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Transforming project delivery: integrated project delivery

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Abstract: The design and construction industry has long suffered low productivity and poor project outcomes. Collaborative approaches to project delivery offer an opportunity to transform outcomes by creating incentives in an environment that incentivizes high performance. This paper examines integrated project delivery (IPD), a collaborative contractual approach that alters a project's fundamental commercial, organizational, and legal structures to minimize dysfunction and stimulate performance. IPD's basic structures are introduced, followed by a critical examination of current and new research on IPD augmented by the author's insights from structuring over 150 IPD projects. An online appendix provides additional information regarding the reasoning behind the IPD structures.

Keywords: infrastructure, project delivery, integrated project delivery, IPD, alliancing

JEL classification: K2, L7, O2

I. Introduction

For decades, experts and commentators have despaired over projects failing to meet essential cost, schedule, and functionality goals (Latham, 1994; Egan, 1998; Miller *et al.*, 2000; CURT, 2004, 2006; McKinsey, 2015; World Economic Forum, 2016). Their concerns, insights, and conclusions are equally relevant today.

This universal dissatisfaction with infrastructure performance is compounded by the size of the problem. The World Economic Forum estimates that the total annual revenue for the construction industry is almost USD 10 trillion and accounts for 6 per cent of the global gross domestic product (World Economic Forum, 2016). Estimates of non-value activity exceed 30 per cent (Egan, 1998; Miller *et al.*, 2009). Labour

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I would like to thank those who have laboured with me to improve infrastructure delivery, including the American Institute of Architects, California Council IPD Task Force; Martin Fischer, Atul Khanzode, and Dean Reed, my co-authors of *Integrating Project Delivery*, with whom I have shared many discussions regarding project delivery; Philip Bernstein, Renée Cheng, the many clients who have entrusted me with their projects and allowed me to turn IPD from a theory to a practice; and my wife, Marilyn Ezzy, and our family who have supported my passion for improving project delivery.

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productivity studies indicate that construction productivity has fallen approximately 20 per cent during the same period where manufacturing productivity has improved by 250 per cent (Teicholz, 2004, 2013). McKinsey Global estimates that the productivity losses account for USD 1.6 trillion—essentially half the cost of the world's infrastructure needs (McKinsey, 2017). Even assuming some error in estimating waste and productivity loss, the size of the problem is staggering.

Moreover, the problem is especially severe in megaprojects[1] where cost overruns of 50–100 per cent in real terms are common, and overruns above 100 per cent are not unknown (Flyvbjerg *et al.*, 2003). Megaprojects have consistently underperformed (Miller *et al.*, 2000). Merrow found that 65 per cent of the 318 industrial megaprojects he studied failed even using very lenient measures of success (Merrow, 2011).[2] McKinsey is even more critical, finding that 98 per cent of megaprojects suffer cost overruns of more than 30 per cent, and 77 per cent are at least 40 per cent late (McKinsey, 2015). The average cost overrun was 80 per cent, and schedule slippage averaged 20 months (McKinsey, 2015). As noted by Merrow, megaprojects have mega-failures. They don't go slightly wrong; they tend to fall entirely apart (Merrow, 2011).

Rampant failure might suggest insoluble problems. But industry analysts have long recommended the elements required to achieve improved outcomes. For example, the Egan and CURT reports seek to transform the industry by creating fully integrated and collaborative project teams with shared risk-reward aligned to project outcome (Egan, 1998; CURT, 2006). Their recommendations are very similar to the formula proposed by CURT, AIA, AIACC, the World Economic Forum, and McKinsey Global Institute (CURT, 2004, 2006; AIA/AIACC, 2007; AIACC, 2007, 2014; World Economic Forum, 2016; McKinsey, 2017). However, achieving these experts' recommendations requires fundamental changes in project delivery that challenge stakeholders (Ebrahimi and Dowlatabadi, 2019).

IPD principles are proposed as a key strategy in breaking the failure cycle that has confounded the design and construction industry. Several project delivery methods, such as 'partnered contracts', 'project alliances', and 'integrated project delivery', can be configured to include many recommended elements (Lahdenperä, 2012). IPD is the most prescriptive, including all required elements.[3]

This paper introduces the key IPD elements, examines the research on its effectiveness, including new research by the author, comments on research limitations, discusses the purpose behind the structural changes in IPD, and concludes with recommendations for further research and analysis. The conclusions are supported by the referenced information and the author's experience in structuring over 150 IPD projects. The discussion uses the industry terms that are defined below.

