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INTEGRATED PROJECT DELIVERY (IPD) FOR HEALTHCARE PROJECTS: A COMPANY-SPECIFIC ANALYSIS

A.S. Hanna[1], Z. Zhu[2], and J.T. Morrison[3]

ABSTRACT

Organizations are increasingly looking to Integrated Project Delivery (IPD) to provide leaner and more successful projects in their construction efforts. Of particular interest is IPD in the healthcare sector, which has a higher instance of megaprojects and a higher overall level of complexity and risk. Therefore, the risk-sharing model espoused by IPD is more attractive than conventional delivery like Design-Bid-Build (DBB) or Construction Manager At-Risk (CMR).

A major contractor worked with the researchers to evaluate its performance on two recent healthcare projects on which it deployed IPD techniques as the first step in a potential organizational shift to the IPD paradigm. Eleven projects were collected – the two IPD projects as well as nine similar projects delivered under CMR within the last five years. These were compared to twenty healthcare projects completed by other firms in terms of eighteen key performance metrics.

Logically, lean ideals native to IPD led to better performance in several metrics; particularly those that have been previously identified as strongly correlated with project success such as cost and schedule growth, as well as in overall project performance in terms of the Project Performance Index (PPI). Buoyed by strong results, the company intends to continue with IPD.

KEYWORDS

Integrated project delivery (IPD), lean construction, process, project delivery systems, project performance

INTRODUCTION

It is an indisputable fact that healthcare construction in the United States will continue to experience increases in demand over the next several decades. For proof of this sustained increase, one needs to look no further than a U.S. Census Bureau forecast. Vespa et al. found that in the year 2020, it was estimated that 56.1 million individuals (or roughly 17% of the population) were over the age of 65, but by 2060, these numbers are due to increase to 94.7 million and 23%, respectively (2020). Therefore, it is unsurprising that inpatient care days in hospitals and medical facilities are forecast to outpace population growth by 22% by 2050 (Pallin et al, 2014). It is thus logical that U.S. construction spending in the healthcare sector

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increased from $42 million per month in January 2013 to $55.7 million in January 2023, an increase of 32% in a decade (Federal Reserve Bank of St. Louis, 2023).

Accordingly, there are an increased number of firms seeking to enter the healthcare construction space and/or improve their existing practice in that area. It was forecast that construction firms that work in the healthcare space should continue to enjoy "growth in revenue, profit, and backlog," given that supply-chain issues and inflationary pressures have not slowed the rate of healthcare construction executed or planned, characteristic of the sector's historical steadiness even through economic uncertainty (Obando, 2022).

One such firm, a top-twenty contractor in the United States as reported by the Engineering News-Record (ENR), has a large and successful healthcare construction practice but had only just begun to implement integrated project delivery (IPD) on healthcare-sector projects[4]. This is in line with previous research: an American Institute of Architects (AIA) survey in 2011 found that a much higher percentage of its members reported "awareness" (83%) or demonstrated an "understanding" of the IPD system (40%) than had ever executed a project under that model (13%) (AIA Center for Integrated Practice, 2012).

The low industry penetration of IPD is due to various entrenched obstacles. As was found by Fish, the three principal obstacles to IPD adoption are unfamiliarity with or unavailability of suitable contract documents for the requisite multiparty agreements, lack of available insurance products in the marketplace that are appropriate for the risk-sharing paradigm, and difficulty aligning the project team to the necessary culture of facilitation (Fish, 2011). Building upon this work, Kahavandi et al. identified that contractual challenges were the most significant, followed by environmental factors (including legislative obstacles and insurance product availability) (2019).

Beyond these enumerated obstacles, there is another perception-related barrier to IPD use. While volumes have been written extolling the virtues of lean construction by academia, and IPD, some research has argued that IPD has almost become overexposed and that the industry-wide publicity of IPD leads to inflated expectations, becoming in fact a further obstacle to adoption (Bilbo et al, 2014).

Given that major contracting firms of the type which engaged the researchers for this investigation are exceptionally risk-averse and can be opposed to sharing information to the degree that IPD requires, leaders of change who were internal proponents of IPD needed to present a quantitative-based analysis of the pilot projects' performance to help make their case and overcome the obstacles previously noted (Zachariah & Goldsmith, 2022). Thus, the researchers were engaged by the company to perform such an analysis.

