STAKEHOLDER PERSPECTIVES ON ADOPTION OF INTEGRATED PROJECT DELIVERY (IPD)

by

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Abstract

Projects in the Architecture, Engineering, and Construction (AEC) industry frequently perform below expectations related to a variety of metrics for success. Various reasons have been found for these persistent performance gaps; the segregation of processes, services, and actors involved in project delivery in the construction sector has been identified as a root cause. This results in a broken agency, self-interested behaviour, and uncoordinated efforts, which make it difficult to optimize a product as a system.

The project delivery method is important in defining the nature of the relationships between project participants, the structure and organization of the project, and eventually the end results. Many have emphasized the need for more collaborative and integrated methods for project delivery in the AEC industry. Integrated Project Delivery (IPD) is one such method. Several studies have demonstrated that IPD outperforms conventional methods.

In this thesis, I use qualitative methods to characterize environments supportive of IPD and keys to its successful implementation. I also investigate whether the contractual risk sharing framing of IPD hinder or enhance innovation adoption. Finally, I identify the factors that can impede IPD adoption for public sector projects in British Columbia.

I found that while executing IPD is perceived to be beneficial in many ways, successful implementations require specific preconditions beyond educating the industry about IPD principles. Success with this method requires development of novel approaches to project planning and management, and early acculturation to collaboration across the AEC industry.

IPD was found to be instrumental in addressing some of the barriers to innovation adoption; however, foundational changes to the existing policies, regulations, and programs governing the industry's operations, and alternative business and financing models are required to alter the industry's approach towards innovation adoption.

It was also found that while IPD could improve project delivery for the public sector in British Columbia, provincial decision-making processes and procurement regulations prohibit its adoption here.

Lay Summary

Successful delivery of building projects has been a challenge for a long time. Compartmentalization of design, construction, and operation processes and a sequential approach to project delivery has been found to be a root cause. This fragmented approach results in a broken agency and having different sets of stakeholders, values, and decision-makers for each phase of the project and area of work. Integrated Project Delivery (IPD) is a novel collaborative method that is shown to outperform conventional alternatives. This thesis uses qualitative methods to explore the context required for IPD to be effective. The findings show that creating such context is both a technical and a social challenge.

Preface

Four original stand-alone research chapters (Chapter 2-5) are included in this thesis and are intended for publication in peer-reviewed journals. I am the primary responsible person for this work. In all of the research chapters, my contributions include: 1) identification of research questions, 2) developing the study design, 3) undertaking research activities, 4) conducting data collection and analysis, and 5) preparing the manuscripts. Professors Hadi Dowlatabadi, Murray Hodgson, and Mark Gorgolewski helped in shaping my doctoral research proposal and provided valuable insights into the study design and conceptual development of the work. My Ph.D. supervisor, Dr. Hadi Dowlatabadi, contributed to the interpretation of results, verified my analysis, and drew attention to the conceptual shortfalls of the work. He also provided comments for revision of several drafts for each of the chapters included in my thesis.

Chapter 2: Perceived *Benefits of Integrated Project Delivery (IPD) and Characteristics of Suitable Projects and Project Owners*

In this chapter, I designed the study, conducted the literature review, performed data collection and analysis, and wrote the manuscript. Hadi Dowlatabadi helped with conceptual development, refining the structure of the paper, and interpretation of findings. Hadi Dowlatabadi, Murray Hodgson, Thomas Froese, and Mark Gorgolewski provided valuable comments for revision of several drafts. This paper will be submitted to a peer-reviewed journal relevant to project delivery methods.

Chapter 3: Perceived Challenges in Implementing Integrated Project Delivery (IPD): Insights from Stakeholders in the U.S. and Canada for a Path Forward

In this chapter, I designed the study, conducted the literature review, performed data collection and analysis, and wrote the manuscript. Hadi Dowlatabadi helped with conceptual development, refining the structure of the paper, and interpretation of findings. Hadi Dowlatabadi, Murray Hodgson, Thomas Froese, Mark Gorgolewski, and Daniel Ugalde De La Vega reviewed the manuscript and provided comments on the structure of the paper and interpretation of findings.

Four anonymous reviewers for the *International Journal of Construction Education and Research* offered constructive comments on the scope of the work and structure of the paper. This paper was published in *International Journal of Construction Education and Research* in October 2018.

Chapter 4: The Perceived Impact of Integrated Project Delivery (IPD) on Diffusion of Innovations in the Architecture, Engineering, and Construction (AEC) Industry

In this chapter, I designed the study, conducted the literature review, performed data collection and analysis, and wrote the manuscript. Hadi Dowlatabadi contributed to the conceptual development, provided valuable insights into the analysis and interpretation of findings. He also helped to refine the structure of the paper. Thomas Froese offered valuable comments on the approach to data analysis. Hadi Dowlatabadi, Thomas Froese, and Mark Gorgolewski provided comments for revision of several drafts. This paper will be submitted to a peer-reviewed journal with a focus on innovation adoption in the architecture, engineering, and construction industry.

Chapter 5: Exploring Adoption of IPD for the First Time in an Organization: Using the Case of Healthcare Organizations in the Lower Mainland, British Columbia

In this chapter, I designed the study, conducted the literature review, performed data collection and analysis, and wrote the manuscript. Hadi Dowlatabadi helped with conceptual development and contributed to the research design and interpretation of findings. Hadi Dowlatabadi, Thomas Froese, and Mark Gorgolewski provided comments for revision of several drafts. This paper will be submitted to a peer-reviewed journal relevant to innovation implementation.

This research was approved by Behavioral Research Ethics Board at the University of British Columbia (UBC BREB Number: H16-01457, Project Title: Understanding the Role of Integrated Project Delivery (IPD) in the Built Environment).

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List of Abbreviations

(Alphabetical)

AEC	Architecture, Engineering, and Construction
AIA	American Institute of Architects
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BC	British Columbia
BCCA	British Columbia Construction Association
BFs	Behavioural Factors
BIM	Building Information Modeling
BPE	Building Performance Evaluation
BREEAM	Building Research Establishment Environmental Assessment Method
C	Constructors
CBA	Choosing By Advantage
CEDM	Centre for Climate and Energy Decision Making
CII	Construction Industry Institute
CMR	Construction Manager at Risk
CREATE	Collaborative Research and Training Experience
CURT	Construction Users Roundtable
D	Designers
DB	Design-Build
DBB	Design-Bid-Build
ESCO	Energy Service Company
GC	General Contractor
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GLM	Generalized Linear Model
GMP	Guaranteed Maximum Price
ID	Integrated Design
IDDS	Integrated Design and Delivery Solutions

IEQ	Indoor Environmental Quality
IES	Illuminating Engineering Society
iiSBE	International Initiative for a Sustainable Built Environment
IPD	Integrated Project Delivery
ISOFs	Industry Standards and Operational Factors
KPI	Key Performance Indicator
LEED	Leadership in Energy and Environmental Design
LFFs	Legal and Financial Factors
LMC	Lower Mainland Consolidation
LMFM	Lower Mainland Facilities Management
LMHO	Lower Mainland Health Organizations
NBI	New Building Institute
NIST	National Institute of Standards and Technology
NSERC	Natural Sciences and Engineering Research Council of Canada
O	Owners
OFs	Organizational Factors
P3	Public-Private Partnerships
PA	Project Alliancing
PBC	Partnerships British Columbia
PDM	Project Delivery Method
PP	Project Partnering
RFP	Request for Proposal
RFQ	Request for Qualification
U.S.	United States

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Dedication

For my dearest dad

who lived his life with hope and stayed as strong as Soheil until the last moment.

Chapter 1: Introduction

Successful delivery of building projects has been a challenge for a long time. Projects in the Architecture, Engineering, and Construction (AEC) industry frequently perform poorly against a variety of success measures such as cost, schedule, and quality; they therefore fail to meet owners' expectations (CURT, 2007; Hanna, 2016; Liberda, Ruwanpura, & Jergeas, 2003; Rolstadås, Hetland, Jergeas, & Westney, 2011a; Weshah, El-Ghandour, Cowe Falls, & Jergeas, 2014; Zadeh, Dehghan, Ruwanpura, & Jergeas, 2014). Numerous reports generated by actors within the AEC industry have pointed to this long-lasting issue and have emphasized the necessity to improve project delivery in this sector of the economy. The Latham report, titled "*Constructing the Team,*" published in 1994 is one such report that attracted much attention. The Construction Industry Council (CIC) and the government of the United Kingdom (UK) jointly commissioned Sir Michael Latham to evaluate the AEC industry as a whole, investigate the causes of its low performance, and identify effective strategies to address them. In his report, Latham describes the AEC industry as " ineffective" and "incapable of delivering for its customers" (Latham, 1994).

Another key report focused on the issues of quality and efficiency in the AEC industry is "*Rethinking Construction,*" which was published in 1998. This report (also known as the Egan report) was developed by the Construction Task Force in the UK – a task force formed to implement a recommendation in the Latham report. The Egan report reviewed the operational structure of several manufacturing and service industries (such as steel making, grocery retailing, and car manufacturing) that were known as "successful" industries in the UK at the time, to identify lessons for improving the AEC industry. This report also emphasizes that the industry is "under-achieving," and has "low profitability" and "too many clients that are dissatisfied with its overall performance" (Construction Task Force, 1998).

Similar reports can also be found in North America. One organization based in the United States (U.S.), which has published a number of reports on the inefficiency and low performance of the AEC industry is the Construction Users Roundtable (CURT). For example, in a white paper published in 2004 (CURT, 2004), and another one published two years later (CURT, 2006),

CURT points to the persistent quality issues, poor performance, and client dissatisfaction in the AEC industry and highlights the need for a fundamental change in the operational structure and processes within the industry.

The performance-related issues experienced in the AEC industry are persistent. This is illustrated by finding even more recent publications pointing to persistence of the same set of problems. For example, in its report titled "*Shaping the Future of Construction,*" the World Economic Forum (WEF) highlights the unimpressive record of the AEC industry and questions why this sector of the economy has such enduring challenges with regards to productivity, performance, and efficiency (WEF, 2016). The nature of these challenges is unpacked in the following section.

1.1 Performance Gaps

A variety of metrics can be used to describe the long-lasting performance-related issues in the AEC industry. These include labour productivity (Liberda et al., 2003; Shashank, Hazra, & Pal, 2014; WEF, 2016), cost (CEC, 2015; Hanna, 2016), delivery time (Konchar & Sanvido, 1998; Menches & Hanna, 2006; Wa'el Alaghbari, Mohd. Razali A. Kadir, Azizah Salim, & Ernawati, 2007), safety (Chan, Scott, & Lam, 2002; Molenaar & Navarro, 2011; Zhao, McCoy, & Kleiner, 2016; Zhao, McCoy, Kleiner, Mills, & Lingard, 2016), quality (Chan et al., 2002; Konchar & Sanvido, 1998; Molenaar & Navarro, 2011), and material waste (Chan et al., 2002; Hosseini Teshnizi, 2015). Other metrics relate to post-occupancy performance of buildings, such as energy use and GHG emissions (McCoy, Zhao, Paige, Agee, & Mo, 2017; Menezes, Cripps, Bouchlaghem, & Buswell, 2012; Turner & Frankel, 2008), water use (Bartlett et al., 2014), and indoor environmental quality measures (i.e. lighting, acoustics, thermal environment, and air quality (C. Brown, 2016; Gorgolewski et al., 2016; Scannell, Hodgson, Villarreal, & Gifford, 2015)).

Terms such as "credibility gap" (Bordass, Cohen, & Field, 2004), and more recently "performance gap" (Bartlett et al., 2014; Fedoruk, Cole, Robinson, & Cayuela, 2015; Gorgolewski et al., 2016; Mallory-Hill & Gorgolewski, 2018) are used to describe the discrepancy between the anticipated and actual (i.e. measured) performance of building projects. A review of the literature indicates that performance gaps have been observed in a variety of

metrics (including those mentioned above) that could be used to define the performance of a building project and the building itself, as the project's final product. A few examples of studies focused on different dimensions of the performance gap are presented below.

Labour productivity: Labour productivity is of central importance in the AEC industry, and many have expressed concern over the low productivity of labour in this sector of the economy (Allmon, Hass, Borcherding, & Goodrum, 2000; Liberda et al., 2003; Shashank et al., 2014; WEF, 2016). Numerous studies have tried to understand how to best measure labour productivity in the AEC industry (e.g., Allmon et al., 2000), what factors influence labour productivity (e.g., Jarkas & Bitar, 2012), whether or not it has declined over time (e.g., Rojas & Aramvareekul, 2003), and how it compares with labour productivity in other industries (Yi & Chan, 2014). These studies reveal contradictory trends in construction labour productivity, depending on how "productivity" is defined and what dataset is used. Among studies that rely on macroeconomics data, many indicate a significant decline in construction labour productivity over time (Rojas & Aramvareekul, 2003). The "*Shaping the Future of Construction*" report published by WEF based on data provided by the U.S. Bureau of Economic Analysis (BEA), and the Bureau of Labour Statistics (BLS) (WEF, 2016) represents one example of a study of this type.

Cost and delivery time: Many studies have reported performance gaps with regard to project cost and delivery time (e.g., Frimpong, Oluwoye, & Crawford, 2003; Kaming, Olomolaiye, Holt, & Harris, 1997; Taghi Zadeh, Dehghan, Ruwanpura, & Jergeas, 2016; Weshah et al., 2014). For example, a survey of more than 200 building owners carried out by FMI Corporation and Construction Management Association of America (CMAA) indicated that 30% of projects do not meet budget or schedule (FMI Corporation, 2007). In another study, Thomsen et al. (2009) found that on average, 40-50% of projects in the AEC industry fall behind their original schedule.

Safety: Safety performance in the AEC industry is a complex phenomenon, which has a major influence on many other aspects of construction projects including economic, procedural, legal, and organizational (Chan et al., 2002; Hinze, Devenport, & Giang, 2006; Saunders et al., 2017; Sawacha, Naoum, & Fong, 1999; Wakefield et al., 2014; Zhao, McCoy, Kleiner, Mills, et al.,

2016). Numerous researchers study the rate of accidents on construction sites (e.g., Pinto, Nunes, & Ribeiro, 2011), why they occur (e.g., Sawacha et al., 1999), and how they can be prevented (Jannadi, 1995; O'Connor, Loomis, Runyan, dal Santo, & Schulman, 2005). Despite these efforts, the AEC industry is recognized as one of the least safe sectors (Im et al., 2009; Sawacha et al., 1999); the risk of fatality is reported at five times greater, and the risk of major injuries two and a half times higher in the AEC industry compared to other manufacturing based industries (Sawacha et al., 1999).

Quality: Although difficult to measure, many have studied the performance of the AEC industry concerning the quality of the projects delivered. Using a variety of qualitative and quantitative metrics (e.g., aesthetics, as-built condition of major building systems, number of deficiency issues and punch list items, cost of warranty and latent defects), many have reported poor quality of both workmanship and the final product in the AEC industry (Abdul-Rahman, Wang, Wood, & Khoo, 2014; Ashford, 1989; Kazaz & Birgonul, 2005).

Material waste: Solid waste generation is another area of concern in the AEC industry. Even though several strategies exist for construction material effectiveness (e.g., reuse, recycling), and many green building rating systems such as Leadership in Energy and Environmental Design (LEED) have incorporated material use and solid waste generation in their assessment categories (USGBC, 2013), building projects typically generate more than the anticipated amount of solid waste during construction (Hosseini Teshnizi, 2015; Poon, Yu, & Jaillon, 2004). Many studies have reported that around 10% of the raw materials delivered to construction sites is wasted and ends up in landfills (e.g., Bossink & Brouwers, 1996; Enshassi, 1996; Li Hao, Hill, & Yin Shen, 2008). Some studies indicate that construction sites produce up to 37% of material waste (CEC, 2015).

Performance gap has been also observed in metrics related to post-occupancy performance of buildings. Studies that are focused on this aspect of the performance gap often use predictions made by assessment tools and rating systems such as LEED, Building Research Establishment Environmental Assessment Method (BREEAM), and Green Globes in their comparisons of

anticipated versus actual performance of buildings (Akerstream, Knirsch, & Pauls, 2013; Bartlett et al., 2014).

Development and use of tools and rating systems (e.g., LEED, BREEAM, Green Globes) that assess building performance are examples of initiatives that have been taken to facilitate the delivery of buildings that respond to their predetermined values and objectives (Cole, 1999). These assessment tools have inserted definitions and characteristics of *green* buildings into the market, and have promoted demand for these types of facilities (Cole, 2006), yet these principles and design benchmarks have not been ensured the realization of building projects' values and objectives (Bartlett et al., 2014; Birt & Newsham, 2009; Bordass et al., 2004; G. Newsham et al., 2012; PlaNYC, 2012; Scofield, 2009, 2013). Furthermore, as noted by Akerstream et al. (2013), most green building rating systems base their evaluation on predicted rather than actual performance of buildings post-occupancy. Building performance is seldom verified voluntarily (Oates & Sullivan, 2012), and is often at considerable variance from expectations (Gorgolewski et al., 2016; Mallory-Hill & Gorgolewski, 2018). A few examples of studies focused on the performance gap with regard to the post-occupancy performance of buildings are presented below.

Energy use: In 2008, the New Building Institute (NBI) published one of the first studies to report a significant gap between predicted and actual energy use of certified green buildings (Turner & Frankel, 2008). After analyzing the energy performance data of 121 commercial LEED-certified buildings, Turner and Frankel (2008) reported that the actual energy use in more than half of these buildings varied from the design estimate by more than 25 percent. Many other studies have since reported similar findings. For example, Oates & Sullivan (2012) report a 75 percent performance gap in the energy use of office and educational LEED-certified buildings; echoed by Bartlett et al. (2014). Menezes et al. (2012) used the CarbonBuzz database and reported a 60 to 70 percent performance gap in electricity use in offices and schools, and more than 85 percent in university campuses.

Water use: While predictions of water use in buildings are at times not as precise as predictions of energy demand (Mallory-Hill & Gorgolewski, 2018), many studies report performance gaps in

water use. For example, Bartlett et al. (2014) indicate a wide range of differences – from 4% to 138% – between predicted and actual water use in the green buildings they studied. The amount of water usage in some of these buildings was more than the predicted values, while in others it was less.

Indoor environmental quality (IEQ): Studies of indoor environmental quality (IEQ) measures such as lighting, acoustics, thermal environment, and air quality often use occupant surveys to elicit occupants' level of satisfaction with different aspects of IEQ (e.g., Brown, 2016; Brown & Gorgolewski, 2015), or compare spot measurements with values recommended in industry standards and reference guides (e.g., Hodgson, 2016; Scannell, Hodgson, Villarreal, & Gifford, 2015) such as IES Lighting Handbook (IES, 2011), ANSI S 12.60-2002 (ANSI, 2002), and ASHRAE 62.1 standard (ASHRAE, 2007). Low levels of occupant satisfaction with different IEQ measures and deviation of spot measurements from recommended levels have been reported in a number of studies (e.g., Bartlett et al., 2014; Brown, 2016; Scannell et al., 2015). For example, Scannell et al. (2015) found that the average sound levels in occupied learning spaces (they studied 11 buildings) considerably exceeded the maximum standards.

Studies have shown that building occupancy, which often changes considerably from design assumptions, can dramatically affect various aspects of building performance such as energy and water use, acoustics, thermal environment, and air quality (Azar & Menassa, 2012; Davis & Nutter, 2010; Mallory-Hill & Gorgolewski, 2018; Salehi, Terim Cavka, Frisque, Whitehead, & Bushe, 2015). Therefore, studies of building performance need to take changes in occupancy numbers into consideration, and normalize energy and water use, and indoor environmental quality measures for design occupancy before they assess whether or not a performance gap exists.

Bartlett et al. (2014) indicated that the actual number of occupants on a typical day in the nine buildings they studied varied by a range of -57% to +20%, and the actual operating hours exceeded predictions by up to 82%. These changes were found to influence different aspects of building performance. In another study, Diamond et al. (1992) showed that increased occupancy levels in comparison with prediction values was one of the leading causes of the up to 23%

energy performance gap in the first two years of operation for the 27 commercial buildings they studied. Significant differences between the anticipated and actual number of building operating hours have also been reported in many studies (Masoso & Grobler, 2010; Webber et al., 2006).

The issue of the performance gap, in its different dimensions (Figure 1.1), is a major problem within the AEC industry. This persistent issue can lead to additional costs and dissatisfied clients, wasted resources, increased emissions, and harm to occupants' health and wellbeing. Many studies have investigated reasons for performance gaps (Chu, 2016; De Wilde, 2014; Fedoruk, 2013; A. McCoy et al., 2018; Salehi et al., 2015; Terim Cavka, Salehi, Frisque, & Bushe, 2014), how they can be resolved (Imam, Coley, & Walker, 2017; Miller, Nagy, & Schlueter, 2015; Y. Sun, 2014), and what can be learned from project performance evaluation studies to inform stakeholders and improve future building projects (Calì, Osterhage, Streblow, & Müller, 2016; Tronchin, Manfren, & Tagliabue, 2016).

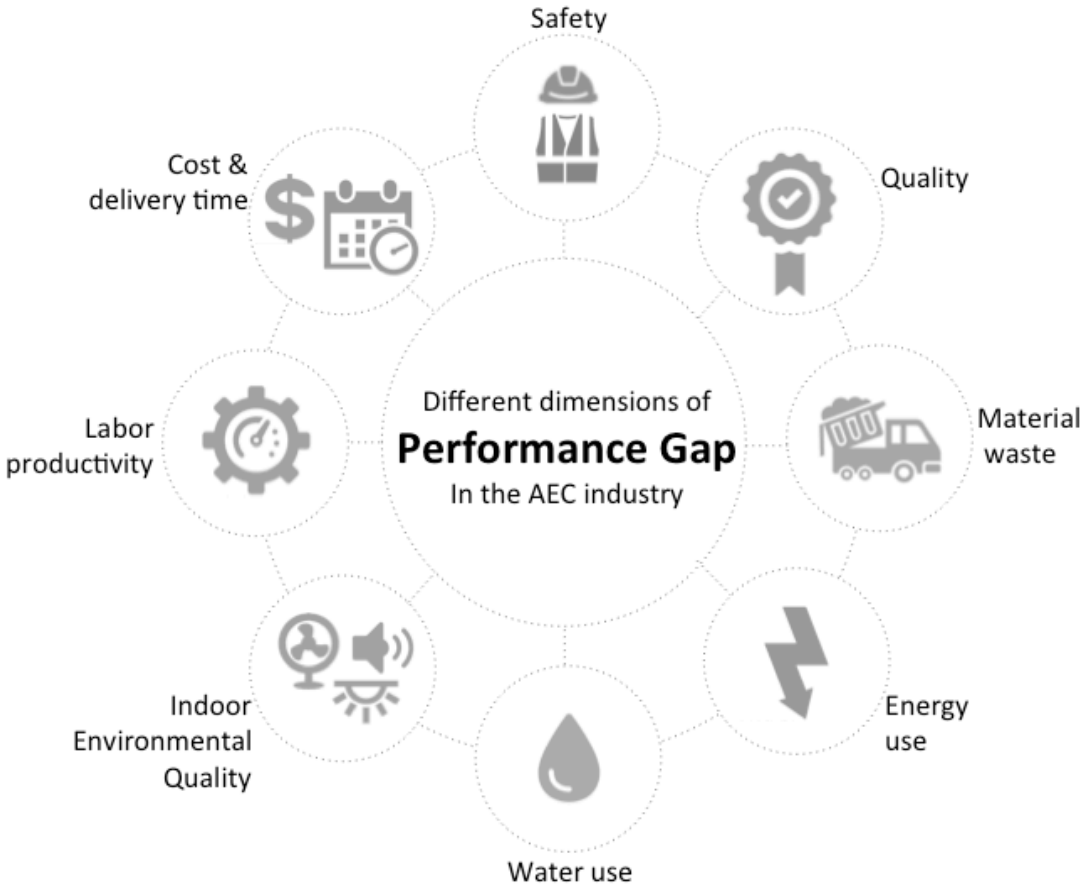


Figure 1.1: Different dimensions of the performance gap in the AEC industry

1.2 Reasons for Performance Gaps

A review of the literature indicates a variety of reasons for performance gaps. These reasons can stem from different stages of the life cycle of a project – from planning and design through to operation and occupancy. Performance gaps occur due to:

- Lack of clear performance objectives and misalignment of targets among different stakeholder groups participating in a project development process (Bordass, Leaman, & Ruyssevelt, 2001; Carbon Trust, 2011; Cohen, Standeven, Bordass, & Leaman, 2001; Newsham et al., 2012; Newsham, Mancini, & Birt, 2009);
- Poor understanding of contextual variables (Chu, 2016; Fedoruk, 2013; Fedoruk et al., 2015; Terim Cavka et al., 2014);
- Use of innovative and smart technologies without considering the required level of support and building management capacities (Blumsack & Fernandez, 2012; Bordass et al., 2001; Chu, 2016; Fedoruk, 2013; Fedoruk et al., 2015; Salehi et al., 2015);
- Deficient use of design-assist tools in design decision-making processes (Austin, 2013; Carbon Trust, 2011; Chu, 2016; De Wilde, 2014; Zero Carbon Hub, 2013);
- Inaccuracies in predictions (Azar & Menassa, 2012; Bartlett et al., 2014; Beauregard, Berkland, & Hoque, 2011; Cheshire, 2013; Chu, 2016; Davis & Nutter, 2010; Raftery, Keane, & Costa, 2011; Salehi et al., 2015; Terim Cavka et al., 2014);
- Faulty integration of building systems and construction quality issues (Chu, 2016; De Wilde, 2014; Fedoruk, 2013; Menezes et al., 2012);
- Value engineering during construction without considering the consequent impacts on building performance (Bordass et al., 2004; De Wilde, 2014; Fedoruk, 2013);
- Incomplete commissioning (Chu, 2016; Fedoruk, 2013; Fedoruk et al., 2015; Mills, 2011; Monfet, 2011; Newsham et al., 2012; Zero Carbon Hub, 2013);
- Poor handover and lack of robust processes for verification of estimated savings and achievement of performance targets after project completion (Chu, 2016; De Wilde, 2014; Fedoruk, 2013; Zero Carbon Hub, 2013);
- Changes in the course of operation and maintenance (Bartlett et al., 2014; Cheshire, 2013; Gorgolewski et al., 2016; Newsham et al., 2012; Salehi et al., 2015; Terim Cavka et al., 2014);

- Changes in building use and occupant behaviour (Azar & Menassa, 2012; Bartlett et al., 2014; Brown, 2009; Chu, 2016; Davis & Nutter, 2010; Salehi et al., 2015; Wang, Yan, & Jiang, 2011).

The findings of various studies focused on project performance evaluation suggest that a root cause of performance gaps is disintegrated processes, the uncoordinated behaviour of different stakeholder groups, and emphasis on local rather than holistic optimization throughout the project. Many have flagged that addressing the issue of performance gaps in order to truly realize high-performance buildings requires adoption of highly integrated approaches to design and development, and robust strategies to guarantee the continuous collaboration and alliance of all stakeholder groups participating in various phases of a project (Ashcraft, 2014; CEC, 2015; Chu, 2016; Fedoruk, 2013; Fischer et al., 2017; Korkmaz, Messner, Riley, & Magnet, 2010; Korkmaz, Swarp, & Riley, 2013; Wakefield et al., 2014; Zhao, Mccoy, Bulbul, Fiori, & Nikkhoo, 2015). This is not a new discovery; it has been more than 20 years since the fragmented structure of the AEC industry was officially recognized as a root cause of many of the problems faced in this sector. For example, in the Latham report "*Constructing the Team,*" published in 1994, the "adversarial" and "fragmented" nature of the AEC industry and "lack of integration of design and construction processes" are highlighted as key causes of the industry's ineffectiveness and inability to deliver for its customers (Latham, 1994). Similar notes can be found in the Egan report, "*Rethinking Construction*" published in 1998:

> *"The rationale behind the development of an integrated process is that the efficiency of project delivery is presently constrained by the largely separated processes through which they are generally planned, designed, and constructed. These processes reflect the fragmented structure of the industry and sustain a contractual and confrontational culture."* (Construction Task Force, 1998, p. 19)

The white papers published by CURT (e.g., WP-1202 and WP-1003) also point to the same issue:

> *"The Committee [CURT Committee] concluded that the difficulties experienced in typical construction projects, including those identified by CURT members, are artefacts of a construction process fraught by lack of cooperation and poor information integration."* (CURT, 2004, p. 2)

Even more recent reports such as "*Shaping the Future of Construction,*" published by WEF in 2016, also highlight the separated processes within the AEC industry as a major point of concern:

> *"The fragmentation of the [AEC] industry, together with a lowest-price culture, often entails compromises on labour or environmental performance."* (WEF, 2016, p. 31)

These examples indicate that fragmentation has been recognized as a root cause of the AEC industry's low performance for a long time. However, existing approaches towards organizing and executing the work, and structuring projects have not been effective in addressing this major issue.

1.3 Project Delivery Method

Research shows that high levels of communication and integration in project teams, interdisciplinary interaction, and early involvement of project participants are vital for optimal solutions in design and development processes (Aarseth, Andersen, Jergeas, & Ahola, 2012; Chu, 2016; Enache-Pommer & Horman, 2009; Lapinski, Horman, & Riley, 2006; Magent, Korkmaz, Klotz, & Riley, 2009; Reed & 7group, 2009; Robichaud & Anantatmula, 2011), and the delivery of high-performance buildings (Korkmaz et al., 2010). Therefore, many researchers have focused on examining the factors that affect the degree of integration in project teams (e.g., Azari & Kim, 2016; Korkmaz et al., 2013), and interpersonal (e.g., Zhang & He, 2016; Zhang, He, & Zhou, 2013) and inter-organizational relationships (e.g., Erdogan, Anumba, Bouchlaghem, & Nielsen, 2014; T. Wang, Tang, Du, Duffield, & Wei, 2016).

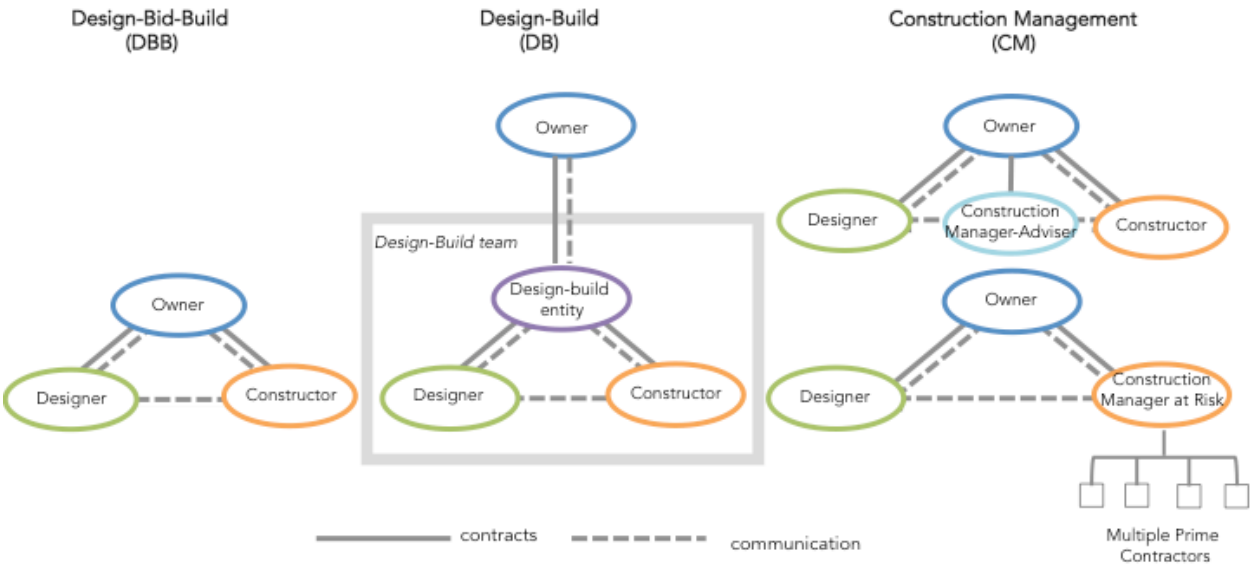
The methods used for procurement and delivery of a project have been found to play an important role in shaping project organization, nature of the relationships among team members,

legal and commercial terms (AIA-AGC, 2004; Ashcraft, 2014; Fischer et al., 2017; Thomsen et al., 2009), and eventual project performance and end results (Al Khalil, 2002; El Asmar, Hanna, & Loh, 2013, 2016; Hanna, 2016; Konchar & Sanvido, 1998; Korkmaz et al., 2013). Project delivery methods also affect the rate of innovation adoption in projects (Lahdenperä, 2012; Sheffer, 2011; Taylor & Levitt, 2007). Several definitions of a project delivery method can be found in the literature. For example, El Asmar et al. (2013) define this term as:

> *"…A system that determines the relationships between the different project stakeholders and their timing of engagement to provide a built facility."* (El Asmar et al., 2013, P.1)

Various types of project delivery methods (PDM) are used in the AEC industry (Arroyo, 2014; El Asmar et al., 2013; Korkmaz et al., 2013; Moazzami, Ruwanpura, & Jergeas, 2013; Rolstadas, Hetland, Jergeas, & Westney, 2011b). Three popular methods are Design-Bid-Build (DBB), Design-Build (DB), and Construction Management (CM) (El Asmar et al., 2013; Korkmaz et al., 2013; Moazzami, Dehghan, F Jergeas, & Ruwanpura, 2015; Moazzami et al., 2013; Rolstadas et al., 2011b). These methods have distinct differences with regard to the "relationships between different project stakeholders" and "timing of their engagement," the two key components of the definition of project delivery method described by El Asmar et al. (2013).

Figure 1.2 illustrates the differences between these three methods concerning the contractual relationships and communications among key stakeholders. In terms of the timing of the involvement of different parties, AIA (2007) explains that under DBB, the general contractor (GC) gets involved when the design is fully complete; however, under DB, the GC gets involved in early phases of the design, and in many cases design and construction services are provided by a single entity. Under CM, a construction manager gets involved early in the design process and can either act only as an advisor and provide project management services to design and construction agents (CMa: Construction Manager-Adviser), or can also hold construction responsibilities in the project and be paid an additional fee for advisory services provided during the design stage (CMc: Construction Manager-Constructor or CMR: Construction Manager at Risk).



Note: The figure is adapted from AIA (2007)

Figure 1.2: Comparison of DBB, DB, and CM with respect to contractual relationships and communications among key stakeholders

Many have studied the performance of different project delivery methods including DBB, DB, and CM. For example, Bennett et al. (1996) compared DBB with DB with regard to quality, schedule, and cost performance and found DB to be superior to DBB. Ibbs et al. (2003) also compared DBB with DB and found the latter is superior with respect to schedule, but not cost and labour productivity. Another example is a study conducted by Korkmaz et al. (2010) that found that DB and CMR are superior to a DBB model in terms of achieving sustainability goals in building projects. While these studies show that some delivery methods outperform others, they also indicate that the conventional methods have not been able to address the long-lasting problems of the AEC industry. Many projects still fall far short of expectations across various measures of success, such as schedule, cost, and quality (CURT, 2007), and fail to meet owners' expectations (Ashcraft, 2014; Hanna, 2016; Lahdenperä, 2012).

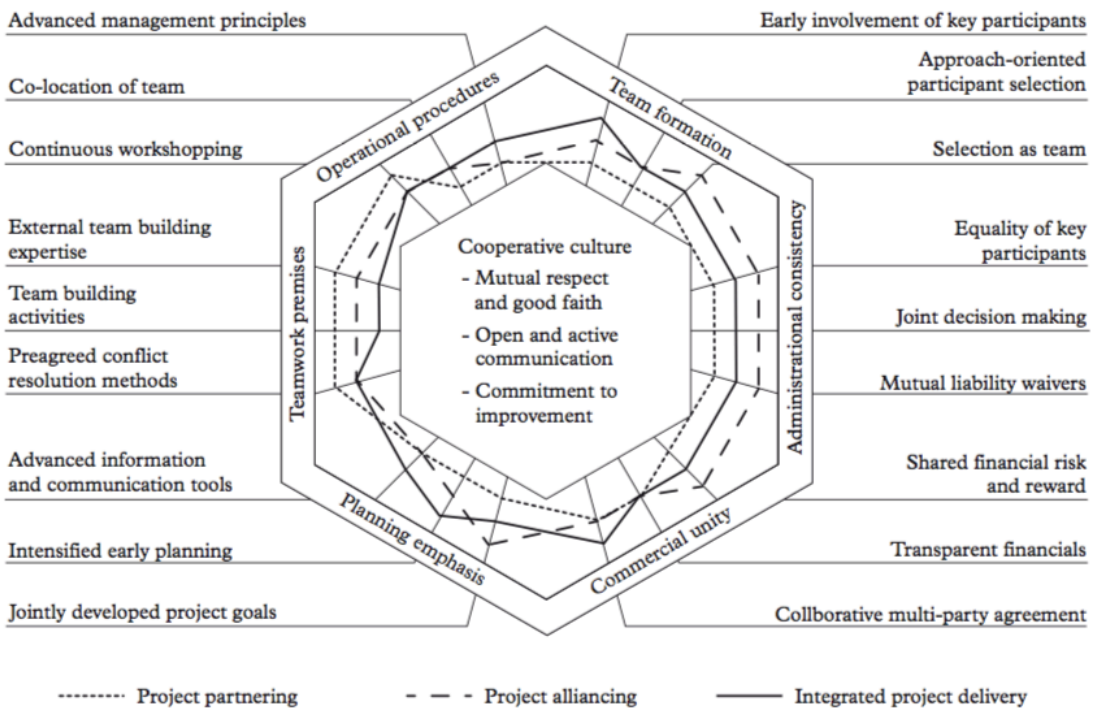
According to the Economist (2000), inefficiencies, delays, and mistakes account for more than 30% of yearly expenditure on construction in the U.S. A study conducted by Forbes and Ahmed (2011) shows a loss of 17 to 36 billion dollars per year due to dysfunctional communication between two key stakeholder groups: designers and constructors. Another study, which was

conducted by Thomsen et al. (2009), reported considerable delays in close to half of the construction projects they observed. The results of these studies indicate the need for fundamental change in the way projects are structured, executed, and organized in the AEC industry. Lack of effective communication, information sharing, and collaboration among various groups of stakeholders who operate in their silos have been identified as key reasons for the continued poor performance of conventional delivery methods in the AEC industry (AIA, 2007; CURT, 2007; Hanna, 2016). Relational contracting and collaborative arrangements for project delivery have been presented as solutions (Ashcraft, 2014; Fischer et al., 2017; Hanna, 2016; Lahdenperä, 2012).

1.4 Integrated Project Delivery (IPD)

Integrated Project Delivery (IPD) is one of the three main collaborative forms of project delivery (AIA-AIACC, 2010; Lichtig, 2006; Matthews & Howell, 2005); project partnering (PP) and project alliancing (PA) being the other two approaches gaining ground (Cheung, Yiu, & Chim, 2006; Rahman & Kumaraswamy, 2002; Rowlinson & Cheung, 2004).

While these three relational project delivery arrangements share some principles, there are distinct differences in their procedural practices, tools, and techniques. To varying degrees, these arrangements may include elements of early involvement of key stakeholders, shared risk and reward, joint decision-making, transparent financials, and collaborative multi-party agreement. Figure 1.3 illustrates how these three methods weigh different features of collaboration and integration.



Note: Degree of exploitation of each integration feature increases with distance from the center. The figure is adapted from Lahdenperä (2012).

Figure 1.3: Comparison of three collaborative forms of project delivery with respect to their key integration features

The analyses of IPD, PP, and PA conducted by Lahdenperä (2012) show that IPD has mostly been used for "vertical" building construction, rather than "horizontal" projects such as roads and utility infrastructure. Lahdenperä (2012) explains that the use of IPD is more common than PP and PA in North America.

