

Article

# Factors Driving Success of Cost Management Practices in Integrated Project Delivery (IPD)

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Received: 1 September 2020; Accepted: 10 November 2020; Published: date

**Abstract:** Integrated project delivery (IPD) is a mode of project procurement recognised as facilitating superior project performance. However, this success is contingent on effective cost management practices that share cost data with all project stakeholders in an accurate, timely and transparent manner. Despite an extensive literature on aspects of cost management, none identifies the essential ingredients required of an effective cost management system, sufficiently robust to support successful IPD projects. Candidate cost management augmenting practices are drawn from the literature, and presented for scrutiny in questionnaire form, to fifty IPD experienced experts, based in the US, UK and Australia. Findings reveal activity-based costing (ABC) to be effective at identifying overhead costs and creating accounting transparency. Similarly, earned value management (EVM), in combination with ABC, is effective at developing mathematical models for equitable risk–reward distribution. Moreover, web-based management systems, as supported by Building Information Modelling (BIM), are effective at generating trust and collaboration on which IPD success depends. A questionnaire survey using purposive sampling was conducted to assess the factors driving success of implementing IPD regarding cost management process. The contribution to knowledge made by this paper is in identifying requisite support mechanisms essential to elevate traditional cost management practices to the higher standard needed to ensure IPD delivery success.

**Keywords:** construction; risk–reward sharing; alliancing; partnerships; cost estimation; 5D BIM; web-based systems; ICT cost data; digitalisation

## 1. Introduction

Integrated project delivery (IPD) is characterised by early, collaborative engagement of key stakeholders throughout all the phases of a project [1,2]. Compared to traditional methods of project delivery, such as design-bid-build, construction management at-risk and design-build, IPD is regarded as a superior delivery mode [3,4]. Evidence shows that IPD has the potential for improving fourteen key metrics of project performance, including quality, scheduling, communication management and cost performance [2,3]. Moreover, IPD facilitates trust among project participants, in that it fosters open pricing and transparency [2].

Notwithstanding these benefits, the IPD approach is not commonly adopted [5,6]. Major barriers have been identified that hinder widespread adoption [7,8], with IPD requiring extensive support systems [9]. Failure to establish these support systems from the project outset can erode

the successful delivery of IPD projects [10]. The required support systems include fair IPD compensation models, full and effective information sharing, responsive decision-making regimes, and suitable liability waivers between stakeholders [11,12]. Of the support systems, the IPD compensation model (also known as risk–reward compensation) is of primary importance [13]. It is this that plays a pivotal role in stimulating creativity, motivating collaboration, and sustaining performance [14,15]. The compensation model identifies costs – direct, indirect, and overhead – and, more significantly, allocates profit-at-risk percentage compensation across project participants. An agreed upon, fair IPD compensation model is thus a vital precondition to successful project delivery [10,16–18]. Moreover, sound cost management practices are the mainstay of IPD compensation models [19,20]. Consequently, researchers have attempted to identify those factors that affect the success of cost management practices in IPD projects, a brief description of which follows.

The IPD cost management system must be integrated; resilient to the loss of cost information throughout all stages of the project [13,15]. The cost structure must also flag potential hidden profits within the estimated costs, according to Allison, Ashcraft, Cheng, Klawens and Pease [18]. This transparency is essential in fostering trust between stakeholders [13,21]. Moreover, according to Roy, *et al.* [22], all participants must be continuously involved and engaged in any decision making.

One of the advantages of using IPD is to enable establishing sustainable relationships among built environment practitioners [23]. Additionally, cost management represents one of the significant barriers to fostering the adoption of IPD in the AEC industry [20]. As a result, improving the cost management practices for the IPD approach facilitates the implementation of IPD and converts the relationships among parties to be sustainable.

The existing cost management literature tends to be narrow in scope, with each study focusing on select aspects of cost management systems, also absent from the literature is an examination of the factors driving success of cost management practices in Integrated project delivery (IPD). This, therefore, represents a significant knowledge gap, as already noted by researchers (see Durdyev, Hosseini, Martek, Ismail and Arashpour [10] and Elghaish, Abrishami and Hosseini [17]). This study addresses this gap and identifies the antecedents to the successful design of cost management practices in IPD projects – including BIM-enabled IPD projects.

