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A Game Theory Perspective on Delivery Methods in Construction

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Abstract

Question: Why is Integrated Project Delivery (IPD) a relatively underutilized procurement method in construction?

Purpose: Expose and explain a few market failures that owners/developers might be ignoring by choosing traditional methods over IPD.

Research Method: Game theoretic modeling and application of microeconomic principles. Informed by interviews with IPD participants, we model the important strategic and social advantages of IPD that complement more well-known efficiency advantages.

Findings: Our primary insight is that traditional design-bid-build projects encounter pervasive moral hazard problems and externalities that reduce the efficiency of construction and create conflict between participants. At a basic human behavior level, IPD eliminates or mitigates these issues.

Limitations: The interviews we conducted provide insight, not empirical inference. Therefore, this paper stands on its theoretical contribution and makes no boast of providing representative data or causal analysis.

Implications: Owners/developers would do well to embrace IPD given its social and strategic contributions to Lean Construction. Additional efficiencies we highlight complement the more well-known advantages, possibly tipping the scales toward IPD for a greater number of construction projects.

Value for practitioners: This paper will explain how non-integrated methods such as design-bid-build create greater cost and conflict than previously realized. It suggests a path forward through (scalable) IPD that mitigates these costs.

Keywords: Integrated Project Delivery, Procurement Methods, Moral Hazard, Cooperative Methods, Circular Economy, Construction Efficiency, Lean Procurement

Paper type: Full paper

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Introduction

The construction industry has a complicated reputation. It is known for its highly visible and impressive accomplishments, but also for its rough and combative culture. It is at once highly productive and highly wasteful, both intensely coordinated and resolutely independent. To industry participants, such tensions are business as usual, and likely viewed as part of the job. Unfortunately, the ubiquity of conflict and waste in construction is only rivaled by its litigious nature. Each year, over 20% of construction contracts end in dispute (IACCM, 2014). Moreover, Li, et al. (2021) assert that chronic stress is the most significant occupational hazard for construction project managers (CPMs). Yang, et al. (2017) add that “job stress significantly aggravates CPM’s job burnout, and rather than traditional project objective management, stakeholder relationship management is the main stressor” (pg. 1272).

Many people may see these characteristics as natural and immovable. We are convinced otherwise. Cooperative methods of construction management are possible—and practical. Models such as Design-Build, Design-Assist, and Integrated Project Delivery (IPD) stand as excellent alternatives to the traditional, and we shall argue socially harmful, design-bid-build delivery method (Darrington, 2011). Yet, principals (the economic term generally used for project owners and, or developers) are often hesitant or resistant to adopt such approaches, despite scores of research lauding their many advantages (Franz et al, 2017; Choi et al, 2019). Such documented benefits include improved project quality, better value, improved constructability, fewer claims and disputes, higher efficiency, and reduced rework (Hettiaarachchige et al, 2022) — all of which directly or indirectly impact the financial advantages for principals. One possible reason project owners forgo IPD is that they are so familiar and comfortable with design-bid-build that its disadvantages have faded into the background through common risk mitigation strategies. Kent and Becerik-Gerber (2010) highlight a high degree of contractual risk as a major barrier to using IPD. Kahvandi et al (2018) provided an extensive literature review of studies addressing the implementation challenges associated with IPD. Simply being informed about the benefits of an alternative method such as IPD does not sufficiently inspire switching because the proposed new methods solve problems for which they are already well adjusted. Principals thus inaccurately weigh the relative costs and benefits of IPD and underutilize it as a delivery method. To correct this calculus and promote a more well-functioning industry, we discuss the incentive structures behind design-bid-build and contrast them to those within IPD.

Existing studies have focused on many non-human elements of IPD: risk sharing (Kent & Becerik-Gerber, 2010; Zhang & Li , 2014), contract disputes (Collins & Parrish, 2014), insurance complications, comparative outcomes, and construction efficiency (Hettiaarachchige et al, 2022). Few research papers have explored the social considerations of IPD. Those that have, e.g., (Sujan et al, 2020; Kim & Dossick, 2011) focus on detailing the collaborative nature required in this delivery method. Zhang and Li (2014) approached the risk/reward compensation problem of IPD by applying the Nash Bargaining Solution (NBS) model.

This study established an application of economic game theory to resolve perceived risk challenges associated with IPD. San Cristobal (2015) applied game theory to resolving contract conflict associated with construction schedules and Grzyl, Apollo, and Kristowski (2019) use game theory to legal conflict resolution in construction. Kim and Dossick (2011), find five structural variables that promote greater integration, e.g. the contractual structure, the cultural structure, the organizational structure, lean principles and practices, and building information modelling. The research presented herein considers the application of game theory to specifically examine the advantages of IPD rather than the risks or challenges. To our knowledge, no studies have further explored the specific behavioral and strategic side through an economic lens. We take a social science approach to fill this gap in the literature. In doing so, we intend to inform the industry about lesser-understood problems within traditional design-bid-build methods and highlight the important role that IPD can play in improving the way that architectural, engineering, and construction (AEC) participants create the built environment.

Our primary insight is that IPD overcomes the moral hazard problems in traditional design-bid-build (DBB). Specifically, that IPD increases efficiencies and reduces conflict between AEC participants. Using a simple economic model of asymmetric information, we show how hidden actions, or more accurately, the potential for hidden actions, misaligns the incentives of principals and builders and allows builders to extract information rents from the principal in the form of additional performance-based payouts. If principals are unwilling or unable to provide such incentives, the system encourages builders to engineer profit in socially destructive ways.