OBJECTIVES AND SCOPE

In order to assist the company in its analysis of its IPD pilot efforts, the following research objectives were set forth: 1) understand what performance metrics had the most impact on the key stakeholders in the company; 2) quantify those performance metrics for the IPD pilot projects as well as other comparable projects within the company's portfolio delivered by other methods; 3) compare the company's performance under both IPD and non-IPD delivery models to the industry at large; 4) present results in a clear and engaging way; and 5) create a process that could be repeatable at other companies, thus generating a benefit to the healthcare construction sector at large as it seeks to become leaner and incorporate IPD more significantly.

Throughout this paper, IPD is used not only to represent the delivery system but also as a shorthand for the lean techniques and practices that are inherent to it. This is because it is difficult to realize the desired benefits of IPD without embracing and implementing lean practices. The Construction Industry Institute (CII)'s research team DCC-06, led by Hanna,

[4] To protect confidentiality, the firm in question will not be named, but will be referred to as 'the company' throughout.

noted that the use of lean techniques was a key concept imperative to an IPD deployment (Hanna & Morrison, 2021).

RESEARCH METHOD

The study presented herein was conducted in four principal phases, as presented in Figure 1. Each phase is characterized in detail in the following sections.

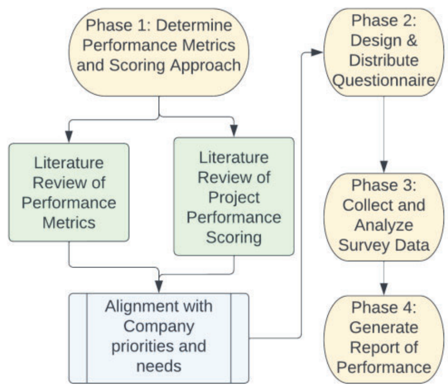

Figure 1: Research Method Overview

LITERATURE REVIEW AND METRIC/SCORING SELECTION

Project Performance Metric Selection

There is a significant body of work in project performance analysis which contains a variety of different scoring systems and performance metrics to compare projects. The general chronology of project delivery systems both over time (in terms of adoption) and effectiveness (in terms of project performance) proceeds from Design-Bid-Build (DBB) to CMR, then to Design-Build (DB)[5] and culminates with IPD (Ibrahim & Hanna, 2019).

To determine what performance metrics to utilize in their analysis, the researchers worked closely with representatives from the company to assess what metrics informed their operating decisions. Particularly useful in this discussion was the work of Iskandar et al., who performed a healthcare-focused quantitative analysis of project performance. Among the most significant metrics identified by the Iskandar study were: design quality (as measured by requests for information (RFI) per million dollars), construction speed, schedule growth and cost growth (Iskandar et al. 2019). However, Iskandar did not compare projects through the lens of project delivery systems.

Similarly, Labib performed a two-part model development on a dataset composed of state-financed projects, which included a high percentage of institutional work. Labib's model formulation was based on eight metrics, and had among the most robust validation process in the literature (Labib, 2019).

Per the method agreed upon by the researchers with the company, the company reviewed the performance metrics to assess which could reasonably be tracked by their project staff, and which were of import to their decision-making. The resultant eighteen metrics, divided into eight holistic areas, that were selected from the literature and augmented by the company's business intelligence needs are presented in Table 1, below, alongside definitions thereof which serve to ensure an understanding of the metrics in use by the reader and to improve the portability of the approach to other companies who might wish to perform a similar analysis.

[5] DB is occasionally interchangeably referred to as Engineer-Procure-Construct (EPC).