[1] Generally accepted as projects with costs exceeding USD 1 billion.

[2] Merrow's 'thresholds for failure' were: Cost overruns > 25%; Cost competitiveness > 25%; Schedule slippage > 25%; Schedule competitiveness > 50%; and Production vs plan—significantly reduced production into year 2. Fifty per cent of all projects, and 78 per cent of petrochemical projects failed at least one of these criteria. As noted by Merrow, very few projects failed on only one dimension (2011, Table 3.1, pp. 36–7).

[3] Figure 11, *Elements of a Collaborative Partnerships* (World Economic Forum, 2016), is virtually identical to the requirements in *Integrated Project Delivery: An Updated Working Definition* (AIACC, 2014), particularly p. 13, *Optimized IPD*.

(i) Terminology

Building information modelling (BIM)

There are many definitions of BIM that reflect the definer's particular focus. Essentially, it uses digital software to develop and represent a project from conception through operations. It can be used for design development, optimization, construction simulation, facilities management, and operation, and is characterized by creating data-rich, three-dimensional visualizations.

Construction management at risk (CMR)

CMR is a form of contracting where the prime contractor retains the specialty contractors and they, perhaps in combination with the contractor, perform the actual construction work. The contractor is referred to as a construction manager to emphasize its planning and coordination role. The construction management is 'at risk' because compensation is either a fixed amount, or more commonly, is a cost-plus arrangement limited by a guaranteed maximum price (GMP) cap. In CMR, the owner retains the contractor after design or during the design period to provide constructability and cost information.

Design–Bid–Build (DBB)

In this project delivery method, architects and engineers complete the design on the employer's behalf. The employer then seeks bids from interested builders and awards a construction contract. Although the owner need not award to the lowest bidder, many employers using this approach must, or prefer to, award the work to the lowest responsible bid. Because bidding requires a complete design, the process is inherently sequential and does not permit the involvement of the builders and suppliers during the design period.

Design–Build (D–B)

In this project delivery method, the employer retains a single organization to provide design services and execute the project. The design-builder may be a single organization, a joint venture, or special purpose entity, or a party that contractually engages other parties to provide either design or construction services. D–B has many variations reflecting different compensation approaches (fixed price, cost plus, cost plus with a guaranteed maximum price) and different project scopes (D–B with operation, maintenance, financing, or any combinations of these). Flexibility also varies. Some D–B projects only require adherence to performance specifications; others require compliance with a provided preliminary design. Any of these variations can affect the project outcome.

Early contractor involvement

In early contractor involvement, a contractor and key specialty contractors provide the designers with cost, constructability, and systems information. 'Design assist' is a similar term, although it often implies a less comprehensive integration of builders and suppliers into the project development process.

Fixed price or lump sum

These are synonymous with contracts that pay a set amount—subject to change orders/variations—for the project.

Guaranteed maximum price (GMP)

A GMP is a cap on compensation often used with CMR and D–B project delivery methods. If the incurred costs, as defined in the contract, are less than the GMP, the owner only pays the actual cost. If the costs exceed the GMP, the owner pays the GMP. A GMP may include a shared savings provision that splits the difference between cost and the GMP, retaining a portion for the owner and providing the remainder to the contractor.

Lean construction or design

'Lean' is the application of philosophies and processes developed by Toyota Motor Corporation to design and construction. It emphasizes 'waste' reduction. Waste is any activity that does not provide value to the 'client'. For example, rework, excess inventory, searching for tools or information do not provide value. Lean, therefore, seeks to structure work to minimize waste activities. Almost any project delivery method can incorporate some Lean practices, although the more collaborative project delivery methods can suit Lean best. The Lean Construction Institute (leanconstruction.org) and the International Group for Lean Construction (iglc.net) are the leading information sources. There are also local and national Lean groups.

Non-value activity (waste)

In Lean terms, non-value activity is any resource expenditure that does not directly result in output that a customer would be willing to purchase. Unused and discarded material, labour spent looking for information, tools, or material, and rework are examples of non-value activity. Non-value activity is also referred to as waste.

