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ScienceDirect

International Journal of Project Management 37 (2019) 395–409

International Journal of Project Management

www.elsevier.com/locate/ijproman

Comparative analysis between integrated project delivery and lean project delivery

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Received 30 January 2017; received in revised form 8 January 2019; accepted 27 January 2019
Available online xxxx

Abstract

Integrated Project Delivery (IPD) and Lean Project Delivery (LPD) are innovative approaches that are capturing the attention of the construction industry. However, there is a confusion about the definitions of these approaches and how they integrate a project delivery process. This confusion negatively affects the learning process, which could create a barrier to advancing them. Based on a structured literature review and two case illustrations, this study aims to clarify the similarities and differences between IPD and LPD. This paper presents a comparative analysis of these approaches through a structured analysis of the project organizations, contractual relationships, and operational systems. The results showed that the operational system is perhaps the most relevant difference between these approaches for their definition as a project delivery system. The core of both approaches is to encourage the use of integrated project organizations, relational contracting, and integrated process as mechanisms to integrate a project delivery system.

Keywords: Integrated project delivery; Lean project delivery; Project organization; Contractual relationship; Operational system

1. Introduction

"*Suppliers in several project-based industries are facing increasing pressure to tailor their project delivery methods according to the specific needs of an individual client*" (Hobday, 1998; Mutka and Aaltonen, 2013). Such context has been familiar in the construction industry. Evolution of delivery methods (e.g., design – bid – build, design – build, construction management at risk) for value creation represents a response to the client's requirements and project complexity.

Delivery methods represent a type of solution business model; that is, a business model that describes how resources are combined and transformed in order to generate value for customers and other stakeholders. This represents how a value generating company will be rewarded by its exchange partners that receive value from it (Magretta, 2002).

Project-based industries are implementing new delivery methods with a new logic of business model in order to improve project performance (Kujala et al., 2010). Integrated Project Delivery (IPD) is an approach that is rapidly gaining popularity in the design and construction industry. The United States (U.S.) construction industry has started to use integrated project delivery (IPD) in an attempt to achieve more collaboration and, hopefully, better performance (Mesa et al., 2016; El Asmar et al., 2013;

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https://doi.org/10.1016/j.ijproman.2019.01.012
0263-7863/00

Cheng et al., 2011; AIA National and AIA California C, 2010). With similar goals, Lean Project Delivery (LPD) is an alternative approach to develop construction projects collaboratively. LPD has evolved from a management approach focused on the construction stage to an alternative method of project delivery that uses lean concepts and principles to guide contracting, design and supply chain management (CURT, 2007).

IPD and LPD have become a disruptor to the standard logic of the business models for how the construction industry delivers projects. Their implementation requires changes in the way the design and construction industry manage their business model in order to create value and align objectives and interest of key stakeholders with project objectives. According to Storbacka (2011), this new solution business model requires more collaborative management, business planning needs to involve customers more, and the measures used to control the business have to acknowledge its cross-functional nature.

Practitioners and researchers sometimes use IPD and LPD concepts interchangeably. However, there are also researchers who have defined boundaries between them (El Asmar, 2012). The American Institute of Architects AIA National and AIA California C (2010) stated that: *"within the AEC industry, there is a fair amount of confusion about the difference between lean construction and IPD." "Lean construction is a production control system that seeks to apply principles of the "Toyota Way" of manufacturing to the construction process… Lean construction is a set of tools in support of IPD but is not the entire process."* Smith et al. (2011) stated that: *"Lean construction is more than just a production control system and more than simply a set of tools. It offers a new way of thinking about and managing work in projects." "...IPD is written from a design perspective – that of architects and engineers, while the authors of LPD came from a construction production background."* Do et al. (2015) stated that: "Together IPD and Target Value Design (TVD) form a new project delivery system, which is often referred to as Lean Integrated Project Delivery, IPD/TVD, or just IPD." The National Association of State Facilities Administrators NASFA, COAA, APPA, AGC, AIA (2010) similarly stated that: *"Another term often used to refer to a form of Integrated Project Delivery is Lean Project Delivery System…" "In fact, in this era of evolving terminology, many refer to IPD as "Lean Project Delivery" where the application of "lean thinking" and "lean principles" are applied throughout the project."*

Literature demonstrates a confusing landscape regarding the use of IPD and LPD systems. It shows that there are different theoretical and professional conclusions about how IPD and LPD apply to the design and construction industry for integrating the project delivery process. This confusing landscape negatively affects the study of these systems and continued learning about how they can be improved. Clarity is particularly important when examining project performance with these two methods. Confusion could generate barriers that inhibit the use of, or decision to use, these systems in the design and construction industry. The aim of this study is to understand how these methods work in an attempt to improve project performance in project-based firms, using two cases of the construction industry.

This study addresses the following research question: How do IPD and LPD each integrate a project delivery process? In other words, this study seeks to clarify how IPD and LPD work at the level analysis of project delivery system, and what IPD and LPD characteristics integrate a project delivery process to create value. Authors define project delivery systems from different points of view, such as the roles and relationships between the project participants, the sequence of the project definition, design and construction process or the way work is managed and executed in the course of 'producing' the project (AIA National and AIA California C, 2007; ASCE, 2000; Dorsey, 1997; Ireland, 1984; Kenig, 2011; Moynihan and Harsh, 2016; Sarkar and Mangrola, 2016; Alarcón et al., 2011; Lichtig, 2005; Mossman et al., 2010; Thomsen et al., 2009). For the purpose of this research, a project delivery system *defines the roles and relationships between the participants (organizational structure); the timing and sequence of events and practices and techniques of management (operational system); and the contractual responsibilities (contractual relationships) for defining, designing and constructing a project* (Mesa et al., 2016). This definition of project delivery system can be summarized in three distinguishing characteristics as proposed by Thomsen et al. (2009): organizational structure, contractual relationships, and operational systems. These characteristics will be the basis for the comparison between IPD and LPD.

Based on the project delivery definition, this research performs a thorough literature review to make a comparative analysis between IPD and LPD in terms of distinguishing characteristics: the organizational structure, contractual relationship, and operational system. It then illustrates this analysis on two building projects. This research will add to the body of knowledge in project delivery system research and help the design and construction industry to understand similarities and differences between IPD and LPD from a theoretical and practical point of view. This research does not intend to offer a guideline to decide if one or other of these approaches would be best for a particular construction project, but it will provide additional knowledge for this complex decision.

The paper is organized into seven sections. In the second section, the paper explains the research methodology. Then, the paper discusses the IPD and LPD based on literature review. The fourth section makes a comparison between IPD and LPD at the level of project delivery system in terms of the project organization, contractual relationship, and operational system. The fifth section presents two case illustrations to exemplify the application of IPD and LPD. After comparing and discussing these two case illustrations, the paper concludes with a summary of the findings, discusses the contributions, the limitations and makes suggestions for future research.

2. Methodology

The research's methodology is based on a literature review and two case illustrations. Due to the research's aim of

addressing an analysis at level of the project delivery system, the research explores how the literature theorizes IPD and LPD in terms of distinguishing characteristics of a project delivery system: organizational structure, contractual relationship, and operational system.

