

Interactions of key factors affecting the implementation of integrated project delivery in the global construction industry: a systematic review

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Abstract

Purpose – Integrated project delivery (IPD) is an 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 sustainability through waste reduction. Though numerous articles on factors related to IPD are available, the interactions between factors associated with IPD are a research gap. This study addresses this research gap and aims to identify the interactions between key factors of IPD.

Design/methodology/approach – A systematic literature review (SLR) was conducted using three databases and key publishers – Scopus, Emerald and ScienceDirect. The SLR identified 222 factors related to IPD by studying 66 articles. The factors were uploaded to VOSViewer to identify the critical factors through repetition. Each of the 66 articles was examined to determine the interactions between factors through deductive reasoning. The interactions were visualised using VENSIM, and analysis methods such as nodes, degree of centrality and eigenvector centrality were used to identify the critical factors of IPD.

Findings – A total of 127 factors were identified, of which mutual respect and trust, resistance to change, challenging cultural paradigms, client/owner's resistance to change, difficulties in achieving financial transparency, interoperability and cost estimation challenges were deemed critical factors of IPD. The implications of this research will aid researchers and industry practitioners in comprehensively understanding the interactions between key factors, thus preparing solutions to increase IPD implementation for sustainable construction in the global context.

Originality/value – This study is the first to analyse the interactions between IPD factors in the global construction industry based solely on an SLR. While several articles have been written on the factors of IPD implementation globally, the interactions have never been studied before.

Keywords Integrated project delivery, Challenges, Barriers, Obstacles

Paper type Literature review

1. Introduction

The American Institute of Architects (AIA) describes integrated project delivery (IPD) as a project delivery approach that integrates people, systems, business structures and practices



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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 (AIA, 2007). IPD leverages early contributions of expertise and knowledge by applying new technology, enabling all project participants to reach their highest potential while expanding the value they provide throughout the project lifecycle. Evidence shows that IPD can improve project performance metrics, including communication, cost, quality and scheduling. IPD relies on open pricing techniques and fiscal transparency among participants (Ahmad *et al.*, 2019). Additionally, documented case studies reveal that IPD can save 2%–10% of total project costs, and savings up to 30% are expected if the project team succeeds in integrating strategic partnering (Zhang *et al.*, 2018).

Furthermore, IPD can increase the success in constructing greener buildings through the efficient consumption of essential resources and waste reduction, thus promoting sustainability (Ghassemi and Becerik-Gerber, 2011). Also, IPD has largely been promoted due to its potential to facilitate BIM on construction projects (Kent and Becerik-Gerber, 2010). Coupling BIM and IPD is proven to enhance efficiency, enable the exploration of alternative approaches, expand market opportunities and reduce project errors (Kent and Becerik-Gerber, 2010). IPD is widely regarded as a modern project delivery approach in the construction industry that provides the most effective and efficient way of procuring built assets (Rowlinson, 2017). However, IPD presents challenges for the project team, making its implementation difficult (Naismith *et al.*, 2016). From a construction professional's perspective, despite the advantages of IPD, its implementation requires significant changes to processes such as making agreements, organising teams and sharing risks and rewards. These amendments clash with traditional construction practices and create barriers to IPD (Ma *et al.*, 2022). Although various studies have investigated IPD factors and categorised them into several groups, such as communication, legal, technological, organisational, governmental and financial (Bin Asad *et al.*, 2023), there is yet to be a study on the interactions between factors that affect its implementation. This study aims to rank the factors influencing IPD based on their interactions.

This article investigates the interactions between factors influencing IPD based on a comprehensive systematic literature review (SLR). Although some interactions were explicitly mentioned, the researcher used deductive reasoning to investigate interactions between factors that were not explicit. This research is aligned with the United Nations Sustainable Development Goal (SDG) 11- Sustainable Cities and Communities. As previously stated, IPD promotes sustainable construction through efficient consumption of essential resources and waste reduction.

2. Literature review

Generally, the prevalent barriers to IPD implementation are classified as cultural, financial (F), legal (L) and technical (T) problems (Korb *et al.*, 2016). Legal barriers refer to issues with risk allocation, insurance and liability (Kent and Becerik-Gerber, 2010). IPD contracts reduce the ability of project participants to sue one another; however, the current insurance products are designed to allocate liability to each participant, complicating the contractual arrangements (Naismith *et al.*, 2016). Cultural and organisational (CO) barriers within the construction industry refer to resistance to change, whether from the client or the project stakeholders and lack of leadership (Azhar *et al.*, 2014). It is believed that since IPD projects require significant additional costs and design requirements, they should be reserved for large and complex projects (Tucker and Gilge, 2013). Another idea is that IPD is more advantageous in repetitive facilities than in one-off projects (Cleves and Gallo, 2012). Often,

the challenge is to overcome the notion of traditional industry practices (Lichtig, 2006). Firms are used to traditional construction practices, and because of issues such as unawareness, lack of information sharing and risk in new processes, they show resistance to change. Other factors related to IPD, such as the high financial costs of new software, lack of technically trained professionals, and BIM and IPD integration challenges, fall under the technological theme. It is mandatory to establish information management protocols from conception, including ownership information, responsibility, access and information regarding project information (Azhar *et al.*, 2014). The availability of adequate IT infrastructure is not compulsory for IPD implementation; however, experts believe that it is required for the level of collaboration needed (Eastman *et al.*, 2011).

Collaboration and communication (CC) is classified as a theme for IPD factors that include factors such as lack of integration between key stakeholders, insufficient mutual respect and trust among project participants and issues with achieving joint project control mainly because of self-interest among the project participants (Ebrahimi and Dowlatabadi, 2018). Issues such as high initial investment, the absence of a financially capable owner and the absence of evidence about the return on investment of implementing IPD are some of the factors under the financial theme (Abou Dargham *et al.*, 2019). Finally, the final theme of IPD factors is Governmental/ Political (GP), particularly the lack of governmental support concerning policies, incentives and regulations that do not aid IPD implementation (Rosayuru *et al.*, 2019). While several articles mention the factors of IPD, there is yet to be a study on the interactions between the key factors of IPD. This study addresses this research gap through an in-depth analysis of the interactions between factors, allowing the researcher to rank the factors and distinguish between them.

3. Methodology

An SLR was conducted to identify all existing factors related to IPD in the literature using three databases and key publishers such as Scopus, Emerald and ScienceDirect. The 14-step research procedure is detailed below:

- (1) *Rationale*: various articles have detailed the factors of IPD. However, the interactions between these factors remain a research gap.
- (2) *Objective*: identify and rank key IPD factors based on their interactions.
- (3) Inclusion and exclusion criteria are shown in Table 1.
- (4) *Databases used*:

Table 1. SLR inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Articles mentioning barriers to IPD	Non-integrated project delivery and construction-related articles
English language papers	Articles without mention of barriers to integrated project delivery
Articles published between the years 2009–2023	Non-English language papers Articles published before the year 2009 Systematic literature reviews

Source(s): Authors' own work

- Scopus,
 - Emerald,
 - ScienceDirect.
- (5) *Search string*: (1) Scopus: “Integrated Project Delivery” AND “Barriers” OR “Challenges” OR “Obstacles” published from 2009 to 2023; (2) Emerald: “Integrated Project Delivery” AND “Challenges” published from 2009 to 2023; (3) ScienceDirect: “Integrated Project Delivery” AND “Challenges” published from 2009 to 2023.
- (6) The total number of articles selected was 128; of which, 66 had either explicitly or implicitly mentioned factors.

Table A1 details all 66 articles.

- (7) *Search for articles*: Table 2 shows the initial search results of each database, and Figure 1 shows the PRISMA chart for the SLR process.
- (8) *Factor identification*: each article was read twice to identify the factors influencing IPD. The identified factors were grouped into themes such as CC, CO, financial (F), governmental/political (GP), legal (L) and technological (T).
- (9) *Determining relevance*: 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 but fell short of expectations and could not reveal all the factors, interactions and polarity.
- (10) *Interrelations and polarity*: each of the 66 articles was studied to identify interrelations and the polarity of the interaction of 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.
- (11) *Organising identified interrelations and polarity*: 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 placed in the intersecting cells of the Excel workbook.
- (12) *Visualising interrelations and polarity*: the identified interactions between factors and their polarity were visualised in a causal loop diagram using VENSIM software.
- (13) *Analysis*: three analysis methods, including author frequency, degree of centrality and eigenvector centrality, were used to identify and rank the critical factors in the factor network:
- *13.1 Author frequency* – an author factor matrix was created and summarised in Excel format.

Table 2. SLR search results

Search engine	Search string	Results
Scopus	“Integrated Project Delivery” AND “Barriers” OR “Challenges” OR “Obstacles” published from 2009 to 2023	174
Emerald	“Integrated Project Delivery” AND “Challenges” published from 2009 to 2023	397
ScienceDirect	“Integrated Project Delivery” AND “Challenges” published from 2009 to 2023	318

