# Developing a multidimensional performance measurement framework for international construction joint ventures (ICJVs): The perspective of Ghana-hosted ICJVs' practitioners

Mershack O. Tetteh[a*], Albert P.C. Chan[a], Amos Darko[a], Beliz Ozorhon[b], and Emmanuel Adinyira[c]

[a]Department of Building and Real Estate, The Hong Kong Polytechnic University, 11 Yuk Choi Rd, Hung Hom, Kowloon, Hong Kong, China.

[b]Department of Civil Engineering, Bogazici University, 34342 Bebek Istanbul, Turkey

[c]Department of Construction Technology and Management, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

## Declaration of interest

No potential conflict of interest was reported by the authors.

## Data Availability Statement

Some or all data, models, or codes used during the study are available from the corresponding author by request.

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[*] *Corresponding author*
*E-mail address*: mershack-opoku.tetteh@connect.polyu.hk (M.O. Tetteh), albert.chan@polyu.edu.hk (A.P.C. Chan), amos1.darko@polyu.edu.hk (A. Darko), beliz.ozorhon@boun.edu.tr (B. Ozorhon), eadinyira.cap@knust.edu.gh (E. Adinyira)

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## Abstract

**Purpose –** International construction Joint ventures (ICJVs) will fully realize their potential for success and effectively monitor performance when an adequate and suitable performance benchmark is established. However, existing studies fall short of *adequately* providing a *mutually* acceptable benchmark for assessing the performance of ICJVs. This study aims to develop an adequate and suitable performance measurement framework for ICJVs.

**Design/methodology/approach –** A twofold structured questionnaire survey, supplemented by semi-structured interviews, was used to collect data from practitioners of ICJVs hosted in the developing country of Ghana. The data were analyzed by using descriptive statistics, confirmatory factor analysis, and a hybrid-fuzzy logic approach.

**Findings –** A list of 30 performance indicators (PIs), defined by project performance, perceived satisfaction, company/partner performance, socio-environmental performance, and performance of ICJV management, was validated and proved to be significant. Only 22 out of the 30 PIs, focusing on project efficiency, societal improvement, and organizational goals, are realized by the ICJVs practitioners. Further, suitable determinants and viable quantitative ranges for measuring each PI are established to prevent different interpretations of the meanings of PIs and objectively express the level of success in quantitative terms. The results call for further investigation of the convergence between the practice of and research into some PIs (e.g., socio-environmental performance) and a range of different performance levels in a more scientific manner.

**Practical implications –** This study not only advances the knowledge base and practice of performance measurement in ICJVs but could also assist stakeholders and decision-makers to assess, compare and monitor the performance of different ICJV projects on common grounds objectively.

**Originality/value –** This study not only comprehensively assessed performance indicators (PIs) – *what to measure* – but also systematically determined suitable determinants – *how to measure* – for each PI.



**Keywords**: International construction joint ventures, performance measures, indicators, determinants, quantitative range, performance level.

## Introduction

International construction joint ventures (ICJVs), a hybrid-oriented project-based collaboration arrangement, are established for delivering megaprojects wherein at least one partner's headquarters is outside the country where the venture is operating (Brockmann and Brezinski, 2013). ICJVs are gaining space in the global construction markets at an increasing rate, enabling construction firms to achieve faster results more wisely and promote innovation (Kobayashi et al. 2009). Yet ICJVs are very complex to manage and not always successful due to, the difficulty of aligning the objectives and motivations of large and highly diversified multinational companies, the multifaceted project nature, cultural and environmental complicatedness, and so on (Tetteh et al. 2021a). Given the unique and complicated nature of ICJVs, developing an *adequate* and *suitable* performance measurement framework for ICJVs is crucial to better ensure their success based on an improved understanding of the most important provisions to be made. Moreover, in order to achieve continuous improvement over time, there is a need to develop an appropriate performance measurement framework with which to assess, monitor, and benchmark ICJVs project performance.

For ICJVs specifically, very few "performance measurement" studies have been conducted, yet they have some limitations. First, they do not provide *full* and *mutually* acceptable performance indicators (PIs) for assessing the performance of ICJVs. Thus, they are significantly impacted by superficial understanding, lack of unison, and reduced validity. For example, Almohsen and Ruwanpura (2016) identified only 11 PIs for assessing the performance of ICJVs. Ozorhon et al. (2010a) also empirically analyzed 17 PIs without considering the views of the international/foreign partners of ICJVs. Not only is ICJVs performance measurement multidimensional but considering the views of all partnered firms in a single study is critical (Mohr, 2006). The identification of complete PIs in harmony with the strategic objectives of all partners would facilitate better cooperation capabilities in optimizing solutions and enhancing ICJVs performance. Tetteh et al. (2019) extensively reviewed "ICJVs performance measurement" literature and identified 35 PIs, yet it is only a literature review study that lacks empirical validation. That to say, the authors' study does not have any context, it rather summarizes and discusses previous related publications addressing the present interest by providing a comprehensive list of PIs for ICJVs. Second, the existing studies focused primarily on the PIs – *what to measure* – with no attempt

57 at determining *how to measure* the PIs. ICJVs practitioners are not only interested in knowing the PIs
58 but also need help in determining *how to measure* (hereafter only referred to as "determinants")
59 performance precisely. Both of which are urgently needed and of significant importance if ICJVs
60 performance is to be properly assessed and monitored and provide value to stakeholders. A study that
61 offers more adequate PIs and suitable determinants for each PI is missing. Generally, there is no
62 standardize performance measurement framework to monitor and benchmark the performance of ICJV
63 projects (Tetteh and Chan, 2019). Hence, this study aims to address these gaps in the extant research by
64 developing an adequate and suitable performance measurement framework for ICJVs, using Ghana-
65 hosted ICJVs as a case. Using Ghana-hosted ICJVs in this study does not mean that this study intends
66 to provide a performance measurement benchmark for ICJVs operating in Ghana. However, it is
67 important to note that ICJVs are crucial to global infrastructure projects, whose host countries typically
68 lack execution capacity or required managerial and technological expertise (Brockmann and Brezinski,
69 2013). Developing countries, such as Ghana, for many valid reasons, e.g., lack of advanced technology
70 and various forms of resources, enter ICJV to mitigate risks and acquire technology transfer from the
71 partnered firms. Hence, foreign direct investment through ICJVs has increased lately in Ghana (Ghana
72 Investment Promotion Centre (GIPC), 2021). Besides, successful implementation and management of
73 ICJVs are challenging for especially developing countries, which Ghana is not an exemption, and the
74 failure of an ICJV could lead fatal problems on the project. Thus, the study that aimed at developing an
75 adequate and suitable performance measurement framework for ICJVs, using the developing country
76 of Ghana as a case, is timely and important.

77 The scope of this study is limited to ICJVs founded for the purpose of completing construction
78 projects by architectural, engineering, and construction (AEC) firms in Ghana. Hong (2014) highlighted
79 that the majority of construction joint ventures are created between contractors. This is further supported
80 by industry-wide surveys in numerous past research studies addressing ICJV concerns. (Mohamed,
81 2003; Almohsen and Ruwanpura, 2016; Tetteh et al. 2021a).

82 ***The Goal and Objectives of this Study***

83 The goals of this study were twofold: (1) to evaluate and establish suitable PIs for assessing the
84 performance of ICJVs; and (2) to establish suitable determinants and quantitative ranges viable for

85 measuring each PI to prevent varying interpretations of PIs and objectively quantify the degree of
86 success. Four objectives have been set to reach this goal, including (1) identifying and empirically
87 testing the validity of the PIs for measuring the performance of ICJVs hosted in the developing country
88 of Ghana; (2) prioritizing the PIs for better and more effective performance monitoring and
89 benchmarking of ICJV projects; (3) identifying the key determinants for measuring each of the
90 prioritized PIs; and (4) defining reasonable quantitative ranges for different performance levels of each
91 of the PIs. In order to accomplish this, an industry-wide questionnaire survey was conducted with
92 Ghanaian partners/local partners and their foreign counterparts of ICJVs to identify and assess the
93 suitability of a list of potential PIs and determinants based on their measurability, level of importance
94 and obtainability using a 7-point Likert scale, respectively. This was supplemented by follow-up
95 interviews. After testing the validity and prioritizing the PIs, and identifying the key determinants,
96 reasonable quantitative ranges for measuring different performance levels of each of the prioritized PIs
97 were defined following a second survey that asked participants to rate each PI on five performance
98 levels (i.e., poor, average, good, very good, and excellent).

99 This study offers novel insights for ICJV frontliners (top/senior managers), construction
100 stakeholders and researchers in several ways. First, the findings of this study facilitate better
101 understanding of ICJVs performance measurement, by providing insights into what constitutes a
102 successful ICJV, helping ICJV practitioners, all stakeholders, and researchers to assess, monitor and
103 benchmark ICJVs project performance and manage more successful ICJV projects. The framework
104 could be used as a post-project appraisal tool after the completion and evaluation stage of ICJVs
105 lifecycle. Second, this study guides practitioners to assess multiple aspects of the ICJV performance
106 and to reflect on how they operate and steadily drive up ICJVs performance. It also assists ICJV
107 stakeholders and decision-makers to assess, compare and monitor the performance of different ICJV
108 projects on common grounds objectively. Lastly, it provides opportunities for top managers and
109 decision- and policymakers to legislate for and implement appropriate policies to steadily drive up
110 ICJVs performance improvement and strive for construction excellence.

111 **Literature Review**

112 ***Conceptualization of ICJVs Performance Measurements***

The concept of "performance measurement" has long been studied in the construction industry in general as it is useful for tracking and improving pre-defined expectations of stakeholders. Different project definitions warrant different performance criteria (Lauras et al. 2010). Thus, the concept of organizational performance measurement is a contentious subject for both practitioners and researchers in different fields of practice. In the field of international business, performance measurement has been the focal research interest, yet no unanimous conclusion exists (Tetteh and Chan, 2019). For ICJVs specifically, their operationalization is even more problematic due to the idiosyncratic PIs and determinants adopted by partnering firms (Ozorhon et al. 2010a; Lin and Ho, 2013). While cost, time, and quality remain the common criteria for assessing projects performance, previous studies have used a combination of financial, objective and/or subjective measures such as profitability, cost position, duration, survival, satisfaction, reputation, etc. to assess ICJVs performance (Mohamed, 2003; Sillars and Kangari, 2004; Almohsen and Ruwanpura, 2016). For example, project managers' perception of the efficiency and effectiveness of ICJV operations is reflected by using subjective measures such as stability, overall satisfaction, reputation, etc. Objective measures focus on hard/independent data, which can be obtained from third parties (e.g., profitability, cost position, duration, etc.).