The research casts a wide net with the literature review, but the most appropriate documents came from academic databases, including International Group for Lean Construction (IGLC), Web of Science, Science Direct and American Society of Civil Engineers (ASCE) to find the relevant literature.

The review involved searching for "integrated project delivery" and "lean project delivery" in these academic databases. A total of 578 papers were identified that contained "integrated project delivery" in the databases: IGLC (38), Web of Science (86), Science Direct (149) and ASCE (343). On the other hand, a total of 62 papers were identified that contained "lean project delivery" in the databases: IGLC (39), Web of Science (6), Science Direct (20) and ASCE (36).

In order to refine the list of papers, the review focused on identifying IPD and LPD definition; and three relevant distinguishing characteristics of a project delivery system: organizational structure, contractual relationship, and operational system. The papers were rejected when IPD, LPD, and distinguishing characteristics were mentioned but not discussed, or when they were used in a different meaning or context.

Refining the list of papers resulted in a database of 76 papers that were published by the following journals or professional organizations: Journal of Construction Engineering and Management, Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, International Journal of Project Management, International Group for Lean Construction, The National Association of State Facilities Administrators, and The American Institute of Architects. The 76 papers were then sorted according to the theme, IPD or LPD. The review focused on a thorough reading of each paper in order to identify information that allowed a description of the evolution of the IPD or LPD definition, and a discussion of each IPD or LPD distinguishing characteristic. Some papers were rejected based on the criterion explained in the paragraph above.

Two case illustrations were used to exemplify the discussion of IPD and LPD as project delivery systems. To select the IPD and LPD projects for analysis, this research applied the following criteria: a) the project must use a type of agreement that is signed at least by the owner, architect, and constructor (i.e., multi-party IPD agreement); b) the project should be a vertical building; and c) the authors must have access to key participants who are willing to share their experience and information. Two building projects that accomplish all previous characteristics were selected after an extensive search: a healthcare project and a conference center. These two building projects are particularly illustrative as while conducting the interviews, the healthcare project implemented an LPD contract to involve key participants early on in the project definition stage and the conference center which was in the construction stage, implemented an IPD contract to involve the owner, the architect and the constructor early on in the design stage.

The data collection consisted of interviews that focused on obtaining information about the project organizational structure, that is, how the owner, the architect, the CM/GC, key consultant and key subcontractor were organized (project team) and how they were involved in the definition, design and construction stage; the type of contractual relationships among the key participants; and the operational system, that is, how the owner worked with the architect, the CM/GC, key consultants and key subcontractors to manage the project. An average of six interviews was conducted for each project to obtain all information. Each interview took an average of 90 min. In addition, the data collection also used other documents, such as draft contracts, validation report studies, and previous research (thesis and papers). These documents allowed us to confirm and verify the information from the interviews, especially for the healthcare project.

In summary, the literature used the IPD definition from AIA and NASFA reports. The primary LPD references were from founding members of the Lean Construction Institute. Based on this premise, the research reviewed each publication to follow the evolution of the IPD and LPD system concept and proposed a definition. Based on the three main distinguishing characteristics, the research made a comparison between the IPD and LPD systems in order to identify similarities and differences as project delivery systems, and what IPD and LPD characteristics make a delivery process integrated. Finally, the research used two case illustrations in order to exemplify the application of IPD and LPD as project delivery systems.

3. Defining IPD and LPD

3.1. Integrated project delivery

Different authors and professional organizations propose different definitions for the IPD system in the current body of literature. These competing definitions create a confusing landscape. The most common IPD definitions used by literature are from the AIA National and AIA California C (2007, 2010) and NASFA, COAA, APPA, AGC, AIA (2010). The following paragraphs introduce these definitions. The aim is to provide a common IPD system definition that the paper will use.

AIA (2007) defines IPD as a "*project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction*." However, under this definition, any traditional project delivery system could be considered an integrated approach for project delivery. For example, design-build (DB) could be IPD because it integrates contractual responsibility for the design and construction under a single source contract, as could construction management at risk (CMR) because the CM/GC is early involved in the design phase.

In 2010, AIA presented a new IPD definition. In comparison with the definition presented in 2007, this new definition more explicitly distinguishes between a traditional and IPD system.

In this case, AIA defines IPD 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.*" It is this inclusion of a multi-party contract with shared risk and reward that is the key change to the AIA definition.

The NASFA, COAA, APPA, AGC, AIA (2010) provides an alternate definition of IPD as a philosophy or delivery system. The NASFA IPD philosophy occurs when integrated practices or philosophies are applied to more traditional delivery systems such as design-bid-build (DBB), CMR and DB. IPD as a delivery system occurs when the owner has elected to sign a multi-party contract with the prime designer, contractor and/or other key members of the project team.

Using the AIA and NASFA definitions and highlighting that an IPD delivery system requires the use of a multi-party contract, this research defines *IPD as an approach that integrates people, systems, business structures and practices through a multi-party agreement to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design and construction.*

3.2. Defining lean project delivery system

The LPD system recently emerged as a new approach to deliver projects based on three fundamental goals: deliver a product, maximize value and minimize waste (Ballard, 2000; Ballard and Howell, 2003). There are two milestones in the creation of LPD as a delivery system. The first is the definition of a project-based production system and second is the definition of an agreement for LPD.

Initially, LPD focused on a project-based production system to support a new and better way to design and build capital facilities. LPD applies a collaborative process that aligns the project organization and the project operational system without reference to any specific commercial terms (Ballard, 2000; Smith et al., 2011). The system is comprised of a number of phases that captures both the linear and the iterative nature of the design and construction process. It recognizes the importance of certain aspects of design and construction happening in parallel rather than sequentially (Fig. 1) (Mossman et al., 2010). The main characteristics of this LPD definitional milestone are: the project is structured and managed as a value generating process; downstream stakeholders are involved in front-end planning and design through cross-functional teams; project control has the job of execution as opposed to reliance on after-the-fact variance detection; optimization efforts are focused on making workflow reliable as opposed to improving productivity; pull techniques are used to govern the flow of materials and information through networks of cooperating specialists; capacity and inventory buffers are used to absorb variability and feedback loops are incorporated at every level, dedicated to rapid system adjustment (i.e., learning) (Ballard, 2000).