The research approach of the study presented in this paper is rooted in previously established economic theory and its recent applications to construction management and economics (Gryzl et al, 2019; San Cristobal, 2015; Holmstrom, 2016). The hypotheses are informed by a series of interviews conducted with stakeholders of previously completed IPD projects. After speaking with a multitude of participants ranging from principals to trade partners and sub-contractors, an important pattern became ineluctable. Participants emphatically preferred the process of an IPD build compared to a conventional build. The primary reason was because of improved inter-personal interactions and lower stress in relationship management. We therefore consider this preference for IPD as an integral condition for principals to achieve their project goals.

The paper proceeds as follows: the next section discusses the theoretical basis of our claims and describes the game theory model; immediately following, we present a summary of the interviews we conducted with past IPD participants; and the final section concludes.

Theoretical basis

The AEC industry is experiencing an evolutionary change in the contractual nature and execution of their services (Kent & Becerik-Gerber, 2010), e.g. Design-Build, partnering, project alliancing, and IPD. As new methods for delivering the built environment are explored, challenges arise, and benefits are realized. The American Institute of Architects (AIA) 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 project participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.* (The American Institute of Architects, 2007)" What differentiates IPD arrangements from typical hard-bid contracts is that participants are bound together in a multi-party agreement where profit gains or losses are shared across stakeholders. IPD extends the advantages of Design-Build, or Design-Assist to contractually bind the designer, the construction manager, and the specialty trade partners with the principal. A mutual 'sink-or-swim' relationship exists rather than pitting each of these stakeholders against each other – as is often the case with traditional Design-Bid-Build (DBB) procurement. Hence, IPD creates greater congruence of profit motives. Instead of having participants chasing their own margins to fill their individual profit buckets, often at the expense of others, there is a single profit bucket for which each participant seeks to fill, knowing the total is likely greater than the sum of its parts. What principals may not realize is that this greater congruence generates three important, and heretofore unheralded, advantages: smaller externality effects across contributors in the construction process, fewer points of financial extraction in negotiated incentives, and increased productivity in person-to-person interactions. We explore each of these in turn. Where previous studies have addressed familiar advantages of IPD, we apply game theory methodologies to consider additional advantages. See Figure 1 for a graphical depiction of this paper's contribution in relation to prior knowledge.

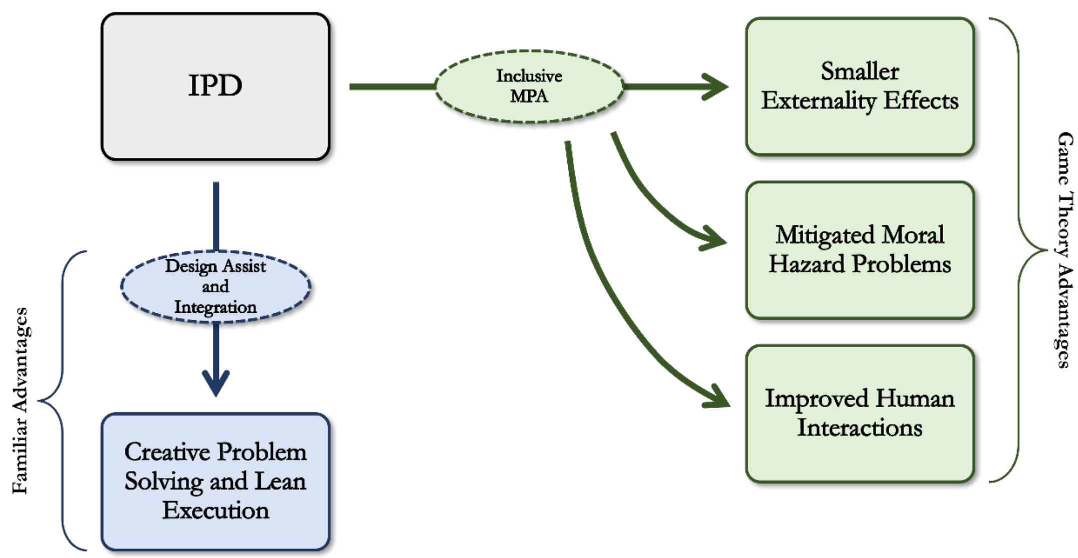

Figure 1: Advantages of IPD

Although we are not the first to note IPD's advantage in human interactions (Matthews & Howell, 2005 for example), we found it difficult to talk about externalities and moral hazard without also discussing complementary culture effects. In fact, studies suggest that relationships of trust promote creative solutions, cost control measures, and innovations that pair well with fundamental changes to the incentive structures we highlight (Kalsaas, 2013; Kalsaas et al, 2018, Lundvall, 1992). These factors combine to generate tangible pecuniary benefits that will almost certainly compensate for the more frontloaded costs of IPD.