Target cost

The target cost in an IPD project is an amount that serves as a goal and a metric to evaluate project success. If the target cost is exceeded, the IPD team's profit is diminished. If the project is delivered below target cost, a percentage of the savings is added to the team's profit. The specific savings formula and target cost elements may differ between IPD projects and are specified in the IPD agreement.

As this glossary indicates, merely stating that a project is CMR omits significant factors affecting performance. Within CMR, the compensation method could be fixed price, cost plus, GMP, GMP with shared savings. The project could be a sequential DBB project or some form of 'Early contractor involvement'. D–B has even more variations. The upshot is that drawing statistical inferences without considering—and normalizing—the variability in project delivery types and compensation schemes is fraught with potential error, compounded by the differences between projects themselves.

II. Principles of integrated project delivery

IPD was developed in the early 2000s to address dissatisfaction with project outcomes and the existing systems that did not optimize cost, schedule, and quality. In response, two groups explored alternatives to existing project delivery systems. A group of Lean proponents worked to increase project value but soon realized that the deep collaboration among key project participants required for Lean was challenging to achieve using traditional project delivery methods. To overcome the limitations, they created a multiparty agreement where the key parties pooled their proposed profit, jointly managed the project through consensus, and used Lean processes during execution. William Lichtig incorporated these principles into a multiparty contract referred to as an Integrated Form of Agreement (IFOA) (Lichtig, 2006). Around the same time, the American Institute of Architects, California Council (AIACC) examined how structural issues affected project performance and hindered using new technologies, such as BIM. Like the Lean proponents, the AIACC group concluded that a new contractual approach was required. The two approaches are now intertwined. Current IPD implementations include Lean, BIM, co-location, and other high-performance elements (Lahdenperä, 2012).

The AIACC's IPD Task Force published the first set of IPD principles and standards (AIACC, 2007) that the American Institute of Architects (AIA) subsequently adopted in the AIA/AIACC IPD Guide (AIA/AIACC, 2007) and incorporated into published AIA contract templates.[4]

The AIA initially defined IPD as a general statement of principles.

> Integrated Project Delivery (IPD) is 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. (AIA/AIACC, 2007)

As IPD developed, these principles developed into specific business and contract elements reflected in a multiparty contract that integrates the key participants in a virtual organization aligned to the project goals. These IPD elements are summarized in Table 1.

These elements avoid the dysfunctions of traditional, segregated contracts and promote efficiency and innovation (Fischer *et al.*, 2017; Ashcraft, 2021). Fischer and Allison discuss specific steps for implementing the principles (Fischer *et al.*, 2017; Allison *et al.*, 2018). In combination, the IPD structures interact to create a project delivery system that is relational, collaborative, and includes specific structural and behavioural components. IPD is relational and collaborative, but it is also contractual. The online appendix explains the reasons behind IPD.

III. Review of IPD research

As IPD projects proliferated, researchers examined whether IPD provided better performance than alternative delivery systems. Recent literature surveys list currently available information (Engebø *et al.*, 2020; Viana *et al.*, 2020). Investigators have differed in their methods and differ moderately in their conclusions, but support using IPD.

The principal investigative methodologies are case studies, subjective comparisons, weighted indices, simulations, and quantifiable data. As discussed below, each approach has strengths and limitations. The author's research blends subjective comparisons with

[4] AIA Contract Documents C-191 and C-195 (2008).

Table 1: Elements of integrated project delivery

Structural elements of IPD		Behavioural elements of IPD
Business model	*Contract structure*	*Enabling behaviours*
Profit separated from cost	Early involvement of key participants	Optimize the whole, not the parts
Costs guaranteed to completion	Jointly developed and validated targets/goals	Trust
Limited entitlement to change orders	Shared risk/reward, based on project outcomes	Integration of information, people, and systems
Profit based on agreed project outcomes	Joint project control and decision-making	Continuous improvement/learning
	Reduced liability among risk/reward members	Appropriate use of technology
		Collaboration

Source: AIACC, 2014.

quantified data to overcome some limitations of prior studies. The studies are summarized in Table 2 and then discussed in detail.