In the literature, for example, Mohamed (2003) assessed the performance of ICJVs by using value, profit, and satisfaction. Lin and Ho (2013) also used "client satisfaction" as a proxy for measuring the whole performance of ICJVs. Nonetheless, the existing studies largely focused on a single dimension of ICJV performance, project performance, and with a limited set of PIs, inadequate for assessing the performance of ICJVs. Ozorhon et al. (2010b) highlighted the need for multidimensional performance measurement for ICJVs and defined performance measurement of ICJVs, with 17 PIs, in relation to the ICJV "project performance" (an objective criterion that measures the degree to which predetermined project goals and expectations are met – project-level performance), "company/partner performance" (a subjective criterion that measures the extent to which pre-set organizational objectives of a company/partner are achieved based on the ICJV project undertaken – organizational level performance), "performance of ICJV management" (a subjective criterion that determines the extent of controlling the ICJV operations or taking part in official duties – centralized level performance), and "perceived satisfaction with the ICJV" (a subjective criterion that measures the extent to which an IJV

has achieved its overall objectives – individual-level performance). Later, "socio-environmental performance", a fifth dimension, (a hybrid criterion, a combination of objective and subject measures) was added to determine the ICJV operational impacts in terms of social and environmental sustainability– society level performance (Tetteh et al. 2019). Figure 1 shows the theoretical framework for ICJVs performance measurement. Overall, these five dimensions of ICJVs performance were defined by 35 underlying PIs of both subjective and objective measures. Table 1 presents a list of the PIs for evaluating the performance of ICJVs.

While performance measurement of ICJVs becomes more important, there has been no attempt at establishing the determinants for measuring the PIs. The determinants give clarification on the degree of attainment of the PIs (Yeung et al. 2008). Only a handful of studies in related fields have partly documented the determinants for a very few PIs yet are fragmented in the literature (Gransberg et al. 1999; Cox et al. 2003; Ramirez et al. 2004; Yeung et al. 2008). Thus, it is difficult to find the determinants for the comprehensive list of PIs in a single study. Besides, different determinants have been used for assessing the available PIs in the literature. For instance, while one assessor might measure quality performance by the "percentage cost of rework to the total project cost", another assessor might measure it by the "average number of nonconformance reports produced per month". Yeung et al. (2008) highlighted that "even if a mutually agreed set of determinants exists, its qualitative nature could lead to subjective judgment instead of evidence-based assessment and judgment". It is therefore necessary to develop quantitative determinants for each PI objectively based upon quantitative evidence. Based on a critical literature analysis and semi-structured interview, a comprehensive list of 70 determinants was identified (Table 1). The identification process has been explained in the succeeding section.

**<Please Insert Table 1 here>**

**<Please Insert Figure 1 here>**

***Knowledge Gaps***

It appears that only the study of Ozorhon et al. (2010a) empirically validated the very few available PIs for ICJVs, yet it did not consider the views of the foreign/international partners of ICJV and lacks the

169 socio-environmental performance dimension of ICJVs. More so, the validity of the comprehensive list
170 of PIs and determinants are yet to be thoroughly investigated. As the determinants are realized, there is
171 a need to develop well-defined quantitative ranges for each PI to objectively express the level of success
172 in quantitative terms (Yeung et al. 2008) – entirely missing in ICJV literature. Using cost performance
173 as an example; an outcome below budget by 2% might represent "good performance" by one who is
174 less demanding, whereas below budget by 5% may be viewed as "average performance" by another
175 whose expectation is high. The determinants together with their quantitative ranges are necessary for
176 quantitative evidence-based assessment of ICJVs performance. Lastly, there is a lack of research on the
177 prioritization of significant PIs for assessing the performance of ICJVs by focal firms. A critical survey
178 of the literature advocates that an adequate blend of the PIs should satisfy the multidimensional
179 performance assessment of ICJVs (Tetteh and Chan, 2019). Therefore, this study aims to address these
180 identified gaps by developing an adequate and suitable performance measurement framework for ICJVs
181 using Ghana as a case.

182 **Research Method**

183 For better triangulation of the results, the study was conducted in three parts: (1) development of
184 performance measurement framework, (2) investigation of weights for PIs, and determinants, and (3)
185 discussion and validation of the research findings as expounded (Figure 2). The exact methods used
186 include a literature review, interviews, and a structured questionnaire survey.

187 **<Please Insert Figure 2 here>**

188 ***Development of the Measurement Framework***

189 This part focused on identifying the PIs and determinants for assessing the performance of ICJVs. As
190 mentioned earlier, this research builds on the study of Tetteh et al. (2019) that identified and clustered
191 35 PMs into five performance dimensions (discussed above) through a systematic literature review to
192 determine their validity in Ghana. Thus, the authors' study established the theoretical framework or
193 base for the present study, to empirically examine the significance of the PIs in the Ghanaian context.
194 To reach the list of PIs, a focus meeting with a panel of two professors, a senior lecturer, and three joint
195 venture (JV) managers were convened to review and verify the relevance and comprehensiveness of the
196 35 identified PIs. The panel members had extensive theoretical and practical knowledge of ICJVs

197 implementation. They had adequate direct hands-on experience with ICJVs worldwide (at least five
198 years), and they had been involved in the implementation of at least one ICJV project. After the focus
199 meeting, some of the PIs were combined or embedded as one as they were thought to be repetitive. For
200 example, "environmental performance" was regarded as part of "environmental compliance" to reflect
201 on the socio-environmental performance of ICJVs. Note that only the PIs that are recognized by the
202 experts as suitable, applicable and comprehensive are included in Table 1. To identify suitable
203 determinants for each PI, a literature review and semi-structured interviews were conducted. Some
204 determinants were directly identified from the literature and archival data (i.e., ICJVs projects
205 documentations), especially those connected to project performance and corporate sustainability due to
206 their increasing interest. As ICJVs performance measurement is multidimensional and the determinants
207 for measuring each PI are limited, semi-structured interviews via face-to-face or telephone (based on
208 proximity) were conducted with experts, academics and industry practitioners, who had extensive
209 research experience in ICJVs (published at least two papers) and sufficient direct hands-on experience
210 with ICJVs implementation globally (involved in more than one ICJV projects), respectively. The semi-
211 structured interview comprised two sections: (1) participant background information (e.g., years of
212 industry experience, number of ICJV-related papers published and number of ICJV projects involved
213 in); and (2) participants' knowledge about performance measurement and determinants used for
214 measuring PIs (e.g., how do you measure PIs such as "profitability" of ICJV firm). According to
215 Cabaniss (2002), an "expert is someone qualified to hold a position or someone having exclusive
216 expertise or skills that is indisputable by that person's leadership in a professional organization or
217 someone with publications in a recognized journal". A total of six academics (two professors, three
218 senior lecturers and one postdoctoral fellow) and 13 practitioners (from Hong Kong, the US, and Ghana)
219 were involved. Overall, 70 determinants were identified after the process (Table 1).

220 ***Investigation of Weights for PIs and Determinants***

221 This stage involved the empirical investigation of the different PIs and determinants to determine their
222 importance and realization in practice. The steps involved survey design, sample and data collection,
223 validation and prioritization of the PIs, the relevance of the determinants based on their performance
224 levels (PLs), and the extent of realization of the overall measurement framework.

225 ***Survey Design***

226 An industry-wide questionnaire survey, supplemented by follow-up interviews, was conducted to assess
227 the relevance of the PIs and determinants in practice. Questionnaire survey is suitable for collecting
228 large data from different locations and helpful for achieving "quantifiability and objectiveness" (Holyk,
229 2008). Previous ICJV studies employed questionnaire surveys to gather data (e.g., Lin and Ho, 2013;
230 Almohsen and Ruwanpura, 2016). The questionnaire comprised two main sections: (1) participant
231 background information, and (2) participants' assessment of the PIs and determinants (i.e.,
232 measurability, level of importance, and obtainability). Using a scale of 1 – 7, participants were first
233 asked to rate: (1) the level of importance of each PI and determinants (i.e., 1 – not important to 7 – most
234 important), and (2) the level of realization of the PIs (i.e., 1 – not realized to 7 – most realized). For the
235 determinants, participants were asked to rate them in terms of their measurability, obtainability, and the
236 level of importance. The second part of the survey focused on determining the expectation of
237 participants on each PI based on five different PLs (i.e., poor, average, good, very good, and excellent).
238 While these two different scales provide broader details for evaluation, extensively used in construction
239 management studies, and make data set suitable for different statistical analysis (Ameyaw and Chan,
240 2015; Chan et al. 2018), the combination of the two in a survey reduces fatigue and ensures careful
241 assessment. Before the main survey, the questionnaire was pilot tested with a representative sample of
242 11 industry practitioners (from Hong Kong, USA, China, Ghana, etc.) who had hands-on experience in
243 ICJV implementation, to verify the content relevance and representativeness, wording, and
244 answerability of questions. They all agreed that the questions are suitable and well structured.

245 ***Sample and Data Collection***

246 The population of the study comprised all registered ICJV projects, arranged by Ghanaian/local firms
247 and their foreign counterparts, completed or ongoing, by the Ghana Investment Promotion Centre
248 (GIPC), within the last decade (GIPC, 2022). Based on the records maintained by the GIPC, a list of
249 134 ICJV projects, was identified, as of December 2021. It is important to mention that participants
250 usually have hazy memories of past events, thus, it was reasonable to collect data from ICJVs dissolved
251 for not more than a decade or still active (e.g., Ali et al. 2021; Tetteh et al. 2022). Considering the nature
252 of ICJV – "*complete and disperse*" – limiting direct access or connection to respondents, alongside the

habitually low response rate in the construction industry, all the 134 ICJV projects were targeted for the survey (Zhang and Qian, 2017). For each ICJV project, the questionnaire was administered to both the local and foreign partner's representatives. Thus, overall, 268 questionnaires were distributed. According to Mohr (2006), gathering data from multiple partners in the same ICJV represents a reasonable approach for this kind of study.

The questionnaire survey was administered through face-to-face interviews and via emails (online) depending on the proximity and whether the project is still ongoing or completed. ICJV frontliners (e.g., project consultants, contractors, quantity surveyors, architects, etc.) were deemed fit for this study as they have access to strategic information and knowledge of the ICJV performance. To solicit online participation, personalized emails with attached *Word* file were sent to respective firms.

The detail of the participants' information is shown in Table 2. Of the 268 questionnaires that were distributed, 84 valid responses were collected for analysis. 38 of which were administered via email and 46 through a face-to-face interview. 51 (61%) were local partners and the remaining 33 (39%) were foreign partners. The imbalance between the local and foreign participants is reasonable because for ICJVs that have been already dissolved, getting the foreign partners onboard was difficult. More than half of the respondents have had over 11 (66%) years of working experience operating in both the domestic and international markets and majority of them have positions as project consultants (30%), and contractors (29%) – composed of construction managers/superintendents and executives. Architects and quantity surveyors constituted 27 (32%) of the total participants, and the remaining 10%, others, included site engineers, and safety officers. More so, more than half of the respondents 71 (85%) have been involved in at least 2 ICJV projects. The diversified working knowledge and direct hands-on experiences of the participants in ICJV implementation increase the reliability and credibility of the study results.