Smaller externality effects

Integrated project delivery and Lean Project Delivery (LPD) are conceptually created to minimize resource use and maximize benefits to the development, design, and construction team. One way they accomplish this is by aligning each individual's costs and benefits to those of other contributors and the project as a whole. In economics terms, IPD helps solve a pervasive externality problem that plagues traditional methods. When an owner handles each sub-contractor individually, and pays them for only their narrow deliverable, the sub-contractor performs the task with little to no mind for what must happen after them. The downstream workers thus pay some of the costs of decisions made upstream. This is a classic externality problem that is likely to pervade each step of the construction process when performed independently. While each specialist is bidding and performing their task at the lowest possible cost, thus creating the illusions of cost savings for the project as a whole, they do not account for the costs they pass down in the form of externalities which materialize in the form of higher bids/payouts for other trades. A simple example, albeit a whimsical one, is the causal relationship between trades. The quality of framing, or the lack thereof, has many downstream implications. Consider a wall that is erected out of plumb by the smallest measure. Even ½ inch of variance from bottom to top will create a chain reaction. The finish carpenter will now be required to compensate as best as they can to install a door in that wall that offsets the lean in the framing. The drywall contractor will need to take additional time to compensate for uneven surfaces between the framing and the finish carpentry. The painter will need additional caulk to fill gaps between the drywall surface and the trim. The finish carpenter will most likely require excessive finish nailing or screws to secure the door and trim. This also translates to additional work for the painter. Each downstream trade carries additional costs from the neglect of the initial framing carpenter. However, If the incentives of the trades were more aligned, each professional would take greater care to prevent negative deviations and there would be an overall cost savings.

Perhaps a more meaningful and frequently encountered example is the conflict between structural systems and mechanical systems within a building. In a traditional design-bid-build approach, the structural and mechanical systems have already been designed and the specialty trade partners are asked to bid as designed and erect or install their respective systems. There is often conflict in the design, commonly known as clash. This occurs when the space in design does not accommodate for interaction of the two systems. For example, a beam that intersects with HVAC ductwork. At the point that the mechanical contractor arrives on site, the structure is already in place and very little can be done by the structural contractor to change the beams in place. It often falls on the mechanical contractor to engineer a solution, and most solutions will certainly impact performance of the mechanical system. In these conditions, the owner warrants the insufficiency of the plans and therefore bears the cost of the change, additional labor, materials, and lost time.

In both examples provided, it is the owner who ultimately bears the burden. Either of inferior quality (as is the case in the poor framing), or the additional costs due to insufficiency in design. In these and many other cases, the contractors are misaligned in their motivations of providing quality construction on time and within budget. Such misalignment of incentives leads to a natural overprovision of project failures and under-provision of project efficiencies. IPD provides a solution to such externality problems by realigning incentives toward a common goal and internalizing what was previously externalizable between stakeholders. It also creates opportunities to implement construction techniques that are otherwise difficult to coordinate.

Fewer points of financial extraction

Risk management is at the center of concern in any capital investment project (Doshi et al, 2017). As such, traditional construction contracts foster an adversarial relationship between the parties as these parties seek to mitigate their financial risks (Humphreys et al, 2003). Naturally, construction companies develop strategies towards that end and become extremely protective of those mitigation methods. One such method is for the construction manager to find efficiencies in the construction system which saves money through reducing wasted resources, e.g., materials, labor, equipment use (Ajayi & Oyedele, 2018; Begum et al, 2006). These companies are motivated by the financial benefits of reducing waste (Liu et al, 2020) but are often concerned about disclosing those benefits for fear of losing claim to them. Conventional contracts permit opacity of process and allow contractors to extract whatever financial efficiencies they can create—sometimes in unethical ways (Ali, 2017; Shah & Alotaibi, 2018). Thus, we see the economic rents inherent in the usual contractual relationship.

Whenever a principal hires an agent (the term we use for contractors and trade professionals) and does not perfectly observe the agent's behavior, there is room for what economists call a 'moral hazard problem.' The basic idea is that the agent's incentives are correlated, but not entirely aligned with the principal's, leaving incentive for the agent to pursue their own self-interest and behave in a way that the principal does not like. If the principal cannot perfectly observe and dissuade such behavior, they may forgo the relationship and both parties lose the economic gains from exchange—a market failure. Alternatively, they can accept that agents will pursue self-interests and hire them anyway, knowing that the end product will not be as good and/or agents will extract more of the surplus in the form of information rents.

Such moral hazard problems occur frequently in construction and are exacerbated by conventional procurement methods. Here, of course, principals are the owners and/or developers and contractors/trades professionals are the agents. To understand our thesis, consider the following model adapted from (Holmstrom, 2016). We make no claim to be the progenitors of this theory, but we believe it fits the construction context so well that simply adapting the theory to this application is a useful contribution, and twisting or reinventing the concept is unnecessary. For early work on moral hazard in economics, see Arrow (1971).

Suppose a principal hires a contractor to perform a task on a traditional build. The Principal gets a payoff of R (for revenue) if the build is of high quality, zero otherwise. Once under contract, the Contractor may choose to devote high effort (do it right) or low effort (cut corners) to the build. If they devote high effort, it costs them 1, if they devote low effort, it costs them 0. One can think of these numbers as the costs associated with any additional time and effort devoted beyond the minimum necessary to perform the task. High effort guarantees a high-quality build, but low effort means there is only a 50% chance that the build is high quality. Thus, the expected value of low effort to the Principal is only $R/2$ (simplified from $0.5(R) + 0.5(0)$). Table 1 summarizes the game setting. Note that there is nothing critical about the seemingly extreme values of zero. These values have simply been normalized to zero to make the model very simple and tractable. What's important is the relative values associated with high and low quality and high and low effort. Using non-zero values does not affect the model's predictions at all.