Source(s): Authors’ own work

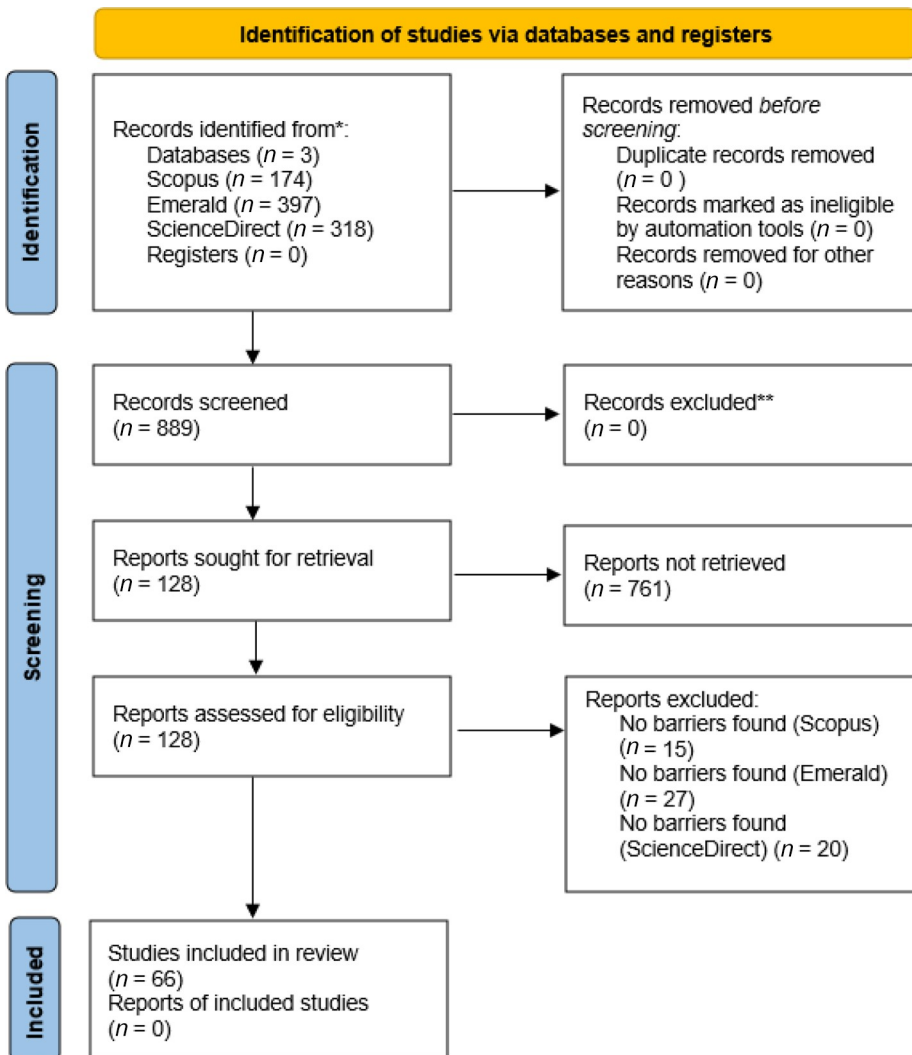


Figure 1. PRISMA chart for the SLR process

Source: Authors' own work

- 13.2 Degree centrality:
 - 13.2.1 Nodes – a network is formally defined by $G = (N, E)$, where N is the nodes and E is the edges associated with the respective nodes (Ramirez-Arellano et al., 2020). Through the calculation of edges, a node's centrality can be measured. Centrality indicates a node's importance within its network.
 - 13.2.2 Degree centrality – degree centrality is a local centrality calculated from a node's immediate neighbourhood links (Bamakan et al., 2019). The

degree centrality for a node is its degree (Golbeck, 2015). Mostly, the numbers are converted to a 0–1 scale, and the node with the highest degree in the network has a degree centrality of 1. Every other node’s centrality will be a fraction of its degree compared with the most popular node. This research followed Purushothaman *et al.* (2024) in calculating the degree of centrality.

- **13.3 Eigenvector centrality** – While degree centrality measures the number of connections a node has, it does not differentiate between the importance of each node within the network (Tortosa *et al.*, 2017). Eigenvector centrality suggests that a node is more central as it is connected to important (central) nodes (Bonacich, 2007). Eigenvector centrality measures a node’s degree and its neighbours’ degree. Using the power iteration method, each node within a network is assigned a value; the higher the value, the greater the level of influence within the network (Meghanathan, 2015). To summarise, connections to high-valued nodes contribute more to the score of a node than equal connections to low-valued nodes. This research followed Meghanathan (2015) in calculating the Eigenvector centrality.

- (14) **Analysis consolidation:** The results of all three analyses were consolidated, ranked and listed in a single table for comparison. The factors that appeared in all three analysis rankings were deemed critical. Most factors act in conjunction with other factors and often interact to cause a ripple effect. Hence, based on the two analyses of the interrelation, the factors that appeared in both were deemed next-level critical factors.

4. Results and discussion

The SLR process resulted in 66 articles from 2009 to 2023. Figure 2 shows the year-wise distribution of the 66 articles. These articles were from 25 countries spread over five continents, which shows that IPD is researched globally. Figure 3 shows the distribution of 66 articles per country/region.

It is evident from Figure 3 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,

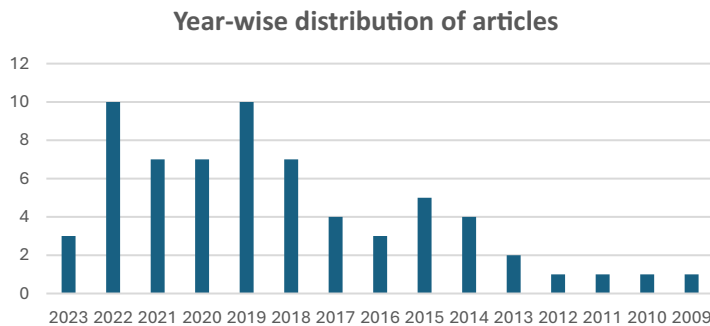


Figure 2. Year-wise distribution of SLR results

Source: Authors’ own work

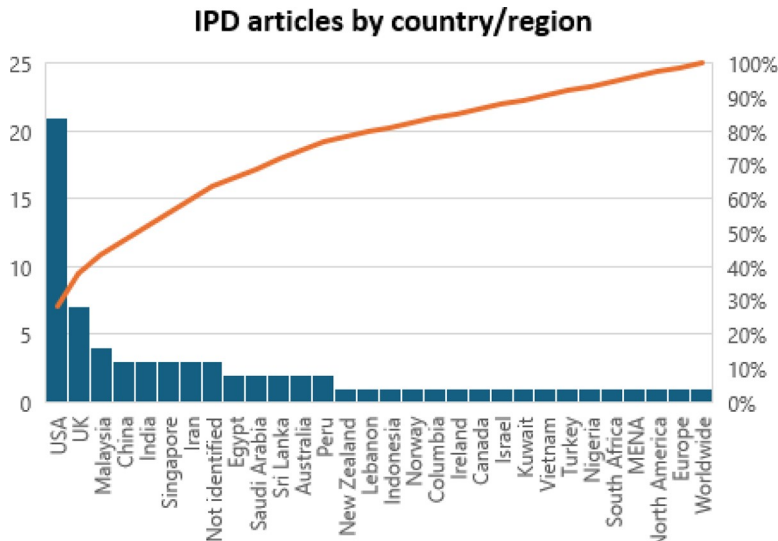


Figure 3. Distribution of SLR results by country/region
Source: Authors' own work

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 country specifically; instead, they mentioned the following regions: Europe, MENA and North America. Finally, one article research was based worldwide. It can be concluded that the adoption of IPD is gaining popularity worldwide, but a higher number of articles are from the USA or even 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. Table 3 details all 127 factors, themes, sample author references and the total number of authors who identified the factors.

CC contains seven factors, the most repetitive being the lack of CC among construction stakeholders (15 author references) and mutual respect and trust between stakeholders (10 author references). CO contains 64 factors, with the most repetitive being 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 20 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 28 factors, the most repetitive being contractual *L* aspects (27 author references) and lack of insurance policies and bonding arrangements (6 author references). *T* contains six factors, with the most repetitive being lack of usage of *T* advancements (e.g. BIM) (24 author references) and 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 in Figure 4.

Table 3. Factors to IPD

Barriers	Barrier theme	Sample author(s) references	Author frequency
Lack of CC among construction stakeholders (LoC)	CC	Durdyev <i>et al.</i> (2019), Ma <i>et al.</i> (2022)	15
Mutual respect and trust (MR&T)	CC	Roy <i>et al.</i> (2018)	10
Lack of integration of key stakeholders (LoI)	CC	Kahvandi <i>et al.</i> (2019), Osman <i>et al.</i> (2017)	7
Self-protective approach (SPA)	CC	Sherif <i>et al.</i> (2022), Sherif and Abotaleb (2023)	6
Lack of transparency (LoT)	CC	Charlesraj and Gupta (2019), Hettiaarachchige <i>et al.</i> (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 <i>et al.</i> (2022)	1
Lack of IPD awareness/knowledge among stakeholders (LoIA)	CO	Forero <i>et al.</i> (2015), Alqahtani <i>et al.</i> (2022)	18
Challenging cultural paradigms (CCP)	CO	Naismith <i>et al.</i> (2016), Dalui <i>et al.</i> (2021)	17
Resistance to change among stakeholders (RtC)	CO	Li and Ma (2017), Karasu <i>et al.</i> (2022)	9
Inherent difficulties in changing organisational culture (IDCOC)	CO	Zhang <i>et al.</i> (2018), Zuber <i>et al.</i> (2019)	7
Client's / owner's resistance to change (CRtC)	CO	Naismith <i>et al.</i> (2016), Govender <i>et al.</i> (2018)	6
Lack of existing training material (LoETM)	CO	Hettiaarachchige <i>et al.</i> (2022)	5
Awareness and willingness about IPD among owners (AaW)	CO	Khanna <i>et al.</i> (2021), Jadidoleslami <i>et al.</i> (2022)	4
Early contractor involvement (ECI)	CO	Sherif <i>et al.</i> (2022), Ma <i>et al.</i> (2022)	4
Lack of experience and skills (LoES)	CO	Khanna <i>et al.</i> (2021)	4
Lack of interest to upgrade (LoIU)	CO	Khanna <i>et al.</i> (2021)	4
Interoperability (I)	CO	Azhar <i>et al.</i> (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 <i>et al.</i> (2022)	3
Integration of information and knowledge management systems (IIKMS)	CO	Charlesraj and Gupta (2019), Roy <i>et al.</i> (2018)	3
Lack of proficiency and strong management of the employer (LoPr)	CO	Kahvandi <i>et al.</i> (2018)	3
Industry participants lack chances to receive IPD-related training (IPLC)	CO	Ma <i>et al.</i> (2022)	
Lack of trained professionals (LoTP)	CO	Naismith <i>et al.</i> (2016)	3
Developing high-quality design (DHQD)	CO	Ebrahimi and Dowlatabadi (2018)	3
Unclear responsibilities of the parties (UR)	CO	Hettiaarachchige <i>et al.</i> (2022)	3
Owner not identifying advantages (ONIA)	CO	Govender <i>et al.</i> (2018), Karasu <i>et al.</i> (2022)	2

(continued)