## 2. Contextual Background

### 2.1. Integrated project delivery (IPD)

The term IPD refers to a project delivery approach that integrates all project dimensions, including people, organisations and business structure, right from the conceptualisation stage [24,25]. Kent and Becerik-Gerber [11] argue that IPDs main objective is to eliminate fragmentation that results when a project is led by a single entity such as a master builder over the entire project stages. IPD attempts to mobilise all participants' resources to maximise value and minimise waste [11]. As an example, studies show that projects employing IPD have been successful in minimising defects associated with dimensional and geometric variations and as a result, improve the energy performance of buildings [9,26–29]. Moreover, other advantages of IPD include enhancing the trust among project parties [20], minimising the gap between client expectation and design [23], and reducing the cost through the collaboration between all project parties [30].

The equitable sharing of risk and reward sits at the financial heart of the IPD approach [31]. Achieving this requires a continuous cost estimation feedback loop over a pre-detailed design stage [18]. Several techniques have been recommended to optimise cost management practices of IPD projects [10,18–20].

### 2.2. Earned value management

Earned value management (EVM) is a quantitative project management technique for measuring project progress and providing early warning of looming budget overruns and schedule delays [32,33]. Khamooshi and Abdi [34] showed EVM to be successful at delivering accurate cost and schedule metrics. According to Naeni, *et al.* [35], the “earned value technique is a crucial technique in analysing and controlling the performance of a project.” The difference between project scheduling as represented through Work Breakdown Structure (WBS), and actual outcomes, as evidenced by the expenditures, is however a barrier to the effective implementation of EVM [33]. The EVM system, therefore, needs to be smarter; it must be equipped with sufficient capabilities able to synthesise data from multiple sources and automatically generate cost control reports [36]. The interoperability needed to build federated project cost control sheets can be achieved with dedicated technologies, including visualisation tools [37].

### 2.3. Activity-based costing

Resource-based costing (RBC) is a major traditional cost accountant method. It relies on volume-based allocation (VBA), in which the cost of resources is directly allocated to objects, regardless of the accounting cost structure distribution of direct, indirect, and overhead costs [20]. Traditional methods fail to find the key decision variables that affect the total cost, particularly overhead costs [38]. Activity-based costing (ABC) prevents this distortion by allocating costs through multi-pools. Thus, this method determines the overhead costs needed to transform the resources into activities that can deliver the final product [39,40]. The ABC approach can measure costs based on activities and link cost drivers to the impact measures of a certain product or services [41]. The ABC method, therefore, can improve the efficiency and accuracy of cost-related information and further monitor and control project costs [42]. This is particularly applicable to a collaborative working environment, such as IPD, where multiple stakeholders can all impact cost drivers [38].

### 2.4. D/5D BIM Automation

Integrating BIM into daily construction activities can facilitate automatic updating of all site information and, as such, can enhance productivity, as well as strengthen relationships amongst stakeholders and improve trust [43]. BIM 4D automation improves the quality of the collected data and reduces human interference in the data collection process [44,45]. Similarly, 5D BIM provides an effective methodology for cost data collection and analysis of construction projects [46–48].

Automated data collection methods have been improving, benefiting from the introduction of various kinds of technologies, such as barcoding, 3D laser scanning and photogrammetry [49–51]. Eastman, *et al.* [52], however, are of the view that there is no comprehensive BIM-based cost management platform that can perform all cost-related processes.

Research studies have considered various means for improving cost management practices of IPD projects [46,53].

## 3. IPD Literature and Research Gap

Numerous studies on the theme of IPD have been carried out. These are presented chronologically as Table 1. This literature reveals certain emphases. Studies related to cost management practices of IPD have, for the most part, attempted to develop tools and techniques that improve these costing practices. Most recent examples are the techniques proposed by Elghaish, Abrishami, Hosseini, Abu-Samra and Gaterell [20]. However, these studies do not enlighten on the critical success factors of cost management practices.

