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Article

Integrated Project Delivery: New Zealand's Comprehensive Factor Interaction Framework

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Abstract

Integrated project delivery (IPD), as the practical manifestation of lean construction principles, integrates people, systems, and business structures into a collaborative process that harnesses the collective skills of all participants. This approach enhances sustainability by reducing waste and advancing alignment with the United Nations Sustainable Development Goals (SDGs). The purpose of this study is to develop a practical framework that elucidates the interacting factors influencing IPD implementation within New Zealand's (NZ) construction industry, offering transferable insights for other countries with comparable demographics. A systematic literature review of 66 articles identified 127 factors affecting IPD adoption. Deductive reasoning informed the development of open-ended questions for semi-structured interviews with 18 experts, yielding 142 factor interactions. These findings were triangulated with 137 survey responses for validation. Statistical analysis using *t*-tests confirmed 88 significant interactions (based on *p*-values), which were ranked via the Relative Importance Index (RII), visualised using Vensim software, and analysed through centrality techniques to construct a comprehensive IPD interaction framework. This study represents the first comprehensive investigation of IPD factor interactions in the NZ construction sector. The resulting framework provides researchers and practitioners with deeper insights into these dynamics to overcome barriers and promote wider IPD adoption for sustainable construction outcomes.

Keywords: integrated project delivery; factors; interactions; project delivery; construction; sustainability; SDG

1. Introduction

The construction and building sector is a major driver of global environmental degradation and resource depletion, responsible for a significant share of energy consumption, raw material use, and waste generation. Recent research underscores that the construction industry accounts for approximately 40% of global greenhouse gas emissions and over one-third of total energy use, placing immense pressure on natural resources and waste management systems [1]. Achieving the United Nations (UN) Sustainable Development Goals (SDGs) by 2030 requires fundamental shifts in project delivery practices, particularly through collaborative models like integrated project delivery (IPD). IPD, the practical implementation of lean construction (LC) principles, has emerged as a transformative approach to address these challenges by promoting collaboration across traditionally fragmented project phases.

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Ashcraft [2] notes that IPD fundamentally restructures organisational and contractual frameworks to minimise inefficiencies and foster high-performance outcomes. Empirical studies further indicate that IPD, especially when combined with building information modelling (BIM), delivers measurable improvements in sustainability metrics, such as reductions in operational energy consumption, increased cost and schedule efficiency, and improved coordination among stakeholders [3].

The alignment of IPD with the UN SDGs is especially noteworthy from a sustainability standpoint. The attainment of the SDGs necessitates integrated, multi-stakeholder collaboration, particularly for objectives indirectly shaped by the construction sector, such as SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 10 (reduced inequalities), and SDG 16 (peace, justice, and strong institutions). IPD offers a structured platform for harmonising diverse stakeholder interests—including those of public agencies, private enterprises, non-governmental organisations, and academic institutions—within a comprehensive project framework. Such integration enables the realisation of cross-sectoral synergies, facilitating the simultaneous pursuit of multiple SDG targets.

The implications for energy demand underscore the critical role of integrated delivery models. Santika et al. [4] identified 25 energy-related SDG targets, finding that only a minority contribute to reducing energy demand, whereas most require increased energy inputs. This suggests that SDG achievement may drive up global energy requirements, necessitating integrated planning strategies to balance energy efficiency, infrastructure development, and environmental performance. IPD supports these holistic solutions through interdisciplinary collaboration and lifecycle-based optimisation of resource and energy utilisation. In this context, SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production) are noteworthy for the construction sector. SDG 11.6 emphasises the reduction in urban environmental impacts, notably air quality and waste management. Construction activities constitute major sources of air, water, and soil pollution and generate significant construction and demolition waste. Addressing these challenges requires coordinated, integrated project strategies.

IPD enables such coordination by supporting early-stage decisions regarding material selection, construction techniques, and waste management, thus mitigating negative environmental externalities. Similarly, SDG 12.2 calls for the sustainable management and efficient utilisation of natural resources. Given the construction industry's substantial raw material consumption, its contribution to this target is crucial. IPD enables project teams to collaboratively implement resource-efficient design, embrace circular economy principles, and optimise material flows throughout the project lifecycle. This integrated strategy not only improves resource efficiency but also sustains project performance and economic feasibility. In summary, IPD serves as a pivotal enabler for aligning construction practices with the SDGs. By embedding collaboration, transparency, and lifecycle thinking in project governance, IPD fosters the concurrent achievement of environmental, social, and economic goals.

Recent studies have affirmed that integrating construction management with environmental engineering is essential for sustainable development, and that IPD offers a robust, scalable framework to support this integration [1]. Although existing research highlights IPD's potential to enhance collaboration, cost and schedule performance, quality, innovation, and sustainability [5–7], its widespread adoption has been slow. This reluctance is largely due to the significant cultural, contractual, and organisational transformations required to move from conventional hierarchical models to highly collaborative systems [8,9]. While numerous studies have identified discrete barriers, there remains limited insight into how these factors interact dynamically throughout the project lifecycle [10]. This research identifies factors that constitute barriers to implementing IPD. This study addresses this critical gap by developing a comprehensive framework that captures the complex interdependencies among the factors influencing the implementation of IPD.

1.1. Historical Development of Integrated Project Delivery

Research into IPD methods began in the 1960s, with an early focus on project integration and milestone concepts such as PERT, GARM, and Gemba Kaizen. From the 1980s, relational contracting approaches—including Lean Project Delivery System, Alliancing, and Partnering—gained traction, particularly in Australia and the UK. Modern IPD emerged with Sutter Health's initiative in the early 2000s, which introduced a single integrated agreement aligning owners, designers, and contractors through collaborative incentives and shared risk. This agreement used financial incentives from the Alliancing model [11], enabled alternative dispute resolution, and waived liability for damages [12]. The project finished under budget and improved stakeholder satisfaction [13], marking the start of the current IPD era [14].

Despite its promise, IPD remains theoretically immature and faces resistance, with slow uptake attributed to limited contractual understanding and challenges in implementation. Precursors to IPD emphasised multi-party agreements, shared risk-reward, and collaborative practices. The core of IPD lies in its contractual and operational framework, which mandates collective decision-making, fiscal transparency, intensified planning, and joint project control. Essential features include early involvement of key parties, open-book financials, collaboratively set performance targets, and reduced liability among participants. IPD's effectiveness is enhanced by LC principles, BIM, and co-location, all of which foster collaboration, trust, and communication.

However, widespread adoption is impeded by industrial, legal, cultural, and governmental barriers, as well as high upfront investment requirements. Key contractual concerns include data sharing, dispute resolution, insurance, risk allocation, and incentives. The lack of government support and comprehensive understanding of contract mechanisms further constrain implementation, with the impact of these factors varying by country. Interactions among collaboration, financial, legal, technological, organisational, and governmental elements remain underexplored; yet, understanding these relationships is vital for improving IPD outcomes and developing models that reflect industry complexity. While collaborative contracting focuses on structures and practices, its success heavily depends on underlying governance mechanisms. LC underpins the IPD model [15].

1.2. Historical Development of Lean Construction

The impetus for the construction industry to adopt LC is widely attributed to the significant performance improvements observed in the manufacturing sector [16], particularly through the lean production principles of the Toyota Production System (TPS), beginning in the 1950s [17]. The success of TPS subsequently inspired the application of lean concepts across various industries, including construction.

Nevertheless, the foundational principles of lean management had already been present in construction practices well before the recent surge in interest [18]. Early efforts by practitioners to implement lean principles gained considerable momentum following Koskela's [19] influential proposal for a new production philosophy in construction. This framework was later refined and formalised as the Transformation-Flow-Value (TFV) theory of production [20]. The TFV theory shares core objectives with lean manufacturing, emphasising the minimisation of waste, the maximisation of productivity, and the enhancement of product value.

A further critical contribution was the identification of workflow variability in construction processes [21], which led to the development of the Last Planner System (LPS)—a lean-based tool for construction planning and control [22]. Within the LPS, workflow variability is assessed by comparing tasks assigned by the last planner ('will' be done) against those actually completed ('did') within the designated timeframe [23].

Subsequent research on adapting lean production techniques to construction has included the application of 5S (sort, set in order, shine, standardise, and sustain) to improve project visualisation [24], the implementation of Poka-yoke systems to ensure earlier quality compliance [25], the use of Kanban for on-site inventory management [26], and the adoption of the PDCA (plan-do-check-act) cycle to facilitate more precise process redesign. IPD is the practical implementation of LC principles.

1.3. Research Gap

Despite increasing scholarly attention to collaborative contracting and IPD, significant gaps persist in current research. Although numerous studies have highlighted specific barriers to IPD implementation, there remains a notable absence of holistic frameworks that illustrate the dynamic interplay among these factors and their collective impact on implementation outcomes [27,28]. It is important to note that factors do not act in isolation, they interact with each other, thus amplifying their collective impact. This lack of integrative perspective hinders both theoretical advancement and practical strategies for enhancing the adoption of collaborative delivery models.

Comprehension of these interactions will provide deeper insights into how factors relate, and expand existing knowledge into new contexts, while supporting more accurate predictions [28]. Moreover, the existing literature seldom examines the systemic nature of these interactions within the broader context of project ecosystems and relational governance in temporary organisations.

This study addresses these deficiencies by developing a comprehensive framework that maps the complex interdependencies among factors shaping IPD implementation. While the empirical focus is on the NZ construction sector—a relatively small yet project-intensive market—the research aims to generate broader theoretical insights into the System Dynamics of collaborative project organising, transcending the specifics of this context. This study aims to address the following research question (RQ):

How do key factors interact to influence the implementation of collaborative contracting approaches such as integrated project delivery?

2. Materials and Methods

A systematic literature review (SLR) was conducted to identify all existing factors related to IPD and their interactions in the literature, using three databases and key publishers, including Scopus, Emerald, and ScienceDirect. The identified factors and interactions were used to frame open-ended questions for 18 semi-structured interviews (SSIs) with professionals in the NZ construction industry. For validation, the output from the 18 SSIs was triangulated with 137 survey responses targeting the general workforce of the NZ construction industry. Figure 1 presents an overview of the methodology for this study.