The initial case studies commissioned by the AIA examined six IPD projects and reported favourably, although the projects were in progress (Cohen, 2010). Cheng extended this case study by adding an additional example, providing greater detail, and integrating survey data that indicated participants were very satisfied with design quality and efficiency (Cheng, 2012). Her conclusions were positive, but she recognized that the sample was limited. The same research group expanded their survey significantly and reported detailed information on each project (Cheng, 2015). Respondents compared their experience on IPD projects with their experience on other project delivery approaches concerning schedule predictability, cost and budget control, building quality, change quantity, change handling, morale, and overall value delivered. Approximately 85 per cent of the respondents deemed schedule predictability and cost control better or significantly better. Ninety per cent found that the overall value was better or significantly better (Cheng, 2015). The author's independent research reinforces these subjective comparison findings. Other researchers have used case studies to evaluate why IPD is successful (Tillmann *et al.*, 2012).

Investigators have also used a comparative case study model, choosing similar projects and comparing outcomes on specified criteria. Bilbo compared two healthcare projects delivered by the same design and construction firms that used CMR and IPD, respectively. The IPD project had significantly higher cost savings (–10.27 per cent from budget) compared to CMR (–3.13 per cent), but more schedule growth (+16.63 per cent) compared to (–1.72 per cent) (Bilbo *et al.*, 2015). The IPD team claimed the lower average cost ($271/sq. ft. compared to a market cost of $360/sq. ft) was due to early collaboration, and that the delays may have been due to weather and permit delays, not project performance (Bilbo *et al.*, 2015). Adamtey compared two transmission control buildings constructed using D–B and IPD. The projects used similar structural systems, although the IPD project was more extensive and complicated. The IPD project was approximately 12 per cent less expensive than the D–B project, had less schedule growth, one-third fewer change orders than the D–B project, and, unlike the D–B project, had negative cost growth (Adamtey, 2021). The IPD team credited their close collaboration

Table 2: Summary of IPD research

Methodology	Investigators	Conclusions
IPD case studies	Cohen, 2010; Cheng, 2012; Cheng, 2016	IPD had a positive effect on cost, schedule, quality, and team morale.
Comparative case studies	Bilbo *et al.*, 2015; Adamtey, 2021	Bilbo determined that the IPD project was significantly less expensive than the CMR comparison but did not meet schedule goals for extraneous reasons. Adamtey found that the IPD project was less expensive than the D–B comparison, although the IPD project was larger and had less schedule growth.
Subjective surveys	Cheng, 2015; LCI, 2016; Choi *et al.*, 2019, and Ashcraft, as reported in this paper	Investigators found a significantly higher satisfaction with IPD on cost, schedule, and quality than other project delivery systems. Ashcraft also found that 86.1 per centof the IPD projects reported an increase in the profit pool due to an indication of performance exceeding initial expectations.
Quantitative comparisons	Cho and Ballard, 2011; El Asmar *et al.*, 2013; Bilbo *et al.*, 2015; Ibrahim and Hanna, 2019; Ibrahim *et al.*, 2020; Kelly and Ilozor, 2020	When compared to all other project delivery methods, IPD was superior. In pair-wise comparisons, the results varied. In a smaller study focused on the Last Planner System™, Cho and Ballard did not detect a statistically significant difference between project delivery outcomes. Kelly and Ilozor agreed, but found a small benefit for IPD at the 90 per cent confidence level. Kelly and Ilozor 'cautiously recommended' IPD. The other pair-wise studies found that IPD was statistically superior in some aspects, although the specific benefits differed among studies.
Weighted ratings and simulations	El Asmar *et al.*, 2016; Hanna, 2016; Mesa *et al.*, 2016	El Asmar and Hanna developed a weighted rating system to compare project delivery systems and reported that IPD projects outscored other project delivery systems. Mesa and Molenaar created a predictive model using characteristics correlated with project success that predicted better outcomes using IPD for complex projects.

during co-location and the extensive BIM use (Adamtey, 2021). These are factors that other researchers have found correlated with project performance (Molenaar *et al.*, 2014). Overall, Cheng, Bilbo, and Adamtey's case studies provide insight into the IPD project details and why they can outperform other project delivery systems. However, they are limited to only comparing two project pairs, cannot be assumed to apply universally, and are very sensitive to project choice.

Several researchers have attempted to quantify the IPD performance against other project delivery methods. The studies that compare IPD against non-IPD projects generally support IPD use. The studies that attempt to compare IPD to specific individual project delivery methods find a statistically significant improvement over design-bid-build. Compared to design-build and CMR, IPD fares well, but the improvement is less clear. However, even the least favorable studies cautiously recommend IPD. (Kelly and Ilozor, 2020) No study found that IPD was statistically inferior in any aspect.