The second milestone in defining LPD as a project delivery system involved the adoption of a relational contract. Traditional forms of contracts and the associated business structures do not facilitate the pursuit of lean ideals (Ballard and Howell, 2005). This relational contract is named Integrated Form of Agreement (IFOA) for LPD. IFOA embraces the

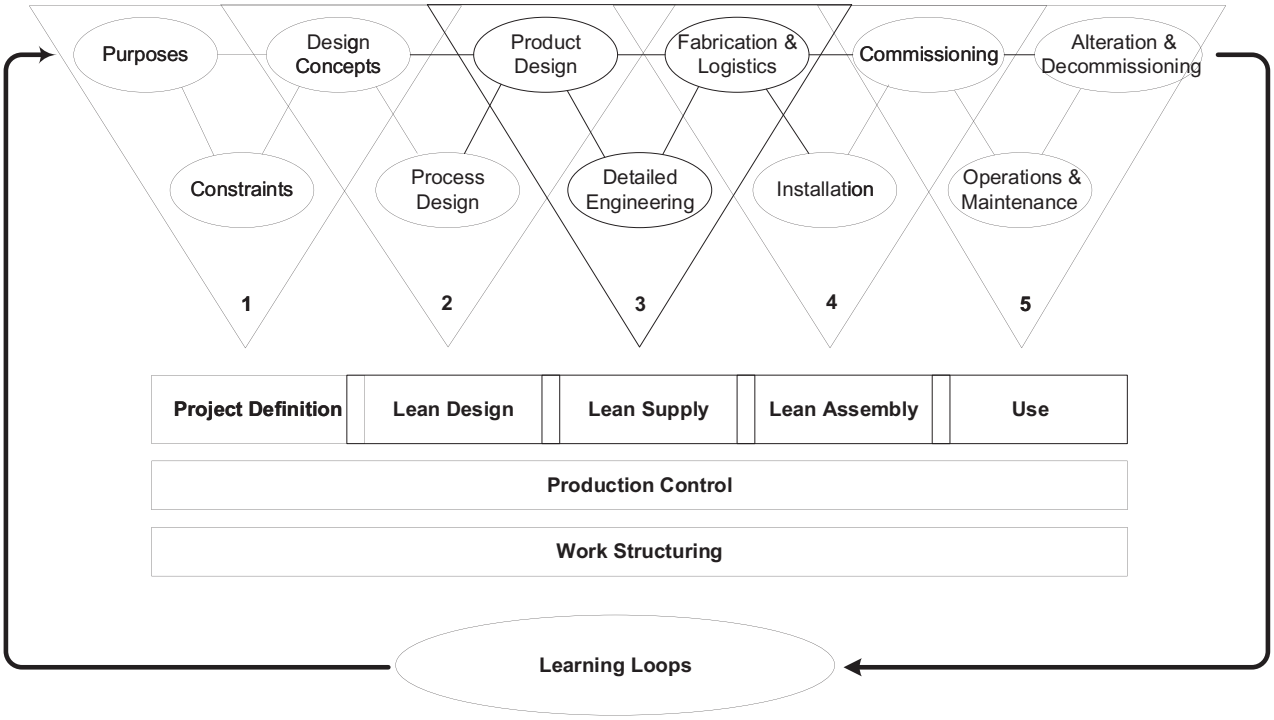

Fig. 1. Lean project delivery system (adapted from Ballard, 2008).

underlying principles of lean project delivery and the Five Big Ideas (Lichtig, 2006), which are: (1) genuine collaboration throughout design, planning, and execution; (2) increase relatedness among all project participants; (3) projects are networks of commitments; (4) optimize the project, not the pieces; and (5) tightly couple action with learning. With these additional concepts, LPD addresses each level of a project delivery system – project organization, contractual relationship, and operational system.

Based on this literature review, the LPD system has evolved from a *project-based production system* to a "robust" system that includes not only the definition and relationship of phases of the project delivery process in a different way but also the application of new organizational, contractual and operational concepts and methods. In line with the IPD definition, LPD is an *approach that integrates people, systems, business structures and practices through a collaborative project organization, a relational contract and lean operational system to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design and construction.*

In summary, IPD and LPD have some similarities and differences based on the conceptual definition from the literature review. IPD could be defined as a philosophy or a delivery system. IPD as a delivery system requires the use of a multiparty agreement. LPD requires an operating system, relational commercial terms, and a collaborative project organization. However, these differences are not enough to make a detailed comparison at the project delivery system level. This research seeks to explore the IPD and LPD characteristics that integrate a project delivery process.

4. Comparison between IPD and LPD distinguishing characteristics

In the previous sections, the research analyzed the conceptual definition of IPD and LPD systems. In comparing both definitions, one can see that there are some similarities and differences. The aim of this section is to analyze the IPD and LPD definition at the level of a project delivery system.

First, this section will introduce an analysis of the empirical evidence of previous research on IPD and LPD to understand what type of context earlier studies have been made. Second, it will compare IPD and LPD based on the previous analysis by a detailed discussion of distinguishing characteristics: project organization, contractual relationship, and operational system.

4.1. Background

Table 1 summarizes past research on IPD and LPD distinguishing characteristics. Recent research on project organization addressed different topics, for example, the impact of team integration on project performance, party selection and communication behaviors on the implementation of IPD, and advantages and disadvantages for the design team when the contractor is involved in the early phases of design. On contractual relationship, research focused on the characterization of multi-party relational contracting and integrated agreement for LPD, shared responsibilities and their relationship with financial incentives in IPD projects. On operational systems, research focused on the impact of BIM on IPD projects, impact of Target Value Design and Last Planner System on LPD projects.

Table 1
Previous researches on IPD and LPD distinguishing characteristics.

Authors	Year	Project organization	Contractual relationship	Operational system
AIA	2007	✓		
Ashcraft	2011	✓		
Azhar et al.	2015	✓		
Ballard	2008			✓
Ballard	2000			✓
Ballard and Howell	2003			✓
Ballard and Reiser	2004			✓
Bröchner and Badenfelt	2011	✓		
Chan et al.	2010		✓	
El Asmar et al.	2013	✓		
El-Adaway	2010		✓	
El-Adaway et al.	2017		✓	
Fish and Keen	2012	✓		
Franz et al.	2016	✓		
Hanna	2016	✓	✓	
Harper et al.	2016		✓	
Hickethier et al.	2013	✓		
Kent and Becerik-Gerber	2010	✓		
Kim and Dossick	2011			✓
Konchar and Sanvido	1998	✓		
Lee et al.	2014		✓	✓
Lichtig	2006		✓	
Lichtig	2005		✓	
Mesa et al.	2016	✓	✓	
Mossman et al.	2010	✓	✓	✓
NASFA et al.	2010	✓		
Ning and Yng Ling	2014		✓	
Sarkar and Mangrola	2016		✓	
Smith et al.	2011		✓	✓
Sødal et al.	2014	✓		✓
Thomsen	2009	✓		
Tillmann et al.	2014	✓		
Xie and Liu	2017		✓	
Walker	1989		✓	
Zhang et al.	2013	✓		
Zimina et al.	2012			✓

In summary, research addressed one or two distinguishing characteristics of IPD or LPD, but separately. They did not analyze the distinguishing characteristics together in order to understand IPD and LPD as a project delivery system and what IPD and LPD characteristics integrate the project delivery process.

4.2. Project organization

The IPD and LPD systems have similar perspectives with regards to the project organization. They both promote early involvement of key participants and integrated teams that are composed of people with different backgrounds (Sødal et al., 2014; Ashcraft, 2011; Tillmann et al., 2014).

Early involvement of key participants is one of the IPD and LPD principles (AIA National and AIA California C, 2007; Ballard, 2000). Construction projects are temporary organizations with many functional specialists. Usually, but not always,

these specialists belong to a different organization and come together only for the duration of the project (Mitropoulos, 1994; Meng, 2012). These organizations are generally the owner, designer, constructor, consultants and subcontractors. The timing of these key participants usually is fragmented throughout the definition, design and construction.

Traditionally, the definition stage includes the owner and designer. Then, the design development introduces design consultants in addition to the owner and designer. Finally, the construction stage includes the constructor. This fragmented approach avoids the opportunity to promote early involvement of key participants and take advantage of their expertise, for example, the constructor's expertise (Konchar and Sanvido, 1998).