Since its introduction to the AEC industry, IPD has become the subject of great interest (CURT, 2007; El Asmar et al., 2013, 2016; Hanna, 2016). IPD is believed to have the potential to address the enduring challenges faced by the industry through removing the barriers that burden conventional delivery methods such as DBB, DB, and CM (Thomsen et al., 2009). IPD is defined as "*a project delivery method distinguished by a contractual agreement between a minimum of the owner, design professional, and builder where risk and reward are shared, and stakeholder success is dependent on project success*" (AIA-AIACC, 2010, P.4). American

Institute of Architects (AIA) and AIA California Council (2010, P.6) describe seven contractual and three behavioural principles embodied in IPD:

- *Contractual principles*
  - *Key participants bound together as equals*
  - *Shared financial risk and reward based on project outcome*
  - *Liability waiver between key participants*
  - *Fiscal transparency between key participants*
  - *Early involvement of key participants*
  - *Jointly developed project target criteria*
  - *Collaborative decision-making*

- *Behavioural principles*
  - *Mutual respect and trust*
  - *Willingness to collaborate*
  - *Open communication*

1.5 Problem Statement

As described in the previous sections, the AEC industry has been wrestling with a variety of challenges for a long time. Many believe a collaborative form of project delivery is a solution. IPD, a relatively new method (AIA, 2007; Lahdenperä, 2012), introduces innovative principles for the collaborative delivery of projects in the AEC industry of North America. Frustrations with conventional delivery methods, waste, inefficiencies, and lower than expected performance of projects have triggered IPD adoption in a growing number of projects (AIA, 2007; AIA California Council, 2014).

Several scholars have studied the performance of IPD in comparison with conventional delivery methods using a variety of key performance indicators (KPIs) (e.g., AIA, 2012; Cho & Ballard, 2011; El Asmar et al., 2013, 2016; Hanna, 2016; IPDA, 2016). One of the largest and most comprehensive studies of IPD performance was conducted by El Asmar et al. (2013). In that study, the authors identified the statistically superior performance of IPD in 14 out of 31 metrics

across the following performance areas: quality, schedule, project changes, communication among stakeholders, environmental, and financial performance.

The success stories of IPD projects such as those presented by AIA-AIACC (2010), AIA (2012), and IPDA (2016), as well as the demonstrated outperformance of IPD versus non-IPD projects in quantitative studies (e.g., El Asmar et al., 2013) lead to the impression that IPD holds the key to realizing high-performance projects in any context and with any player. Such an impression can lead to the implementation of IPD in unsuitable settings and with inappropriate players, leading to project failure.

IPD is an innovation for the AEC industry (Mollaoglu-Korkmaz, Miller, & Sun, 2014; Paik, Miller, Mollaoglu, & Sun, 2017; Sun, Mollaoglu, Miller, & Manata, 2015); the implementation of such innovations requires a supportive environment as well as capable and skilled players (Klein & Sorra, 1996). Adopting IPD, like any other innovation, without a full understanding of the type of context and players required for its successful implementation, can result in the failure of a highly competent innovation (Klein & Sorra, 1996; Mollaoglu-Korkmaz et al., 2014; Paik et al., 2017). Therefore, in my thesis, I aim to understand the perceived characteristics of a supportive environment and fitting players for implementing IPD, and to explore what new competencies and changes are needed in the existing structure of the AEC industry to better facilitate IPD implementation. The answers to these questions will help industry stakeholders understand the steps needed to utilize IPD at its full potential for delivery of high-performance projects.

While IPD is itself an innovative approach to project delivery, a secondary question that I aim to answer is whether IPD is supportive of adopting innovations in building projects. Many innovative design and construction methods, products, and building materials exist that, despite their potential, have experienced weak diffusion (Goodrum & Haas, 2000; Sheffer & Levitt, 2010; Sheffer, 2011) and failed implementation leading to a performance gap (Bartlett et al., 2014; Chu, 2016; Fedoruk, 2013; Fedoruk et al., 2015). Industry fragmentation has been identified as one of the key reasons for this phenomenon (Hall et al., 2014; Sheffer, 2011). Given that IPD aims to create an integrated and collaborative environment for the delivery of projects,

it should be able to facilitate innovation adoption and create a pathway for the delivery of high-performance building projects. However, risk sharing may also slow the adoption of new technologies when their risk is uncertain. In my thesis, I explore the perceived role of IPD in facilitating innovation adoption from the perspective of those who have had direct experience with this method. This exploration will improve our understanding of whether IPD is believed to be a viable means to address the barriers to innovation adoption in the AEC industry, or whether there are barriers beyond the reach of project delivery methods.

My thesis consists of four independent yet interrelated studies exploring:

- The perceived benefits of IPD and characteristics of suitable projects and project owners,
- The perceived challenges in implementing IPD,
- The perceived role of IPD in the adoption of innovations, and
- The areas of challenge perceived to hinder implementation of IPD for the first time in an organization.

The research objectives for each of these studies are explained in the following section.

1.6 Objectives

The purpose of this research is to understand the characteristics of an environment that key stakeholders perceive to be supportive of IPD, and also the characteristics of players that are believed to be suitable for implementing this PDM. Furthermore, this research aims to explore what changes are needed in the current structure of the AEC industry to better accommodate IPD. It also aims to explore whether IPD is perceived to be able to facilitate the adoption of innovation in this sector of the economy. The specific objectives of each of the four studies presented in this thesis are as follows:

- Chapter 2 (Study No.1):
    - To identify the perceived benefits of IPD that encourage stakeholders to choose this method over conventional PDMs
    - To determine project characteristics that are believed to make it suitable for IPD

- To identify the characteristics of owners who are perceived to be suited for the adoption of IPD

- Chapter 3 (Study No.2):
  - To characterize the challenges to implementing IPD according to different stakeholder groups that have experience in working on both, IPD and non-IPD projects

- Chapter 4 (Study No.3):
  - To understand whether IPD, compared to conventional methods, is perceived to be instrumental in facilitating the adoption of innovations in the AEC industry
  - To identify the IPD components that are believed to be able to play a positive role in facilitating innovation adoption in IPD projects
  - To explore how the impacts of IPD components on various dimensions of fragmentation is believed to affect adoption of different types of innovations

- Chapter 5 (Study No.4):
  - To determine the effectiveness of IPD principles in improving project performance as seen by members of the facilities management department of healthcare organizations in the Lower Mainland, British Columbia (an example of organizations that do not have any direct IPD experience)
  - To identify the areas of challenge believed to hinder IPD implementation for delivery of healthcare facilities in the Lower Mainland, British Columbia
  - To characterize the pathways to overcome the perceived barriers to IPD implementation by healthcare organizations in the Lower Mainland, British Columbia

Due to the nature of the research questions, I selected a qualitative approach for this study to capture a comprehensive understanding of the AEC industry professionals' experience and opinions towards IPD. The use of qualitative methods allows researchers to gather in-depth insights for answering 'why?' and 'how?' questions (Marshall, 1996). Various combination of

literature reviews, semi-structured interviews, a questionnaire survey, and a series of stakeholder workshops were employed to achieve the objectives of the four studies presented in this thesis. Figure 1.4 portrays which methods were used in each study. A detailed description of the data collection and analysis methods used for each study is provided in the corresponding chapters.

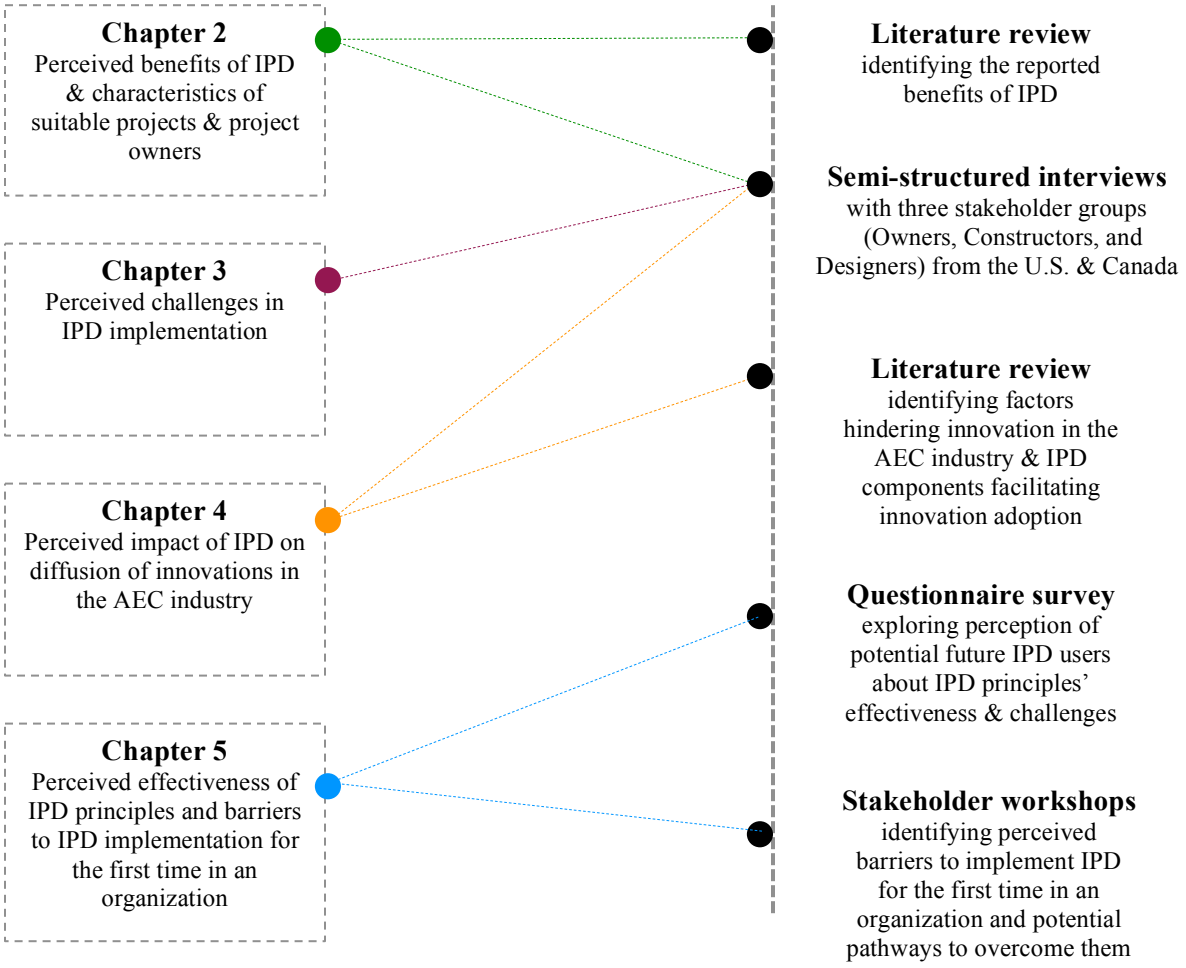


Figure 1.4: Summary of the data collection methods used in each chapter of the thesis

1.7 Thesis Structure

This thesis consists of six chapters: an introduction chapter, four original research chapters, and a conclusion chapter.

Chapter 1 is this chapter, which provides background information about different dimensions of the performance gap, project delivery methods, IPD, the point of departure and purpose of this research, and the objectives of each of the studies included in this thesis.

Chapter 2 compares the reported benefits of IPD in the literature with stakeholders' perceived benefits of IPD and the reasons behind their choice of this delivery method. This chapter also characterizes projects and project owners that are recognized to be suitable for IPD adoption.

Chapter 3 determines the challenges of implementing IPD as perceived by different groups of stakeholders and explains whether the observation of challenges was sensitive to the extent of experience with this PDM. These findings were used to develop four key suggestions for improving the efficacy and success of IPD implementation.

Chapter 4 presents the barriers to diffusion of innovations in the AEC industry and explores whether IPD is believed to be able to overcome these barriers. Stakeholders' perceptions of the role of IPD versus conventional delivery methods with respect to innovation adoption are explained, and the recognized role of IPD components in the adoption of different types of innovations are discussed.

In Chapter 5, I used the facilities management department of Lower Mainland health organizations in British Columbia as an example of an association that does not have any direct experience with IPD and is examining the use of this PDM for the first time. This chapter aims to explore the perceptions of those who have not used IPD with regard to 1) the effectiveness of IPD principles on various aspects of project performance, 2) the areas of challenge that could hinder implementing IPD in an organization, and 3) the pathways to overcome these perceived barriers.

Chapter 6 is the concluding chapter. In this chapter, I briefly summarize the findings from each of the substantive chapters and present a set of recommendations for how to prepare for and implement IPD. This chapter also outlines the limitations of the work and provides suggestions for future research.

Chapter 2: Perceived Benefits of Integrated Project Delivery (IPD) and Characteristics of Suitable Projects and Project Owners

2.1 Introduction

As noted in the previous chapter, projects in the AEC industry can be developed using several project delivery methods. Until early in the twentieth century, a Master Builder was hired to conduct the design and construction processes of a new facility. Rising complexity in buildings and advancements in technology demanded various specializations in design and construction services. This phenomenon led to innovations for the planning, design, and construction of new facilities (Konchar & Sanvido, 1998; Molenaar & Songer, 1998; Paik, Miller, Mollaoglu, & Sun, 2017).

There are numerous definitions of PDM in the literature (Azari, Kim, Ballard, & Cho, 2014; Cho, Ballard, Azari, & Kim, 2010; Rigby, McCoy, & Garvin, 2012). I have adopted Konchar and Sanvido's (1998) definition of PDM: "the relationships, roles, and responsibilities of the parties and sequence of activities required to provide a facility." Thomsen et al. (2009) explain that each PDM functions within three domains:

- The *project's organization*, i.e., the timing of participants' engagement, how they share information and communicate, and when decisions are made;
- The *commercial terms*, i.e., the interconnections among project participants, how they are bound to each other, and what economic incentives are provided to them; and
- The *operating system*, i.e., how the project is managed and executed, what activities are taken throughout the process and how decisions are analyzed.

The delivery methods used by the AEC industry can be distinguished by the particular solutions each offers in project's organization, commercial terms, and the operating system. DBB is one of the most commonly used PDMs. This method was developed as a response to the increase in service specializations early in the twentieth century (Konchar & Sanvido, 1998). By offering a sequential approach (design, bid, and then build) to project delivery, DBB lowers the interactions

among project participants, particularly in the design phase. In simpler and smaller projects, this is a cost saving without a penalty. However, in large complex projects, this approach can readily lead to interoperability issues, design inefficiency (Korkmaz et al., 2013), errors and disputes, delays in the construction schedule and ultimately, higher costs (Konchar & Sanvido, 1998; Molenaar & Songer, 1998). CM and DB – two other popular PDMs – were developed as a response to these deficiencies in order to improve practices and project outcomes (Konchar & Sanvido, 1998; Paik et al., 2017). However, the AEC industry continues to be inefficient, adversarial and fragmented in its operations (Baiden, Price, & Dainty, 2006; El-adaway, 2010; Hanna, 2016; Lichtig, 2006; P. E. Love, Gunasekaran, & Li, 1998; Sive, 2009).

It was noted in the previous chapter that the outcomes of projects could be measured using a variety of metrics (e.g., time, cost, system quality, number of defects and changes, labour safety). A great many studies have shown PDM characteristics influence project outcomes (e.g., Chan, Scott, & Lam, 2002; Cho & Ballard, 2011; Col Debella & Ries, 2006; El Asmar, Hanna, & Loh, 2013, 2016; El Wardani, Messner, & Horman, 2006; Gultekin, Korkmaz, Riley, & Leicht, 2013; Hanna, 2016; Ibbs, Kwak, Ng, & Odabasi, 2003; Konchar & Sanvido, 1998; Korkmaz, Messner, Riley, & Magnet, 2010; Korkmaz et al., 2013; Lim & Mohamed, 1999; Menches & Hanna, 2006; Molenaar & Navarro, 2011; Pocock, 1996; Riley, Sanvido, Horman, McLaughlin, & Kerr, 2005; Rojas & Kell, 2008). Most of these studies indicate that projects delivered through more collaborative methods outperform those implemented using less collaborative PDMs.

Developing approaches that facilitate collaboration throughout the project and enhance integration of services and stakeholders has been a key focus of recent innovations in the AEC industry (Azari & Kim, 2016; Gultekin et al., 2013; Zhao et al., 2015). This trend can be observed not only in the evolution of PDMs, but also in other developments such as Building Information Modeling (BIM) (Azhar, 2011; S. Azhar, Khalfan, & Maqsood, 2015; Porwal & Hewage, 2013), BIM-based applications (Ilhan & Yaman, 2016; Inyim, Rivera, & Zhu, 2014), Integrated Design (ID) (Azari & Kim, 2016; Kibert, 2016), and Integrated Design and Delivery Solutions (IDDS) (Owen et al., 2010).

Gultekin et al. (2013) believe that to create a collaborative and integrative environment, the methods and contractual agreements used for delivering projects in the AEC industry need to mimic a master builders' mindsets. Employing relational contracting practices is offered as a solution to this need. Such practices are regarded as means to create integration in the project and improve the performance outcomes (Krumm, 2001; Lahdenperä, 2012). As mentioned previously, IPD is one of the most recent relational PDMs in North America that aims to address the disintegration issues in the AEC industry (Gultekin et al., 2013). The contractual arrangements under IPD provide a framework for cost and quality control, harmonized efforts, and converging interests (Paik et al., 2017; Zaghloul & Hartman, 2003). Hall et al. (2014) argue that the concept of "Master Builder" is re-envisioned through IPD.

According to AIA (2007), the key actors participating in IPD projects (1) are contractually bound together under a single multiparty contract, (2) join at early stages of the project and execute collaborative decision-making and management of the work, (3) share the financial risks and profits based on project success which is evaluated by collectively developed criteria, (4) openly communicate with fiscal transparency, and (5) have limited liability among themselves. IPDs are expected to be highly likely to achieve their performance goals due to unique strategies such as tying organizational success to project success (Ashcraft, 2014; Fischer et al., 2017; Molenaar, Sobin, & Antillón, 2010; Zhang, Cheng, & Fan, 2016). The benefits of IPD (AIA, 2012; IPDA, 2016; Pishdad-Bozorgi & Beliveau, 2016a, 2016b) and its superior performance compared to other, more conventional, PDMs have been demonstrated in several studies (El Asmar et al., 2013, 2016; Hanna, 2016).

The AEC industry professionals and project owners are generally familiar with conventional project delivery methods such as DBB, DB, and CM. On this basis, they can select the appropriate PDM for different types of projects. However, industry stakeholders are less familiar with IPD and its features (Bilbo, Bigelow, Escamilla, & Lockwood, 2015; Hanna, 2016). The results of a survey conducted by AIA indicate that only 40% of AIA members have an "understanding" of IPD, and only 13% have implemented this PDM (AIA, 2011). Kent and Becerik-Gerber (2010) also reported similar results: more than half (55.3%) of respondents had no direct experience with IPD. Biblo et al. (2015) attribute the low adoption of IPD to lack of

awareness about this method across the industry. Other reasons could be uncertainty about the suitability of projects, stakeholders, and owners for this PDM.

The benefits of IPD have been documented through a number of case studies. However, to the best of my knowledge, there is no systematic study of how IPD has been chosen as the delivery method over conventional alternatives. The present study was designed to address this knowledge gap through the following questions:

- What are the perceived benefits of IPD that encourage stakeholders to choose this method over conventional PDMs?
- What project characteristics are believed to make it suitable for IPD?
- What are the characteristics of owners who are recognized to be suited for the adoption of IPD?

I conducted a literature review to identify the reported benefits of IPD. Informed by that step, I devised the protocol for semi-structured interviews with 39 industry stakeholders to understand their perception of IPD benefits and seek answers to the other two questions listed above.

The remainder of this paper is structured as follows. Section 2.2 explains the methodology and the procedures for data collection and analysis. Section 2.3 presents the findings. Section 2.4 provides a discussion of the outcomes. I conclude by discussing the theoretical and practical implications of my findings, the limitations of the work and the opportunities for future research (Section 2.5).

2.2 Methods

This study was conducted in two phases. In *Phase I*, a literature review was conducted to identify the reported benefits of IPD. In *Phase II*, representatives from three primary stakeholder groups: Owners, Constructors, and Designers, who had IPD experience were interviewed to (1) capture the perceived benefits of IPD and reasons behind choosing IPD rather than other delivery methods, and (2) characterize projects and project owners perceived to be suitable for IPD use.

The findings from *Phase II* are used to identify concordance between case study literature, and research participants' perspectives, and also to characterize and compare the responses of Owners, Constructors, and Designers.

2.2.1 Phase I

The scope of the literature survey was limited to publications between 2010-17, reporting on case studies that used IPD to deliver a building in the U.S. or Canada. Case studies of other types of construction projects such as bridges, roads, or utility infrastructure projects using IPD, and purely conceptual and theoretical articles, were excluded. The literature search included: books, conference proceedings, professional magazines, white papers, theses, and peer-reviewed journals. These search criteria led to 23 publications. Content analysis was used to gather information about IPD benefits and reasons for its use from these publications. Three distinct approaches to content analysis are available: conventional, directed, and summative (Hsieh & Shannon, 2005). I used the conventional approach. IPD benefits and reasons for its adoption that were reported in the selected publications were captured and documented as codes. These codes were used in the process of content analysis to identify emergent themes. The pattern matching technique (Saldana, 2015) was then employed to group the data with common themes into a smaller number of categories. The results are presented in Section 2.3.

2.2.2 Phase II

In *Phase II*, I used semi-structured interviews to gather qualitative information regarding the research questions. Marshal (1996) notes that a qualitative approach is the most suitable way of answering 'why?' and 'how?' questions. Adoption of the semi-structured interview method allows researchers to pose key questions without limiting the scope of in-depth discussions that would follow with participants (Noor, 2008).

A purposeful sampling strategy (Creswell, 2012) was adopted to identify interviewees from three primary stakeholder groups—Owners, Constructors, and Designers—who had worked in both IPD (using multiparty contracts) and non-IPD projects in the U.S. and/or Canada and had the capacity to inform the study. IPD case study reports, research papers, white papers, and publicly available IPD projects descriptions were reviewed, and members of the AIA IPD steering committee were contacted to identify IPD projects owners and participants. The participating

firms were contacted to identify individuals who worked on IPD projects. These potential interviewees were contacted by email/LinkedIn. In the first contact, I introduced the purpose of the study, asked the individuals to confirm their fit with the sampling criteria and willingness to participate in the research, and invited them to recommend other potential participants. I contacted 70 individuals in total. Thirty-nine respondents met the selection criteria and were interested in participating in the research. Twelve of these individuals were identified through iterative identification by those that were contacted initially (Herath, 2004).

Five potential participants were invited to pilot test the interview protocol. This step helped in refining the interview questions and maximizing their effectiveness. After this stage, the revised protocol (See Appendix A) was used for conducting the interviews. In total, 39 interviews were carried out (11 phone interviews, 28 in-person interviews) between July and October 2016, each averaging one hour. For conducting the in-person interviews, I met with the participants at their project sites or offices in the U.S. or Canada. Table 2-1 summarizes participants' demographics. To protect confidentiality, participants are identified by stakeholder group and numbers (e.g., owner O1-O16; constructor C1-C8; designer D1-D15). In Table 2-1, the Owners group includes participants that acted as project owners/clients or owner's representatives in IPD projects; the Constructors group includes general contractors and trade partners; and the Designers group includes architects, engineers, and interior designers. Overall, the interviewees had been participants in more than two dozen IPD projects (delivered under multiparty contracts as reported by the interviewees) in the U.S. and Canada. In general, these projects were complex institutional facilities and commercial buildings including healthcare facilities, academic buildings, civic facilities, offices, and laboratories. These projects were located in five U.S. regions and the two regions in Canada listed in Table 2-1. The interviewees are not intended to represent all AEC professionals with IPD experience, but rather as a sub-group who were enthusiastic about sharing their knowledge and experience with this PDM.

Table 2-1: Research participants' demographics

Participants demographics	All groups	Owners	Constructors	Designers
Total number	39	16	8	15
Gender				
Female	11	4	1	6
Male	28	12	7	9
Experience with IPD				
One time only	17	8	0	9
> One time	22	8	8	6
Location				
U.S.-West	4	1	2	1
U.S.-Southwest	5	0	0	5
U.S.-Midwest	12	8	2	2
U.S.-Southeast	9	5	0	4
U.S.-Northeast	2	0	0	2
Canada-Ontario	6	2	3	1
Canada-Prairies	1	0	1	0

All except five respondents consented to be audio recorded. The verbatim transcripts were produced thereafter for 34 recorded interviews; I took notes of the participants' responses and the comments they made during those five interviews that were not audio recorded. The field notes and transcripts were compiled and coded using NVivo software (version 11), a qualitative data analysis tool. Coding was first conducted based on a deductive approach (Elo & Kyngäs, 2008; Marshall & Rossman, 2014) to test whether or not the industry actors' perspectives regarding the research questions are consistent with the findings from the literature review. The interview materials were coded for correspondence with or exemplification of the categories and coding schemes that emerged from the content analysis of *Phase I*.

The subset of data that did not fit the categories constructed in *Phase I* were analyzed based on an inductive approach (Elo & Kyngäs, 2008; Patton, 2002). In this process, new categories were freely created to identify the emergent themes. The Pattern matching technique (Saldana, 2015) was used afterwards to group the statements with a common code into a smaller number of categories. Multiple iterations of coding were conducted to reassess the coding structure and the identified themes; this is an internal validity measure in qualitative research used to improve the credibility of the findings and control for agreement among the coding results (Creswell, 2013). Also, the outcomes of *Phase I* and *II* were triangulated. Triangulation is a validation technique in qualitative research that uses multiple sources of data (e.g., literature review and interviews with

different stakeholder groups as conducted in this study) to provide corroborating evidence (Creswell, 2012; Ely, Anzul, Friedman, Garner, & Steinmetz, 1991; Miles & Huberman, 1994). The results of this work are presented in Sections 2.3 and 2.4.

The interviews were used to capture in-depth qualitative data, and also to identify the trends and prevalent themes, as well as the concordance among and across different groups of participants. Therefore, to add further context to the qualitative findings, descriptive statistics (e.g., proportions) were used, where appropriate. This step was done to describe the trends in this context, not to infer or suggest generalizability (Hsieh & Shannon, 2005). To summarize the themes in the qualitative interview data, I used counts of concepts raised by each interviewee and aggregated these by Owners, Constructors, and Designers; this helped me develop a graphic approach to display the patterns of agreement and disagreement among the participants. Moreover, I tested differences across different groups for statistical significance. A set of binary values (0 or 1) was created for each identified IPD benefit and reason for its adoption, as well as each suitability characteristic specified by the participants. For example, if respondent O1 pointed to IPD benefit X, the value was coded to 1; if not, to 0. The dataset follows a binomial distribution as it only contained values of 0 or 1. Generalized Linear Model (GLM) with *logit* function (Whitlock & Schluter, 2015) was used to test the differences between groups. The null hypothesis was that different groups held similar views in relation to the identified benefits and suitability characteristics of IPD. The reviewed literature is silent on this point or on whether subjective perspectives evolve with the extent of IPD experience. The analyses show that on some issues, stakeholders' perspectives differ to statistically significant levels, but that the extent of experience with IPD does not lead to an evolution in perspectives. The results are elaborated in Section 2.3.

For those perceived benefits and reasons for selecting IPD that the GLM test identified significant differences (at 0.001, 0.01, or 0.05 levels) between the three groups of stakeholders, TukeyHSD test using *glht* function (Whitlock & Schluter, 2015) in the multcomp package in R Studio was used to determine the differences between each pair (Owners and Constructors, Constructors and Designers, Owners and Designers). To help the reader better understand the

methodology, all the steps taken in the process of data collection and analysis are demonstrated in Figure 2.1. The findings are presented in the following section.

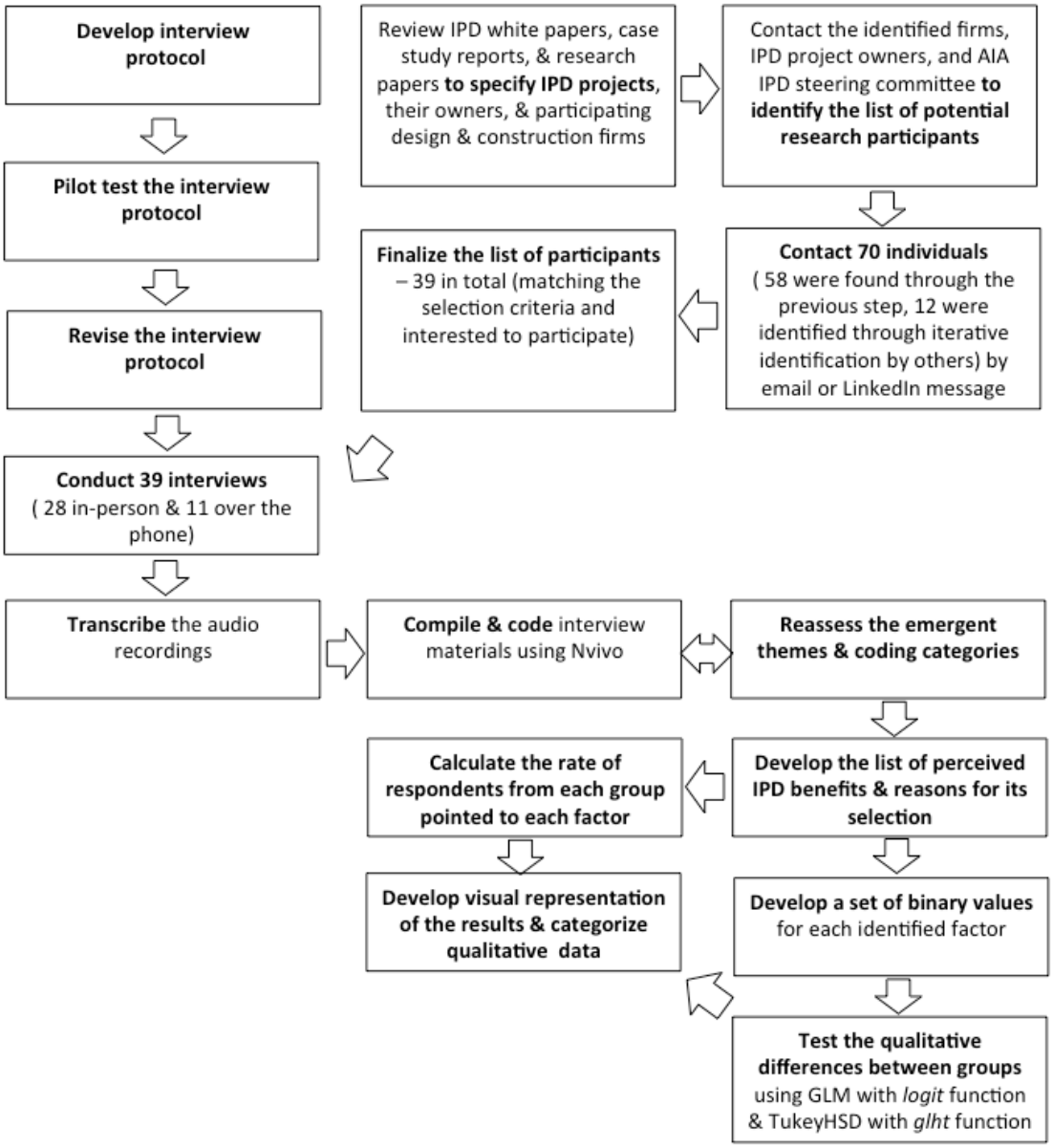


Figure 2.1: Schematic of the steps taken for data collection and analysis

2.3 Findings

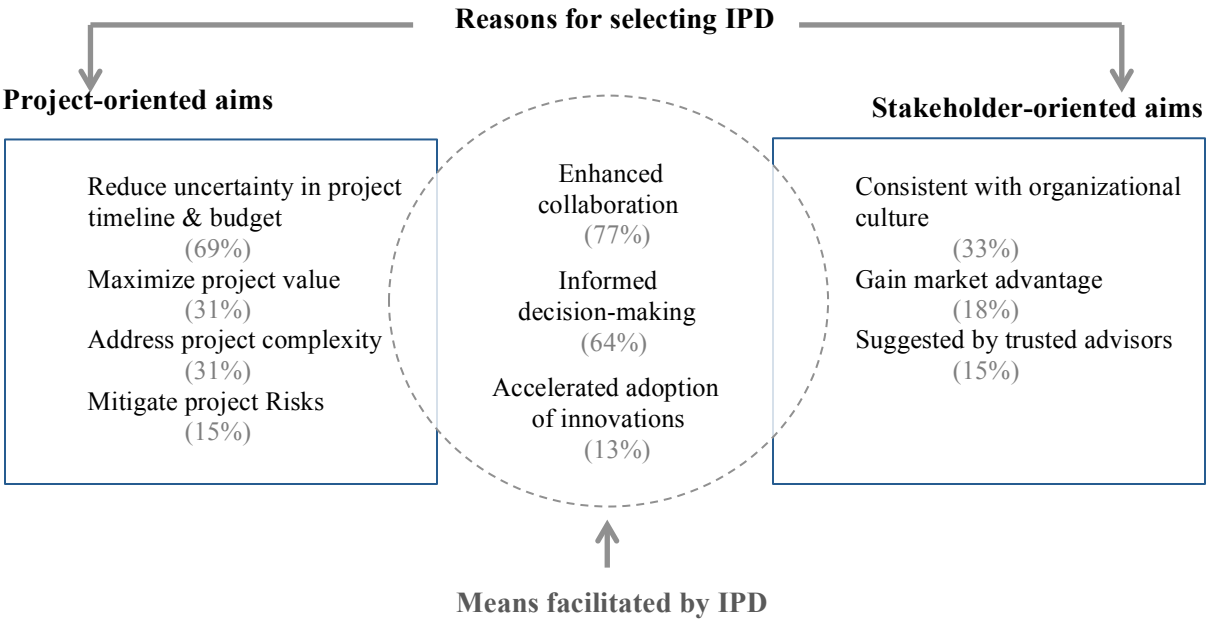
Table 2-2 lists the IPD benefits identified in *Phase I*. It is likely that there are additional benefits in selecting IPD; however, this table only lists those that were explicitly reported in the case studies reviewed for this study. The references are listed in the chronological order indicating when each concept was first mentioned in the literature. This table is useful for understanding the answer to the question: "why use IPD?"

Table 2-2: Summary of IPD benefits reported in the reviewed literature

IPD benefits	References ordered by date of publication																							
	%	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Enhancing collaboration	57	✓	✓		✓				✓		✓	✓	✓		✓	✓	✓		✓			✓	✓	
Achieving project goals	43	✓			✓	✓		✓					✓		✓		✓		✓			✓	✓	
Gaining market advantage	22	✓		✓			✓									✓						✓		
Mitigating project risks	22		✓				✓	✓						✓								✓		
Maximizing project value	9		✓																			✓		
Facilitating innovation adoption	17						✓							✓				✓	✓					
Addressing project complexity	17						✓									✓			✓			✓		
Enabling informed decision making	13							✓	✓													✓		
Facilitating BIM utilization	4									✓														
Being consistent with the firm's organizational culture	13										✓											✓		✓
Promoting trust	9																			✓	✓			

✓ indicates inclusion of the specific IPD benefit in the reference.
References: A= AIA (2010); B= Duke et al. (2010) ; C= Becerik-Gerber & Kent (2010);D= Kent & Becerik-Gerber (2010);E= Ghassemi& Becerik-Gerber (2011);F= AIA (2012) ;G= Lee et al. (2013);H= Zhang et al. (2013);I= Bynum et al. (2013);J= Ashcraft (2013);K= El Asmar et al. (2013); L= Lostuvali et al. (2014) ;M= Hall et al. (2014);N= Bilbo at al.(2015) ;O= Cheng et al. (2015);P= CEC (2015);Q= Hall & Lehtinen (2015);R= Bygballe et al.(2015); S= Pishdad-Bozorgi & Beliveau(2016b);T= Pishdad-Bozorgi & Beliveau (2016a);U= IPDA (2016);V= Franz et al.(2017); W= Paik et al. (2017).

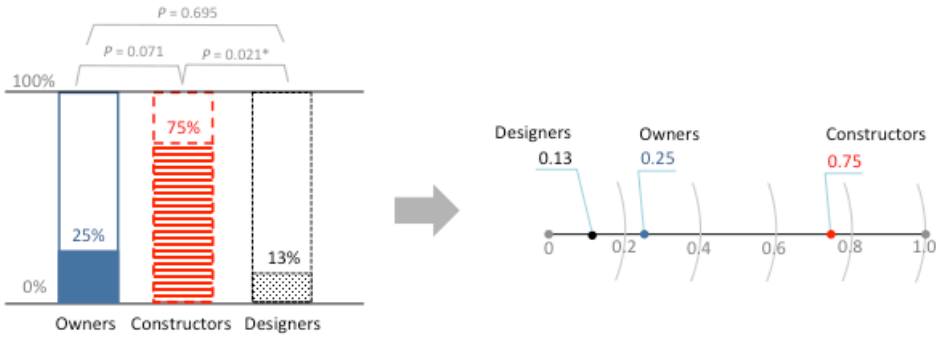
Adopting a means and ends approach to categorizing reasons for selecting IPD that were perceived and mentioned by the research participants, I found seven ends relevant to the project and stakeholders, and three means of meeting these ends facilitated by IPD (Figure 2.2).



Note: The numbers in parentheses indicate the % of participants that pointed to each factor

Figure 2.2: A means/ends description of reasons for selecting IPD as perceived by the respondents

The key insight from this study is best depicted as how different stakeholders perceived benefits of IPD and their reasons for selecting this PDM, as well as how they perceived characteristics of projects and project owners suitable for this PDM. These findings are summarized in Figure 2.4 and Figure 2.7. Figure 2.3 uses one of the identified IPD benefits and reasons for its selection ("Maximize project value") as an example to provide a depiction of how I translate stakeholder responses into a scalar metric and compare responses across stakeholder groups. In Figure 2.3, I represent the frequency with which different stakeholders mentioned the IPD benefit of ("Maximize project value"). Furthermore, this scalar variable allows me to compare the response from different stakeholders and test whether they represent statistically distinct responses from various stakeholder groups.



An example of perceived IPD benefits	*P*- value (O-C-D)
Maximize project value**	0.009

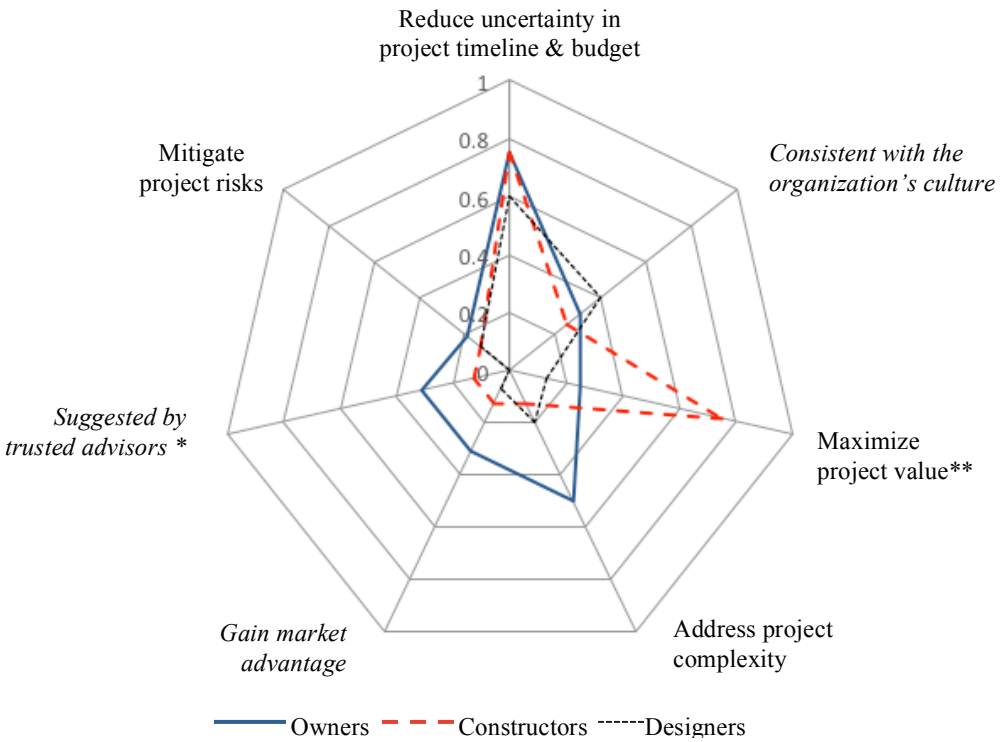
Note: Two ways of visualizing the rate of respondents from Owners, Constructors, and Designers who pointed to the IPD benefit of: "Maximize project value" are presented in this figure. Statistically significant difference at 0.01 level (**) was found between the fractions of respondents from the three groups that pointed to this perceived IPD benefit (*p*-value: 0.009). O-C-D: comparison between Owners, Constructors, and Designers.