El Asmar, Hanna, and Loh compared quantitative statistics from12 IPD projects to 23 non-IPD projects concluding at a 95 per cent confidence level that IPD provided better quality, delivery speed, communication performance, profitability. At a 90 per cent confidence level, IPD outperformed the non-IPD projects in 8 out of 9 performance levels. (El Asmar *et al.*, 2013) They did not find a statistically significant difference in cost parameters but concluded that IPD provided significant advantages in quality at no additional cost. (El Asmar *et al.*, 2013)

Hanna compared 32 projects and found they were statistically superior in communications and cost management (Hanna, 2016). Ibrahim and Hanna studied 109 projects and statistically cross-compared them between DBB, CMR, D–B, and IPD. They concluded that at a 95 per cent confidence level, IPD outperformed DBB in eight metrics, outperformed CMR in two metrics, and D–B in two metrics. No project delivery system outperformed IPD, and the authors recommended moving from DBB towards IPD (Ibrahim and Hanna, 2019).

Ibrahim, Hanna, and Kievit performed pair-wise statistical analyses of 109 projects using 12 metrics. At a 95 per cent confidence level, IPD outperformed DBB on all performance metrics, outperformed CMR on two performance metrics, and a third metric at the 90 per cent confidence level. IPD outperformed D–B on two performance metrics at the 95 per cent level and an additional metric at the 90 per cent level (Ibrahim *et al.*, 2020). No project delivery method outperformed IPD on any metric at 90 or 95 per cent confidence levels.

In contrast, Kelly and Ilozor's study did not support a statistically significant difference between IPD and D–B or CMR at the 95 per cent level (Kelly and Ilozor, 2020). Their results were similar to an earlier comparative study of the Last Planner ™ Lean scheduling system that compared 12 IPD projects (Cho and Ballard, 2011). Interestingly, Ballard participated in a later case study on why IPD projects are successful (Tillmann *et al.*, 2012).

While Kelly and Ilozor did not find significance at the 95 per cent level, at the 90 per cent level they concluded that IPD had less cost growth than DBB and CMR with a guaranteed maximum price and less schedule growth than DBB. Interestingly, they discussed several reasons why their study might not have wholly captured IPD's benefits and 'cautiously recommend' IPD. All the projects were from a single contractor, except for six projects where data from AIA case studies were used. Moreover, the data set was heavily weighted (approximately 80 per cent) from one geographic region, but the report did not include the regional project distribution.

Quantitative analyses are superficially attractive, but they may be no more accurate, and even less accurate, than subjective comparisons. As noted in the terminology discussion, a project delivery designation may include many variants that differ significantly. Kelly and Ilozor, for example, found differences between CMR with a guaranteed maximum price and CMR with cost-plus compensation (Kelly and Ilozor, 2020). Error can be introduced if these variances are not considered and controlled.

Project delivery is also a very noisy environment where it is difficult to normalize differences among projects. Project complexity, geographic location, logistics, market conditions, labour conditions, management and team competence, estimation accuracy, available technology, weather or other environmental events, community and government support (or opposition), changes in rules and regulations, supply chain disturbances, and, most recently, pandemics, may all affect project outcomes. Even incidents on other projects may affect a project if it detracts from a participant's ability to complete its tasks on the studied project. Moreover, there may be correlations between project difficulty and project delivery choice. D–B and fixed price CMR, for example, may be differentially chosen for projects that are relatively straightforward and well defined. Unless one can confidently say that projects are similar in all but project delivery, statistics should be used cautiously and only if supported by other methods.

The subjective comparisons are subject to bias errors, notably self-selection, availability, and confirmation (Ariely, 2008; Kahneman, 2011). However, in comparing IPD to other project delivery systems, the survey participants can account for differences between projects and filter out noise that affects quantitative comparison. Subjective assessments must also be used cautiously and in combination with other methods.

El Asmar, Hanna, and Loh attempted to avoid the complexities in quantitative comparisons by using a weighted composite index—Project Quarterback Rating (PQR)—that blends 23 criteria from seven categories. Essentially, they use factors believed to be correlated with performance and index projects by the factors. Interestingly, they found a continuous improvement in PQR from DBB (–0.66) to CMR (–0.03) to D–B (0.25), and IPD (0.53) (El Asmar *et al.*, 2016). This is consistent with studies that correlate team cohesion and integration with increased performance (Molenaar *et al.*, 2014; Mesa *et al.*, 2016; Franz *et al.*, 2017; Choi *et al.*, 2019). Composite indices have promise but need to be validated by other researchers as they are sensitive to weightings. Mesa *et al*. have used a computational simulation that predicts superior performance by IPD (Mesa *et al.*, 2016).