**<Please Insert Table 2 here>**

## Results and Analysis

### *Validation and Prioritization of PIs*

Prior to the analysis, Cronbach's alpha (α) was applied to measure the internal consistency between the survey items. The results demonstrated the satisfactory closeness of the survey sets as a group with an

281 "α" value greater than 0.7 (Nunnally, 1994). A confirmatory factor analysis (CFA), a distinctive form
282 of factor analysis, was used to test the significance and validity of the PIs. The software R package,
283 *lavaan* and *semPlot*, was used to measure the convergent validity, reliability, and discriminant validity
284 of the performance dimensions and PIs. "R" is a popular open-source statistical platform for
285 computations and data analysis. Although several structural equation modeling (SEM) software
286 packages are available, in the R environment, the *lavaan* and *semPlot* package is recommended because
287 it is easy to use and, rich with modeling features. It also can handle non-normal data and a small sample
288 size (Oberski, 2014).

289 To determine the weighted importance and prioritization of the PIs, respectively, fuzzy extent
290 analytical hierarchy process (FEAHP), and fuzzy technique for order of preference by similarity to ideal
291 solution (FTOPSIS) techniques were used. As multicriteria decision-making (MCDM) methods, both
292 techniques were used to deal effectively with the imprecision and ambiguity embedded in human
293 rationality and judgment. The novelty of these two approaches lies in the integration of fuzzy Delphi
294 Method (FDM), which provides estimates of *true* weights for a given criteria from a fuzzy comparison
295 matrix, and their extensive use (Hsu and Yang, 2000). For example, Hsu et al. (2017) identified key
296 performance factors for sustainable development in SMEs using these approaches. Yuan et al. (2010)
297 also used these techniques to model the performance objectives of public-private partnerships based on
298 the perspectives of stakeholders. The prioritization, using the FTOPSIS technique, is based on the
299 concept that the selected alternative should have the shortest and farthest distance from the positive
300 ideal solution (PIS) and negative ideal solution (NIS), respectively. The entire steps involved are
301 provided in Appendix I.

302 ***Validation of the PIs***

303 The CFA results demonstrated that the initial model was good enough based on the model fit indices
304 (see Tables 3 – 5). From Table 3, the measurement reliability of the PIs was sustained by greater
305 composite reliability and α values greater than 0.9. Convergent validity, which measures how well the
306 PIs define their respective constructs, was supported by high and acceptable goodness-of-fit indices as
307 listed in Table 4. These included the ratio of chi-square to the degree of freedom ($\chi^2/D_f = 1.652$), non-
308 normed fit index (NNFI = 0.791), comparative fit index (CFI = 0.938), root mean square error of

309 approximation (RMSEA = 0.063), standardized root mean square residual (SRMSR = 0.066), and
310 Tucker-Lewis index (TLI = 0.932). Table 5 shows the discriminant validity results, testing whether
311 performance constructs are significantly different from each other. Based on the results, all correlations
312 were significantly different from unity, implying no multicollinearity. The square root of the AVE
313 scores is also greater than the off-diagonal correlations, indicating good discriminant validity. Overall,
314 the validity of the constructs and PIs was achieved. Although many of the responses came from the
315 Ghanaian partners, the involvement of the foreign partners homogenizes the results for wider adoption
316 and implementation in homogenous economies.

317 **<Please Insert Table 3 here>**

318 **<Please Insert Table 4 here>**

319 **<Please Insert Table 5 here>**

320 ***Prioritization of PIs***

321 Table 6 – 8 shows the prioritization computations of the PIs within their respective performance
322 constructs based on the FEAHP and FTOPSIS techniques. The approach is regarded as reasonable, as
323 the study not only focus on providing an understanding of the significance of PIs but also to develop a
324 robust and all-inclusive performance measurement framework for ICJVs.

325 ***Application of the Techniques***

326 For the FEAHP technique, using Excel, the evaluation value of the relative significance of each PI given
327 by each participant was transformed to TFNs by applying Eqns. (1) and (2) (see Appendix I). For
328 example, the aggregated TFNs of the importance of "client satisfaction – PP4" is (1.000, 8.140, 10.000).
329 Note that due to space and word limitations, the evaluation values for all the responses cannot be
330 presented. Table 6 contains all the aggregated TFNs ($A(\lambda)$) for each PI. The next step is the computation
331 of the synthetic values following Eqn. (3) (see Appendix I). For example, based on the evaluations of
332 perceived satisfaction (PS) dimension, the synthetic values of the sub-factors are:

333 PS1 = (3.000, 9.593, 10.000) $\otimes$ $(6.00, 19.08, 20)^{-1}$ = (0.150, 0.503, 1.667)

334 PS2= (3.000, 9.487, 10.000) $\otimes$ $(6.00, 19.08, 20)^{-1}$ = (0.150, 0.497, 1.667)

Next, these fuzzy values are then employed to determine the degree of possibility values using Eqns. (4) – (5) (see Appendix I).

$V(PS1 \geq PS2) = 1, \quad V(PS2 \geq PS1) = = \frac{0.150 - 1.667}{(0.497 - 1.667)-(0.503 - 0.150)} = 0.996$

After determining the degree of possibility values, the minimum degree of possibility values for each PI is used for the computation of normalized values.

$\min PS1 = \min V(PS1 \geq PS2) = \min(1) = 1.000$

$\min PS2 = \min V(PS2 \geq PS1) = \min(0.996) = 0.996$

The final weights after normalization of the weight vector ($V$) in reference to the PIs and the main criteria are presented in Table 6, columns 5 and 6, respectively.

Similarly, for the FTOPSIS technique, the linguistic variables ratings of the extent to which the PIs are realized were converted to TFNs and finally aggregated. After finding the integrated fuzzy ratings, Eqns. (6) and (7) (see Appendix I) were applied to determine the normalized integrated fuzzy relational matrices and the weighted normalized matrices, respectively. The combined and weighted normalized decision matrix is depicted in Table 7. Using PP1 as an example, the normalized decision matrix and weighted normalized matrix are calculated as follows:

$\tilde{r}_{ij} = (3.000/10, 8.862/10, 10.000/10) = (0.300, 0.633, 1.000)$

$\widetilde{V}_{ij} = (0.300, 0.633, 1.000) \otimes 0.028559 = (0.008568, 0.01807558, 0.02855872)$

Next, the distance of each of the alternative from PIS and NIS was determined by employing Eqns. (8) – (12) (see Appendix I).

$d(A_1, A^+) = \sqrt{\frac{1}{3}[(0.008568 - 0.002906)^2 + (0.018076 - 0.023034)^2 + (0.028559 - 0.029061)^2]} =$

0.00435

$d(A_1, A^-) = \sqrt{\frac{1}{3}[(0.008568 - 0.000)^2 + (0.018076 - 0.019088)^2 + (0.028559 - 0.028082)^2]}$

$= 0.00499$

Finally, the *CC*s for all the PIs are determined and ranked accordingly (close to 1) as shown in Table 8. Thus, a larger $CC_i$ value represents a better alternative. This is achieved using Eq. (13) (see Appendix I). For example, the $CC_i$ for PP1 is calculated as:

$$CC_i = \frac{0.00499}{0.00435 + 0.00499} = 0.534$$

**<Please Insert Table 6 here>**

**<Please Insert Table 7 here>**

**<Please Insert Table 8 here>**

From Table 8, under the project-based performance (PP), the top three PIs include "achieving the required project quality (PP3) – 1.000", "profitability (PP7) – 0.679", and "good safety performance (PP5) – 0.628". Under company/partner-based performance (CP), "communication, learning, and development (CP10) – 1.000", "creating long-term relationships (CP7) – 0.768", and "technology acquisition (CP4) – 0.749", appeared as the highly prioritized PIs. Under performance of ICJV management (PM), the "effectiveness of exercising operational control of the ICJV (PM2) – 1.000" emerged as the key PI for assessing the performance of ICJVs. Similarly, under perceived satisfaction with the ICJV (PS), "Overall satisfaction (PS1) – 1.000" which gives an overall impression of the performance of ICJVs beyond all financial and objective assessments was ranked highest. Lastly, under the socio-environmental dimension (SP), the highest prioritized PIs include "sustainable job creation (SP1) – 1.000", and "stakeholder engagement (SP2) – 0.939". These findings have been adequately explained (its relevance in the Ghanaian context and beyond) in the "Discussion and Validation of Findings" section.

***Determinants and PLs***

Table 9 summarizes the results, based on the mean expectation (ME) and coefficient of variation (CV), of each determinant in relation to the five performance levels. The determinants with the highest average mean score values were selected (see Appendix II). A careful examination of the CV confirms moderate deviations of the ME in most of the PLs defining the determinants. Nonetheless, the deviations for determinants such as "variation of actual project cost expressed as a percentage of final agreed project cost" (CV_average = -3.35; CV_good = 1.47); and "variation of actual completion schedule expressed as a percentage of final agreed completion schedule" (CV_average = -2.18; CV_good = 1.82) are high. Overall, there are differences in expectations among the participants in the perceived PLs of each

389 determinant. While assessors can simply use the ME values as a general guideline to differentiate an
390 "average" and "good" performance of an ICJV, it is crucial to develop appropriate quantitative ranges
391 of suitable expectations for each PL. Figure 3 presents an example of a range of PLs in relation to the
392 quantitative range of cost performance. Chow and Ng (2007) and Yeung et al. (2008) adopted a similar
393 approach for assessing engineering consultants and partnering projects performance, respectively. In
394 this study, for example, an ICJV project of "good" and "excellent" cost performance is the one below
395 budgeted cost by 0.47% to 2.54% and 4.54% and above, respectively. Similarly, an ICJV project of
396 "very good" and "excellent" schedule performance is the one ahead of schedule by 6.98% to 12.54%
397 and 12.54% and above, respectively. To determine the "very good" schedule performance, for example,
398 the lower boundary for the "very good" PL was taken as the average of the ME for "good" (ME_good
399 = 1.12) and "very good" (ME_very good = 3.96) PLs. Table 10 presents the quantitative ranges for each
400 of the 30 PIs.