Figure 2.3: A visual explanation of how research findings are summarized into a scalar metric using the perceived IPD benefit of "Maximize project value" as an example

It can be seen from the bar chart presented in Figure 2.3, that 25% of Owners, 75% of Constructors, and 13% of Designers pointed to "Maximize project value." These results are plotted on a scale from 0-1 with stakeholders differentiated by color (dark blue for Owners, red for Constructors, and gray for Designers). Furthermore, Figure 2.3 shows that there are statistically significant differences between perceptions of the three stakeholder groups with regard to "Maximize project value," as a reason for selecting IPD – reported as a *p*-value of 0.009 for the differences among Owners, Constructors, and Designers. This result is statistically significant at the 0.01 level (marked with two asterisks (**)).

In Figure 2.4, I use a scalar for each of the seven factors representing project and stakeholder ends as discussed by stakeholders (plotting them along one axis of the polygon). Each axis is just as described in Figure 2.3, both in depiction and display of statistically significant differences among stakeholders. Each corner of the polygon represents one factor. The score along each polygon axis represents the fraction of respondents from each stakeholder group who mentioned that specific factor. A score of 1 means every member of that stakeholder group mentioned this driver and 0.5 indicates that only half the group mentioned it. Different line styles were used to represent the responses from each stakeholder group. The solid blue line represents Owners, the

dashed red line represents Constructors, and the dotted gray line represents Designers. The factors around this polygon are listed clockwise in descending order of total frequency of being noted by all stakeholders.



Reasons for selecting IPD	*p*-value			
	O-C-D	**D-O**	**C-O**	**C-D**
Maximize project value	0.009**	0.695	0.071	0.021*
Suggested by trusted advisors	0.023*	0.334	0.556	0.999

Note: Factors with statistically significant differences at ≤0.01 (**) and ≤0.05 (*) levels among stakeholder groups are listed in this table. O-C-D: comparison between Owners, Constructors, & Designer; D-O: comparison between Designers & Owners; C-O: comparison between Constructors & Owners; C-D: comparison between Constructors & Designers. In this graph, the project ends are romanized, and stakeholder ends are *italicized*. The rate of the respondents within each sector who pointed to each factor increases with distance from the center.

Figure 2.4: Summary of reasons (project-oriented and stakeholders-oriented ends) for selecting IPD as perceived by the interviewees of three stakeholder groups

Figure 2.4 shows that the stakeholder ends were generally mentioned by a larger fraction of Owners than Constructors or Designers. This figure also shows that the level of concordance among stakeholder groups varies across different factors. For example, while the concordance level is relatively high for "Reduce uncertainty in project timeline and budget," it is relatively

low for “Maximize project value” (Figure 2.4). Statistically significant differences were found between the three stakeholder groups in relation to two of the factors they mentioned as benefits of IPD and the reasons for selecting this PDM (Figure 2.4). As explained earlier, this means that the fractions of participants from the three groups that pointed to these two factors were statistically different. For example, it can be seen in Figure 2.4 that the statistical test showed a *p*-value of 0.009 for “Maximize project value,” a specified reason for selecting IPD. This result is statistically significant at the 0.01 level (marked with two asterisks (**)), and indicates that statistically different fractions of Owners, Constructors, and Designers pointed to “Maximize project value.” The *p*-values related to comparisons between each pair are also presented in Figure 2.4.

Power analysis was conducted to determine the probability of detecting an effect size of 0.15, which is a medium effect size for linear models according to Cohen (1988). The results indicate that for a sample size of 39 and with a significance level of 0.05 (Whitlock & Schluter, 2015), this study has 54% power to detect an effect size of 0.15. This means that there is 54% probability that the statistical tests can reject the null hypothesis and conclude that there are significant differences between the three stakeholder groups in relation to their perceptions regarding the benefits of IPD. According to the power calculations, to reach higher percentages of power, for example, 80% which is commonly used by scholars (J. Cohen, 1988), a sample size of 67 was required. It is important to mention that the primary objective of this research was to collect in-depth qualitative data regarding the perceived benefits of IPD, and not to infer generalizability with regard to differences between different groups of respondents.

As noted earlier, the qualitative data collected from the interviews were also used to identify the characteristics of projects and project owners recognized to be suitable for IPD. The project characteristics identified to be important to examine when selecting IPD and the characteristics of project owners perceived to be suitable for this PDM are listed in Figure 2.5 and Figure 2.6, respectively. The percentages indicated in parentheses in these two figures represent the fraction of respondents from all stakeholders that pointed to each characteristic. Figure 2.7 uses the approach taken to develop Figure 2.4, for summarizing stakeholder perceptions about IPD projects and owners’ characteristics. The respondents pointed to five categories of project

characteristics that need to be examined for selecting IPD (Figure 2.5 and Figure 2.7). Project complexity and size and dollar value were mentioned by more respondents than categories such as ownership type or the regulatory context. Figure 2.7 also shows that the level of concordance among the three groups varies across different categories. For example, the concordance level is relatively high for "Size and dollar value," but not for "Ownership type" which was only noted by a small number of Designers.

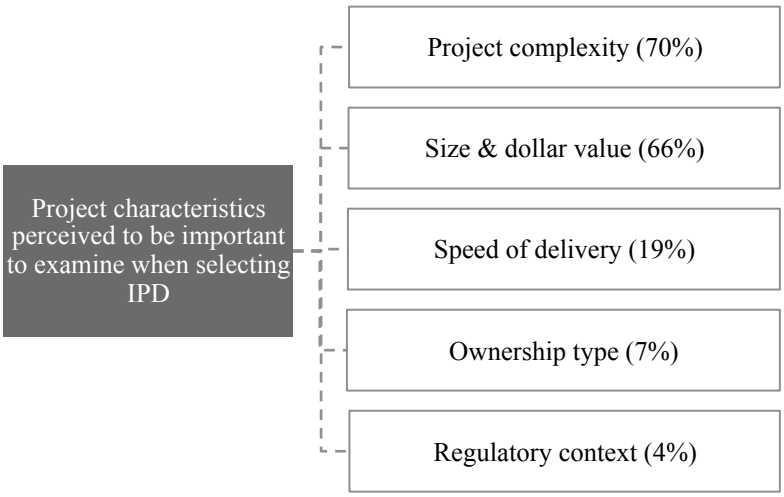


Figure 2.5: Project characteristics perceived to be important to examine when selecting IPD and the frequency of participants that pointed to each factor

Project participants identified seven characteristics that an owner should have to be a suitable and true partner for IPD (Figure 2.6 and Figure 2.7).

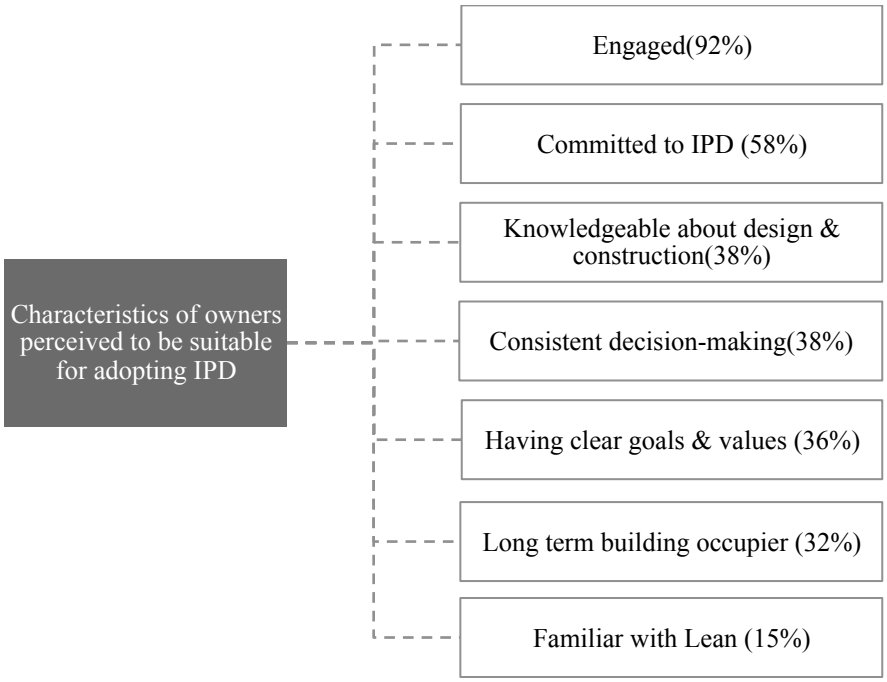
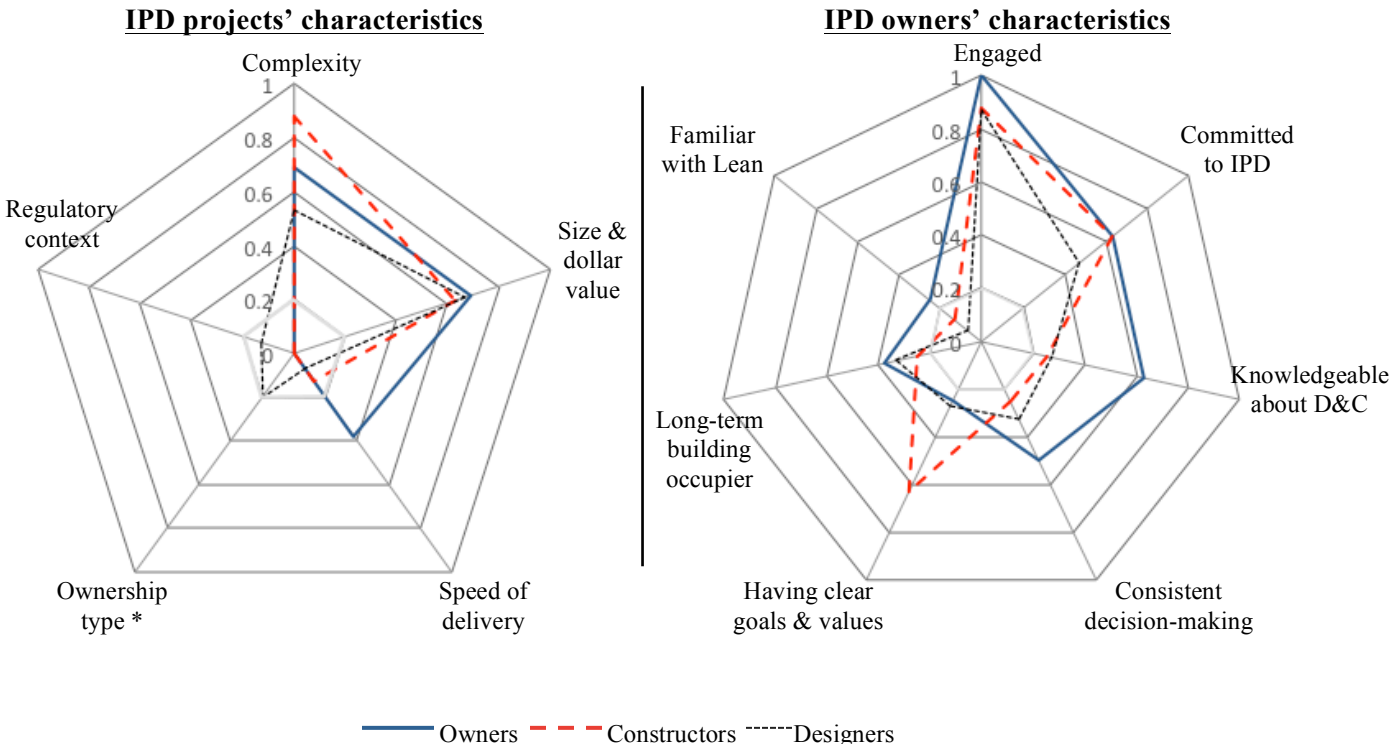


Figure 2.6: Characteristics of owners perceived to be suitable for adopting IPD and the frequency of participants that pointed to each factor

To be engaged in the process and to be committed to IPD are two characteristics that were noted by a large fraction of respondents. Many owners believed that being knowledgeable about design and construction is also an important characteristic that owners should have if they want to participate in an IPD. This characteristic was only mentioned by less than 40% of Constructors and Designers (Figure 2.7).



IPD projects characteristics	*p*-value			
	O-C-D	**D-O**	**C-O**	**C-D**
Ownership type	0.046*	0.999	1	0.999

Note: The factor with a statistically significant difference at ≤0.05 (*) level among stakeholder groups is listed in this table. O-C-D: comparison between Owners, Constructors, & Designer; D-O: comparison between Designers & Owners; C-O: comparison between Constructors & Owners; C-D: comparison between Constructors & Designers. The rate of the respondents within each sector who pointed to each factor increases with distance from the center.

Figure 2.7: Summary of IPD projects and owners' characteristics as perceived by the interviewees of three stakeholder groups

Respondents' perceptions were also analyzed to test whether experience with IPD makes a difference to responses. The results indicate that experience only changes a small subset of findings. Greater experience with IPD led to more emphasis on project value. In contrast, first-timers emphasized the speed of delivery. The details of these results are presented in Figure B-1 and Figure B-2 in Appendix B.

2.3.1 Reasons for Selecting IPD

All IPD benefits identified in the reviewed publications were checked and validated via the interview results except two: promoting trust (Pishdad-Bozorgi & Beliveau, 2016a, 2016b), and

facilitating BIM utilization (Bynum et al., 2013). The interviews introduced one stakeholder-oriented factor ("Suggested by trusted advisors") that was not noted in the reviewed literature. It is noteworthy that this factor was identified by a relatively small fraction of interviewees (15%). One of the project-oriented benefits/ reasons ("Reduce uncertainty in project timeline and budget") was mentioned by more than half of the respondents (Figure 2.2). The details of support by stakeholder group for this factor is presented below:

2.3.1.1 Reduce Uncertainty in Project Timeline and Budget:

Three quarter of Owners and Constructors and more than half of Designers (60%) noted that IPD is being chosen to assure accountability of performance by team members and therefore reduce uncertainty in achieving project goals. These respondents explained that the contractual environment and financial arrangements within IPD require project participants to aim for the common goal of project success. One designer said as firms' compensations are tied to project success under IPD, there is more incentive to perform better as a project participant and realize project goals such as those related to timeline and budget.

> *"…In IPD, we are not just going to talk about the project goals in the initial kick-off visioning meeting. In the next 30 months that we are designing and constructing the building, we are going to hold ourselves accountable to them."(D11)*

The interviews also highlight that IPD project participants collectively design a set of performance metrics as they negotiate the IPD contract. These performance metrics are then used to assess the project outcomes and determine the share of each participant from the profit pool. The respondents explained that the performance metrics under IPD are designed based on the project values. These may include lowest first cost, shortest delivery time, lowest maintenance cost, improved energy performance of the building, and enhanced occupants' experience.

Several respondents mentioned that generally there is less certainty in achieving project goals where conventional delivery methods are used. One owner described that in DB, for example, the design-builder's economic model typically does not provide the owner with the best quality. This respondent explained that under DB, design and construction entities tend to deliver the

building to the agreed price; however, the quality of the final product can be lower than what the owner desired.

2.3.2 Means facilitated by IPD

Two of the specified means that help achieve the project-oriented ends and are facilitated by IPD were mentioned by more than half of the respondents (Figure 2.2). These two are described below:

2.3.2.1 Enhanced Collaboration:

The majority of respondents from all stakeholder groups (69% of Owners, 75% of Constructors, and 87% of Designers) explained that IPD structure enhances collaboration among project team members, which helps in achieving project ends. Many of these respondents noted that multiparty agreements with shared risk and reward principles encourage a high level of collaboration that cannot be achieved through conventional methods.

> *"…In DB [design-build] for example, people collaborate, but as there is not that contractual tie for sharing profits by everybody, people collaborate only to a certain point and you are not going to have that level of transparency. It's because you say well, I only get 5%, so I work only for that 5%."(C4)*

A number of respondents, mainly from Designers, highlighted that IPD engenders a team approach towards problem-solving, which is key to project success.

> *"…You select IPD because you are trying to get a more holistic approach to the project as opposed to a more traditionally defined approach. So, in here [IPD] you get more cooperation, faster results, and hopefully better ones. You get everybody earlier, working together for the same goals."(D15)*

2.3.2.2 Informed Decision Making:

Fifty-six percent of Owners, 63% of Constructors and a larger fraction of Designers (73%) believed that IPD enables informed decision-making throughout the project. This subset of respondents pointed to the early involvement of key stakeholders under IPD, describing how it

allows the project to benefit from the inputs provided by various parties. A number of owners noted that under conventional methods, projects are sometimes delivered without an accurate understanding of owners' needs; however, IPD allows them to get engaged in the process and provide input. Twelve respondents from Constructors and Designers confirmed the importance of owners' input and active participation in the project.

> *"Under IPD, owners have far more knowledge of the building operation systems, so when they deal with their operations, they are far better educated on how the building should function. Under conventional methods, we all do operational manuals at the end of the project, but half the time they gather dust on the shelf, and no one opens them."(D8)*

Furthermore, many designers pointed to the benefits of early involvement of constructors, especially trade partners, and described how it helps them in the design process. One designer said IPD allows the team to move together throughout different phases of the project as opposed to conventional methods where some members join later and undo what has been done before.

2.3.3 Projects Suitable for IPD

The findings show that five project characteristics are believed to be important to examine when selecting IPD (Figure 2.5). About two-thirds of the participants pointed to project complexity, and size and dollar value (70% and 66%, respectively). A brief description of how each stakeholder group views these project characteristics are described below. Three other project characteristics were also mentioned, but by only a small fraction of interviewees (Figure 2.5).

2.3.3.1 Project complexity:

Sixty-nine percent of Owners, 88% of Constructors, and slightly more than half of Designers (53%) pointed to project complexity as an important factor to examine when selecting IPD. All these participants believed that the complexity of the project favours selecting IPD as the delivery method. It was explained throughout the interviews that complex buildings with highly integrated systems require technical expertise from different specialists, and engender complexity in all three domains of project delivery explained by Thomsen et al. (2009): the *project's organization*, the *commercial terms*, and the *operating system*. These projects require a

high level of coordination and communication among team members, which can be facilitated through IPD. Many participants noted that a project's procurement team needs to carefully assess the degree of product and organizational complexity at the early stages of the project to be able to select a suitable PDM. The interviewees believed that IPD is capable of addressing project complexity. For instance, one constructor explained that IPD allows the project team to capture a comprehensive understanding of the building as a whole, which is the key to solving complex problems.

2.3.3.2 Project size and dollar value:

Sixty-nine percent of Owners, 63% of Constructors, and 67% of Designers pointed to project size and dollar value as another factor that needs careful examination when selecting PDM. Two third of these respondents believed that given the organizational and transactional costs for IPD, this method should only be used in large projects with a high dollar value. The other third believe that IPD is suitable for any size project. Interestingly, those who advised limiting the use of IPD in larger projects were those with least experience. Those who thought IPD was useful regardless of project size were the stakeholders with the greatest level of experience using IPD.

The interviewees pointed to various cost thresholds for a project to be suitable for IPD; however, all agreed that the larger the project, the easier it is to implement IPD. Two owners, both with one-time-only IPD experience, noted that IPD use is advantageous in projects that cost more than $35M. These interviewees mentioned that for projects with lower costs, IPD could be used as a philosophy, and some of its tools (e.g., Lean tools) can be adopted in the project; however, applying it fully with the use of multi-party contracts is not beneficial. These participants explained that full implementation of IPD requires a significant amount of resources, particularly at early stages of the project, which can be challenging to provide for small dollar value projects. One constructor who had worked on several IPD projects noted that projects that cost less than $20M are challenging to deliver by IPD.

> *"Anything under 20M dollars is tough because then you are not getting that critical mass of fund and people to do it [IPD]. You can certainly take elements of Lean construction and have partial IPD. IPD is really that type of contract that absorbs the Lean*

construction into it. So, you can take it at a number of levels, but if you want a really good one, you need that critical mass of funds to be able to pay for it." (C4)

One experienced IPD designer believed that the cost threshold for a project to be suitable for IPD is $10M. One owner who had the experience of working in multiple IPD projects mentioned that when IPD was first introduced, there was a general understanding among industry professionals that this PDM is suitable for projects that cost more than $150M. This threshold dropped to $100M and then to $75M as the industry became more experienced with IPD. This participant explained that a thorough cost and benefit analysis is required at the procurement stage to understand both the cost premium for delivering the project with IPD and the expected return on such investment.

2.3.4 Owners Suitable for IPD

The interviewees identified seven characteristics that they perceived would make owners suitable for adopting IPD (Figure 2.6). Ninety-two percent of respondents mentioned that 'being engaged' was vital; 58% mentioned, 'being committed to IPD.' A more detailed description of these characteristics and their role in successful implementation of IPD, from the interviewees' point of view, are discussed below.

2.3.4.1 Engaged:

All Owners, and a vast majority of Constructors (88%) and Designers (87%), noted that an IPD owner needs to be fully engaged and actively participate in the project. Many of these respondents identified significant differences between conventional projects and IPD projects in relation to the role of the owner. They explained that IPD requires the owners to have a much higher level of involvement and responsiveness compared to the conventional methods. Twelve owners stated that those owner organizations who are interested in IPD need to allocate the time and staff to be fully engaged in the IPD process. One Owner noted:

"Owners need to understand that just because you decide to do IPD, it does not mean that it fixes things for you. If you are willing to do IPD, you better be willing to put your time in. If you put your time in, you will get the value out of the project. If you choose not to though, you can very easily counteract the IPD process." (O13)

Several respondents from all three stakeholder groups emphasized that IPD owners need to have a collaborative culture in their organization, believe in a flatter organizational structure, and be willing to act as an equal stakeholder throughout the process. These respondents explained that owner organizations that believe in a hierarchy of power and top-down organizational structure are not suitable for IPD because such cultures prevent true collaboration and engagement. Several respondents mainly from Constructors and Designers added that IPD owners also need to have strong communication skills to be able to participate in the project actively.

2.3.4.2 Committed to IPD:

Sixty-three percent of Owners, and Constructors, and 47% of Designers mentioned that being committed to IPD is a fundamental pre-requisite for an IPD owner. This subset of respondents explained that IPD requires the AEC community to execute the work differently compared to the normal practice. This requirement necessitates major changes in behaviour. Many believed that such changes do not occur unless the owner is fully supportive and committed to IPD principles and processes in all stages of the project. Owners are believed to have a central role in keeping the whole team committed to IPD.

Several incidents were described where IPD teams saw some members revert to traditional habits and stakeholder schisms. According to the respondents, these were more likely to occur when teams were under schedule and budget pressure. Many interviewees emphasized the critical role of owners in managing such situations. One designer said:

> *"Owners have to champion IPD even in difficult situations and maintain a commitment to it; otherwise the whole process will fall apart." (D4)*

Several owners noted that they have often faced resistance to IPD, from either the broader AEC community (i.e., designers, general contractors, trade partners) or various people within their own organizations. Many of them said coping with resisters and naysayers could be a significant challenge for IPD owners. Addressing this challenge requires genuine commitment and belief in this unconventional project-delivery method.

2.4 Discussion

The findings presented here replicate those found in the reviewed literature on factors favouring adoption of IPD. Furthermore, the interviews highlight differences among key stakeholders in relation to their perceptions of IPD benefits and its role in providing a *better* means to meet the ends of projects and stakeholders. The findings show a high level of agreement between Owners, Constructors, and Designers with regard to the role of IPD in reducing uncertainty in project timeline and budget; however, significant differences were observed among the perception of the three groups in relation to the role of IPD in maximizing project values. Notably, a larger fraction of Constructors than Owners and Designers pointed to this factor as a key reason for selecting IPD. This finding suggests that while the majority of all three groups are convinced by IPD's potential in fulfilling project goals, more Constructors believe this PDM is capable of realizing more than the expected values for the project.

It should also be noted that interviewees did not point to "reduced liability concerns" as a reason for selecting IPD. It is possible that the participants assumed this as a given and did not feel the need to bring it up. The level of experience with IPD did not affect the results in general.

The role of IPD in enhancing collaboration among team members and facilitating the achievement of project goals have been highlighted in several other studies as well (e.g., Bilbo et al., 2015; Bygballe et al., 2015; CEC, 2015; Franz et al., 2017; IPDA, 2016; Lostuvali et al., 2014). AIA (2007) highlights that while traditional project delivery encourages unilateral effort, IPD fosters multi-lateral open information sharing and collaboration, providing the opportunity to design, build, and operate as efficiently as possible. Team integration and collaboration throughout the project cycle is vital to optimize the whole, rather than separate slices of the pie (AIA California Council, 2014; CEC, 2015). IPD has a promising system in place for achieving project goals. Developing the project goals collectively, and tying compensations to project outcomes, rather than firms' performance increase the probability of achieving project goals. This argument is supported by other scholars such as Ashcraft (2014) and Fischer et al.(2017).

Realizing project goals in the AEC industry has been a persistent challenge. Our interviewees believe that IPD can be used to address this challenge – given the right project and owner. These

findings confirm previous research showing that owners' engagement throughout projects and their strong on-going commitment to the principles of this PDM are key to the successful implementation of IPD. AIA (2007) identifies specific responsibilities for the owner in each phase of an IPD project which prescribes continuous and active participation of the owner in all phases.

It is generally believed that owner's opportunity to influence project outcomes is enhanced through IPD only if the owner gets fully engaged in the process (Ashcraft, 2013, 2014; Fischer et al., 2017). Fischer et al. (2017) and IPDA (2016) argue that higher level of owner's engagement in IPD leads to higher achievement in projects due to a variety of reasons including early clarification of project goals – this too was noted by respondents in this research. Considering the different roles of the owner under IPD compared to conventional methods, owner organizations need to assure that they have compatible values and culture as well as adequate time and resources to dedicate to the process. My findings indicate that having the ability to make consistent and timely decisions is a key characteristic of owners who are suitable for IPD. This finding can partially explain why several interviewees mentioned that IPD is more suitable for private than public sector projects. Decision-making in the public sector is often characterized as a slow process (e.g., Al-Kharashi & Skitmore, 2009; Arditi, Akan, & Gurdamar, 1985). Moreover, many jurisdictions have statutory and contractual limits for public projects that conflict with IPD. Azhar et al. (2015) acknowledge these limits but expect that the use of IPD in public projects will receive increasing attention in the near future if specific procedural and contractual barriers are addressed.

The findings of this research also show that owner organizations need to continuously renew their support and commitment to IPD principles throughout the process. Ongoing education and training the team members on IPD principles and strategies is both a representation of and also a contributor to a continued commitment to the process.

One of the caveats in this study is that most of the owners interviewed were also going to occupy the buildings being delivered using IPD. This leads to a circular argument in owner engagement. Those who are going to be owner-occupiers can be expected to be more engaged in the project.

Furthermore, to the best of my knowledge, IPD contracts have only once included a clause releasing project funds after a post-occupancy evaluation (Carmichael, 2015). However, if most IPD projects are owner-occupied, the decisions relevant to building performance may be implicit in the design intent and decisions made along the way to address these. Follow up research is needed to explore this issue through interviews with owners who are not occupants of their IPD projects. As shown in several case studies (e.g., El Asmar et al., 2013, 2016; Hanna, 2016), IPD has superior performance compared to conventional methods in several aspects. Therefore, speculative projects may also benefit from IPD improving the performance of the industry as a whole.

A large fraction of participants noted that IPD enhances informed decision-making processes throughout the project. Previous studies have identified various deficiencies in decision-making processes commonly used under conventional delivery methods in the AEC industry. These include lack of transparency and inadequate flow of information, late involvement of key project stakeholders, weak identification of alternatives and decision-analysis, and insufficient documentation of any processes (Arroyo, 2014; Fischer & Adams, 2010). Arroyo (2014) argues that conventional decision-making processes within the AEC industry rarely involve adequate discussion among project participants, and decisions are often made in the absence of a clear and shared rationale. This phenomenon can lead to unnecessary iterations and suboptimal decisions. The issues of transparency and data sharing can be tackled through liability waivers among project participants – a key principle in IPD. Moreover, as AIA (2007) highlights, the contract structure of multi-party agreements forces the parties to communicate closely, discuss and negotiate key decisions. Under this structure, all parties who place their profits at risk are in theory empowered to have a say in the decisions. AIA California Council (2014) notes that this kind of structure facilitates informed decision-making and lowers the probability of errant decisions.

2.5 Conclusion

This study showed that case studies of IPD and semi-structured interviews with 39 AEC industry actors grouped as three stakeholders − Owners, Constructors, and Designers − had broad agreement on the benefits of IPD over conventional PDMs. Participants were able to compare

their experience with IPD to projects delivered using other PDMs in the U.S. and Canada. My study participants' level of experience with IPD projects varied from novice to veteran. Yet, in most cases, their perspectives on the benefits of IPD and the characteristics of projects and project owners recognized to be suited to this method of project delivery were the same.

The interview findings identify seven stakeholder-oriented and project-oriented benefits of IPD that encourage selecting this method over conventional alternatives. Reducing uncertainty in the project timeline and budget was identified as the top reason for selecting IPD. The participants also specified three means facilitated by IPD that help in achieving the project-oriented ends. Enhanced collaboration among project participants and informed decision-making throughout the project are the two means embodied in IPD that were mentioned by the majority of the interviewees. This research also shows that large projects, both in size and scope, and those with a high level of complexity are believed to be particularly well suited for IPD.

This study also presents key characteristics of owners who are recognized to be a good fit for IPD. Notably: being fully engaged, participating in various project stages, and having a strong commitment to IPD principles. Given the advantages of IPD, findings in this study could be used to guide project teams, at the procurement stage, to examine suitability for adopting IPD. The benefits of IPD, project, and stakeholder ends, and how IPD provides the means for achieving these can be utilized for promoting the use of this PDM and educating the industry actors about its potentials, features, and requirements.

There are some limitations to this research including self-selected interviewees, and participants' awareness of my background in architecture. Moreover, the success attributed to the particulars of project and its participants is non-falsifiable. The benefits of IPD adoption more broadly can be established by comparing the outcomes associated with similar projects delivered using conventional PDMs with and without owner-occupied buildings. A follow-up study is required to better understand why stakeholders differ in their perspectives on IPD's fortes and foibles. Future research should also examine the degree to which each of the identified factors contributed to the success/performance of the IPD projects. It would be valuable to study how each of the identified factors (e.g., complexity level of the project, the degree of owners'

commitment to IPD) can be measured. Finally, it is important to track the evolution of the project and owner characteristics as this PDM matures and the industry actors gain more experience with Integrated Project Delivery.

Chapter 3: Perceived Challenges in Implementing Integrated Project Delivery (IPD): Insights from Stakeholders in the U.S. and Canada for a Path Forward

Chapter 2 indicated that there are several benefits associated with the use of IPD. Considering the many benefits related to adopting this PDM, one may ask why this method has not been adopted more broadly, and what are the challenges in implementing IPD in a project? This chapter aims to find answers to these questions.

3.1 Introduction

It was noted that the AEC industry is characterized as an inefficient, fragmented and adversarial environment that delivers projects with lower than expected outcomes resulting in wasted resources and client dissatisfaction (Hanna, 2016; Lichtig, 2006). Many have highlighted the necessity of substantial change in the way projects are structured and executed within the AEC industry (Ashcraft, 2014; CEC, 2015). The aggregate measure of this inefficiency is captured by labour productivity over time. Between 1964 and 2012, labour productivity of the construction industry fell 19%, while all other non-farm industries improved by over 153% (WEF, 2016). A study conducted by the U.S. National Institute of Standards and Technology (NIST) in 2004 indicated the loss of $15.8 billion per year in the AEC industry as a result of inadequate interoperability among computer-aided design, engineering, and software systems (Gallaher, O'Connor, Dettbarn, Jr., & Gilday, 2004). This is equal to 2.7% of the total value added by the construction industry to the U.S. GDP in 2004 (BEA, 2016). This is a small fraction in absolute terms, but a potential indicator of much larger aggregate inefficiency across the whole construction sector. As explained earlier, there are also several post-occupancy evaluation studies (e.g., Bartlett et al., 2014) indicating significant discrepancies between expectations and outcomes in projects delivered by this sector of the economy.

The output of the AEC industry, like many others, is project based (McCoy, Thabet, & Badinelli, 2008; Ramazani & Jergeas, 2014; Taylor & Levitt, 2007; Zhao, McCoy, Kleiner, & Feng, 2016). This is accomplished through a joint effort by specialists from various firms who offer different skill sets and are contracted to work on a specific project (Taylor and Levitt 2004). Thus, the industry can be described as being comprised of *modular clusters* that together

form a whole product (Baldwin & Clark, 2000; Powell, 1990; Schilling, 2000; Staudenmayer, Tripsas, & Tucci, 2005). However in AEC, unlike automobile or airplane manufacturing, these modular clusters are loosely organized around a decentralized structure (Sheffer, 2011), leading to the noted challenges in project delivery.

As noted in Chapter 1, it is widely believed that poor outcomes within the AEC industry are rooted in the segregation of the processes, actors, and the services needed to deliver projects (CEC, 2015; Fergusson, 1993; Lichtig, 2006; Mauck, Lichtig, Christian, & Darrington, 2009). Kent and Becerik-Gerber (2010) argue that the processes, which traditionally used to be led by one "master builder" from conception to completion have become fragmented. The segregation of these processes, and fragmentation among industry sectors have increased, as buildings have become more complex and the industry more specialized (Kent & Becerik-Gerber, 2010). In the AEC industry, firms and individuals often enter into a project in different phases. Under a 'business as usual' approach, project participants are only responsible for their own phase and owners pay the bills and deal with all risks in project outcomes. Optimizing a building as a system is difficult when it is created using a fragmented approach (CEC, 2015). Many have emphasized that shifting towards a more systematized, collaborative and integrated approach to project delivery is needed to improve both quality and efficiency within the AEC industry (AIA, 2007; Ashcraft, 2014; CEC, 2015; Rigby et al., 2012; Rolstadas, Hetland, Jergeas, & Westney, 2011c; Wakefield et al., 2014).

As discussed, various relational project-delivery arrangements have been and are being developed in order to address the challenges born of fragmentation in the industry (Hall et al., 2014; Lahdenperä, 2012); IPD, one such method emerging in North America, is believed by many to have the potential to revolutionize the practices and project outcomes within the AEC industry (El Asmar et al., 2013). In traditional PDMs, the owner has separate contracts with each specialized actor (e.g., the designer, the constructor). In IPD, on the other hand, there is typically one single contract (Kent & Becerik-Gerber, 2010) entered into by the owner and all stakeholders with primary roles in the project (e.g., architects, constructors, trade partners, consultants). Kent and Becerik-Gerber (2010) argue that this contracting approach maximizes collaboration and coordination without disruption by self-interest that dominates the behaviour

of parties operating under separate contracts. The six key principles of IPD presented earlier ((1) multi-party agreement, (2) early involvement of key participants, (3) collaborative decision-making and control, (4) shared risk and rewards, (5) liability waivers among key participants, and (6) jointly developed project goals (AIA, 2007)), have the potential for the formation of a strong team environment and collaborative framework. They also aim to encourage information flow and knowledge sharing among project participants.

The AEC industry has shown great interest in IPD. Professional organizations such as AIA, the Construction Industry Institute (CII), the Construction Users Roundtable (CURT), and ConsensusDOCS have shown their support and interest in IPD (e.g., AIA, 2007, 2012; AIA California Council, 2014; CII, 2011; ConsensusDOCS, 2016; CURT, 2007). In its 2014 report, AIA California Council stated "we are aware of over 200 projects that use multi-party contracts to incentivize and reward their teams in project execution, with likely 100s or even 1,000s that use the principles of IPD to improve project outcomes" (AIA California Council, 2014, p. 1). However, to the best of my knowledge, there are no systematic data on the number and nature of IPD, or IPD inspired projects, in North America.

This trend is also reflected in academic research on IPD. According to Kahvandi et al. (2017), the number of studies on IPD has increased from four in 2007 to 34 in 2014, the majority being from the U.S. Table 3-1 summarizes the primary focus areas in the existing literature on IPD.

Table 3-1: Summary of the primary focus areas in the existing literature on IPD

Primary focus areas in the existing literature on IPD	Examples of references
IPD principles and implementation process	(Nanda, Rybkowski, Pati, & Nejati, 2016), (IPDA, 2016), (Austin, Pishdad-Bozorgi, & Garza, 2016), (CEC, 2015), (Bygballe et al., 2015), (Azhar et al., 2015), (Arroyo, 2014), (Lostuvali et al., 2014), (H. W. Lee et al., 2013), (El-adaway, 2013), (H. Ashcraft, 2013), (Lahdenperä, 2012), (Menches & Chen, 2012), (AIA, 2012), (Ghassemi & Becerik-Gerber, 2011), (Kent & Becerik-Gerber, 2010), (Singleton, 2010), (AIA-AIACC, 2010), (Sumner & Slattery, 2010), (Matthews & Howell, 2005)
IPD and project team environment	(Franz et al., 2017), (Pishdad-Bozorgi & Beliveau, 2016b), (Pishdad-Bozorgi & Beliveau, 2016a), (Seyis, Ergen, & Pizzi, 2016), (Zhang et al., 2016), (Townes, Franz, & Leicht, 2015), (Bygballe et al., 2015), (Arroyo, 2014), (Abdirad & Pishdad-Bozorgi, 2014), (Zhang et al., 2013), (Pishdad & Beliveau, 2010), (Sumner & Slattery, 2010)
IPD in comparison with other project delivery methods	(El Asmar et al., 2016), (Hanna, 2016), (Bilbo et al., 2015), (Hanks, 2015), (Fernandez-Solis et al., 2013), (El Asmar et al., 2013), (Bynum et al., 2013), (Lahdenperä, 2012)
IPD and BIM	(Chang, Pan, & Howard, 2017), (Nawi, Haron, Hamid, Kamar, & Baharuddin, 2014), (Monteiro, Mêda, & Poças Martins, 2014), (Teng, Wu, Zhou, Zhao, & Cao, 2013), (Bynum et al., 2013), (Cooley & Cholakis, 2013), (Ilozor & J Kelly, 2012), (Pishdad & Beliveau, 2010)
IPD and innovation	(Paik et al., 2017), (Paolillo, Olson, & Straub, 2016), (Hall & Lehtinen, 2015), (Hall et al., 2014), (Mollaoglu-Korkmaz et al., 2014)

The benefits of IPD have been demonstrated through numerous case studies (e.g., AIA, 2012; Cheng & Johnson, 2016; El Asmar et al., 2013) and were further investigated in Chapter 2. Reviewing the benefits of IPD lead to the question of why this method has not been more broadly adopted? Hence, it is important to learn of challenges that might be encountered in adopting this process. There is little research on challenges in the implementation of IPD in

practice. The objective of this study is to characterize the challenges in implementing IPD as perceived by three key stakeholder groups: owners, constructors, and designers with IPD experience in the U.S. and Canada. In order to achieve this objective, 39 semi-structured interviews were conducted. Interviewees that had the experience of working in both IPD and non-IPD projects were asked the following question:

- What are the challenges that you have experienced in IPD projects, which you would have not experienced in conventional projects?

The in-depth qualitative data collected from the interviews were also used to answer the following questions:

1- Do practitioners with more IPD experience report different challenges in the implementation of IPD than novice IPD practitioners? If they do, solutions need to be sought at a deeper level than IPD principles alone.
2- Is the local norm for conflict resolution correlated with perceived challenges in adopting IPD? If it is, one needs to design the acculturation process paying attention to prior expectations about dispute resolution.
3- Do IPD practitioners of different genders report different perceptions in the implementation of IPD? If they do, insights from social psychology of collaboration by women and men could be employed in selecting and preparing IPD teams for greater success.

Identifying the challenges helps IPD teams to be better prepared and develop expectations commensurate with their competencies and resources. It also points towards new skills and competencies needed in the industry to benefit from the full potential of IPD.

The structure of this chapter is as follows: section 3.2 describes the methodology used for data collection and analysis. Findings are presented in the following two sections (Sections 3.3 and 3.4). After that, the key lessons for improving the efficacy and success of IPD implementation are discussed (Section 3.5). Finally, the chapter concludes with discussions of the implications of

the findings, broader lessons for understanding the main challenges associated with IPD implementation in the U.S. and Canada, limitations of the present study, and suggestions for follow-up research (Section 3.6).