Key participants in IPD or LPD, at least the owner, designer and constructor, as well as key design consultants such as mechanical and electrical, are involved in the earliest design stage in order to develop a better understanding of the project (AIA National and AIA California C, 2007; El Asmar et al., 2013; Franz et al., 2016; Hickethier et al., 2013; Sødal et al., 2014). They work together to collaborate in the process of developing and validating project goals and contribute to better design decisions and constructability for project success (Azhar et al., 2015; NASFA, COAA, APPA, AGC, AIA, 2010). This integration of key participants can address the problem of fragmentation between design and construction professionals that results in inefficient designs, increased errors and disputes, higher costs and inefficient work practices and costly changes in the construction stage (Konchar and Sanvido, 1998; Kent and Becerik-Gerber, 2010).

In addition, the early involvement in IPD or LPD also seeks to align and integrate key participants, which have diverse interests and objectives that sometimes converge, and other time are opposed (Thomsen et al., 2009), in order to form an integrated team that works together in a collaborative way.

Both IPD and LPD organizations are built around integrated teams. The integrated team is an interdisciplinary and cross-functional team that involves people from different parties who possess diverse expertise and knowledge (Ashcraft, 2011; Tillmann et al., 2014; Bröchner and Badenfelt, 2011; Zhang et al., 2013; Ashcraft, 2011). This integrated team is comprised of at least the owner, designer and constructor, but in some projects often also includes representatives from key design consultants and specialty trade contractors (Thomsen et al., 2009). The number of cross-functional teams, how they will be directed and coordinated, their individual scope, and how teams are overlapped will depend significantly on the size and technical details of the project (Ashcraft, 2011). According to Fish and Keen (2012), this group of individuals must trust each other and know that the other members of the team are also working towards the best interest of the project.

4.3. Contractual relationship

According to the IPD and LPD definition, both delivery systems use a multi-party form of relational contract. Before explaining each type of contract, the concept of relational contracting and the reason this the systems use this type of contract will be introduced. Then, an analysis of the principles of the IPD and LPD relational contracts will be presented.

4.3.1. Relational contract

Contracts can be classified into discrete and relational exchanges (Williamson, 1979). Discrete contracts emphasize the common norms of a competitive character, such as the attempt to closely specify and impose strict liability for performance. Conversely, relational contracts emphasize the common norms of a cooperative character, such as preservation of the relation in contractual solidarity. Macneil (2000) stated that any transaction is embedded in complex relations. Hence, understanding any transaction requires understanding all the essential elements of its enveloping relationships that might significantly affect the transaction.

In the construction industry, transactional contracts refer to the exchange of goods and services to design and build a project. This “transaction” is embedded in the construction supply chain relationship. Supply chain relationships in construction are rather diverse. Compared to other industries, the construction supply chain is often more complex and involves a larger number of key participants, such as the owner, designer, design consultants, constructor, and various suppliers, resulting in a supply chain relationship that changes from organization to organization and from project to project (Meng, 2012). As a result, complicated relationships exist within the construction supply chain and they can adversely affect project performance if they are not managed effectively (Walker, 1989; Chan et al., 2010; Ning and Yng Ling, 2014). Traditional commercial terms that govern and manage these relationships create a vertical chain of relationships that flow back to the owner but do not interconnect project participants across contractual lines. As a result of this contract structure, each participant operates under commercial terms that provide an economic incentive for it to maximize its own interests regardless of whether its actions would hurt other project participants or benefit the project as a whole (Thomsen et al., 2009).

The construction industry is introducing relational contracts to promote an innovative and non-confrontational relationship-based approach. In the construction industry, relational contracts embrace and underpin different approaches, including partnering, alliancing, joint venture, public-private partnership, and better risk-sharing mechanisms (Chan et al., 2010; El-adaway et al., 2017; El-adaway, 2010; Yeung et al., 2012). The main literature regarding relational contracting in the construction industry provides different definitions. Yeung et al. (2012) defined relational contracting around five core elements: commitment, trust, cooperation and communication, common goals and objectives, and win-win philosophy. McLennan (2000) defined relational contracting as a way to maximize project outcomes in a complicated environment by adopting a conscious approach to build up and manage relationships alongside the cooperative application of ever-improving project processes. Kumaraswamy et al. (2005) defined relational contracting as a process to establish the working relationships between the parties through a mutually developed, formal strategy of commitment and communication aimed at win-win

situations for all parties. Sanders and Moore (1992) defined relational contracting as a process to generate an organizational environment of trust, open communication and employee involvement. In summary, relational contracting is based on a recognition of mutual benefits and 'win–win' scenarios through more cooperative relationships between the contracting parties (Palaneeswaran et al., 2003; Yng Ling et al., 2014) creating a system of collaboration and shared responsibility, rewards and risk, all tied to the amount of value generated by the end product (Cleves and Michel, 2009).

4.3.2. IPD relational contract

IPD requires relational contracting in the development of a construction project to promote collaboration and coordination between all project participants and to ensure project success (Hanna, 2016). This type of contract is the vehicle that allows these goals to be reached successfully without being complicated by separate contracts that create opposing motives (Kent and Becerik-Gerber, 2010).

The IPD system uses a form of relational contracting called multiparty agreement (Harper et al., 2016; AIA National and AIA California C, 2007). This agreement is a single contract that is signed by the owner, architect and constructors, and perhaps other key participants, for the design, construction and commissioning of a project (Sarkar and Mangrola, 2016). The multiparty agreement provides a legal framework to align the individual interest and objectives with project success with a collaborative environment in which the parties operate to enhance cost and performance goals that the parties jointly establish (AIA National and AIA California C, 2007; NASFA, COAA, APPA, AGC, AIA, 2010). The multiparty agreement requires shared financial risk and reward, early involvement of all parties, collaborative decision-making, liability waivers, fiscal transparency, and integrated design (Cohen, 2010; NASFA, COAA, APPA, AGC, AIA, 2010; Thomsen et al., 2009; Xie and Liu, 2017).

The multi-party agreement embraces both contractual and behavioral principles. The contractual principles are: key participants bound together as equals; shared financial risk and reward based on project outcome; liability waivers between key participants; fiscal transparency between key participants; early involvement of key participants; intensified design; jointly developed project target criteria; and collaborative decision-making. The behavioral principles are: mutual respect and trust, willingness to collaborate, and open communication (AIA National and AIA California C, 2007, NASFA, COAA, APPA, AGC, AIA, 2010).

4.3.3. LPD relational contract

The LPD system uses a form of relational contracting called Integrated Form of Agreement (IFOA) (Lichtig, 2005, 2006), that creates the contractual and financial framework to facilitate the effective collaboration between construction project participants (Kent and Becerik-Gerber, 2010; Parrish et al., 2008). The IFOA is a single contract that is signed by at least the owner, architect and constructor. The key consultants and key subcontractors may also sign this agreement (Lichtig, 2005). The purpose of this integrated agreement is to provide a legal framework that aligns and integrates key participants in early stages and encourages a collaborative team working towards project success through planning, designing, construction and commissioning of the project (IFOA, 2008). To achieve this goal, the IFOA embraces the underlying principles of lean project delivery and Five Big Ideas. The IFOA also promotes the following lean behaviors: collaboration, trust, promised-based management and continuous improvement (Lichtig, 2006).