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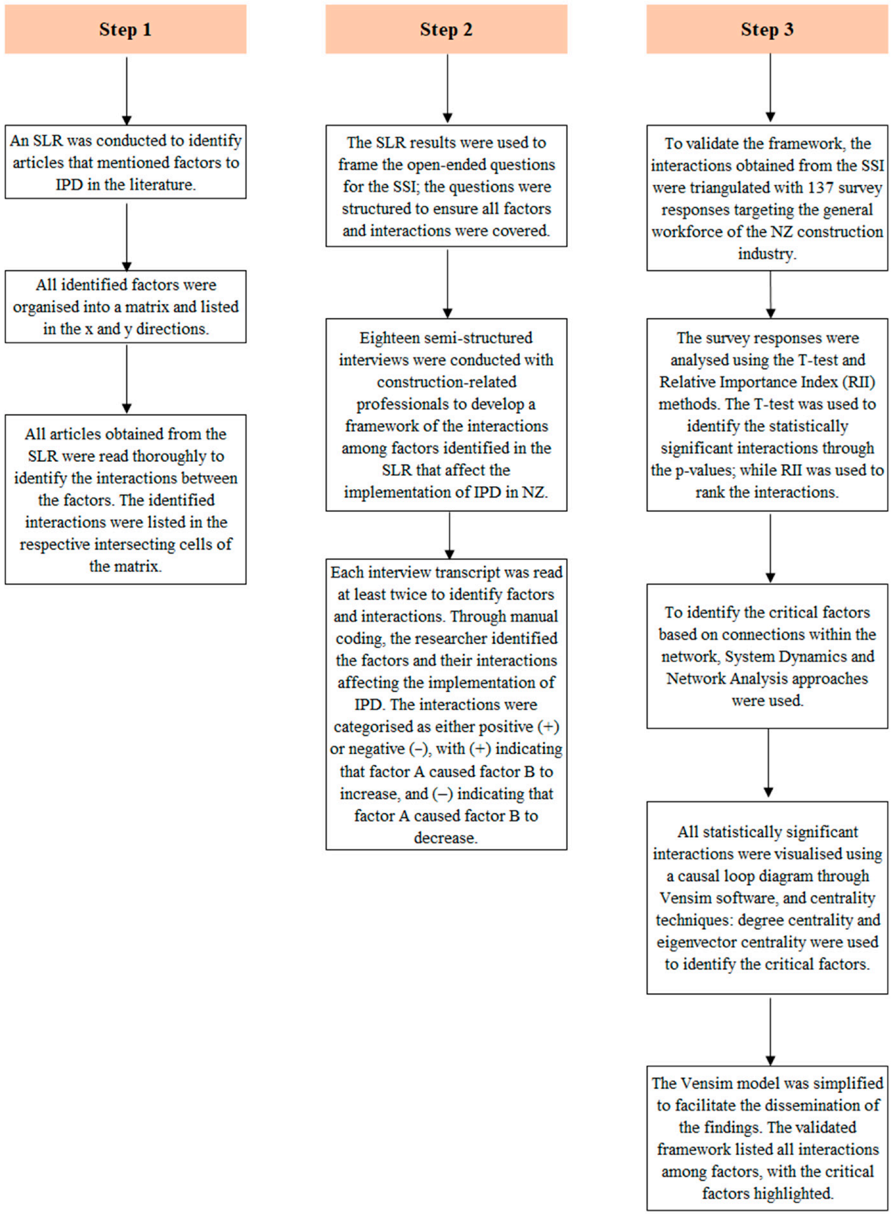

Figure 1. Overview of the methodology (source: author's own work).

The three-step research procedure is detailed below:

Step 1 was an SLR to identify factors and their interactions related to IPD in the literature. As previously mentioned, the rationale for the SLR was the fact that various articles have mentioned factors to IPD implementation; however, the interactions between these factors remain a research gap. The study selection followed the PRISMA 2020 guidelines [29]. The inclusion criteria were articles that explored barriers to IPD adoption, published in English, between 2009 and 2023. The exclusion criteria were non-IPD and construction-related articles, articles not mentioning barriers to IPD, non-English language articles, articles published before 2009, and systematic literature reviews. Three databases were used for the SLR: Scopus, Emerald, and ScienceDirect. The last date all three databases were checked was 1 June 2023. The search used keywords such as "Integrated Project Delivery" AND "Barriers," OR "Challenges," OR "Obstacles" in Scopus, "Integrated Project Delivery" AND "Challenges" in Emerald, and "Integrated Project Delivery" AND "Challenges" in ScienceDirect, all published from 2009 to 2023. Figure 2 shows the PRISMA flow diagram for the SLR process. Sixty-six articles were selected that addressed relevant factors, and each article was read twice to identify the factors influencing IPD implementation. Table A1 details the sixty-six articles selected. The identified factors were grouped into themes such as collaboration and communication, cultural/organisational, financial, legal, technological, and governmental/political. Next, each of the sixty-six articles was studied to identify the interactions between factors and their polarity, i.e., whether the interaction 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. Following this, a matrix was created in an Excel workbook that contained all factors identified from the SLR. The factors were listed in the x and y directions of the matrix, and the polarity of their interactions was listed in the respective intersecting cells.

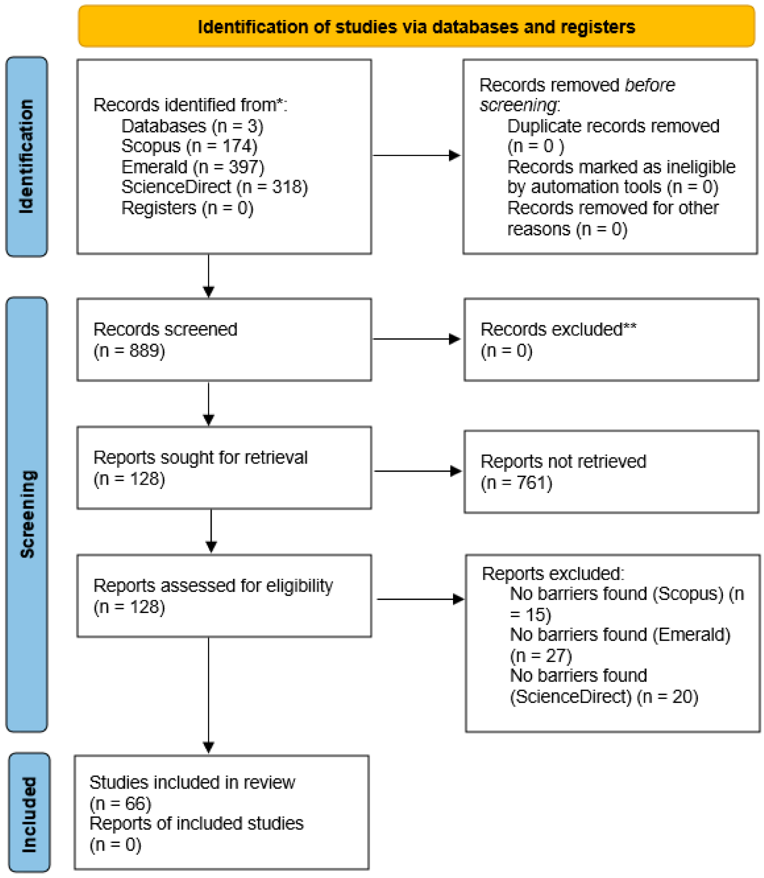

Figure 2. PRISMA chart for the SLR process; * = records identified, ** = records excluded (source: author's own work).

Step 2 used the SLR results to create open-ended questions for the semi-structured interviews (SSIs), ensuring all identified factors and interactions were covered, to develop a framework of the interactions between the factors that affect the implementation of IPD in NZ. Eighteen SSIs were conducted online with construction professionals, each lasting 41–62 min and transcribed using the application's built-in feature. No new data was obtained after 15 SSIs, thus the researcher deemed that saturation was obtained after 18 SSIs. The participants were recruited using purposive sampling. The criteria to recruit participants were:

- Prior experience in applying IPD as a project delivery method.
- Prior experience with IPD-related project delivery methods, such as Alliancing or collaborative contracting.

As there was a limited number of construction professionals with IPD experience in NZ, the snowball sampling technique was also used, with selected participants able to refer other participants who met the requirements. To maintain privacy, the interviewees were identified as 'C.' Table 1 details the profiles of the interviewees.

Table 1. Interviewee profiles (source: author's own work).

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+
C14	Quality Lead	10+
C15	Project Manager	15+
C16	Project Manager	20+
C17	BIM Coordinator	10+
C18	Project Planner	10+

Interview transcripts were reviewed at least twice to identify factors and interactions. Manual coding was used to identify factors and their interactions affecting IPD implementation. Interactions were classified as positive (+) if factor A increased factor B, or negative (−) if factor A decreased factor B. This process was repeated for all 18 interviewees, with results recorded in an Excel workbook. From the 18 SSIs, 142 factor interactions were identified. A sample transcription coding is shown below:

'I believe 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 contractors' lack of familiarity with the IPD approach (LoF) increases stakeholders' resistance to change (RtC).

Step 3 validated the framework by rephrasing identified interactions into a survey for the broader NZ construction sector. 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 NZ. 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.

To calculate the sample size, the following equation was used:

$$n0 = \frac{z^2 pq}{e^2} \quad (1)$$

where n0 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 [30]. 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 [31], at least 106 projects employed the IPD model [32]. Thus, p was considered as 21.5 percent. Thus, solving for $n0$ gives the following:

$$n0 = \frac{1.96^2 * 0.215(1 - 0.215)}{0.07^2}, \qquad n0 = 132.32$$

The minimum number of survey responses required was set as 132.

The survey used a five-point scale (Strongly Agree to Strongly Disagree) and received 137 responses, exceeding the minimum requirement of 132. Results were analysed via the Relative Importance Index (RII) and t-test (significance if $p < 0.05$) methods; high RII but insignificant t-test results were discarded. To calculate the RII, the following equation was used:

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

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. High RII values represented strong agreement of the survey respondents with the respective factor interaction, compared with low RII values, which represented weak agreement.

With an independent sample size of n = 137, the normality assumption is satisfied via the Central Limit Theorem [33]. To completely bypass the homogeneity of variance assumption, significance ($p < 0.05$) was evaluated using Welch's t-test (Equal Variances Not Assumed), eliminating the need for formal preliminary testing of variances [34]. A total of 88 interactions were statistically significant ($p < 0.05$), while 54 interactions were statistically insignificant ($p > 0.05$) and thus discarded. Next, System Dynamics (SD) and Network Analysis (NA) were used to identify the critical factors. SD used a Causal Loop Diagram (CLD) in Vensim PLE x64 to simulate system behaviour [27]. NA focused on node-level analysis and centrality techniques (Degree and Eigenvector Centrality) to identify critical factors.

Degree Centrality (DC) measures a node's connections, scaled 0–1. 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. Eigenvector Centrality (EC) considers both a node's connections and those of its neighbours, giving higher scores to nodes linked to other important nodes [35]. As this research aimed to identify the critical factors of IPD in NZ 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. This research followed Meghanathan [35] to calculate EC.

Centrality results were consolidated and compared with SLR frequency; factors appearing in all analyses were deemed critical. Those found in both centrality results were next-level critical. Finally, the Vensim diagram was simplified to facilitate the dissemination of the results.

3. Results

A total of 127 IPD factors were identified in the SLR. Figure 3 presents the identified factors listed according to their frequency, from highest to lowest. Table A2 presents the interactions identified from the SLR, and Table A3 presents those identified from the SSIs. Table 2 details the statistically significant interactions identified from the survey results, based on *p*-values, and ranked using the RII method, and Figure 4 visualises them using Vensim. Table 3 presents the analysis of IPD factors derived from statistically significant interactions, using NA techniques such as DC and EC, as well as SLR frequency. Table 4 presents the critical factors that appeared in every analysis, and Figure 5 visualises the top 10 factors in every analysis performed. To facilitate dissemination of the findings, Figure 6 illustrates the validated framework, a simplified version of the complex Vensim model. The EC computation, RII results and *p*-values are available in the Supplementary File.

Statistically significant interactions

Table 2. Statistically significant interactions (source: author's own work).