**Table 1.** The previous studies on the topic of integrated project delivery (IPD)

Authors	Contribution and Limitations
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Elghaish, Abrishami, Hosseini and Abu-Samra [30]	Providing a new approach to develop a fair compensation structure of the IPD-based BIM and activity-based costing (ABC).
Elghaish, Abrishami, Abu Samra, Gaterell, Hosseini and Wise [19]	Developing a methodology to develop the project budget by estimating the minimum and maximum potential cash inflow to enable project parties to make the right decision before the construction stage commence.
Elghaish, Abrishami, Hosseini, Abu-Samra and Gaterell [20]	Providing a fair model to estimate the three main transactions in the IPD projects, which are reimbursed cost, profit and cost saving.
Kahvandi, <i>et al.</i> [54]	Exploring various key critical success factors, largely from a managerial perspective, with limited attention to cost estimation issues.
Pishdad-Bozorgi and Srivastava [21]	A model to share risks and rewards using a game theory approach, particularly for cases in which project cost exceed the profit-at-risk percentage. Their study only provided an overview of the model with future empirical research needed to assess its practicality and quantify its impacts.
Alves, <i>et al.</i> [55]	Presenting various techniques commonly used for TVD and applicable to the IPD context.
Tillmann, <i>et al.</i> [56]	Discussed the underlying mechanisms of cost estimation within IPD-oriented projects and exploring the factors that influence success. Despite the study's contributions, it does not focus on the tactics of allocating overhead resources
Ballard, <i>et al.</i> [57]	Recommended a set of procedures to enhance the chance of success in IPD cost estimation processes. Although the authors acknowledged that following TVD principles is a critical success factor, no explicit technique or procedure was recommended to make the recommendations useful in practical terms
Zhang and Li [15]	Developed a risk-reward compensation mechanism by combining risk perception and the Nash bargaining solution (NBS) techniques. However, this model does not consider the method of sharing actual risk-reward amongst participants and overlooked the impact of IPD compensation structure in successful profit/cost-saving sharing
Zhang and Li [15]	Combined risk perception and the Nash bargaining solution (NBS) techniques to formulate a risk-reward compensation model. However, the model was not sufficiently comprehensive to cover all possible types of engineering data, lacked empirical validity and, hence, required empirical studies.
Liu and Bates [14]	Articulated a probabilistic contingency calculation model to predict proper contingency to minimise cost overrun; nevertheless, a mechanism to share pain/gain percentages remain unexplored.

Pishdad-Bozorgi, <i>et al.</i> [58]	Discussed the potential of integration between TVD, BIM and IPD cost estimation
Ross [59],	Proposed risk–reward sharing model as the risk–reward ratio is measured by the overall performance score (OPS), which is a scale between 0 and 100, where 0 to 50 represents the pain scope, and 50 to 100 represent the gain range. After computing the risk–reward ration using OPS, the project participants should share this ratio in correspondence with the contract.

Studies whose focus is identifying the success of IPD projects also suffer from shortfalls. Kahvandi, Saghatforoush, Ravasan and Mansouri [54] identify factors that promote the success of IPD projects, but only from a general managerial perspective, and do not take into account cost management practices. Tillmann, Do and Ballard [56] describe the success of cost estimation practices of IPD projects but the study does not provide solutions and fails to consider how overhead resources are allocated.

Given the extensive literature available on IPD, with none yet fully describing the mechanism by which effective cost management practices are developed, there remains a need for a study that offers a list of antecedents to success in cost management practices. This then is the aim of this study.

