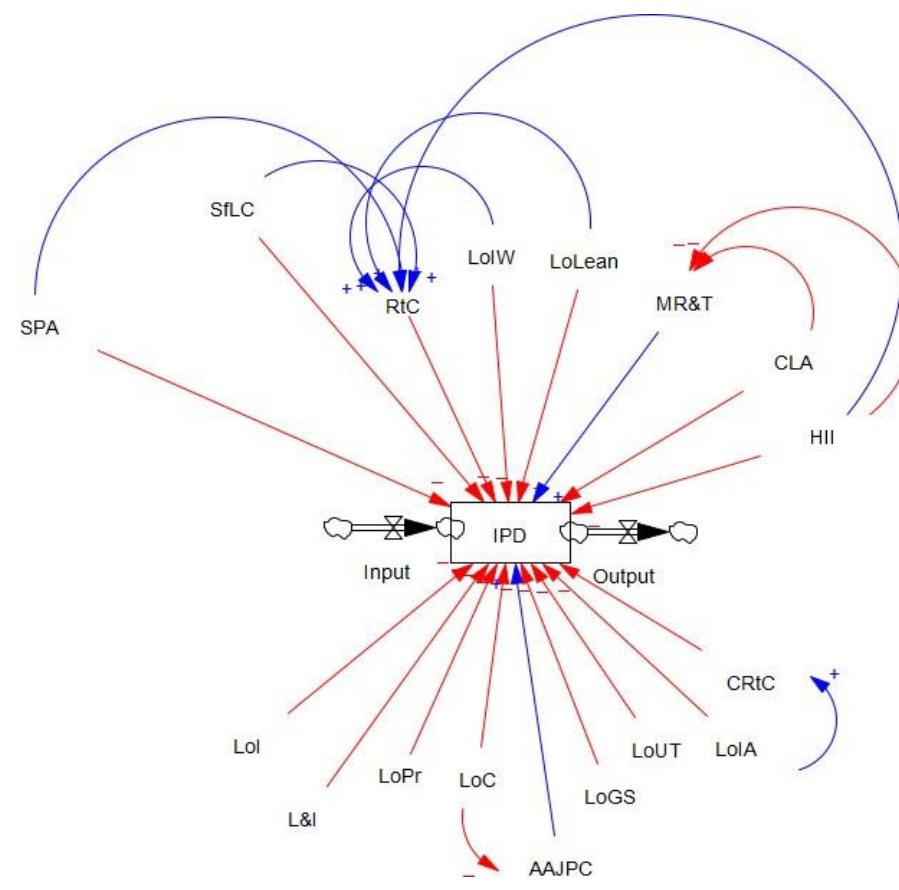


Figure 29: Interviewee C11

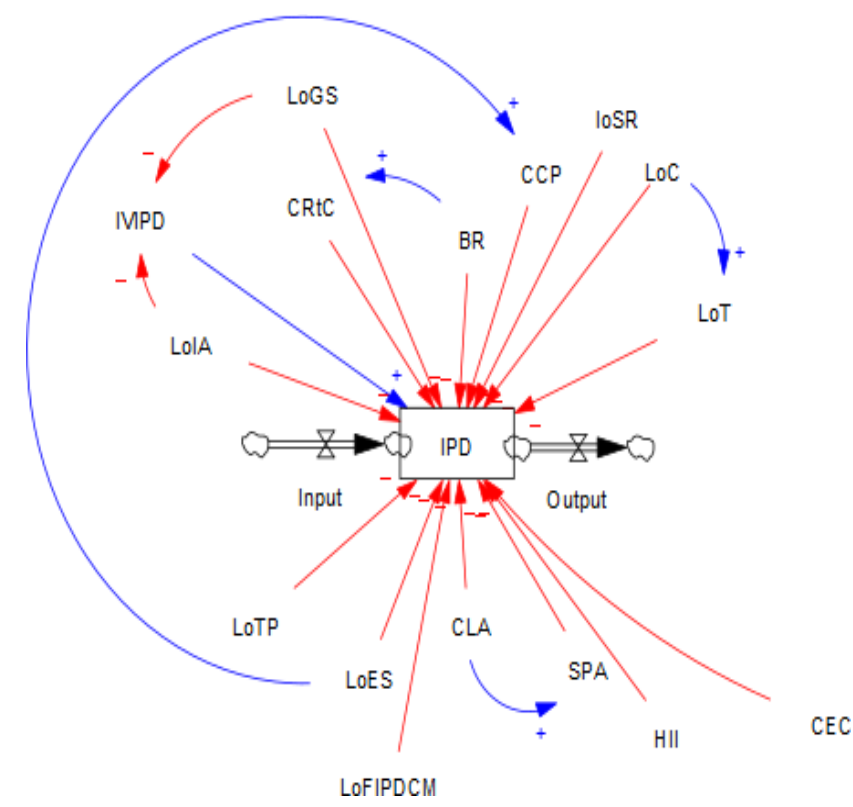