IV. Hanson Bridgett composite survey

The author undertook a combined qualitative/quantitative survey of IPD projects that used a novel method to evaluate project success. The survey was sent to owners and team members on projects in the Hanson Bridgett client roster, publicized on LinkedIn, and announced on the Integrated Project Delivery Alliance and the LeanIPD blog websites. The data are not random because they rely on self-reporting.

Eighty-one survey responses were received representing 55 unique projects, 46 of which reported outcomes (the balance are projects that are not yet complete). The average project value (design plus construction cost) was USD $102,250,333 and the largest completed project was valued at USD $1,500,000,000. Several larger projects within the survey were still in the design or construction phases. Two projects exceeded USD 1 billion; both were completed below budget and on schedule—a tiny sample, but notable given the failure rate of megaprojects.

There are several unique aspects to the survey. Because IPD projects adjust the team profit based on project outcome, the increase or decrease in the profit pool is a measure of project performance. An increase or decrease in profit is a direct measure of project outcome because the profit adjustment is based on the difference between planned and actual project outcome. Moreover, target cost adjustment during the project factors out extraneous reasons for cost growth. It provides quantitative confirmation of subjective perception of success.

However, a profitability metric is subject to the accuracy of initial targets. Survey participants assessed the accuracy of the initial targets to account for possible errors. On a scale of 1 to 5, they assessed the cost targets from 'significantly understated' to 'significantly overstated', where 3.0 was a correct estimate. The average design score was 2.92, and the average construction score was 3.1. Thus, the respondents believe the estimates at target cost were reasonably accurate. No other study has reported assessing initial target accuracy, although this significantly affects quantitative assessments.

Thirty-six projects reported the increase or decrease in the profit pool due to project outcome, which is summarized in Table 3. Figure 1 displays the distribution of the positive outcomes.

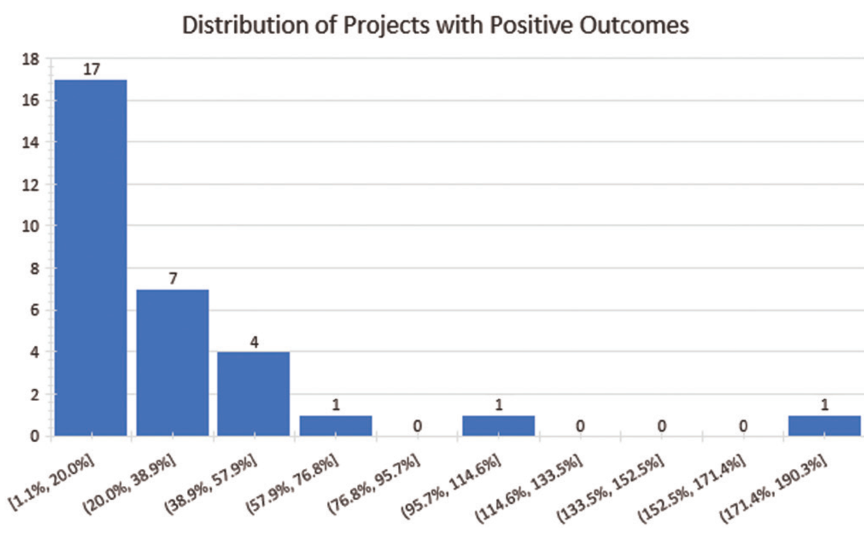
Because the 'negative' projects reduced but did not eliminate the profit pool, these projects did not increase the owner's project cost. Thus, from an owner's perspective, 94.44 per cent of the projects were completed within budget. From the participants' perspective, 86.11 per cent of the projects were completed below target cost.[5] The profit

Table 3: Profit adjustment based on project outcome

Profit adjustment	Sample size	Sample percentage	Average profit adjustment from initially anticipated profit (%)
Increase	31	86.11	29.02
Decrease	3	8.33	(32.77)
Loss	2	5.56	(100)

Source: Hanson Bridgett Survey, 2021.