Table 3. Continued

Barriers	Barrier theme	Sample author(s) references	Author frequency
Participation (P)	CO	Charlesraj and Gupta (2019), Sherif and Abotaleb (2023)	2
Making sound and timely decisions (MSTD)	CO	Ebrahimi and Dowlatabadi (2018)	2
Risk allocation mechanism (RAM)	CO	Azhar <i>et al.</i> (2015)	2
Different criteria for services procurement (DCfSP)	CO	Azhar <i>et al.</i> (2015)	2
Mindset of individuals (MoI)	CO	Khanna <i>et al.</i> (2021)	2
Lack of lean knowledge (LoLean)	CO	Tillmann <i>et al.</i> (2012)	2
Lack of owner involvement (LoOI)	CO	Gomez <i>et al.</i> (2018a, 2018b)	2
Lack of organisational communication (LOCm)	CO	Hettiaarachchige <i>et al.</i> (2022)	2
Lack of promotion of IPD (LoP)	CO	Forero <i>et al.</i> (2015), McDonnell (2015)	2
Inculcating the values of IPD (IVIPD)	CO	Korb <i>et al.</i> (2016)	2
Lack of coordination in managing the project (LoCo)	CO	Kahvandi <i>et al.</i> (2018), Psomas and Alzraiee (2020)	2
Lack of partnering as a tool for achieving lean construction performance (LoPtLC)	CO	Sari <i>et al.</i> (2023)	1
Lack of effective information sharing (LoEI)	CO	Elghaish <i>et al.</i> (2020a, 2020b, 2020c)	1
Lack of responsive decision-making regimes (LoRDM)	CO	Elghaish <i>et al.</i> (2020a, 2020b, 2020c)	1
Assigning project leadership (APL)	CO	Naismith <i>et al.</i> (2016)	1
Attitude-related barriers (ARB)	CO	Evans <i>et al.</i> (2021)	1
Business risk (BR)	CO	Naismith <i>et al.</i> (2016)	1
Difficulties in converting strategic decisions to operational levels (DiC)	CO	Zhang <i>et al.</i> (2020)	1
Inefficiency in resource planning (IiR)	CO	Hettiaarachchige <i>et al.</i> (2022)	1
Lack of leadership and uncertainty of risk involved (LoL)	CO	Naismith <i>et al.</i> (2016)	1
Lack of constraint analysis and planning process (LoCA)	CO	Gomez <i>et al.</i> (2018a, 2018b)	1
Lack of familiarity of contractors with the IPD approach (LoF)	CO	Kahvandi <i>et al.</i> (2018)	1
Lack of a standard way to measure the degree of design integration (LoSW)	CO	Ma <i>et al.</i> (2022)	1
Lack of a standard way to measure the whole life cycle project quality (LoSWW)	CO	Ma <i>et al.</i> (2022)	1
Lack of proper definition of responsibilities of each party to the contract (LoPDR)	CO	Kahvandi <i>et al.</i> (2018)	1
Lack of proper definition of the culture of teamwork among project key stakeholders (LoPDC)	CO	Kahvandi <i>et al.</i> (2018)	1
Lack of sufficient knowledge about design, construction, and maintenance among representatives of the employer (LoSK)	CO	Kahvandi <i>et al.</i> (2018)	1

(continued)

Table 3. Continued

Barriers	Barrier theme	Sample author(s) 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. (2014)	1
Lack of industry-wide standardisation (LoIW)	CO	Kent and Becerik-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 (2018)	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 Becerik-Gerber (2010)	3
The high F cost of new software and equipment (HFCNS)	F	Hettiaarachchige et al. (2022)	3
Lack of fair IPD compensation models (LoFIPDCM)	F	Elghaish et al. (2020a, 2020b, 2020c)	3
Misunderstandings in risk contingency accounting (MIR)	F	Elghaish et al. (2020a, 2020b, 2020c)	2
Difficulties in achieving F transparency (DiA)	F	Rodrigues and Lindhard (2021)	2
Hard pricing (HP)	F	Elghaish et al. (2020a, 2020b, 2020c)	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. (2020a, 2020b, 2020c)	1

(continued)

Table 3. Continued

Barriers	Barrier theme	Sample author(s) references	Author frequency
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. (2020a, 2020b, 2020c)	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
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. (2020a, 2020b, 2020c)	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

(continued)

Table 3. Continued

Barriers	Barrier theme	Sample author(s) references	Author frequency
Application of IPD principles with no standard contract agreement (AIPDNC)	L	Gomez et al. (2018a, 2018b)	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
Uncertainty of risk involved in multi-party contracts (URMPC)	L	Naismith et al. (2016)	1
Differences in contracting methodology (DiCM)	L	Clevenger and Mulholland (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. (2019)	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

Source(s): Authors' own work

This SLR aimed to detail the factors to IPD and display the connectivity between factors. The results of SLR are shown in [Table 3](#), and the connectivity between factors is offered through the VOSViewer visualisation diagram. The VOSViewer identifies and connects the most common factors to IPD from the 222 factors found in the SLR. The results from VOSViewer group the factors into five colour categories, indicating the connections between the factors. 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, contractual *L* aspect, arrangement, compensation, uncertainty, policy, *L*, 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 are IPD awareness/knowledge, stakeholder, mistrust, collaboration, communication, owner, IPD method, integration and

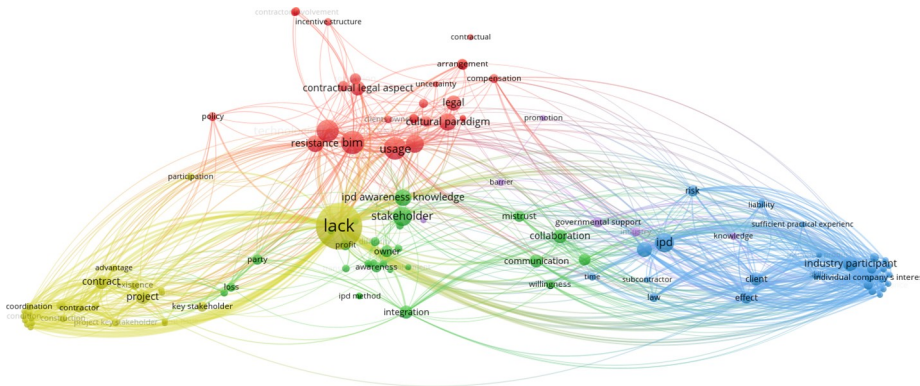


Figure 4. Key factors to IPD implementation shown in VOSViewer
Source: Authors' own work

willingness. The factors in blue are risk, liability, time, law, client effect, sufficient practical experience, industry participation and individual company's interest. The factors in purple are governmental support, industry, knowledge and promotion. It is also pertinent to know that the larger the font of a factor, the more significance it has. The factors in the red colour category can be categorised into cultural paradigms, resistance – either because of contractual L aspects, F matters such as compensation or incentive structure, or because of BIM usage required. The factors in yellow can be categorised as a lack of essential requirements, such as coordination between key stakeholders, competent contractors, etc. Lack is the largest font out of all the factors displayed. 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 – it is clear that 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 in implementing IPD and develop mutual trust among themselves through fair compensation models and paying profits.

Table 4. Key factors to IPD grouped as per various analyses

Factor	Incoming nodes	Outgoing nodes	Total nodes	Frequency (identified by number 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)
LoLA	0	3	3	18	0.43	0
LoIP	0	3	3	6	0.43	0
MR and 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)
NAIT	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

Source(s): Authors' own work

- The GP theme has two factors: lack of governmental support and lack of professional bodies. The limitation is obvious in that governments must step in to increase the implementation of IPD – creating professional bodies that overlook 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 the use of T advancements (e.g. 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. 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. 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. The 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 results from VOSViewer show the key factors and how they are linked to each other 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 5](#) shows the interactions between the key factors with polarity included.

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 relevant to note 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 4](#) groups the factors in terms of nodes, degree centrality and eigenvector centrality.

4.1 Nodes

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 LoLP, 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 other factors impact it. CLA, RtC and URMPc impact CRtC. However, it can be noted from the VENSIM figure

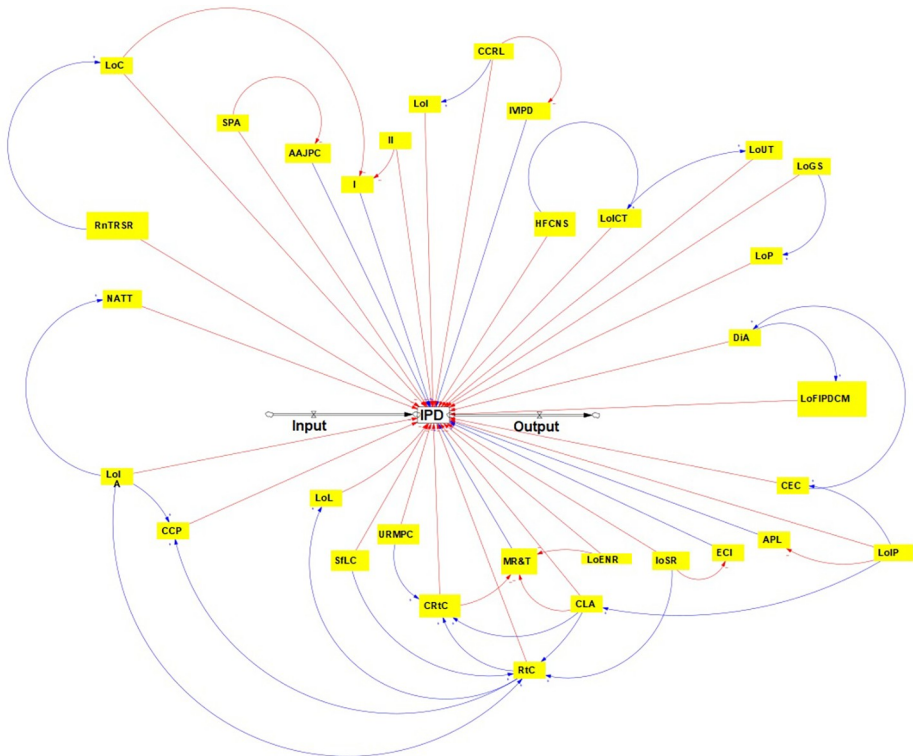


Figure 5. Interactions between key factors to IPD implementation shown in VENSIM
Source: Authors' own work

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 – 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 RnC. 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 nodes. CEC, DiA, LoC and LoICT are the only factors in equilibrium – influence rendered equals influence received. CCP and I each comprised two incoming nodes, suggesting that other factors 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, URMP, all consist of 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 URMP have one outgoing node, indicating that they impact other factors.