In comparison with other forms of contracting (e.g. DBB, DB and CMR) that focuses on commercial terms and project organization, but not on the operational system, the IFOA takes care of the organization, the commercial terms, and the operational system of the project (Darrington et al., 2009; Lostuvali et al., 2014).

4.4. Operational system

According to the IPD and LPD definitions presented in Section 3, the operational system is one of the most relevant differences between these two delivery systems. Whereas the LPD system uses only a lean operational system that is aligned with the collaborative project organization and the relational contract to encourage integration (Ballard, 2008, Mossman et al., 2010, Smith et al., 2011), the IPD definition does not address a specific operational system as an essential means to align and integrate key participants. IPD seeks to improve project outcomes through a collaborative approach of aligning the incentives and goals of the project team through shared risk and reward via the early involvement of key participants, who sign the same multiparty contract (Kent and Becerik-Gerber, 2010; AIA National and AIA California C, 2010), regardless of what operating system is being used (El Asmar et al., 2013).

Even though IPD does not address a specific operational system by definition, IPD encourages a new way to manage and execute the design and construction process (AIA National and AIA California C, 2007). In a traditional delivery method (e.g., design – bid – build), the design and construction process is developed sequentially and is made up of segregating the key participants; that is, there is a lack of integration among the owner, designer and constructor. The key participants retain information for their own benefit and create silos of knowledge and expertise (El Asmar et al., 2013; Konchar and Sanvido, 1998; Thomsen et al., 2009). IPD encourages all project participants to embrace collaborative innovation and value-based decision making, intensified early planning, early contributions of knowledge and expertise, open communication within the project team, lean principles of design, construction and operations, and co-location of teams ("big room"). IPD also encourages the use of an appropriate information technology such as Building Information Modeling (BIM) as additional characteristics or principles in order to enhance team collaboration and facilitate the real-time sharing of project information, the realization of enhanced three-dimensional (3D) visualization, and the early contribution of knowledge and experience from contractors (AIA National and AIA California C, 2007; Lee et al., 2014).

LPD requires by definition a lean operational system in addition to the collaborative project organization and the

relational contract as an essential means to align and integrate key participants. The lean operational system views the project as a production system through the lens of a lean, or flow-based, approach. Additionally, the project is structured and managed as a value generating process, and downstream key participants are involved in front-end planning and design through cross-functional teams (Ballard, 2000; Howell, 2011). The key participants or project team are collocated in a same office, referred to as a "big room", that is a large facility, where some of the critical problems such as delays in decision-making, problems in communication, disparity in design iterations are eliminated, and trust is increased (Dave et al., 2015).

The lean operational system encourages the use of different tools with the purpose of maximizing value or eliminating waste, from the design and construction process. The main lean tools are: Last Planner System (LPS), Target Value Design (TVD), A3 reports, Value Stream Mapping and Set-Based Design. LPD also encourages BIM due to it is highly complementary to the lean tools (Ballard and Reiser, 2004; Kim and Dossick, 2011; Mossman et al., 2010; Smith et al., 2011).

4.5. IPD and LPD comparison summary

Table 2 shows a summary of the comparison between the IPD and LPD system. In general, IPD and LPD share the same characteristics regarding project organization in that they both encourage integration of project teams and the early involvement of key participants. The IPD and LPD forms of relational contracting share similar concepts to align and integrate key participants such as collaboration, early involvement and trust. However, they use different contract implementation approaches. For example, IFOA incorporates lean principles and tools to manage the project from the design stage, as well as creates conditions for the teams to share rewards and risks while working together to deliver the best value for the client (Lostuvali et al., 2012). The IPD contract does not incorporate lean principles. Finally, the operational system is perhaps the most relevant difference to define IPD and LPD as project delivery systems. The LPD system requires a lean operational system, whereby IPD does not require a specific operational system for its definition as a project delivery system.

5. Case illustrations

This section illustrates the IPD and LPD system using two building projects. The aim is to illustrate a practical application of LPD and IPD projects and to make a comparison between these two delivery systems. Each case illustration explains the three distinguishing characteristics of project organization, contractual relationship, and operational system. The first section presents an LPD healthcare project. The second presents an IPD conference center project. These building

Table 2
Comparison of IPD and LPD systems.

	IPD	LPD
Project Organization	Integrated Governance Integrated Project Team Early involvement of key participants	Integrated Governance Integrated Project Team Early involvement of key participants
Contractual Relationships	Nature of the contract: Relational The relational contract embraces: Contractual principles • Key participants bound together as equals • Shared financial risk and reward based on project outcome • Liability waivers between key participants • Fiscal transparency between key participants • Early involvement of key participants • Intensified design • Jointly developed project target criteria • Collaborative decision-making Behavioral Principles: • Mutual respect and trust • Willingness to collaborate • Open communication	Nature of the contract: Relational The relational contract embraces: Five Big Ideas: 1. Collaborate; really collaborate, throughout design, planning, and execution 2. Increase relatedness among all project participants 3. Project are networks of commitments 4. Optimize the project, no pieces 5. Tightly couple action with learning Lean Principles: • Define value from the perspective of the customer • Map the value stream • Create flow • Allow customer demand to pace and pull production • Manage continuous improvement Lean behaviors: • Collaboration • Trust • Promise-based management • Continuous improvement
Operational System	Does not require a specific operational system for its definition as project delivery system	Lean Operational System • Flow-based approach • Predictable and rapid workflow • Optimize the project, not piece Lean tools: • Target Value Design • Last Planner System • Set-Based Design

projects were chosen because they used a form of relational contracting, which is a defining characteristic of the LPD and IPD systems. The healthcare project used the IFOA, and the conference center project used the Standard Tri-Party Agreement for IPD - ConsensusDocs 300.

5.1. Healthcare project

This healthcare project consists of 555 patient beds and 18 operating rooms. The project is located in San Francisco, California and is approximately 858,000 square feet with 14 floors. The following sections explain its project organization, contractual relationship, and operational system.

5.1.1. Project organization

The healthcare project involved the CM/GC and the key trade contractors with the owner, designer and consultants from the validation phase. Fig. 2 shows the time in the project delivery process at which they were hired (horizontal axis). Based on the early involvement of the key participants, the healthcare project created an integrated project team organization (Fig. 3). The integrated team included a governing team (Core Group) and cross-functional teams (Cluster Groups). The Core Group provided primary leadership. This group included a senior representative from the owner, the architect and the CM/GC.

The integrated team was organized into interdisciplinary and cross-functional working teams (Cluster Groups) (Fig. 4). The Cluster Groups were separated by design areas such as structural, interior, mechanical, electrical and plumbing (MEP), and medical equipment. Each group was responsible for coordinating their design area both internally and between other Cluster Groups. These groups had a specified leader; however, everybody could be a leader in a logical and reasonable way. These groups were dynamic in their inclusion of people; that is, the people included in a particular cluster group were changing over time according to the needs or requirements of the design tasks.