Figure 30: Interviewee C12

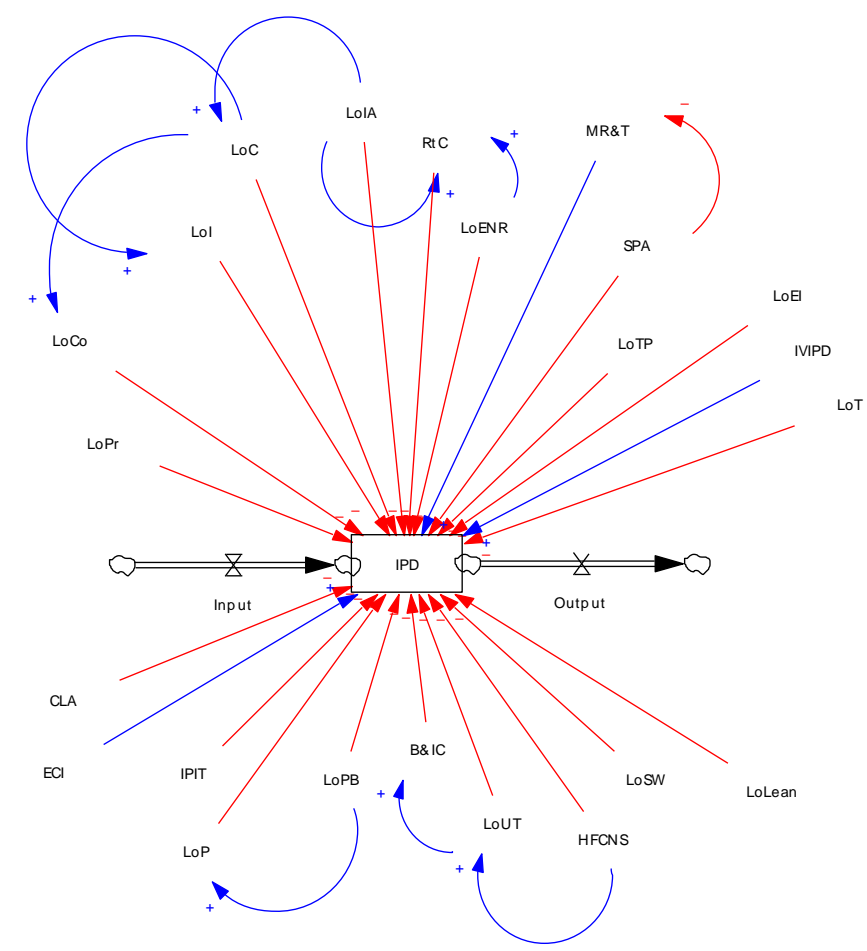


Figure 31: Interviewee C13