The critical factors to IPD based on interactions (three 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 using IPD. Resistance among stakeholders causes challenging cultural paradigms, which 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 causes resistance from the client and the project stakeholders, 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 IPD cost estimation. 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.

4.2 Degree of centrality

As per the node analysis, RtC has the highest number of nodes and thus has a degree centrality of 1. The critical factors with a higher degree of centrality compared to others, likewise the node analysis, 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 factor often has the same degree and, thus, it is impossible to rank the factors uniquely. Eigenvector centrality goes beyond degree centrality and allows for further analysis to distinguish between factors in a network.

4.3 Eigenvector centrality

The main principle of eigenvector centrality is that links from important factors are worth more than links from unimportant factors. For computing the values, all factors start equal, but factors with more edges gain importance as the calculation progresses based on the significance of the factors to which they are connected. After many iterations, the values stabilise, resulting in the final values for eigenvector centrality. To compute the eigenvector centrality, all factors to IPD were arranged in a matrix (Figure 6). 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 in terms of their appearance in the iterations, i.e. 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 6 details the eigenvector centrality computation.

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

- (1) 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.
 - While LoFIPDCM only has a single connection, 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.
- (2) 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.
- (3) RtC, CEC, LoUT and I (eigenvalue 0.11 in the second iteration)
 - RtC is impacted by four factors, and it impacts three factors. All of its connected factors, apart from SfLC are highly ranked in the centrality analyses. However, its significance remained within two iterations.
 - CEC has important connections such as DiA. However, computations revealed that its significance remained within two iterations.
 - LoUT is impacted by LoICT, which is not highly ranked but is an essential factor within the network. This relationship deemed LoUT relevant, but not highly critical, as it did not move past two iterations.
 - Two factors impact I. Of the two factors, LoC is slightly important within the network.

Table 5 compares the top factors of IPD from various analyses, including frequency, degree of centrality and eigenvector centrality.

Table 5 shows that MR&T, RtC and CCP are the only critical factors that are highly rated in all analyses. Despite frequency ranking, which is the number of authors who identified it as a factor for IPD, the factors that appear in degree centrality and eigenvector centrality analyses should be considered critical and studied in more detail because of the interlink effect. Hence, it is vital to consider the factors CRtC, DiA, I and CEC that appear in these two analyses.

Table 5. Comparison between the top factors to IPD as per various analyses

Factor	Degree of centrality	Degree centrality rank	Factor	Eigenvector centrality	Eigenvector centrality rank	Factor	Frequency	Frequency rank
RfC	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
RfC	0.57	2	RfC	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		DfA	0.18 (3 Iterations)	2	HfI	16	5
LoIA	0.43		LoL	0.18 (3 Iterations)	2	LoC	15	6
CCP	0.29	6-12	RfC	0.11 (2 Iterations)	3-6	MR&T	10	7
DfA	0.29		CEC	0.11 (2 Iterations)		RfC	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							

Source(s): Authors' own work

MR&T (degree of centrality rank, 3; Eigenvector centrality rank, 1; frequency rank, 7)

Mutual respect and trust can be divided into goodwill and competence trust (Zhang *et al.*, 2018). Goodwill trust positively impacts collaboration, while competence trust has 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).

RtC (degree of centrality rank, 1; Eigenvector centrality rank, 3; frequency rank, 8)

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. 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).

CCP (degree of centrality rank, 6; Eigenvector centrality rank, 2; frequency rank, 4)

Challenging cultural paradigms arise because several construction companies are unwilling to apply an alternate approach, there is little information about the process and there is little industry support (Ebekozi *et al.*, 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.

CRTc (degree of centrality rank, 2; Eigenvector centrality rank, 2)

The client's resistance to change makes IPD implementation unlikely. 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 and Ma, 2017). Govender *et al.* (2018) identified clients' not seeing the advantages of IPD as a significant barrier to its implementation. Karasu *et al.* (2022) also concluded that clients and owners play a key role in transitioning to a more collaborative approach.

DiA (degree of centrality rank, 7; Eigenvector centrality rank, 2)

Difficulties in achieving financial transparency reduce collaboration and trust among project stakeholders (Ahmad *et al.*, 2019). The elements of sharing risks, rewards and financial transparency can take time to establish (Rodrigues and Lindhard, 2021). To increase financial transparency among project stakeholders, the 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 increase understanding and minimise risks (Rodrigues and Lindhard, 2021).

I (degree of centrality rank, 8; Eigenvector centrality 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 more equity in information sharing, they become open to increased coordination, which 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. Furthermore, as inter-

organisational integration significantly contributes to implementing multi-party contacts in IPD projects, the interoperability issue must be addressed.

CEC (degree of centrality rank, 9; Eigenvector centrality rank, 4)

IPD lacks an accurate cost estimation methodology at the front end of a project when little information is available (Elghaish *et al.*, 2020a). Additionally, several financial management challenges are associated with integrating BIM with IPD (Elghaish and 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 of managing cost savings through distinguishing between saved resources from the organisation level to the daily task level, which increases trust among stakeholders (Elghaish *et al.*, 2020a).

5. Conclusion

The factors of IPD are prevalent in the literature; however, the interactions between these factors are a research gap. This study aimed to fill this gap by conducting a comprehensive SLR, which identified 127 IPD factors. These factors were then uploaded to VOSViewer software to determine the key elements in the literature. The results revealed connections between the key factors, but the polarity was missing. Therefore, deductive reasoning was used to determine the polarity among the key factors. The polarity was visualised using a causal loop diagram created with VENSIM software. The factors and their interlinks were analysed through frequency, degree of centrality, and Eigenvector centrality rankings. The critical factors of IPD are:

- MR&T, RtC and CCP that appeared in all three analyses; and
- CRtC, DiA, I and CEC that appeared in the degree of centrality and eigenvector centrality analyses.

In conclusion, industry practitioners and academics should concentrate on these key factors and their interactions to develop solutions for overcoming them.

5.1 Limitations

The limitations of SLR include risks of bias, such as selection bias, publication bias, attrition bias and selective outcome reporting. Articles published in less-known and non-English databases may have been excluded. However, the SLR process overcomes these limitations.

5.2 Originality

This study is the first to analyse the interactions between IPD factors in the global construction industry based solely on an SLR. While there are several articles on the factors of IPD implementation globally, the interactions have never been studied before. The factors of IPD do not function in isolation but rather interact with other factors within the factor network, increasing their impact on its implementation in the global construction industry. Through deductive reasoning, this research identified IPD factors, whether positive or negative, that influence each other. Additionally, this research study contains an in-depth analysis through various methods, such as frequency, nodes, degree of centrality and eigenvector centrality, to identify the critical factors in the IPD factor network. The factors that were among the top in every analysis were identified as the most significant.

5.3 Practical and theoretical implications

The practical implications of this study include guiding industry practitioners to understand how key factors interact and influence each other, thereby affecting the global implementation of IPD. Additionally, since the critical factors have been identified through various analysis methods, practitioners can focus specifically on these factors. The current research highlights mutual respect and trust, resistance to change and challenging cultural paradigms as consistent critical factors across all analyses. Furthermore, the client's resistance to change, cost estimation challenges, difficulties in achieving financial transparency and interoperability have been identified as additional critical factors. This knowledge will assist industry professionals in developing a solution-oriented framework to address these critical factors, ultimately increasing IPD adoption within the global construction industry. Greater implementation of IPD is expected to enhance sustainability practices, ultimately benefiting society. Given that this is the first study exploring the interactions between factors and IPD implementation worldwide, its theoretical implications include encouraging further research to validate these findings. Additionally, further studies could examine the individual critical factors to strengthen the results of this investigation. Similarly, researchers and academics can develop a solution-focused framework to help overcome these key challenges.

Industry practitioners will understand the key factors and how they influence or are influenced by others. With their direct experience in project execution, they will benefit from this knowledge, helping them anticipate potential issues. This allows them to develop possible solutions in advance. Stakeholders in the construction sector, when given the chance to adopt the IPD project delivery method, will recognise the interactions between factors and potential challenges. Unlike practitioners, stakeholders may not be directly involved in project execution; however, this knowledge will assist them in making vital management decisions both at the project's start and during construction. The interactions between IPD factors have been explored for the first time, and researchers can build on this foundation. Further investigation of this study's results can help confirm the findings, and other analysis methods can be explored. Additionally, since this study only examines the interactions between IPD factors from existing literature, researchers can conduct studies in specific countries to identify country-specific dynamics. Academics interested in teaching about collaborative contracting, like IPD, and the barriers to its implementation, will also benefit from these insights. The findings can be incorporated into educational programs, not just at universities but also in trade schools where practical and on-the-job issues are addressed.

5.4 Future studies

This study is a building block for researchers to focus on solving critical factors to IPD implementation. As the factors have been narrowed down to the most significant ones, this study should motivate researchers to focus solely on the solutions that will significantly impact the practical implementation of IPD in the global construction industry. Additionally, future research can investigate the key factors of IPD along with their interactions in individual countries.

References

- Abanda, F.H., Vidalakis, C., Oti, A.H. and Tah, J.H. (2015), "A critical analysis of building information modelling systems used in construction projects", *Advances in Engineering Software*, Vol. 90, pp. 183-201, doi: [10.1016/j.advengsoft.2015.08.00](https://doi.org/10.1016/j.advengsoft.2015.08.00).