Factor A	Factor B	Polarity	RII Value	*p*-Value
High initial investment (HII)	Client's resistance to change (CRtC)	+	0.872	<0.001
Lack of Information Communications Technology use (LoICT)	Lack of technology use (LoUT)	+	0.869	<0.001
High initial investment (HII)	Resistance to change (RtC)	+	0.860	<0.001
Lack of technology use (LoUT)	BIM and IPD integration challenges (B&IC)	+	0.848	<0.001
Lack of IPD awareness (LoIA)	Resistance to change (RtC)	+	0.847	<0.001
Lack of familiarity of contractors (LoF)	Resistance to change (RtC)	+	0.842	<0.001
Risks and incentives (R&I)	Selection of compensation and incentive structure (SoCIS)	+	0.841	<0.001
Lack of IPD awareness (LoIA)	Lack of interest to upgrade (LoIU)	+	0.835	0.003
Compensation structure (CS)	Resistance to change (RtC)	+	0.834	0.004
Seeking for lowest cost (SfLC)	Client's resistance to change (CRtC)	+	0.833	<0.001
Contractual legal aspects (CLA)	Self-protective approach (SPA)	+	0.832	0.043
Mindset of individuals (MoI)	Difficulties in changing organisational culture (IDCOC)	+	0.832	<0.001
Lack of transparency in contractor's spending (LoTSC)	Client's resistance to change (CRtC)	+	0.830	<0.001
Lack of promotion (LoP)	Lack of IPD awareness (LoIA)	+	0.828	0.005
Lack of promotion (LoP)	Awareness and willingness among owners (AaW)	−	0.827	0.005

Table 2. *Cont.*

Factor A	Factor B	Polarity	RII Value	*p*-Value
Business risk (BR)	Client's resistance to change (CRtC)	+	0.827	0.001
Seeking for lowest cost (SfLC)	Resistance to change (RtC)	+	0.825	0.045
Lack of IPD awareness (LoIA)	Lack of industry standardisation (LoIW)	+	0.823	0.037
Lack of efficient information sharing (LoEI)	Poor data transfer (PDT)	+	0.820	0.012
Lack of collaboration (LoC)	Lack of coordination (LoCo)	+	0.817	<0.001
Lack of proficiency of employer (LoPr)	Making sound and timely decisions (MSTD)	–	0.815	0.046
Lack of constraint analysis (LoCA)	Project management difficulties (PM)	+	0.815	0.048
Lack of IPD awareness (LoIA)	Client's resistance to change (CRtC)	+	0.814	0.019
Early definition of targets without design development (EDTG)	Developing high-quality design (DHQD)	+	0.776	0.046
Compensation structure (CS)	Lack of collaboration among stakeholders (LoC)	+	0.771	0.002
Lack of integration (LoI)	Lack of interest to upgrade (LoIU)	+	0.771	0.021
Project objectives-related barriers (PORB)	Client's resistance to change (CRtC)	+	0.771	0.019
Lack of efficient information sharing (LoEI)	Lack of industry standardisation (LoIW)	+	0.770	0.011
Lack of constraint analysis (LoCA)	Structure for facilitation (SfF)	–	0.770	0.034
Client needs to pay additional design fees (TCPAFTM)	Client's resistance to change (CRtC)	+	0.769	0.011
Lack of integration (LoI)	Resistance to change (RtC)	+	0.769	0.01
Lack of familiarity of contractors (LoF)	Difficulties converting strategic decisions to operational levels (DiC)	+	0.769	0.021
Project objectives-related barriers (PORB)	Resistance to change (RtC)	+	0.768	0.011
Lack of lean knowledge (LoLean)	Inculcating IPD values (IVIPD)	–	0.767	0.026
Lack of experience and skills (LoES)	Challenging cultural paradigms (CCP)	+	0.767	0.011
Client needs to pay additional fees for IPD agreement (TCPACNA)	Client's resistance to change (CRtC)	+	0.766	<0.001
Compensation structure (CS)	Mutual respect and trust (MR&T)	–	0.765	0.013
Self-protective approach (SPA)	Mutual respect and trust (MR&T)	–	0.765	0.026
Client's resistance to change (CRtC)	Implementation of strict rules (IoSR)	+	0.758	<0.001
Client needs to pay additional design fees (TCPAFTM)	Contractual legal aspects (CLA)	+	0.758	0.002
Lack of industry standardisation (LoIW)	Lack of professional bodies (LoPB)	+	0.757	0.001
Lack of lean knowledge (LoLean)	Resistance to change (RtC)	+	0.756	0.023
Lack of industry standardisation (LoIW)	High initial investment (HII)	+	0.755	0.009

Table 2. *Cont.*

Factor A	Factor B	Polarity	RII Value	*p*-Value
Lack of collaboration (LoC)	Lack of integration (LoI)	+	0.755	0.001
Self-protective approach (SPA)	Achieving joint project control (AAJPC)	–	0.754	0.006
Logistical challenges (LC)	Resistance to change (RtC)	+	0.754	<0.001
High cost of new software (HFCNS)	Resistance to change (RtC)	+	0.753	<0.001
Lack of transparency (LoT)	Lack of integration (LoI)	+	0.753	0.002
Project objectives-related barriers (PORB)	Lack of industry standardisation (LoIW)	+	0.748	<0.001
Lack of existing training material (LoETM)	Lack of technology use (LoUT)	+	0.747	<0.001
Self-protective approach (SPA)	Lack of collaboration (LoC)	+	0.747	<0.001
Challenging cultural paradigms (CCP)	Project management difficulties (PM)	+	0.747	<0.001
High initial investment (HII)	Mutual respect and trust (MR&T)	–	0.747	0.002
Contractual legal aspects (CLA)	Achieving joint project control (AAJPC)	–	0.745	<0.001
Self-protective approach (SPA)	Resistance to change (RtC)	+	0.745	<0.001
Lack of organisational communication (LOCm)	Difficulties converting strategic decisions to operational levels (DiC)	+	0.745	<0.001
Logistical challenges (LC)	Lack of industry standardisation (LoIW)	+	0.744	<0.001
Project Management difficulties (PM)	Mutual respect and trust (MR&T)	–	0.743	<0.001
Misunderstandings in risk contingency accounting (MIR)	Cost estimation challenges (CEC)	+	0.741	0.003
Rewards not tailored for risks involved (RnTRSR)	Lack of governmental support (LoGS)	+	0.741	<0.001
Self-protective approach (SPA)	Lack of interest to upgrade (LoIU)	+	0.737	<0.001
Lack of IPD awareness (LoIA)	Lack of technology use (LoUT)	+	0.737	<0.001
Lack of lean knowledge (LoLean)	Mutual respect and trust (MR&T)	–	0.737	<0.001
High cost of new software (HFCNS)	Lack of technology use (LoUT)	+	0.736	<0.001
Lack of governmental support (LoGS)	Lack of industry standardisation (LoIW)	+	0.735	<0.001
Industry participants lack chances to receive training (IPLC)	Lack of technology use (LoUT)	+	0.735	<0.001
Implementation of strict rules (IoSR)	Owner not identifying advantages (ONIA)	+	0.731	<0.001
Lack of professional bodies (LoPB)	Lack of promotion (LoP)	+	0.726	<0.001
Lack of promotion (LoP)	Lack of governmental support (LoGS)	+	0.723	<0.001
Lack of IPD awareness (LoIA)	Lack of governmental support (LoGS)	+	0.722	<0.001
Lack of governmental support (LoGS)	Lack of professional bodies (LoPB)	+	0.722	<0.001

Table 2. *Cont.*

Factor A	Factor B	Polarity	RII Value	*p*-Value
Lack of governmental support (LoGS)	Inculcating IPD values (IVIPD)	+	0.721	<0.001
High cost of new software (HFCNS)	Client's resistance to change (CRtC)	+	0.720	<0.001
Challenging cultural paradigms (CCP)	Lack of collaboration (LoC)	+	0.720	<0.001
Lack of trained professionals (LoTP)	Mutual respect and trust (MR&T)	−	0.719	<0.001
Challenging cultural paradigms (CCP)	Mutual respect and trust (MR&T)	−	0.715	<0.001
Lack of governmental support (LoGS)	Resistance to change (RtC)	+	0.712	<0.001
Resistance to change (RtC)	Lack of technology use (LoUT)	+	0.706	<0.001
Lack of IPD awareness (LoIA)	Lack of coordination (LoCo)	+	0.703	<0.001
Lack of governmental support (LoGS)	Lack of existing training material (LoETM)	+	0.696	<0.001
Lack of governmental support (LoGS)	Mutual respect and trust (MR&T)	−	0.693	<0.001
Challenging cultural paradigms (CCP)	Lack of technology use (LoUT)	+	0.691	<0.001
Contractual legal aspects (CLA)	Mutual respect and trust (MR&T)	−	0.688	<0.001
Contractual legal aspects (CLA)	Lack of governmental support (LoGS)	+	0.684	<0.001
Project objectives-related barriers (PORB)	Lack of technology use (LoUT)	+	0.677	<0.001
Lack of governmental support (LoGS)	High initial investment (HII)	+	0.659	<0.001
Contractual legal aspects (CLA)	Lack of collaboration (LoC)	+	0.657	<0.001
Contractual legal aspects (CLA)	Lack of insurance policies (LoIP)	+	0.649	<0.001

Analyses of IPD factors obtained from the statistically significant interactions

Table 3. Analyses of IPD factors (source: author's own work).

Factor	SLR Frequency	IN	ON	TN	DC	EC
Misunderstandings in risk contingency accounting (MIR)	2	0	1	1	0.08	0
Cost estimation challenges (CEC)	5	1	0	1	0.08	0
Contractual legal aspects (CLA)	27	1	6	7	0.54	0
Self-protective approach (SPA)	6	1	5	6	0.46	0
Achieving joint project control (AAJPC)	2	2	0	2	0.15	0
Lack of insurance policies (LoIP)	6	1	0	1	0.08	0

Table 3. *Cont.*

Factor	SLR Frequency	IN	ON	TN	DC	EC
Lack of governmental support (LoGS)	8	3	8	11	0.85	0.141
Mutual respect and trust (MR&T)	10	9	0	9	0.69	0.215
Lack of collaboration (LoC)	15	4	2	6	0.46	0
Implementation of strict rules (IoSR)	2	0	2	2	0.15	0
Owner not identifying advantages (ONIA)	2	1	0	1	0.08	0
Client's resistance to change (CRtC)	6	10	0	10	0.77	0.332
High cost of new software (HFCNS)	3	0	3	3	0.23	0
Lack of technology use (LoUT)	24	8	1	9	0.69	0.465
Project objectives-related barriers (PORB)	1	0	4	4	0.31	0
Resistance to change (RtC)	9	12	1	13	1	0.405
Challenging cultural paradigms (CCP)	17	1	4	5	0.38	0
Lack of existing training material (LoETM)	5	1	1	2	0.15	0.0682
Lack of IPD awareness (LoIA)	18	1	7	8	0.62	0.207
Industry participants lack chances to receive training (IPLC)	3	0	1	1	0.08	0
BIM and IPD integration challenges (B&IC)	2	1	0	1	0.08	0.353
Lack of Information Communications Technology use (LoICT)	2	0	1	1	0.08	0
Reward not tailored to reflect risks involved (RnTRSR)	4	0	1	1	0.08	0
High initial investment (HII)	16	2	3	5	0.38	0.194
Lack of promotion (LoP)	2	2	2	4	0.31	0.218
Lack of professional bodies (LoPB)	1	2	1	3	0.23	0.2
Lack of industry standardisation (LoIW)	1	5	2	7	0.54	0.233
Inculcating IPD values (IVIPD)	2	2	0	2	0.15	0.0706
Compensation structure (CS)	5	0	3	3	0.23	0
Seeking for lowest cost (SfLC)	1	0	2	2	0.15	0
Client needs to pay additional fees for IPD agreement (TCPACNA)	1	0	1	1	0.08	0
Client needs to pay additional design fees (TCPAFTM)	1	0	2	2	0.15	0
Lack of transparency in contractor's spending (LoTSC)	1	0	1	1	0.08	0

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Table 3. *Cont.*

Factor	SLR Frequency	IN	ON	TN	DC	EC
Risks and incentives (R&I)	1	0	1	1	0.08	0
Selection of compensation and incentive structure (SoCIS)	2	1	0	1	0.08	0
Lack of interest to upgrade (LoIU)	4	3	0	3	0.23	0.163
Lack of integration (LoI)	7	2	2	4	0.31	0
Lack of transparency (LoT)	2	0	1	1	0.08	0
Lack of trained professionals (LoTP)	3	0	1	1	0.08	0
Lack of coordination (LoCo)	2	2	0	2	0.15	0.137
Lack of lean knowledge (LoLean)	2	0	3	3	0.23	0
Project management difficulties (PM)	1	2	1	3	0.23	0
Awareness and willingness among owners (AaW)	4	1	0	1	0.08	0.206
Lack of familiarity of contractors (LoF)	1	0	2	2	0.15	0
Logistical challenges (LC)	1	0	2	2	0.15	0
Business risk (BR)	1	0	1	1	0.08	0
Early definition of targets without design development (EDTG)	1	0	1	1	0.08	0
Development of high-quality design (DHQD)	3	1	0	1	0.08	0
Difficulties converting strategic decisions to operational levels (DiC)	1	2	0	2	0.15	0
Lack of organisational communication (LOCm)	2	0	1	1	0.08	0
Lack of proficiency of employer (LoPr)	3	0	1	1	0.08	0
Making sound and timely decisions (MSTD)	2	1	0	1	0.08	0
Lack of efficient information sharing (LoEI)	1	0	2	2	0.15	0
Poor data transfer (PDT)	1	1	0	1	0.08	0
Lack of constraint analysis (LoCA)	1	0	2	2	0.15	0
Mindset of individuals (MoI)	2	0	1	1	0.08	0
Difficulties in changing organisational culture (IDCOC)	7	1	0	1	0.08	0

Table 3. *Cont.*

Factor	SLR Frequency	IN	ON	TN	DC	EC
Lack of experience and skills (LoES)	4	0	1	1	0.08	0
Structure for facilitation (SfF)	1	1	0	1	0.08	0

IN: Incoming Nodes; ON: Outgoing Nodes; TN: Total Nodes.