#### 4. Research Method

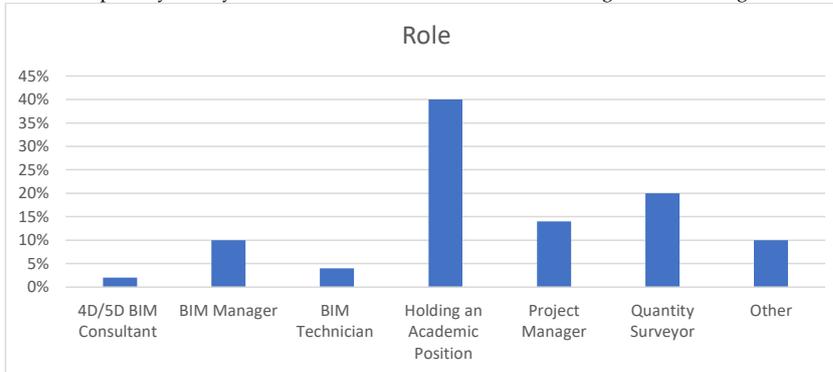
The research approach is through a questionnaire survey, using purposive sampling. Such sampling entails “identification and selection of information-rich cases related to the phenomenon of interest.” [60] Individuals who are knowledgeable and experienced regarding the topic are chosen [61], where participants fulfil a set of qualifying criteria [60].

An online questionnaire was designed to identify the antecedents of success for cost management practices of IPD projects. The questions sought to check and assess the status quo of cost management methods and validate the effectiveness of some solutions in dealing with IPD cost management. Purposive sampling is defined as non-random sampling where members of the target population with predefined qualifications also meet certain practical criteria, such as accessibility, proximity and availability [61,62]. The sampling criteria for this study require participants to have (1) a theoretical and practical background regarding BIM, (2) a sufficient level of understanding regarding the IPD approach, and (3) access to cost management tools and methods, whether traditional or 4D/5D BIM. A pilot study was first conducted with six BIM and IPD experts, located in the UK. The analysis of their responses confirmed that the designed questionnaire was fit for purpose.

Questionnaires were sent out in 2018 via emails and LinkedIn. Questions in the survey were categorised into two main categories, namely success factors of the IPD process, and improving IPD implementation. The questionnaire was designed using Google form. After data were collected, the results were downloaded as XML format. The data were then exported to SPSS to test their consistency and to perform the descriptive analysis. Given purposive sampling was used in the research reported in this paper, there was no need for cleaning the data collected. Reliability of the collected data was assessed, returning a Cronbach alpha coefficient (CA) of 0.854. This indicates that all the items in the questionnaire are relevant to the research [63]. Questionnaire results were statistically analysed using SPSS in order to determine the average of all responses for each question. Then, the importance of each factor was ranked according to the mean value.

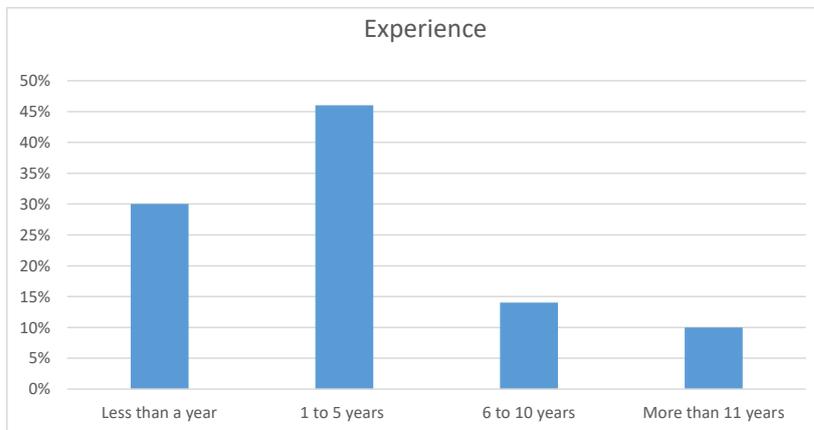
#### *Participants’ Profiles*

There were 50 participants; 40% of whom were academics – lecturers or researchers while 20% were quantity surveyors, with the remainder from diverse backgrounds. See Figure 1.



**Figure 1.** Role of participants.

Figure 2 shows the range of experience of participants. A majority of participants recorded 1 to 5 years (46%), while some 10% of participants had experience exceeding 11 years. Most of the respondents who had less experience with IPD are PhD researchers and academics. Although those participants had fewer years of experience with IPD, their insightful views significantly help the authors to define the challenges and gaps in the knowledge in the field of IPD. Therefore, they met the sampling criteria and were invited to participate in this research.