Figure 1: Distribution of projects with positive outcomes



Source: Hanson Bridgett Survey, 2021.

[5] All projects increased or decreased profit based on the difference between the contractual target cost and actual cost. Two projects also used other factors.

histogram (Figure 1) displays the distribution of positive profit outcomes. As noted, two projects were at or over budget.

The respondents subjectively assessed four areas: the accuracy of the initial design and construction estimates; whether they agreed or disagreed with certain statements about their IPD projects; whether they would use IPD for a similar project; and whether they would recommend an IPD project to others. The responses are summarized in Table 4. In addition, they provided general comments regarding why IPD worked or did not work, how IPD could be improved, and a final open-response item for anything the respondent wanted to add (see appendix). The comments overwhelmingly favoured using IPD.

The respondents were asked to 'strongly disagree' or 'strongly agree' with the following statements on a scale of 1 to 5. A midpoint of 3 indicates ambivalence.

The differences in outcome between questions are slight. However, it is interesting to note that the largest difference was whether IPD projects met the owner's goals (4.81) and the participants' goals (4.65).

Finally, the participants stated whether they would want to use IPD for a similar project in the future. Seventy-six (94 per cent) said yes; 4 (5 per cent) said maybe; and 1 (0.9 per cent) said no.[6]

Many of the respondents had significant IPD experience. In this survey, six respondents had participated in more than ten IPD projects, two respondents had participated in more than 50 IPD projects, and the median experience was four projects. Because the subjective questions drew on their entire IPD experience, the responses reflect many more projects than the objective data.

Another interesting observation relates to the 'negative' and 'loss' projects. One might expect the subjective reviews for these projects to reflect dissatisfaction with the outcomes, but they did not. Even where projects underperformed, the participants indicated that they would use IPD on a similar project and recommend it to others. The

Table 4: Subjective comparision of IPD to non-IPD projects

Assertion	Average	Std Dev.
Compared to non-IPD projects, the project participants better understood the project goals.	4.65	0.73
Compared to non-IPD projects, project participants share information more openly and honestly.	4.69	0.58
Compared to non-IPD projects, project participants dealt with unanticipated problems more collaboratively and effectively.	4.70	0.68
Compared to non-IPD projects, project participants better understood the project goals.	4.75	0.54
Compared to non-IPD projects, the project was more successful in achieving the owner's goals.	4.81	0.45
Compared to non-IPD projects, the project was more successful in achieving the project team's goals.	4.65	0.69

Source: Hanson Bridgett Survey, 2021.

[6] The 'no' response explained that the owner wanted the benefits of IPD but did not want to change any of its behaviours.

objective data alone incorrectly imply that the participants did not consider these projects successful.[7]

The Hanson Bridgett survey did not request information regarding disputes. However, in the over 150 projects structured by the author, only one project has initiated formal dispute proceedings. Although formal statistics do not exist, disputes in IPD projects appear to be quite rare; this is quite different from the industry at large, where formal disputes are commonplace (Arcadis, 2021).

While the survey adds to the existing research, it is subject to several sources of error. It is not a randomized study but contains self-reported data that could be skewed towards positive outcomes. Confirmation bias and faded memories are other sources of error (Kahneman, 2011). If there were multiple responses for a project, the responses based on reviewing records were used. However, the responses are consistent with prior subjective studies, providing confidence in the outcome.

V. International IPD developments

Integrated project delivery, either explicitly described as IPD or as principles implemented under another project delivery methodology, such as alliancing, continues to develop internationally. In addition to projects in North America, the author has worked on IPD projects in the United Kingdom, Norway, and Ireland. Finland has undertaken almost 100 IPD projects (Saarinen, 2021), and alliances have been undertaken in Australia, New Zealand, Canada, and elsewhere (Miller *et al.*, 2000; Mosey, 2019), Key references have been republished in Chinese (*Integrating Project Delivery*) and German *(IPD: An Action Guide for Leaders*).