3.2 Methods

Semi-structured interviews were used to capture a comprehensive understanding of perceived challenges to implementing IPD. Please refer to Section 2.2.2 for the details of interviewees recruitment process, the steps that were taken for pilot testing the interview protocol, the procedure of conducting and recording 39 interviews (with Owners, Constructors, and Designer) and demographics of the study participants. Multi-sectorial perspectives regarding the challenges in implementing IPD relative to conventional project-delivery methods were obtained during the interviews (See Appendix A). Using NVivo software (version 11) coding was carried out based on an inductive approach (Elo & Kyngäs, 2008). Categories were freely generated in the first round of coding to identify the perceived challenges in implementing IPD as expressed by the respondents. The emergent themes were reassessed in the subsequent iterations of coding, and repetitious or very similar categories were removed. These resulted in constructing *level-1* categories of challenge (28 in total) in IPD implementation. The pattern matching technique (Saldana, 2015) was adopted to reduce the number of *level-1* categories by "collapsing" (Burnard, 1991) those that were similar into broader categories. This step resulted in constructing *level-2* categories of challenge (seven in total). The results of these analyses are summarized in Table 3-2.

As described in Section 2.2.2, multiple iterations of coding, comparing the results of the interviews with different stakeholder groups, and reassessing the identified themes were used as validity measure (Creswell, 2013) to control for agreement among the coding results and ensure the reliability of the findings (Creswell, 2012; Ely et al., 1991; Miles & Huberman, 1994).

Similar to the approach taken in Chapter 2 to data analysis, the interviews were not only used to capture in-depth qualitative data but also to identify the trends and prevalent themes, as well as the concordance among and across different groups of participants. Therefore, to add further context to the qualitative findings, descriptive statistics (e.g., proportions) were used where

appropriate. This was done to describe the trends in this specific context, not to infer or suggest generalizability (Hsieh & Shannon, 2005). Moreover, a set of binary values (0 or 1) was developed based on the results specifying who mentioned what challenge. For example, if participant D1 pointed to challenge Y, the corresponding value in the binary set was marked with 1, and if not, with 0. This was conducted to test the qualitative differences in the responses of Owners, Constructors, and Designers for statistical significance. As explained in Section 2.2.2, since the data set only contained values of 0 or 1, following a binomial distribution, the Generalized Linear Model (GLM) with l*ogit* function (Whitlock & Schluter, 2015) was used in this study.

The null hypothesis was that no statistically significant difference exists between the stakeholder groups in relation to the challenges they identified. For those perceived challenges that the GLM test identified significant differences (at 0.001, 0.01, or 0.05 levels) between the three groups, TukeyHSD test using *glht* function (Whitlock & Schluter, 2015) in the multcomp package in R Studio was used to determine the differences between each pair (Owners and Constructors, Constructors and Designers, Owners and Designers). The results are presented in the following section.

3.3 Findings

The analyses identified 28 perceived challenges in implementing IPD relative to conventional project-delivery methods at the *level-1* category, which are grouped in seven broader categories at *level-2* (Table3-2).

Table 3-2: *Level-1* & *Level-2* categories of challenge in implementing IPD

Perceived challenges in implementing IPD	% of participants who pointed to each challenge
Sustaining a collaborative environment	**100**
Communication	85
Ensuring on-going commitment	72
Managing timeline & workload	68
Establishing mutual respect & trust	65
Holding shared responsibilities	38
Documenting & tracking information	23
Changing team members along the project	19
Dealing with the operating environment	**95**
Fragmented industry	83
IPD contract conditions	64
Trade & consultant reluctance to participate in IPD	64
Selecting the right team	**90**
Lack of required characteristics & capabilities	90
Team members' incompatibility	87
Embedding IPD concepts	**90**
Lack of experience with IPD components	90
On-boarding, training & coaching	76
Knowledge gap among actors	54
Making sound & timely decisions	**90**
Group decision-making	58
Issue of power	56
Timing of decision-making	41
Identifying objectives & performance measures	41
Developing & analyzing decision alternatives	37
Ensuring commitment to objectives	28
Changing actors' roles	**67**
Overshadowing designers	51
Ensuring trades' active involvement	36
Owner-architect relationship	13
Developing high-quality design	**62**
Cost & schedule reduction as key targets	50
Conducting design iterations	32
Focus on 1st cost, not life cycle cost	30
Conducting design exploration	22

Note: Level-1 categories are presented in **boldface** and the corresponding relevant Level-2 categories of challenge are listed underneath each.

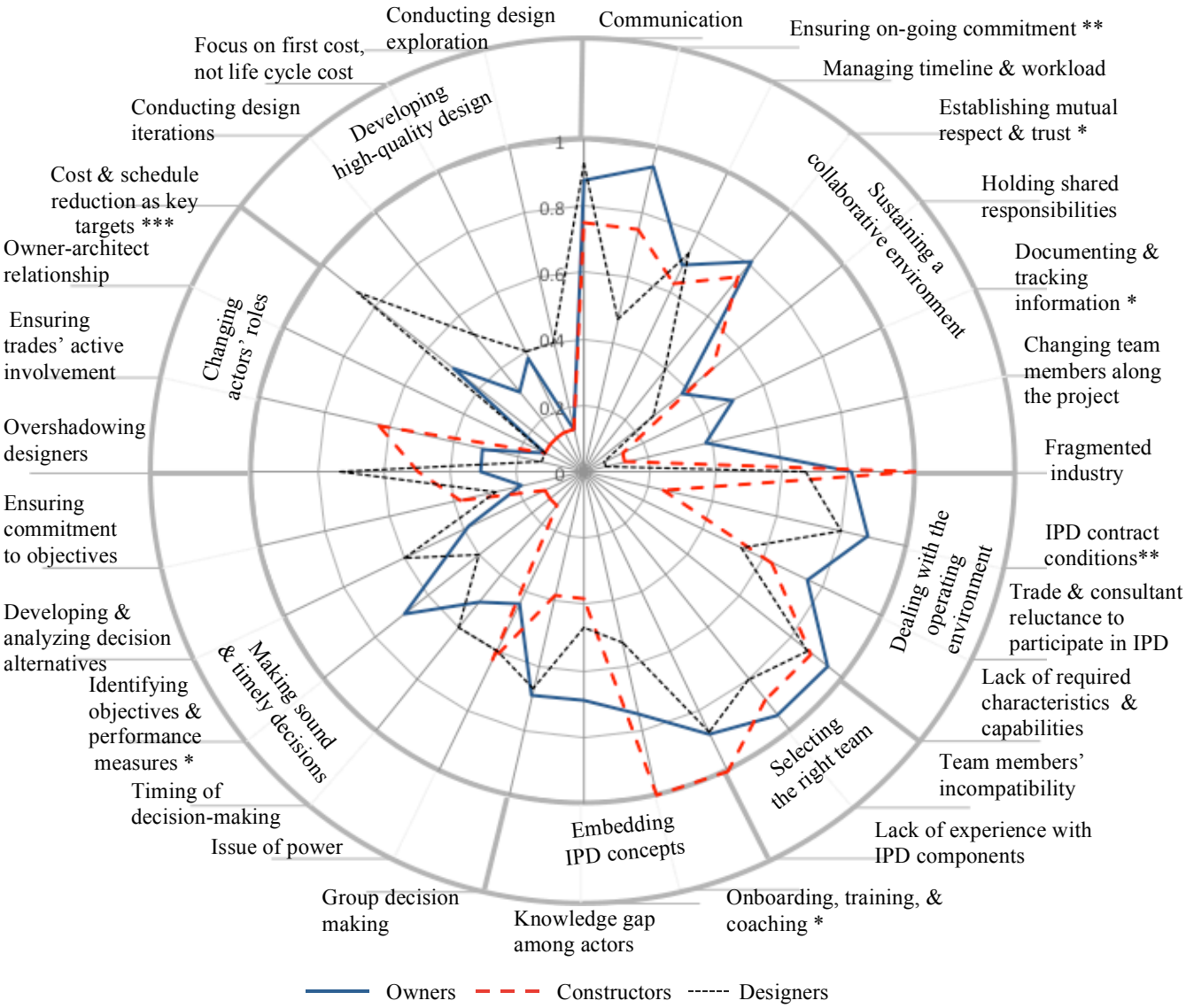
My results show differences between the challenges related to IPD perceived by distinct stakeholder groups. Figure 3.1 presents the results quantitatively. This figure was developed following the approach that was taken for creating Figure 2.4 and Figure 2.7 (See Section 2.3). In

Figure 3.1, *level-1* categories of challenge are listed along each polygon axis; *level-2* categories of challenge are presented in the outer ring. The fraction of the respondents from each stakeholder group who pointed to each of the 28 challenges at the *level-1* category is indicated with a score (between 1 and 0) along each polygon axis. For example, when all members of a stakeholder group pointed to challenge X, the corresponding score was indicated as 1, and when only half of them pointed to that challenge, the score was indicated as 0.5. In Figure 3.1, the rate of the respondents within each sector who pointed to each challenge increases with distance from the center. In this figure, the analyses results of responses from each stakeholder group are presented with a different line style: Owners are presented with the dark blue solid line, Constructors with the red dashed line, and Designers with the gray dotted line.

The seven *level-2* categories of challenges are ordered in the outer ring around the polygon (in the clockwise direction) in descending order of mentions by respondents. The challenges at the *level-1* category are listed within their corresponding group in the order of descending rate of participants (in the clockwise direction) who pointed to them. For example, "Lack of experience with IPD components" was the most commonly mentioned challenge (by 90% of participants) in the group of "Embedding IPD concepts." The challenges related to "knowledge gap among actors" were the least commonly mentioned sub-challenge (by 54% of participants) in this group.

As seen in Figure 3.1, there exist various levels of concordance among Owners, Constructors, and Designers across different identified challenges. For instance, while the concordance level among the three stakeholder groups is relatively high in relation to the challenges regarding "Selecting the right team," it is relatively low in relation to the challenges identified in "Developing high-quality design." Statistically significant differences were found between stakeholder groups in relation to seven of the challenges of the *level-1* category (Figure 3.1). This means that the fractions of participants from the three groups that pointed to these seven challenges were statistically different. For example, it can be seen in Figure 3.1 that the statistical test showed a *p*-value of 0.010 for the challenge of "Ensuring on-going commitment." This result is statistically significant at the 0.01 level (marked with two asterisks (**)), and indicates that statistically different fraction of Owners, Constructors, and Designers pointed to the challenge of

“Ensuring on-going commitment” in the process of IPD implementation. The *p*-values related to comparisons between each pair are also presented in Figure 3.1.



Challenge at the *level-1* category	*p*-value			
	O-C-D	***D-O***	***C-O***	***C-D***
Cost & schedule reduction as key targets	0.001***	0.096	0.221	0.010**
IPD contract conditions	0.006**	0.840	0.017*	0.045*
Ensuring ongoing commitment	0.010**	0.036*	0.435	0.405
Documenting & tracking information	0.012*	0.050*	0.220	0.885
Identifying objectives & performance measures	0.021*	0.246	0.050*	0.392
Onboarding, training & coaching	0.022*	0.381	0.213	0.057
Establishing mutual respect & trust	0.043*	0.062	0.933	0.267

Note: Sub-challenges with statistically significant differences at ≤0.001 (***), ≤0.01 (**) and ≤0.05 (*) levels among stakeholder are listed in this table. O-C-D: comparison between Owners, Constructors, & Designer; D-O: comparison between Designers & Owners; C-O: comparison between Constructors & Owners; C-D: comparison between Constructors & Designers.

Figure 3.1: The challenges in IPD implementation perceived by three stakeholder groups

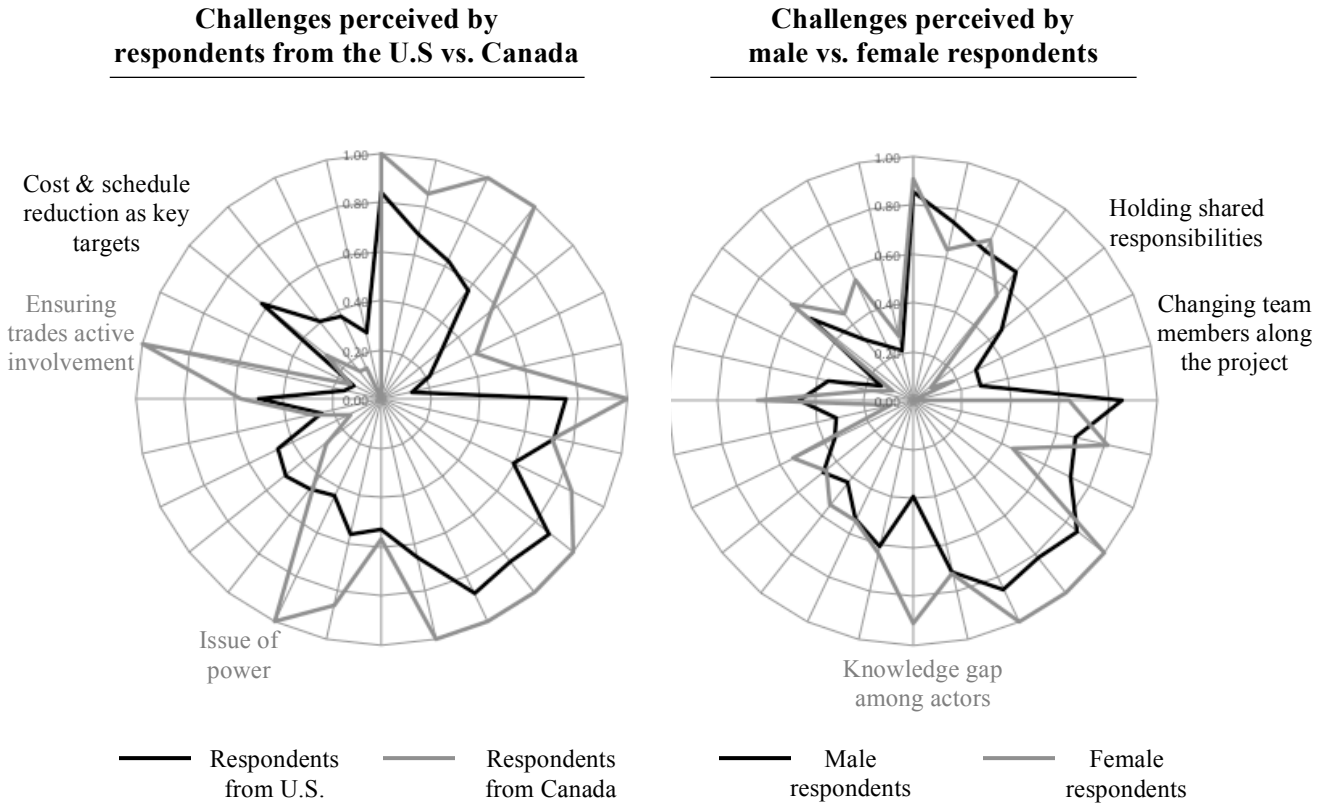
I also tested whether the level of experience with IPD, country of practice, and gender affect the perceptions of the interviewees regarding the challenges of IPD implementation. This was conducted to find answers to the three additional questions presented in Section 3.1. Compared to Canada, the U.S. has a longer history with IPD (AIA, 2007; Matthews & Howell, 2005), and also has a larger number of IPD projects implemented (IPDA, 2016). Moreover, the level of litigiousness is markedly different in these two countries (Tinaikar, 2017). Therefore, I tested whether participants from the U.S., and Canada have different perceptions with regard to challenges in IPD implementation.

Furthermore, many scholars have studied the effect of gender on cooperative and collaborative behavior reporting differences between men and women (Eagly & Johannesen-Schmidt, 2002; Stump, Hilpert, Husman, Chung, & Kim, 2013). Therefore, differences between responses collected from male and female interviewees was tested to understand whether perceptions of challenges of working in IPD, as a collaborative environment, vary by gender.

The analyses show that IPD experience level does not change the outcomes considerably; especially for the top five groups of challenge at the *level-2* category: 1) Sustaining a collaborative environment, 2) Dealing with the operating environment, 3) Selecting the right team, 4) Embedding IPD concepts, and 5) Making sound and timely decisions. The level of experience with IPD was shown to make more noticeable differences in relation to the two less commonly stated groups of challenge at the *level-2* category: "Changing actors' roles," and "Developing high-quality design" (See Figure C-1 and Table C-1 in Appendix C).

Figure 3.2 presents the challenges in IPD implementation as perceived by respondents with different gender and country of practice. It can be seen that these two factors were found to be in correlation with reported perceived challenges. A noticeably larger fraction of respondents from Canada than those from the U.S. pointed to the "Issue of power" and the challenge of "Ensuring trades' active involvement" throughout the project. These are related to two broader categories of challenge: "Making sound and timely decisions," and "Changing actors' roles," respectively. On the contrary, a higher percentage of the respondents from the U.S. than those from Canada highlighted the challenge of "Cost and schedule reduction as key targets" in IPD projects.

The analysis of responses given by male and female interviewees indicated noteworthy results. More men than women found “Holding shared responsibilities” and “Changing team members along the project,” which are part of the larger challenge of “Sustaining a collaborative environment,” challenging. On the other hand, “Knowledge gap among actors” which is a sub-challenge of “Embedding IPD concepts” was perceived as challenge by a larger fraction of female versus male respondents (Figure 3.2).



Challenges at the *level-1* category	*p*-value
Ensuring trades active involvement	6.26e-06***
Issue of power	0.002**
Knowledge gap among actors	0.002**
Changing team members along the project	0.014*
Holding shared responsibilities	0.019*
Cost & schedule reduction as key targets	0.1

Note: The sub-challenges around each polygon are ordered similar to Figure 3.1. The three challenges with the most noticeable differences between the two compared groups are identified around each polygon. The color of the text is in harmony with the color of the line that represents the group of respondents with more members pointing to each challenge. For example, "Issue of power" is presented in gray color because a higher number of respondents from Canada (represented with gray color in the figure) than those from the U.S. pointed to this challenge. The six challenges identified in these graphs and their corresponding *p*-values are listed in the table; those with statistically significant differences at ≤0.001 (***), ≤0.01 (**) and ≤0.05 (*) levels among the compared groups are marked with an asterisk(s). In these graphs, the rate of the respondents within each sector who pointed to each challenge increases with distance from the center.

Figure 3.2: The challenges in IPD implementation as perceived by respondents with different gender and country of practice

3.4 Detailed Description of the Findings

The analyses indicated that five out of seven identified groups of challenge at the *level-2* category were mentioned by minimum 90% of the respondents of all groups. The other two identified groups were pointed at by a smaller fraction of interviewees, but still higher than 60% (Table 3-3). According to the results, slightly more than a quarter of the challenges of the *level-1* category (8 out of 28), were mentioned by at least half of the respondents from each stakeholder group (Figure 3.1). The detailed description of these set of sub-challenges are presented below:

Table 3-3: % of respondents from each stakeholder group who pointed to the categories of challenge in implementing IPD

Categories of challenge [a]	**Owners** (N=16) %	**Constructors** (N=8) %	**Designers** (N=15) %	**Total** (N=39) %
1. Sustaining a collaborative environment	100	100	100	100
2. Dealing with the operating environment	100	100	87	95
3. Selecting the right team	94	88	87	90
4. Embedding IPD concepts	88	100	87	90
5. Making sound & timely decisions	94	75	93	90
6. Changing actors roles	50	75	80	67
7. Developing high-quality design	56	25	87	62

[a] The categories of challenge (*at level-2*) are ordered based on the total number of respondents that identified them. This order does not, however, represent the relative importance of each challenge for IPD implementation in the U.S. and Canada.

3.4.1 Communication

Eighty-eight percent of Owners, 75% of Constructors, and 93% of Designers pointed to the challenges with communication among IPD team members. They emphasized that successful implementation of IPD requires an atmosphere and mechanisms that enable open, transparent, concise, and trusting communication among project participants at all phases of the work. However, creating and maintaining such an environment had been challenging for some teams. Respondents from all three groups noted that actors who join IPD projects with a traditional adversarial mentality can impede transparent communication and sharing of timely and accurate information. Incidents were described when correct and timely information was withheld in self-interest:

"...Four, five months before the project was done, they [trade partners] communicated that they were under budget and they were doing well. I do not know what happened, but I think they were not giving the best information. At the end of that, they ended up blowing the budget for [sic] 100 to 200 grand at the end. And we did not find out until the end of the project." (C5)

Specifying the right amount of communication among project participants was also identified as a challenge. Several Owners and most of Designers highlighted that sometimes there are "excessive" number of meetings in an IPD setting, which do not necessarily bring value to the project.

3.4.2 Managing Timeline and Workload

The challenge of managing the timeline and workload in IPD projects was highlighted by 69% of Owners, 63% of Constructors, and 73% of Designers. These interviewees explained that the project's organization and operating system are different in IPD compared to conventional methods. These differences affect the amount of time and resources required for executing the work in various phases of the project. According to the respondents, misunderstanding these needs has led to misallocation of resources in many IPD projects. Several examples were given of incidents where the tasks required for each phase of IPD were not well predefined, and that the allocated resources were not aligned with the effort level, especially in early phases of the work.

"...One of the big challenges is that we are all still adjusting to what it means to be in IPD projects, especially from the staffing perspective and pricing perspective. How do you allocate your time? Your team's time? Its one of those things that we are still trying to figure out. How many resources do you need to put in the front end in an IPD project and, if you have not planned accordingly, you could not perform as well as you might have because you did not allocate the right resources. It is about the intensity of it. In IPD projects, that front end is really intense, much more intense than a traditional method." (D5)

3.4.3 Fragmented Industry

Eighty-one percent of Owners, all Constructors, and 67% of Designers identified the long history of compartmentalization and fragmentation in the building industry as a barrier to IPD implementation. These respondents noted that traditional approaches to project delivery have encouraged disintegration of industry actors, practices and services. Industry professionals are used to working in silos and have clear lines of responsibility among team members. Changing the norms of the industry and breaking the silos are challenging. One owner noted that as long as the whole industry is not prepared for such a transformation, IPD would not reach its full potential:

> *"...We have aspects of our work that have to go out [of the project environment] and come back and go out and come back, and when they go out, they go out into an un-Lean environment, and they get bogged down and we have to work really hard to pull them back here and that took a lot of energy and a lot of team effort which I think probably created most of our inefficiency and our project's pitfalls and frustration." (O12)*

3.4.4 Trades' and Consultants' Reluctance to Participate in IPD

Seventy-five percent of Owners, 63% of Constructors, and 53% of Designers pointed to the difficulty of finding trade partners and consultants who are willing to join multi-party agreements. Interviewees explained this reluctance to join IPD exists for several reasons: (1) fear of partnership and risk and reward sharing structure, (2) uncertainty about IPD implications, and the risks embodied in IPD adoption, and (3) the need for holding new and unfamiliar responsibilities under IPD model (e.g., early engagement of trade partners and contribution in developing the design).

3.4.5 Lack of Required Characteristics and Capabilities by Team Members

Ninety-four percent of Owners, 88% of Constructors, and 87% of Designers pointed to the characteristics of a well-functioning team in IPD environment and emphasized how their absence creates significant challenges. The organizational culture, norms, and values of the participating entities play an essential role in IPD implementation. A large fraction of the interviewees from all three groups noted that organizations that assimilate shared definition of success, encourage the use of new processes/techniques, and embrace innovation, have the potential to function well

under IPD. Interviewees also highlighted that the participating organizations and their personnel need to be willing to empower team members and establish a flatter organizational structure.

More than 75% of the respondents from each group noted that IPD team members need to be accountable, and reliable, and have the capacity to function efficiently in a highly integrated environment. The importance of these attributes was highlighted in relation to the shared responsibilities under IPD. Several owners mentioned that having an adequate level of "soft skills" is a crucial factor to consider in the process of selecting IPD team members.

> *"…An IPD project demands so much more than technical competence. I actually would almost take a leader and someone who can communicate, and someone who is willing to put himself out there and try new things and has good communication skills and maybe less experienced or less technically seen as being the expert in their field. Because that will actually drive far more value in IPD and I do not know if people recognize that." (O13)*

3.4.6 Team Members' Incompatibility

Ninety-four percent of Owners, 88% of Constructors, and 80% of Designers noted that considering the importance of team dynamics under IPD, team members not only need to have the required characteristics and capabilities, but also members' personalities need to "fit together." This set of respondents mentioned that compatibility among players is important in all team settings, but in IPD its impact is amplified given the way this method works. These interviewees gave several examples of IPD projects that suffered from incompatibility between their team members.

3.4.7 Lack of Experience with IPD Components

Industry actors' lack of experience with IPD components was identified as another major challenge by 89% of Owners, all Constructors, and 88% of Designers. These respondents noted several examples where IPD teams failed to identify their defects in time, leading to significant losses for the projects. It was explained that such failure was caused by the scarcity of experienced individuals in the team who could effectively advise throughout the process. Moreover, according to the interviewees, there are design and construction firms in North

America that are regarded as "IPD experts" due to their participation in several IPD projects. However, despite their reputation, not all their personnel are well-experienced and trained in IPD principles. Respondents reported incidents where these firms assigned individuals to IPD projects who were not familiar with this delivery method, leading to dissatisfied clients.

3.4.8 Onboarding, Training, and Coaching

Members of all respondent groups emphasized that team members need to learn what IPD is, why it is being used for a project, how IPD and conventional projects differ, what project participants should expect from an IPD environment, and what is expected from them in return. It was learned throughout the interviews that there is no one-size-fits-all approach to training, coaching, and on-boarding in IPD projects. Depending on the team composition and level of direct experience with IPD principles, processes, and Lean tools, education and training programs may vary. Nevertheless, 75% of Owners, all Constructors, and 53% of Designers noted that these activities are often overlooked in the current practice of IPD, hindering a full appreciation of IPD principles and a mastery of the Lean tools required for executing projects. They also noted a tendency to short-change and overlook training and coaching efforts when facing schedule and budget pressures.

One owner noted that implementing IPD requires ongoing training throughout the project, rather than limiting it to the initial phase of a project. According to this respondent, ongoing training is particularly important when teams have little or no prior experience with IPD, and to help with the acculturation and onboarding of team members who begin in later phases of the work:

> *"…I would say always just keep learning and educating all the time if you are in an IPD (project). This will help to get you in the mindset for collaboration also…what we have found is that generally new members sometimes sit at the back of the room and they do not talk as much as they should. It is important to constantly keep educating people to let them know how it [IPD] works." (O7)*

It can be seen in Table 3-3 that relative to other groups of challenge at the *level-2* category, "Developing high-quality design" was mentioned by the smallest fraction of the respondents

(62%), mainly by Designers (87%). Analyses indicated that designers were concerned about the quality of design and therefore final product in IPD projects due to what they called as "*too much focus on the first cost rather than life-cycle cost,*" as well as the challenges they faced for conducting design exploration and design iterations. This concern was best articulated by one designer from the U.S. that had the experience of participating in multiple IPD projects:

> *"…IPD projects are very driven towards cost and schedule at this point. I think they are wholly silent on performance and the other big issue that we worry about is quality. I would underscore this about 100 times that there is nothing in IPD contract that speculates the level of quality […] when you think of the IPD contract, it is not really set up to allow us to design higher quality or achieve better quality buildings. That motivation does not exist on it right now." (D7)*

Several designers noted that in order to assure high-quality products, IPD contracts need to include post-occupancy performance measures as part of the compensation formula:

> *"...If we want to achieve operational goals or performance goals, then IPD contracts have to be adjusted to address motivating that particular effort [...] IPD right now only focuses on the first cost, and that is extremely, extremely short-sighted." (D11)*

As mentioned in Chapter 2, to the best of my knowledge, there is only one IPD project (Carmichael, 2015) that has included post-occupancy evaluation (POE) as a requirement in the contract. One of the owners who had extensive experience with IPD noted that:

> *"This [including POE as an obligation in IPD contract] has been done occasionally, but not often…it is actually a very small number of projects that have done that. One problem with POE is that using it for compensation requires holding open the project accounting, which most firms do not want to do. They want to grade the project and then distribute the appropriate amount of profit and close their books. POE is mostly used for sustainability projects." (O16)*

If Designers' concern in relation to quality of design and final product under the IPD model is valid, then one can ask why organizations such as Sutter Health in California (J. Love, Lampas, & Leuenberger, 2015), or Akron Children's Hospital in Ohio (Crain's Akron Business, 2017) have used IPD for delivery of multiple facilities one after another? Analysis of the comments provided by owners who had delivered several projects using IPD (without having POE as an obligation in their contracts) highlighted five reasons for their repeated choice of this PDM. These reasons, in no specific order, are as follows:

1) Reliability and predictability of project outcomes (e.g., cost, schedule, quality of the final product)

   "There were not a lot of change orders, very little rework…we have been always pleasantly surprised that there were no surprises in our IPD projects. We always knew how the building would look like. For example, when we took the first group of NICU [Neonatal Intensive Care Unit] nurses to this one, I was in the elevator with them. They got out of the elevator, and they looked around, and they said: "we are cool, we know where we are"… They had been in that space in the cardboards so many times. There were no surprises. They were ready for that building."(O14)

2) Exceeding expectations in relation to cost, schedule and quality of the final product (e.g., achieving a higher level of LEED certification than what was expected, high-quality installation, maintainability)

   "We got a great building… more than we even thought we were going to be able to do, and everyone is very happy with the outcome of it. We were able to do more and more things; we have actually added scope to the project. When we were closer to the end, we had better projections on how much the project was going to cost, and we were doing very well on the success metrics. So, we reduced the amount of contingency and, we started spending it on better things…oh, just to add… we had LEED Silver expectation in our success metrics, but we received LEED Gold." (O10)

3) High level of collaboration leading to:

   a. Direct access to high-quality information helpful in the process of decision-making
   b. Direct relationship with major risk drivers
   c. Enhanced sense of ownership of the project
   d. Pleasant work environment

"Our organization is very collaborative, and it is very natural for us to do IPD. We always thought our culture would be helpful because we have a very collaborative culture. What I mean by that is how we all work every day. We support our people; if anyone is down we get together to figure out…so we always felt that would help us to be successful in IPD environment." (O11)

"In all our projects, everyone has always really enjoyed working in that [IPD] setting, the trade partners, and the architects, and the engineers, and constructors. I think everyone much prefers this method of working on a project. I mean if you go out there [in the big room], they are all laughing, but they are doing a lot of good work. But they are kind of picking on each other and having a little bit of fun too." (O10)

4) Lack of legal disputes

"You know how much energy we spend on claims, legal disputes and those sort of things in normal projects? We do not have that in IPD. There is not much headache when we are in IPD." (O1)

5) Positive impacts of using IPD and Lean concepts on operational processes in the organization

"Using IPD helps us tackle different issues in our business; it is not only about our buildings. For example, now hospitals in the United States are especially being forced to rethink their operation, and become more efficient in how they deliver care; they are

doing that through the use of more collaboration across their enterprise. IPD helps us in that process." (O3)

These comments show that even though post-occupancy performance measures were not included in IPD contracts, the outcomes have been satisfactory enough to make these owners use IPD repeatedly. It was noted in Chapter 2 that most of the owners that were interviewed in this study were owner-occupiers, which leads to a circular argument in owner engagement. Being an owner-occupier and engaged in decision-making processes may lead to design intents that have decisions relevant to building performance already implicit in them. One of the owners who had extensive experience with IPD mentioned that:

> *"The upshot is that owner satisfaction is much higher in IPD projects. When setting up teams, we often tell them that the duty of the project team is to achieve the owner's objective, which is solving an owner problem, taking advantage of an opportunity, or a blend of these. To the extent these are reflected in the design intent, the team is responsible for achieving these goals, not just building what has been designed. However, we only occasionally tie these concepts [post occupancy performance measures] into the compensation formula. The right team with the right owner can achieve the objectives even without such a thing." (O16)*

This comment once again highlights the importance of the team and the role of owner engagement in the success of IPD. Based on the interviewees observations noted above, it could be argued that a highly collaborative team with an engaged and committed owner can create the environment needed for project success and achieving a high quality product even without having POE obligation in IPD contracts. However, in the absence of such high quality team, Designers' concerns in relation to quality of design and the end product can be valid and therefore embedding post-occupancy performance measures in IPD contracts may be helpful. This hypothesis needs to be tested in future studies.

3.5 Discussion

This study found that, in terms of stakeholder perceptions, greater experience does not have a significant impact on challenges in the implementation of IPD. However, both gender and country of practice are correlated with the nature and significance of perceived challenges.

Four key lessons for improving the efficacy and success of IPD implementation can be drawn from the challenges identified in this research (Figure 3.3). Challenges such as team members' incompatibility, lack of required characteristics and capabilities, and those related to commitment and holding shared responsibilities point to the first lesson: focus on partnership capability in IPD team selection. The success of an IPD project was found to be highly dependent on team members' characteristics, capabilities, compatibility, and commitment to change traditional behaviours. This finding is confirmed by several other studies (e.g., Ashcraft, 2014; CEC, 2015; Fischer, Ashcraft, Reed, & Khanzode, 2017; IPDA, 2016; Townes, Franz, & Leicht, 2015; Zhang, Cheng, & Fan, 2016). The results of the present study suggest that selecting the right partners for IPD requires different techniques and processes than financial review and background screening the suffices for the conventional approach to project delivery. Project partners need to be vetted for the new culture, behavior, and processes required in IPD. This confirms the findings of the study conducted by Ashcraft (2013).

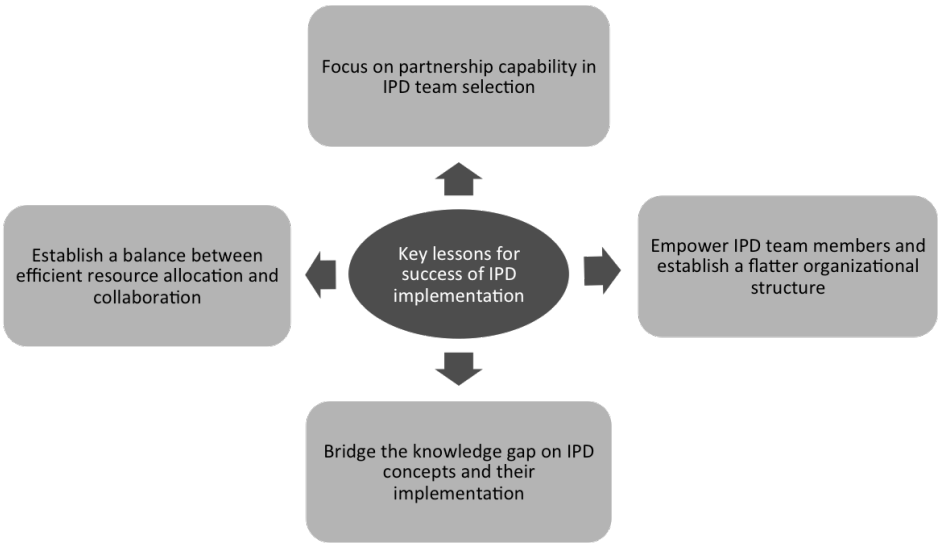


Figure 3.3: Summary of the key lessons for the success of IPD implementation

As noted in Section 3.1, studying IPD and project team environment is one of the main focus areas in the existing literature on IPD. Novel team selection mechanisms based on simulating the team environment (in the form of IPD workshop or progressive interviews) as suggested by Towens et al. (2015) and Dossick et al. (2013), as well as utilizing Interorganizational Transactive Memory System as introduced by Zhang et al. (2016) can help assembling a well-functioning team for IPD projects.

The second lesson that can be drawn from the present study is that participating organizations and their personnel need to be willing to empower IPD team members and establish a flatter organizational structure. This lesson is drawn from challenges such as the issue of power, group decision-making, establishing mutual respect and trust, overshadowing designers, and those related to trade partners' active involvement. Executing IPD requires an environment that fosters mutual respect and trust, and enables individuals to participate in the decision-making processes actively. Participants need to feel safe to suggest innovations and express their opinions, which indeed need to be judged, based on their merits, and not on the status and the role of their presenter. Creating such an environment is challenging if there exist traditional hierarchical relationships between project participants.

Some scholars such as Franz et al. (2017) argue that team integration is significantly affected by the selected project delivery method and the use of methods like IPD results in more cohesive teams. Others such as Pishdad-Bozorgi and Beliveau (2016) conclude that IPD promotes trust, which is an important element for enhancing team dynamics and relationships. However, the present study showed that even IPD teams could face challenges in developing a genuinely collaborative, integrated and united teams. Fulfilling the collective actions and developing a team that values each member's opinions and appreciates their skills, capabilities, and contribution to the project while treating them with respect require efforts beyond the careful selection of project delivery method. Stringent and rigorous rules in relation to the interactions within the team need to be established.

The necessity of bridging the knowledge gaps in IPD concepts and their implementation is another lesson that can be learned from this research. This lesson is drawn from challenges such

as knowledge gap among actors, lack of experience with IPD components, IPD contract conditions, and those related to onboarding, training, and coaching. As noted by Kent & Becerik-Gerber (2010), a majority of the industry actors have little to no prior experience with IPD. The present research indicated that lack of in-depth understanding of IPD concepts and implementation methods is still an issue creating significant challenges in the current practice of IPD. Integrated Project Delivery requires project participants to enter each other's area of work crossing the lines of traditionally defined disciplines. This may feel restrictive to those who are used to taking the lead on specific aspects of the project. For example, the findings showed that for some architects, sharing the control over design decisions was viewed as burdensome. Educating the industry actors on IPD concepts and preparing them for holding new positions and blend of responsibilities is an essential element in implementing IPD, which have not received enough attention in the current practice of Integrated Project Delivery. The approaches taken to train teams for IPD in the projects reviewed by IPDA (2016) can be considered for preparing future teams to work in IPD environment.

The challenges related to managing timeline and workload, communication, documenting and tracking information, and those related to design exploration and iterations point to the fourth lesson: establish a balance between efficient resource allocation and collaboration. This study showed that ideally, IPD teams need ongoing training and coaching, which takes significant time and resources. IPD asks for the early involvement of key participants and their continuous and close collaboration throughout the project. Conventionally, there would be no training and project elements involved−only those needed in that phase. Consequently, IPD demands to impose far greater resource allocation at the start of the project which is believed to save time and frustration down the line (CEC, 2015). The findings point to the lingering challenge in many different ways in which the allocation of resources to IPD project phases and the facilitation of collaboration among team members, need to improve through the development of suitable protocols. Implementing IPD requires rethinking project planning and management.

3.6 Conclusion

Semi-structured interviews were used to identify challenges in the implementation of IPD from the perspective of owners, constructors, and designers in the U.S. and Canada. The respondents

were selected based on their history with both conventional and IPD projects so that they could provide a comparison of the two.

IPD has significant differences with traditional methods of project delivery. These differences can be found in the roles and responsibilities held by project participants, the business model, and contract structure, as well as the processes implemented for executing the work. These differences and their practical implications are at odds with conventions familiar to the stakeholders. If IPD is to reach its full potential the AEC industry needs to embrace the far-reaching cultural change needed to support a team approach to developing a project from inception to operations post-occupancy.

This study identified 28 perceived challenges in seven categories in the process of IPD implementation. Sustaining a collaborative environment, dealing with the operating environment, and selecting the right team were found to be the top three challenges. While respondents from the three stakeholder groups agreed on several points, divergences were also observed in their perspectives. For example, all stakeholders identified several challenges in the process of selecting the right team for their IPD projects. However, there was less concordance about challenges to developing high-quality design. Designers were considerably more concerned about the quality of design in an IPD setting. Similarly, challenges in making sound and timely decisions were more emphasized by the Owners and Designers than the Constructors.

Investment in training, coaching, and planning, as well as documentation, and reporting the information generated during the project may seem unnecessary because they do not directly produce real work. Therefore, there is a tendency to reduce the amount of time and resources spent on preparation, acculturation, planning, and monitoring. Yet, as indicated in the present study, this lack of adequate preparation is hindering IPD success.

The major contribution of this research to the AEC industry and to the construction engineering and management literature is that the challenge with successful IPD does not end with educating the industry about IPD principles and concepts. Successful IPDs require a cultural change in the AEC industry and development of effective strategies for project planning, resource allocation,

and management. Perhaps one approach can be through universities implementing capstone projects involving design and engineering students working together on project delivery for real or imaginary clients.