401 **<Please Insert Table 9 here>**

402 **<Please Insert Figure 3 here>**

403 **<Please Insert Table 10 here>**

404 ***Realization of the PIs***

405 While prioritizing the PIs based on their $CC_i$ values, determining the realization of the PIs is necessary
406 for identifying the convergence between the practice of, and research into the performance measurement
407 of ICJVs. It is important to recognize that a PI may have the highest closeness coefficient value, yet its
408 mean value may be low compared with those under the same performance construct. The combination
409 of mean and $CC_i$ values demonstrate rigor in identifying the most significant and mutually acceptable
410 PIs for assessing the performance of ICJVs (Yuan et al. 2018). Figure 4 presents the two-dimensional
411 realization analysis diagram of PIs. This helped to distinguish between the most realized and less
412 realized PIs for assessing the performance of ICJVs in Ghana. From Figure 4, with mean values on the
413 $x$-axis and $CC_i$ values on the $y$-axis, the *most realized* PIs fall in Quadrant I, where both the mean and
414 $CC_i$ values exceed the average. Conversely, when both the mean and $CC_i$ values are below the average,
415 the PI is defined as *less realized* and falls within Quadrant III. On the other hand, when either the mean

or the $CC_i$ value exceeds the average, the PI is known as *realized* and falls within Quadrant II or IV. The results showed that 16 PIs are *most realized* (Quadrant I), and 6 PIs are *realized* (Quadrant II/IV). With the 16 measures that fell in Quadrant I, most of the PIs (including CP1, CP2, CP3, CP4, CP7, CP9, CP10, and CP11) were related to company/partner-based performance, demonstrating that ICJVs performance measurement is directly linked to the partner companies. The study by Ozorhon et al. (2010a) also confirms the prioritization of company/partner-based performance over the other performance dimensions by Turkish partners of ICJVs. The goal incongruence among partners in ICJV prelude the attention for this performance measure dimension. The results further revealed PIs that promote sustainability are *"less realized"* – Quadrant III (i.e. "SP3 – social reporting", "SP4 – avoidance of material wastage", "SP5 – pollution reduction"). Aside from the unbalanced views and infancy of sustainable performance attainability, especially in developing countries (Shen et al. 2011), one of the possible reasons that could result in the less realization of the socio-environmental performance may be due to lack of suitable determinants for the related PIs, thereby making performance monitoring and benchmarking difficult. Overall, there is a need for practitioners to improve their organizational performance toward sustainability potentials by modifying their present approach.

**<Please Insert Figure 4 here>**

**Discussion and Validation of Findings**

For completeness and better understanding of the concept, the discussion is positioned primarily within the geographical context of this study, even though the global knowledge and experiences are accounted for. This, therefore, does not mean that this study intends to provide a performance measurement benchmark for ICJVs operating in the developing country of Ghana only, but to reinforce the discussion and provide a measurement model for potential ICJVs yet to be formed as well. Overall, the findings support the multidimensionality of ICJVs performance. Based on the prioritization of the PIs within their respective dimensions, it is noted that "project-based performance" keeps evolving in recent times. In this era – *the 21st century* – stakeholders are more concerned with the efficiency of the project, referring to whether the project is done right, time after time, to achieve the desired quality, functionality, and performance (Turner and Xue, 2018). Compared with normal-sized infrastructure

projects, ICJV projects receive more attention from the government, the public, and the media because of their nature (i.e., large-scale investment, political importance, socio-economic and environmental impact, and so on). In the developing country such as Ghana, for example, the majority of ICJV projects are government-funded, thus the monies are generated from taxes or borrowed from an external source. Therefore, critical attention is paid to such projects by the general public, while the government implements stricter regulations for smooth construction. In a recent study by He et al. (2021), "achieving the required project quality" is a key benchmark of success for large and complex infrastructure projects. One of the interviewees reported that "*...regardless of the project uncertainties and deviations, even common in small projects, delivering the desired outcome and benefit (quality) is what we strive for. If we can achieve this goal then we can boast of success at the project and management level, given the complexities surrounding ICJVs.*" The ranking of "achieving the required project quality" as the top PI is reasonable because the majority of the participants were project consultants (indirectly representing project owners). It is logical for project owners (clients) to determine whether the project meets the required standard, rather than involving the ICJV partners, to prevent potentially biased opinions. However, it would be more interesting and promising for future studies to comprehensively engage project clients/owners to verify and assess the performance of ICJVs using key PIs that are more client-focused (e.g., client satisfaction, achieving project quality, etc.). "Profitability" is also an imperative PI that partnering firms accept and translate into the ICJV performance management framework. In a study by Almohsen and Ruwanpura (2016), profitability was the highest contributor to the measurement of ICJVs performance. More so, a "good safety performance" is not only an important PI for assessing the project performance of ICJVs, but for every construction organization (Hassanein and Hanna, 2008). In Ghana, safety issues are prevalent, especially in infrastructure projects, compared to countries like the UK, USA, Singapore, etc. Thus, the awareness and practice of achieving "zero injuries, zero pollution, and zero accident" have been an important agenda for every construction organization (Manu et al., 2018). In promoting "good safety performance", one of the key approaches used is that government contracts are awarded to firms who show good safety performance records within specific periods.

The primary objective to enter ICJVs, especially for firms in developing countries, is to build capacity in diverse forms, including but not limited to technology and knowledge acquisition, improve managerial skills, etc. (Ozorhon et al. 2010a; Chan et al., 2020). It is, therefore, not surprising that PIs such as "communication, learning, and development", "creating long-term relationships", and "technology acquisition", were highly ranked. According to Ozorhon and Oral (2017) realization of these PIs significantly improves sustainability in the construction environment worldwide. Tetteh et al. (2021a) confirmed that the knowledge and competencies harnessed from partner companies are necessary to sustain economic growth and social development in most developing countries. More so, "effectiveness of exercising operational control" is considered a key PI for assessing the performance of ICJVs because it does not depend on ownership but rather on the managerial and operational competencies of partners (Lee et al. 2003). Likewise, "overall satisfaction" is widely used in ICJVs performance measurement (Ozorhon et al. 2010b; Lin and Ho, 2013). Mohamed (2003) highlighted that it allows managers to have a continued relationship with their partners beyond the project under investigation. From the socio-environmental performance perspective, ICJVs create massive job opportunities and stimulate job mobility, especially in the local/host markets. For this reason, job creation is always viewed as an important PI for evaluating the performance of ICJVs – "sustainable job creation". In Ghana, for example, the Local Content and Local Participation, Regulation 2013 L.I. 2204, ensures that the local workforces outnumber foreign or international officials in ICJVs implementation. Likewise, given that ICJV projects lie in improving and enabling people's lives and social development, respectively (Shen et al. 2011), without satisfying the needs of stakeholders, the project may be regarded as a failure (He et al. 2020). Therefore, the performance of ICJVs is also connected to the success in engaging stakeholders. In summary, the highly prioritized PIs suggest that ICJVs performance measurement is focused more on project efficiency, societal improvement, and organizational gains.

Lastly, while a simple and practical way to define PLs and quantitative ranges of PIs is provided, the results suggest that accurate estimation (in a more scientific way) of the PLs and quantitative ranges would provide superior flexibility for assessors to assess the performance of ICJVs objectively, reliably, and practically.

## Conclusions, Limitations, and Future Research

This study aimed at developing an all-inclusive multidimensional performance measurement framework for ICJVs hosted in the developing country of Ghana. A comprehensive list of PIs and different sets of determinants were identified through a critical survey of relevant literature and semi-structured interviews. The data were collected using structured questionnaire survey and semi-structured interviews with 84 practitioners of ICJVs hosted in the developing country of Ghana. Descriptive statistics, confirmatory factor analysis (CFA) and a hybrid-fuzzy logic approach were used to analyze the data. The CFA results validated the importance of 30 PIs defined by project performance, perceived satisfaction, company/partner performance, socio-environmental performance, and performance of ICJV management. The results from the hybrid-fuzzy technique indicated that "achieving the required project quality", "communication, learning, and development", "effectiveness of operational control", "overall satisfaction", and "sustainable job creation" are the top most significant indicators for assessing the performance of ICJVs. Based on a two-dimensional realization analysis, only 22 out of the 30 PIs are realized, which focused on project efficiency, societal improvement, and organizational goals. The results also revealed that most of the PIs are less realized (e.g., those under socio-environmental performance), calling for further investigation and analysis. Further, suitable determinants and reasonable quantitative ranges for each PI are established to avoid different interpretations of the meanings of PIs and objectively express the level of success in quantitative terms.

Theoretically, this study extends the current ICJV literature by identifying, validating, and prioritizing the PIs and determinants for measuring the performance of ICJVs. A more standardized and complete set of PIs and determinants that have been validated will not only assist future researchers in selecting key performance measures that are most relevant to their study but also make legitimate commendations to practitioners relative to the successful performance management of an ICJV. Defining reasonable quantitative ranges for different performance levels of each of the PIs would allow for a level playing field in which projects developed through ICJVs could be evaluated and compared with one another. As result, a standard can be established by which the success of future ICJV projects can be evaluated. Practically, this study contributes to better understanding of the measures for assessing the performance of ICJVs, which assist ICJV practitioners to reflect on how they operate and measure

the success of their ICJVs. Further, the developed framework will help practitioners of ICJVs and decision-makers to assess, monitor, benchmark and improve ICJVs success in a more practical, reliable, objective, and comprehensive manner. While an adequate combination of the measures allows addressing the multidimensionality of ICJVs performance, the prioritization of the measures would help practitioners to focus more on the most significant measures when launching ICJVs.

This study has some limitations that are worth mentioning. First, while the PIs and determinants used suit all ICJVs, focusing on ICJVs established in Ghana may affect the generalizability of the results. Second, the number of responses received from the two partners was relatively low and given that the local partners constitute the majority of the respondents could have some influence on the results. Thus, this must be given due consideration when interpreting the results. Lastly, acknowledging that the proposed framework is not a generic one, collecting data from multiple partners in the same ICJV represents a reasonable approach to standardize the results for wider adoption and implementation. Because of these limitations, future studies should be aimed at developing a more complete performance measurement framework for ICJVs. In doing so, future research should be conducted to establish a more scientific way to define a quantitative range for different performance levels. In addition, to obtain more concrete and practical results, it is important to employ different case studies (real ICJVs projects) that incorporate large secondary data from literature and more archival data (i.e. ICJVs projects documentations) and collect different ICJV experts' opinions through an international survey to drive better triangulation of the results. More importantly, it is in the remit of future studies to apply the same research methods in different countries/jurisdictions to draw inferences on the similarities and differences for international comparisons. This would no doubt enhance the unification and standardization of ICJVs performance measurement framework.