- Abdirad, H. and Dossick, C.S. (2019), "Restructuration of architectural practice in integrated project delivery (IPD): two case studies", *Engineering, Construction and Architectural Management*, Vol. 26 No. 1, pp. 104-117, doi: [10.1108/ECAM-05-2018-0196](https://doi.org/10.1108/ECAM-05-2018-0196).
- Ahmad, I., Azhar, N. and Chowdhury, A. (2019), "Enhancement of IPD characteristics as impelled by information and communication technology", *Journal of Management in Engineering*, Vol. 35 No. 1, doi: [10.1061/\(ASCE\)ME.1943-5479.0000670](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000670).
- Ahmad, M.O., Abdul Nabi, M., El-Adaway, I.H., Caranci, D., Eberle, J., Hawkins, Z. and Sparrow, R. (2021), "Contractual guidelines for promoting integrated project delivery", *Journal of Construction Engineering and Management*, Vol. 147 No. 11, p. 05021008, doi: [10.1061/\(ASCE\)CO.1943-7862.0002173](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002173).
- Alinezhad, M., Saghatforoush, E., Kahvandi, Z. and Preece, C. (2020), "Analysis of the benefits of implementation of ipd for construction project stakeholders", *Civil Engineering Journal*, Vol. 6 No. 8, pp. 1609-1621, doi: [10.28991/cej-2020-03091570](https://doi.org/10.28991/cej-2020-03091570).
- Alqahtani, F.K., Alsanad, A., Alsanad, A., Sherif, M. and Mohamed, A.G. (2022), "Scrutinising the adoption of integrated project delivery in the Kingdom of Saudi Arabia construction sector", *Buildings*, Vol. 12 No. 12, p. 2144, doi: [10.3390/buildings12122144](https://doi.org/10.3390/buildings12122144).
- Architects, AIA (2007), "Integrated project delivery – a working definition", available at: <http://aiacc.org/wpcontent/uploads/2010/07/>
- Azhar, N., Kang, Y. and Ahmad, I. (2015), "Critical look into the relationship between information and communication technology and integrated project delivery in public sector construction", *Journal of Management in Engineering*, Vol. 31 No. 5, p. 04014091, doi: [10.1061/\(ASCE\)ME.1943-5479.0000334](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000334).
- Azhar, N., Kang, Y. and Ahmad, I.U. (2014), "Factors influencing integrated project delivery in publicly owned construction projects: an information modelling perspective", *Procedia Engineering*, Vol. 77, pp. 213-221, doi: [10.1016/j.proeng.2014.07.019](https://doi.org/10.1016/j.proeng.2014.07.019).
- Bamakan, S.M.H., Nurgaliev, I. and Qu, Q. (2019), "Opinion leader detection: a methodological review", *Expert Systems with Applications*, Vol. 115, pp. 200-222, ISSN 0957-4174, doi: [10.1016/j.eswa.2018.07.069](https://doi.org/10.1016/j.eswa.2018.07.069).
- Bilbo, D., Bigelow, B., Escamilla, E. and Lockwood, C. (2014), "Comparison of construction manager at risk and integrated project delivery performance on healthcare projects: a comparative case study", *International Journal of Construction Education and Research*, Vol. 11 No. 1, pp. 40-53, doi: [10.1080/15578771.2013.872734](https://doi.org/10.1080/15578771.2013.872734).
- Asad, S.B., Purushothaman, M.B. and Poshdar, M. (2023), "Key factors affecting the implementation of integrated project delivery for sustainable construction", *Smart and Sustainable Built Environment (SASBE)*, pp. 1-33, available at: https://www.researchgate.net/publication/375959602_Key_factors_affecting_the_implementation_of_integrated_project_delivery_for_sustainable_construction (accessed 20 October 2024).
- Bonacich, P. (2007), "Some unique properties of eigenvector centrality", *Social Networks*, Vol. 29 No. 4, pp. 555-564, ISSN 03788733, doi: [10.1016/j.socnet.2007.04.002](https://doi.org/10.1016/j.socnet.2007.04.002).
- Buk'hail, S.R. and Al-Sabah, R.S. (2022), "Exploring the barriers to implementing the integrated project delivery method", *Journal of King Saud University - Engineering Sciences*, Vol. 36 No. 8, pp. 543-551, doi: [10.1016/j.jksues.2022.04.003](https://doi.org/10.1016/j.jksues.2022.04.003).
- Charlesraj, V.P.C. and Gupta, V. (2019), "Analysis of the Perceptions of Beneficiaries and Intermediaries on Implementing IPD in Indian Construction", *Proceedings of the 36th International Symposium on Automation and Robotics in Construction (ISARC)*, *International Association for Automation and Robotics in Construction (IAARC)*, Banff, Canada, doi: [10.22260/ISARC2019/0125](https://doi.org/10.22260/ISARC2019/0125).
- Clevenger, C. and Mulholland, S. (2018), "Contracting methods for integrated project delivery: a healthcare case study", *American Society of Civil Engineers (ASCE) Library, Construction Research Congress*, pp. 191-201, doi: [10.1061/9780784481295.020](https://doi.org/10.1061/9780784481295.020).

- Cleves, J.A. and Gallo, L.D. (2012), "Integrated project delivery: the game changer", in: American Bar Association's Forum on Construction Industry 2012, pp. 26-28. Las Vegas: American Bar Association, available at: www.hansonbridgett.com/sites/default/files/sitecore/Files/Publications/2012-ABA-Construction-Industry-Plenary-7-Paper.pdf (accessed 10 June 2024).
- Dalui, P., Elghaish, F., Brooks, T. and McIlwaine, S. (2021), "Integrated project delivery with BIM: a methodical approach within the UK consulting sector", *Journal of Information Technology in Construction*, Vol. 26, pp. 922-935, doi: [10.36680/j.itcon.2021.049](https://doi.org/10.36680/j.itcon.2021.049).
- Dargham, S.A., Hatoum, M.B., Tohme, M. and Hamzeh, F. (2019), "Implementation of integrated project delivery in Lebanon: overcoming the challenges", *Proceedings of the 27th Annual Conference of the International Group for Lean Construction (IGLC)*, International Group for Lean Construction (IGLC), Lebanon, pp. 917-928, doi: [10.24928/2019/0242](https://doi.org/10.24928/2019/0242).
- Dossick, C.S., Azari, R., Woo Kim, Y. and El-Anwar, O. (2013), "IPD in practice: sustaining collaboration in healthcare design and construction", *Building Solutions for Architectural Engineering*, pp. 377-386, doi: [10.1061/9780784412909.036](https://doi.org/10.1061/9780784412909.036).
- Durdyev, S., Hosseini, M.R., Martek, I., Ismail, S. and Arashpour, M. (2019), "Barriers to the use of integrated project delivery (IPD): a quantified model for Malaysia", *Engineering, Construction and Architectural Management*, Vol. 27 No. 1, pp. 186-204, doi: [10.1108/ECAM-12-2018-0535](https://doi.org/10.1108/ECAM-12-2018-0535).
- Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011), *BIM Handbook: A Guide to Building Information Modeling*, 2nd ed, John Wiley & Sons, NJ, ISBN 978-0-470-54137-1.
- Ebekozien, A., Aigbavboa, C.O., Aigbedion, M., Ogbaini, I.F. and Aginah, I.L. (2022), "Integrated project delivery in the Nigerian construction sector: an unexplored approach from the stakeholders' perspective", *Engineering, Construction and Architectural Management*, Vol. 30 No. 4, pp. 1519-1535, doi: [10.1108/ECAM-09-2021-0823](https://doi.org/10.1108/ECAM-09-2021-0823).
- Ebrahimi, G. and Dowlatabadi, H. (2018), "Perceived challenges in implementing integrated project delivery (IPD): insights from stakeholders in the U.S. and Canada for a path forward", *International Journal of Construction Education and Research*, Vol. 15 No. 4, pp. 291-314, doi: [10.1080/15578771.2018.1525446](https://doi.org/10.1080/15578771.2018.1525446).
- Elghaish, F. and Abrishami, S. (2020), "A centralised cost management system: exploiting EVM and ABC within IPD", *Engineering, Construction and Architectural Management*, Vol. 28 No. 2, pp. 549-569, doi: [10.1108/ECAM-11-2019-0623](https://doi.org/10.1108/ECAM-11-2019-0623).
- Elghaish, F., Abrishami, S. and Hosseini, M.R. (2020a), "Integrated project delivery with blockchain: an automated F system", *Automation in Construction*, Vol. 114, p. 103182, doi: [10.1016/j.autcon.2020.103182](https://doi.org/10.1016/j.autcon.2020.103182).
- Elghaish, F., Abrishami, S., Hosseini, M.R. and Abu-Samra, S. (2020b), "Revolutionising cost structure for integrated project delivery: a BIM-based solution", *Engineering, Construction and Architectural Management*, Vol. 28 No. 4, pp. 1214-1240, doi: [10.1108/ECAM-04-2019-0222](https://doi.org/10.1108/ECAM-04-2019-0222).
- Elghaish, F., Hosseini, M.R., Talebi, S., Abrishami, S., Martek, I. and Kagioglou, M. (2020c), "Factors driving success of cost management practices in integrated project delivery (IPD)", *Sustainability*, Vol. 12 No. 22, p. 9539, doi: [10.3390/su12229539](https://doi.org/10.3390/su12229539).
- Evans, M. and Farrell, P. (2020), "Barriers to integrating building information modelling (BIM) and lean construction practices on construction mega-projects: a Delphi study", *Benchmarking: An International Journal*, Vol. 28 No. 2, p. 652-669, doi: [10.1108/BIJ-04-2020-0169](https://doi.org/10.1108/BIJ-04-2020-0169).
- Evans, M. and Farrell, P. (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", *Journal of Engineering, Design and Technology*, Vol. 21 No. 2, pp. 376-416, doi: [10.1108/JEDT-08-2021-0402](https://doi.org/10.1108/JEDT-08-2021-0402).
- Evans, M., Farrell, P., Elbeltagi, E. and Dion, H. (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",