As with all such studies, a major limitation is the self-selected nature of participation of the interviewees in this research. Furthermore, participants' awareness of my background in architecture may have led them, especially Designers, to speak more openly about their particular concerns.

It would be valuable to study how the challenges in implementing IPD evolve as this method of project delivery matures in the AEC industry. Follow-up studies could involve the use of a questionnaire based on this study to track subjective perceptions about challenges with implementation of IPD. Other follow-up research can be focused on how gender, social, and legal or political contexts shape subjective perspectives in relation to the challenges of IPD implementation.

Chapter 4: The Perceived impact of Integrated Project Delivery (IPD) on Diffusion of Innovations in the Architecture, Engineering, and Construction (AEC) Industry

As explained in Chapter 1, some innovations in the AEC sector have the potential to address deep-rooted problems in the industry, but various barriers have impeded their broad adoption. This chapter identifies these barriers and explores whether IPD is perceived to hinder or facilitate innovation adoption in this sector of the economy.

4.1 Introduction

The term "innovation" has been described in various ways. Schumpeter (1961) defines the term as an effort that produces economic gain through increasing income or decreasing costs. Freeman (1974) describes innovation as the "actual use of nontrivial change in a process, product, or system that is novel to the institution developing the change." Rogers (1983) and Slaughter (1998) refer to products, processes, or ideas perceived to be new by organizations or individuals that adopt them. Seaden et al. (2001) acknowledge the variation between definitions of innovation presented by different sources and note that certain commonalities can be observed among them; innovation is increasingly being viewed as a process that boosts the competitive position of a firm by way of implementing new ideas.

IPD is itself recognized as an innovative method for delivery of projects in the North American AEC industry (AIA, 2007, 2012; AIA California Council, 2014). This PDM has demonstrated potential for improving project schedule and quality while reducing overall project costs (El Asmar et al., 2013, 2016; Hanna, 2016). The central objective of this paper is to understand whether, from the perspective of IPD stakeholders, its processes (i.e., early involvement of key participants, liability waivers, and risk and reward sharing (AIA, 2007; Ashcraft, 2011; Fischer et al., 2017)) hinder or facilitate the adoption of innovation in building projects.

Russell et al. (2006) underscore how innovation is frequently defined from the perspective of a single firm and its economic wellbeing. They also note that innovation is most commonly viewed as a process, which involves all three steps of invention, development, and

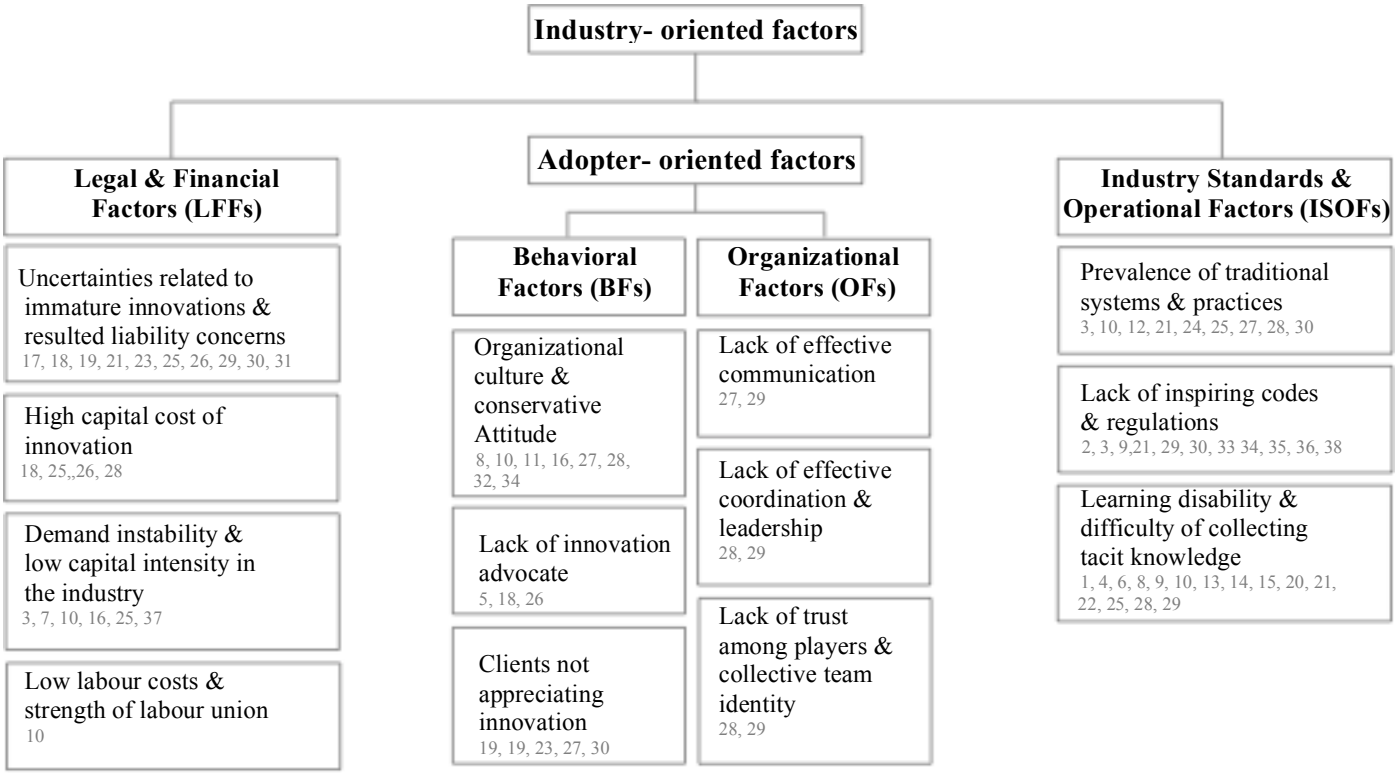
implementation. Such interpretations may not apply to projects of the AEC industry executed by a large number of firms, over the tight timetable of a project. In this chapter, I adopt the approach taken by Russell et al. (2006) to characterize innovation in the AEC industry as the use of advanced practices and creative concepts in "the design of the physical project; delivery organization; terms of agreements; methods of executing a function or activity; and financing arrangements."

In the AEC industry, innovation is classified in various ways. For example, one approach to classifying innovations is to consider whether they involve changes in a *product*, *process*, *organizational-contractual relationships*, or *financial-revenue arrangements* (Russell et al., 2006). One other approach is to categorize innovations based on the extent of their influence on building modules and domains of craft institutions and specializations. Following this approach, innovations can be classified as *modular* vs. *integral* (Sheffer, 2011), *bounded* vs. *unbounded* (Harty, 2005), *incremental* vs. *systematic* (Taylor & Levitt, 2004), and *focal* vs. *complex* (Ferlie, Fitzgerald, Wood, & Hawkins, 2005). In this chapter, I use the terms suggested by Sheffer (2011): modular vs. integral. An example of modular innovations can be an energy efficient heat pump. Implementing a modular innovation only involves one area of specialization (mechanical engineering in the case of an energy efficient heat pump,) whereas implementation of an integral innovation involves a variety of specialization areas and creates a change in the conventional process. A prefabricated building component is an example of integral innovation.

Despite the potential to address deep-rooted problems of the AEC industry, many innovations have faced slow adoption and weak diffusion through the industry (Dubois & Gadde, 2002; Goodrum & Haas, 2000; Hall et al., 2014; Koebel et al., 2015; Rigby et al., 2012; Sanderford, Mccoy, & Keefe, 2018; Sheffer & Levitt, 2010; Sheffer, 2011; Taylor & Levitt, 2004). For example, a large number of technically feasible and economically attractive innovations to enhance energy efficiency in buildings have had slow market penetration (Hall et al., 2014; Koebel et al., 2015; McCoy, Ahn, & Pearce, 2012; Sanderford, Koebel, & McCoy, 2015). Sheffer (2011) explains that the AEC industry is generally slow to adopt innovations, but the rate of adoption varies for different types of innovation. This is because the industry structure affects their diffusion differently. Diffusion is much slower for innovations that cross the boundaries of

an individual module in a building and alter interfaces (*integral innovations*) than those that are limited to one individual module (*modular innovations*) (Sheffer, 2011).

A thorough review of the literature on the adoption of innovation in the AEC industry identified a long list of impediments, which I classify into two groups: the *adopter-oriented* factors, and the *industry-oriented* factors. The former group involves factors related to individuals or firms as the adopting units, while the latter involves factors associated with the broader context, the industry structure, and its operational characteristics. Figure 4.1 illustrates the factors that were found in the literature relevant to both categories. It can be seen in this figure that the *adopter-oriented* factors can be further classified into two sub-categories: Behavioural Factors (BFs), and Organizational Factors (OFs). The *industry-oriented* factors can also be catalogued into two sub-categories: Industry Standards and Operational Factors (ISOFs), and Legal and Financial Factors (LFFs). Undoubtedly, the behaviour, decisions, and practices employed by the members of the industry are shaped by their surrounding environment. Therefore, the *adopter-oriented* and *industry-oriented* factors are not independent of each other.



References: 1: (Bowley,1966); 2: (Oster & Quigley,1977); 3: (Tatum,1986); 4: (Nam & Tatum,1988); 5: (Nam & Tatum,1997); 6: (Hass et al.,1999); 7: (Ball,1999); 8: (Barlow, 2000); 9: (Gann & Salter, 2000); 10: (Goodrum & Haas, 2000); 11: (Hunter & Jupp, 2001); 12: (Kumaraswamy & Dulaimi, 2001); 13: (Dubois & Gadde, 2002); 14: (Lutzenhiser, Kunkle, & Biggart, 2003); 15: (Taylor & Levitt, 2004); 16: (Reichstein, Salter, & Gann, 2005); 17: (Hendricks & Calkins, 2006);18: (McCoy, 2007); 19: (McCoy et al., 2008); 20: (Granade et al., 2009); 21: (McCoy, Thabet, & Badinelli, 2009); 22: (Walsh, Urban, & Herkel, 2009); 23: (McCoy, Badinelli, Koebel, & Thabet, 2010); 24: (Beamish & Biggart, 2010); 25: (Sheffer & Levitt, 2010b); 26: (McCoy, Thabet, & Badinelli, 2011); 27: (Gambatese & Hallowell, 2011); 28: (Sheffer, 2011); 29: (Rigby et al., 2012); 30: (McCoy et al., 2012); 31: (Bynum et al., 2013); 32: (Porwal & Hewage, 2013); 33: (Sanderford, McCoy, Keefe, & Zhao, 2014); 34: (Azhar et al., 2015); 35: (Sanderford et al., 2015); 36: (Koebel et al., 2015); 37: (Zhao, McCoy, Kleiner, & Feng, 2016); 38: (Sanderford et al., 2018).

Figure 4.1: Summary of the industry-oriented and adopter-oriented factors hindering innovation diffusion in the AEC industry as reported in the reviewed literature

While understanding the factors that inhibit innovation adoption in the AEC industry (Figure 4.1) is important, it is vital to explore why such factors exist, and how are they connected. Many studies have pointed to industry fragmentation as one of the main underlying barriers to diffusion of innovation in the AEC industry (Barlow, 2000; Dubois & Gadde, 2002; Gann & Salter, 2000; Granade et al., 2009; Haas et al., 1999; Koebel et al., 2015; Lutzenhiser et al., 2003; McCoy et al., 2009; Nam & Tatum, 1988; Rigby et al., 2012; Sheffer & Levitt, 2010a; Taylor & Levitt,

2004; Walsh et al., 2009). Industry fragmentation hinders learning and accumulation of knowledge which are vital components of innovation diffusion and adoption (Sheffer, 2011; Taylor & Levitt, 2004, 2007).

Fergusson (1993) characterizes the AEC industry with three dimensions of fragmentation: vertical, horizontal, and longitudinal. Vertical fissures occur between different phases of the project's lifecycle (e.g., design, construction, operation); horizontal fissures occur between different disciplines, and specialized trades (e.g., mechanical, electrical, architectural); and longitudinal fissures occur between projects because project teams often disperse at the end of projects. These dimensions of fragmentation, especially the first two, are the results of the transition from an industry that was centered on "master builders" to an industry that necessitated various kinds of specialties. This demand emerged from advancements in technologies, materials and construction methods, leading to greater complexity in buildings (Konchar & Sanvido, 1998; Paik et al., 2017).

Due to the vertical and horizontal fissures, joint coordination and learning are not possible, and therefore, firms need to accumulate knowledge separately about how to design, implement, and operate an innovation (Sheffer, 2011). This phenomenon not only slows down the learning process, but also impairs achieving a comprehensive understanding of the appropriateness and effectiveness of an innovation for the project as a whole. Moreover, given the prevalence of longitudinal fragmentation (McCoy, 2007; McCoy et al., 2009; McCoy et al., 2011; Rigby et al., 2012; Sanderford et al., 2015; Zhao et al., 2015; Zhao, McCoy, Kleiner, & Feng, 2016), the tacit knowledge gained through team collaborations in one project cannot be transferred from project to project (Taylor & Levitt, 2004).

IPD has the potential to address the three dimensions of fragmentation described above. IPD principles (i.e., (1) use of a multi-party contract, (2) liability waiver among key stakeholders, (3) risk and reward sharing, (4) early involvement of key participants, (5) joint development and validation of project goals, and (6) collaborative decision-making and control (AIA, 2007)) should help in team cohesion and reducing vertical and horizontal fragmentation. IPD aims to achieve exceptional results through the formation of a strong team environment (AIA California

Council, 2014; CEC, 2015; Fischer et al., 2017); therefore, a considerable amount of resources are invested in team building throughout a project (IPDA, 2016). This should lead to a greater interest in keeping teams together for the next IPD project in order to reduce the overhead and apply the lessons learned as a team through the previous work. Therefore, IPD has the potential to reduce longitudinal fragmentation across the industry as well.

The study conducted by Sheffer (2011) shows that addressing vertical and horizontal fragmentation increases the adoption of integral innovations in a project, but it does not have a significant effect on the adoption of modular innovations. Based on this finding, when compared to conventional project delivery methods, IPD should facilitate the adoption of integral innovations to a greater extent. The cross-functional teams in IPD (Ashcraft, 2011) blur the boundaries between different disciplines making the adoption of integral innovations similar to modular innovations.

A review of the literature revealed a small number of studies that have investigated innovation adoption in IPD projects. Hall et al. (2014) focused on the adoption of integral innovations in IPD and identified a number of IPD elements that facilitate implementation of integral innovations. Hall & Lehtinen (2015) built on earlier findings and explored how agile cost shifting, an IPD element, contributes to the implementation of integral innovations. While not being entirely focused on the examination of innovation adoption in IPD, Austin et al. (2016) noted how a reduced level of liability, a characteristic of IPDs, drive projects in innovative directions.

The collaborative nature of IPD, characterised by reduced liability concerns, diminished fear of information sharing, and collective decision-making and leadership, should hypothetically create an environment that enhances learning and enables improved knowledge of the risks and uncertainties associated with the projects. However, this hypothesis has yet to be tested in a variety of contexts.

The present study aims to (1) explore whether IPD, compared to conventional methods, is perceived to be instrumental in facilitating adoption of innovations in the AEC industry, (2)

identify the IPD components that are believed to be able to play a positive role in facilitating innovation adoption in IPD projects, and (3) explore how the impacts of IPD components on three dimensions of fragmentation is recognized to affect adoption of modular and integral innovations.

Similar to the studies presented in the previous two chapters, a qualitative approach using semi-structured interviews was undertaken to achieve the aims of the study. The interviews invited stakeholders to express their perspectives on differences between IPD and conventional PDMs on innovation adoption. Similar to Chapter 3 (See Section 3.3), I also examined the correlation between respondents' perceptions and (1) the level of experience with IPD, (2) gender, and (3) country of practice. The findings of this research facilitate understanding whether IPD is perceived to have the potential to alter industry's approach towards innovation adoption giving way to new technologies, designs, and practices to address enduring problems of the industry.

The structure of the remainder of this chapter is as follows. Section 4.2 presents the methodology used for data collection and analysis. The findings are described in Section 4.3, and the discussion of the results is provided in Section 4.4. The chapter concludes by presenting the theoretical and practical implications of the findings, limitations of the work, and suggestions for future studies in Section 4.5.

4.2 Methods

Similar to the previous two chapters, semi-structured interviews were used to capture a deep understanding of participants' opinions on the topic. The details of the steps taken for recruiting participants, pilot testing the interview protocol, and the procedure followed for conducting and documenting 39 interviews (with Owners, Constructors, and Designer), as well as the demographics of research participants, are described in Section 2.2.2 of this thesis.

For this study, the interviewees were asked:

- Whether they believe IPD, in comparison with conventional methods, provides a more or less suitable environment for adoption of innovations?

- Which IPD components they believe can facilitate the adoption of innovations in IPD projects?

The interviewees were requested to give examples of innovations adopted in their IPD projects. This information was later used to differentiate modular from integral innovations.
NVivo (version 11) was used to compile and code the interview materials. Participants responses to the question of whether they believe IPD, compared to conventional delivery methods, provides a more or less suitable environment for adoption of innovations were grouped in two categories: (1) "IPD provides a more suitable environment" and (2) "not sure" (no participant answered "IPD provides a less suitable environment" to this question.) The interviewees responses to the question of which IPD components they believe can facilitate innovation adoption in IPD projects were first coded following deductive approach (Marshall & Rossman, 2014). This approach was taken to test whether the IPD components noted by the interviewees are consistent with the findings of previous studies on the topic. Therefore, where possible, terminology was borrowed from the previous studies (e.g., Hall et al., 2014; Hall & Lehtinen, 2015) to describe the IPD components identified by the interviewees. An inductive approach (Elo & Kyngäs, 2008; Patton, 2002) was adopted on the subset of the qualitative data that did not match the predefined categories defined in the literature review. Similar to the approach taken in the previous two chapters, the interview narratives were coded in multiple iterations reassessing the generated coding schemes and categories to improve the credibility of the findings. As mentioned earlier, this is a common internal validity measure in qualitative research (Creswell, 2013). Triangulating the results from the interviews with Owners, Constructors, and Designers, and the findings of previous studies on the topic was another validation technique used in this study (Creswell, 2012; Miles & Huberman, 1994).

Similar to the approach taken for data analysis in the studies presented in Chapters 2 and 3 (See Section 2.2.2), apart from deriving in-depth qualitative data, I used the interviews to count the number of respondents from each stakeholder group who pointed to specific IPD components perceived to play a positive role in facilitating innovation adoption in IPD projects. The fraction of each group who agreed on the role of each IPD component in innovation adoption was then

calculated to compare the level of agreement/disagreement among sectors. The findings are described in the following section.

4.3 Findings

In response to the question of whether IPD provides a more or less suitable environment for adoption of innovations, 36 interviewees (92.3%) said they believe IPD creates a more suitable environment for innovation adoption. Among this group, ten respondents held the opinion that compared to conventional delivery methods, IPD better facilitates consideration of a broader suite of innovative options in a project; however, it is uncertain whether or not it leads to innovation implementation. Three interviewees did not explicitly differentiate the role of IPD in consideration or implementation of innovation. They expressed uncertainty in whether IPD makes any difference in terms of innovation adoption in a project. None of the interviewees said IPD provides a less suitable environment for innovation adoption compared to the conventional methods.

Interviewees were also asked which IPD components they believe best facilitate innovation adoption in IPD projects. Interviewees noted 12 IPD components. These components and the frequency of the respondents that pointed to each are listed in Figure 4.2.

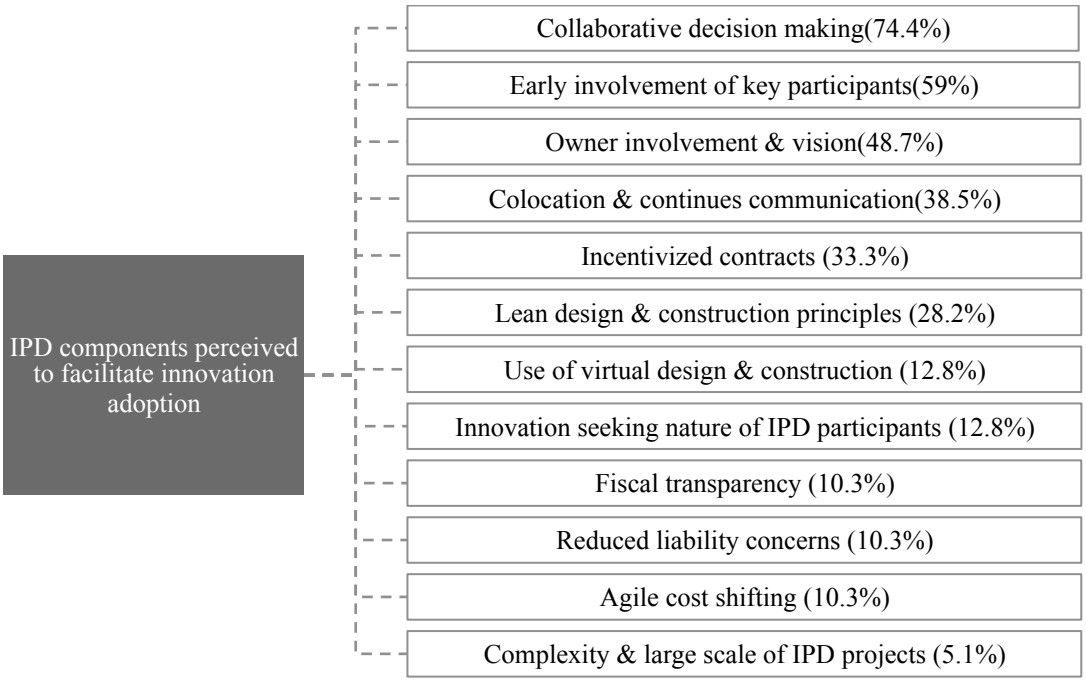
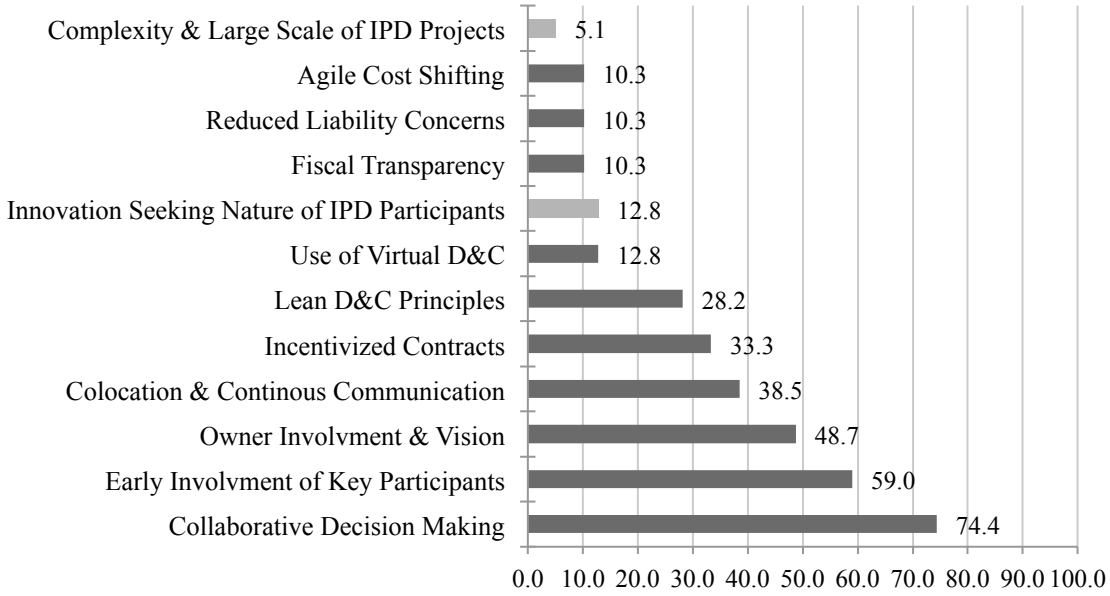


Figure 4.2: IPD components perceived to facilitate innovation adoption and the frequency of participants that pointed to each factor

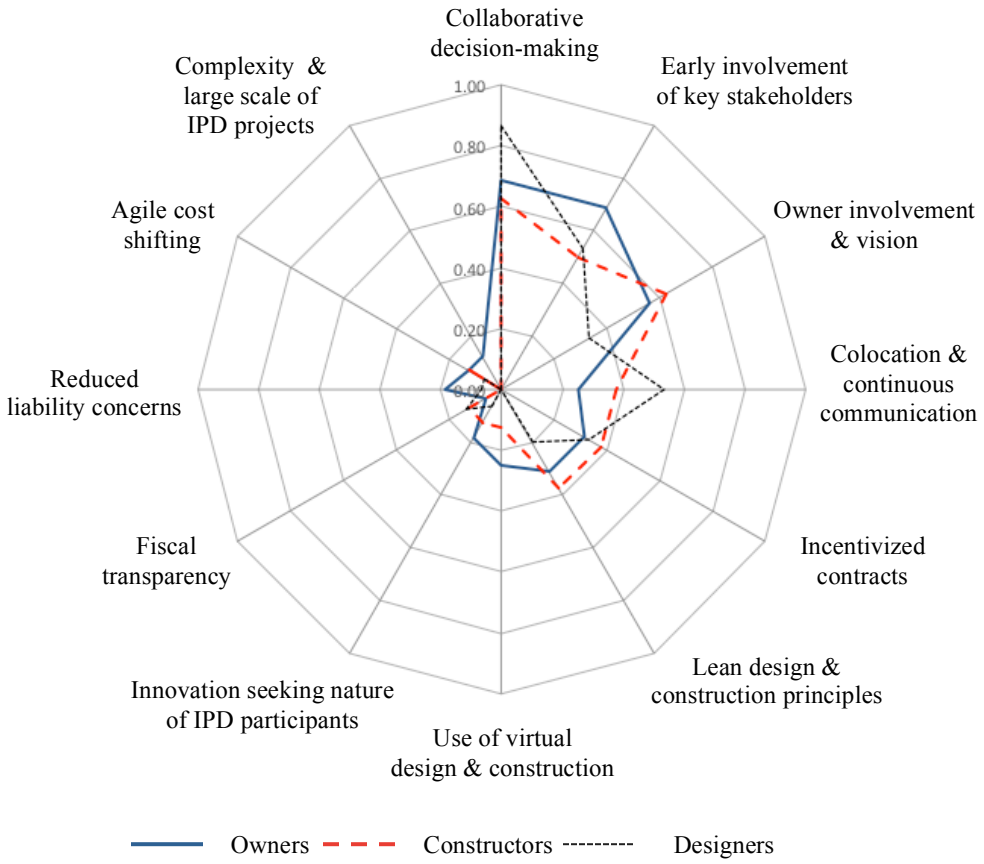
Figure 4.3 indicates the IPD elements perceived to facilitate innovation adoption as noted by the interviewees and reported in the reviewed literature. It can be seen that all ten IPD elements identified as facilitators of innovation adoption in previous studies were confirmed in this research. Furthermore, the interviews introduced two components as facilitators of innovation adoption that were not noted in earlier studies: (1) innovation seeking nature of IPD participants, and (2) complexity and large scale of IPD projects. While only a small number of respondents pointed to these two components, it is still important to highlight that some held the opinion that the innovation seeking nature of those who participate in IPD, and the typical complexity and large scale of IPD projects call for innovations.



Note: The IPD components presented with dark gray bars have been identified by research participants and also have been reported in previous studies (Hall et al., 2014; Hall & Lehtinen, 2015; Austin et al., 2016); however, those presented with light gray bars are new and have not been noted in earlier studies. The figures in front of each bar indicate the fraction of the respondents that pointed to each factor.

Figure 4.3: List of the IPD components perceived to facilitate innovation adoption as noted by the interviewees and reported in the literature

The approach that was taken to develop Figure 2.4 and Figure 2.7 in Chapter 2 (See Section 2.3) was used to create Figure 4.4 and summarize the results for different stakeholder groups. In this figure, the 12 identified IPD components were arranged around the polygon in the order by descending rate of response from participants in all groups (in the clockwise direction). The fraction of the interviewees from Owners, Constructors, and Designers who pointed to each IPD component was calculated and used as a score along the corresponding polygon axis. For example, if four out of eight constructors pointed to component A, the score of 0.5 was used along the relevant polygon axis indicating the fraction of Constructors that mentioned component A. In Figure 4.4, the results for each stakeholder group are presented with different line styles. Owners are represented with the dark blue solid line, Constructors with the red dashed line, and Designers with the gray dotted line.



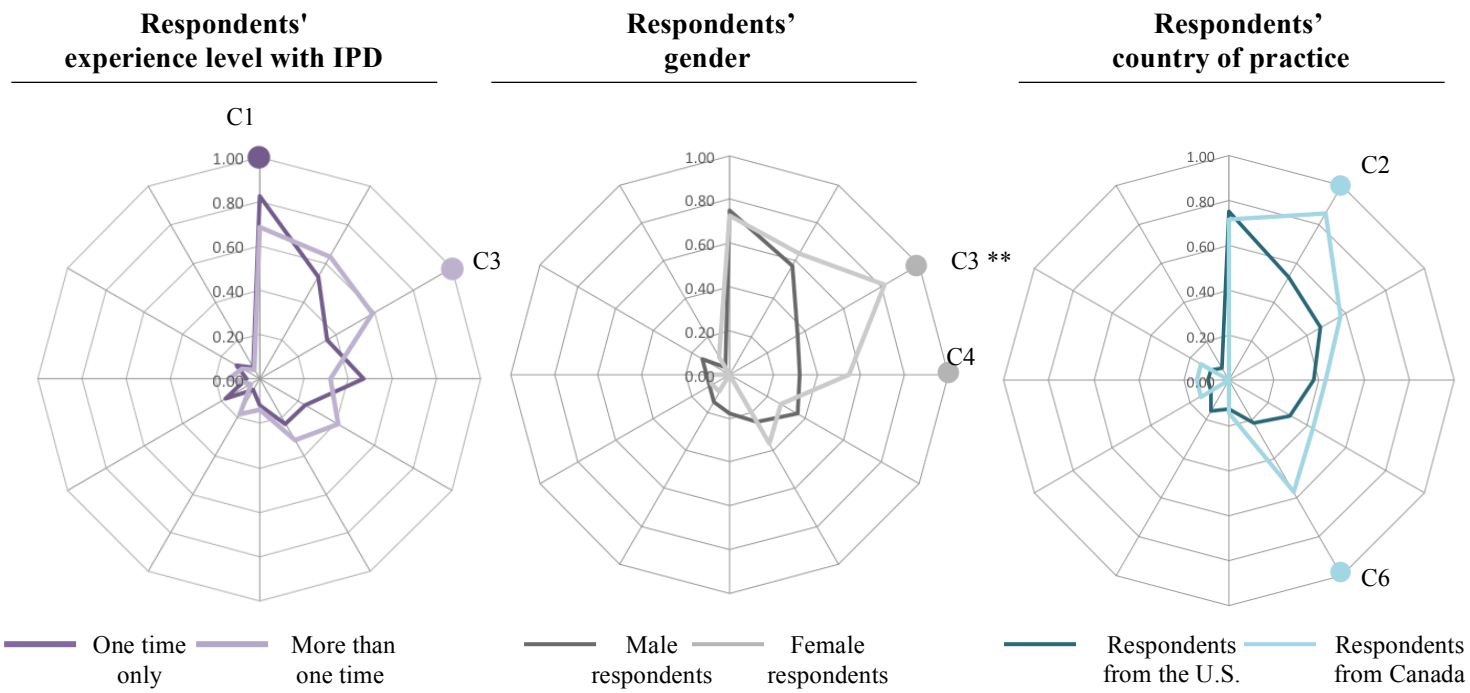
Note: The rate of the respondents within each sector who pointed to each IPD component increases with distance from the center.

Figure 4.4: Summary of the IPD components facilitate innovation adoption as perceived by the interviewees of three stakeholder groups

Figure 4.4 illustrates that there exist various levels of concordance among the three stakeholder groups across different IPD components. The majority of all three groups pointed to the perceived role of "Collaborative decision-making" and "Early involvement of key stakeholders" in facilitating innovation consideration and adoption in IPD projects. Among all three groups, Designers had the largest fraction of respondents (87%) that mentioned the former component, while the latter component was noted by a greater portion of Owners (69%) than Constructors and Designers. Another notable finding is related to "Owner involvement and vision." A higher level of concordance exists between Owners and Constructors compared to the third group regarding the perceived role of this component in innovation consideration and adoption in IPD projects. The most distinct level of homogeneity in the perceptions of the three groups was

observed in relation to the “Incentivized contracts” and “Fiscal transparency.” No statistically significant differences at ≤0.001, ≤0.01, or ≤0.05 levels were found among the three groups in relation to their perceptions regarding the role of IPD components in innovation consideration and adoption.

Similar to the study presented in Chapter 3, for this research I also tested the correlation between interviewees’ perceptions with regard to the role of IPD components in innovation adoption and (1) level of experience with IPD, (2) gender, and (3) country of practice. Figure 4.5 presents the results of these analyses. The diagrams in this figure were also created following the same methods used for Figure 2.4 and Figure 2.7 in Chapter 2 (See Section 2.3). In Figure 4.5, the sequence of the IPD components around the polygons follows the order presented in Figure 4.4; therefore, the labels of the IPD components are not repeated around the polygons in this figure. Similar to Chapter 3, analyses were also conducted (using GLM with l*ogit* function (See Section 3.2)) to test the qualitative differences in the responses of the examined groups for statistical significance at ≤0.001, ≤0.01, or ≤0.05 levels. A statistically significant difference among the groups was found for only one of the factors (Figure 4.5); however, noticeable differences were observed with regard to other IPD components that are worth mentioning. Where these noticeable differences were found between the perceptions of the two examined groups in relation to a component, the corresponding axis in Figure 4.5 was marked to help the reader. The color of the marking symbol is in harmony with the color of the line representing the group of respondents, which had a larger portion of its members pointing to that particular component.



IPD component	*p*-value
C3: Owner involvement and vision	0.008**

Note: The IPD component (C3) with a statistically significant difference at ≤0.01 (**) level among the compared groups is marked with two asterisks. In these graphs, the rate of the respondents within each group that pointed to each component increases with distance from the center. The IPD components around each polygon are ordered similar to Figure 4.4. The components with the most noticeable differences between the two compared groups are marked. The color of the marking symbol is in harmony with the color of the line representing the group of respondents, which had larger portion of its members pointing to that particular component (C1: Collaborative decision making; C2: Early involvement of key stakeholders; C3: Owner involvement and vision; C4: Colocation and continuous communication; C6: Lean design and construction principles).

Figure 4.5: Summary of the IPD components that facilitate innovation adoption as perceived by interviewees with different level of IPD experience, gender, and country of practice

Figure 4.5 shows that the level of experience with IPD have a noticeable correlation with respondents' perception with regard to the role of two of the identified IPD components in innovation adoption. A larger fraction of more experienced respondents identified "Owner involvement and vision" as an important component for facilitating innovation consideration and adoption in IPD projects. However, among those with one IPD project under their belt, there was more emphasis on the role of "Collaborative decision-making."

The analyses conducted to examine the coloration between participants' perception with regard to the role of IPD components in innovation adoption and gender and country of practice also demonstrated interesting results. A remarkably larger percentage of female respondents perceived the role of "Owner involvement and vision" important in facilitating innovation consideration and adoption in IPD. A similar but less pronounced pattern was found in relation to "Colocation & continuous communication" (See Figure 4.5and Table D-1 in Appendix D).

Analyses were also conducted to examine how interviewees' perceptions are correlated with the combination of (1) country of practice and level of experience, (2) country of practice and gender, and (3) gender and level of experience. The results are presented in Table D-2 in Appendix D. These results indicate that while female and male respondents both appreciated the role of "Collaborative decision-making" in innovation adoption, greater experience with IPD was correlated with waned perceived importance of this component among male participants. In contrast, gaining more experience with IPD was correlated with a higher emphasis on the importance of "Early involvement of key stakeholders" among female participants.

Comparing the perceptions of respondents from Canada with those from the U.S. also showed interesting results. For those from Canada, gaining experience in IPD was shown to be correlated with the raised perceived importance of "Collaborative decision-making" in innovation adoption; however, this was not the case for the respondents from the U.S. (See Table D-2 in Appendix D).

It is also noteworthy that a considerably larger fraction of female and male interviewees from Canada compared to their counterparts from the U.S. believe in the importance of "Early involvement of key stakeholders" (See Table D-2 in Appendix D).

As demonstrated in Figure 4.2, collaborative decision-making and early involvement of key stakeholders were the two IPD components that were mentioned by more than half of the respondents (74.4% and 59%, respectively). The detailed description of these two IPD components are provided below:

4.3.1 Collaborative Decision-Making

Collaborative decision-making was the most commonly mentioned IPD component perceived to facilitate innovation consideration and adoption in a project. According to 74.4% of the respondents, breaking down the traditional silos, engaging participants from different stakeholder groups in the process of decision-making and knowledge sharing, and allowing various viewpoints to be heard pave the way for presenting and considering innovations, and examining their merits for the project.

Addressing horizontal fragmentation and overcoming disciplinary silos were perceived to be important for the adoption of integral innovations such as prefabricated building units. A number of interviewees mentioned that joint design enabled them to implement this type of innovation in their IPD projects.

> *"…We needed 100 restrooms for the building. One option was to build them on-site as we normally would. Another option was to build them off-site. We knew this would save us money and give us consistent quality. The architects, mechanical, electrical…everybody worked together to make it possible…so they just brought them to the site and dropped them in the building with a crane, and then hooked them up. This saved us quite a bit of money, and the consistency of the quality was very good…They did the same kind of work for the wiring harnesses, so we did not need to wire up everything on site, it was amazing."(O14, > One time, Female, U.S. practitioner)*

The role of collaborative decision-making in promoting innovation adoption was also mentioned when interviewees were explaining other IPD components such as "Incentivized contracts" and "Reduced liability concerns" (Figure 4.2). Interviewees noted that if project participants collectively agree on the advantages of an innovation, it is much more probable to consider it for implementation in an IPD environment compared to a scenario where conventional delivery methods are employed. They explained that in projects where the risks associated with implementing an innovation are not distributed among the project team; it is much less likely that

the innovation will be adopted. This is relevant to both, modular and integral innovations. For instance,

> *"...IPD could allow innovation adoption because the decisions to do something are made jointly. But under a conventional project, if there is something that I think it exposes me to more risk, I unilaterally will make the decision not to do it. Under the IPD arrangement where the team is sharing risk and reward, then those [innovative] items would be vetted amongst the major players: the owner, the design team, and the construction team. Those risks would be evaluated jointly, and the team might do something that individuals might not because the risk is spread out on a larger group of parties and everybody is participating in that risk, versus just one party alone."(D10, One time only, Male, U.S. practitioner)*

4.3.2 Early Involvement of Key Stakeholders

More than half of the respondents (59%) pointed to the importance of early involvement of general contractors, trade partners, and end users in facilitating innovation consideration and adoption in IPD projects. Respondents explained that early communication with contractors and trade partners, and getting their input from initial phases of the project had two benefits. First, in helping designers and owners to better understand the construction related implications and feasibility of an innovation for the project, and its associated costs and risks. Second, in gaining familiarity with the proposed innovation since the early stages of the project, and participating in its examination eliminate the risk of an unknown for general contractors and trade partners allowing them to price the item more realistically, and contribute to enabling the implementation of the innovation more willingly. In other words, addressing vertical fragmentation through early involvement of general contractors and trade partners reduces the perceived risks of both modular and integral innovations that spill over from one silo to another.

> *"When you design a building that employs new technologies, and innovation and you do not have a lot of trade input, you have a problem. When you put that design out in the market, and it's something that people don't quite know what it is, the first thing they are going to do when they price it is that they price it higher because there is stuff that they*

do not quite understand, or they price it too low because they do not understand and then it would be a huge burden on them and your team if they have not priced it correctly. What happens often is that they price a bunch of money because of its risk. That means that would be the first thing that they cut out of the project when they go over budget." (C5, > One time, Female, Canada practitioner)

Many also identified end users' early involvement in the project as a factor important to innovation adoption. It was explained throughout the interviews that active participation of end users in the design process allows discovering new ideas and finding practical solutions for design challenges. Reducing vertical fragmentation by early involvement of end users was perceived to be important for adoption of integral innovations and creating the potential for innovative work.