Table 1: Selected Performance Metrics

Area	Metric and Type		Definition/Formula
Communication	RFI per \$1M	Ratio	$\frac{\text{Number of Project RFI}}{\text{Project Cost in Millions}}$
	RFI processing time	Number	Count of days between submission of an RFI and a resolution
Change Management	Change order processing time	Number	Count of days between submission of a change order and a resolution
	Absolute Value of % Change	Ratio	$\frac{\text{Absolute Change Amount}}{\text{Project Total Cost}}$
	Specific Factor-Related % Change[6]	Ratio	$\frac{\text{Change Amount due to Factor}}{\text{Project Total Cost}}$
Business	Company Image	Scale	5-point Likert scale[7]
Quality	Project System Quality	Scale	5-point Likert scale
	Punchlist items per \$1M	Ratio	$\frac{\text{Count of Punchlist Items}}{\text{Project Total Cost}}$
Safety	OSHA Recordable Rate[8]	Ratio	$\frac{(\text{OSHA Recordable Injuries}) * (200{,}000)}{\text{Total Project Work Hours}}$
Cost	Construction Cost Growth	%	$\left(\frac{\text{Actual cost} - \text{Initial estimated cost}}{\text{Initial estimated cost}}\right) * 100$
	Budget Factor	Ratio	$\frac{\text{Actual cost}}{\text{Initial estimated cost+Cost of approved changes}}$
Schedule	Construction Speed (ft^2/Day)	Ratio	$\frac{\text{Construction ft}^2}{\text{Construction Duration (Days)}}$
	Schedule growth	%	$\left(\frac{\text{Actual duration} - \text{Target duration}}{\text{Target duration}}\right) * 100$
	Schedule intensity (\$/Day)	Ratio	$\frac{\text{Final Construction Cost}}{\text{Construction Duration}}$
Labour Productivity	Work Value per Labour Cost	Ratio	$\frac{\text{Sell Value of Self} - \text{Performed Work}}{\text{Self} - \text{Performed Labour Cost}}$

PROJECT PERFORMANCE SCORING METHOD

In selecting a scoring tool to use here, one must consider that IPD is a more recent iteration in construction, which disqualifies from consideration the notable preceding work of Konchar and Sanvido (1998), Ibbs (2003), Rojas & Kell (2008), and Sullivan et al. (2017) among others which did not consider IPD. Additionally, while these studies and the general body of literature of which they are representative have done a great deal to advance the operational understanding of PDS in the industry, there is another factor by which this effort was constrained: many previously published works include a great deal of analysis and/or quantification of performance metrics, but lack a unifying method or standardization approach

[6] Three versions of this metric were assessed: Program-related, Design-related, and Quality-related percent change, bringing the total to 18.

[7] All 'scale' metrics were of interest to the company but are not used for quantitative analysis due to their qualitative nature.

[8] While safety is of paramount importance to the construction industry at large and to the company in question, previous research has found that safety is largely ingrained in company culture to the point where it is independent of PDS (Hanna & Morrison, 2021). As such, safety factors were gathered but are not assessed or reported.

by which a project's performance can be distilled into a single number. This is an attractive proposition for industry professionals, as it more easily facilitates the comparison of projects to each other and makes for simpler reporting to leadership. Standardization also facilitates a more ready comparison of projects in a like-to-like fashion.

Therefore, the preceding work the authors could consider for application in this effort consists of work published largely since 2016 which considered IPD. The work fitting this description which was considered included El Asmar et al. (2016), Ibrahim et al. (2018) and the combination of Labib (2019) and Hanna & Morrison (2021).

Among El Asmar et al.'s most notable research contributions were their observation that there was a significant gap in the literature - a single, comprehensive metric to assess project performance did not yet exist - and their creation of the Project Quarterback Rating (PQR) to begin addressing it (2016). The PQR was comprised of 23 individual metrics within seven holistic performance areas, namely: customer relations, safety, schedule, cost, quality, financial performance, and communication (El Asmar et al. 2016). However, while IPD was included by the El Asmar study, only 35 projects in total were considered, and IPD was at the time "emerging" by the study's own admission (El Asmar et al. 2016). Furthermore, the El Asmar study was based in part upon subjective weights (i.e. opinion based) which reduce its accuracy as compared to more recent efforts.

Ibrahim et al. reported in the Construction Research Congress a robust investigation of 12 performance metrics in six areas, considering IPD alongside DBB, DB, and CMR, but the focus of the study was not on a distillation of this analysis into the kind of single numeric score the researchers and the company were seeking (Ibrahim et al. 2018).

The researchers had previously reviewed with the company the Project Performance Index (PPI) which was developed by Labib. However, the original work of Labib was based on a dataset that, while it contained numerous institutional projects that are comparable to healthcare-sector work, did not contain IPD projects (Labib, 2019). Enter the work of Hanna & Morrison, which validated the applicability of Labib's model on IPD projects in the course of their own development of the Project Performance Score (PPS) for downstream and chemical construction, another industry sector that has a comparable level of complexity to healthcare sector work (2021).