Table 1: Summary of the game setting

	Cost to Contractor	Prob. High Quality	Prob. Low Quality	Benefit to Principal
High Effort	1	100%	0%	R
Low Effort	0	50%	50%	R/2

Naturally, the Principal would like to motivate the Contractor to give high effort (thus guaranteeing a payoff of R). This can be difficult, however, since it is in the Contractor's private interest to cut corners. The Principal thus proposes an incentive contract: if they see high effort, they pay the Contractor a bonus of w. If they see low effort, they do not pay a bonus. The Principal's profit maximization problem is thus to find the smallest possible bonus that would induce high effort. To find this bonus, we use backwards induction and begin with the Contractor's choice of effort given w. On the left-hand side of equation 1 is the Contractor's payoff from choosing high effort (and therefore getting the bonus). On the right-hand side, is the Contractor's payoff from choosing low effort (and therefore no bonus). By setting the two sides equal to each other and solving for w, we find the indifference point for the Contractor—that is, the value of w that makes the Contractor indifferent to doing the job well or cutting corners. We assume for the sake of simplicity that, if indifferent, the Contractor will choose high effort and reap the bonus.

$$w - 1 = 0 \tag{1}$$

The solution $w^*=1$ aligns with our intuition that the Principal needs to pay a bonus at least as large as the cost of high effort.

To finish solving for the subgame perfect Nash equilibrium, we simply need to determine when the Principal is willing to pay w^*. On the left-hand side of equation 2 is the Principal's payoff from offering the bonus contract w^*. On the right-hand side is their payoff from abandoning the incentive contract and simply taking their chances with the quality of build, knowing that they are going to get low effort.

$$\begin{gathered} R - 1 \geq 0.5(R) + 0.5(0) \\ R \geq 2 \end{gathered} \tag{2}$$

Solving the equation yields that the Principal would offer the incentive contract with $w^*=1$ as long as R is greater than or equal to 2, meaning that they are happy with the arrangement so long as the additional revenue from a high-quality build is sufficiently large.

So far, so good. In this baseline case, the Principal can perfectly observe the Contractor's effort, and they simply need to incentivize them by paying a bonus equal to the additional cost of high effort. The scenario becomes more interesting when you allow for asymmetric information, meaning one side of the exchange has more information than the other. Suppose instead that effort is not observable (a principal is not watching the jobsite ordinarily) but quality is. The Contractor now has an informational advantage since they are the only ones who truly know whether high effort was given. Now the Principal proposes a contract where *w* is only paid if they see that the build is of high quality. Of course, high quality is correlated with high effort, so it's still a meaningful incentive, but now the Principal cannot observe effort, so they must tie the bonus to an imperfect proxy, in this case quality.

Beginning once again at the end of the game with the Contractor's decision, we solve for *w* in equation 3.

$$w - 1 = 0.5(w) + 0.5(0) \qquad (3)$$
$$w** = 2$$

This time the minimum *w* to induce high effort is 2, much higher than before. The increase occurs because the Contractor can secretly cut corners and still get the bonus half the time. Hence, the Principal must incentivize them more than usual to guarantee high effort and therefore high quality. The difference in *w* between the complete information case and the asymmetric information case is what economists call an **information rent**. The Contractor can extract it because they can perform a hidden action that is against the Principals wishes—a moral hazard.

Our postulation is that many agents enjoy such information rents under the traditional construction model. This is not to say that they always cut corners—on the contrary, they give high effort in this equilibrium—but that they extract more of the surplus value because they have the option to cut corners without being directly detected. To the extent that IPD removes this information asymmetry, it also removes the information rents and eliminates a common market failure.

For the sake of completeness, we finish solving for the equilibrium under asymmetric information by finding the Principal's new minimum revenue:

$$R - 2 \geq 0.5(R) + 0.5(0) \qquad (4)$$
$$R \geq 4$$

This value is twice what it was under complete information. The intuition of this result is that from a principal's point of view, the moral hazard problem is only worth solving if high quality is important. Principals will only bother creating incentives for high effort if the internal rate of return (IRR) they get from a high-quality build is equal to or higher than those IRR projections without the incentives.

Hence, two equilibria exist in this model of asymmetric information: one for low *R* values, and one for high *R* values. The model's prediction is that low budget projects with low efficiency requirements and short life cycles (represented by small *R* in the model) will not be worth paying a bonus over to guarantee high quality, so builders will cut corners in equilibrium and produce a structure that is most likely low quality. It is a self-fulfilling prophecy brought on, not by the specifications of the project itself per se, but by the moral hazard problem within traditional construction management. This moral hazard is likely to be solved, however, in higher budget projects with stringent efficiency requirements and longer life cycles. In such cases, the equilibrium flips, and we expect principals to incentivize high effort so that they get high quality. Again, the outcome is not realized because of project specifications alone, but because a principal solved the moral hazard problem.

Practically speaking, what hidden information or actions do contractors and trade professionals wish to keep private? Some things, almost certainly, are of questionable legality and/or ethics, such as misclassification of workers, but we do not mean to paint the industry as being corrupt or malfeasant. Indeed, much of the private information that organizations protect is entirely above board. Such is their right, and we make no value judgment about it. Rather, we hope to shed light on the fact that organizations benefit substantially from lack of transparency about their methods and margins, and they may be hesitant to embrace an alternative management system that demands disclosure of such information.

Integration requires ‘opening up the books’ to the IPD members and being transparent about how the ‘sausage is made.’ For many in the industry, this means giving up extractive strategies such as knowingly underbidding the insufficiency of a design and working to ‘make-up’ profits in the eventuality of redesign. These practices are generally the source of contractual friction and therefore contribute to the combative, litigious norms for which construction has become known. Principals would do well for both the industry and their own bottom lines to demand integrated methods that promote transparency and mitigate moral hazards.