"The discussion we had with the workers [end users] about the process was not about how we are doing the work. It was about how we should be doing it and how we should be setting up the space for it. So, we went from there with that standpoint, and the people who were going to use the space said here is how we should do this, here is how it should flow, and designers were watching them, and then they [designers] came back and said: 'Ok, we took your ideas and here is the design, what do you guys think?'. Then, they [end users] looked at the design, and they were like: '... oh, yeah, let's move this here...' and so it was a back and forth. We actually worked with their [end users] layout; it was actually their idea." (O9, One time only, Male, U.S. practitioner)

4.4 Discussion

This study indicated that IPD is perceived to be able to provide a more suitable environment for consideration and adoption of innovations compared to conventional delivery methods. Interviews with stakeholders proposed 12 IPD components that are believed to play a positive role in innovation consideration and adoption in projects of the AEC industry. The findings of this research validate the results of the study conducted by Hall et al. (2014) and introduce three additional factors that are found to enhance innovation consideration and adoption in IPD. The innovation seeking nature of IPD projects' participants and typical complexity of projects

delivered by IPD are two of these additional factors that were not noted in previous studies. The third factor is reduced liability concerns in IPD environment that was identified by Austin et al. (2016) for its influence on innovation, but was seldom mentioned by the participants of the study conducted by Hall et al. (2014). Austin et al. (2016) did not examine the level of influence associated with reduced liability concerns in comparison with other IPD principles with regard to innovation adoption. The results of my study indicate that only a small fraction of the participants (10.3%) pointed to this factor (Figure 4.3). Follow-up studies may be warranted to tease out the relationship between liability and adoption of innovation in greater detail.

The IPD components identified in this study could address the vertical and horizontal fragmentation described by Fergusson (1993). Early and sustained involvement of trade partners, owner, and end users throughout the project, and their participation in decision-making processes could eliminate the fissures between design, construction, and operation; thereby addressing vertical fragmentation. Use of incentivized multi-party contracts and agile cost shifting could break the traditional silos between different disciplines addressing horizontal fragmentation. Enhanced information exchange and communication through IPD components such as colocation, reduced liability concerns, fiscal transparency, and the use of Lean principles, and virtual design and construction could help to address both vertical and horizontal fragmentation (Figure 4.6).

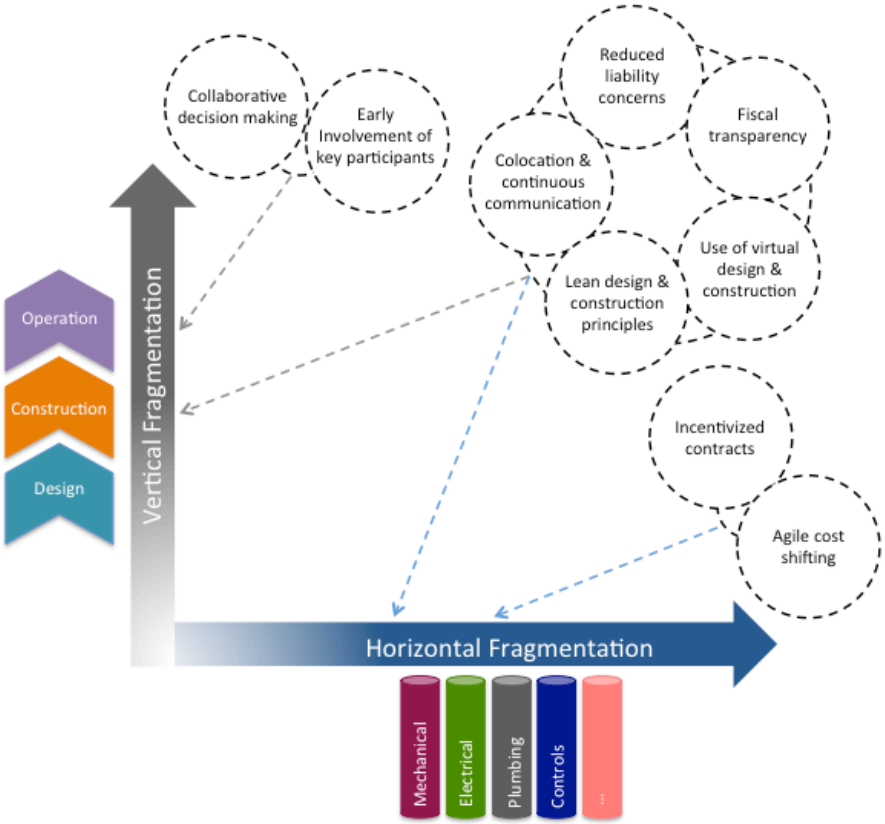


Figure 4.6: The IPD components that could address vertical and/or horizontal fragmentation in the AEC industry

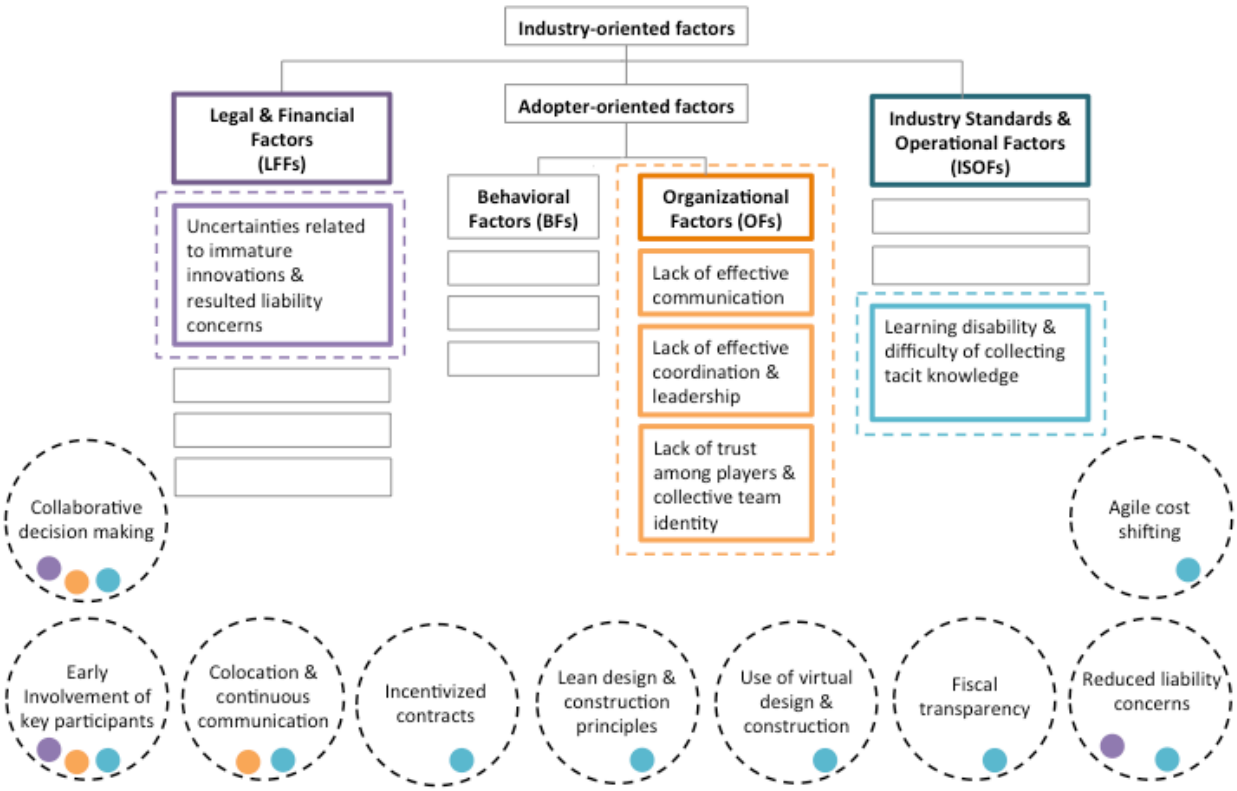
The findings of this study do not support the hypothesis regarding the role of IPD in reducing longitudinal fragmentation. A number of participants from the present study as well as some of those who participated in the study conducted by Hall et al. (2014) noted a high turnover of personnel between their IPD projects. Sheffer (2011) explains that it is likely that the AEC industries in different countries experience varying degrees of longitudinal fragmentation. Addressing this dimension of fissure could depend on the level of labour mobility (McCann & Simonen, 2005), and market thickness (McLaren, 2003). Keeping IPD teams together may also be a feature of socio-economic contexts where bidding for a project requires evidence of prior collaboration among project team members. Thus, I identify testing IPD's ability to keep teams together as a potential subject for future research.

The IPD components perceived to be facilitators of innovation consideration and adoption in this study alter the interface between the division of work in a project and enhance integration of the disciplines, which is essential for adoption of integral innovations (Sheffer, 2011). Therefore, it can be argued that IPD can influence the adoption of integral innovations to a greater extent than modular innovations. This argument supports Sheffer's (2011) findings which demonstrated that creating vertical and horizontal integration increases adoption of integral innovations, but is unlikely to make considerable changes in the adoption rate for modular innovations.

The findings of the present study also help to understand which of the factors that impede innovation adoption in the AEC industry could be addressed by IPD. Considering the impediments listed in Figure 4.1 and IPD components that were identified as facilitators of innovation consideration and adoption by the interviewees (Figure 4.2), it can be argued that IPD is better equipped to navigate the *adopter-oriented* barriers than the *industry-oriented* barriers to innovation adoption. The Organizational Factors (OFs) hindering innovation such as lack of effective communication (Gambatese & Hallowell, 2011), coordination, leadership, trust among players, and collective team identify (Sheffer, 2011) could be tackled by IPD. Collaborative decision-making, early involvement of key participants, colocation and continuous communication are examples of IPD components mentioned in the interviews that have the potential to address the OFs (Figure 4.7).

The other group of *adopter-oriented* barriers, the Behavioural Factors (BFs) (Figure 4.1), could also be addressed by IPD but their elimination depends considerably on the culture, characteristics, and the values of the organizations and the individuals participating in IPD projects. This highlights the importance of team selection in IPD which was highlighted in Chapter 3 of my thesis, as well as several other studies (e.g., Aarseth et al., 2012; Ashcraft, 2014; Fischer et al., 2017; IPDA, 2016; Ramazani & Jergeas, 2014; Rolstadas, Hetland, Jergeas, & Westney, 2011d; Taghi Zadeh et al., 2016; Townes et al., 2015; Weshah et al., 2014; Zadeh et al., 2014; Zhang et al., 2016). IPD's ability to address the BFs may also depend on the utilized business model and whether or not the contract incentivizes the team to have a long-term perspective towards the project. If participants' compensation, which is linked to project success in IPD, is tied to the operational performance of the building post-occupancy, the team would

probably be more inclined to implement innovations that positively affect the long-term performance of the facility. This hypothesis needs to be tested in future studies.



Note: Figure 4.1 was used as the basis of this diagram. The *Industry-oriented* and *Adopter-oriented* barriers to innovation adoption that could be tackled by nine of the IPD components identified by research participants are highlighted in this diagram. These nine IPD components are indicated in the nine circular text boxes positioned at the bottom of the diagram. The color of the marking symbol in each of these circular text boxes is in harmony with the color of the rectangular text box indicating the barrier to innovation adoption that could be tackled by that specific IPD component. For example, "Learning disability & difficulty of collecting tacit knowledge" under the ISOFs category is presented in a light blue rectangular text box, and there is a light blue marking symbol in the circular text box presenting "Agile cost shifting". This means that this IPD component could address the issue of "Learning disability & difficulty of collecting tacit knowledge". Multiple marking symbols in some of the circular text boxes indicate that the corresponding IPD component could address multiple barriers to innovation adoption presented in this diagram.

Figure 4.7: *Industry-oriented* and *adopter-oriented* barriers to innovation adoption in the AEC industry that could be addressed by IPD components identified by the interviewees

IPD may also be able to address some of the *industry-oriented* barriers to innovation adoption. For example, the uncertainties related to immature innovations and associated liability concerns, listed in the category of Legal and Financial Factors (LFFs) in Figure 4.1, could be tackled by IPD. Reduced liability concerns stemmed from liability waivers, together with collaborative

decision-making, and early involvement of key stakeholders are three IPD components highlighted in the interviews that could help to address this barrier (Figure 4.7). Direct connection between reduced liability concerns and innovation adoption was made by only a small number of research participants; however, the implications of reduced liability concerns and diminished fear of failure in innovation adoption are folded into other IPD components such as collaborative decision-making, which was mentioned by almost 75% of the participants (Figure 4.2).

Diminishing risk-aversion among team members and enhancing information exchange through liability waivers, and enabling participants from various areas of expertise to take part in identifying the uncertainties related to an innovation, and analyzing its suitability for the project could navigate the aforementioned barrier (Figure 4.7). While these IPD components could be helpful, project teams need to allocate adequate resources to conduct the additional research required to understand how the implementation of innovations affects the project. Allocation of resources for this purpose could be a challenge for IPD teams as efforts are front-loaded under this delivery method (Fischer et al., 2017; IPDA, 2016) and therefore, allocating extra time and other resources for evaluating innovations may be burdensome.

As also noted by Hall et al. (2014), IPD has the potential to overcome learning disability and difficulty of collecting tacit knowledge, a barrier to innovation adoption from the category of Industry Standards and Operational Factors (ISOFs) in Figure 4.1. The discussion above regarding the role of IPD in addressing vertical and horizontal fragmentation explains how this delivery method could tackle learning disability in the AEC industry (Figure 4.7).

I argue that the elimination of other *industry-oriented* barriers indicated in Figure 4.1 is beyond the capabilities of a project delivery method and requires interventions in the cultural, legal, and financial structure of the industry. Actions like developing supportive policies, and regulations, creating incentive programs for innovation adoption and giving rise to alternative business and financing models such as those employed by ESCO service providers (Ástmarsson, Jensen, & Maslesa, 2013) are examples of interventions that could overcome the *industry-oriented* barriers

to innovation adoption. However, such actions have faced opposition from various institutions such as commercial banks and utilities in some jurisdictions (Sheffer & Levitt, 2010).

4.5 Conclusion

The literature on innovation in the AEC industry was reviewed to identify the barriers to innovation adoption; and semi-structured interviews with 39 participants from three stakeholder groups −Owners, Constructors, and Designers− were conducted to: (1) better understand whether IPD, compared to conventional methods, is found to be instrumental in facilitating innovation adoption in the AEC industry, (2) identify the IPD components that are believed to be able to play a positive role in facilitating innovation adoption, and (3) characterize the perceived impacts of IPD on vertical, horizontal and longitudinal fragmentation and adoption of modular versus integral innovations. The interviewees had the experience of working on both IPD and non-IPD projects and were able to provide a comparison of the two.

This study indicates that compared to conventional delivery methods, IPD is perceived to be better equipped to provide a suitable environment for consideration and adoption of innovations. There are 12 IPD components that are believed to facilitate innovation adoption through addressing vertical and horizontal fragmentations. The findings suggest that IPD is found to be more instrumental in facilitating the adoption of integral versus modular innovations. The role of IPD in reducing longitudinal fragmentation remains to be seen.

The 12 IPD components identified by the interviewees have the potential to address some of the barriers to innovation adoption in the AEC industry. Barriers identified in the literature were classified as the *adopter-oriented* factors and the *industry-oriented* factors. It was argued that IPD is better equipped to navigate the barriers from the former group than the latter group.

Collaborative decision-making, early involvement of key stakeholders, and owner involvement and vision are the top three IPD components facilitating innovation adoption as per the views of the respondents. The findings indicated divergences between the perspectives of the respondents from different stakeholder groups in relation to some IPD components. For example, comparable portions of Owners and Constructors pointed to the role of owner involvement and vision in the

adoption of innovations; however, a considerably smaller percentage of Designers noted the effectiveness of this IPD component.

This research also demonstrated that respondents' perceptions of the role of IPD components in innovation adoption correlate with their level of experience with IPD, gender, and country of practice. Greater experience with IPD was shown to have different implications for women versus men in relation to their perceptions about the role of "Early involvement of key stakeholders" in innovation adoption. For women, greater experience with IPD was shown to be correlated with a higher level of perceived importance of this component; however, this was the opposite for the male respondents.

The analyses indicated that while both female and male respondents appreciated the role of "Collaborative decision-making" in innovation adoption, gaining more experience with IPD was correlated with a lower emphasis on the importance of this component among male participants. Moreover, the analyses showed that for those from Canada, gaining experience in IPD was correlated with an amplified perception of the importance of "Collaborative decision-making" in innovation adoption; however, this was not the case for the respondents from the U.S. Future studies with larger sample size could investigate in further details the relationship between IPD professionals' perceptions in relation to the role of IPD in innovation adoption and their level of IPD experience, gender, and country of practice.

The main contribution of this research to the AEC industry and to the literature in the field is that while IPD is perceived to facilitate innovation consideration in projects, it cannot guarantee successful implementation of innovations; IPD cannot overcome all barriers to innovation diffusion and adoption that exist in the AEC industry. It was argued that addressing these barriers requires foundational changes to the policies, regulations, and programs governing industry's operations, and utilization of alternative business and financing models.

The findings related to the correlation between the country of practice and the perceived role of IPD components suggest the potential for a third level of factors affecting innovation adoption, which is beyond "*adopter-oriented*" and "*industry-oriented*" levels indicated in Figure 4.1.

Adoption of innovations such as IPD could also depend on the socio-economic, legal, and cultural context within which the AEC industry is operating. Further studies outside Canada and the U.S. will be needed to verify and fully characterize this hypothesis.

The following are known major limitations to this study: a) the participants were self-selected and b) the participants reported perceptions about IPD components effective in promoting adoption of innovation were not verified in independent case study projects. A follow-up study could address the latter limitation by conducting a comparison of innovation adoption related outcomes in comparable projects with and without the use of the IPD components identified in this research. This follow-up study could also examine the degree of effectiveness of each IPD component for the adoption of innovations. Moreover, it is also important to study how gender, country of practice, level of experience with IPD, and the position held in projects (e.g., owner, constructor, designer) shape perceptions regarding the role of IPD and its components in facilitating innovation adoption.

Chapter 5: Exploring Adoption of IPD for the First Time in an Organization: Using the Case of Healthcare Organizations in the Lower Mainland, British Columbia

The perceived benefits of IPD and its role in the adoption of innovations in the AEC industry were described in Chapters 2 and 4. The challenges of implementing this PDM were specified in Chapter 3. This chapter explores the impressions of the effectiveness of IPD principles in project performance by those who have no direct experience with this method. This chapter also identifies the areas of challenge believed to hinder adoption of IPD (which itself is an innovation) for the first time in an organization. I used the facilities management department of the healthcare organizations in the Lower Mainland, British Columbia as a case study for this chapter.

5.1 Introduction

Chapter 4 discussed how gaining competitive advantage for an organization and improving existing processes and practices require innovation (Sanderford et al., 2014; Mollaoglu-Korkmaz et al., 2014). As noted by Sheffer (2011) and Russell et al. (2006), there are various approaches to classifying innovations; In this chapter, I adopt one that classifies innovations by their primary purpose, in this case: "technical" and "organizational" (Nofera, Korkmaz, Miller, & Toole, 2011), or "technical" and "administrative" (Subramanian & Nilakanta, 1996). Nofera et al. (2011) argue that while *technical innovation* can occur in "product" or "process", *organizational innovation* involve changes in management techniques, organizational structure, and strategic orientations of an organization. Subramanian & Nilakanta (1996) differentiate innovations in a similar way; they explain that *technical innovations* are those that take place in components (and the approach to their operation) affecting the technical system of an organization and potentially, the way the process is administered. Whereas, *administrative innovations* take place in administrative processes and how they are organized and governed; this type of innovation enhances existing workflow practices (Vakola & Rezgui, 2000), and indirectly lead to *technical innovations* (Mollaoglu-Korkmaz et al., 2014). Thus, there can be complementarity between *technical* and *administrative innovations*.

Previous studies have identified a variety of individual, structural, and cultural/social/contextual factors impacting the success of innovation implementation in an organization (Gambatese & Hallowell, 2011; Koebel et al., 2015; Mollaoglu-Korkmaz et al., 2014; Nofera et al., 2011; Sanderford et al., 2018; Subramanian & Nilakanta, 1996; Zhao et al., 2015). These factors include: ownership and structure of the organization (Gambatese & Hallowell, 2011); degree of centralization, formalization, and specialization in the adopting unit; availability of resource slack (Subramanian & Nilakanta, 1996); demographics, experience (Hausman, 2005; Lee, Wong, & Chong, 2005), and characteristics of managers (Gambatese & Hallowell, 2011); and socio-political and contextual factors such as economics, policy and industry sector (McQuater et al., 1998; Ortt, 1998).

Klein and Sorra (1996) developed a theoretical framework for innovation implementation in organizations. Their framework includes four key constructs: implementation context (e.g., employees' skills, incentives, and absence of obstacles), innovation value fit, implementation effectiveness, and innovation effectiveness. They argue that organizations need the proper implementation context and effective value fit to be able to implement innovations successfully. They explain that an organization with a strong implementation context helps their employees to gain the required skills, establishes a reward system and develops mechanisms for removing obstacles to innovation implementation. In their model, Klein and Sorra (1996) refer to innovation value fit as "the extent to which targeted users perceive that use of the innovation will foster the fulfillment of their values."

Mollaoglu-Korkmaz et al. (2014) tested Klein and Sorra's model's fit to AEC project teams and found out that effective implementation of innovations such as IPD (that are integral (Sheffer, 2011) by nature) in the projects of the AEC industry also requires effective coordination mechanisms, communication behaviours, and culture-fit. They used the findings of their study to add few constructs to Klein and Sorra's innovation implementation model.

IPD has been recognized as an administrative innovation (Mollaoglu-Korkmaz et al., 2014; Paik et al., 2017; Sun, Mollaoglu, Miller, & Manata, 2015). Collective risk management, open-book financing, executing a multi-party contract, and contingency of participating entities' profits on

project outcomes are some of the innovative attributes of IPD. Like any innovation, implementing IPD requires a supportive environment in the adopting organization. In this chapter, I aim to (1) explore the perceived effectiveness of IPD principles in various aspects of project performance by those who have not used this PDM before, (2) identify the areas of challenge believed to hinder implementing IPD, as an integral administrative innovation, for the first time in an organization, and (3) characterize the pathways to overcome these perceived barriers. I used the facilities management department of the healthcare organizations in the Lower Mainland, British Columbia (BC) as an example of potential IPD adopters (that does not have any direct experience with this PDM) and based my analysis for this chapter on this case study.

The healthcare organizations often need to deliver large and complex facilities, which are found to be best suited to IPD according to the findings of my second chapter. Reviewing the studies on IPD show that this delivery method has been mostly implemented by healthcare organizations. El Asmar et al. (2013) noted that 50% of the IPD projects in their database were healthcare facilities; the results of the survey conducted by Cheng et al. (2015) indicate that 28 out of 59 (47.50%) IPD projects included in their study were healthcare projects. The implementation of IPD has resulted in superior performance (El Asmar et al., 2013; Hanna, 2016). This explains the continuous use of this delivery method by healthcare organizations such as Sutter Health in California (Love et al., 2015) and Akron Children's Hospital in Ohio (Crain's Akron Business, 2017).

Given the perceived suitability of IPD for delivery of complex projects and their strong track record in healthcare facilities, their adoption is expected to pay dividends to public sector healthcare organizations. However, public sector projects have been developed under different institutional frameworks than the privately-owned facilities noted above.

If IPD is to be adopted by a public sector healthcare organization, there is a need to characterize potential barriers to the adoption of this integral administrative innovation.

In Canada, the healthcare system is publicly funded, and delivery of healthcare is mostly a provincial jurisdiction (Government of Canada, 2018). Within the Province of British Columbia (BC), healthcare delivery is managed regionally (Government of British Columbia, 2018). In the Lower Mainland region of BC, healthcare services are provided by Fraser Health Authority, Vancouver Coastal Health, Providence Health Care, and Provincial Health Services Authority. In 2010, these four healthcare organizations consolidated to improve the efficiency of services across support areas. This partnership is called the Lower Mainland Consolidation (LMC). The Lower Mainland Facilities Management (LMFM) department within LMC provides facilities management services to the four Lower Mainland Health Organizations (LMHO). LMFM serves more than 2.5 million British Columbians (Fraser Health Authority, 2016) or over 50% of the province's population (Auditor General of British Columbia, 2018).

I approached LMFM to run workshops to discuss project delivery methods and engage their members in an understanding of IPD and possible perceived institutional barriers to its adoption.

The following research questions were developed for this study:

- How do members of LMFM, who have no direct experience with IPD, perceive the effectiveness of IPD principles in various aspects of project performance?
- What areas of challenge are believed to hinder IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC?
- What are the pathways to overcome the perceived barriers to IPD implementation by healthcare organizations in the Lower Mainland, BC?

In order to find the answers to these questions, a survey questionnaire and a series of stakeholders' workshops were employed to elicit the opinions of members of LMFM. The findings of this study enhance our understanding of innovation implementation; bring insights to (1) the perceived effectiveness of IPD in various aspects of project performance from the perspective of those who have no direct experience with this PDM, (2) the areas of challenge believed to hinder implementing IPD for the first time in an organization (using the facilities

management department of healthcare organizations in the Lower Mainland, BC as a case study); and (3) the proposed pathways to address such barriers.

The structure of the remainder of this chapter is as follows. Section 5.2 explains the data collection and analyses methods. Section 5.3 presents the findings and Section 5.4 provides a discussion of the results and concludes with key findings.

5.2 Data Collection and Analysis

The data for this study was obtained by elicitation of stakeholder opinions using a questionnaire and a series of group discussions in three workshops. An invitation to a project delivery workshop with a focus on IPD was distributed by email among the staff of LMFM.
The project delivery workshop was followed by two additional sessions to continue the discussion on IPD and its perceived applicability to the building projects delivered by the healthcare organizations in the Lower Mainland, BC. The structure of the stakeholder workshops and the activities conducted during each session are described below.

5.2.1 First Stakeholder Workshop

A three-hour project delivery workshop was held at the LMFM's office in Vancouver, BC. This workshop had 18 participants from the organization who accepted the electronic invite sent to them. I conducted three types of activities in the first workshop: 1) inviting participants to complete a questionnaire during the session, 2) delivering a presentation on conventional project delivery methods and IPD together with some of my previous research findings, and 3) facilitating a group discussion on IPD. The structure of this workshop was as follows:

After the opening remarks and introducing the scope and structure of the workshop, I distributed a two-part-questionnaire among the participants and invited them to complete *questionnaire-part 1*. After they finished responding, I delivered a presentation on conventional PDMs such as DBB, DB, and CM, and explained the following regarding IPD to standardize the participants' understanding of this method: IPD definition, its key principles, contractual structure, and business model. I used AIA sources (e.g., AIA, 2007; AIA California Council, 2014) to develop this presentation explaining the IPD model and its differences with conventional methods (e.g., DBB, DB, and CM).

After this presentation, I invited the participants to complete *questionnaire-part 2.* When they finished responding, I presented the results of my previous research on IPD regarding the perceived characteristics of projects and the suitability of project owners for adoption of IPD, and the identified challenges to implementing this PDM (Chapters 2 and 3 of my thesis). The structure of the questionnaire and the types of questions listed in its two parts are described in Section 5.2.4.

After presenting my research findings on the perceived characteristics and challenges, we had a group discussion on the potential adoption of IPD in the province of British Columbia. The participants were asked to identify the areas of challenge believed to hinder implementing IPD for delivery of healthcare facilities in the Lower Mainland, BC.

5.2.2 Second Stakeholder Workshop

Four of the participants of the first workshop who were actively involved in procurement and planning of projects delivered by LMFM expressed interest in continuing the discussion on IPD. Therefore, they were invited to the second workshop. This two-hour workshop also took place at LMFM's office in Vancouver, BC.

At the start of this session, I briefly presented the areas of challenge believed to impede IPD use by LMFM that were identified during the group discussion in the first workshop. The remainder of the session was focused on brainstorming regarding the pathways to overcome the perceived obstacles to IPD implementation for delivery of healthcare facilities for this region. At the end of this workshop, the participants recommended I engage three other individuals from the planning department at LMFM in the discussions around IPD. These three individuals did not participate in the two previous workshops but several LMFM members considered them to be key to the decision-making processes of the organization.

5.2.3 Third Stakeholder Workshop:

Two of the participants in the second workshop plus the three individuals identified as key stakeholders (proxy for owners), joined the third workshop. This session lasted for one hour and was also held at LMFM's office in Vancouver, BC.

I gave a short presentation on IPD to familiarize the three new participants with the method and the key points of discussion covered in the last two workshops. After that, a group discussion took place focused on identifying possible next steps towards IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC.

The group discussions in all three workshops were documented using written field notes. The notes were compiled and coded using NVivo (version 11). The analysis of the qualitative data was conducted following the approach explained in previous chapters.

5.2.4 Questionnaire and Accompanying Information

The questionnaire distributed to the participants in the first workshop was divided into two parts:

5.2.4.1 Questionnaire-Part 1

Questionnaire-part 1 asked for background information on the stakeholder such as the area of work, years of experience in the building industry, and level of awareness and experience with IPD. This part also included questions regarding the client type (private vs. public), project type (e.g., healthcare, residential, industrial), and budget category of the projects that the participants had worked on during their career. Moreover, they were asked to indicate how they perceive the typical performance of building projects in relation to budget, schedule, and meeting energy performance targets (See Appendix E- Section E.1).

5.2.4.2 Questionnaire-Part 2

Questionnaire-part 2 was focused on IPD. Participants were asked to indicate how they perceive the effectiveness of IPD key principles in various aspects of project performance, the level of challenge in implementing IPD key principles, and the likelihood of using or recommending IPD as a method for delivering building projects in BC (See Appendix E). *Questionnaire-part 2* was accompanied by a guide sheet, which included descriptions of the key principles of IPD. AIA sources on IPD were used to develop the guide sheet (See Appendix E- Section E.2). Descriptive statistics were used to analyze and describe the data collected from the questionnaire.

5.3 Findings

The findings from the survey and group discussions are presented in this section. The survey data was used to describe participants' background, and their perceptions regarding the effectiveness of IPD key principles in various aspects of project performance, and the level of challenge in implementing these principles. The areas of challenge believed to hinder IPD use at LMFM and the proposed pathways to overcome these obstacles are discussed using the findings from the group discussions that took place during the three stakeholders' workshops.

From the 18 participants of the first workshop, seven individuals completed both *part 1* and *part 2* of the questionnaire. Table 5-1 presents some background information about these individuals. The respondents' self-reported work experience in a variety of projects including healthcare, residential, office, industrial, recreational, and mixed-use facilities. They were generally more experienced in projects with budgets below $25M. Table 5-1 shows that three out of seven respondents were informed about IPD before attending the first workshop. None of the respondents had any direct experience with IPD.

Table 5-1: Background information on survey respondents

Respondents	Area of work	Years of experience in the building industry	What % of the projects you worked on had public clients	What % of the projects you worked on had private clients	Awareness & experience level with IPD
R1	Procurement	5-10	100 %	0%	Informed, but no direct experience
R2	Planning	>10	40%	60%	Informed, but no direct experience
R3	Planning	<2	100%	0%	Not informed, no direct experience
R4	Planning	>10	20%	80%	Informed, but no direct experience
R5	Planning	>10	50%	50%	Not informed, no direct experience
R6	Planning	>10	100%	0%	Not informed, no direct experience
R7	Energy management	>10	40%	60%	Not informed, no direct experience

In *questionnaire-part 1,* respondents were also asked to indicate their opinion regarding the typical performance of building projects with respect to budget, schedule and meeting energy

performance targets. On average, participants indicated that more than 40% of the building projects come in above or considerably above budget. They believed that close to 50% of the building projects are completed close to the estimated schedule, but 35% take longer or much longer than what was anticipated. In relation to energy performance, the participants indicated that on average close to 70% of buildings do not meet their energy performance targets.

5.3.1 Perceived Effectiveness of IPD Principles in Various Aspects of Project Performance and the Level of Challenge in their Implementation

As part of the *questionnaire-part 2,* participants were asked to rank IPD principles based on their perceived effectiveness in improving cost control, schedule control, and meeting energy performance objectives for a building project in BC. Figure 5.1 to Figure 5.3 present participants' responses to these questions (Also see Figure F-1 to Figure F-4 in Appendix F). Figure 5.1 shows that shared risk and reward was perceived by the majority of the respondents as the first most effective principle for controlling cost in a project. Fiscal transparency and reduced liability were also recognized as principles with a high level of effectiveness in cost control.

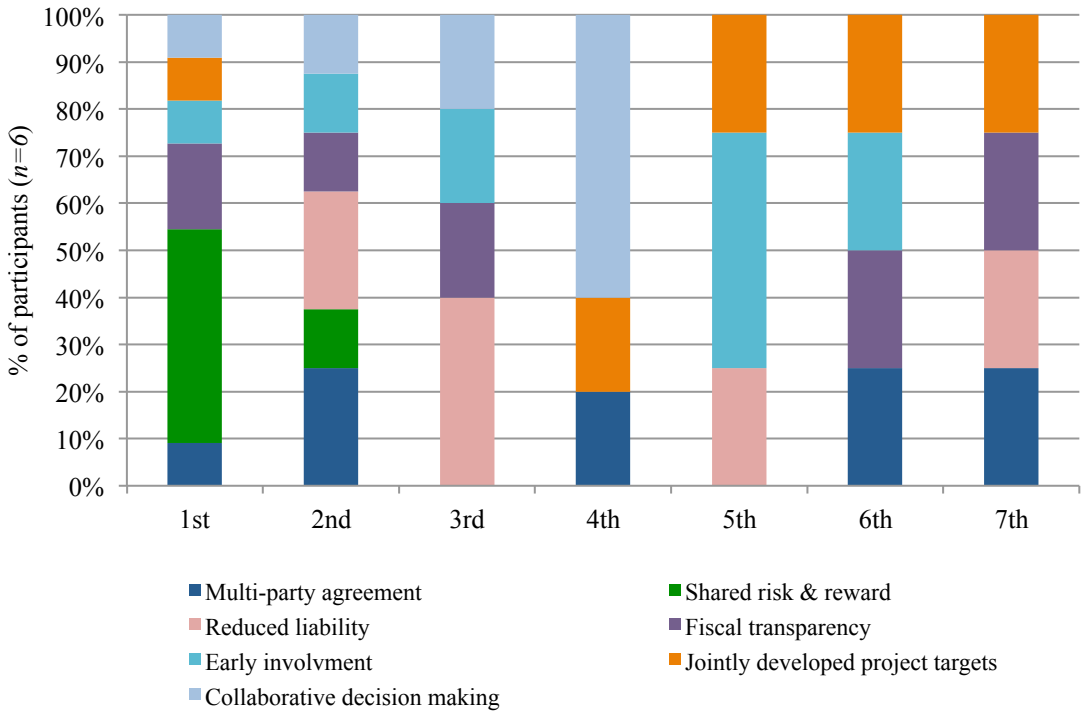


Figure 5.1: Order of IPD principles based on their perceived effectiveness in cost control

Shared risk and reward was identified as a highly effective principle for controlling schedule as well. It is indicated in Figure 5.2 that collaborative decision-making was ordered second by the majority for schedule control. It can be seen in this figure that a large portion of the respondents placed multi-party agreement in one of the first three levels.

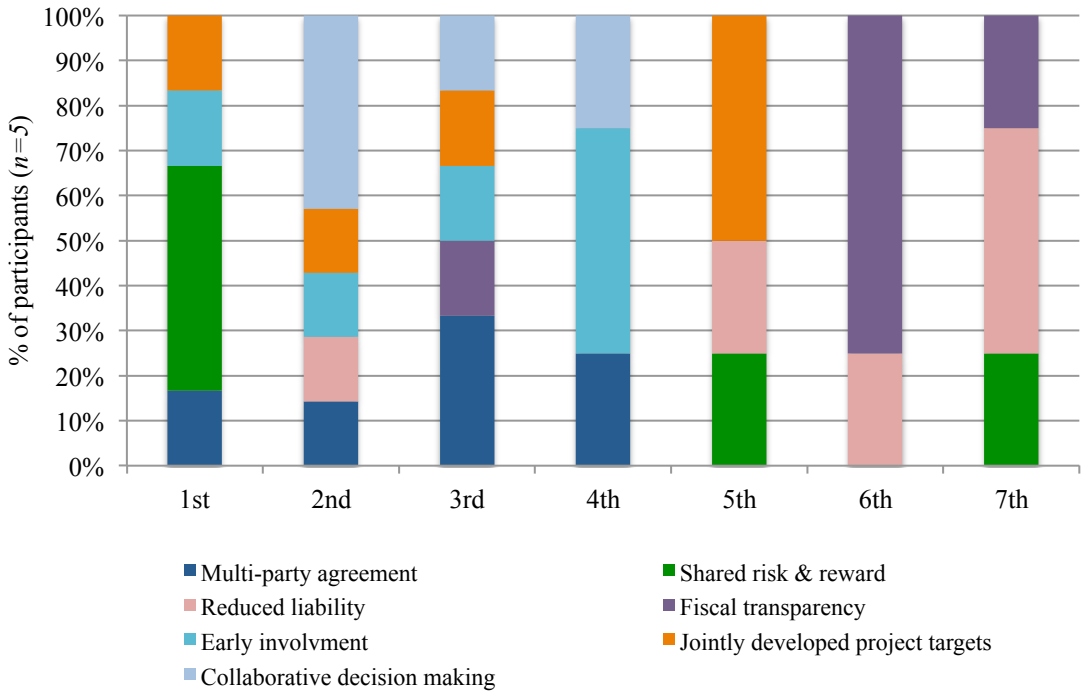


Figure 5.2: Order of IPD principles based on their perceived effectiveness in schedule control

Figure 5.3 presents the order of IPD principles based on their perceived effectiveness for achieving energy performance targets in a project.

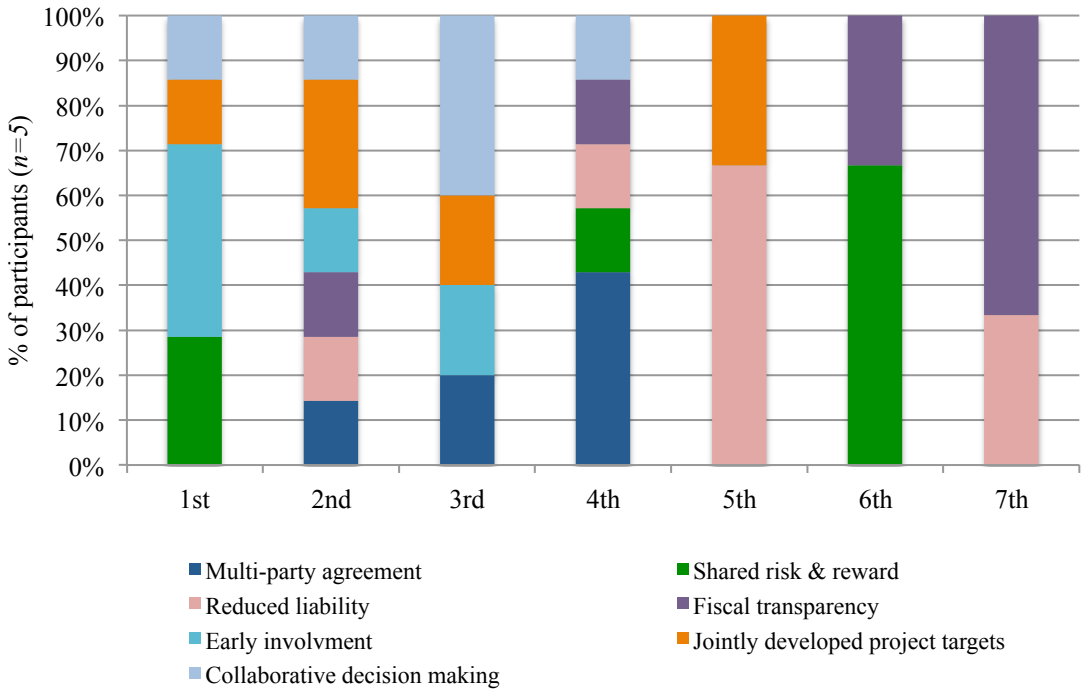


Figure 5.3: Order of IPD principles based on their perceived effectiveness in meeting energy performance targets

According to the majority of respondents, early involvement of key stakeholders, followed by the joint development of project targets, and collaborative decision-making are perceived as the three most effective principles for meeting energy performance targets (Figure 5.3).