Thus, given that the PPI model was developed on a large dataset of projects (189) and on a variety of institutional projects (correctional facilities, medical research, military installations, engineering science labs, etc.), and that its merit was validated on IPD projects by a separate effort, the researchers and company agreed to use the PPI model (Labib, 2019; Hanna & Morrison, 2021).

The Project Performance Index

Labib's PPI score is as follows (2019):

$$\begin{aligned} PPI\ =\ & -1.101 \times RFI\ processing\ time - 0.219\ \times Percentage\ change \\ & -0.241 \times Schedule\ growth\ - 0.022 \times Schedule\ factor \\ & -0.014\ \times Number\ of\ RFIs\ per\ millionUSD + 0.011 \times Construction\ speed \\ & +0.67 \end{aligned} \quad \text{(Eq. 1)}$$

An astute reader will note that this equation does not utilize all 15 factors that were previously identified. This is because while all performance metrics identified were relevant to the company's operations and business intelligence needs, not all of them have been found to correlate to project performance, and some (such as company image) are not true quantitative metrics as defined in Table 1 previously. Therefore, they are not weighted or used to calculate the PPI here.

Adding further value to the company's efforts, the PPI score can be scaled into a numeric value between MinR (1) and MaxR (10), which creates a useful and intuitive shorthand for project performance comparison as shown in Equation 2 (Labib, 2019).

$$PPI_{scaled} = \frac{(PPI - PPI_{Min})*(MaxR - MinR)}{PPI_{Max} - PPI_{Min}} + MinR \quad \text{(Eq. 2)}$$

DATA COLLECTION AND CHARACTERISTICS

After the target performance metrics and project scoring strategy had been agreed to, the researchers worked with the company to design a questionnaire that could be circulated to collect the data needed for analysis. The questionnaire was structured to align with similar data collection vehicles that have been used by the researchers over the last decade, to ensure a uniform dataset from which informed and accurate comparisons can be drawn. The questionnaire includes thirteen sections, as follows: Project Characteristics (I), Special Conditions (II), Prefabrication Usage (III), Contracting Strategy/PDS (IV), performance data for communication, change, quality, safety, cost, schedule, labor, and business (V-XII) and contact information for required follow-up questions (XIII). For brevity, the survey is not included in its entirety in this paper. The survey was distributed to the company's corporate offices in major markets across the midwestern United States, from which eleven medical sector projects were gathered. A further twenty healthcare specific projects were supplied from project data maintained at the University of Wisconsin - Madison to provide a database from which to comparatively evaluate PDS performance. Project data from the assembled dataset were plotted using the boxplot, a common statistical tool.

DATA CHARACTERISTICS

The eleven company projects and twenty industry projects that were analysed in this effort were executed between 2007 and 2021 in all cases, and specifically within 2017-2021 for the company's projects. The company data consisted of two IPD projects from their pilot work with the delivery system and nine CMR projects. The industry data consisted of seven IPD projects, and nine CMR projects. While the company did not directly deliver any projects under DBB, the researchers also included four such projects as an additional comparison since the data was available. All datapoints were from projects completed in the United States, with the largest share of projects being completed in Wisconsin (18). Other states represented in the data by multiple projects included Missouri (3), Minnesota (2), Illinois (2), and Florida (2).

The cost data in these projects were standardized for time and location using the RSMeans 2021 historical cost indexes and city cost indices. The reference location and year in this study are Chicago and 2021, respectively. The standardized cost of the projects ranged from $3 million to $661 million with an average of $152 million.

RESULTS AND DISCUSSION

The thirty-one assembled projects were first characterized in terms of key characteristics (cost, location, delivery system, etc.). Then, the projects were analyzed by delivery system chosen and scored using the previously provided PPI equations, as well as for each of the eighteen performance metrics. The PPI scores and a selection of the performance metrics will be presented in this section for comparison and discussion. In each box plot in this section, the result of the pertinent equation defined in Table 1, previously, is plotted on the Y axis. Further, in each case the company's specific project data will be presented in light grey and on the right-hand side of the comparison, while the industry data will be presented in dark grey and on the left.

COST PERFORMANCE EVALUATION AND COMPARISON

The two metrics used to measure cost performance were cost growth and project budget factor. It should be noted that one of the company projects did not report cost data sufficient for analysis and was therefore excluded. Thus, only 30 projects are assessed here. Figures 2 and 3 present the box plots for each of the cost metrics.