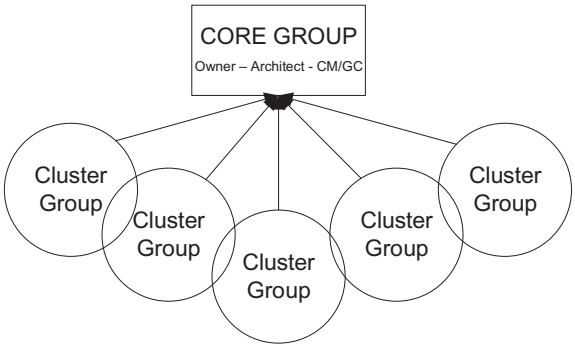

Fig. 3. Integrated team – healthcare project (adapted from Ashcraft, 2011).

The integrated team was physically co-located in a shared office where sessions in target costing, digital prototyping, and value analysis took place real time. This office became a collaborative work environment for full-time and visiting team members (Rybkowski, 2009). The project delivery process is defined by the process of Target Value Design (TVD). In this process, the integrated team defines a set of targets (cost and scheduling) in the validation phase. Once these targets were established, the integrated team sought to maximize owner value within the boundaries of these two targets. Finally, the facility was built according to these set targets.

5.1.2. Contractual relationship

The healthcare project used the IFOA. The IFOA was signed by the owner, architect, CM/GC, key consultants and key subcontractors, and was issued from the definition stage. "*The cornerstone of CHH's IFOA is to share risks and rewards between the partners, having them co-located to foster collaboration, and have all customers of the value chain integrated from the very beginning*." (Lostuvali et al., 2012). The IFOA established collaborative commercial terms, for instance, a risk pool as a risk/reward sharing mechanism that included the architect, CM/GC, key consultants, and key subcontractors. The IFOA also addressed the implementation of lean tools such as the Last Planner System (LPS) and Target

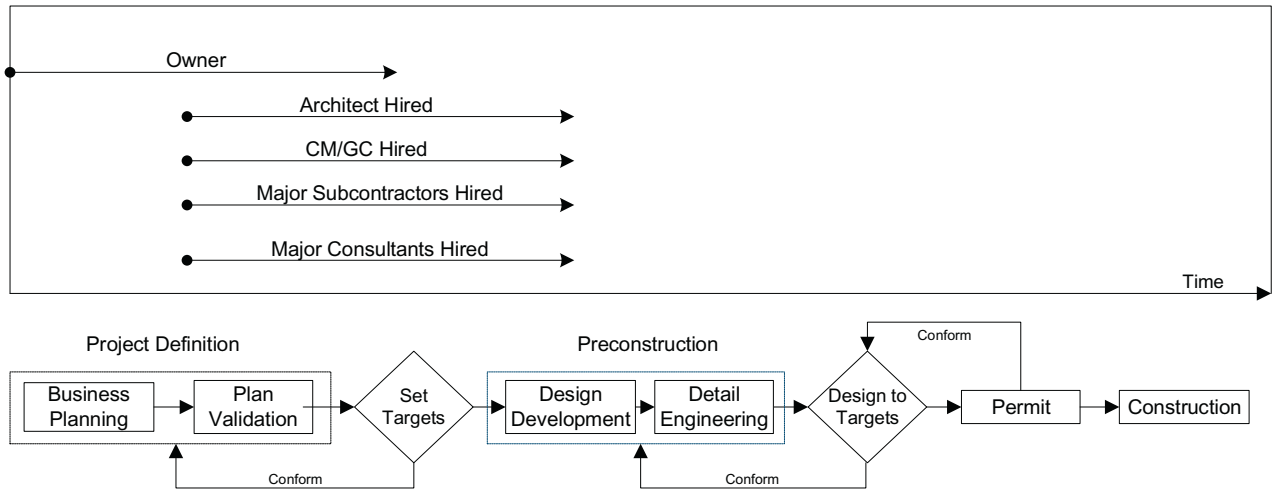

Fig. 2. Design phase integration of healthcare project.

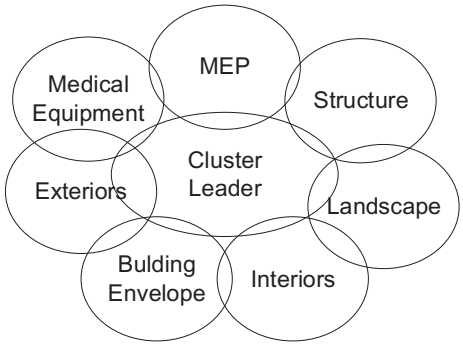

Fig. 4. Cluster group.

Value Design (TVD) to support the relational expectations (Ballard, 2008; Mossman et al., 2010).

5.1.3. Operational system

The operational system was based on lean project management. The healthcare project integrated the CM/GC and key subcontractors with the owner, the architect and key consultants from the definition stage in order to form an IPD team. In the definition stage, the integrated team validated the business planning that was presented by the owner and defined the target cost and constraints for the project. In the preconstruction stage, the team designed the project to meet the target cost and constraints. Finally, the project was built for these targets.

In order to coordinate the interdependence among the key participants, they were co-located in the same office, "big room," to maximize collaboration and facilitate informal and formal interaction and discussions about design, engineering, estimates and milestones (Rybkowski, 2009; Lostuvali et al., 2012). Regular meetings were scheduled for formal cross-functional coordination of the entire integrated team and individual Cluster Groups. Four types of meetings were defined: TVD, LPS, cluster and subcommittee meetings. The integrated team met in a "big room" two times per week for approximately two hours each meeting: once for the TVD meeting and once for the LPS meeting. The cluster groups individually met two or three hours per week. These meetings were scheduled at different times so that team members could attend other cluster meetings. Additionally, a core group meeting was scheduled weekly (Rybkowski, 2009).

The healthcare project also used simple tools such as swim lane diagrams and Value Stream Mapping (VSM) to organize the operational system; that is to manage the teams, information flows and exchange of information over time (Lostuvali et al., 2012).

Additionally, the healthcare project used Building Information Modeling (BIM) as a technological means to increase and support integration and cross-functional work. "It was a basic requirement of the healthcare project that all trades, architects, and engineers design and draw in BIM software, which opens the opportunity to see adjacent scope and changes, and adjust systems/components before they create clashes (clash avoidance early on in design)." (Lostuvali et al., 2012).

5.2. Conference CENTER project

The project consisted of a conference center and a multimedia resource center. The conference center consisted of 50 individual rooms, living rooms, gardens, and an area for administration with a center for professional development. The multimedia resource center consisted of a meditation chapel, an auditorium, an interactive audiovisual library, a scale model of Jerusalem, an exposition of biblical artifacts and an area for relaxation and meals. The conference center is located in Abus Gosh, Jerusalem and is approximately 75,500 sf.

5.2.1. Project organization

Fig. 5 shows the project organization that was structured around a Collaborative Team. The Collaborative Team included the owner, the architect and the CM/GC. The Collaborative Team was in charge of coordinating key consultants and key subcontractors, who were involved in different stages working individually as functional areas.

The project organization evolved as the architect, the CM/GC, key consultants and key subcontractors were involved. Fig. 6 shows the time at which the key participants were hired through the project delivery process (horizontal axis). The architect was involved in the definition stage. The CM/GC and key consultants were involved in the preconstruction stage. Key subcontractors were involved in the construction stage.