- Journal of Engineering, Design and Technology*, Vol. 21 No. 3, pp. 778-818, doi: [10.1108/JEDT-02-2021-0070](https://doi.org/10.1108/JEDT-02-2021-0070).
- Forero, S., Cardenas, S., Vargas, G. and Garcia, C. (2015), *A deeper look into the perception and disposition to integrated project delivery (IPD) in Colombia*, pp. 297-306, available at: <https://www.semanticscholar.org/paper/A-DEEPER-LOOK-INTO-THE-PERCEPTION-AND-DISPOSITION-Forero-C%3%A1rdenas/bd740251b106f16c5d5fb427876f22f3211e2b5c> (accessed 5 May 2024).
- Ghassemi, R. and Becerik-Gerber, B. (2011), "Transitioning to integrated project delivery: potential barriers and lessons learned", *Lean Construction Journal*, pp. 377-386, doi: [10.60164/uwvk0fog7](https://doi.org/10.60164/uwvk0fog7).
- Golbeck, J. (2015), *Introduction to Social Media Investigation: a Hands-on Approach*, Syngress, ISBN 978-0-12-801656-5.
- Gomez, S., Ballard, G., Naderpajouh, N. and Ruiz, S. (2018a), *Integrated project delivery for infrastructure projects in Peru, 26th Annual Conference of the International Group for Lean Construction, International Group for Lean Construction (IGLC), Chennai*, pp. 452-462, doi: [10.24928/2018/0506](https://doi.org/10.24928/2018/0506).
- Gomez, S., Naderpajouh, N., Ballard, G., Hastak, M., Weidner, T. and Barriga, P. (2018b), *Implications of the Integrated Project Delivery Research in Practice*, American Society of Civil Engineers (ASCE), New Orleans, doi: [10.1061/9780784481301.009](https://doi.org/10.1061/9780784481301.009).
- Govender, K., Nyagwachi, J., Smallwood, J.J. and Allen, C.J. (2018), "The awareness of integrated project delivery and building information modelling – facilitating construction projects", *International Journal of Sustainable Development and Planning*, Vol. 13 No. 1, pp. 121-129, doi: [10.2495/SDP-V13-N1-121-129](https://doi.org/10.2495/SDP-V13-N1-121-129).
- Hettiaarachchige, N., Rathnasinghe, A., Ranadewa, K. and Thurairajah, N. (2022), "Lean integrated project delivery for construction procurement: the case of Sri Lanka", *Buildings*, Vol. 12 No. 5, p. 524, doi: [10.3390/buildings12050524](https://doi.org/10.3390/buildings12050524).
- Ibidapo, O., London, K., Elmualim, A., Pablo, Z. and Bayetto, P. (2017), "Exploring opportunities of integrated project delivery in off-site manufacturing of the Australian housing sector", *International Research Conference 2017: Shaping Tomorrow's Built Environment*, Zenodo, Manchester, ISBN: 978-1-912337-04-0.
- Jadidoleslami, S., Saghatforoush, E., Heravi, A. and Preece, C. (2022), "A practical framework to facilitate constructability implementation using the integrated project delivery (IPD) approach: a case study", *International Journal of Construction Management*, Vol. 22 No. 7, pp. 1225-1239, doi: [10.1080/15623599.2019.1686834](https://doi.org/10.1080/15623599.2019.1686834).
- Kahvandi, Z., Saghatforoush, E., Mahoud, M. and Preece, C. (2019), "Analysis of the barriers to the implementation of integrated project delivery (IPD): a meta-synthesis approach", *Journal of Engineering, Project, and Production Management*, Vol. 9 No. 1, pp. 2-11, doi: [10.2478/jeppm-2019-0002](https://doi.org/10.2478/jeppm-2019-0002).
- Kahvandi, Z., Saghatforoush, E., Ravasan, A. and Mansouri, T. (2018), "An FCM-based dynamic modelling of integrated project delivery implementation challenges in construction projects", *Lean Construction Journal*, available at: <https://www.semanticscholar.org/paper/An-FCM-Based-Dynamic-Modelling-of-Integrated-in-Kahvandi-Saghatforoush/28482c10b9e1ff2388f9a83c28d736ce5f016b3d> (accessed on 15 June 2024)
- Karasu, T., Aaltonen, K. and Haapasalo, H. (2022), "The interplay of IPD and BIM: a systematic literature review", *Construction Innovation*, Vol. 23 No. 3, pp. 640-664, doi: [10.1108/CI-07-2021-0134](https://doi.org/10.1108/CI-07-2021-0134).
- Kent, D. and Becerik-Gerber, B. (2010), "Understanding construction industry experience and attitudes toward integrated project delivery", *Journal of Construction Engineering and Management*, Vol. 136 No. 8, pp. 815-825, doi: [10.1061/_ASCE_CO.1943-7862.0000188](https://doi.org/10.1061/_ASCE_CO.1943-7862.0000188).

- Khanna, M., Faris Elghaish, F., McIlwaine, S. and Tara Brooks, T. (2021), "Feasibility of implementing IPD approach for infrastructure projects in developing countries", *Journal of Information Technology in Construction*, Vol. 26, pp. 902-921, doi: [10.36680/j.itcon.2021.048](https://doi.org/10.36680/j.itcon.2021.048).
- Korb, S., Haronian, E., Sacks, R., Judez, P. and Shaked, O. (2016), "Overcoming "but we're different": an IPD implementation in the Middle East", *24th Annual Conference of the International Group for Lean Construction*, available at: https://www.academia.edu/34116594/OVERCOMING_BUT_WERE_DIFFERENT_AN_IPD_IMPLEMENTATION_IN_THE_MIDDLE_EAST (accessed 7 June 2024).
- Laurent, J. and Leicht, R.M. (2019), "Practices for designing cross-functional teams for integrated project delivery", *Journal of Construction Engineering and Management*, Vol. 145 No. 3, p. 05019001, doi: [10.1061/\(ASCE\)CO.1943-7862.0001605](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001605).
- Li, S. and Ma, Q. (2017), "Barriers and challenges to implement integrated project delivery in China", *25th Annual Conference of the International Group for Lean Construction, International Group for Lean Construction (IGLC), Greece*, doi: [10.24928/2017/0119](https://doi.org/10.24928/2017/0119).
- Lichtig, W.A. (2006), "The integrated agreement for lean project delivery", *Construction Lawyer*, Vol. 26 No. 3, pp. 25, doi: [10.1002/9781444319675.ch6](https://doi.org/10.1002/9781444319675.ch6).
- Ma, Q., Cheung, S.O. and Li, S. (2023), "Optimum risk/reward sharing framework to incentivise integrated project delivery adoption", *Construction Management and Economics*, Vol. 41 No. 6, pp. 519-535, doi: [10.1080/01446193.2023.2169316](https://doi.org/10.1080/01446193.2023.2169316).
- Ma, Q., Li, S., Teo, P.X. and Ling, F.Y.Y. (2022), "Barriers to adopting integrated project delivery practices", *Engineering, Construction and Architectural Management*, Vol. 30 No. 9, pp. 4171-4191, doi: [10.1108/ECAM-09-2019-0498](https://doi.org/10.1108/ECAM-09-2019-0498).
- McDonnell, F. (2015), Integrated project delivery: a focus on integrated project delivery, the enablers for this process, and the challenges and barriers to IPD within an Irish context, available at: <https://www.semanticscholar.org/paper/Integrated-Project-Delivery-A-focus-on-integrated-McDonnell/e8eb205dd867376261bba53d4edec34237da449d> (accessed 14 April 2024).
- Meghanathan, N. (2015), "Exploiting the discriminating power of the eigenvector centrality measure to detect graph isomorphism", *International Journal in Foundations of Computer Science and Technology*, Vol. 5 No. 6, pp. 1-13, doi: [10.5121/ijfct.2015.5601](https://doi.org/10.5121/ijfct.2015.5601).
- Naismith, N., Tookey, J., Ghaffarian Hoseini, A. and Kekreja, R. (2016), "The adoption of integrated project delivery in public sector projects in New Zealand: the way forward", *The 5th World Construction Symposium 2016: Greening Environment, Eco Innovations and Entrepreneurship*, available at: www.semanticscholar.org/paper/THE-ADOPTION-OF-INTEGRATED-PROJECT-DELIVERY-IN-IN-Naismith-Tookey/2cba68e7164c14dff511e368f52a8f168d588fb1, (accessed 11 April 2024).
- O'Connor, P.J. (2009), "Integrated project delivery: collaboration through new contract forms", Working Paper, Faegre and Benson LLP, Minneapolis, available at: www.faedrinker.com/webfiles/AGC-IPD%20Paper.pdf (accessed 20 August 2024).
- Olawumi, T.O., Chan, D.W., Wong, J.K. and Chan, A.P. (2018), "Barriers to the integration of BIM and sustainability practices in construction projects: a Delphi survey of international experts", *Journal of Building Engineering*, Vol. 20, pp. 60-71, doi: [10.1016/j.jobe.2018.06.017](https://doi.org/10.1016/j.jobe.2018.06.017).
- Osman, W., Nawi, M., Shafie, M., Ibrahim, F. and Al Bakri, A. (2017), "An integrated procurement system: a study of construction firm readiness towards implementing of integrated project delivery (IPD)", *International Journal of Supply Chain Management*, Vol. 6 No. 3, pp. 360-366, available at: <https://core.ac.uk/download/pdf/230751898.pdf>
- Porwal, A. and Hewage, K.N. (2013), "Building information modeling (BIM) partnering framework for public construction projects", *Automation in Construction*, Vol. 31, pp. 204-214, doi: [10.1016/j.autcon.2012.12.004](https://doi.org/10.1016/j.autcon.2012.12.004).
- Psomas, L. and Alzraiee, H. (2020), "A technology platform for a successful implementation of integrated project delivery for medium size projects", *37th International Symposium on Automation and Robotics in Construction*, available at: www.semanticscholar.org/paper/A-Technology-Platform-