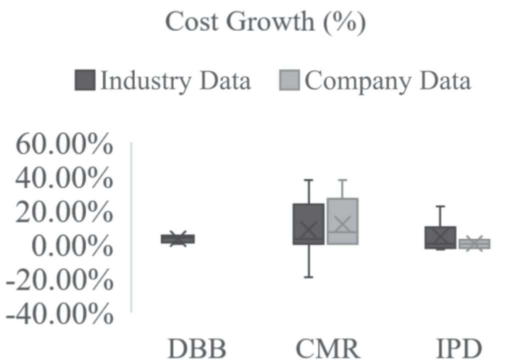

Figure 2: Cost Growth Performance

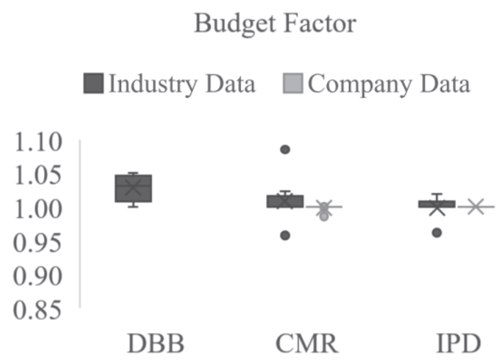

Figure 3: Budget Factor Performance

It is apparent that the projects delivered under CMR by both the company and the industry at large have higher cost growth and a higher budget factor than those delivered under IPD. In comparison to the industry at large, the company's CMR projects have both a higher mean and higher range in cost growth. This implies that the company tended to experience higher actual cost than baseline estimates. However, the same CMR projects had a budget factor quite close to 1, which implies that the majority of the cost growth percentage was due to approved change orders, rather than any degree of poor project performance. By considering these metrics in tandem, the company can ascertain a more impactful picture of its performance than by considering either alone. On the IPD projects that were examined, the company's cost growth was 0%, outpacing the industry data's (4.23%).

Schedule Performance Evaluation and Comparison

Figures 4 and 5, below, present schedule performance as measured by schedule intensity, and construction speed. All projects in the dataset reported sufficient information to be included in the schedule analysis. However, it was found that the company experienced negligeable schedule growth on all its reported projects, indicative of strong operational practice. Thus, the value of visualizing schedule growth for comparison is limited, and the figure is omitted.

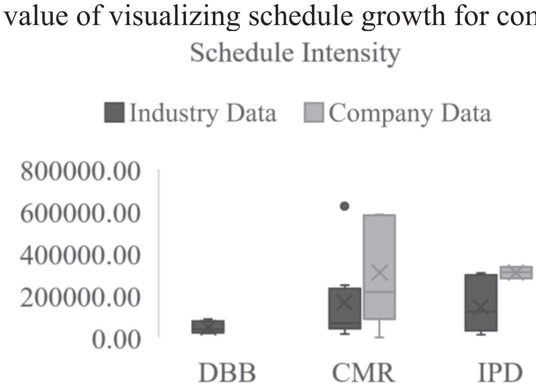

Figure 4: Schedule Intensity Performance

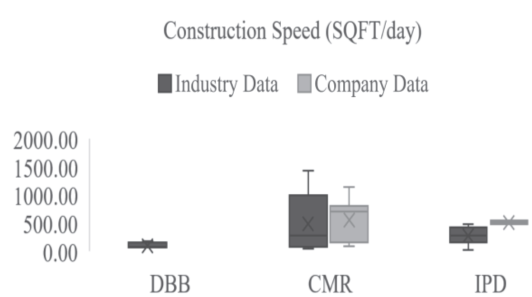

Figure 5: Construction Speed Performance

Both the company's CMR projects and those of the industry at large slightly outperformed IPD projects in terms of construction speed. Additionally, the company's projects under both delivery systems were faster (in terms of construction speed) and more intense than the average. This speaks to corporate culture and project approach in addition to PDS selection.

Encouragingly, the company saw little-to-no schedule growth, regardless of delivery method (the industry by contrast experienced 19.2% schedule growth in CMR and 14.2% in IPD).

Change Management Performance Evaluation and Comparison

Change management was measured in terms of three metrics: change order processing time, absolute project percent change, and percent change ascribable to program, design, or quality. The company's IPD projects experience no change due to design or quality, vastly outperforming both their own CMR projects and the industry at large. However, the specific reason-related percent change comparison is not reported as individual figures for brevity.