5.2.2. Contractual relationship

The conference center project used a type of relational contract called Tri-party Agreement for Integrated Project Delivery – ConsensusDocs 300. This agreement was signed by the owner, the architect and the CM/GC. The agreement addressed the risk/reward sharing mechanism of open book and incentive plans to ensure project success as well as collaborative commercial terms to align and integrate the Collaborative

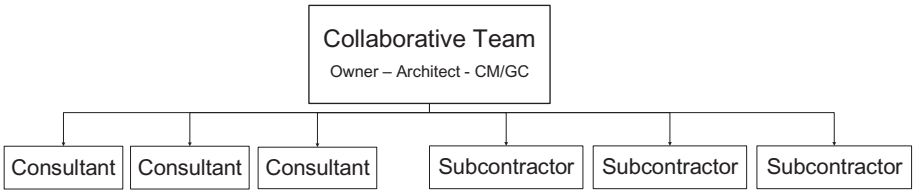

Fig. 5. Project organization – conference center project.

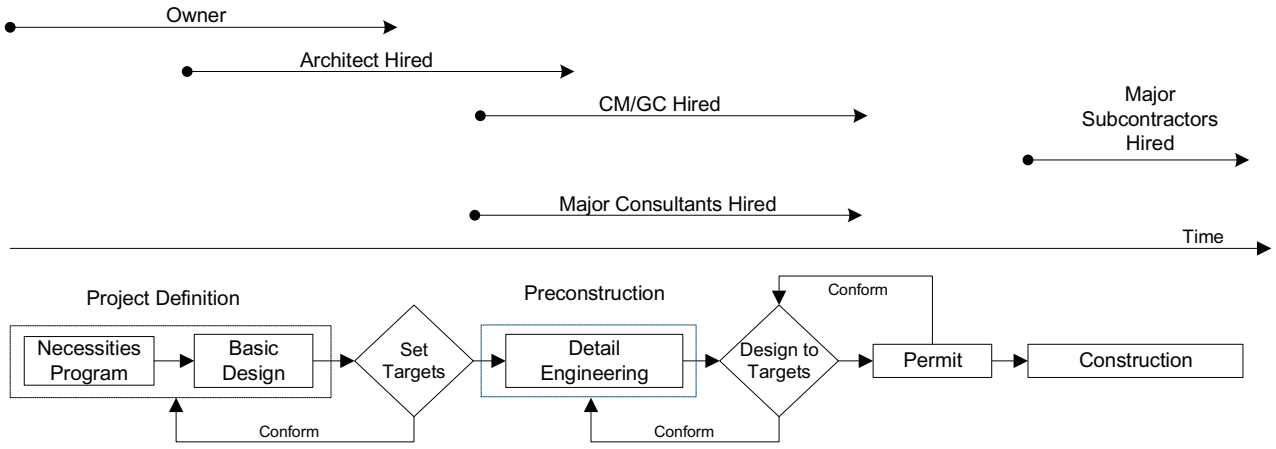

Fig. 6. Design phase integration of healthcare project.

Team. The agreement did not consider the implementation of lean principles and lean tools.

5.2.3. Operational system

The conference center project managed and executed the design and construction process very similar to traditional project management, and the key participant did not use lean project management. In the definition phase, the owner and architect were the only key project participants. The owner developed the program plan and the architect developed the basic design within the target cost and constraints according to the owner's requirements that were within the owner's program plan. The CM/GC started working with the owner and architect in the preconstruction phase. They formed the Collaborative Team. Despite this collaborative team approach, the key consultants continued working independently during the preconstruction phase. The Collaborative Team was in charge of coordinating the key consultants to design within the target cost and constraints. The key subcontractors did not participate at an early stage and began working during the construction phase. During this final phase, the site manager coordinated the construction and the key subcontractors built the facility while the key consultants coordinated the design.

6. Discussion of results

This section comprises two parts. The first one discusses the key issues on earlier literature and contributions of the comparative analysis towards researchers and practitioners. The second one describes the results of the IPD and LPD projects as case illustrations.

In the first research operational question, this study explored about IPD and LPD work at the project delivery system level of analysis. The earlier literature showed that different authors present their definition of IPD or LPD. However, authors used AIA National and AIA California C (2007, 2010) principally and NASFA, COAA, APPA, AGC, AIA (2010) reports to define IPD, and research from founding members of the Lean Construction Institute to define LPD. Despite these definitions, the literature review also showed that there is a lack of understanding and a unified conceptual framework that explores what IPD and LPD are at the level of the project delivery system. Earlier research has separately emphasized the project organization (Franz et al., 2016, Hanna, 2016, Sødal et al., 2014), contractual relationship (AIA National and AIA California C, 2007; El-adaway et al., 2017; Lichtig, 2006; Lichtig, 2005; Xie and Liu, 2017) and the operational system (Ballard, 2000; Ballard, 2008; Sødal et al., 2014; Mossman et al., 2010; Zimina et al., 2012), but separately. This study contributed to clarifying similarities and differences between IPD and LPD at the level of the project delivery system. The analysis of one single distinguishing characteristic is not sufficient for understanding the whole picture of IPD and LPD as project delivery systems. In order to understand the logic of the solution business model of this type project delivery system, following the definition proposed by Storbacka (2011) and Magretta (2002), it is necessary to put together the three distinguishing characteristics (Thomsen et al., 2009): organizational structure, contractual relationships, and operational systems.

In the second research operational question, this study explored about what IPD and LPD mechanisms integrate a project delivery process to create value. In project-based firms due to fragmentation and level of specialization, delivering complex projects requires purchasing subprojects and expertise from other organizations (Martinsuo and Ahola, 2010). Project-based firms must integrate that components, skills, and knowledge to produce complex solutions (Hobbs and Andersen, 2001; Hobday et al., 2005). The success of delivering these complex solutions depends on the efficient functioning of the entire inter-organizational network (Gann and Salter, 2000).

Project-based firms have used different mechanisms to increase project integration (Franz et al., 2016, Mitropoulos, 1994, Martinsuo and Ahola, 2010). IPD and LPD, as a project delivery system, propose a new configuration of a solution business model to integrate the delivery process and manage the entire inter-organizational network. Despite the differences, the core of both approaches is to encourage the use of integrated project organizations, relational contracting, and collaborative management as mechanisms to integrate a project delivery system.

Table 3
Comparison between healthcare and conference center project.

	Healthcare – LPD Project	Conference Center – IPD Project
Project organization	Integrated Governance – Core Group Cluster Groups – Interdisciplinary and Cross-Functional Groups. Co-location Early participation of General Contractor and key subcontractors from the validation phase	Integrated Governance – Collaborative Team Functional or Specialized Areas No Co-location Early participation of General Contractor on engineering phase.
Contractual Relationship	Relational Contract: IFOA • Reward/Risk Sharing Mechanism • Open Book • Incentive Plans • LPD Principles	Relational Contract: Consensus 300 • Reward/Risk Sharing Mechanism • Open Book • Incentive Plans
Operational System	Lean Project Management Tools: • Target Value Design • Last Planner System • Set-based design • BIM	Traditional Project Management Tools: • Paper-based design • 2D design

The two case illustrations about IPD and LPD projects exemplify the logic of the solution business models to integrate the project delivery process. Table 3 shows a comparison between the distinguishing characteristics of the healthcare and conference center projects. The healthcare project has the distinguishing characteristics which define it as an LPD project. The conference center project has the distinguishing characteristics which define it as an IPD project.