In Germany, the Bundesinstitut für Bau-, Stadt-, und Raumforschung (Federal Institute for Research on Building, Urban Affairs and Spatial Development) has commissioned a research project to consider whether alternative contract models could improve the cost and schedule reliability of major projects. The research team concluded that traditional contract models provided little opportunity for optimization. They recommended integrating builders early in the design process, aligning economic interests with common project goals, and cooperatively engaging participants in the design and construction process. The report proposed three multiparty contract models that are consistent with IPD principles and German procurement laws (Breyer *et al.*, 2020). Regulations to implement German IPD projects are currently being developed, and at least 11 significant IPD projects are under way, with over half of the projects being in the public sector.[8]

IPD has also been recognized and recommended by influential global organizations. As noted previously, the World Economic Forum recommendations for delivering major

[7] This affirmation of IPD, even where projects did not meet targets, accords with comments made to the author on projects where participants stated that the projects would have fared much worse under traditional project delivery. For instance, the owner in the worst-performing project in the survey has committed to a 5-year capital programme using IPD. The owner believes the approach coped with adversity better than had another project delivery method been used.

[8] Private communications with Professor Dr Antje Boldt, one of the report's authors and counsel for several German IPD projects.

projects are almost identical to the optimal IPD definition from AIACC (AIACC, 2014; World Economic Forum, 2016). The International Federation of Consulting Engineers (FIDIC), an influential publisher of standard construction contracts, has recognized the need for more collaborative models and has created a task force to develop a new collaborative contract (FIDIC, 2021).

There is a clear international trend toward more collaborative project delivery methods, and we should anticipate that implementation details will adapt to local conditions, practices, and laws. IPD is influencing and leading this trend. IPD requires fundamentally restructuring project implementation and reversing many years of adversarial behaviour. Fundamental change rarely happens quickly. IPD was first proposed 14 years ago, and the current formulation is only 7 years old (AIACC, 2014). In contrast, 28 years have elapsed since Sir Michael Latham's seminal report on problems in the building industry (Latham, 1994). From this perspective, the trend is encouraging.

VI. Conclusions

Choosing a project delivery method is an important decision. Even minor improvements in productivity result in significant resource savings that can be invested in more or better projects or used for other social purposes. Moreover, the research indicates that quality and satisfaction can also be improved by selecting a collaborative project delivery system.

Projects need to go forward, and project sponsors must choose among project delivery systems. Characterizations of project delivery systems are insufficiently precise, and variables between projects are too significant to expect quantitative certainty.

The totality of the research supports using collaborative project delivery and IPD. The subjective comparisons, case studies, indices, and simulations favour IPD over competitive project delivery systems, and the quantitative comparisons are less definitive but provide some support for IPD. No study had suggested that IPD is less effective than other systems. In addition, IPD's underlying precepts are consistent with research correlating projects success with team integration and cohesion.

While there are considerations other than efficiency and quality when choosing a project delivery method, where these are paramount, sponsors should consider IPD or a similar collaborative project delivery system.

(i) Recommendations for further research

Small sample sizes hampered initial IPD research, which was inevitable given the relative newness of IPD. Increasing the number of projects studies increases confidence in the conclusions.

Reliability and resilience are essential characteristics that are often overlooked. Cheng *et al*. reported that IPD teams were resilient (Cheng *et al.*, 2016). IPD project teams have told the author that the IPD projects coped with the Covid-19 pandemic more successfully than their projects executed with other project delivery systems. In another private conversation, the director of a health care organization noted that only one IPD project out of 28 exceeded its project budget and that one project only exceeded the budget by 0.2 per cent. Although the organization was committed to efficient project delivery, it also sought to predict optimal project costs accurately and then deliver at that budget. Variation from a predicted outcome lessened the organization's ability to allocate its resources properly. Anecdotal evidence, such as the private discussions summarized here, and detailed case studies, suggest that IPD improves predictability and reliability because the teams are engaged, aligned, and thoroughly validate the projects (Cheng *et al.*, 2016). Resilience and reliability have not featured in existing research and should be critically investigated.

Uniformity in project delivery factors is also essential. The existing studies examine different characteristics, thus making it challenging to aggregate and compare results. The approach taken in the Hanson Bridgett study was to use the satisfaction conditions established by the project team to measure project success, but this approach may overly emphasize cost. A more comprehensive and consistent set of standards would improve comparisons.

A methodology needs to be developed to 'handicap' projects to normalize comparisons between projects. For example, cost growth associated with a specific project delivery system on a low-difficulty project would be more significant than cost growth on a highly innovative or challenging project. The Construction Industry Institute is engaged in a current research project to identify factors that affect project outcomes.[9] This type of research could lead to developing indices that normalize project data and increase comparison accuracy.

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