Change order processing time, shown in Figure 7, is presented on a 7 point scale: 1 (1-7 days), 2 (8-14 days), 3 (15-21 days), 4 (22-28 days), 5 (29-35 days), 6 (36-42 days), and 7 (greater than 42 days).

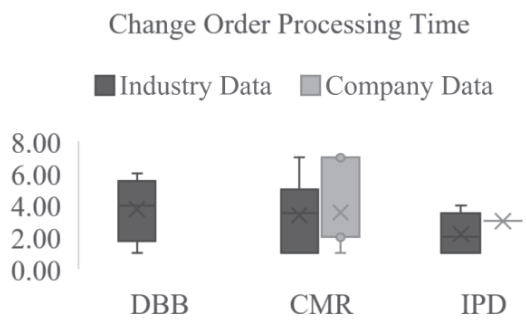

Figure 6: Change Order Processing Time Performance

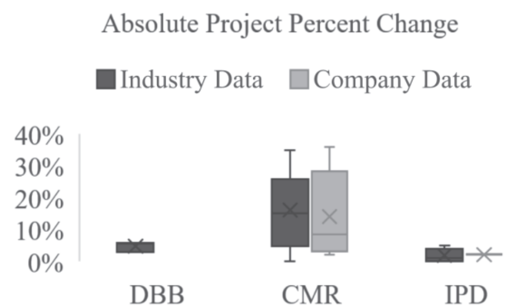

Figure 7: Absolute Project Percent Change Performance

As is evident, the company experienced higher change order processing time for both CMR and IPD than the industry at large. However, it should be noted that change order processing time is frequently beyond the control of the contractor directly. IPD projects for both the company and the industry experienced a lower volume of percent change, as shown in Fig. 7.

Communication and Design Quality Evaluation and Comparison

Similarly to the presentation of change order processing time in the preceding section, RFI processing time is presented on a five-point scale: 1 (1-7 days), 2 (8-14), 3 (15-21), 4 (22-28), and 5 (29-35 days). DBB, as would be expected, has the highest number of RFI per million dollars on average, followed by CMR and IPD, indicative of the increased coordination and design quality that IPD can produce due to more collaboration among the project team and an incentive of a shared risk pool. The company specifically saw higher numbers of RFI per million dollars than the industry at large, and a more variable processing time under IPD.

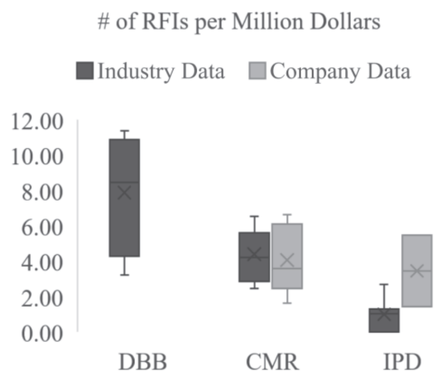

Figure 8: # of RFIs per Million Dollars Performance

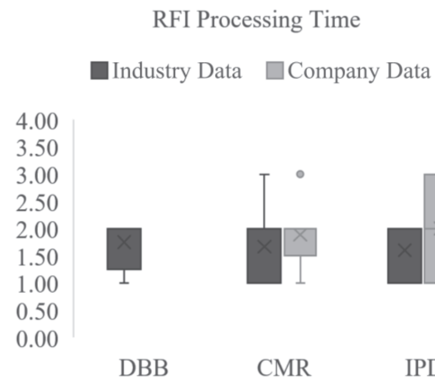

Figure 9: RFI Processing Time Performance

PPI Performance Evaluation and Comparison

The PPI scores from 22 projects[9] were calculated, scaled, and then compared. The results are shown in Figure 18. The performance ranges of the CMR and IPD projects are close. However, the average scaled PPI score of the CMR projects is lower than the IPD projects in general. The company outperformed the rest of the industry in terms of both CMR and IPD projects.