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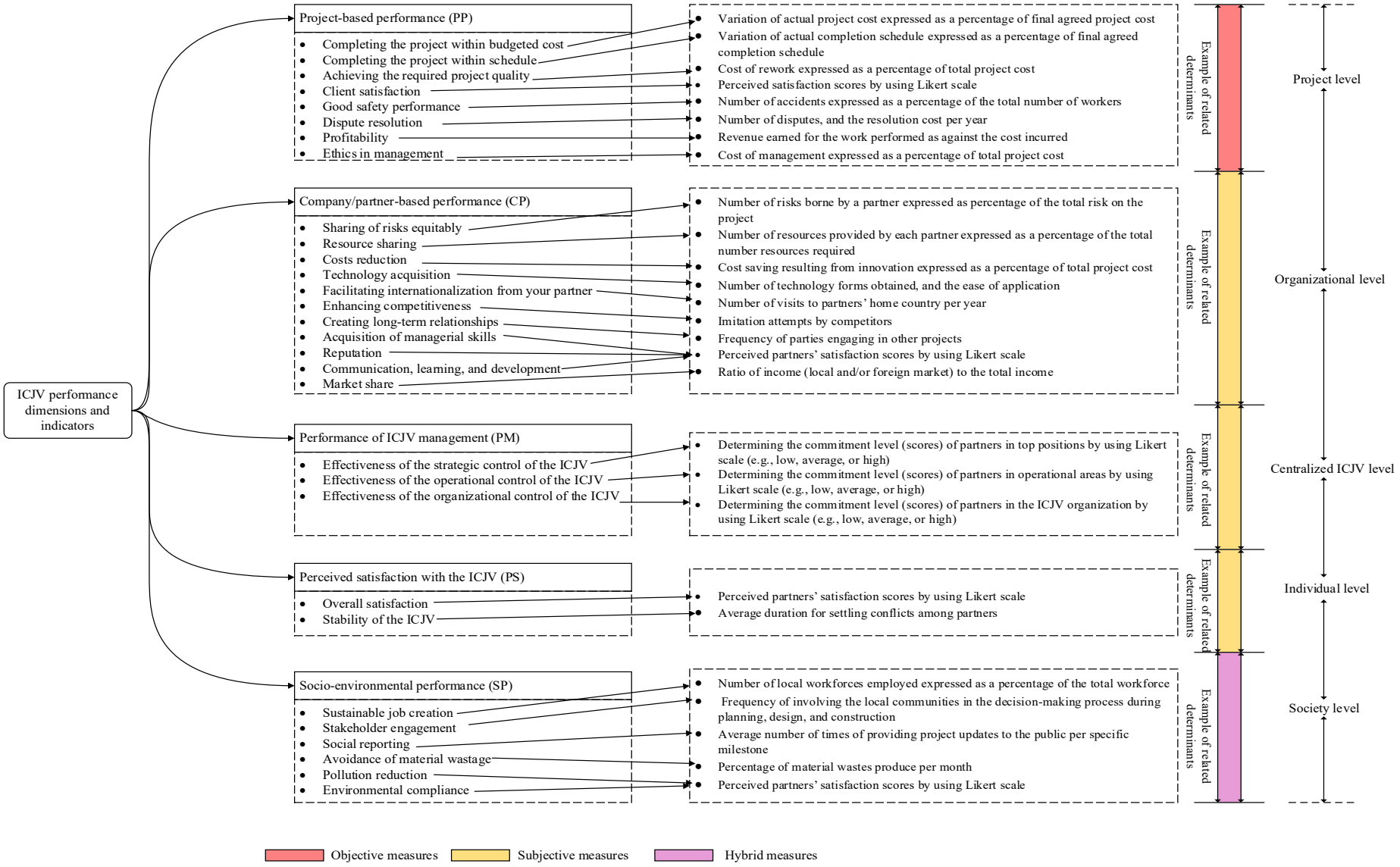