Increased productivity in person-to-person interactions

Construction culture features regular combativeness and discourteous behavior (Jaffar, Tharim, & Shuib, 2011), often under the guise that it is necessary to communicate forcefully and push work forward. But a tough culture can become a toxic culture very easily, undoing good intentions and creating major productivity losses. To the extent that conventional contracting sets the stage for interorganizational conflict, it is directly responsible for such inefficiencies.

How costly can these things be? Surprisingly, quite costly, even for mild infractions. Andersson and Pearson (1999) define workplace incivility as: “low-intensity deviant behavior with ambiguous intent to harm the target, in violation of workplace norms for mutual respect” (457). Based on this definition, Lim et al (2008) maintain that “both direct and vicarious experiences of incivility contribute independently to various work and health outcomes, even after controlling for general job stress” (104). Such experiences have substantial effects. Lewis and Malecha (2011) estimate that workplace incivility reduces nurses’ productivity by nearly 20%. Similarly, Hoel and Cooper (2000) report that “victims of workplace bullying self-rate their level of productivity 7 percent lower than do non victims” (224).[3] Moreover, executives in Fortune 1000 firms may spend as much as 13% of their time dealing with incivilities (Pearson & Porath, 2005). Costs in the construction industry are even higher. Brockman (2014) estimates that the average cost of a conflict incident in construction is $10,948 and requires over 160 hours to resolve.[4] Even more compelling, principals and contractors in India ranked conflict among project participants as the number one factor affecting project cost (Lyer & Jha, 2005).

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[3] See Cortina, et al. (2016) for further discussion of the incidence and effects of workplace incivilities. See also Anjum, et al. (2018) for a study of workplace toxicity on productivity in Pakistan.

[4] The distribution is highly right-skewed, so the median cost is only 5.25 hours and $300. Thus, $10,948 should not be seen as the cost of a typical conflict incident. However, the mean is still the most relevant figure when thinking about costs over time. Incidents occur regularly, so a company that builds consistently should expect to encounter the full distribution of incidents and the average of those costs.

Incivility and bullying are also linked to higher profile problems. According to Pearson and Porath (2005), “low intensity aggression in the workplace can lead to an upward spiral, resulting in increased aggression and more purposeful efforts to harm one another” (8). Given that violent incidents on construction sites were responsible for 55 deaths in 2020 (U.S. BLS, 2021), the culture of conflict—even normalized habits of incivility—is too expensive to ignore.

Finally, the macho culture of argument and conflict poses a barrier to women in construction (Amaratunga et al, 2006); a barrier that can be quite costly. Hunt et al (2020) find that companies in the highest quartile of diversity for their executive teams were 25% more likely to enjoy above average profitability than companies in the lowest quartile. Additionally, when women make up a third or more of a company’s executives, they are 48% more likely to outperform their competitors. Although these figures were based on a pool of industries and not just heavy industry, construction may be missing out on even more diversity benefits given the extreme underrepresentation of women throughout the ranks.

There are solutions. Fully integrated methods such as IPD remove pinch points for conflict. When each participant is working towards a common profit, there is no monetary bellow fanning the flames of interorganizational disagreement. On the contrary, parties are monetarily motivated to play nice and avoid disputes altogether. When disputes do arise, parties are incentivized to resolve them quickly and cost effectively. Moreover, the coordinating powers of IPD reduce miscommunication between trades, keeping them from stepping on each other’s toes on the jobsite. We find it compelling that at the same time conflict between participants was ranked as the highest factor affecting project cost, Lyer and Jha (2005) also find “the most important factor among all success and failure factors turns out to be ‘coordination among project participants’” (293).

In summary, the potential for productivity improvements simply due to amicable interactions should not be overlooked. Although it’s difficult empirically to separate out how much of IPD’s benefit is due to coordination and how much is due to interpersonal improvements, research from multiple perspectives establishes the mechanism and points toward substantial effects.

Participant insights

In this section, we distill the experiences of several stakeholders in recent projects that used the method of IPD. We spoke to owner representatives, architects, construction managers (CMs), contractors, engineers, and trades professionals. We wanted to get a sense of participant’s experiences across roles in the construction process and from top to bottom in the multi-party agreement. Most interviews lasted about an hour and were conducted casually without a commonly dictated set of questions. Our goal was to listen and glean rather than guide the conversations toward identifying specific variables (as is often the goal for factor analysis). To this end, participants were encouraged to share their experiences candidly and informally. Usually, the interviewees answered our curiosities in the course of conversation without much facilitation or specific inquiry.

The most emphatic common thread we found was that human-to-human interactions between stakeholders were 180 degrees different than they were for most projects. Rather than the usual combative struggle between parties, IPD brought interactions that were cooperative and productive. Many participants shared that IPD was a breath of fresh air and completely worth the dissonance of learning a new way of doing things. When asked whether they would rather do another IPD or a design-bid-build, all else being equal, participants across the board enthusiastically chose IPD, some declaring they would work exclusively on IPD projects if possible.

Of course, this pattern came from a relatively narrow set of people, so we can make no strong claim to represent the experiences of IPD participants as a whole. Indeed, some professionals reading this may have had a negative experience. Yet, the unanimity with which we heard such passionate testimony, and the intensity of contrast they reported suggests that there is something transformative about IPD, something worth paying attention to, even if not yet shown to be empirically regular.