Ordering IPD principles based on the perceived level of challenge in their implementation was the focus of another survey question. According to Figure 5.4, fiscal transparency and shared risk and reward are recognized as two of the highly challenging IPD principles for implementation. Early involvement of key stakeholders and joint development of project targets were identified as less challenging IPD principles.

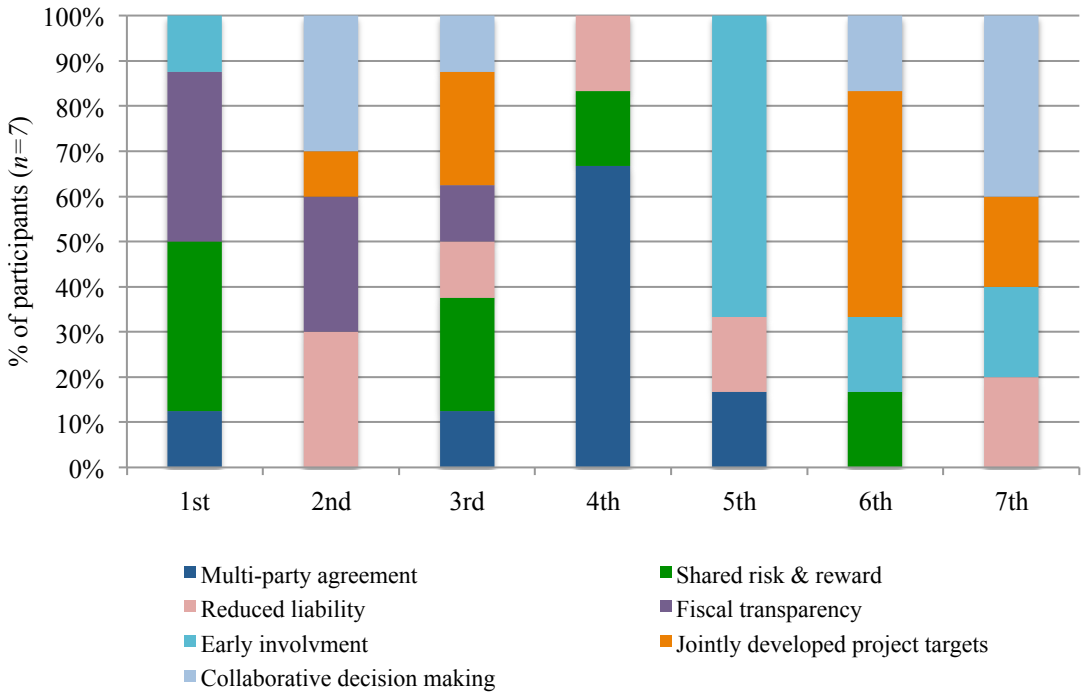


Figure 5.4: Order of IPD principles based on the perceived level of challenge in their implementation

The participants were also asked to identify the likelihood of 1) recommending IPD, and 2) wanting to use IPD for delivering a building project in BC (Figure 5.5).

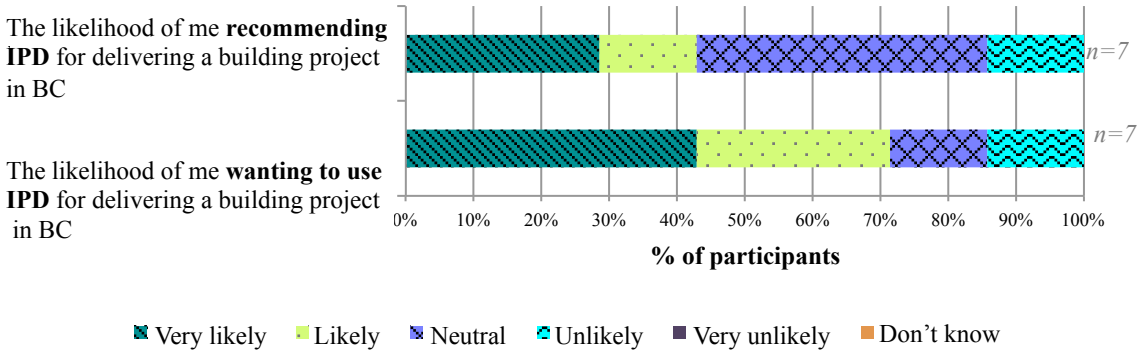


Figure 5.5: The likelihood of recommending IPD and wanting to use IPD for delivering a building project in BC as noted by research participants

Figure 5.5 shows that the likelihood of participants wanting to use IPD is higher than the likelihood of them recommending this method for delivering a building project in BC. During the first workshop, one of the participants mentioned that:

> *" I would love to work in an IPD project here in BC, but to suggest it to others; I first need to exactly know what it means to do an IPD." (workshop participant)*

5.3.2 The Areas of Challenge Perceived to Hinder IPD Implementation for Delivery of Healthcare Facilities in the Lower Mainland, BC

Participants mentioned during the workshops that there currently exist stringent public rules for procurement and delivery of healthcare facilities in the region, which may impede adoption of IPD. Throughout the discussion session in the first workshop, the group identified eight possible areas of challenge believed to hinder IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC (Figure 5.6). These eight areas are as follows:

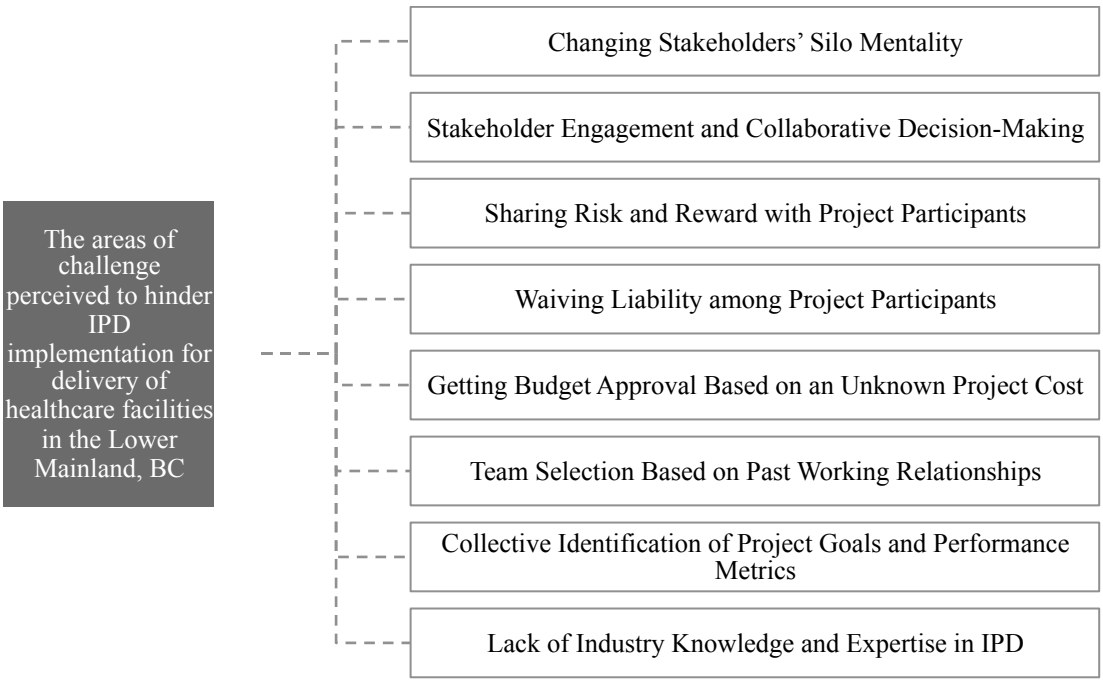


Figure 5.6: The areas of challenge perceived to hinder IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC

5.3.2.1 Changing Stakeholders' Silo Mentality

The participants explained that project members often tend to focus on risk mitigation for their own area of work. They acknowledged that executing IPD would affect the project members' level of control over different systems. The participants anticipated a high level of discomfort and challenge for project teams to break the silos and operate without clear separation and division of responsibilities.

5.3.2.2 Stakeholder Engagement and Collaborative Decision-Making

The participants noted that the large number of stakeholders in health organizations and variation in their areas of work and interest would make the process of collaborative decision-making challenging and slow. They explained that the key decision-makers in the healthcare organizations often do not actively participate in stakeholder engagement sessions due to lack of time and patience; therefore, they will not be able to fully understand the needs of the various groups and their impacts on the project requirements. This lack of engagement and understanding makes it difficult for the decision-makers to approve the budget for a project that exceeds the minimum requirements.

5.3.2.3 Sharing Risk and Reward with Project Participants

It was explained throughout the discussion session that most public sector organizations, including healthcare organizations, tend to transfer risk to other parties and pay the costs associated with transferred risk rather than retaining or sharing risk. This approach to risk management can be observed in Public-Private Partnerships (P3s). The general understanding among participants was that transferring the risk to the party best equipped to manage the risk allows the public sector to benefit in a number of ways. The participants mentioned that those who believe in the merits of risk transfer would challenge IPD and question how risk sharing can be a better strategy for risk management.

5.3.2.4 Waiving Liability among Project Participants

IPD arrangement regarding liability was perceived as one of the key areas of challenge for health organizations. The participants noted that risk sharing and waiving liability are two closely related IPD principles that could face major oppositions by key decision makers. It was pointed

out by many that liability among project members would not be waived unless the healthcare organizations become convinced of the merits of risk sharing over risk transfer.

5.3.2.5 Getting Budget Approval Based on an Unknown Project Cost

The participants noted that getting budget approval for IPD projects would be challenging when the project cost is unknown. They explained that in conventional contracts (e.g., lump sum or Guaranteed Maximum Price (GMP) contracts), healthcare organizations request the budget based on a fixed price cap. Participants noted that due to the separation of profit from project cost (e.g., cost of labour, equipment, and material), the absence of a contractual cost cap in IPD, and contingency of parties' profit on performance outcome, the final project cost can remain unknown until the completion of the project; they expected this to cause a challenge in the process of obtaining budget approval from the Ministry of Finance.

5.3.2.6 Team Selection Based on Past Working Relationships

Selecting project team members was identified as another possible area of challenge in implementing IPD. The participants noted that establishing the project team based on past working relationships and pre-existing levels of trust would be suitable for IPD; however, this approach to team formation is not a viable option for healthcare organizations due to existing procurement rules. It was mentioned throughout the workshop that the conventional form of Request For Proposal (RFP) and the processes that are usually followed for proposal evaluations need to be altered to meet IPD requirements.

5.3.2.7 Collective Identification of Project Goals and Performance Metrics

Joint identification of project goals and performance metrics was perceived as another challenging aspect of IPD. The participants explained that project goals are traditionally defined by the healthcare organizations and dictated to other parties. Deciding on the project goals and performance metrics in collaboration with constructors and designers was recognized to be burdensome as it is an unusual process for the organization. Including post-occupancy performance measures in the compensation formula and extending the payment period until the building is in operation were identified as major challenges.

5.3.2.8 Lack of Industry Knowledge and Expertise in IPD

It was mentioned throughout the workshop that the design and construction industry of BC is not widely familiar with IPD making it such that there is little to no local expertise with this PDM. The participants were concerned that healthcare organizations might not even receive an adequate number of proposals from bidders if they decide to use IPD for a project. Moreover, they stressed that using IPD may lead to a failure if healthcare organizations implement this method before there is enough capacity in BC to execute IPD.

5.3.3 Proposed Pathways to Overcome the Perceived Barriers to IPD Use

During the second and third workshops, the participants discussed the potential solutions to overcome the areas of challenge perceived to hinder IPD use in the Lower Mainland healthcare organizations. The group noted that implementing true IPD and overcoming the existing regulatory obstacles could be possible through two pathways (1) setting up a trust for the healthcare organizations, which could allow more flexibility in procurement and operational procedures facilitating the use of IPD; and (2) engaging Partnerships BC (PBC) in the process of developing a business model for using IPD in public sector projects in the region. The participants explained that PBC has strong connections with the Ministry of Finance and can directly discuss the viability of IPD as a procurement alternative with the Treasury Board.

It was noted throughout the workshops that the above-mentioned pathways involve fundamental changes to existing legal frameworks, which would likely be slow in execution. Therefore, the group suggested a series of actions that could be taken meanwhile. The participants admitted that this set of actions does not lead to delivery of true IPD projects; however, it allows the healthcare organizations to deliver IPD-like projects by using those IPD principles that fit within the existing rules. This set of actions is described below:

5.3.3.1 Qualification-Based Team Selection

The participants noted that healthcare organizations could follow a qualification-based approach to team selection in projects; there is no obligation to select parties merely based on price proposals. It was explained that this approach to team selection is similar to CMR with this difference that usually in CMR, the parties are dealing with a fixed price for the project, which has been previously approved by the Ministry of Finance.

5.3.3.2 Sharing Savings through Guaranteed Maximum Price (GMP) Contracts

It was suggested throughout the workshops that in order to incentivize the parties to realize project objectives, the healthcare organizations could use a performance metric to measure project outcomes and share the savings with all partners if targets are achieved at lower costs. The participants explained that the healthcare organizations could follow conventional methods for developing a business plan and setting a price ceiling for the project. Once the budget is approved, a GMP contract can be written describing the conditions under which project partners would receive a share of the project savings. Many believed that in this model, the participating entities are incentivized to focus their efforts and resources on aspects of the project that are prioritized in the performance metric. The participants believed that even if the budget were tight, this model would allow the healthcare organizations to achieve more of the targets that matter to them most.

5.3.3.3 Using Lean Tools and Building Information Modeling (BIM) in Projects

The participants noted that using Lean tools (e.g., A3[1], Choosing By Advantage[2], Plus/Delta[3], pull planning[4]) and BIM in conventional projects would be advantageous. They mentioned that using this set of tools would not only assist teams to execute projects more efficiently, but also help in preparing the foundations for implementing true IPD.

Pilot testing IPD in a small-scale project was seen as an effective step towards educating the stakeholders and examining the applicability of this method to healthcare projects in the region. The participants identified two types of projects that could be considered for pilot testing IPD: 1) residential care facilities, and 2) retrofit projects. They explained that compared to larger projects such as acute care hospitals, these two types of projects are often more flexible in their requirements; therefore, it should be less challenging to get permission to deliver them with IPD.

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[1] A3 is a Lean tool that is used for reporting, problem-solving, and documenting decision-making processes. A3 is a one-page report (in A3 size) that presents: problem background, problem description, analysis results, proposed actions, and implementation plan (IPDA, 2016).

[2] Choosing By Advantage or CBA is a decision-making method that assesses and compares decision alternatives based on their advantages, not the combination of advantages and disadvantages (Arroyo, 2014).

[3] Plus/Delta is a Lean tool used for evaluating an activity with the aim of identifying what produced value (Plus), and what needs to be improved (Delta) (Fischer, Ashcraft, Reed, & Khanzode, 2017).

[4] Pull planning is a Lean tool used for scheduling the work that is based on identifying the end goals and the key milestones and plan the work backwards, from the end goals back to the first milestone (IPDA, 2016)

Participants mentioned that healthcare organizations often look for alternative ways of delivering residential care facilities. They explained that conventional methods such as DBB or DB often do not result in successful projects: DBB normally ends up with higher prices, and in DB projects, owners usually have less control over quality. Moreover, it was noted that due to potential changes in care models and the rise of land prices in the Lower Mainland, BC, residential care facilities are normally planned for a short lifespan (approximately 30 years); therefore, more flexibility in procurement rules is expected for this type of facilities.

5.4 Discussion and Conclusion

Workshop participants were a group of individuals working at the facilities management department of healthcare organizations in the Lower Mainland, BC. They had no prior direct experience with IPD. Their initial impressions were that a number of IPD principles could be effective in improving project outcomes but they would likely be challenging to implement. Sharing risk and reward, and fiscal transparency are believed to be two of the most effective principles for controlling cost and schedule in a project. However, the participants perceived these principles to be very challenging to implement in the delivery of healthcare facilities in the Lower Mainland, BC. In contrast, the early involvement of key stakeholders and joint development of project targets were seen less challenging to execute. These two principles were recognized to be the most effective for meeting energy performance related objectives in a building project.

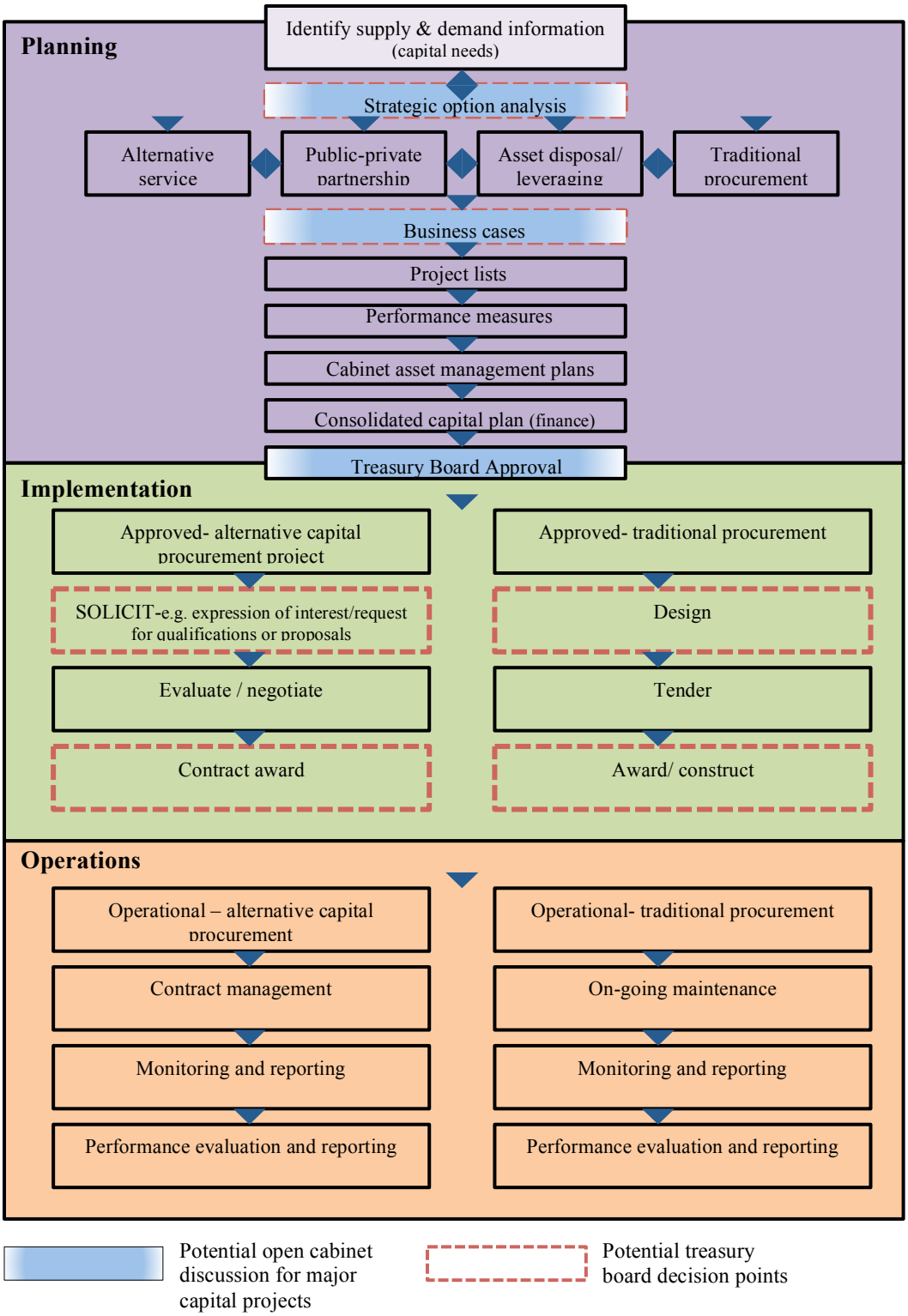
The majority of the participants expressed interest in using IPD but were less willing to recommend it to others. This is likely due to a lack of personal experience with IPD, hence a reluctance to endorse an unknown innovation. Implementing Integrated Project Delivery in small-scale projects such as residential care facilities was identified as a first potential step for the healthcare organizations towards gaining experience with IPD. However, as discussed in Chapter 2, those who had direct experience with working on IPD projects perceived this PDM to be best suited to large complex projects; coordination and learning costs may prove too expensive to defray in small projects.

Current procedures and regulations for procurement and delivery of public sector healthcare facilities in the region were seen as an impediment to IPD implementation. Figure 5.7 presents the typical asset management procedure undertaken by public sector organizations in BC, including the healthcare organizations, throughout the lifecycle of an asset from planning to operation and maintenance.

According to the capital asset management guidelines developed by the Province of British Columbia, protecting the public interest and providing the best value for money are the key principles in all phases of a project, from planning and procurement to operation, disposal or renewal. These guidelines explain that the procurement processes employed by public sector organizations need to be competitive, open, inclusive, fair, and transparent (Province of British Columbia, 2002).

The Ministry of Finance has developed a Capital Procurement Checklist using various references to help public sector organizations meet government procurement policy requirements. According to this checklist, standard industry Request for Qualification (RFQ) and Request for Proposal (RFP) need to be used as part of the project team selection process to ensure competition and get the best value for money (BC Ministry of Finance, 2007). Therefore, public sector organizations cannot skip the competition phase and pre-select IPD team members based on prior collaborations and established relationships even though it could favour IPD model based on the findings of Chapters 2 and 3.

The Capital Procurement Checklist notes that making RFQ requirements too narrow reduces competition and undermines potential value for money that is in conflict with the principles of government's procurement policy requirements (BC Ministry of Finance, 2007). IPD is a new method and is still foreign to many in the AEC industry. Thus, including familiarity and prior experience with IPD as part of the requirements in RFQs may narrow down the qualified bidders to a very few number of design and construction firms in Canada resulting in reduced and insufficient competition; some may even call such requirement unfair and complain to the government.



Note: This figure is adapted from the Province of British Columbia (2002)

Figure 5.7: Typical asset management procedure in BC public sector organizations

According to provincial procurement policies, bidders' requests and observations need to be appropriately dealt with and responded to clearly (Province of British Columbia, 2002). Limited knowledge and experience with IPD may limit public sector organizations in taking corrective actions and responding to legitimate questions with sufficient clarity to avoid claims of institutional mismanagement.

Another objective in procurement processes of publicly funded capital construction projects is the fair and cost-effective allocation of risks and responsibilities (Province of British Columbia, 2002). The Capital Procurement Checklist notes that using non-standard documents, which inappropriately allocate risk among parties, may result in price impact, un-intended risk allocation, and contractors that decline to bid (BC Ministry of Finance, 2007). Risk sharing, which is one of the key principles of IPD model, is not a common practice in the industry and may be perceived as an inappropriate approach to risk management. The fear of the unknown may hinder many to bid and participate in a project that allocates risks in an unfamiliar manner. Many may question why public sector organizations are willing to share rather than transfer the risks as they usually do.

Public sector organizations often believe that their contracting approaches, especially public-private partnership (P3), lead to a delegation of risk management to private partners. However, Jensen and Dowlatabadi (2017) found that using the P3 model in BC was both more expensive and did not guarantee performance or reduce project risks. Other studies of P3s and healthcare facilities have shown that the use of the P3 model rather than traditional public procurement can lead to higher costs without enhancements in quality; this is especially true when P3 contracts do not include long-term operational services and are only used to provide the hard physical assets (UK House of Commons, 2011). Therefore, it is important that healthcare organizations carefully examine the life cycle costs and benefits of various approaches to risk management and not base their decisions on the theoretical advantages of risk transfer. Employing risk-sharing mechanisms instead of risk transfer models could actually expose the healthcare organizations to less risk in the long run.

The areas of challenge perceived to impede IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC noted by workshop participants suggest that there is a need to develop education and training programs in IPD for AEC professionals in BC. Public sector organizations such as Lower Mainland healthcare organizations could partner with professional associations such as British Columbia Construction Associations (BCCA) and develop a series of information sessions and workshops on IPD to engage various groups of stakeholders. Although small in number, there are owners, designers, and contractors in other provinces of Canada that have direct experience with IPD. Public sector organizations in BC could create a platform for local firms to learn from the experience of these professionals and get familiar with IPD principles.

As discussed in Chapter 2, there are various project-oriented and stakeholder-oriented benefits in implementing IPD as determined by the interviewees with direct experience of working on IPD projects. Chapter 2 also identified complexity, typical for healthcare facilities, as one of the main characteristics of projects found to be suited to IPD. Moreover, there is a strong track record of IPD in U.S. healthcare organizations affirming the suitability of this method to healthcare facilities. Thus, IPD could be well suited for delivery of healthcare facilities in the Lower Mainland, BC; however, it is important to examine whether healthcare organizations in the region possess characteristics that make them suitable to be owners of IPD projects. Future studies can focus on this examination in greater details.

In Chapter 2, I show that owners who are deeply engaged in each stage of decision-making and are strongly committed to IPD principles are believed to be good fits for Integrated Project Delivery. However, the members of LMFM that participated in the IPD workshops found stakeholder engagement and collaborative decision-making to be challenging to execute at their organization, as they are not normal practice in their projects. A more in-depth investigation of the organizational characteristics of LMHO would indicate whether they could be suitable partners for IPD projects or not.

Integrated Project Delivery has already been adopted by a number of public sector organizations in Canada including St. Jerome's University (The Globe and Mail, 2017), The Town of Oakville

(The Town of Oakville, 2018), City of Barrie (City of Barrie, 2018), and Moose Jaw Regional Hospital (Hendley, 2017). The adoption of IPD by these organizations indicates that public sector procurement rules in Canada are not necessarily against IPD and they could support organizations that are willing to uptake this delivery method. A future study could focus on understanding IPD implementation processes followed by the public sector organizations listed above. This would help organizations such as LMHO learn how to prepare for adoption of integral administrative innovations like IPD.

It is important to note that the participants in this study had no direct experience with IPD and their level of familiarity with this PDM was also limited. Their opinions regarding the effectiveness of IPD principles and the challenge of their implementation were merely based on their impressions of this PDM and did not stem from direct experience with this method. Therefore, the reality of IPD, the actual effectiveness of its key principles, and the level of challenge associated with them may be different from the perception of LMFM members that participated in this study. This group of individuals, though small in number, was recognized to be most informed about the processes in their organization and the barriers that could be faced for adopting IPD by Lower Mainland healthcare organizations. Therefore, this is the major contribution of this study.

Chapter 6: Conclusion

The purpose of this research was to characterize the environment that is perceived to support IPD and also to characterize the players that are considered to be suitable for implementing this PDM. Moreover, the aim was also to understand what new competencies and changes are needed in the existing structure of the AEC industry to better facilitate IPD implementation, and to explore the role of IPD in navigating the barriers to innovation adoption in this sector of the economy. In order to achieve these overall goals, four interrelated qualitative studies were carried out using literature reviews, semi-structured interviews, questionnaires, and stakeholder workshops. The specific objectives, findings, and major contributions of these four studies are briefly summarized below.

6.1 Brief Summary of Each Chapter

6.1.1 Chapter 2: Perceived Benefits of Integrated Project Delivery (IPD) and Characteristics of Suitable Projects and Project Owners

Study No. 1 (Chapter 2) was conducted to identify the perceived benefits of IPD that encourage stakeholders to choose this method over conventional PDMs. This study also explored what different groups of stakeholders (Owners, Constructors, and Designers) identify as the characteristics of projects and project owners suitable for IPD use. The findings of this study revealed that there are four project-oriented and three stakeholder-oriented perceived benefits of IPD that encourage selection of this method over conventional alternatives for project delivery. Reducing uncertainty in project timeline and budget, maximizing project value, addressing project complexity, and mitigating project risks were identified as the perceived project-oriented ends. Consistency with the organization's culture, gaining market advantage, and being suggested by trusted advisors were highlighted as the perceived stakeholder-oriented reasons for selecting IPD.

Reducing uncertainty in project timeline and budget was identified as the top driver for choosing IPD, mentioned by 69% of the participants with high concordance among Owners, Constructors, and Designers. The most noticeable variation in stakeholders' perceptions was found in relation to the role of IPD in maximizing project value. A significantly larger fraction of Constructors

than the other two groups pointed to this factor as a reason for selecting IPD. This chapter showed that achieving the aforementioned project-oriented ends is made possible through three means that are perceived to be fundamental to IPD: enhanced collaboration, informed decision-making, and accelerated adoption of innovation.

Comparing the benefits of IPD identified by the research participants with IPD benefits reported in the literature indicated that all except two (promoting trust and facilitating BIM utilization) of the IPD benefits highlighted in reviewed publications were perceived as benefits of choosing IPD over conventional alternatives. Selecting IPD based on the suggestions received by trusted advisors was a reason for stakeholders' choice of this PDM that was not mentioned in the reviewed literature.

Study No. 1 (Chapter 2) also characterized projects and project owners that are found to be a good fit for IPD. Complex projects and those with large size and scope were noted to be well suited for IPD. Owners that get fully engaged and hold a strong commitment to IPD principles throughout the project were recognized as more suitable for adopting this delivery method from the perspective of the research participants.

The major contribution of this study to the AEC industry and the literature in the field is that stakeholders' perceptions of the benefits of IPD are aligned with those reported in the literature. While IPD is believed to have the means to realize these benefits, there are specific types of projects and project owners that are perceived to be more suitable for IPD. The use of this delivery method may not result in the reported benefits if the project and the project owner lack the required characteristics as outlined in this chapter.

6.1.2 Chapter 3: Perceived Challenges in Implementing Integrated Project Delivery (IPD): Insights from Stakeholders in the U.S. and Canada for a Path Forward

The perceived benefits of IPD demonstrated in Chapter 2 lead to the question of why this method has not been more broadly adopted? Hence, it is important to identify challenges that might be encountered in adopting this process. Therefore, Study No.2 (Chapter 3) was conducted with the

objective of characterizing the challenges in implementing IPD as perceived by different stakeholder groups that have experience working on both IPD and non-IPD projects.
In total, research participants identified 28 challenges, which were categorized into seven groups. The challenges mentioned by at least 90% of the respondents were related to five categories: 1) sustaining a collaborative environment, 2) dealing with the operating environment, 3) selecting the right team, 4) embedding IPD concepts, and 5) making sound and timely decisions.

The analyses showed that gender, country of practice, and belonging to a specific stakeholder group are correlated with interviewees' perception with regard to some of the identified challenges. The extent of respondents' experience with IPD did not correlate with the broad findings of this study. Analysis of the identified challenges suggests the following four key lessons for improving the efficacy and success of IPD implementation: 1) focusing on partnership capability in IPD team selection, 2) empowering team members and establishing a flatter organizational structure, 3) bridging the knowledge gap on IPD concepts and their implementation, and 4) establishing a balance between efficient resource allocation and collaboration.

This study contributes to the AEC industry and the construction engineering and management literature by indicating that successful implementation of IPD will not be achieved by principles only; it requires investment in preparation and acculturation, rethinking project planning and management, and cultural change in the AEC industry.

6.1.3 Chapter 4: The Perceived Impact of Integrated Project Delivery (IPD) on Diffusion of Innovations in the Architecture, Engineering, and Construction (AEC) Industry

Study No. 3 (Chapter 4) identified various barriers to diffusion of innovations in the AEC industry and examined whether, compared to conventional methods, IPD is perceived to be instrumental in enabling innovation adoption in building projects. This chapter also explored the IPD components that are believed to have the capacity to play a positive role in facilitating the adoption of innovations. Furthermore, in this study I investigated how the impact of IPD components on various dimensions of fragmentation is perceived to affect the adoption of different types of innovations.

The barriers to adoption of innovations in the AEC industry found in the literature were categorized into two groups: *adopter-oriented* barriers, and *industry-oriented* barriers. The findings suggest that IPD is more influential in navigating barriers to the former group than the latter.

Study No. 3 (Chapter 4) differentiated *integral* innovations – those that cross conventionally defined boundaries of specializations in the industry – from *modular* innovations, which fit within those boundaries. The findings indicated that IPD is believed to facilitate the adoption of *integral* innovations but does not interact with *modular* innovations.

Research participants found 12 IPD components instrumental in addressing the barriers to innovation adoption in building projects. Collaborative decision-making, early involvement of key stakeholders, and owner involvement and vision were the three IPD components that were most commonly mentioned by the research participants. The first two components were noted by more than half of the respondents.

Similar to Chapter 3, analyses were conducted to examine whether participants' perceptions of the role of IPD components in innovation adoption vary based on the stakeholder group, level of experience with IPD, gender, and country of practice. The results demonstrated noticeable divergence between the perspectives of participants from different groups in relation to some of the IPD components. For example, testing the differences between perceptions of respondents from various stakeholder groups indicated that a considerably larger fraction of Owners and Constructors pointed to the role of owner involvement and vision in addressing the barriers to adoption of innovations in IPD projects, compared with Designers.

Both female and male respondents appreciated the importance of collaborative decision-making; however, this waned with experience for male participants. In contrast, greater experience with IPD was found to be correlated with a higher level of perceived importance of early involvement of key stakeholders among female participants.

Country of practice was also found to be correlated with the perceived role of IPD components in addressing the barriers to innovation adoption. A noticeably larger fraction of those from Canada than those from the U.S. pointed to the role of early involvement of key stakeholders, and Lean design and construction principles in facilitating innovation adoption in IPD projects. This finding suggests that there may be a third level of barriers, beyond *adopter-oriented* and *industry-oriented barriers* (listed in Chapter 4), to adoption of innovations like IPD in the AEC industry; the socio-economic, legal, and cultural context within which the industry is operating may also affect innovation adoption in building projects.

The major contribution of this study to the AEC industry and the literature in the field is that while IPD is found to be instrumental in addressing some of the barriers to adoption of innovations in the AEC industry, foundational changes to the policies, regulations, and programs governing the industry's operations, and utilization of alternative business and financing models are required to alter the industry's approach towards innovation adoption.

6.1.4 Chapter 5: Exploring Adoption of IPD for the First Time in an Organization: Using the Case of Healthcare Organizations in the Lower Mainland, British Columbia

Considering that IPD itself is an innovative approach to project delivery, Study No. 4 (Chapter 5) focused on: identifying the areas of challenge perceived to hinder IPD implementation for the first time in an organization; characterizing the expected pathways to overcome the perceived barriers to IPD implementation in the studied organization; and understanding how those who do not have direct experience with IPD perceive the effectiveness of its overarching principles on various aspects of project performance.

It was shown in Chapter 2 that complex projects, such as healthcare facilities, are believed to be well suited to IPD. Previous studies have also shown a strong track record of IPD in U.S. healthcare organizations, which confirms the suitability of this method for healthcare facilities. Therefore, the facilities management department of healthcare organizations in the Lower Mainland, British Columbia, which had never implemented IPD, was approached to engage their members in learning about this method and what they see as the institutional barriers to its adoption.

A number of IPD principles were identified by members to be highly effective in enhancing their project outcomes, but challenging to execute for delivery of healthcare facilities in the Lower Mainland, BC. Among those, sharing risk and reward, and fiscal transparency were perceived to be the most effective principles for cost and schedule control, while early involvement of key stakeholders and joint development of project targets were recognized to be the most effective ones for meeting energy performance related objectives in a project.

Research participants identified eight areas of challenge that they thought would hinder IPD implementation for delivery of healthcare facilities in the Lower Mainland, BC. Some, such as the difficulty of executing stakeholder engagement and collaborative decision-making, were related to the characteristics of the organization. Others, such as those associated with team selection procedures, were related to the existing public procurement rules. Yet others, such as stakeholders' silo mentality and lack of industry-wide knowledge and expertise in IPD, were related to the broader context within which the organization is operating.

The major contribution of this study to knowledge is that while IPD could potentially be a suitable method for delivery of certain projects (e.g., healthcare facilities in the Lower Mainland, BC), the absence of the characteristics identified in earlier studies as making an organization suitable for IPD (described in Chapter 2), as well as the lack of a supportive environment and necessary contextual factors are perceived to impede implementation of this innovation for the first time in organizations. In the specific context of BC healthcare facilities, reconsidering procurement rules, building capacity in the AEC industry and associated organizations, and educating industry actors are perceived to be instrumental steps towards the adoption of IPD.

The participants of this study had no direct experience with this method. Therefore, their perceptions with regard to the effectiveness of IPD principles, and challenges identified with regard to their implementation may be different from the reality of IPD. The individuals from the facilities management department of healthcare organizations in the Lower Mainland, BC that participated in this study were most informed about the processes in their organizations and the barriers that could be faced when using IPD for delivery of healthcare facilities in the region.

6.2 Discussion

The point of departure for this research was the observation of different dimensions of the performance gap in the AEC industry, which are found to be rooted in disintegrated processes, emphasis on local rather than holistic optimization throughout the project, and uncoordinated behaviour of different stakeholder groups. With its innovative principles, IPD is believed by many to have the potential to address these long-lasting challenges for some project types. Several scholars have reported success stories of IPD projects, and have demonstrated outperformance of this PDM over conventional alternatives. In the search for the characteristics of a supportive environment and fitting players that enable the full potential of IPD, this study showed that there are a number of benefits that participating interviewees believe to be associated with IPD, which encourage stakeholders to select this method of project delivery over conventional models. However, realizing these benefits could be impeded in the event that the project, owner, and the broader team lack the set of characteristics that are believed to make them suitable for IPD.

The findings show that the role of owners is critical in IPD. As the party assembling the team, defining the overarching goals of the project, and the one in charge of responding to scepticism towards IPD within their own organizations and the project team, owners need to be fully engaged and committed, and truly believe in the merits of IPD to be suited for adoption of this PDM. This study also showed that, considering the importance of the collaborative approach to problem-solving under the IPD model, the participating entities and their personnel need to have the capacities and make a continuous effort to create an environment that promotes mutual respect and trust, transparency, and information flow. The participants felt that creating such an environment was facilitated by establishing a flatter organizational structure in the project, empowering IPD team members to actively participate in decision-making processes, feeling ownership of the project, and developing a collective team identity.

The broader implementation context was also found to be important. IPD is an integral innovation, and its implementation requires investment in acculturation, preparation, and capacity building. Implementing IPD necessitates a supportive social, legal, and cultural environment. Such an environment can be created by navigating the barriers to innovation

diffusion in the AEC industry (presented in Chapter 4). Learning disability and difficulty of collecting tacit knowledge is one such barrier that impedes adoption of integral innovations such as IPD. Disbanding teams at the end of a project and significant changes to the composition of core project teams (longitudinal fragmentation) leads to the loss of tacit knowledge gained throughout the IPD implementation process in a project. This phenomenon hinders collective learning and has a destructive effect on the team's ability to substitute old knowledge with regard to IPD. Therefore, an implementation context that enables keeping IPD teams together across a number of projects, thereby enhancing relational stability within the AEC industry, could help to address the issue of learning disability and difficulty of collecting tacit knowledge.

Local regulations, policies, and inventive programs that inspire adoption of innovations can also play a positive role in building a supportive implementation context for IPD. In an environment where the regulations serve to maintain the status quo, it is more challenging to replace conventional systems and practices with innovative PDMs such as IPD. More specifically, regulations regarding competitive bidding processes and selecting bidders with the lowest price hinder working with the same set of players across projects and team selection based on partnership capability.

Presence of innovation advocates and clients who appreciate innovative alternatives can also help build a supportive implementation context for IPD. Presence of progressive individuals and organizations that carry innovative ideas from inception all the way to the development and implementation phases, or those that are able to persuade others to do so, participate in innovative processes, and lead such efforts can facilitate the adoption of innovations such as IPD in the AEC industry. Moreover, clients that invite innovation to their projects and support finding ways to execute innovative ideas irrespective of bureaucratic barriers faced throughout the process can further contribute to creating a supportive context for implementing innovations like IPD. It is important to consider that merely the presence of such individuals is not sufficient; they need to have an adequate level of power in their organization, as well as access to resources (e.g., time, funds) for research and development to be able to nurture their innovative ideas and leadership skills. This is an important point of consideration for those involved in strategic decision-making processes in organizations engaged in the AEC industry.