**Figure 1.** Theoretical framework for ICJV performance measurement (Adapted from Tetteh, 2022)

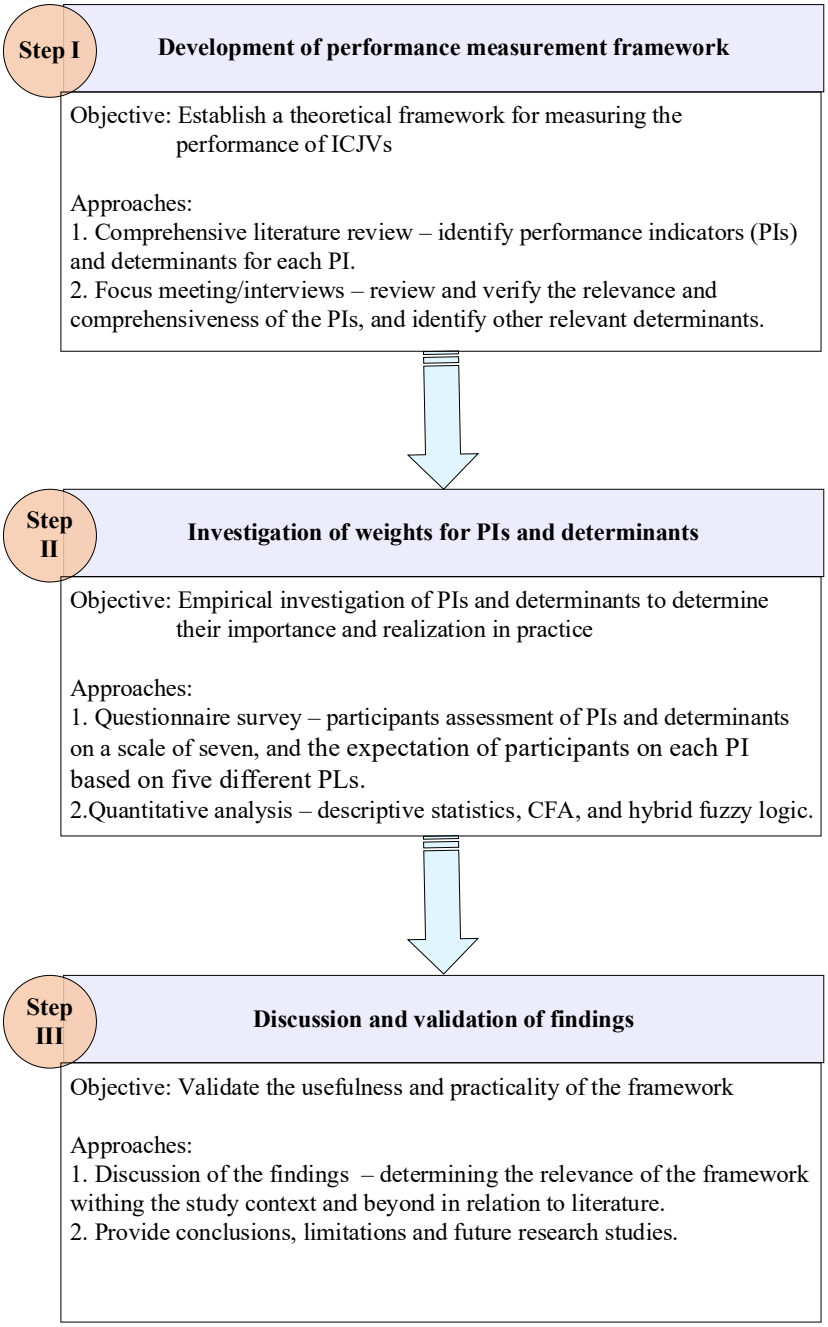


**Figure 2.** The research design

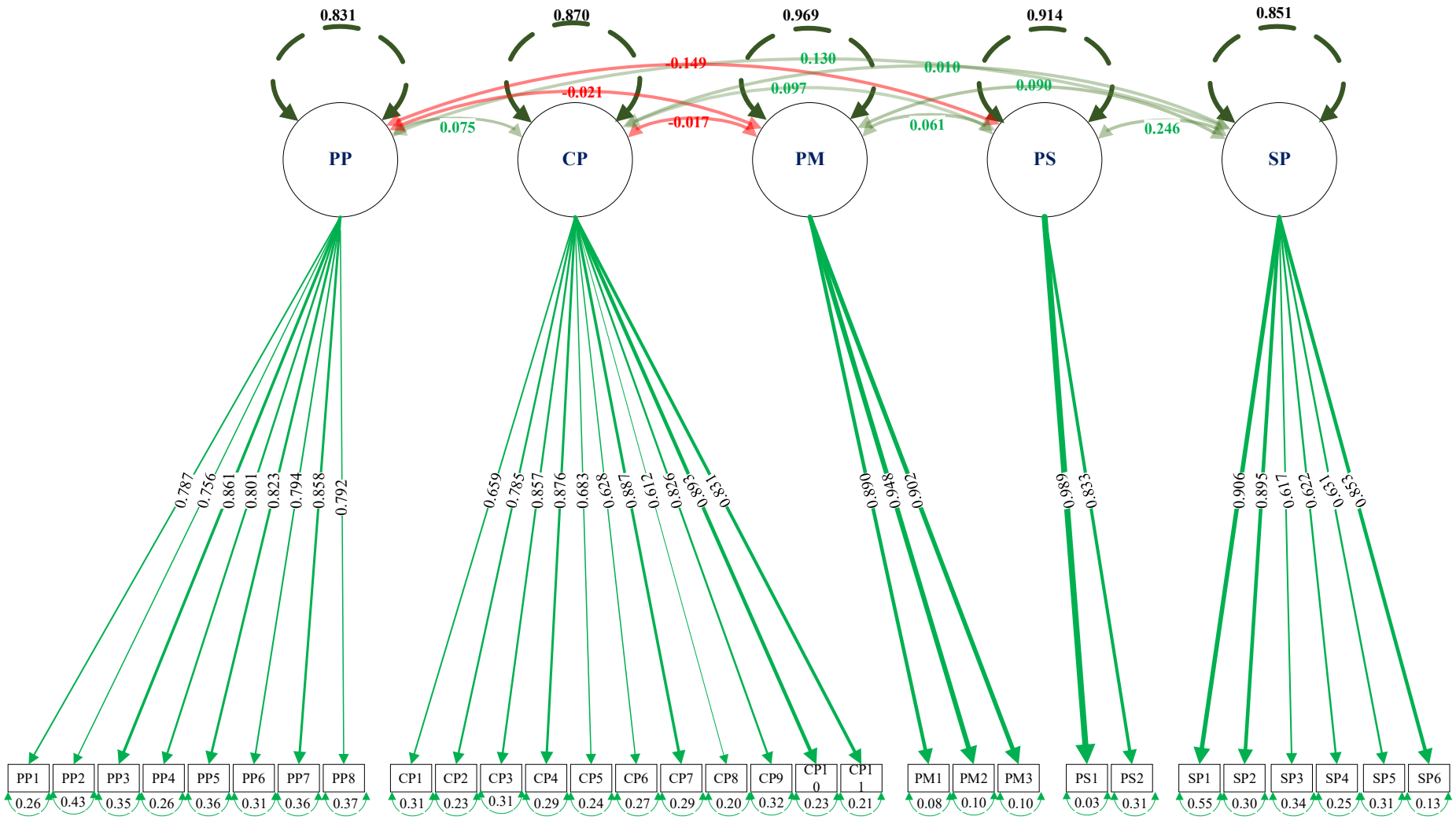


**Figure 3.** Final CFA model of ICJV PIs

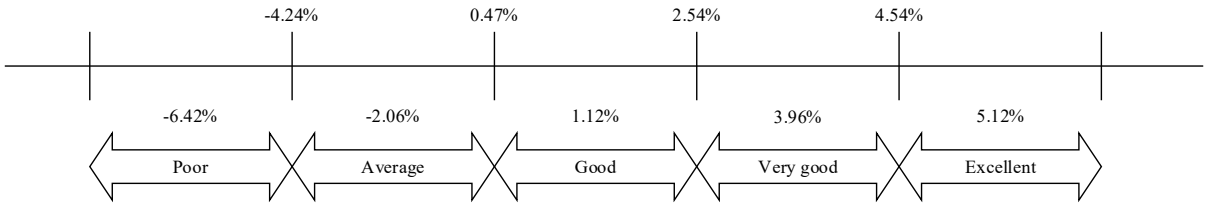


**Figure 4.** Range of PLs in relation to quantitative range of cost performance

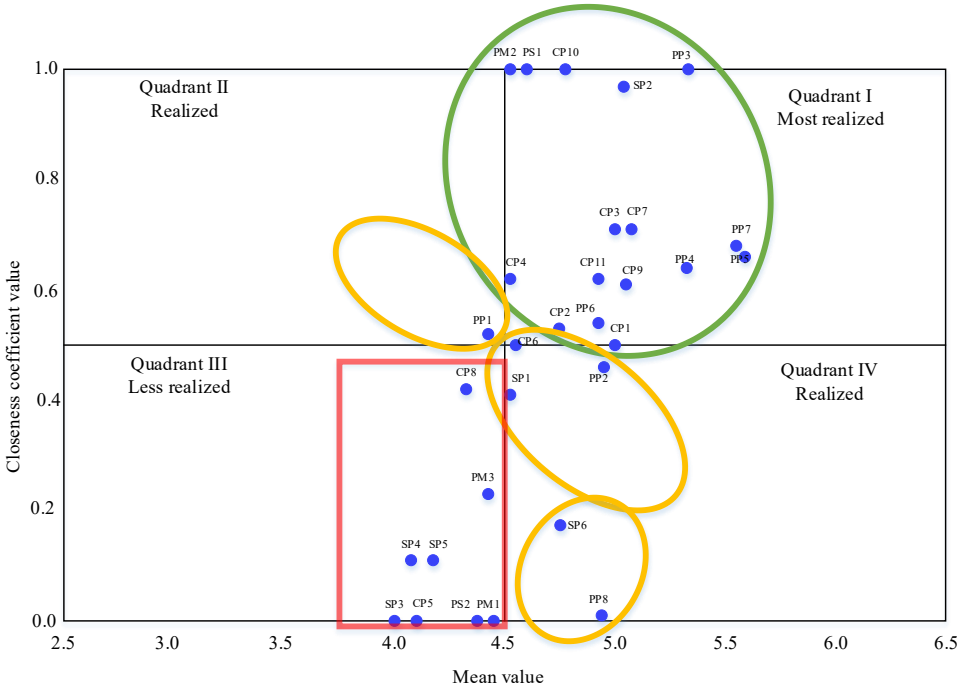


**Figure 5.** Realization analysis diagram of ICJVs performance measurement framework

**Table 1.** Performance dimensions, indicators, and determinants for ICJVs (Adapted from Ozorhon et al. 2010b and Tetteh et al. 2019)

| Performance dimensions | Code | Performance indicators (PIs) | Determinants | Sources |
|---|---|---|---|---|
| Project-based performance | PP1 | Project cost | a. Variation of actual project cost expressed as a proportion of final agreed project cost<br>b. Composite cost performance score by using Likert scale | Cox et al. (2003), Yeung et al. (2008) |
| | PP2 | Project schedule | a. Variation of actual completion schedule expressed as a proportion of final agreed completion schedule<br>b. Composite schedule performance score by using Likert scale | Cox et al. (2003), Yeung et al. (2008) |
| | PP3 | Required quality | a. Cost of rework expressed as a proportion of total project cost<br>b. Average number of nonconformance reports produced per month<br>c. Perceived customers' satisfaction scores by using Likert scale | Fayek et al. (2003), Yeung et al. (2009), Leon et al. (2018) |
| | PP4 | Client satisfaction | a. Perceived client satisfaction score with services including project schedule, cost, quality of work, etc. procedures by using Likert scale | Leon et al. (2018) |
| | PP5 | Good safety performance | a. Number of accidents expressed as a proportion of the total number of workers<br>b. Number of days lost expressed as a proportion of yearly average of workers<br>c. Perceived key stakeholders' satisfaction scores by using Likert scale (e.g., poor, average, excellent) | Ramirez et al. (2004), Castillo et al. (2018) |
| | PP6 | Dispute resolution | a. Number of disputes, and the resolution cost per year<br>b. Dispute resolution cost expressed as a proportion of original contract cost<br>c. Average duration for settling disputes<br>d. Perceived partners' satisfaction scores by using Likert scale | Gransberg et al. (1999), Sohail and Baldwin (2004) |
| | PP7 | Profitability | a. Revenue earned for the work performed as against the cost incurred<br>b. Perceived partners' satisfaction scores by using Likert scale | Jin et al. (2013), Leon et al. (2018) |
| | PP8 | Ethics in management | a. Cost of management expressed as a proportion of total project cost<br>b. Perceived partners' satisfaction scores by using Likert scale | Ramirez et al. (2004), Interview |

| | | | | |
|---|---|---|---|---|
| Company/partner-based performance | CP1 | Sharing of risks equitably | a. Number of risks borne by a partner expressed as proportion of the total risk on the project<br>b. Perceived partners' satisfaction scores by using Likert scale | Favié et al. (2009), Hwang et al. (2017) |
| | CP2 | Resource sharing | a. Percentage ratio of resources provided by each partner to the total volume of work to be completed<br>b. Number of resources provided by each partner expressed as a proportion of the total number resources required<br>c. Perceived partners' satisfaction scores by using Likert scale | Yung-Chul (2013) |
| | CP3 | Cost reduction | a. Cost saving resulting from innovation expressed as a proportion of total project cost<br>b. Perceived partners' satisfaction scores by using Likert scale | Yeung et al. (2008) |
| | CP4 | Technology acquisition | a. Number of technology forms obtained, and the ease of application<br>b. Perceived partners' satisfaction scores by using Likert scale | Yeung et al. (2008) |
| | CP5 | Facilitating internationalization | a. Number of visits to partners' home country per year<br>b. Number of international networks obtained after completion of ICJV project<br>c. Perceived partners' satisfaction scores by using Likert scale | Interview |
| | CP6 | Enhancing competitiveness | a. International projects secured expressed as a proportion of the total number of projects per year<br>b. Imitation attempts by competitors<br>c. Perceived partners' satisfaction scores by using Likert scale | Interview |
| | CP7 | Creating long-term relationships | a. Frequency of parties engaging in other projects<br>b. Frequency of meeting partners' expectation<br>c. Perceived partners' satisfaction scores by using Likert scale | Interview |
| | CP8 | Acquisition of managerial skills | a. Number of managerial skills acquired and the ease of implementation<br>b. Perceived partners' satisfaction scores by using Likert scale | Yeung et al. (2008) |
| | CP9 | Reputation | a. Number of additional projects secured during the ICJV project execution<br>b. Ratio of commendations to the number of complaints by the client | Interview |

| | | | | |
|---|---|---|---|---|
| | | | c. Perceived partners' satisfaction scores by using Likert scale | |
| | CP10 | Communication, learning, and development | a. Variation of the number of formal letters and emails sent between parties per months against the number with previous similar projects<br>b. Number of formal and informal days training provided in skills development related to construction management<br>c. Perceived partners' satisfaction scores by using Likert scale | Sohail and Baldwin (2004), Yeung et al. (2008) |
| | CP11 | Market share | a. Ratio of income (local and/or foreign market) to the total income<br>b. Number of projects secured (local and/or foreign market) compared with the previous year<br>c. Perceived partners' satisfaction scores by using Likert scale | Jin et al. (2013), Interview |
| Performance of ICJV management | PM1 | Effective strategic control | a. Percentage of partners' personnel in top management level<br>b. Determining the commitment level (scores) of partners in top positions by using Likert scale (e.g., low, average, or high) | Luo (2001), Interview |
| | PM2 | Effective operational control | a. Percentage of partners' personnel in key functional and operational areas<br>b. Determining the commitment level (scores) of partners in operational areas by using Likert scale (e.g., low, average, or high) | Luo (2001), Interview |
| | PM3 | Effective organizational control | a. Percentage of partners' personnel in managing the ICJV organization<br>b. Determining the commitment level (scores) of partners in the ICJV organization by using Likert scale (e.g., low, average, or high) | Luo (2001), Interview |
| Perceived satisfaction with the ICJV | PS1 | Overall satisfaction | a. Perceived partners' satisfaction scores by using Likert scale | Luo (2001), Lin and Ho (2013) |
| | PS2 | Stability of the ICJV | a. Average duration for settling conflicts among partners<br>b. Perceived partners' satisfaction scores by using Likert scale | Gale and Luo (2004) |
| Socio-environmental performance | SP1 | Sustainable job creation | a. Number of local workforces employed expressed as a proportion of the total workforce<br>b. Perceived partners' satisfaction scores by using Likert scale | Jin et al. (2013), Gianni et al. (2017) |

| | | | | |
|---|---|---|---|---|
| SP2 | Stakeholder engagement | a. | Frequency of involving the local communities in the decision-making process during planning, design, and construction | Sohail and Baldwin (2004), |
| | | b. | The attendance and contribution level of locals during decision-making | |
| | | c. | Perceived partners' satisfaction scores by using Likert scale | |
| SP3 | Social reporting | a. | Average number of times of providing project updates to the public per specific milestone | Gianni et al. (2017) |
| | | b. | Perceived partners' satisfaction scores by using Likert scale | |
| SP4 | Avoidance of material wastage | a. | Percentage of material wastes produce per month | Gianni et al. (2017) |
| | | b. | Perceived partners' satisfaction scores by using Likert scale | |
| SP5 | Pollution reduction | a. | Percentage of pollutants (i.e. water, noise, air) produce per month | Gianni et al. (2017) |
| | | b. | Perceived partners' satisfaction scores by using Likert scale | |
| SP6 | Environmental compliance | a. | Summation of earned rating for each indicator based on the measurement and the assigned priority according to local regulations and conditions | Leon et al. (2 018), Interview |
| | | b. | Perceived partners' satisfaction scores by using Likert scale | |