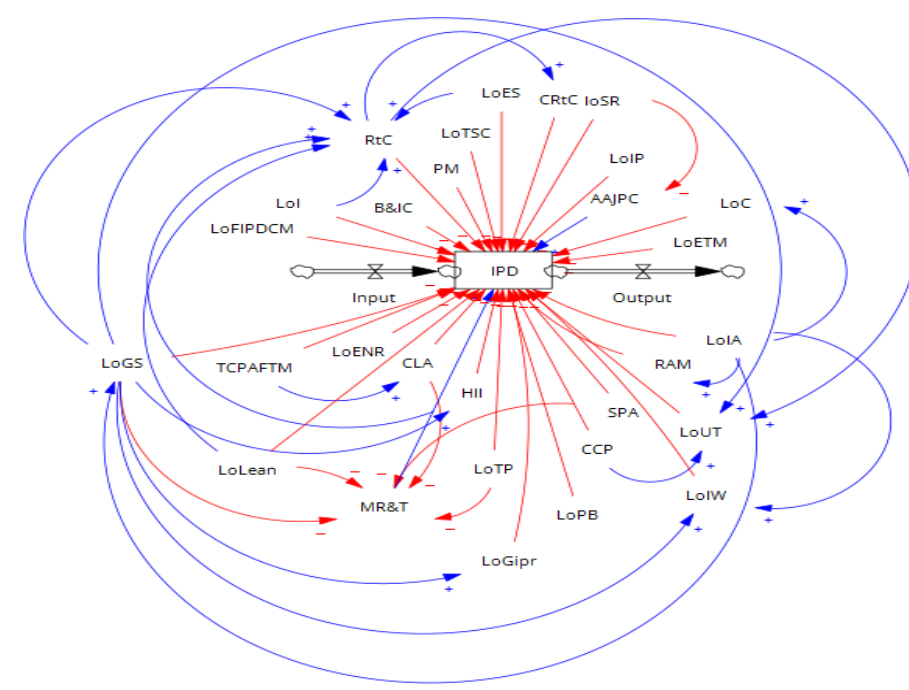


Figure 32: Interviewee C14

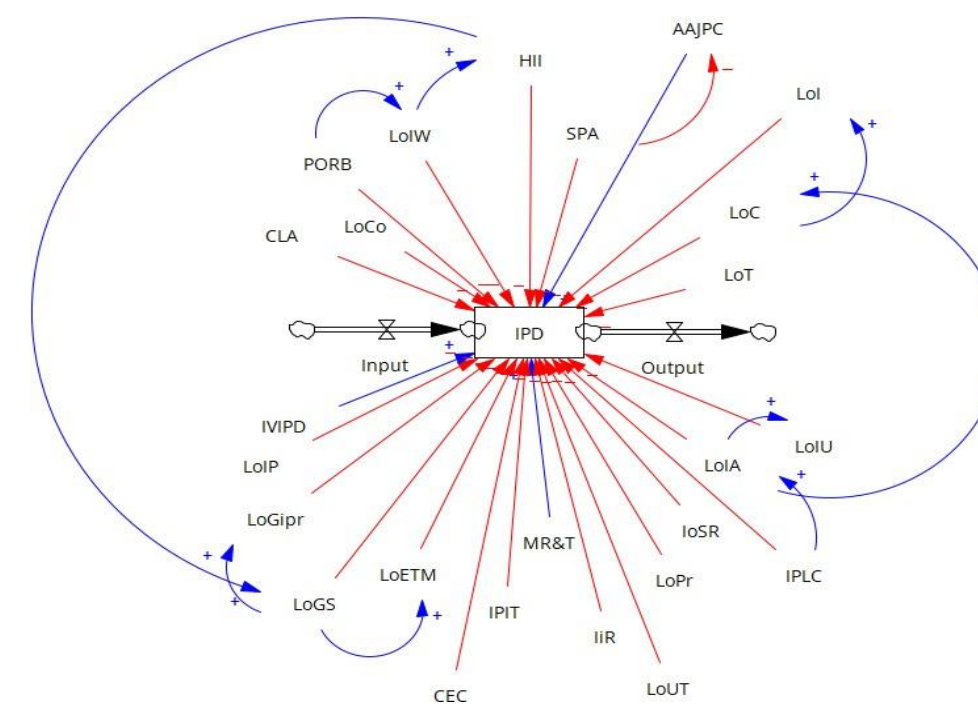