Critical factors

The results of all analyses were listed in a comparison table to identify the critical factors of IPD in the NZ context. Table 4 details the results of all analyses.

Table 4. Comparison between IPD factors as per the results of all analyses (source: author's own work).

Factor	DC (Survey)	DC Rank	Factor	EC (Survey)	EC Rank	Factor	SLR Frequency	Frequency Rank
Resistance to change (RtC)	1	1	**Lack of technology use (LoUT)**	0.465	1	Contractual legal aspects (CLA)	27	1
Lack of governmental support (LoGS)	0.85	2	**Resistance to change (RtC)**	0.405	2	**Lack of technology use (LoUT)**	24	2
Client's resistance to change (CRtC)	0.77	3	BIM and IPD Integration challenges (B&IC)	0.353	3	**Lack of IPD awareness (LoIA)**	18	3
Mutual respect and trust (MR&T)	0.69	4	**Client's resistance to change (CRtC)**	0.332	4	Challenging cultural paradigms (CCP)	17	4
Lack of technology use (LoUT)	0.69	4	**Lack of industry standardisation (LoIW)**	0.233	5	High initial investment (HII)	16	5
Lack of IPD awareness (LoIA)	0.62	6	Lack of promotion (LoP)	0.218	6	Lack of collaboration (LoC)	15	6
Lack of industry standardisation (LoIW)	0.54	7	**Mutual respect and trust (MR&T)**	0.215	7	**Mutual respect and trust (MR&T)**	10	7
Contractual legal aspects (CLA)	0.54	7	**Lack of IPD awareness (LoIA)**	0.207	8	**Resistance to change (RtC)**	9	8
Lack of collaboration (LoC)	0.46	9	Awareness and willingness among owners (AaW)	0.206	9	Lack of governmental support (LoGS)	8	9
Self-protective approach (SPA)	0.46	9	Lack of professional bodies (LoPB)	0.2	10	Lack of integration (LoI)	7	10
						Inherent difficulties in changing organisational culture (IDCOC)	7	10

The factors in bold represent the critical factors.

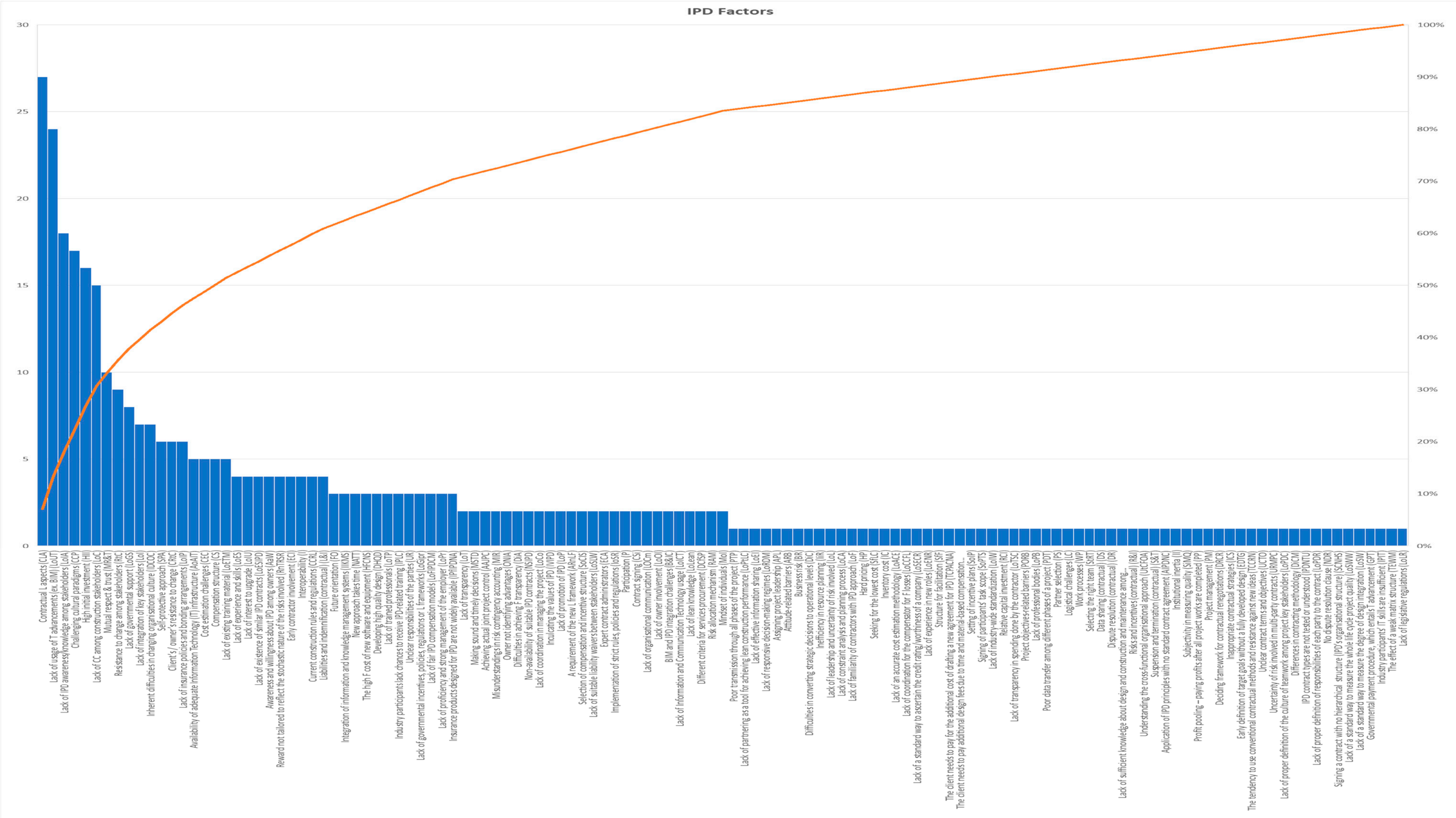

Figure 3. IPD factors identified from the SLR (source: author's own work).

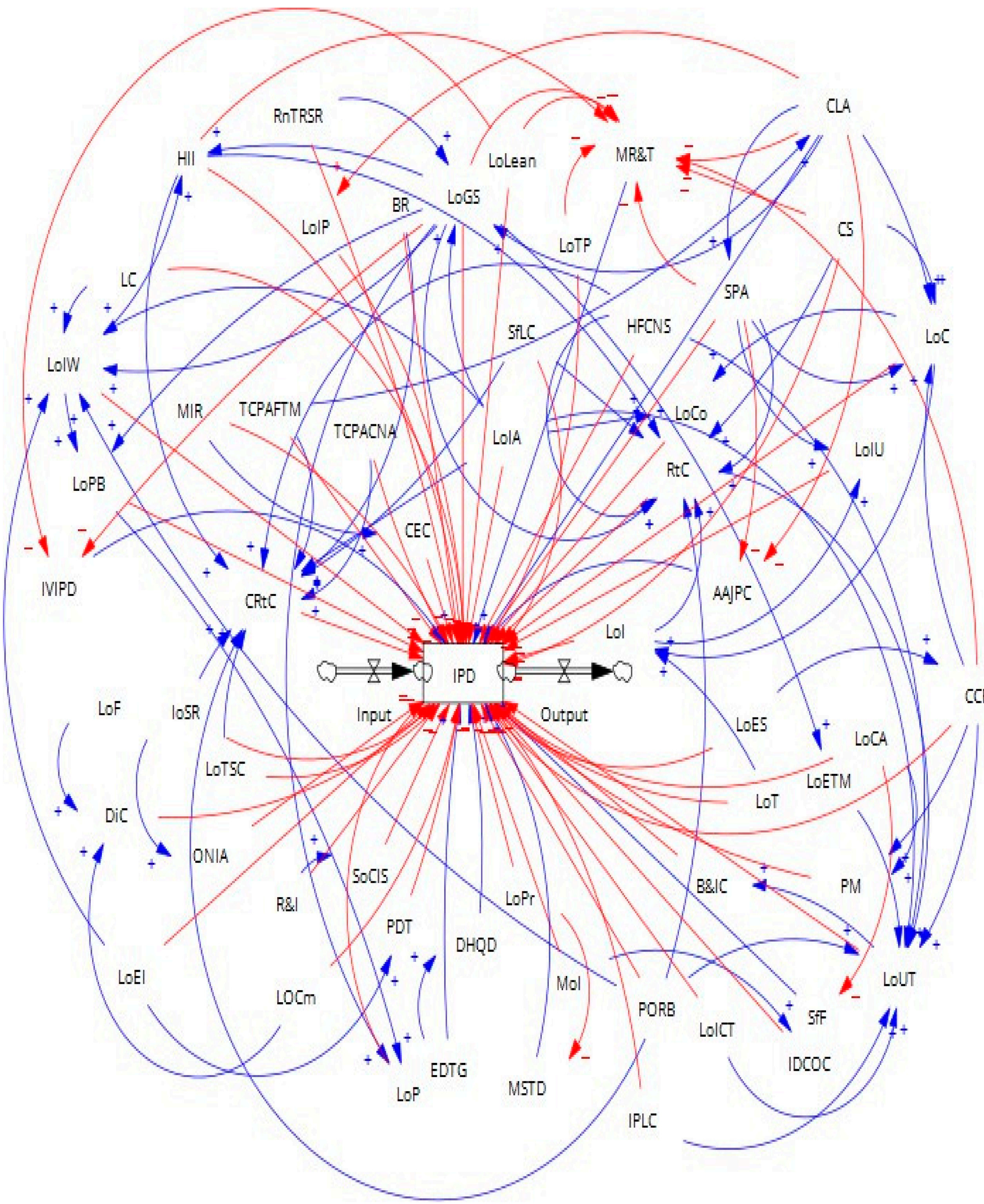

Figure 4. Consolidated Vensim model of all statistically significant factor interactions. The blue arrows represent positive interactions whereas the red arrows represent negative interactions. (source: author's own work).