**Table 2.** Participants information

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Category of participants | | |
| Local partners | 51 | 61% |
| Foreign/international partners | 33 | 39% |
| Job position | | |
| Project consultants | 25 | 30% |
| Architects | 14 | 17% |
| Contractors | 24 | 29% |
| Quantity surveyors | 13 | 15% |
| Others | 8 | 10% |
| Working experience | | |
| Less than 5 years | 5 | 6% |
| 5 – 10 years | 23 | 27% |
| 11 – 15 years | 38 | 45% |
| 16 years and above | 18 | 22% |
| Number of projects executed | | |
| 1 | 13 | 165 |
| 2 | 28 | 33% |
| 3 | 41 | 49% |
| 4 | 2 | 2% |

**Table 3.** Results of measurement reliability of the PIs

| Code | Performance indicators (PIs) | Measurement and reliability analysis | | | | | |
|---|---|---|---|---|---|---|---|
| | | MS | FL | SE | α | AVE | CR |
| *PP* | *Project-based performance* | | | | 0.946 | 0.831 | 0.947 |
| PP1 | Project cost | 4.49 | 0.787 | 0.264 | | | |
| PP2 | Project schedule | 4.33 | 0.756 | 0.429 | | | |
| PP3 | Required quality | 5.35 | 0.861 | 0.352 | | | |
| PP4 | Client satisfaction | 5.32 | 0.801 | 0.258 | | | |
| PP5 | Good safety performance | 5.58 | 0.823 | 0.361 | | | |
| PP6 | Dispute resolution | 4.93 | 0.794 | 0.311 | | | |
| PP7 | Profitability | 5.54 | 0.858 | 0.361 | | | |
| PP8 | Ethics in management | 4.25 | 0.792 | 0.372 | | | |
| *CP* | *Company/partner-based performance* | | | | 0.971 | 0.870 | 0.970 |
| CP1 | Sharing of risks equitably | 5.65 | 0.659 | 0.310 | | | |
| CP2 | Resource sharing | 4.74 | 0.785 | 0.233 | | | |
| CP3 | Costs reduction | 5.07 | 0.857 | 0.308 | | | |
| CP4 | Technology acquisition | 4.55 | 0.876 | 0.294 | | | |
| CP5 | Facilitating internationalization from your partner | 4.13 | 0.683 | 0.238 | | | |
| CP6 | Enhancing competitiveness | 5.87 | 0.628 | 0.269 | | | |
| CP7 | Creating long-term relationships | 5.05 | 0.887 | 0.289 | | | |
| CP8 | Acquisition of managerial skills | 5.52 | 0.612 | 0.203 | | | |
| CP9 | Reputation | 5.15 | 0.826 | 0.317 | | | |
| CP10 | Communication, learning, and development | 4.73 | 0.893 | 0.232 | | | |
| CP11 | Market share | 4.98 | 0.831 | 0.213 | | | |
| *PM* | *Performance of ICJV management* | | | | 0.967 | 0.969 | 0.967 |
| PM1 | Effectiveness of the strategic control of the ICJV | 4.48 | 0.890 | 0.076 | | | |
| PM2 | Effectiveness of the operational control of the ICJV | 4.54 | 0.948 | 0.102 | | | |
| PM3 | Effectiveness of the organizational control of the ICJV | 4.49 | 0.902 | 0.102 | | | |
| *PS* | *Perceived satisfaction with the ICJV* | | | | 0.970 | 0.914 | 0.850 |
| PS1 | Overall satisfaction | 4.57 | 0.989 | 0.278 | | | |
| PS2 | Stability of the ICJV | 4.44 | 0.833 | 0.307 | | | |
| *SP* | *Socio-environmental performance* | | | | 0.946 | 0.851 | 0.951 |
| SP1 | Sustainable job creation | 4.50 | 0.906 | 0.545 | | | |
| SP2 | Stakeholder engagement | 4.12 | 0.895 | 0.313 | | | |
| SP3 | Social reporting | 4.01 | 0.617 | 0.340 | | | |
| SP4 | Avoidance of material wastage | 4.55 | 0.622 | 0.251 | | | |
| SP5 | Pollution reduction | 4.73 | 0.631 | 0.311 | | | |
| SP6 | Environmental compliance | 4.65 | 0.853 | 0.130 | | | |

Note: SE – Standard error; α – Cronbach's alpha; AVE – Average variance extracted; and CR -Composite reliability; MS – Mean score; FL – Factor loading

**Table 4.** Summary of CFA test fit indices

| Measure | Recommended value | Obtained |
|---|---|---|
| $\chi^2/D_f$ | 1 – 2 | 1.652 |
| NNFI | 0 – 1 (perfect fit) | 0.791 |
| CFI | 0 – 1 (perfect fit) | 0.938 |
| RMSEA | < 0.10 – good fit | 0.063 |
| SRMR | < 0.10 – good fit | 0.066 |
| TLI | 0 – (perfect fit) | 0.932 |

**Table 5.** Discriminant validity results

| Performance constructs | Correlation matrix[b] | | | | |
|---|---|---|---|---|---|
| code | PP | CP | PM | PS | SP |
| PP | **0.831** | | | | |
| CP | 0.075 | **0.870** | | | |
| PM | -0.021 | -0.017 | **0.969** | | |
| PS | -0.149 | 0.097 | 0.061 | **0.914** | |
| SP | 0.130 | 0.010 | 0.090 | 0.200 | **0.851** |

Note: [b]Bold values on the diagonal represents the square root of AVE of each latent construct. Off-diagonal values are the correlation between constructs.

**Table 6.** The aggregated and normalized weight of each PI

| Performance dimensions | PIs | $A(\lambda)$ | $S_i$ | $W'$ | $W$ |
|---|---|---|---|---|---|
| Project-based performance (PP) | PP1 | (3.000, 8.862, 10.000) | (0.033, 0.117, 0.431) | 0.982707 | 0.028559 |
| | PP2 | (3.000, 8.164, 10.000) | (0.033, 0.108, 0.431) | 0.961914 | 0.027954 |
| | PP3 | (1.000, 9.418, 10.000) | (0.011, 0.124, 0.431) | 1.000000 | 0.029061 |
| | PP4 | (1.000, 8.140, 10.000) | (0.011, 0.107, 0.431) | 0.961333 | 0.027938 |
| | PP5 | (3.000, 8.331, 10.000) | (0.033, 0.110, 0.431) | 0.966882 | 0.028099 |
| | PP6 | (3.000, 8.034, 10.000) | (0.033, 0.106, 0.431) | 0.958149 | 0.027845 |
| | PP7 | (3.000, 8.479, 10.000) | (0.033, 0.112, 0.431) | 0.971309 | 0.028227 |
| | PP8 | (3.000, 8.120, 10.000) | (0.033, 0.107, 0.431) | 0.960752 | 0.027921 |
| Company/partner-based performance (CP) | CP1 | (3.000, 8.047, 10.000) | (0.025, 0.030, 0.250) | 0.979627 | 0.028469 |
| | CP2 | (3.000, 7.860, 10.000) | (0.025, 0.081, 0.250) | 0.970681 | 0.028209 |
| | CP3 | (5.000, 8.028, 10.000) | (0.042, 0.083, 0.250) | 0.978678 | 0.028442 |
| | CP4 | (3.000, 8.076, 10.000) | (0.025, 0.083, 0.250) | 0.981055 | 0.028511 |
| | CP5 | (3.000, 7.952, 10.000) | (0.025, 0.082, 0.250) | 0.974898 | 0.028332 |
| | CP6 | (3.000, 7.781, 10.000) | (0.025, 0.080, 0.250) | 0.966963 | 0.028101 |
| | CP7 | (3.000, 7.930, 10.000) | (0.025, 0.082, 0.250) | 0.973958 | 0.028304 |
| | CP8 | (3.000, 8.462, 10.000) | (0.025, 0.087, 0.250) | 1.000000 | 0.029061 |
| | CP9 | (3.000, 8.212, 10.000) | (0.025, 0.085, 0.250) | 0.987773 | 0.028706 |
| | CP10 | (5.000, 8.466, 10.000) | (0.042, 0.087, 0.250) | 1.000000 | 0.029061 |
| | CP11 | (3.000, 8.345, 10.000) | (0.025, 0.086, 0.250) | 0.994982 | 0.028915 |
| Performance of ICJV management (PM) | PM1 | (3.000, 9.162, 10.000) | (0.100, 0.333, 0.909) | 1.000000 | 0.029061 |
| | PM2 | (3.000, 9.089, 10.000) | (0.100, 0.331, 0.909) | 1.000000 | 0.029061 |
| | PM3 | (5.000, 9.220, 10.000) | (0.167, 0.336, 0.909) | 1.000000 | 0.029061 |
| Perceived satisfaction with the ICJV (PS) | PS1 | (3.000, 9.593, 10.000) | (0.150, 0.503, 1.667) | 1.000000 | 0.029061 |
| | PS2 | (3.000, 9.487, 10.000) | (0.150, 0.497, 1.667) | 0.996586 | 0.028962 |
| Socio-environmental performance (SP) | SP1 | (1.000, 8.924, 10.000) | (0.011, 0.115, 0.455) | 1.000000 | 0.029061 |
| | SP2 | (3.000, 8.643, 10.000) | (0.033, 0.112, 0.455) | 0.991913 | 0.028826 |
| | SP3 | (3.000, 8.503, 10.000) | (0.033, 0.110, 0.455) | 0.985078 | 0.028628 |
| | SP4 | (1.000, 8.480, 10.000) | (0.011, 0.109, 0.455) | 0.984391 | 0.028608 |
| | SP5 | (5.000, 8.971, 10.000) | (0.056, 0.116, 0.455) | 1.000000 | 0.029061 |
| | SP6 | (3.000, 8.538, 10.000) | (0.033, 0.110, 0.455) | 0.989057 | 0.028743 |