In addition to resounding preference for IPD work life, we gleaned four other themes from the interviews that deserve attention: trust and transparency, norm shifts and sandbagging, scalability, and efficiency.

Trust and transparency

One of the distinguishing characteristics of IPD is the transparency required to share costs and profits. Each member of the multi-party agreement must ‘open their books’ and be up front about how their operation runs. This level of transparency continues throughout the process, requiring each member to pass through whatever cost savings they engineer and be honest about cost increases that occur. Such openness is not the norm in construction. A great deal of trust must be created between participants for them to all step out at once. We liken it to a stag hunt in game theory. If everyone contributes to hunting stag (full transparency in our context) they achieve their goal and there is a much higher payoff for everyone involved. If some parties refuse to buy in, and hunt for hare instead (maintain habits of privacy in our context), they enjoy their small individual prize, but ruin the stag hunt for everyone else. Hence, prior to the hunt, each party must trust that everyone else will contribute to the larger (but riskier) objective and choose stag. Without such trust, each individual is better off hunting hare.

So it is with IPD. Participants need to simultaneously buy in and trust that everyone else will do likewise. This step of faith can be dissonant, especially for professionals accustomed to the much more anti-dependent nature of design-bid-build. Our interviewees confided that building trust and transparency for the project was simultaneously one of the oddest and neatest part of the IPD experience. It was something they had to be intentional about in the early stages, and some interviewees admitted they wish they had been more intentional about as the project progressed; old habits have a way of creeping back in. Yet, the relationships they developed, even as bounden representatives of their respective companies, drove the project forward and created remarkable efficiencies in staff interactions, ultimately increasing productivity and improving problem solving. That isn’t to say there was never disagreement or conflict; simply that there was a baseline of trust that allowed such conflict to be productive rather than destructive. If each party knew that the other was arguing their position in good faith and looking out for the success of the project, they could respond with similar intent and good faith. Relationships matter.

For some companies, the transparency requirement alone could be enough to prevent them from participating. If their habits of practice involve padding change orders, cutting corners, capturing time and material savings, and passing off externalities, changing to an integrated mindset might be too dissonant. Even worse, if their profit-making model involves misclassification of workers or other ethical compromises, transparency is not an option.

At the very least, transparency creates exposure that an organization could view as dangerous to their future viability. Even the most upright and ethical organizations might dislike such vulnerability since there is a chance other participants will use something against them down the road. Local markets can be tight knit, with only a handful of firms providing services and interacting repeatedly with each other. If ever adversarial, firms might fear that previous IPD partners will use inside information to get the upper hand. Many of our interview participants reported that opening up was disconcerting in this way. They were already accustomed to being transparent and above board as a company, so transparency itself was not an issue, but they were nervous that other companies might abuse their inside peek. Hence, a great deal of trust between IPD participants was required to make the team function as it should.

Not every company is willing to take the leap of faith and invest in building trust across organizations. As demonstrated in the theory section of this paper, there are information rents in traditional procurement methods that benefit contractors and trade professionals. Some of these organizations will prefer to remain opaque and just collect these rents over and over. Fair enough; but this preference can make it hard for principals to find like-minded industry partners with which to perform an IPD project. Thus, a dearth of transparent builders could be a barrier to IPD adoption in small, concentrated markets.

Importantly, IPD does not require transparency at the cost of profit. Contractors and trade professionals give up private information rents that they might otherwise earn in a traditional build, but they get a share of efficiency gains through cooperation. What became clear in compiling the experiences of IPD participants is that the total is greater than the sum of its parts, so if each partner is willing to be transparent, on net, they are likely to do better in IPD. Nevertheless, IPD requires courage to be transparent up front, trusting that other stakeholders will do likewise. It is for this reason that we believe IPD to be much more relationship based than traditional contractual management, and as such discordant to the independent, self-reliant culture in the industry.

Norm shifts and sandbagging

As with any new system, old patterns of behavior must give way to new ways of doing things. This transition can be difficult for experienced construction professionals who are accustomed to squeezing margins out of low bids and bearing risk individually. The norm on conventional projects is to create internal contingency plans and offload unexpected additional costs as much as possible, often through change orders. That approach does not make sense in IPD. What was interesting was that such norms manifested themselves in odd ways when people tried to adapt to the integrated approach. Our interview participants reported that team members really bought in to mutual dependence of the project and did not want to be the one to incur unexpected costs for the team. To avoid being the bearer of bad news, many participants started sandbagging; that is, putting off as long as possible precise cost estimates and creating inflated estimates based on large contingencies. The idea is that if I shoot high and come in below estimate, I can report savings to the team and look smart. If I shoot too low and come in with unexpected costs, I must report losses and I look like the bad guy. The longer I can delay narrowing down the contingencies, the longer I can stay neutral and off the hot seat. Unfortunately, when multiple participants did this, it created a flood of reported savings towards the end of the project when they cannot be used efficiently. In one project, the owner became slightly annoyed (obviously not too annoyed since it was extra savings) because they could have converted those savings into additional scope had they been expected earlier.

Unanticipated behaviors like this represent the learning curve with IPD. There are bound to be missteps and mal-adaptations along the way, especially for teams new to integrated delivery methods. With experience they are likely to diminish if we take care to document them as they occur and share possible solutions. Over time, participants will create entirely new norms of engagement, norms that will hopefully reinforce the cooperative and efficient nature of IPD.