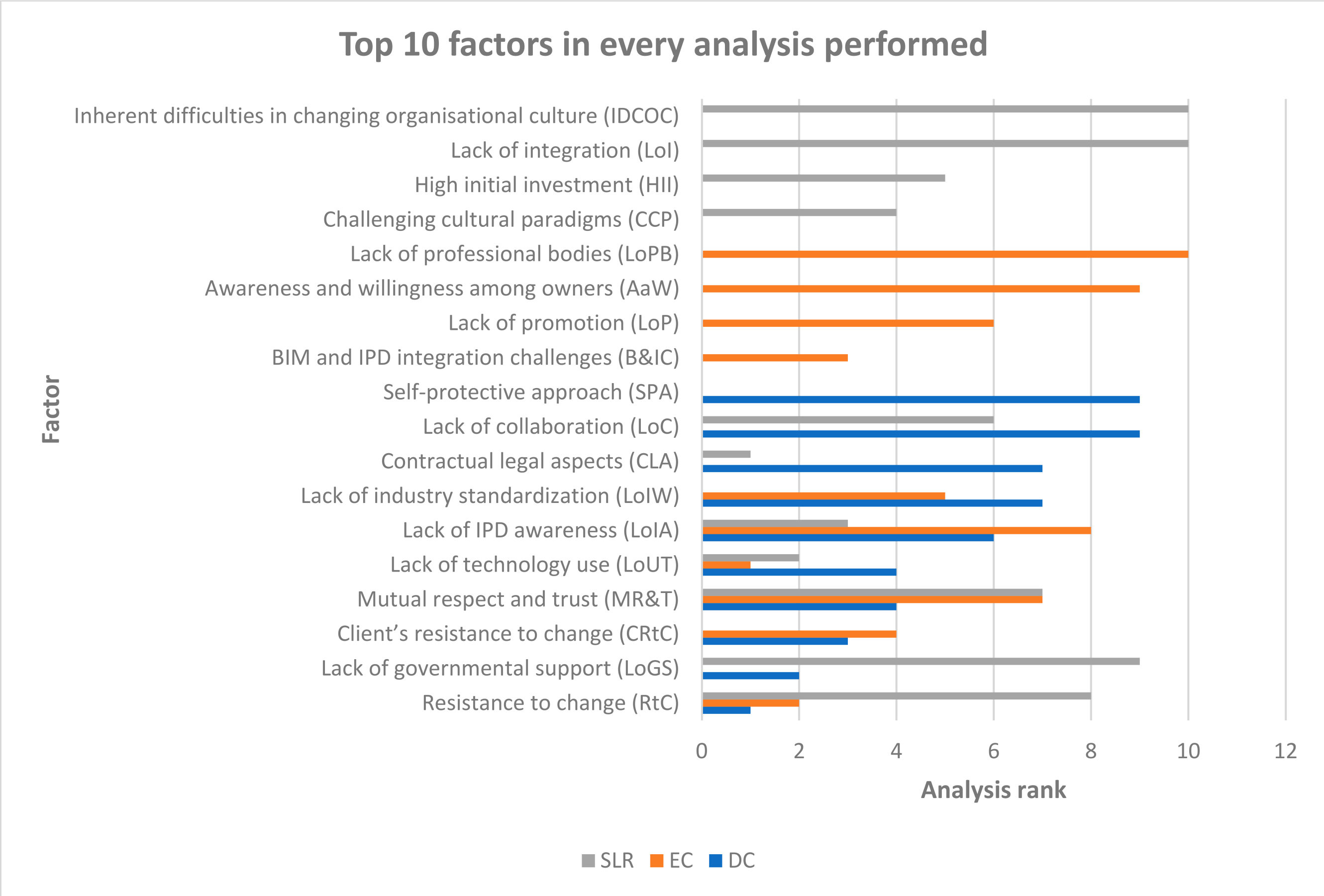

Figure 5. Visualisation of the top 10 factors in every analysis performed (source: author's own work).

Validated framework

The Vensim model, which included the statistically significant interactions, was simplified to facilitate the dissemination of the results. Figure 6 illustrates the validated framework, a simplified version of the complex Vensim model.

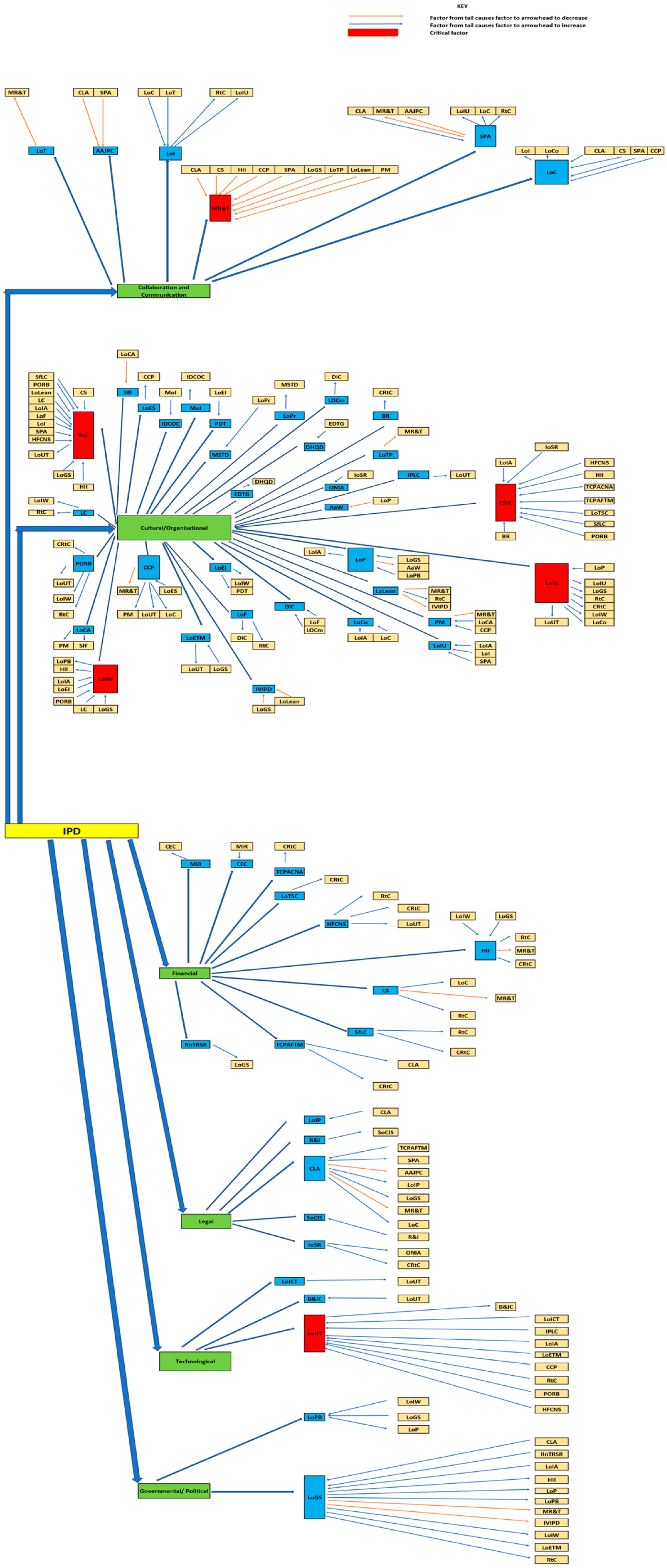

Figure 6. Validated framework of the interactions between the factors of IPD (source: author's own work).

4. Discussion

Developing a comprehensive framework to elucidate the interactions among factors influencing IPD addresses a salient research gap, as prior research has predominantly focused on the identification and ranking of individual barriers. By systematically identifying and analysing these interactions, the framework offers critical insights to advance the implementation and efficacy of IPD practices. Conceived as a standalone reference, the framework supports practitioners, stakeholders, and scholars in engaging with the study's findings. To enhance accessibility, it distils the complex Vensim diagram into a simplified model (see Figure 6), presenting only statistically significant interactions derived from survey data. The framework organises factors into thematic categories—collaboration and communication; cultural/organisational; financial; legal; technological; and governmental/political—enabling the identification of both the most populous themes and the interaction patterns among categories. Each theme comprises a coherent set of factors, with their interrelationships visually represented to illustrate their complexity. Polarity and directional arrows (blue for positive, red for negative) further delineate the nature and magnitude of these interactions, rendering the framework both analytically robust and visually accessible. Ultimately, this framework not only facilitates comprehension and dissemination but also constitutes a substantive contribution to knowledge on project management and delivery systems.

Analysis of the Vensim model shown in Figure 4 revealed multi-factor linkage cycles that can be studied further to identify the unique challenges that hinder the implementation of IPD in NZ. 'Lack of governmental support (LoGS)–lack of promotion (LoP)–lack of IPD awareness (LoIA)–lack of industry standardisation (LoIW)–high initial investment (HII)–resistance to change (RtC)–lack of technology use (LoUT)–BIM and IPD integration challenges (B&IC)' was one of the linkages identified. 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 NZ 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. Additionally, 'lack of industry standardisation (LoIW)–lack of professional bodies (LoPB)–lack of promotion (LoP)–lack of IPD awareness (LoIA)–lack of governmental support (LoGS)–resistance to change (RtC)–lack of technology use (LoUT)–BIM and IPD integration challenges (B&IC)' was another identified factor linkage. The lack of industry standardisation of IPD leads to a lack of professional bodies associated with IPD establishing themselves in NZ. The lack of professional bodies in NZ 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. Further, 'contractual legal aspects (CLA)–lack of governmental support (LoGS)–lack of professional bodies (LoPB)–lack of promotion (LoP)–lack of IPD awareness (LoIA)–resistance to change (RtC)–lack of technology use (LoUT)–BIM and IPD integration challenges (B&IC)' was another linkage identified. The contractual legal aspects of IPD influences the lack of governmental support for IPD in NZ. The lack of governmental support is a reason why professional bodies associated with IPD are not established in NZ. 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. Moreover, 'lack of IPD awareness (LoIA)–lack of governmental support (LoGS)–lack of industry standardisation (LoIW)–high initial investment (HII)–resistance to change (RtC)–lack of technology use (LoUT)–BIM and IPD integration challenges (B&IC)' was also a linkage identified. The lack of IPD awareness among stakeholders influences the lack of governmental support in NZ. The lack of governmental support is a reason for the lack of IPD standardisation in NZ, 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. Finally, the 'reward not tailored to reflect the risks involved (RnTRSR)–lack of governmental support (LoGS)–lack of professional bodies (LoPB)–lack of promotion (LoP)–lack of IPD awareness (LoIA)–resistance to change (RtC)–lack of technology use (LoUT)–BIM and IPD integration challenges (B&IC)' linkage reveals that the rewards associated with the IPD model do not adequately reflect the significance of the risks undertaken, which contributes to the lack of governmental support for the IPD model in NZ. The lack of governmental support is a reason why professional bodies associated with IPD are not 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 critical factors are discussed next.

Resistance to change (RtC), mutual respect and trust (MR&T), lack of technology use (LoUT), and lack of IPD awareness (LoIA) were identified as critical factors because they consistently ranked among the top factors across all analyses. Additionally, client's resistance to change (CRtC) and lack of industry standardisation (LoIW) were deemed critical because they appeared in both centrality analyses (see Table 4). These factors not only ranked highly across multiple analytical techniques but also serve as key hubs that connect different thematic clusters within the framework. The identification of clients' resistance to change (CRtC) and lack of industry standardisation (LoIW) as critical factors in the NZ context reflects the institutional and market characteristics of a relatively small, conservative construction sector.