**Figure 2.** Experience ranges of participants.

Figure 3 illustrates the participants' familiarity with IPD concepts and processes: 46% had a high level of understanding, and 28% an intermediate level, meaning that about three-quarters of the participants were well-versed in IPD issues and processes.

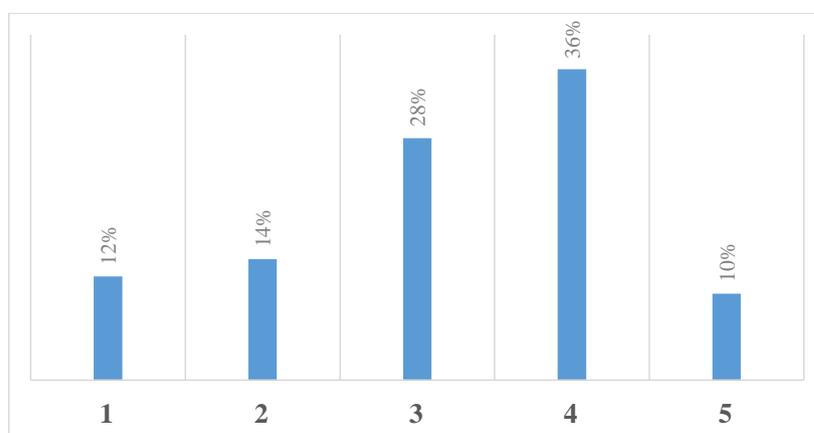


Figure 3. Participants' experiences with IPD.

## 5. Antecedents of Success

The factors facilitating IPD success are explored in two sections. The first section represents the characteristics of the IPD approach, while the second explores how existing IPD characteristics can be further enhanced.

### 5.1. Success Factors of IPD Process

From the literature, four main success factors associated with the IPD-based cost management process can be identified. These are listed in Table 2. Participants were asked to rank these factors in terms of the advantage they bring to IPD. The first factor was “early involvement of all participants from the design stage” with 30%; next, 26% identified an “open pricing technique” (as there is no a tender stage in IPD); 20% prioritised a “fair compensation approach” while the last factor was the “allocation of responsibilities and risks” ranked by 18%. “Other factors” came in at 6%. Thus, a preliminary conclusion is that the four identified factors captured in extant research represent the overwhelming majority of possible influential factors.

Table 2. The IPD success factors.

Factors	Frequency	Percentage	Valid Percentage	Cumulative Percentage
There is no a tendering stage and using an open pricing technique.	13	26.0	26.0	32.0
The allocation of responsibilities and risks should be clear and understandable.	9	18.0	18.0	50.0
The compensation approach (Risk–rewards sharing) is flexible.	10	20.0	20.0	70.0
The early involvement of all participants	15	30.0	30.0	100.0
Other	3	6.0	6.0	6.0
Total	50	100.0	100.0	

### 5.2. Improving IPD Implementation

The literature review also revealed enabling procedures to improve the effectiveness of cost management systems. Participants were asked to evaluate these. Table 3 includes a descriptive analysis of ten factors. These factors are further categorised into four categories, namely: ABC

and EVM integration, cost estimation and budgeting, risk and reward sharing, and general. These factors are ranked from low to high, according to the respondents' assessments.

*ABC and EVM integration category:* Participants were asked to measure the applicability of a set of proposed features of EVM and ABC, enhanced with certain extensions. The first factors (F1 and F2) are related to integrating ABC into EVM in order to develop mathematical models able to calculate risk–reward monetary values for the owner and non-owner parties. The next factor is to develop an automated platform where the developed mathematical models can be implemented automatically. The mean values for both factors were 3.36 and 3.38, respectively. The third factor (F8 in ranking) under this category is related to integration between ABC as a cost estimation tool that optimises the overhead costs, and EVM as a cost control tool to enable calculation of the realised cost saving for each party. This factor was rated highly by respondents, attracting a mean value of 3.82.