Scalability

For large or complicated projects, IPD is a natural choice. In such contexts, there are many parts of a project that would benefit from—or even require—early design input from multiple stakeholders. What about for smaller scale development? Are the gains large enough to cover the up-front cost and effort of building an IPD team? When we asked interview participants this question, we got mixed opinions. Some participants, especially those involved in early stages of the project, felt strongly that IPD could be scaled down successfully. Teams could be smaller and meet less frequently, thus scaling down along with the project size. Other participants, especially those whose contribution was smaller or part of late-stage delivery, were more skeptical. They felt like it would be difficult to justify being at the table so early for relatively small cuts of the profit.

This is a particularly interesting finding. Although we are cautious to not read too much into it since we are dealing with subjective beliefs about hypothetical small-scale projects, the fact that opinions split along stakeholder lines is curious. One way of thinking about it is in terms of percentages versus absolute numbers. Small contributors to an IPD job get an accordingly small percentage of the profit bucket upon completion. This is fine for large projects since a small percentage of a large number is still a large number. But it is not enticing for little projects where a small percentage of a small number is a very small number. In this sense, working hard to create efficiencies for the profit bucket is not worth it. At the end of the day, the small contributor needs to make a profit in absolute terms. They are likely better off doing so with information rents in bid jobs than with efficiency sharing in IPD jobs. For this reason, we think that the transparency required of service providers under IPD may create a barrier to the scalability of full IPD. Including small contributors in the multi-party agreement eliminates information rents that such providers normally enjoy under traditional arrangements. When the scale of the project is large enough, or one's contribution to the project is large enough, participants gladly give up these information rents to get the benefits of integrated efficiencies. When the opposite is true, profit shares from IPD are likely smaller in absolute terms than information rents so service providers will bid for traditional projects and lean away from IPD work. Principals may then have a hard time finding industry partners, even if they can assuage discomfort over unfamiliar contracts.

Another way to view the scalability question is through a framework of average fixed costs. Basic microeconomic theory posits that firm entry and exit decisions are largely determined by marginal revenue and the fixed cost of production. Fixed cost being defined as the cost associated with fixed inputs like capital whose cost does not vary with quantity of output. Sinking time into building relationships and mutual trust is an example of fixed cost; you need it for IPD whether the project is 500 million or 500 thousand, whether you are responsible for 50% of the project or 5%. If you can spread out your fixed cost over high output, it makes the sting a little less painful because your average cost per unit falls (Average Fixed Cost = Fixed Cost/Output). Marginal revenue on the other hand is defined as the additional revenue generated from one additional unit of output (Change in Revenue/Change in Output). In highly competitive markets, which is frequently the case in construction services, marginal revenue is flat, meaning each unit of output sold generates the same additional amount of revenue—price, essentially. Figure 2 shows these concepts graphically.[5] What is important for understanding is that the relative position of average fixed cost (AFC) and marginal revenue (MR) tells a firm whether they want to enter or exit the market. In our context, it tells an owner whether they should pursue a development, and it tells a trades professional whether they should take a job or not. If MR is higher than AFC, they will cover their investment and take the job. If MR is lower than AFC, they should look for opportunities elsewhere. Notice that MR covers AFC only after output becomes high enough. For low levels of output, fixed costs are just too large relative to the small amount of total revenue made at that scale. For the context of IPD, this means that small contributors are less likely to jump into small-scale IPD projects. They will still be bullish about larger projects since that slides them horizontally along the MR line, but for small projects the fixed costs of team/trust building will not get averaged out enough to make it worthwhile. Principals perform a similar calculus. If the up-front costs of forging an IPD team do not scale down along with the size of the project, it could become unattractive to choose that procurement method for small developments.

Of course, a solution to the scaling problem is to reduce the costs of team building so that they become a trivial part of fixed costs, or transform team building expenditures into variable costs so that they scale along with project size. Both paths could be accomplished through repeated partnerships. Our interview participants felt strongly that they could be even more efficient if they worked with each other again, allowing for some tweaks to team composition. The groundwork had already been laid for a behavioral shift, so the we-over-me mentality could very easily be primed again. In general, repeat interactions reduce the

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[5] Economists will be quick to notice that we have sinfully left out marginal cost, average variable cost, and average total cost. Indeed, these components are critical if we are thinking about optimal quantity choice or the shut-down point for market incumbents. Here, however, we are only thinking about market entry based on minimum scale. Declining average fixed cost is sufficient to demonstrate the point without unnecessary detail about variable costs (and hence the real bottom line of average total costs) that might cloud overall understanding.

amount of relearning that takes place in cooperative enterprises; for IPD, it massively reduces the up-front investment required to build social capital.