Resistance to change (RtC) emerged as one of the most dominant, highly connected, and influential factor in the entire framework. Evans and Farrell [36] argue that resistance from traditional construction practices hinders IPD implementation. This resistance can come from stakeholders or clients, who often prefer familiar contracts [37]. Sherif and Abotaleb [38] highlight that stakeholders trust the contract types they know and resist change. Such resistance has limited the skills, knowledge, and experience of construction stakeholders. Therefore, to implement the IPD model more widely, stakeholders' attitudes and perceptions must shift. In the literature, it was found that resistance to change (RtC) increases lack of leadership (LoL) [39], challenging cultural paradigms (CCP) [40], and client's resistance to change (CRtC) [40]. Additionally, it was found that contractual legal aspects (CLA) [41], implementation of strict rules (IoSR) [41], seeking for the lowest cost (SfLC) [42], and lack of IPD awareness (LoIA) [43] each increase resistance to change (RtC). In the NZ context, it was identified that lack of governmental support (LoGS) (RII = 0.712), high initial investment (HII) (RII = 0.86), compensation structure (CS) (RII = 0.834), seeking for the lowest cost (SfLC) (RII = 0.825), high financial cost of new software (HFCNS) (RII = 0.753), lack of familiarity of contractors with IPD (LoF) (RII = 0.842), lack of IPD awareness (LoIA) (RII = 0.847), logistical challenges (LC) (RII = 0.754), lack of lean knowledge (LoLean) (RII = 0.756), project objectives-related barriers (PORB) (RII = 0.768), self-protective approach (SPA) (RII = 0.745), and lack of integration of stakeholders (LoI) (RII = 0.769) each cause resistance to change (RtC) to increase. Furthermore, resistance to change (RtC) increases lack of technology use (LoUT) (RII = 0.706). The factors, lack of IPD awareness (LoIA) and seeking for the lowest cost (SfLC), increasing resistance to change (RtC) were identified in both SLR and NZ contexts. The findings align with institutional theory perspectives on path dependency and reinforce recent research on legitimacy challenges in collaborative contracting [12]. The impact of resistance to change (RtC) on environmental sustainability is the delay it causes in the adoption of LC practices, BIM-integrated design optimisation, and collaborative decision-making that can substantially reduce material waste, construction errors, energy consumption, and carbon emissions. The project parties stick with familiar high-impact methods, leading to higher embodied carbon, increased energy consumption during construction and operation, and greater landfill contributions from demolition waste. In the long term, this hinders the sector's transition to net-zero buildings and circular economy models. Further, the impact of resistance to change (RtC) on social sustainability is that it perpetuates adversarial cultures, fragmented teams, and limited knowledge sharing, which negatively affect worker wellbeing, stakeholder engagement, and the development of collaborative competencies. Moreover, the impact of resistance to change (RtC) on economic sustainability is that it sustains inefficient processes that result in cost overruns, schedule delays, and poor value-for-money outcomes, undermining long-term economic performance of construction projects. Firms miss IPD's documented benefits, such as reduced rework (often 10–20% savings in time and cost) and improved predictability, limiting competitiveness in a market increasingly demanding sustainable outcomes.

Mutual respect and trust (MR&T) functions as a foundational relational mechanism that underpins successful collaborative project organising. Duke et al. [44] argue that a lack of trust is a key barrier to change in the construction industry. Segregated organisational structures often lead to hostile relationships, defensive behaviours, and inefficiency. Trust is mutual confidence between parties, especially when the exchange involves some vulnerability [45]. Mutual respect and trust (MR&T) include goodwill and competence trust; the former fosters collaboration, while the latter has a U-shaped impact [46]. In the literature, it was found that lack of experience in new roles (LoENR) [47], contractual legal aspects (CLA) [48], and client's resistance to change (CRtC) [49] decreases mutual respect and trust (MR&T) among stakeholders. In the NZ context, it was identified that lack of governmental support (LoGS) (RII = 0.693), compensation structure (CS) (RII = 0.765), high initial investment (HII) (RII = 0.747), challenging cultural paradigms (CCP) (RII = 0.715), self-protective approach (SPA) (RII = 0.765), lack of trained professionals (LoTP) (RII = 0.719), lack of lean knowledge (LoLean) (RII = 0.737), project management difficulties (PM) (RII = 0.743), and contractual legal aspects (CLA) (RII = 0.688) decreases mutual respect and trust (MR&T) among stakeholders. Contractual legal aspects (CLA) decreasing mutual respect and trust (MR&T) among stakeholders was identified in both SLR and NZ contexts. These patterns provide rich empirical grounding for relational governance theory by revealing the specific micro-mechanisms through which social capital and collaborative norms are either nurtured or undermined in multi-party temporary organisations [50,51]. The impact of mutual respect and trust (MR&T) on environmental sustainability is that it reduces open information sharing (such as BIM models) and joint innovation, limiting the team's ability to optimise designs for waste reduction and environmental performance. The lack of trust leads to conservative, less sustainable choices. Further, the impact of mutual respect and trust (MR&T) on social sustainability is that it fosters defensive behaviours, increases conflict, and weakens team cohesion, negatively impacting psychological safety, worker morale, open communication, diversity and inclusion initiatives, and equitable stakeholder relationships, thus lowering social sustainability metrics. Moreover, the impact of mutual respect and trust (MR&T) on economic sustainability is that it increases transaction costs, dispute frequency, and inefficiencies in risk allocation and problem-solving. It impacts decision-making and innovation, reducing value, lowering productivity, and weakening financial performance across the project lifecycle.

Regarding lack of technology use (LoUT), the limited use of technology is a major barrier to IPD. Evans and Farrell [36] note that current technology adoption is inadequate for effective IPD. Integrating BIM with IPD boosts collaboration, increases productivity, reduces errors, and encourages innovation [52]. Additionally, combining IPD with BIM and ICT improves technology use and transforms design and construction. However, Ahmed and Sobuz [53] highlight that the main obstacles to IPD adoption in developing countries are the absence of standard BIM contracts and challenges in using BIM collaboratively. In the literature, lack of information and communications technology use (LoICT) has been found to increase lack of technology use (LoUT) [54]. In the NZ context, it was identified that lack of technology use (LoUT) increases BIM and IPD integration challenges (B&IC) (RII = 0.848), and high financial cost of new software (HFCNS) (RII = 0.736), PORB (RII = 0.677), resistance to change (RtC) (RII = 0.706), challenging cultural paradigms (CCP) (RII = 0.691), lack of existing training material (LoETM) (RII = 0.747), lack of IPD awareness (LoIA) (RII = 0.737), lack of chances for industry participants to receive training (IPLC) (RII = 0.735), and lack of information and communications technology use (LoICT) (RII = 0.869) causes lack of technology use (LoUT) to increase. The factor lack of information and communications technology use (LoICT) increases lack of technology use (LoUT) in both SLR and NZ contexts. The impact of the lack of technology use (LoUT) on environmental sustainability is that it affects accurate modelling, clash detection, energy simulation, material optimisation, and real-time performance monitoring —all essential for reducing carbon footprint and resource waste. Additionally, it causes projects to miss opportunities for predictive sustainability assessments. Further, the impact of the lack of technology use (LoUT) on social sustainability is that it restricts effective collaboration and knowledge transfer across distributed project teams, create divides between tech-savvy and less-digital teams or firms, affecting equitable participation and skills development. It may also reduce transparency, limiting accountability to communities and workers. Moreover, the impact of the lack of technology use (LoUT) on economic sustainability is that it prevents productivity gains, data-driven decision-making, and efficiency improvements that could lower overall project costs. Without integrated digital workflows, coordination suffers, leading to errors, rework, delays, and cost escalations. IPD's promised efficiencies in procurement, fabrication, and delivery are severely compromised, reducing overall project profitability and return on investment.

In discussing lack of IPD awareness (LoIA), Kahvandi et al. [55] and Forero et al. [56] both identified a lack of IPD awareness and knowledge as a main barrier to its implementation. Training project participants several months before a project begins can build cooperation and trust. In NZ, this lack of awareness is critical, as much of the construction workforce is unfamiliar with IPD. In the literature, lack of IPD awareness (LoIA) has been found to increase challenging cultural paradigms (CCP) [56], resistance to change (RtC) [43], and a new approach takes time (NATT) [40]. In the NZ context, it was identified that lack of promotion (LoP) (RII = 0.828) increases lack of IPD awareness (LoIA), and lack of IPD awareness (LoIA) increases lack of technology use (LoUT) (RII = 0.737), lack of governmental support (LoGS) (RII = 0.722), lack of interest to upgrade (LoIU) (RII = 0.835), resistance to change (RtC) (RII = 0.847), client's resistance to change (CRtC) (RII = 0.814), lack of industry standardisation (LoIW) (RII = 0.823), and lack of coordination (LoCo) (RII = 0.703). These interactions offer a compelling explanation for the slow diffusion and limited adoption of IPD despite consistent evidence of its superior performance across multiple project outcomes. The impact of the lack of IPD awareness (LoIA) on environmental sustainability is that without sufficient awareness, stakeholders cannot fully leverage IPD's collaborative potential to deliver more sustainable design and construction outcomes. Teams fail to exploit IPD's strength in early collaborative workshops for lifecycle carbon analysis or energy optimisation, resulting in suboptimal environmental outcomes. Further, the impact of the lack of IPD awareness (LoIA) on social sustainability is that it limits the industry's ability to build a skilled, collaborative, and sustainability-conscious workforce. Low awareness restricts the formation of high-functioning, multidisciplinary teams. It limits opportunities for capacity building, knowledge transfer, and equitable risk-sharing, which are vital for workforce development and social value creation. Moreover, the impact of the lack of IPD awareness (LoIA) on economic sustainability is that it prevents organisations from realising the long-term cost savings, innovation benefits, and value creation associated with successful IPD implementation. Stakeholders overlook IPD's potential for aligned incentives and continuous improvement. This leads to continued high transaction costs, inefficient resource allocation, and failure to achieve the cost and schedule certainty that makes sustainable projects financially viable.

Regarding client's resistance to change (CRtC), Karasu et al. [57] noted that clients and owners are crucial to the adoption of a collaborative approach. In NZ, clients' resistance to change is a critical factor, even though it was not highly ranked in the SLR frequency. Without the client's willingness, risk cannot be shared among project stakeholders. Raising awareness of IPD's benefits through ongoing professional development, as suggested by Li and Ma [49], may improve owners' acceptance of IPD. In the literature, it was found that client's resistance to change (CRtC) decreases mutual respect and trust (MR&T) [49], and resistance to change (RtC) [54], contractual legal aspects (CLA) [19], and uncertainty of risk involved in multi-party contracts (URMPC) [19] increases client's resistance to change (CRtC). In the NZ context, it was identified that implementation of strict rules (IoSR) (RII = 0.758), high financial cost of new software (HFCNS) (RII = 0.72), high initial investment (HII) (RII = 0.872), the client needs to pay additional fees for an IPD agreement (TCPACNA) (RII = 0.764), the client needs to pay additional design fees for time and material based compensation (TCPAFTM) (RII = 0.769), lack of transparency in spending by contractor (LoTSC) (RII = 0.83), project objectives-related barriers (PORB) (RII = 0.771), lack of IPD awareness (LoIA) (RII = 0.816), business risk (BR) (RII = 0.827), and seeking for the lowest cost (SfLC) (RII = 0.833) increases client's resistance to change (CRtC). Interestingly, no common interactions of clients' resistance to change (CRtC) were found in the literature and NZ contexts. The impact of client's resistance to change (CRtC) on environmental sustainability is the lack of sustainable design, green technologies, and lifecycle optimisation that IPD enables, because clients frequently prioritise short-term capital cost savings. Clients may reject innovative green solutions that require upfront investment or unfamiliar processes, locking projects into conventional designs with poorer environmental performance (e.g., higher operational energy use over decades). Further, the impact of clients' resistance to change (CRtC) on social sustainability is that it restricts the development of inclusive, long-term collaborative relationships and limits opportunities for meaningful stakeholder participation. Client-driven traditional approaches reduce genuine stakeholder collaboration, marginalising input from local communities, subcontractors, and end-users. This weakens social equity outcomes and public–private partnerships essential for inclusive urban development. Moreover, the impact of client's resistance to change (CRtC) on economic sustainability is that by favouring traditional procurement, whole-life costs are increased, innovation is reduced, and opportunities are missed for value creation through integrated team working. Clients' preference for lowest-bid tenders discourages investment in collaborative models. This results in greater exposure to claims and litigation, undermining long-term financial returns.