*Cost estimation and budgeting category:* Three factors are associated with the use of ABC to optimise cost structure and enhance trust among IPD team members (F3, F4 and F6). F3 and F4 concern the feasibility of developing a new budgeting system that presents different cash-out curves (direct, indirect, overhead and accumulative), based on AB. This is because conventional mechanisms for developing project budgets do not comply with IPD heuristics. F3 proposes the use of ABC to provide further details in terms of minimum and maximum profit boundaries for each party. This is to enable parties to make optimal decisions, particularly during the IPD buyout stage. Moreover, F4 proposes the development of project activities-based ABC to enable tracking of overhead activities. Mean answers were 3.6 and 3.64 respectively, with experts submitting “agree” and “strongly agree” replies to both questions. The third factor (ranked as F6), discussed the role of ABC in optimising the overhead cost during the IPD buyout stage through a determination of the trade package that consumes significant parts of the overhead resources. In this scenario, the IPD team members can move activities such as to create an overlap in overhead activities across different packages, with the effect of maximising the utilisation of overhead resources. The mean score of responses was 3.68.

*Risk and reward sharing, and ICT category:* Factors in this category were highly ranked, reflecting its importance to IPD. These were ranked as F5, F7 and F9, with mean responses of 3.64, 3.72 and 3.86. These factors facilitate the sharing of information among IPD core team members with minimum human interference, to maximise trust, as well as transparency, facilitated by a tool able to visualise the EVM metrics.

*General category:* F10 represents the development of a comprehensive cost management framework for the IPD approach by combining all other nine factors. The mean score for this factor was very high (3.98).

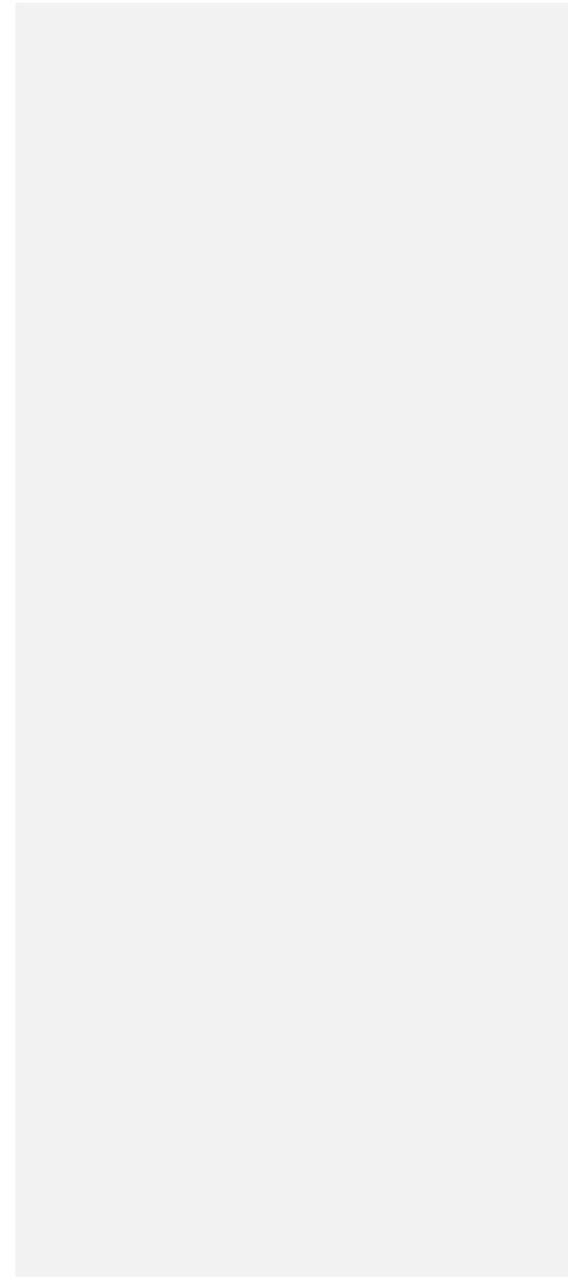
**Table 3.** The proposes recommendations to improve cost management practices of the IPD.