- for-a-Successful-of-Project-Psomas-Alzraiee/dbd676565bd4800741b8d59f39576190c585d21b (accessed 29 June 2024).
- Purushothaman, M.B., Pedro, L. and Ghaffarian Hoseini, A. (2024), "Construction projects: interactions of the causes of delays", *Smart and Sustainable Built Environment*, pp. 1-33, doi: [10.1108/SASBE-11-2023-0334](https://doi.org/10.1108/SASBE-11-2023-0334).
- Rached, F., Hraoui, Y., Karam, A. and Hamzeh, F. (2014), Implementation of IPD in the Middle East and its challenges. *Proceedings International Group for Lean Construction, Oslo, Norway*, Vol. 22, pp. 293-304.
- Ramirez-Arellano, A., Sigarreta Almira, J.M. and Bory-Reyes, J. (2020), "Fractional information dimensions of complex networks", *Chaos: An Interdisciplinary Journal of Nonlinear Science*, Vol. 30 No. 9, p. 093125, doi: [10.1063/5.0018268](https://doi.org/10.1063/5.0018268).
- Rodrigues, M.R. and Lindhard, S.M. (2021), "Benefits and challenges to applying IPD: experiences from a Norwegian mega-project", *Construction Innovation*, Vol. 23 No. 2, pp. 287-305, doi: [10.1108/CI-03-2021-0042](https://doi.org/10.1108/CI-03-2021-0042).
- Rosayuru, H.D.R.R., Waidyasekara, K.G.A.S. and Wijewickrama, M.K.C.S. (2019), "Sustainable BIM based integrated project delivery system for construction industry in Sri Lanka", *International Journal of Construction Management*, Vol. 22 No. 5, pp. 769-783, doi: [10.1080/15623599.2019.1645263](https://doi.org/10.1080/15623599.2019.1645263).
- Rowlinson, S. (2017), "Building information modelling, integrated project delivery and all that", *Construction Innovation*, Vol. 17 No. 1, pp. 45-49, doi: [10.1108/CI-05-2016-0025](https://doi.org/10.1108/CI-05-2016-0025).
- Roy, D., Malsane, S. and Samanta, P. (2018), "Identification of critical challenges for adoption of integrated project delivery", *Lean Construction Journal*, available at: https://www.researchgate.net/publication/325144825_Identification_of_Critical_Challenges_for_Adoption_of_Integrated_Project_DeliveryIPD (accessed 11 July 2024).
- Sari, E.M., Irawan, A.P., Wibowo, M.A., Siregar, J.P., Tamin, R.Z., Praja, A.K.A. and Dewi, M.P. (2023), "Challenge and awareness for implemented integrated project delivery (IPD) in Indonesian projects", *Buildings*, Vol. 13 No. 1, doi: [10.3390/buildings13010262](https://doi.org/10.3390/buildings13010262).
- Seed, W. (2014), *Integrated project delivery requires a new project manager*, 22nd Annual Conference of the International Group for Lean Construction, available at: <https://www.iglc.net/Papers/Details/1035> (accessed 2 July 2024).
- Sherif, M. and Abotaleb, I. (2023), "Application of integrated project delivery (IPD) in Egypt: implementation and challenges", *Proceedings of the Canadian Society of Civil Engineering Annual Conference 2021, Springer, Canada*, pp. 73-84, [10.1007/978-981-19-0503-2_7](https://doi.org/10.1007/978-981-19-0503-2_7).
- Sherif, M., Abotaleb, I. and Alqahtani, F.K. (2022), "Application of integrated project delivery (IPD) in the Middle East: implementation and challenges", *Buildings*, Vol. 12 No. 4, p. 467, doi: [10.3390/buildings12040467](https://doi.org/10.3390/buildings12040467).
- Su, G., Hastak, M., Deng, X. and Khallaf, R. (2021), "Risk sharing strategies for IPD projects: interactional analysis of participants' decision-making", *Journal of Management in Engineering*, Vol. 37 No. 1, p. 04020101, doi: [10.1061/\(ASCE\)ME.1943-5479.0000853](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000853).
- Tillmann, P., Ballard, G., Tzortzopolous, P. and Formoso, C. (2012), How integrated governance contributes to value generation – insights from an IPD case study, 20th Annual Conference of the International Group for Lean Construction, available at: www.semanticscholar.org/paper/How-integrated-governance-contributes-to-value-%3A-an-Tillmann-Ballard/127c5e18fb3cc364bc1e5a13e6ff1c7e17fbd3fd#:~:text=he%20findings%20suggest%20that%20IPD%20enables%20an%20environment,are%20challenged%20in%20a%20dynamic%20and%20collaborative%20environment (accessed 03 July 2024).
- Tortosa, L., Agryzkov, T., Vicent, J.F. and Wilson, R. (2017), "A centrality measure for urban networks based on the eigenvector centrality concept", *Environment and Planning B: Urban Analytics and City Science*, Vol. 46 No. 4, pp. 668-689, doi: [10.1177/2399808317724444](https://doi.org/10.1177/2399808317724444).

- Tucker, R. and Gilge, C. (2013), "Integrated project delivery: managing risk and making it work for all parties", available at: www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/integrated-project-delivery-whitepaper.pdf (accessed 15 August 2024).
- Zhang, L., Huang, S. and Peng, Y. (2018), "Collaboration in integrated project delivery: the effects of trust and formal contracts", *Engineering Management Journal*, Vol. 30 No. 4, pp. 262-273, doi: [10.1080/10429247.2018.1498259](https://doi.org/10.1080/10429247.2018.1498259).
- Zhang, N., Hwang, B.-G., Deng, X. and Tay, F. (2020), "Collaborative contracting in the Singapore construction industry: current status, major barriers and best solutions", *Engineering, Construction and Architectural Management*, Vol. 27 No. 10, pp. 3115-3133, doi: [10.1108/ECAM-08-2019-0451](https://doi.org/10.1108/ECAM-08-2019-0451).
- Zuber, S., Nawi, N. and Nifa, F. (2019), "Construction procurement practice: a review study of integrated project delivery (IPD) in the Malaysian construction projects", *International Journal of Supply Chain Management*, available at: <https://www.semanticscholar.org/paper/Construction-Procurement-Practice%3A-A-Review-Study-Nawi-Zuber/Od17fd5e2d25e6b2c098518b19952a559ed6b0dd> (accessed 18 September 2024).

Further reading

- Aapaaja, A., Herrala, M., Pekuri, A. and Haapasalo, H. (2013), "The characteristics of and cornerstones for creating integrated teams", *International Journal of Managing Projects in Business*, Vol. 6 No. 4, pp. 695-713, doi: [10.1108/IJMPB-09-2012-0056](https://doi.org/10.1108/IJMPB-09-2012-0056).
- Bilge, E.C. (2020), "A real estate development model for Turkey: real estate certificates and integrated project delivery", *Property Management*, Vol. 39 No. 3, pp. 362-375, doi: [10.1108/PM-04-2020-0024](https://doi.org/10.1108/PM-04-2020-0024).
- Ku, K. (2009). The core of Eden: a case study on model-based collaboration for integrated project delivery. *Construction Research Congress 2009: Building a Sustainable Future*, pp. 969-978, doi: [10.1061/41020\(339\)98](https://doi.org/10.1061/41020(339)98)
- Leicht, R. and Harty, C. (2017), "Influence of multiparty IPD contracts on construction innovation, ARCOM", available at: [Influence of multiparty IPD contracts on construction innovation](https://www.researchgate.net/publication/332555054_Influence_of_multiparty_IPD_contracts_on_construction_innovation) (accessed 18 May 2024).
- Nejati, I., Javidruzi, M. and Mohebifar, A. (2014), Feasibility of using an integrated project delivery (IPD) in mass housing collaborative projects, available at: https://www.researchgate.net/publication/332555054_Feasibility_of_using_an_integrated_project_delivery_IPD_in_mass_housing_collaborative_projects (accessed 20 June 2024).
- Osman, W., Nawi, M., Anuar, H., Radzuan, K. and Osman, N. (2015), "Readiness assessment for implementation of integrated project delivery (IPD) in industrialised building system (IBS) projects", *Jurnal Teknologi*, Vol. 77 No. 4, doi: [10.11113/jt.v77.6046](https://doi.org/10.11113/jt.v77.6046).
- Sun, W., Mollaoglu, S., Miller, V. and Manata, B. (2015), "Communication behaviors to implement innovations: how do AEC teams communicate in IPD projects?", *Project Management Journal*, Vol. 46 No. 1, pp. 84-96, doi: [10.1002/pmj.21478](https://doi.org/10.1002/pmj.21478).
- Viana, M., Hadikusumo, B., Saghatforoush, E., Sartori, T. and Kahvandi, Z. (2022), "Adopting an integrated project delivery collaboration framework: a case study of a wastewater treatment plant project in Vietnam", *International Journal of Project Organisation and Management*, Vol. 14 No. 1, doi: [10.1504/IJPOM.2022.121546](https://doi.org/10.1504/IJPOM.2022.121546).

Table A1. SLR results

S. no.	Author(s)	Year	Paper title	Country
1	Naismith <i>et al.</i>	2016	The adoption of integrated project delivery in public sector projects in New Zealand: the way forward	New Zealand
2	Li and Ma	2017	Barriers and Challenges to Implement Integrated Project Delivery in China	China
3	Sherif, Abotaleb and Alqahtani	2022	Application of Integrated Project Delivery (IPD) in the Middle East: Implementation and Challenges	Egypt and Saudi Arabia
4	Ebrahimi and Dowlatabadi	2018	Perceived Challenges in Implementing Integrated Project Delivery (IPD): Insights from Stakeholders in the USA and Canada for a Path Forward	USA and Canada
5	Abou Dargham, Bou Hatoum, Tohme and Hamzeh	2019	Implementation of Integrated Project Delivery in Lebanon: Overcoming the Challenges	Lebanon
6	Sari, Irawan, Wibowo, Siregar, Tamin, Praja and Dewi	2023	Challenge and Awareness for Implemented Integrated Project Delivery (IPD) in Indonesian Projects	Indonesia
7	Durdyev, Hosseini, Martek, Ismail and Arashpour	2019	Barriers to the use of integrated project delivery (IPD): a quantified model for Malaysia	Malaysia
8	Charlesraj and Gupta	2019	Analysis of the Perceptions of Beneficiaries and Intermediaries on Implementing IPD in Indian Construction	India
9	Hettiaarachchige, Rathnasinghe, Ranadewa and Thurairajah	2022	Lean Integrated Project Delivery for Construction Procurement: The Case of Sri Lanka	Sri Lanka
10	Rodrigues and Lindhard	2021	Benefits and challenges to applying IPD: experiences from a Norwegian mega-project	Norway
11	Gomez, Ballard, Naderpajouh and Ruiz	2018	Integrated project delivery for infrastructure projects in Peru	Peru
12	Forero, Cardenas, Vargas and Garcia	2015	A deeper look into the perception and disposition to integrated project delivery (IPD) in Colombia	Colombia
13	McDonnell	2015	A focus on integrated project delivery, the enablers for this process, and the challenges and barriers to IPD within an Irish context	Ireland
14	Zhang, Hwang, Deng and Tay	2020	Collaborative contracting in the Singapore construction industry: current status, major barriers and best solutions	Singapore