Lastly, regarding lack of industry standardisation (LoIW), the construction industry is typically conservative and risk-averse, relying on traditional project delivery models and contracts that may not align with the collaborative nature of IPD [58]. In NZ, the lack of industry standardisation (LoIW) is notable, but was not a key factor in the frequency analysis. To implement IPD successfully, the industry needs a clear strategy: set up suitable contracts, encourage collaboration, invest in training, adopt new technology, involve stakeholders early, and align IPD with project and industry standards [59]. No interactions of the lack of industry standardisation (LoIW) were found in the literature. In the NZ context, it was found that lack of industry standardisation (LoIW) increases both high initial investment (HII) (RII = 0.755) and lack of professional bodies (LoPB) (RII = 0.757). Additionally, it was found that lack of governmental support (LoGS) (RII = 0.735), lack of IPD awareness (LoIA) (RII = 0.823), logistical challenges (LC) (RII = 0.744), lack of efficiency in information sharing (LoEI) (RII = 0.77), and project objectives-related barriers (PORB) (RII = 0.748) increase the lack of industry standardisation (LoIW). The impact of the lack of industry standardisation (LoIW) on environmental sustainability is that it slows the industry-wide scaling and consistent application of sustainable construction practices and performance benchmarks. Inconsistent standards make it difficult to enforce or measure sustainability targets (e.g., carbon budgets or waste diversion rates) across projects and jurisdictions, slowing industry-wide progress. Further, the impact of the lack of industry standardisation (LoIW) on social sustainability is that it creates inconsistency in project delivery approaches, making it harder to establish fair working conditions and consistent collaborative cultures. Variable practices lead to inconsistent labour standards, stakeholder engagement levels, and social impact reporting, undermining reliable contributions to social development goals. Finally, the impact of the lack of industry standardisation (LoIW) on economic sustainability is that it raises transaction costs, legal uncertainties, learning curves, and implementation barriers, discouraging broader investment in IPD and sustainable innovation. It also discourages smaller firms from participating and prevents the sector from achieving scale efficiencies and market confidence in IPD.

A key difference between the critical factors identified is the prominence of the lack of industry standardisation (LoIW) and the client's resistance to change (CRtC) in the NZ context. As NZ is a small island nation, the results may be applicable to other countries with economies similar to NZ's. These factors are compounded by the unique economic, geographic, and cultural characteristics inherent to small island nations. Due to their size and relative isolation, markets like NZ often have a limited pool of experienced construction professionals, less competition, and fewer opportunities for firms to diversify their project delivery portfolios. The scarcity of tier 1 contractors means that innovative models like IPD, which rely on a depth of expertise and willingness to engage in collaborative, risk-sharing arrangements, face significant headwinds. Furthermore, the absence of factual data creates an environment with little precedent or guidance on how innovative project delivery models like IPD should be structured, managed, or evaluated, exacerbating uncertainty and reluctance among key stakeholders. The lack of robust empirical data on IPD performance in the NZ context further reinforces stakeholder hesitance. Without clear evidence of the benefits and risks, clients and contractors alike default to traditional, well-understood methods rather than experimenting with new approaches that could jeopardise project outcomes or financial stability. This conservatism is particularly pronounced in smaller economies where the margin for error is reduced, and the consequences of failed innovation can be more severe and far-reaching. The resistance is not just a matter of risk aversion but also a rational response to the industry's structural limitations in such settings.

Given these challenges, government intervention emerges as the most viable catalyst for change. In environments where market forces and private initiative are insufficient to

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overcome the barriers to innovation, a top-down approach led by public sector projects can set much-needed precedents and de-risk the initial adoption of models like IPD. By mandating or incentivising the use of IPD in government-funded developments, authorities can help build a repository of local case studies, generate data on outcomes, and foster a culture of collaboration and innovation. This, in turn, can encourage the private sector to follow suit, gradually normalising the new model and embedding it within industry practice. Moreover, government-led initiatives can help establish standards, guidelines, and training programmes to address the lack of factual data. By facilitating knowledge sharing and capacity building, the public sector can bridge the gap between local industry capabilities and the demands of more advanced project delivery methods. Over time, this can create a virtuous cycle where increased familiarity and demonstrated success breed further adoption and refinement of innovative approaches. The critical point of discussion is that the transition to innovative project delivery models, such as IPD, in small island nations like NZ hinges on proactive government leadership. Only through deliberate, strategic support from the public sector can the industry overcome its structural limitations, reduce uncertainty, and pave the way for broader transformation. The initiation stage, therefore, is not just a procedural necessity but a fundamental prerequisite for systemic change in such contexts.

5. Conclusions

This study develops a comprehensive framework that elucidates the complex interactions among factors influencing the implementation of IPD in the NZ construction sector. By adopting a systemic perspective, the research demonstrates how collaboration, legal, organisational, technological, financial, and governmental factors interact, thereby shaping the legitimacy and sustainability of collaborative project organising in temporary inter-organisational settings.

This research investigated the interactions between the factors of IPD using three data collection methods: an SLR, which was followed by 18 SSIs, the results of which were triangulated with 137 survey responses from the wider NZ construction industry. The SLR was used to detail a comprehensive list of the factors of IPD and their interactions, and the SSIs were designed to cover all of them. From the triangulated survey responses, using the Relative Importance Index method, all 142 interactions were assigned a value. Furthermore, using the *t*-test, 88 interactions were found to be statistically significant, which 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. To ease the dissemination of the findings, a framework was developed, which was a simplified version of the complicated Vensim model. These results extend current understanding of project ecosystems and relational governance in temporary organisations by showing that successful collaborative contracting depends less on addressing individual barriers and more on managing systemic interdependencies.

Although empirically grounded in the NZ construction context, the framework offers broader theoretical insights into why collaborative delivery models often face implementation difficulties despite their proven performance advantages. Practically, the study provides practitioners and policymakers with a diagnostic tool to identify high-leverage intervention points and design more effective strategies for implementing collaborative contracting approaches.

5.1. Theoretical Implications

This study contributes to the growing body of knowledge on sustainable project delivery by developing a systemic framework that explains the complex interactions among

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factors affecting the implementation of IPD. While previous research has largely examined isolated barriers to IPD, this study advances theoretical understanding by demonstrating how collaboration, legal, organisational, financial, technological, and governmental factors interact to hinder sustainable project outcomes. Moreover, this study also contributes to the sustainability literature by showing how critical factors act as bottlenecks that limit the adoption of delivery models capable of delivering superior environmental, social, and economic performance.

Additionally, this study advances project management theory in three important ways. First, it enriches the project ecosystems perspective by providing empirical evidence that the success of collaborative contracting depends heavily on managing complex, non-linear interdependencies rather than addressing isolated factors. Second, it contributes to legitimacy theory by demonstrating how systemic interactions among factors influence the perceived appropriateness, feasibility, and sustainability of innovative delivery models such as IPD over time. Third, the study extends relational governance and temporary organising scholarship by revealing specific micro-mechanisms that shape the emergence and maintenance of collaborative behaviours in inter-organisational projects.

Furthermore, by integrating System Dynamics and Network Analysis approaches, this research offers a novel methodological contribution to the study of sustainable construction project governance. The findings underscore that achieving sustainability in construction requires careful management of interconnected socio-organisational factors within project ecosystems.

5.2. Practical Implications

The framework developed in this study provides practitioners and policymakers with a powerful diagnostic and intervention-planning tool. By visualising how key factors interact, it enables practitioners and policymakers to move beyond addressing individual barriers toward more effective, systemic strategies that target high-leverage points and break negative reinforcing cycles. How each stakeholder may benefit from this research is outlined below:

Industry Practitioners

Industry practitioners will gain insight into the critical factors influencing integrated project delivery (IPD) and the interrelationships among them. Drawing upon their direct experience in project execution, they will be better positioned to anticipate potential challenges and proactively develop appropriate mitigation strategies.

Stakeholders

Stakeholders within the construction sector, when considering the adoption of the IPD project delivery method, will develop an enhanced understanding of the dynamic interplay between key factors and the associated challenges. Although they may not be directly engaged in day-to-day project execution, this knowledge will support informed managerial decision-making, both at the project's inception and throughout the construction phase.

Client/Owner

As the primary decision-maker in construction projects, the client or owner bears ultimate responsibility for selecting the appropriate project delivery model. The findings of this research will equip clients with a comprehensive understanding of the factors contributing to resistance toward IPD, as well as the anticipated challenges associated with its implementation.

Project Manager

Project managers, who hold overarching responsibility for successful project completion and typically report to senior management and clients, will benefit substantially from this study. The research elucidates the complex interrelationships among IPD factors, including their mutual influences. Given the broad thematic coverage of the identified factors, project managers will be well-prepared to address potential obstacles when implementing the IPD model.

Construction Manager

Construction managers bear primary responsibility for on-site execution and occupy a position of significant authority, subordinate only to the project manager. This research will assist them in navigating practical challenges related to IPD implementation. Although their role centres on site operations, the detailed analysis of factor interactions will provide valuable preparation for participation in IPD-administered projects.

Specific practical recommendations include:

- Implementing early and sustained IPD awareness and training programmes for clients, contractors, and design teams.
- Developing standardised contractual templates and compensation structures that better support relational governance.
- Establishing industry-wide initiatives, potentially led by government or professional bodies, to promote best practices and reduce procurement practices biased toward lowest-cost tenders.
- Integrating IPD principles into construction management education and professional development programmes to build collaborative competencies in future practitioners.

In the NZ context, the findings suggest that government leadership through public-sector pilot projects will be critical for wider IPD adoption. More broadly, the framework can assist organisations in other markets in designing more effective implementation strategies for collaborative contracting.

5.3. Limitations

The limited familiarity with IPD within the NZ construction industry must be acknowledged. Despite the researcher's efforts to ensure rigour, several uncontrollable factors constrained the study. These include the limited direct experience of some interviewees with IPD-administered projects. Furthermore, no government officials were interviewed. The participant sample consisted almost exclusively of construction professionals, including consultants, contractors, engineers, and managers. Consequently, the absence of perspectives from government decision-makers authorised to select project delivery methods for public projects represents a notable limitation.

Additional constraints arise from the study's reliance on qualitative SSIs, which renders the findings dependent on participants' subjective views and susceptible to potential interviewee bias. Finally, as the research commenced with an SLR, it is important to recognise inherent SLR limitations, including selection, publication, attrition, and reporting biases. Nevertheless, the SLR methodology employed in this study was designed to mitigate these risks.

5.4. Future Studies

While the study provides rich insights from the NZ construction industry, the findings are contextually embedded. Future research should test the generalisability of the framework across different countries, industries, and project scales. Longitudinal studies examining how these interactions evolve over the project lifecycle, as well as comparative research between mature and emerging IPD markets, would be particularly valuable. Furthermore, future studies can employ alternative data collection and analysis methods. Additionally, 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.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18168328/s1, Table S1: Eigenvector centrality computation (Source: Author's own work); Table S2: RII results (Source: Author's own work); Table S3: *p*-values (Source: Author's own work).

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article and its Supplementary Materials.

Conflicts of Interest: The authors report no competing interests.

Appendix A

Table A1. SLR search results (source: author's own work).