Factors	Category	Questions	Range	Minimum	Maximum	Mean	Std. Deviation
F1	ABC and EVM Integration	Integrating EVM into IPD can easily facilitate its implementation regarding sharing risk—reward between owner/non-owner parties.	4	1	5	3.36	0.964
F2	ABC and EVM Integration	Using an automated model to show the due payment for all parties based on their achievement against planned values.	4	1	5	3.58	0.906
F3	Cost Estimation/ Budgeting	Providing a separate cash flow for each participant including the proposed proportional cash in based on agreed profit-at-risk percentage.	3	2	5	3.60	0.700
F4	Cost Estimation/ Budgeting	Adopting ABC to develop a list of activities to enable getting reliable cash-out curve (S curve) by considering all costs (direct, indirect, and overhead).	3	2	5	3.64	0.749
F5	Risk—reward sharing and ICT	Developing an EVM-based web report to enable tracking of the project by all participants as well as easy access from different devices.	4	1	5	3.64	0.942
F6	Cost Estimation/ Budgeting	Utilising ABC to identify the different sources of overhead cost clearly.	4	1	5	3.68	0.935
F7	Risk—reward sharing and ICT	A fair allocation system with clear implementation models can enhance implementing IPD.	4	1	5	3.72	0.927
F8	ABC and EVM Integration	Adapting EVM with ABC to identify risk—reward sharing fairly through developing mathematical models for all potential cases.	4	1	5	3.82	0.896
F9	Risk—reward sharing and ICT	Providing an EVM grid to locate the cost performance ratio (CPR) and schedule performance ratio (SPR) to determine the holistic view of project progress.	3	2	5	3.86	0.808
F10	General	Using a comprehensive process for cost management within the entire IPD stages to	4	1	5	3.98	0.820

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increase its implementation and minimise the  
waste of time and resources.

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## 6. Discussion

All factors were presented in a linear scale to ensure the consistency between all answers. The internal consistency of the collected data was verified using a Cronbach alpha coefficient (CA). The results show that the degree of consistency is 0.854. According to [64], the degree of consistency in this research indicates high reliability and an acceptable value. Therefore, in this section, relationships between all relevant factors are presented.

All the IPD success factors identified in the questionnaire were ascribed a high degree of importance by respondents. Specifically cited were that “there is no tender stage, but rather, an open book pricing technique,” “the allocation of responsibilities and risks are clear,” “the compensation of risk adjusted reward is flexible,” and “there is early involvement of all participants.” Therefore, all these features are required if the benefits of the IPD approach are to be maximised. Contrariwise, where parties do not adopt all these features, the desired objectives for employing IPD can expect to be diluted.

Analysis of the ten factors that present as potential enhancements of the cost management process for the IPD approach reveals the most important to be a need for the development of a comprehensive cost management framework. The second category is the sharing of risks and rewards across ICT utilisation. Respondents recommended the utilisation of a visualisation tool to show the outcome of EVM, and thereby facilitate a better understanding of the cost performance outcomes from all IPD team members. Moreover, adopting a web-based management system that shares data among IPD team members can be expected to enhance trust and thereby facilitate timely information exchange which in turn elevates project management outcomes. In this regard, BIM is recommended by both industrial and academic experts as integral to the IPD process [65]. Furthermore, 5D BIM is particularly suited to handling all cost elements (direct, indirect and overhead costs). BIM-based cost management within the IPD approach is uncommon, as compared to traditional applications. Therefore, enabling modifications are required. The recommended improvements of BIM-based cost management are (1) enhancing the integration of 4D and 5D BIM to develop detailed cost budgets that display the compensation structure (estimated cost and profit-at-risk percentage) for each party, both individually and cumulatively, across the entire project. This will provide the necessary transparency, enabling all parties to make informed decisions prior to the buyout stage.