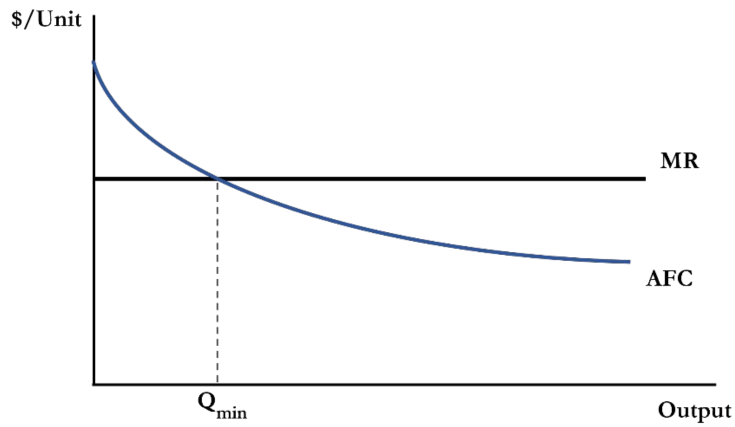

Figure 2: Marginal revenue and average fixed costs

Efficiency and getting lean

Even though efficiency benefits of IPD are well known, we would be remiss to skip them given that they were noted consistently by our participants. Among other things, IPD allowed teams to coordinate MEP systems and reduce the amount of design insufficiency and rework throughout the building process. It also allowed them to choose techniques and materials that massively reduced supply-chain concerns and time on site; choices that are not ordinarily made due to the tradeoff between individual cost and group savings. The social and strategic benefits of IPD and Lean Construction is inherently aligned. While Lean Construction is the practice of synchronizing the sequence and rate of supply chain dynamics (Howell & Ballard, 1998) IPD incentivizes that synchronization (Cheng & Johnson, 2016).

What was remarkable is that some of the largest efficiency improvements originated in unpredictable ways from people who would not otherwise be involved. In one case, a solution to a soil problem was suggested by an electrician. Under traditional methods, that person would have never been in the room, and their creative solution would likely never have come up. Such creativity is the ‘home run ball’ of IPD. Beyond day-to-day marginal efficiencies, IPD catalyzes imaginative solutions with the potential for large spillover effects. When builders regularly interact in common interest, they learn from each other and combine their experiences to create new knowledge. In an industry that tends to be individualistic and internally focused, IPD provides builders the rare opportunity to regularly ideate with motivated peers. We think it serves as an informal platform for research and development.

Finally, one can think of IPD as an *efficiency enhancing* vehicle. It is a philosophy and a platform for generating value and resource savings. What kind of efficiencies it generates, and which resources get saved, is a question of **application**. If steered in the direction of time savings, or material costs, it delivers efficiencies on those dimensions. If it is steered toward energy efficiency, or greater circularity, it will deliver higher social value. Thus, IPD exists as a tool for principals to accomplish their explicit objectives. One can hope that these objectives align with long-term feasibility of the industry. We are convinced that if principals (owners/developers) apply IPD in conjunction with a triple bottom line, they will usher in a new era of highly profitable and socially responsible construction.

Conclusion

In this paper, we have applied essential models of game theory and microeconomics to expose fundamental incentive problems in traditional design-bid-build procurement and highlight unheralded strengths of contractually integrated methods such as IPD. There are three main takeaways: 1) IPD internalizes pervasive externalities that occur between trades during a construction process, reducing overall costs and encouraging construction techniques that are otherwise difficult to coordinate; 2) IPD mitigates widespread moral hazards between principals and contractors, allowing both parties to earn higher payoffs and avoid costly market failures; 3) IPD necessitates new norms of behavior that are more pro-social and reduce the costs associated with a culture of argument and conflict.

In addition to theoretical grounding, these insights were informed by a series of interviews with former IPD participants. Channeling their experiences, we noted a few patterns that undergird the three takeaways above. First, trust is key. Transparency, though uncomfortable, is the vulnerability that ensures mutual commitment toward the shared goal. When everyone buys in and accepts new norms of behavior, the externalities and moral hazards that plague design-bid-build projects largely disappear. It is certainly not easy to establish such relationships, but getting to high levels of trust and transparency is absolutely critical. Second, multi-party agreements, especially those that are inclusive of small contributors, allow new norms to develop that are less combative and more conducive to productivity. These benefits are likely to scale very well, even if fixed costs pose a barrier for IPD in small projects.

Finally, participants revealed that integrating disparate representatives into meetings they ordinarily would not attend fostered creative, convention-busting exchanges that saved significant time and money. One might frame this feature of IPD as research and development (R&D). In an industry with characteristically low profit margin (at least in the US), and little investment in R&D, alternative forms of innovation are critical. IPD offers natural opportunities for imaginative approaches to real time problems. Almost certainly, some of these exchanges will transform the frontier of knowledge and improve the industry as a whole. We think that this feature of IPD could be a fruitful topic for future research.

Of course, we are not the first to highlight advantages of IPD. Research as early as 2005 explored early iterations of IPD; and AIA published the first version of “Integrated Project Delivery: A Guide” in 2007. Yet, principals are slow to adopt this delivery method. It took until recently, in 2021, for Children’s Hospital to complete the first fully Integrated Project Delivery with a multi-party agreement (AIA A195) in the state of Colorado. There have been other projects in the state, which industry has termed, “IPD-light” or some derivative of IPD – but these projects are not fully, contractually integrated. Why does IPD and all of its derivative contractual forms remain a relatively uncommon form of project management?

Previous attempts to answer this question focus on contractual obstacles and high up-front costs (see Kahvandi, et al. 2019 for a recent survey). However, an argument can be made that many of the noted challenges in these studies may exist in other, non-IPD methods.

We maintain that conventional methods remain dominant because of a sticky cultural equilibrium that has blinded principals to the internal and external inefficiencies of existing norms, leading to market failure and under adoption of integrated methods for project delivery.

Far from necessary evils, conflict and waste are products of misaligned incentives in a thoroughly inefficient method of project delivery. The traditional design-bid-build approach juxtaposes each participant's profit against each other's, creating room for conflict and encouraging combative relationships. Alternatives are possible. Cooperative profit-sharing models, such as integrated project delivery, relieve this juxtaposition and create space for entirely new norms of behaviour; norms that reduce conflict and generate social goods. It is our hope that in the future more owners/developers will embrace such procurement methods and lead the industry to greater heights.

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