Figure 33: Interviewee C15

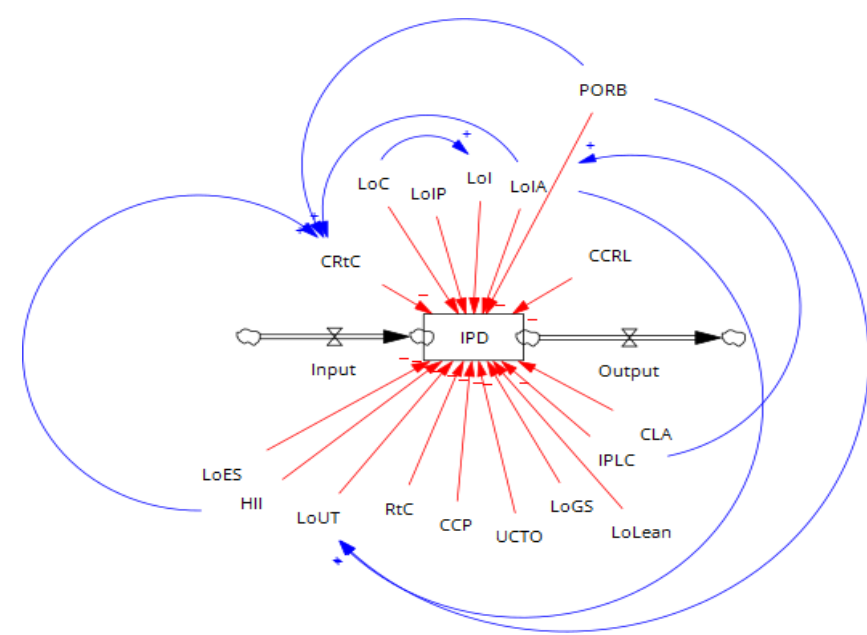


Figure 34: Interviewee C16

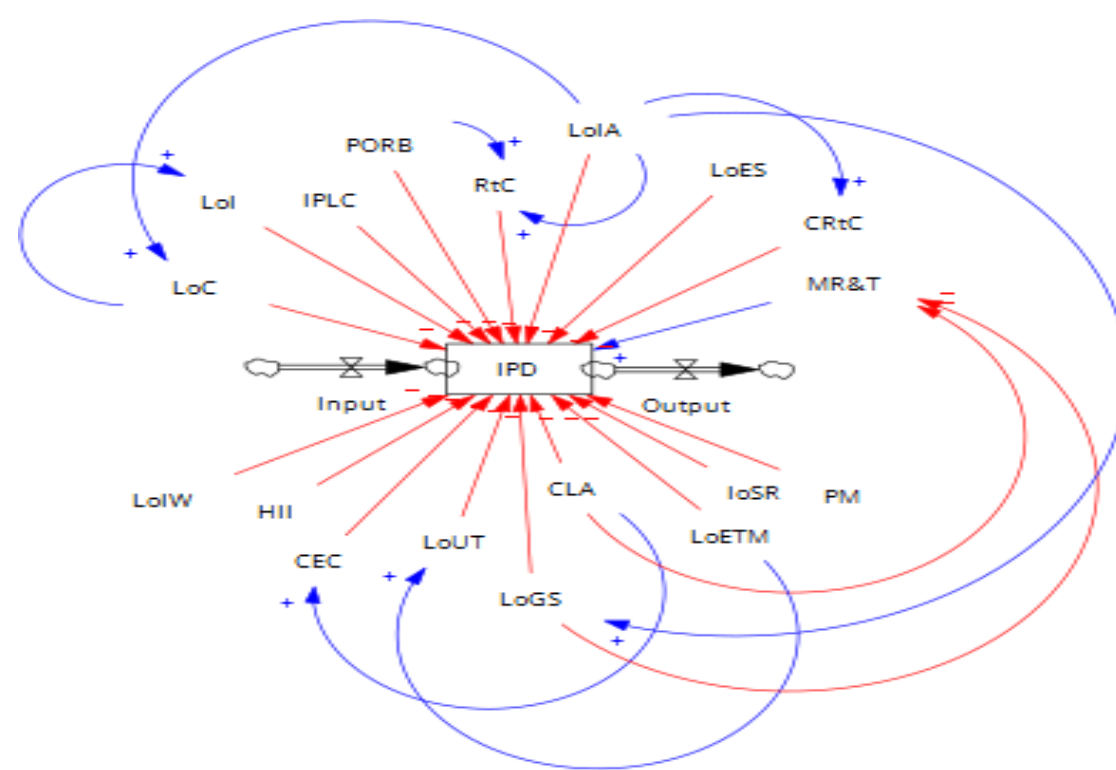