The second important category is cost estimation and budgeting improvements. The cost structure is one of the critical identified issues of IPD cost management [21,22], where, specifically, allocation and distribution of cost overheads presents as a major concern to project stakeholders [66,67]. Indeed, IPD requires relatively greater overheads in order to accommodate the management involvement of several parties across all the project stages [68]. For this reason, participants recommended the employment of ABC tools in order to revitalise the IPD cost structure and enable better cost saving, fairly distributed, between IPD team members. Overhead costs represent a significant proportion of the total project cost averaging some 15% for most construction projects [69]. The corollary is that any misallocation of overhead costs in IPD has the potential of seriously impairing profitability performance of affected parties.

The final category was ABC and EVM integration, which scored a relatively high average of 3.58. This confirms a strong interest in utilising EVM in the cost control tasks in the AEC industry, and further suggests a mandate exists for the development of applications integrating these tools into IPD cost management process. BIM also was favourably assessed, with BIM increasingly adopted at level 3 according to the BIM maturity level [70]. Thus, ongoing integration of BIM and IPD can be expected [20,71].

All the proposed ten features for enhancing the IPD-based cost management process received positive responses, ranging from 3.36 to 3.98. Noteworthy is that those respondents with greater experience, in fact, tended to rank the proposals even more favourably, at between 4 and 5. All respondents, moreover, unanimously agreed that the proposed improvements for an integrated framework could foster the adoption of IPD.

## 7. Conclusion

Integrated project delivery (IPD) is a construction procurement model that integrates all project dimensions, including people, organisations and business structure, right from the conceptualisation stage. It is regarded as a superior delivery mode to traditional methods of project delivery, such as design-bid-build, construction management at-risk, and design-build, in that it has the potential for improving fourteen key metrics of project performance, including quality, scheduling, communication management and cost performance, among others. It is also considered more equitable, collaborative and non-confrontational, thereby diminishing intra-project stakeholder disputes, and also more effective at aligning individual participant goals with those of the project itself.

IPD, however, is not as frequently utilised as these benefits would suggest. This is because IPD requires extensive support systems to be effective; systems not commonly available to projects. Indeed, without this support, IPD can be expected to underperform as a delivery mode. Since the heart of the IPD model is the equitable allocation of profit-at-risk compensation percentages to all project participants, this can only be achieved where information is timely, accurate, and transparently shared between all parties. In such a way, stakeholder destinies are aligned and collaborative problem solving better facilitated, leading to cost minimisation and profit maximisation for all involved. Thus, sound cost management practices and systems are the essential pillars holding up effective IPD procurement models, but what those practices and systems are, and how best these might be harnessed, remains a research contention.

This study puts this question at rest. Fifty suitably qualified experts were interviewed for their insights into IPD. They confirmed the advantage of IPD, in rank order, to be: “early involvement of all participants from the design stage”, “open pricing technique” (as there is no a tender stage in IPD), “fair compensation approach” and “equitable allocation of responsibilities and risks.” The research study went on to further confirm the available strategies to enhance IPD-based cost management. These are: (1) integrating ABC and EVM to enhance the cost management practices for IPD, such as developing an automated model to show the due payment for all parties based on their achievement against planned value; (2) integrating Monte Carlo simulation into 5D BIM as a means to provide continuous cost estimation feedback to enhance the conceptual cost estimation for TVD within IPD pre-detailed design stages; and (3) utilising the ICT order to enhance collaboration and trust among IPD team members. Pursuing these strategies can be expected to strengthen the robustness of the cost management practices on which IPD is so reliant, and in so doing strengthen the overall reliability and desirability of IPD as a preferred construction project procurement model. These recommendations should provide important guidance to practitioners seeking to reap the benefits a successful IPD procurement approach offers.

There are of course limitations to this study. Though the internal reliability of the questionnaire data was validated using Cronbach's alpha, the proposed solutions could be further validated using interviews with IPD and BIM specialists, who may add further insights into IPD projects.

**Author Contributions:** Conceptualization, F.E.; Data curation, S.T.; Formal analysis, F.E. and S.T.; Methodology, F.E., S.T. and I.M.; Supervision, S.A.; Writing – original draft, F.E.; Writing – review & editing, M. R.H., S.T., S.A., I.M. and M.K. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding

**Conflicts of Interest:** The authors declare no conflict of interest.

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