S.N	Author(s)	Year	Paper Title
1	Aapaoja et al. [60]	2013	The characteristics of and cornerstones for creating integrated teams
2	Abdirad and Dossick [61]	2019	Restructuration of architectural practice in integrated project delivery (IPD): two case studies
3	Abou Dargham et al. [62]	2019	Implementation of Integrated Project Delivery in Lebanon: Overcoming the Challenges
4	Ahmad et al. [5]	2019	Enhancement of IPD Characteristics as Impelled by Information and Communication Technology
5	Ahmed et al. [63]	2021	Contractual Guidelines for Promoting Integrated Project Delivery
6	Alinezhad et al. [64]	2020	Analysis of the benefits of implementation of IPD for construction project stakeholders
7	Alqahtani et al. [65]	2022	Scrutinising the Adoption of Integrated Project Delivery in the Kingdom of Saudi Arabia Construction Sector
8	Azhar et al. [66]	2015	Critical look into the relationship between information and communication technology and integrated project delivery in public sector construction
9	Azhar et al. [39]	2014	Factors Influencing Integrated Project Delivery In Publicly Owned Construction Projects: An Information Modelling Perspective
10	Bilbo et al. [67]	2014	Comparison of Construction Manager at Risk and Integrated Project Delivery Performance on Healthcare Projects: A Comparative Case Study
11	Bilge [68]	2021	A real estate development model for Turkey: real estate certificates and integrated project delivery
12	Buk'hail and Al-Sabah [69]	2022	Exploring the Barriers to Implementing the Integrated Project Delivery Method

Table A1. *Cont.*

S.N	Author(s)	Year	Paper Title
13	Charlesraj and Gupta [40]	2019	Analysis of the Perceptions of Beneficiaries and Intermediaries on Implementing IPD in Indian Construction
14	Dalui et al. [70]	2021	Integrated project delivery with BIM: A methodical approach within the UK consulting sector
15	Dossick et al. [71]	2013	IPD in practice: Sustaining collaboration in healthcare design and construction
16	Durdyev et al. [72]	2019	Barriers to the use of integrated project delivery (IPD): a quantified model for Malaysia
17	Ebekozien et al. [73]	2022	Integrated project delivery in the Nigerian construction sector: an unexplored approach from the stakeholders' perspective
18	Ebrahimi and Dowlatabadi [74]	2019	Perceived Challenges in Implementing Integrated Project Delivery (IPD): Insights from Stakeholders in the U.S. and Canada for a Path Forward
19	Elghaish and Abrishami [75]	2020	A centralised cost management system: exploiting EVM and ABC within IPD
20	Elghaish et al. [48]	2020	Revolutionising cost structure for integrated project delivery: a BIM-based solution
21	Elghaish et al. [76]	2020	Integrated project delivery with blockchain: An automated financial system
22	Elghaish et al. [77]	2020	Factors driving the success of cost management practices in integrated project delivery (IPD)
23	Evans and Farrell [78]	2022	A strategic framework managing challenges of integrating lean construction and integrated project delivery on construction megaprojects, towards global integrated delivery transformative initiatives in multinational organisations
24	Evans et al. [79]	2021	Barriers to integrating lean construction and integrated project delivery (IPD) on construction megaprojects towards the global integrated delivery (GID) in multinational organisations: lean IPD&GID transformative initiatives
25	Forero et al. [56]	2015	A deeper look into the perception and disposition to integrated project delivery (ipd) in Colombia
26	Ghassemi and Becerik-Gerber [6]	2011	Transitioning to Integrated Project Delivery: Potential barriers and lessons learned
27	Gomez et al. [80]	2018	Implications of the integrated project delivery research in practice
28	Gomez et al. [81]	2018	Integrated project delivery for infrastructure projects in Peru
29	Govender et al. [82]	2018	The awareness of integrated project delivery and building information modelling—facilitating construction projects
30	Hettiaarachchige et al. [43]	2022	Lean Integrated Project Delivery for Construction Procurement: The Case of Sri Lanka
31	Ibidapo et al. [83]	2017	Exploring Opportunities of Integrated Project Delivery in Off-Site Manufacturing of the Australian Housing Sector
32	Jadidoleslami et al. [84]	2022	A practical framework to facilitate constructability implementation using the integrated project delivery approach: a case study
33	Kahvandi et al. [55]	2019	Analysis of the Barriers to the Implementation of Integrated Project Delivery (IPD): A Meta-Synthesis Approach

Table A1. *Cont.*

S.N	Author(s)	Year	Paper Title
34	Kahvandi et al. [85]	2018	An FCM-based dynamic modelling of integrated project delivery implementation challenges in construction projects
35	Karasu et al. [57]	2022	The interplay of IPD and BIM: a systematic literature review
36	Kent and Gerber [86]	2010	Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery
37	Khanna et al. [52]	2021	Feasibility of implementing IPD approach for infrastructure projects in developing countries
38	Korb et al. [87]	2016	Overcoming "But We're Different": An IPD Implementation in the Middle East
39	Ku [88]	2009	The core of Eden: A case study on model-based collaboration for integrated project delivery
40	Laurent and Leicht [89]	2019	Practices for Designing Cross-Functional Teams for Integrated Project Delivery
41	Leicht and Harty [90]	2017	Influence of multi-party IPD contracts on construction innovation
42	Li and Ma [49]	2017	Barriers and Challenges to Implement Integrated Project Delivery in China
43	Ma et al. [91]	2023	Optimum risk/reward sharing framework to incentivise integrated project delivery adoption
44	Ma et al. [8]	2022	Barriers to adopting integrated project delivery practices
45	McDonnell [92]	2015	A focus on integrated project delivery, the enablers for this process, and the challenges and barriers to IPD within an Irish context
46	Mulholland and Clevenger [93]	2018	Contracting Methods for Integrated Project Delivery: A Healthcare Case Study
47	Naismith et al. [54]	2016	The adoption of integrated project delivery in public sector projects in New Zealand: the way forward
48	Nejati et al. [94]	2014	Feasibility of using an integrated project delivery (IPD) in mass housing collaborative projects
49	Osman et al. [95]	2017	An Integrated Procurement System: A Study of Construction Firm Readiness towards Implementing of Integrated Project Delivery (IPD)
50	Osman et al. [96]	2015	Readiness assessment for implementation of Integrated Project Delivery (IPD) in Industrialised Building System (IBS) projects
51	Psomas and Alzraiee [97]	2020	A Technology Platform for a Successful Implementation of Integrated Project Delivery for Medium Size Projects
52	Rodrigues and Lindhard [98]	2021	Benefits and challenges to applying IPD: experiences from a Norwegian mega-project
53	Rosayuru et al. [99]	2019	Sustainable BIM based integrated project delivery system for construction industry in Sri Lanka
54	Rowlinson [100]	2017	Building information modelling, integrated project delivery and all that
55	Roy et al. [47]	2018	Identification of Critical Challenges for Adoption of Integrated Project Delivery
56	Sari et al. [101]	2023	Challenge and Awareness for Implemented Integrated Project Delivery (IPD) in Indonesian Projects
57	Seed [102]	2014	Integrated project delivery requires a new project manager

Table A1. *Cont.*

S.N	Author(s)	Year	Paper Title
58	Sherif and Abotaleb [38]	2021	Application of Integrated Project Delivery (IPD) in Egypt: Implementation and Challenges
59	Sherif et al. [41]	2022	Application of Integrated Project Delivery (IPD) in the Middle East: Implementation and Challenges
60	Su et al. [103]	2021	Risk Sharing Strategies for IPD Projects: Interactional Analysis of Participants' Decision-Making
61	Sun et al. [104]	2015	Communication behaviours to implement innovations: How do AEC teams communicate in IPD projects?
62	Tillmann et al. [105]	2012	How integrated governance contributes to value generation—Insights from an IPD case study
63	Viana et al. [106]	2022	Adopting an integrated project delivery collaboration framework: a case study of a wastewater treatment plant project in Vietnam
64	Zhang et al. [46]	2018	Collaboration in Integrated Project Delivery: The Effects of Trust and Formal Contracts
65	Zhang et al. [42]	2020	Collaborative contracting in the Singapore construction industry: current status, major barriers and best solutions
66	Zuber et al. [107]	2019	Construction procurement practice: A review study of Integrated Project Delivery (IPD) in the Malaysian construction projects

Table A2. Interactions between IPD factors obtained from SLR (source: author's own work).

	RtC	CLA	CRtC	MR&T	CCP	LoC	I	LoICT	CEC	DiA	LoUT	LoI	ECI	LoFIPDCM	LoP	IVIPD	APL	LoL	AAJPC	NATT
RtC			+		+													+		
CLA	+		+	−																
CRtC				−																
LoIA	+				+															+
LoIP		+							+								−			
LoC							−													
IoSR	+												−							
LoICT											+									
CEC										+										
DiA														+						
LoGS															+					
SPA																			−	
SfLC	+																			
URMPC			+																	
HFCNS								+												
RnTRSR						+														
CCRL												+				−				
LoENR				−																
II							−													

+ Positive; − Negative.

Table A3. Interactions between IPD factors obtained from SSIs (source: author's own work).

	LoC	LoI	SPA	MR&T	AAJPC	LoT	LoIA	RtC	CRtC	LoIW	AaW	LoP	LoIU	IiR	LoF	CCP	LoETM	IVIPD	LoLean	DHQD	ONIA	DiC	UR	MSTD	LoES	PDT	PM	IDCOC	LoCo	RAM	SfF	HII	CEC	LoGS	LoPB	LoGipr	CLA	R&I	SoCIS	LoIP	NSIPD	LoESIPD	LoUT	B&IC
LoC		+		–	–	+	+																						+														+	
LoI						+		+					+																															
SPA	+	+		–	–			+					+																															
AAJPC								+																																				
LoT				–																																								
LoIA	+			–				+	+	+			+		+			–											+	+				+									+	
RtC									+																																		+	
CRtC										+	–																																	
LoIW								+	+																							+			+									
LoP							+				–				+		+																								+	+		
LoIU								+																																				
LoCA									+					+													+				–													
LoF								+								+						+																						
CCP	+			–				+					+														+																+	
LoETM																																											+	
PORB								+	+	+																																	+	
LoLean				–				+										–																										
LoENR								+																																				
IPLC							+																																				+	
EDTG																				+																								
LOCm																						+																						
TEWM																							+																					
LoPr					–																			–																				
LoL																						+																						
LoTP				–						+															+																			
LoES								+					+			+			+																									
LoEI										+												+				+																		
PM				–																																								

Table A3. *Cont.*

	LoC	LoI	SPA	MR&T	AAJPC	LoT	LoIA	RtC	CRtC	LoIW	AaW	LoP	LoIU	IiR	LoF	CCP	LoETM	IVIPD	LoLean	DHQD	ONIA	DiC	UR	MSTD	LoES	PDT	PM	IDCOC	LoCo	RAM	SfF	HII	CEC	LoGS	LoPB	LoGipr	CLA	R&I	SoCIS	LoIP	NSIPD	LoESIPD	LoUT	B&IC
MoI																												+																
LC								+		+																																		
LoSK																																												+
BR									+																																			
HII				–				+	+																									+						+				
HFCNS								+	+																																		+	
RnTRSR									+																									+										
MIR																																	+											
CS	+			–	–			+																																				
SfLC								+	+																									+										
TCPACNA									+																																			
TCPAFTM									+																												+							
HP																																								+				
LoFIPDCM	+			–				+																																				
LoTSC									+																																			
LoGS				–				+		+		+					+	–														+			+	+							+	
LoPB												+																																
CLA	+		+	–				+																									+	+				+		+				
R&I																																							+					
IoSR					–				+												+																							
CCRL			+																																									
LoESIPD															+																													
LoUT								+																									+											+
IPIT								+																																				
LoICT																																											+	

+ Positive; – Negative.

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