Figure 35: Interviewee C17

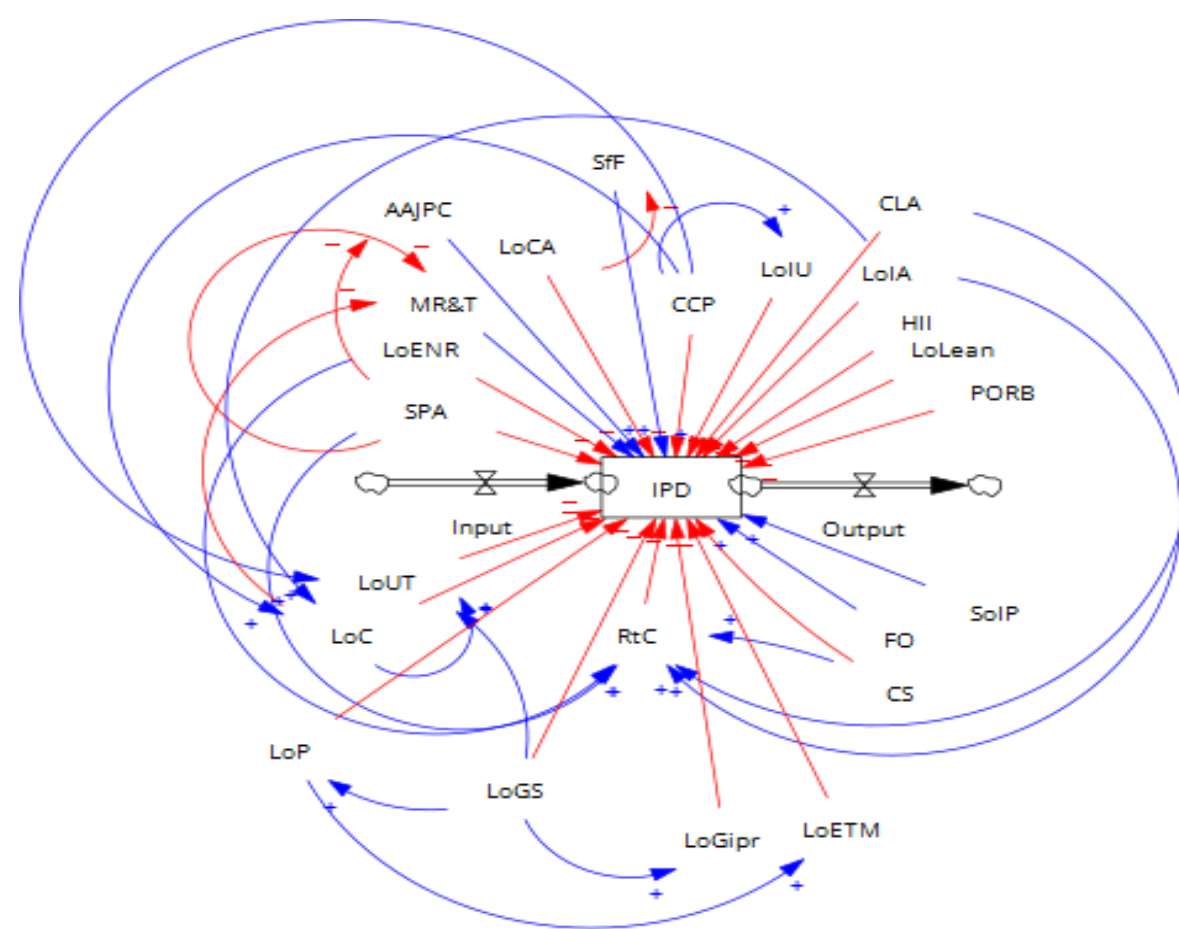


Figure 36: Interviewee C18