The healthcare project used an integrated project organization. In order to achieve early integration, the healthcare project involved the CM/GC and key subcontractors with the owner, architect and key consultants from the validation phase. Additionally, the healthcare project established an integrated governing team (Core Group) and interdisciplinary and cross-functional groups (Cluster Groups) in order to encourage better collaboration and integration. This collaboration and integration were supported by co-location; that is, the integrated team was physically co-located in a shared office where sessions in target costing, digital prototyping, and value analysis took place real time. This office became a collaborative work environment for full-time and visiting team members (Rybkowski, 2009).

On the other hand, the project delivery process was defined by the process of Target Value Design (TVD) with the aim to align the objectives and interests between key participants and the healthcare project. That is, in this process, the integrated team defined a set of targets (cost and scheduling) in the validation phase. Once these targets were established, the integrated team sought to maximize owner value within the boundaries of these two targets.

Conversely, the conference center project's organization shared characteristics of a collaborative and hierarchical project organization. The project organization was comprised of integrated governance (Collaborative Team) and functional or specialized areas that work individually under the coordination of the Collaborative Team. The CM/GC was involved in the preconstruction stage after the owner and the architect defined the basic design. Key subcontractors were involved in the construction phase.

In summary, the healthcare project differs from the conference center project in the team integration structure and the early involvement of CM/GC and key consultants and subcontractors.

The healthcare and conference center projects used different forms of relational contracts in order to encourage integration among key project participants. They used the IFOA and ConsensusDocs 300 respectively. Both projects implemented these contracts with some mechanism such as risk/reward sharing, open book practices and incentive plans to create a contractual and financial framework that aligned objectives and interest and facilitated an effective collaboration among the key project participants in the early stages. However, they differ in the implementation of the principles of lean. As it was mentioned in the Section 4.3.3, the IFOA takes care of the organization, the commercial terms, and the operational system of the project (Darrington et al., 2009; Lostuvali et al., 2014).

Finally, the healthcare project used an operational system that was based on lean project management. This operational system was supported by TVD, LPS, set-based design, co-location and BIM. Each of these tools was included to maximize collaboration and facilitate informal and formal interaction and discussions about design, engineering, estimates and milestones (Rybkowski, 2009; Lostuvali et al., 2012). Conversely, the conference center project's operational system looked like traditional project management. It used the traditional two-dimensional and paper-based design tools.

7. Conclusions

Project-based firms have different options to define the logic of a solution business model of a delivery method based on the configuration of project organization, contractual relationship, and operational system. That configuration will define a unique inter-organizational network that influences the success of the entire project according to how project participants are monitored, controlled and integrated into this network (Martinsuo and Ahola, 2010).

This study focused on analyzing the integration of delivery process in project-based firms by studying two new approaches, IPD and LPD, in the construction industry. In order to address the research question - how do IPD and LPD each integrate a project delivery process? - the study defined IPD and LPD at the level of analysis of project delivery systems, and what organizational, contractual and operational characteristics IPD and LPD use to integrate a project delivery process. Additionally, the study used two case illustrations to exemplify the discussion of IPD and LPD as project delivery systems and their implementation in the construction industry. These two case illustrations describe different ways that project-based firms can define the logic of solution business model and achieve integration in the project delivery process.

The current body of knowledge reveals multiple definitions of IPD and LPD (AIA National and AIA California C, 2010; Do et al., 2015; El Asmar, 2012; NASFA, COAA, APPA, AGC, AIA, 2010; Smith et al., 2011). This paper provides a clear definition of IPD and LPD by combining the most authoritative references (AIA National and AIA California C, 2010, AIA, 2012, NASFA, COAA, APPA, AGC, AIA, 2010, Ballard, 2000, Ballard and Howell, 2003, Mossman et al., 2010, Smith et al., 2011, Lichtig, 2006). The literature review also showed a lack of understanding and unified conceptual framework that explores what IPD and LPD are at the project delivery system level as well as the IPD and LPD characteristics that contribute to an integrated project delivery process.

Overall, IPD and LPD systems have the same perspective with regards to project organization to achieve integration among key project participants. They seek to involve key participants in early stages and form an integrated project team that works together under an environment of collaboration, open communication, and mutual respect and trust. Both IPD and LPD also use integrated governance by executive committees, which include at least the owner, architect, and constructor.

The nature of IPD and LPD agreements is relational to encourage collaboration and alignment of objectives and interest among key project participants. However, the IPD contract and the LPD contract differ in some aspect of how they align and integrate key participants. The main difference stems from the use of lean principles. The contract for LPD is structured around the underlying principles of lean project delivery and Five Big Ideas. Conversely, the contract for IPD does not consider the lean principles.

The main difference between IPD and LPD delivery systems stems from the operational system. The IPD system does not address a specific operational system, whereas the LPD system uses an operational system based on lean principles and the use of lean tools such as Target Value Design, Last Planner System and set-based design. According to Zimina et al. (2012), *"Project organization alone is not enough for collaboration. The process does not finish with signing an IPD or a partnering agreement between companies; the real challenge is to make these companies' staff work as one team on a daily basis. The lean operating system is necessary to make this happen. Technologies such as computer modelling are vital catalysts as well, as they enable transparency and promote shared understanding."*

In summary, the LPD delivery system is distinguished by the requirement of a collaborative project organization, relational contract and lean operational system to align and integrate key participants and encourage a collaborative environment. The IPD delivery system is distinguished by the requirement of a collaborative project organization and relational contracting to align and integrate key participants and encourage a collaborative environment. IPD does not address a specific operational system by definition.

This research has limitations. The comparative analysis was based on a literature review. It did not consider the opinion of professional experts in the construction industry. Additionally, the illustration of the implementation of IPD and LPD systems was based on only two building projects. The purpose of these two case illustrations was not to make a critical analysis, but to exemplify the discussion of IPD and LPD as project delivery systems. Another limitation is that the comparative analysis considered general characteristics of the project organization, contractual relationship, and operational system. For example, the analysis of the contractual relationship compared contractual and behavioral principles and did not consider other characteristics such as incentive plans, method of compensation and responsibilities that may differ between contracts and could have an impact on project outcomes.

According to these limitations, future research should consider input from experienced professionals to gain lessons learned on the effectiveness of these unique methods. More IPD and LPD case illustrations would also be helpful to enrich the discussion about the similarities and differences between these systems. Future research also should address a detailed analysis of the structure of the relational contracts that are used in IPD or LPD projects. Finally, when enough projects are completed under these delivery methods, an empirical study of performance could inform decision makers in structuring organizations, contracts, and operational systems.

Acknowledgements

The authors gratefully acknowledge the experienced professionals who shared their information and knowledge of the two case illustrations. The authors also acknowledge the support provided by Pontificia Universidad Católica de Chile, University of Colorado Boulder, MECESUP program and FONDECYT (Project 1120485).

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