Creating a supportive implementation context for IPD not only helps to benefit from the full potential of this PDM, but also helps address barriers to innovation adoption in the AEC industry in general. As discussed in Chapter 4, IPD was found to be instrumental in addressing some of the barriers to innovation adoption, helping building projects harness innovations that have the potential to tackle deep-rooted problems in the industry. However, not all barriers to innovation adoption can be addressed by IPD; there are some that are beyond the reach of project delivery methods. The foundational changes to the existing frameworks governing industry operations highlighted above can address such barriers to innovation adoption in the AEC industry.

As mentioned previously, IPD was perceived to be more suitable for large projects, both in size and scope, and for those with a high level of complexity. It is important to consider that this novel PDM is still in its infancy, and as discussed, the AEC industry, its players, and the broader implementation context are not yet fully prepared and equipped for executing IPD. Therefore, it could be expected that as this method of project delivery matures, the industry actors become more familiar and experienced with it, and the broader implementation context becomes more supportive of innovations such as IPD, the use of this PDM will get extended to a variety of projects. This trend can already be seen in the current situation; IPD started with healthcare facilities, but now we see its use in other types of projects such as educational facilities, residential buildings, and laboratories.

It was shown that implementing IPD could involve several challenges. Some of these perceived challenges have been persistent and were repeatedly encountered by those who had experience participating in multiple IPD projects. This indicates that educating the industry about IPD principles and concepts is not sufficient for successful implementation of IPD; improving the efficacy of this method requires rethinking the current IPD implementation process, development of novel approaches to project planning and management, and more fundamentally, a cultural change in the AEC industry. Developing a collective team identity and trust-based relationships among individuals from different vertical and horizontal specialities, breaking the long-lasting hierarchy of power in the AEC industry, and employing a leadership-collaboration style are not simple to accomplish over the course of a project. Undergoing such radical shifts for AEC industry members who are accustomed to fragmented projects and the blame culture requires

time and strong support from the organizations they work for, as well as the broader context within which the industry is operating.

6.3 Limitations and Suggestions for Future Research

I conclude by outlining some limitations of this research and several suggestions for future studies. One of the major limitations of my thesis is the self-selected nature of participation in the study. Another limitation is that a number of the participants were aware of my background in Architecture, which may have impacted their responses to the interview questions, particularly those related to the challenges of implementing IPD. It is also important to highlight that in this thesis I explored the perceptions of AEC industry professionals towards IPD's benefits, challenges of implementation, role in facilitating innovation adoption, and barriers to its use for the first time in an organization. I did not collect data that would allow objective assessment of the actual implications of IPD in relation to these study areas. Such an examination could be the focus of follow-up research. Furthermore, although useful for drawing in-depth qualitative data, the sample size of the participants in this study was small to infer or suggest generalizability. Future studies with a larger sample size could address this limitation.

In Chapter 2, the success attributed to the particulars of a project and its participants is non-falsifiable. Comparing the outcomes of comparable projects that implemented conventional delivery methods with and without owner-occupied buildings is required to establish the benefits of implementing IPD more broadly. One other suggestion for future research is to examine the possible ways to measure the extent to which the set of characteristics identified in this chapter are present in a project and a project owner. Another interesting study would be to investigate the extent to which the project and the owner' possession of the identified characteristics contributes to the performance of IPD projects and adoption of innovations.

A follow-up study to Chapter 3 could be conducted using a large dataset to examine the degree to which each of the identified challenges has been experienced across different IPD projects. The characteristics of projects and owners of IPD projects in this data set can also be inspected and compared with those identified in Chapter 2. This would help in understanding whether there is an association between the degree to which different challenges are experienced, and the

characteristics of IPD projects and project owners. Another interesting study would be to monitor the challenges experienced in IPD projects throughout different phases of the work, to understand whether there is a difference between various stages of IPD projects' life cycle with regard to the challenges experienced by participants. For conducting this study, a questionnaire could be developed using the list of the challenges identified in Chapter 3 and distributed between members of a/multiple IPD project(s) periodically over the course of the work.

One limitation of Chapter 4 is that the effectiveness of IPD components that were perceived to be influential in the adoption of innovations was not verified in independent case studies. This limitation can be addressed by comparing innovation related outcomes of comparable projects that did implement the IPD components identified in this chapter with those that did not. Another follow-up study could be done to investigate the extent to which each of the identified IPD components is instrumental in innovation adoption. Moreover, it would be interesting to study whether any correlation exists between experiencing various challenges in IPD projects (Chapter 3) and the degree to which innovations are implemented.

The methods used in Chapter 5 to study the barriers to implementing IPD for delivery of healthcare facilities in the Lower Mainland, BC are limited in that they based on perceived barriers and may vary from the actual barriers. The perceived barriers listed in Chapter 5 are based on participants' understanding of IPD implementation requirements, as well as their understanding of the principles and the frameworks governing the operation of their own organization. These findings need to be validated by a larger dataset. Future studies can also focus on comparing the organizational characteristics of the Lower Mainland health organizations with those public sector organizations across Canada that have implemented IPD (e.g., St. Jerome's University, Township of Oakville, City of Barrie). This comparison would enhance our understanding of the changes required to prepare an organization for implementing innovations such as IPD.

Other follow-up research could investigate how belonging to a specific stakeholder group (e.g., Owner, Designer, Constructor), gender, and country of practice shape subjective perspectives with regard to the benefits of IPD, barriers to its adoption, challenges of its implementation, and

its effectiveness in innovation adoption. Furthermore, as IPD matures in the AEC industry, it would be valuable to study how the benefits and challenges of implementing IPD evolve over time. As the industry becomes more familiar and experienced with this method, it would be of great value to study the type of projects that get delivered using IPD, as well as the type of owner organizations and design and construction firms that participate in IPD projects at different stages of IPD adoption in the industry. Moreover, it would be interesting to investigate how the adoption of innovations evolves over time in IPD projects. And lastly, it would be valuable to explore the spillover effects of IPD, understand the impacts of using this method across project boundaries, and examine whether employing IPD promotes a culture of continuous learning and improvement from project to project in the building industry.

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Appendices

Appendix A

Interview questions for Owners, Constructors, and Designers

Respondent ID: ----------
Interviewee initials: ----------
Date of interview: ---------- Location of interview: ----------
Phone or in-person interview: ----------
Interview start time: ---------- Interview end time: ----------
Voice recorder file ID: ----------

- Background information:
    - Interviewee's gender: ----------
    - Interviewee's country of practice: ----------
    - Interviewee's level of experience with IPD (one time only, or > one time): ---------
    - The IPD projects that the interviewee had worked on: ----------
    - Interviewee's typical role in projects: ----------

- What do you think are the benefits of IPD and what are the reasons to choose IPD rather than other conventional methods such as DB, DBB or CMR for delivering a project in the AEC industry?
    - How can one decide if a project requires formal/contractual (therefore IPD) or informal/non-contractual integration of project teams?
    - What characteristics should a project/product have to be suitable for IPD?
    - What characteristics should a project owner have to be suitable for IPD?

- According to AIA, participatory and collaborative decision-making is a key aspect of IPD. Considering your experience with IPD and non-IPD projects, answer the following questions:
    - How different are the decision-making processes in IPD projects compared to conventional projects?
    - For example, how are conditions of satisfaction /project goals set in IPD projects vs. conventional projects?

- How well do you believe stakeholders' concerns are heard in IPD projects compared to conventional projects?

- How significantly do you believe stakeholders' concerns and opinions affect the project if it's delivered by IPD vs. conventional methods?

    - What mechanisms are employed in IPD projects for learning about stakeholders' concerns?
    - How different are these mechanisms compared to those that are normally employed in conventional projects?

- What mechanisms are used in IPD projects for enforcing a high level of integration and collaboration among project teams?

    - How different are these mechanisms compared to those that are normally used in conventional projects?

- Do you think IPD projects are more or less suitable than conventional projects for the adoption of innovations (e.g. new technologies, designs, materials, etc.)? Why do you think is that?

    - What IPD components do you think affect the adoption of innovations in projects?
    - Do these components facilitate or impede innovation adoption?
    - Please give examples of innovations that were used in your IPD projects. Do you think these innovations would have been adopted in the project if other methods (e.g. DBB, DB, CMR) were used instead of IPD?

- In your experience, what are the challenges of IPD implementation?

    - Do you think you would have experienced these challenges if conventional methods were used instead?

- Considering what you experienced in IPD projects, do you want to engage in an IPD project again? Why? If yes, what would you do differently next time? If no, what aspect of IPD challenges makes them unsuitable for you?

- Any other comments about IPD, its use in the AEC industry, and your experience with this method?

- Specific to Owners in IPD projects:

    - How experienced were you with the processes of design and construction before your IPD project (s)? / How many projects were you involved with before doing IPD?

    - What were the typical challenges in your previous projects that you hoped to overcome through IPD?

- How was the project (delivered by IPD) defined at the beginning, and how did you choose the project team (architects, engineers, contractors, trade partners, owner representative (if any), vendors, commissioning agent, etc.)?

- Did you have a top-down approach or a bottom-up approach for designing the facility (delivered by IPD)? Why did you choose that approach?

- Who was involved from your side (client's side) in the decision-making processes of the project (delivered by IPD)? How were these individuals chosen?

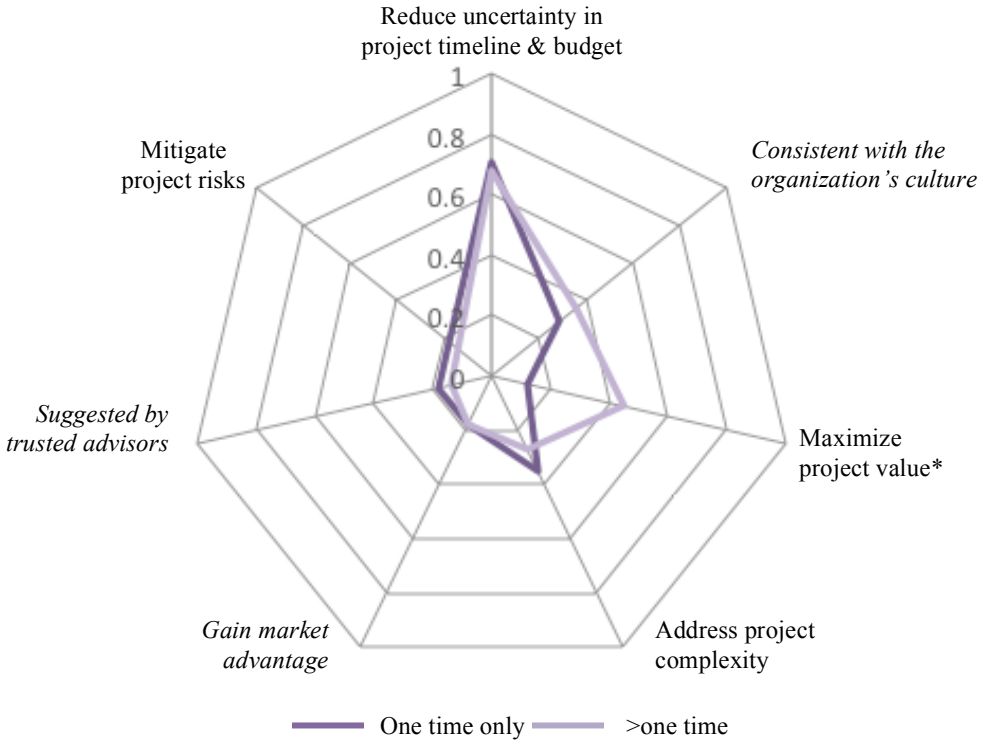
- Who was involved from your side (client's side) in the process of design (concept design, functional design, detail design, implementation documents) of the facility (delivered by IPD)? How were these individuals chosen?

- Do you have a low or high turnover rate in your organization?

- What is the difference between this new facility (delivered by IPD) and your previous projects from the perspective of facility space and the work processes?

    - What new ideas in terms of the facility space and work processes were suggested for your IPD project(i.e., by you to the IPD team, or by IPD team, or any external consultants)?
    - Who introduced those new ideas? When were they suggested?
    - Which of those new ideas were finally incorporated into the project?
    - Please give examples of those new ideas that were accepted, and also those that were rejected? Why were they accepted/rejected?

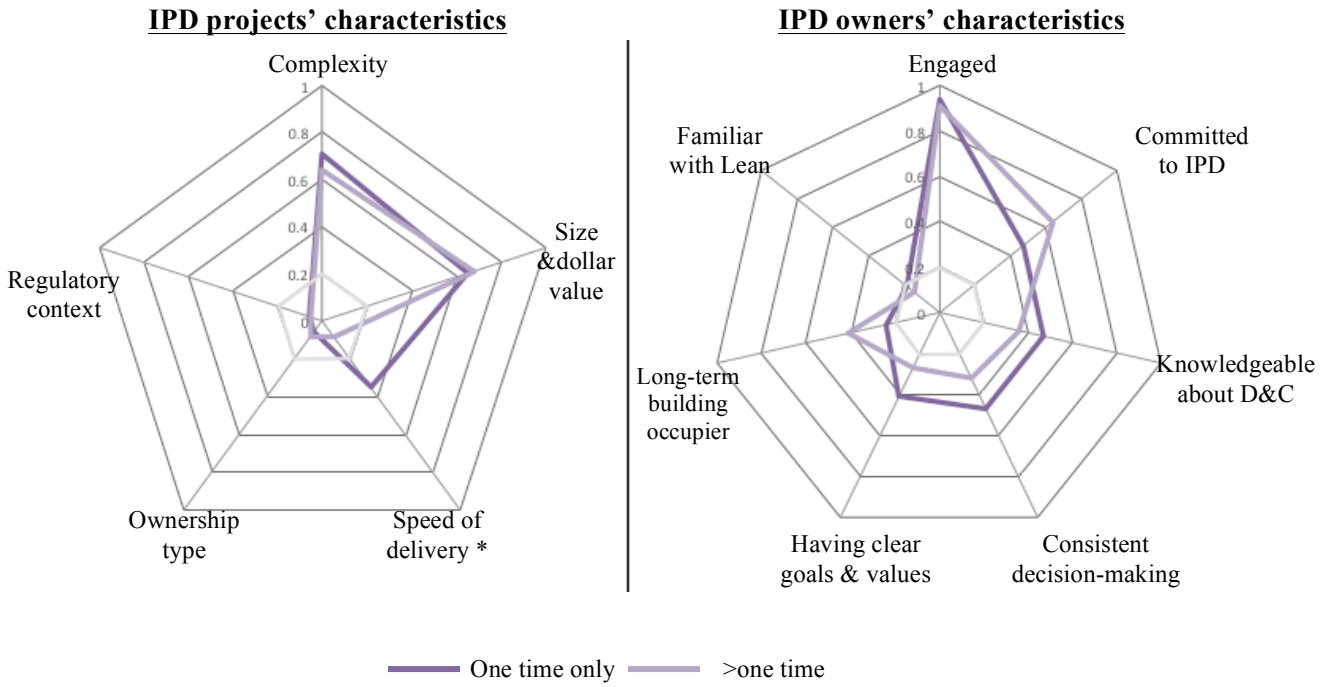
Appendix B



IPD Driver	p-value
Maximize project value	0.019*

Note: The factors with statistically significant difference at ≤ 0.05 (*) level among participants with a various level of IPD experience is listed above. The project ends are romanized and the stakeholder ends are italicized. The rate of the respondents within each sector who pointed to each factor increases with distance from the center.

Figure B-1: Summary of reasons (project-oriented and stakeholder-oriented ends) for selecting IPD as perceived by the interviewees with different level of IPD experience

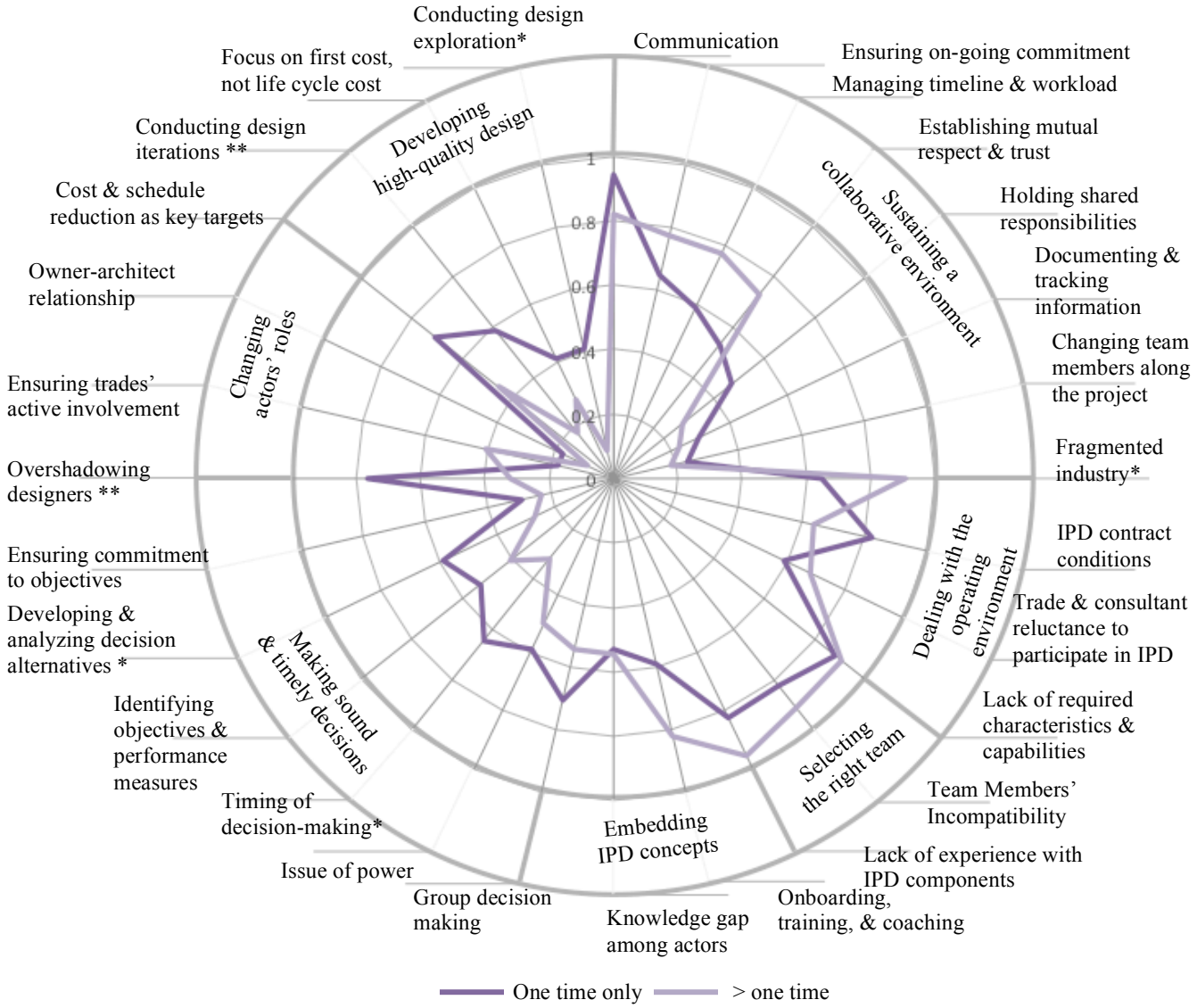


IPD projects characteristics	p-value
Speed of delivery	0.043*

Note: The factor with statistically significant difference at ≤ 0.05 (*) level among participants with a various level of IPD experience is listed above. The rate of the respondents within each sector who pointed to each factor increases with distance from the center.

Figure B-2: Summary of IPD projects and owners' characteristics as perceived by the interviewees with different level of IPD experience

Appendix C



Challenges at the level-1 category	p-value
Overshadowing designers	0.005**
Conducting design iteration	0.008**
Conducting design exploration	0.017*
Timing of decision making	0.040*
Fragmented industry	0.043*
Developing & analyzing decision alternatives	0.046*

Note: Sub-challenges with statistically significant differences at ≤0.01 (**) and ≤0.05 (*) levels among participants with a different level of IPD experience are listed above. The rate of the respondents within each sector who pointed to each challenge increases with distance

Figure C-1: Summary of the challenges in IPD implementation perceived by interviewees with different level of IPD experience

Table C-1: % of respondents with different level of IPD experience who pointed to the categories of challenge in implementing IPD

Categories of challenge [a]	**One time only** (N=17) %	**>One time** (N=22) %	**Total** (N=XX) %
1. Sustaining a collaborative environment	100	100	100
2. Dealing with the operating environment	88.2	100	95
3. Selecting the right team	88.2	90.9	90
4. Embedding IPD concepts	82.4	95.5	90
5. Making sound & timely decisions	88.2	90.9	90
6. Changing actors roles	76.5	59.1	67
7. Developing high-quality design	70.6	54.5	62

[a] The categories of challenge (*at level-2*) are ordered based on the total number of respondents who pointed to them. This order does not, however, represent the relative importance of each challenge for IPD implementation in the U.S. and Canada.

Appendix D

Table D-1: % of respondents from different groups who pointed to each IPD component

IPD Components facilitating innovation adoption [a]	One time only (N=17) %	>One time (N=22) %	Male (N=28) %	Female (N=11) %	U.S. practitioners (N=32) %	Canada practitioners (N=7) %
i. Collaborative decision making	82	68	75	73	75	71
ii. Early involvement of key stakeholders	53	64	57	64	53	86
iii. Owner involvement & vision	35	59	36	82	47	57
iv. Colocation & continuous communications	47	32	32	55	38	43
v. Incentivized contracts	24	41	36	27	31	43
vi. Lean D&C principles	24	32	25	36	22	57
vii. Use of virtual D&C	12	14	18	0	13	14
viii. Innovation seeking nature of IPD participants	6	18	14	9	16	0
ix. Fiscal transparency	18	5	11	9	9	14
x. Reduced liability concerns	6	14	11	9	9	14
xi: Agile cost shifting	12	9	14	0	9	14
xii: Complexity & large scale of IPD projects	6	5	4	9	6	0

[a] The IPD components are ordered based on the total number of respondents who pointed to them. This order does not, however, represent the relative importance of each component for the adoption of innovations in the AEC industry of the U.S. and Canada

Table D-2: % of respondents from different groups who pointed to each IPD component: examining the combined effect of country of practice and level of experience with IPD; country of practice and gender; and gender and level of experience with IPD

Collaborative Decision Making		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	86.67%	50.00%	**Male**	77.27%	66.67%	**Male**	84.62%	66.67%
	> One time	64.71%	80.00%	**Female**	70.00%	100.00%	**Female**	75.00%	71.43%
Early involvement of key stakeholders		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	46.67%	100.00%	**Male**	45.45%	83.33%	**Male**	61.54%	46.67%
	> One time	52.94%	80.00%	**Female**	60.00%	100.00%	**Female**	25.00%	85.71%
Owner involvement & vision		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	33.33%	50.00%	**Male**	31.82%	50.00%	**Male**	30.77%	40.00%
	> One time	58.82%	60.00%	**Female**	80.00%	100.00%	**Female**	50.00%	100.00%
Colocation & continuous communication		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	53.33%	0.00%	**Male**	31.82%	33.33%	**Male**	46.15%	20.00%
	> One time	23.53%	60.00%	**Female**	50.00%	100.00%	**Female**	50.00%	57.14%
Incentivized contracts		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	26.67%	0.00%	**Male**	31.82%	50.00%	**Male**	23.08%	46.67%
	> One time	35.29%	60.00%	**Female**	30.00%	0.00%	**Female**	25.00%	28.57%
Lean design & construction principles		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	20.00%	50.00%	**Male**	18.18%	50.00%	**Male**	23.08%	26.67%
	> One time	23.53%	60.00%	**Female**	30.00%	100.00%	**Female**	25.00%	42.86%
Use of virtual design & construction		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	13.33%	0.00%	**Male**	18.18%	16.67%	**Male**	15.38%	20.00%
	> One time	11.76%	20.00%	**Female**	0.00%	0.00%	**Female**	0.00%	0.00%

Innovation seeking nature of IPD participants		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	6.67%	0.00%	**Male**	18.18%	0.00%	**Male**	7.69%	20.00%
	> One time	23.53%	0.00%	**Female**	10.00%	0.00%	**Female**	0.00%	14.29%
Fiscal transparency		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	20.00%	0.00%	**Male**	9.09%	16.67%	**Male**	15.38%	6.67%
	> One time	0.00%	20.00%	**Female**	10.00%	0.00%	**Female**	25.00%	0.00%
Reduced liability concerns		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	6.67%	0.00%	**Male**	9.09%	16.67%	**Male**	7.69%	13.33%
	> One time	11.76%	20.00%	**Female**	10.00%	0.00%	**Female**	0.00%	14.29%
Agile cost shifting		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	13.33%	0.00%	**Male**	13.64%	16.67%	**Male**	15.38%	13.33%
	> One time	5.88%	20.00%	**Female**	0.00%	0.00%	**Female**	0.00%	0.00%
Complexity & large scale of IPD projects		**U.S. practitioners**	**Canada practitioners**		**U.S. practitioner**	**Canada practitioner**		**One time only**	**> One time**
	One time only	6.67%	0.00%	**Male**	4.55%	0.00%	**Male**	7.69%	0.00%
	> One time	5.88%	0.00%	**Female**	10.00%	0.00%	**Female**	0.00%	14.29%

Appendix E

E.1 Questionnaire-part 1

- **The following questions are about you and your experience in the building industry**

1. Which **stakeholder group** best represents you in a building project?

□Owner
□Designer
□Constructor
□Other (please specify) ____

2. What is your **area of work**?

3. How many **years of experience** do you have in the building industry?

□Less than 2 years
□2-5 years
□5-10 years
□More than 10 years

4. Please indicate % of the total number of your building projects by client type.
(Values should add up to 100%)

____ % of my building projects have **public** clients
____ % of my building projects have **private** clients

5. Please indicate the count for building projects you have been involved with in each **budget** category

____ of my building projects had a budget under $1M
____ of my building projects had a budget between $1 and $10M
____ of my building projects had a budget between $10M and $25M
____ of my building projects had a budget between $25M and $50M
____ of my building projects had a budget over $50M

6. Please indicate the count for building projects you have been involved with in each of the following **project types**?

____ Healthcare
____ Industrial
____ Residential
____ Office
____ Education
____ Cultural/recreational
____ Mixed use
____ Other (please specify)

❖ **The following questions are about all building projects, not just your own experience**

7. Buildings rarely come in exactly on budget. To the best of your knowledge, what % of building projects come in above or below **budget**?
(Values should add up to 100%)

□Don't know – skip to next question

___ % of building projects are completed **considerably below** budget
___ % of building projects are completed **below** budget
___ % of building projects are completed **within** project contingency
___ % of building projects are completed **above** budget
____% of building projects are completed **considerably above** budget

8. Buildings are rarely completed on time. To the best of your knowledge, how does the project completion time differ from the estimated **schedule**? Please write down the % of building projects that fall in to each of the following categories.
(Values should add up to 100%)

□Don't know – skip to next question

___ % of building projects are completed **much earlier** than the estimated schedule
___ % of building projects are completed **earlier** than the estimated schedule
___ % of building projects are completed **close to** the estimated schedule
___ % of building projects are completed **later** than the estimated schedule
____ % of building projects are completed **much later** than the estimated schedule

9. To gain LEED certification or meet other objectives, buildings often have a modeled energy performance. To the best of your knowledge, how does the actual **building energy performance** relate to its modeled performance? Please write down the % of building projects that fall in to each of the following categories.
(Values should add up to 100%)

□Don't know – skip to next question

___% of buildings are **much more efficient** than the estimated performance
___% of buildings are **more efficient** than the estimated performance
___% of buildings are **about as efficient as** the estimated performance
___% of projects are **less efficient** than the estimated performance
___% of buildings **are much less efficient** than the estimated performance

10. To gain Today's presentation is about Integrated Project Delivery (IPD). What is your **awareness and experience level with IPD**?

□ Not well informed about IPD and no direct experience with IPD
□ Informed about IPD, but no direct experience with IPD
□ Have direct experience with IPD

E.2 Questionnaire-Part 2

1. **How effective do you expect IPD** to be as an approach for improving:

➢ **Cost control**	➢ **Schedule control**	➢ **Meeting energy performance targets**
□Don't know	□Don't know	□Don't know
□ very ineffective	□ very ineffective	□ very ineffective
□ ineffective	□ ineffective	□ ineffective
□ neutral	□ neutral	□ neutral
□ effective	□ effective	□ effective
□ very effective	□ very effective	□ very effective

2. Please rank as many IPD principles as you can be confident about in order of effectiveness for improving **cost control** in a building project:
(ties are OK)

____Multi-party agreement
____Shared financial risk and reward based on project outcomes
____Reduced liability between key participants
____Fiscal transparency between key participants
____Early involvement of key participants
____Jointly developed project targets/goals
____Collaborative decision-making

3. Please rank as many IPD principles as you can be confident about in order of effectiveness for improving **schedule control** in a building project:
(ties are OK)

____Multi-party agreement
____Shared financial risk and reward based on project outcomes
____Reduced liability between key participants
____Fiscal transparency between key participants
____Early involvement of key participants
____Jointly developed project targets/goals
____Collaborative decision-making

4. Please rank as many IPD principles as you can be confident about in order of effectiveness for **meeting energy performance targets** in a building project:
(ties are OK)

____Multi-party agreement
____Shared financial risk and reward based on project outcomes
____Reduced liability between key participants
____Fiscal transparency between key participants
____Early involvement of key participants
____Jointly developed project targets/goals
____Collaborative decision-making

5. **Please indicate your perspective** on the following statements?

- IPD is needed to achieve the target of **zero-emission new buildings by 2030**

  □Don't know
  □ disagree strongly
  □ disagree
  □ neutral
  □ agree
  □ agree strongly

- **Post-occupancy performance measures** need to be included in compensation formula for building projects

  □Don't know
  □ disagree strongly
  □ disagree
  □ neutral
  □ agree
  □ agree strongly

6. Please rank as many IPD principles as you can be confident about in order of how **challenging** you believe they are for implementation in a building project in BC.
(ties are OK)

____Multi-party agreement
____Shared financial risk and reward based on project outcomes
____Reduced liability between key participants
____Fiscal transparency between key participants
____Early involvement of key participants
____Jointly developed project targets/goals
____Collaborative decision-making

7. What is the **likelihood** of the following statements?

- I would like to **use IPD** for delivering a building project in BC

  □ Don't know
  □ very unlikely
  □ unlikely
  □ neutral
  □ likely
  □ very likely

- I will **recommend IPD** for delivering a building project in BC

  □ Don't know
  □ very unlikely
  □ unlikely
  □ neutral
  □ likely
  □ very likely

E.3 Guide sheet- IPD Principles: Brief Description

- **Multi-party agreement:**

In a multi-party agreement, the primary project participants (at least owner, architect, and general contractor) execute a single contract specifying their respective roles, rights, obligations, and liabilities.

- **Shared financial risk and reward based on project outcomes:**

In the IPD business model, the profit is tied to achieving agreed project outcomes. If the agreed project outcomes/goals are not met, project profit is reduced or even eliminated. If the project performs better than the goals, the project's profit is increased. Each party shares in the increase or decrease based on their percentage of the project's profit.

- **Reduced liability between key participants:**

Reduced liability is an element in closing the system, forcing the participants to take responsibility for the project rather than attempting to blame other participants in an attempt to escape the impact of a problem. Reduced liability also removes disincentives to direct and continuous communication between the parties.

- **Fiscal transparency between key participants:**

Due to the financial arrangements under IPD, projects are fiscally transparent between contract parties. This provides a higher level of awareness and trust between parties.

- **Early involvement of key participants:**

In an integrated project, the key participants are involved from the earliest practical moment. Decision-making is improved by the influx of knowledge and expertise of all key participants. Their combined knowledge and expertise is most powerful during the project's early stages where informed decisions have the greatest effect.

- **Jointly developed project targets/goals:**

The jointly developed and validated targets/goals are an enforceable "mission statement" for the project. This joint action aligns the team's actions to the agreed goals. Agreement to goals also leads to commitment to achieving them. In addition, they provide a check, through the validation process, on the feasibility of the project.

- **Collaborative decision-making**

In IPD, representatives of key participants are involved in day-to-day decision-making processes. Joint project decision-making empowers the team and accelerates the decision-making processes. It also increases overall ownership of the project.

Appendix F

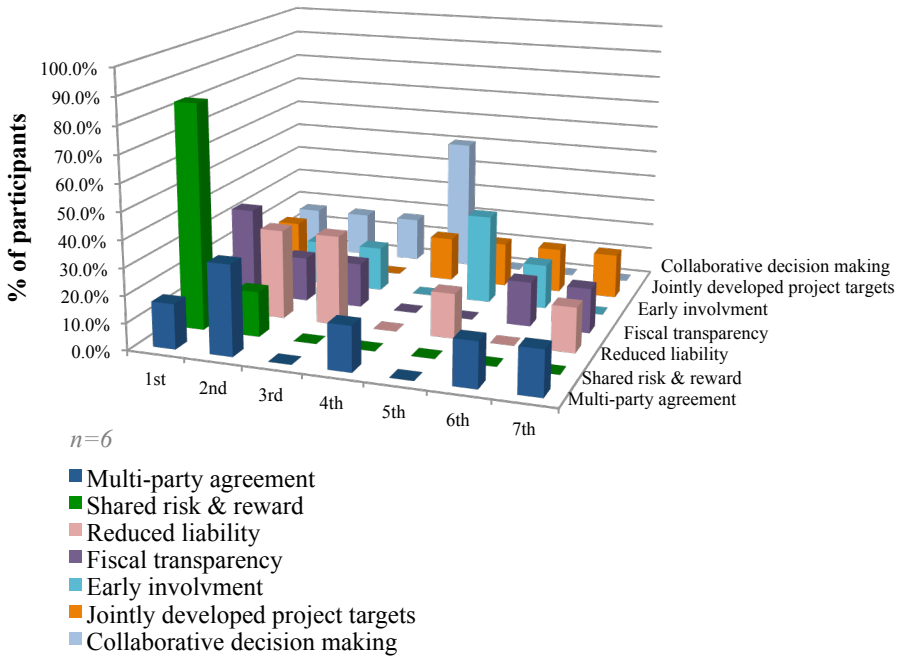


Figure F-1: 3D presentation of the order of IPD principles based on their perceived effectiveness in cost control

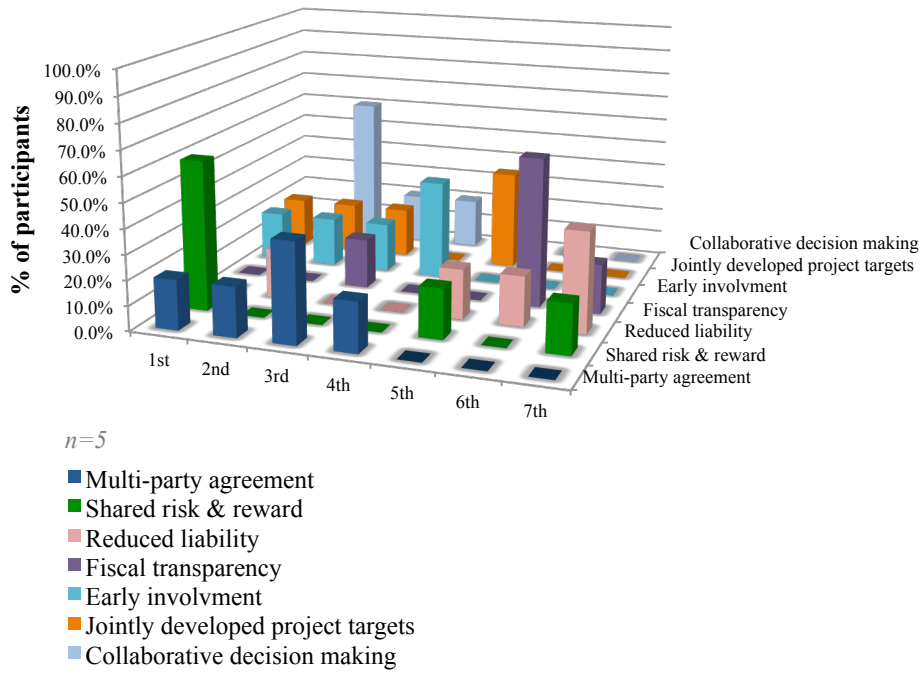


Figure F-2: 3D presentation of the order of IPD principles based on their perceived effectiveness in schedule control

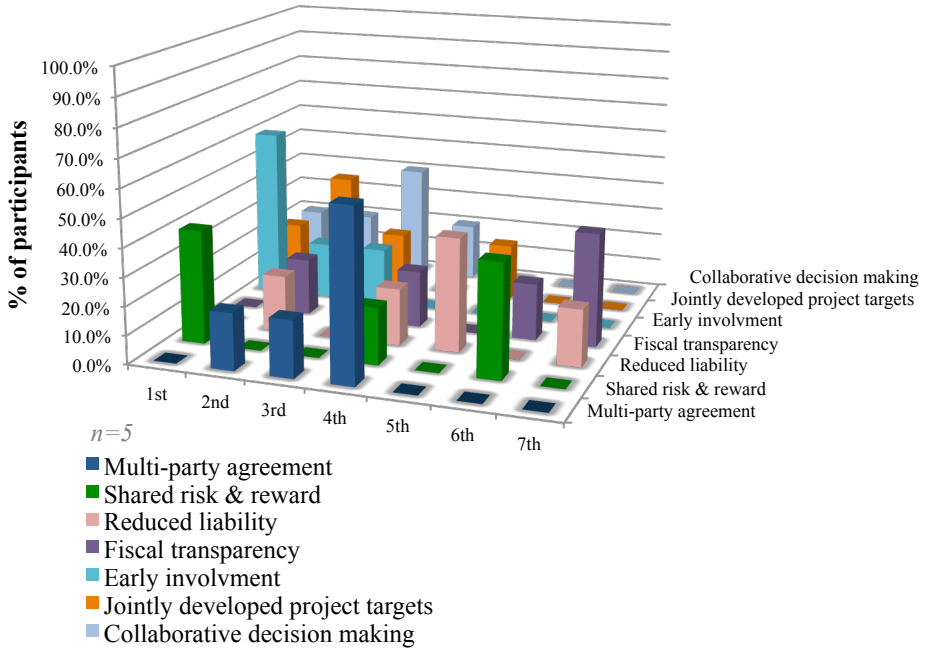


Figure F-3: 3D presentation of the order of IPD principles based on their perceived effectiveness in meeting energy performance targets

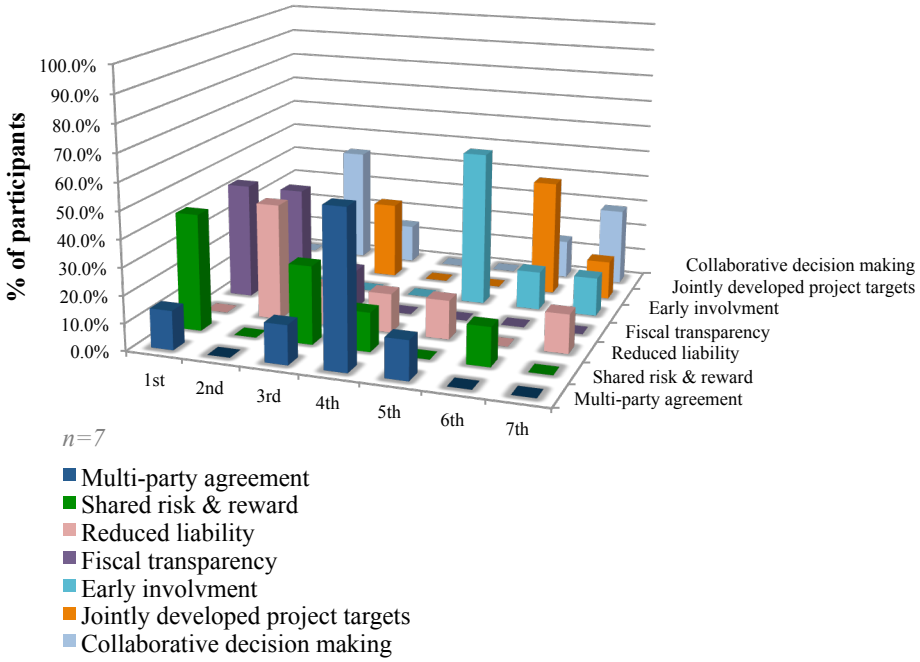


Figure F-4: 3D presentation of the order of IPD principles based on the perceived level of challenge in their implementation