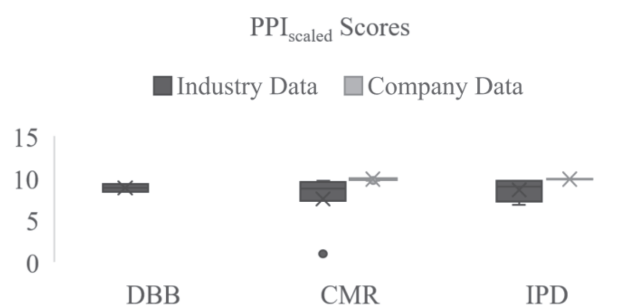

Figure 10: PPI Scoring Performance

Discussion of Results

The overall performance of IPD projects scored better on the PPI than other delivery systems for both the company's IPD pilot projects and the industry project data. Additionally, IPD was the best-performing on average in terms of: Punchlist items per $1M, RFI per $1M, Quality-Related Percent Change, Design-Related Percent Change, Change Order Processing Time, Absolute Project Percent Change, Schedule Growth, Cost Growth, and Budget Factor. This amounts to 64% (9/14) of the assessed metrics (recall that the qualitative metrics, as well as safety, are not differentiators between PDS). The company's consistently better performance than the industry on both IPD and CMR projects is not solely due to the delivery system. The company is a recognized leader in CMR delivery and as such is and was able to realize exceptional performance under that system. This performance is in part due to lean practices that are embedded in the company's culture include use of Building Information Modelling (BIM), the Last Planner system, the Big Room, and others. The researchers believe the company was thus more 'IPD-ready' than it had previously thought and was hence able to realize the benefits that research has long shown IPD can deliver effectively. However, that is not to discount the ability of IPD's risk-sharing, incentivization of collaboration, and multiparty

[9] Sufficent data to calculate the PPI was only available from 22 projects: 2 (9%) DBB, 14 (64%) CMR, and 6 (27%) IPD projects.

strategy to improve communication, design quality, and performance, as was seen in the more expedient processing of changes and reduced amount of overall project change and requests for information, among other performance indicators. The key understanding is that IPD and lean are tied together – lean theory and practice facilitates organizational paradigm shifts, while the IPD system provides an avenue to utilize those lean tools and practices in pursuit of a shared project goal.

LIMITATIONS

As this study was a case-study type examination of a specific company's transition into IPD, it necessarily collected new data only from one company. However, this methodology can be easily adapted to other company-specific examinations, and over time an understanding could be built of the industry's transitions to IPD. For such an investigation to occur, it is likely based on previous work (Hanna & Morrison 2021, Ibrahim et al. 2020, Labib 2019, Antoine et al. 2018) that closer to 100 datapoints would be needed.

Furthermore, this study focused on healthcare sector projects. As a result, findings about the relative performance of the PDS in question may not directly translate to other industry sectors. Again, however, the methodology is sound enough to be applied to other sectors should further researchers wish to do so.

CONCLUSIONS

Thirty-one construction projects from within the healthcare sector were analyzed to assess the performance of a major contractor's transition to IPD in their work. Eleven projects from the contractor were collected (including the two initial IPD pilot efforts) and twenty were supplied from institutional data held by the researchers. Eighteen performance metrics were identified, and fourteen of them were used for comparison (safety, project system quality, and business image were excluded – safety due to its lack of correlation with PDS as defined by previous research, and the other two exclusions due to the structure of the metric being qualitative in nature and therefore ill-suited for comparisons of this type).

The areas in which IPD was the superior performer are logical, given the priority that this lean delivery system places on communication, coordination, change management, scope management, and quality. Specifically, it was found that IPD was the best performing PDS in terms of RFI per million dollars, as well as punch-list items per million dollars, percent change, and change order processing time as compared to CMR. DBB, while included for referential comparison, was not representative, as the company examined did not use the DBB PDS.

Moreover, this paper presents an easy-to-adopt framework for other companies wishing to develop report cards on their IPD efforts to utilize as part of their project scoring. The Project Performance Index (PPI) allows for disparate projects to be compared within a company and across the industry. As an ancillary benefit, performing this type of analysis will encourage contractors to begin tracking more project data (if they do not do so already) which will improve their own outcomes and allow for more detailed research in the future.

Most importantly, the researchers were gratified that the results of this comparative effort included an enthusiastic reception to the IPD pilot projects the company had embarked upon and an intention to pursue more work with this contracting strategy in the future. Given that contractors must be selective about what they bid on, identifying IPD as a differentiator that points toward a more successful project is a valuable insight for this contractor and for other industry practitioners, who can easily apply this method to assess and monitor their own IPD implementation efforts.

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