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Table A1. Continued

S. no.	Author(s)	Year	Paper title	Country
15	Ma, Li, Teo and Ling	2022	Barriers to adopting integrated project delivery practices	China and Singapore
16	Kahvandi, Saghatforoush, Mahoud and Preece	2019	Analysis of the Barriers to the Implementation of Integrated Project Delivery (IPD): A Meta-Synthesis Approach	USA
17	Buk'hail and Al-Sabah	2022	Exploring the Barriers to Implementing the Integrated Project Delivery Method	Kuwait
18	Azhar, Kang and Ahmad	2014	Factors Influencing Integrated Project Delivery In Publicly Owned Construction Projects: An Information Modelling Perspective	USA
19	Ghassemi and Becerik-Gerber	2011	Transitioning to Integrated Project Delivery: Potential barriers and lessons learned	USA
20	Roy, Malsane and Samanta	2018	Identification of Critical Challenges for Adoption of Integrated Project Delivery	India
21	Sherif and Abotaleb	2023	Application of Integrated Project Delivery (IPD) in Egypt: Implementation and Challenges	Egypt
22	Osman <i>et al.</i>	2017	An Integrated Procurement System: A Study of Construction Firm Readiness towards Implementing of Integrated Project Delivery (IPD)	Malaysia
23	Zhang, Huang and Peng	2018	Collaboration in Integrated Project Delivery: The Effects of Trust and Formal Contracts	China
24	Alqahtani, Alsanad, Alसान, Sherif and Mohamed	2022	Scrutinising the Adoption of Integrated Project Delivery in the Kingdom of Saudi Arabia Construction Sector	Saudi Arabia
25	Kahvandi, Saghatforoush, Ravasan and Mansouri	2018	An FCM-based dynamic modelling of integrated project delivery implementation challenges in construction projects	Iran
26	Khanna, Elghaish, Mcllwaine and Brooks	2021	Feasibility of implementing IPD approach for infrastructure projects in developing countries	India
27	Evans, Farrell, Elbeltagi and Dion	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	MENA

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Table A1. Continued

S. no.	Author(s)	Year	Paper title	Country
28	Kent and Becerik Gerber	2010	Understanding Construction Industry Experience and Attitudes toward Integrated Project Delivery	USA
29	Jadidoleslami, Saghatforoush, Heravi and Preece	2022	A practical framework to facilitate constructability implementation using the integrated project delivery approach: a case study	Iran
30	Abdirad and Dossick	2019	Restructuration of architectural practice in integrated project delivery (IPD): two case studies	USA
31	Mulholland and Clevenger	2018	Contracting Methods for Integrated Project Delivery: A Healthcare Case Study	USA
32	Viana <i>et al.</i>	2022	Adopting an integrated project delivery collaboration framework: a case study of a wastewater treatment plant project in Vietnam	Vietnam
33	Elghaish <i>et al.</i>	2020	Revolutionising cost structure for integrated project delivery: a BIM-based solution	UK
34	Ahmad <i>et al.</i>	2019	Enhancement of IPD Characteristics as Impelled by Information and Communication Technology	USA
35	Su <i>et al.</i>	2021	Risk Sharing Strategies for IPD Projects: Interactional Analysis of Participants' Decision-Making	Not identified
36	Elghaish and Abrishami	2020	A centralised cost management system: exploiting EVM and ABC within IPD	UK
37	Elghaish <i>et al.</i>	2020	Integrated project delivery with blockchain: An automated financial system	UK
38	Laurent and Leicht	2019	Practices for Designing Cross-Functional Teams for Integrated Project Delivery	USA
39	Zuber <i>et al.</i>	2019	Construction procurement practice: A review study of Integrated Project Delivery (IPD) in the Malaysian construction projects	Malaysia
40	Psomas and Alzraiee	2020	A Technology Platform for a Successful Implementation of Integrated Project Delivery for Medium Size Projects	USA
41	Gomez <i>et al.</i>	2018	Implications of the integrated project delivery research in practice	Peru
42	Rowlinson	2016	Building information modelling, integrated project delivery and all that	UK, Singapore, North America, Europe

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Table A1. Continued

S. no.	Author(s)	Year	Paper title	Country
43	Leicht and Harty	2017	Influence of multiparty ipd contracts on construction innovation	USA
44	Azhar <i>et al.</i>	2015	Critical look into the relationship between information and communication technology and integrated project delivery in public sector construction	USA
45	Sun <i>et al.</i>	2015	Communication behaviours to implement innovations: How do AEC teams communicate in IPD projects?	USA
46	Osman <i>et al.</i>	2015	Readiness assessment for implementation of Integrated Project Delivery (IPD) in Industrialised Building System (IBS) projects	Malaysia
47	Nejati <i>et al.</i>	2014	Feasibility of using an integrated project delivery (IPD) in mass housing collaborative projects	Iran
48	Seed	2014	Integrated project delivery requires a new project manager	USA
49	Dossick <i>et al.</i>	2013	IPD in practice: Sustaining collaboration in healthcare design and construction	Not identified
50	Aapaoja <i>et al.</i>	2013	The characteristics of and cornerstones for creating integrated teams	USA
51	Tillmann <i>et al.</i>	2012	How integrated governance contributes to value generation - Insights from an IPD case study	USA
52	Ku	2009	The core of Eden: A case study on model-based collaboration for integrated project delivery	UK
53	Ibidapo <i>et al.</i>	2017	Exploring opportunities of integrated project delivery in off-site manufacturing of the Australian housing sector	Australia
54	Bilge	2021	A real estate development model for Turkey: real estate certificates and integrated project delivery	Turkey
55	Ma <i>et al.</i>	2023	An optimum risk/reward sharing framework to incentivise integrated project delivery adoption	USA
56	Elghaish <i>et al.</i>	2020	Factors driving the success of cost management practices in integrated project delivery (IPD)	USA, UK, Australia
57	Bilbo <i>et al.</i>	2014	Comparison of Construction Manager at Risk and Integrated Project Delivery Performance on Healthcare Projects: A Comparative Case Study	USA

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Table A1. Continued

S. no.	Author(s)	Year	Paper title	Country
58	Ebekozien <i>et al.</i>	2022	Integrated project delivery in the Nigerian construction sector: an unexplored approach from the stakeholders' perspective	Nigeria
59	Alinezhad <i>et al.</i>	2020	Analysis of the benefits of implementation of IPD for construction project stakeholders	USA, UK
60	Rosayuru <i>et al.</i>	2019	Sustainable BIM based integrated project delivery system for construction industry in Sri Lanka	Sri Lanka
61	Dalui <i>et al.</i>	2021	Integrated project delivery with BIM: A methodical approach within the UK consulting sector	UK
62	Govender <i>et al.</i>	2018	The awareness of integrated project delivery and building information modelling - facilitating construction projects	South Africa
63	Korb <i>et al.</i>	2016	Overcoming "But We're Different": An IPD Implementation in the Middle East	Israel
64	Karasu <i>et al.</i>	2022	The interplay of IPD and BIM: a systematic literature review	Not identified
65	Evans and Farrell	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	Worldwide
66	Ahmed <i>et al.</i>	2021	Contractual Guidelines for Promoting Integrated Project Delivery	USA

Source(s): Authors' own work

About the authors

Saad Bin Asad is a PhD candidate at Auckland University of Technology in the Department of Built Environment Engineering. Saad is a civil engineer with 4+ years of work experience in the high-rise residential construction sector of Abu Dhabi/Dubai. Additionally, Saad has a master's in construction management from Nottingham Trent University, UK. Saad has firsthand experience of issues with traditional construction project delivery practices and aims to promote collaborative project delivery approaches for the betterment of the construction industry. Saad Bin Asad is the corresponding author and can be contacted at: saad.binasad@autuni.ac.nz

Mahesh Babu Purushothaman aims to bridge the gap between knowledge of key influencing factors and industry outputs. His primary academic and research interests are focused towards developing interactions-inspired approaches to cognitive factors influencing lean, dynamic project scheduling, health and safety, fire egress, digital technologies and women's engagement and concerns in construction, machine learning, and, reciprocally, to use these approaches to understand issues in industrial systems better. Mahesh received his PhD from Auckland University of Technology (AUT) with research interests in the human factors influencing lean manufacturing systems and waste

reduction. He works in the School of Future Environments at Auckland University of Technology. Before joining AUT, Mahesh had 25-plus years of industrial experience at the middle and top management levels, where he managed lean manufacturing units. His experience includes manufacturing, procurement, warehousing, marketing, demand planning and change management. He has implemented projects that combined digital and information technology integration to reduce stress in the manufacturing environment. Mahesh has designed process architecture and was involved in developing IT projects for facilities, manufacturing and SCM. Mahesh has publications in highly ranked Journals and conferences. Mahesh has published a book and two edited books.

Mani Poshdar is a Senior Lecturer in Built Environment Engineering with a proven track record of expertise. He consistently delivers exceptional instruction and showcases adept communication skills. In addition to his teaching excellence, Mani has excelled as a Programme Leader and Director since 2017, steering academic programs, fostering excellence and promoting enriching student learning experiences. His extensive experience in teaching and administrative domains, combined with his unwavering commitment to academic excellence, underscores his significant contributions to construction management and education. Mani has made remarkable strides in the realm of Lean construction and operations management simulation. His expertise in this area is exemplified by a prolific publication record that comprises a plethora of influential research papers, impactful case studies and insightful conference presentations. Mani's innovative work in Lean construction holds the promise of delivering substantial improvements in project management methodologies, with the potential to enhance efficiency, cost-effectiveness and waste reduction within construction processes. Mani's expertise in construction operations management simulation stands as a testament to his ability to empower organizations. By using sophisticated simulations, he facilitates the optimization of processes, proactively identifies and addresses challenges, and enables data-driven decision-making, leading to highly empowered and enhanced project outcomes. Mani's innovative contributions have earned him recognition as a leading Lean construction expert and fostered collaborations with industry partners seeking to implement cutting-edge management practices in their projects.