**Table 7.** Combined and weighted normalized fuzzy decision matrix of PIs realization

| Performance dimensions | PIs | $\zeta(\tilde{\alpha})$ | $\tilde{r}_{ij}$ | $W_j$ | $\tilde{V}_{ij} = \tilde{r}_{ij}$ x $W_j$ |
|---|---|---|---|---|---|
| PP | PP1 | (3.000, 6.329, 10.000) | (0.300, 0.633, 1.000) | 0.028559 | (0.008568, 0.01807558, 0.02855872) |
| | PP2 | (1.000, 7.074, 10.000) | (0.100, 0.707, 1.000) | 0.027954 | (0.002795, 0.01977519, 0.02795445) |
| | PP3 | (1.000, 7.926, 10.000) | (0.100, 0.793, 1.000) | 0.029061 | (0.002906, 0.02303375, 0.02906128) |
| | PP4 | (3.000, 7.852, 10.000) | (0.300, 0.785, 1.000) | 0.027938 | (0.008381, 0.02193616, 0.02793757) |
| | PP5 | (3.000, 8.346, 10.000) | (0.300, 0.835, 1.000) | 0.028099 | (0.008430, 0.02345038, 0.02809883) |
| | PP6 | (3.000, 7.123, 10.000) | (0.300, 0.712, 1.000) | 0.027845 | (0.008354, 0.01983529, 0.02784503) |
| | PP7 | (3.000, 8.284, 10.000) | (0.300, 0.828, 1.000) | 0.028227 | (0.008468, 0.02338351, 0.02822748) |
| | PP8 | (0.000, 7.099, 10.000) | (0.000, 0.710, 1.000) | 0.027921 | (0.000000, 0.01982024, 0.02792068) |
| CP | CP1 | (3.000, 7.309, 10.000) | (0.300, 0.731, 1.000) | 0.028469 | (0.008541, 0.02080713, 0.02846921) |
| | CP2 | (0.000, 6.432, 10.000) | (0.000, 0.643, 1.000) | 0.028209 | (0.000000, 0.01814446, 0.02820923) |
| | CP3 | (0.000, 7.358, 10.000) | (0.000, 0.736, 1.000) | 0.028442 | (0.000000, 0.02092742, 0.02844163) |
| | CP4 | (0.000, 6.443, 10.000) | (0.000, 0.644, 1.000) | 0.028511 | (0.000000, 0.01836956, 0.02851071) |
| | CP5 | (0.000, 5.692, 10.000) | (0.000, 0.569, 1.000) | 0.028332 | (0.000000, 0.01612732, 0.02833178) |
| | CP6 | (1.000, 6.367, 10.000) | (0.100, 0.637, 1.000) | 0.028101 | (0.002810, 0.01789227, 0.02810118) |
| | CP7 | (0.000, 7.259, 10.000) | (0.000, 0.726, 1.000) | 0.028304 | (0.000000, 0.02054694, 0.02830446) |
| | CP8 | (0.000, 5.975, 10.000) | (0.000, 0.598, 1.000) | 0.029061 | (0.000000, 0.01736319, 0.02906128) |
| | CP9 | (1.000, 7.519, 10.000) | (0.100, 0.752, 1.000) | 0.028706 | (0.002871, 0.02158262, 0.02870595) |
| | CP10 | (0.000, 6.691, 10.000) | (0.000, 0.669, 1.000) | 0.029061 | (0.000000, 0.01944594, 0.02906128) |
| | CP11 | (1.000, 7.288, 10.000) | (0.100, 0.729, 1.000) | 0.028915 | (0.002892, 0.02107213, 0.02891545) |
| PM | PM1 | (1.000, 6.185, 10.000) | (0.100, 0.619, 1.000) | 0.029061 | (0.002906, 0.01797494, 0.02906128) |
| | PM2 | (1.000, 6.296, 10.000) | (0.100, 0.630, 1.000) | 0.029061 | (0.002906, 0.01829784, 0.02906128) |
| | PM3 | (1.000, 6.211, 10.000) | (0.100, 0.621, 1.000) | 0.029061 | (0.002906, 0.01804669, 0.02906128) |
| PS | PS1 | (0.000, 6.350, 10.000) | (0.000, 0.635, 1.000) | 0.029061 | (0.000000, 0.01845391, 0.02906128) |
| | PS2 | (1.000, 6.231, 10.000) | (0.100, 0.623, 1.000) | 0.028962 | (0.002896, 0.01804559, 0.02896206) |
| SP | SP1 | (0.000, 6.380, 10.000) | (0.000, 0.638, 1.000) | 0.029061 | (0.000000, 0.01854036, 0.02906128) |
| | SP2 | (1.000, 7.600, 10.000) | (0.100, 0.760, 1.000) | 0.028826 | (0.002883, 0.02190796, 0.02882626) |
| | SP3 | (0.000, 5.493, 10.000) | (0.000, 0.549, 1.000) | 0.028628 | (0.000000, 0.01572660, 0.02862763) |
| | SP4 | (0.000, 5.924, 10.000) | (0.000, 0.592, 1.000) | 0.028608 | (0.000000, 0.01694732, 0.02860766) |
| | SP5 | (0.000, 5.835, 10.000) | (0.000, 0.584, 1.000) | 0.029061 | (0.000000, 0.01695854, 0.02906128) |
| | SP6 | (0.000, 6.650, 10.000) | (0.000, 0.665, 1.000) | 0.028743 | (0.000000, 0.01911427, 0.02874326) |

**Table 8.** Prioritization of PIs

| Performance constructs | Code | Mean | $A^+$ | $A^-$ | $d_i^+$ | $d_i^-$ | $CC_i$ | Rank |
|---|---|---|---|---|---|---|---|---|
| PP | PP1 | 4.49 | (0.0029, 0.0230, 0.0291) | (0.0000, 0.0191, 0.0281) | 0.00435 | 0.00499 | 0.534 | 6 |
| | PP2 | 4.93 | | | 0.00199 | 0.00166 | 0.456 | 7 |
| | PP3 | 5.35 | | | 0.00000 | 0.00289 | 1.000 | 1 |
| | PP4 | 5.32 | | | 0.00329 | 0.00511 | 0.608 | 4 |
| | PP5 | 5.58 | | | 0.00325 | 0.00548 | 0.628 | 3 |
| | PP6 | 4.93 | | | 0.00371 | 0.00484 | 0.566 | 5 |
| | PP7 | 5.54 | | | 0.00259 | 0.00548 | 0.679 | 2 |
| | PP8 | 4.95 | | | 0.00259 | 0.00043 | 0.143 | 8 |
| CP | CP1 | 5.00 | (0.0000, 0.0194, 0.0291) | (0.0000, 0.0161, 0.0283) | 0.00500 | 0.00562 | 0.529 | 8 |
| | CP2 | 4.74 | | | 0.00089 | 0.00117 | 0.565 | 7 |
| | CP3 | 5.07 | | | 0.00069 | 0.00129 | 0.650 | 4 |
| | CP4 | 4.55 | | | 0.00093 | 0.00277 | 0.749 | 3 |
| | CP5 | 4.13 | | | 0.00196 | 0.00000 | 0.000 | 11 |
| | CP6 | 4.60 | | | 0.00193 | 0.00192 | 0.498 | 9 |
| | CP7 | 5.05 | | | 0.00077 | 0.00255 | 0.768 | 2 |
| | CP8 | 4.35 | | | 0.00120 | 0.00083 | 0.408 | 10 |
| | CP9 | 5.15 | | | 0.00208 | 0.00356 | 0.632 | 6 |
| | CP10 | 4.73 | | | 0.00000 | 0.00196 | 1.000 | 1 |
| | CP11 | 4.98 | | | 0.00192 | 0.00332 | 0.634 | 5 |
| PM | PM1 | 4.48 | (0.0029, 0.0183, 0.0291) | (0.0029, 0.0180, 0.0291) | 0.00019 | 0.00000 | 0.000 | 3 |
| | PM2 | 4.54 | | | 0.00000 | 0.00019 | 1.000 | 1 |
| | PM3 | 4.49 | | | 0.00015 | 0.00001 | 0.222 | 2 |
| PS | PS1 | 4.57 | (0.0000, 0.0185, 0.0291) | (0.0029, 0.0180, 0.0290) | 0.00000 | 0.00169 | 1.000 | 1 |
| | PS2 | 4.44 | | | 0.00169 | 0.00000 | 0.000 | 2 |
| SP | SP1 | 4.50 | (0.0029, 0.0215, 0.0291) | (0.0000, 0.0157, 0.0286) | 0.00241 | 0.00376 | 1.000 | 1 |
| | SP2 | 5.12 | | | 0.00025 | 0.00394 | 0.939 | 2 |
| | SP3 | 4.01 | | | 0.00376 | 0.00000 | 0.000 | 6 |
| | SP4 | 4.25 | | | 0.00315 | 0.00070 | 0.183 | 5 |
| | SP5 | 4.23 | | | 0.00308 | 0.00081 | 0.209 | 3 |
| | SP6 | 4.65 | | | 0.00313 | 0.00075 | 0.194 | 4 |

**Table 9.** Mean expectation and coefficient of variance of determinants

| Code | Performance indicators (PIs) and selected determinants | Performance level | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Poor | | Average | | Good | | Very good | | Excellent | |
| | | ME | CV | ME | CV | ME | CV | ME | CV | ME | CV |
| *PP1* | *Completing the project within budgeted cost* | | | | | | | | | | |
| PP1a | Variation of actual project cost expressed as a proportion of final agreed project cost | -6.42% | -0.78 | -2.06% | -3.35 | 1.12% | 1.47 | 3.96% | 0.88 | 5.12% | 0.39 |
| *PP2* | *Completing the project within estimated schedule* | | | | | | | | | | |
| PP2a | Variation of actual completion schedule expressed as a proportion of final agreed completion schedule | -9.57% | -0.40 | -1.29% | -2.18 | 3.64% | 1.82 | 10.31% | 0.65 | 14.76% | 0.64 |
| *PP3* | *Achieving the required quality* | | | | | | | | | | |
| PP3a | Cost of rework expressed as a proportion of total project cost | 10.75% | 1.01 | 3.44% | 0.67 | 1.18% | 0.52 | 0.73% | 0.31 | 0.27% | 0.10 |
| *PP4* | *Client satisfaction* | | | | | | | | | | |
| PP4a | Perceived client satisfaction score by using Likert scale | 2.14 | 0.58 | 4.23 | 0.47 | 6.94 | 0.21 | 8.18 | 0.09 | 9.07 | 0.08 |
| *PP5* | *Good safety performance* | | | | | | | | | | |
| PP5a | Number of accidents expressed as a proportion of the total number of workers | 11.86% | 1.15 | 5.84% | 0.83 | 2.35% | 0.57 | 0.58% | 0.26 | 0.10% | 0.11 |
| *PP6* | *Dispute resolution* | | | | | | | | | | |
| PP6b | Dispute resolution cost expressed as a proportion of original contract cost | 25.00% | 0.49 | 11.05% | 0.30 | 5.55% | 0.13 | 1.35% | 0.08 | 0.45% | 0.05 |
| *PP7* | *Profitability* | | | | | | | | | | |
| PP7a | Percentage of revenue earned for the work performed as against the cost incurred | 21.86% | 1.24 | 35.73% | 1.08 | 48.21% | 0.74 | 71.44% | 0.55 | 89.00% | 0.23 |
| *PP8* | *Ethics in management* | | | | | | | | | | |
| PP8a | Cost of management expressed as a proportion of total project cost | 68.53% | 1.62 | 34.57% | 1.33 | 23.06% | 0.80 | 10.33% | 0.50 | 4.83% | 0.16 |
| *CP1* | *Sharing of risks equitably* | | | | | | | | | | |
| CP1b | Perceived partners' satisfaction scores by using Likert scale | 3.11 | 0.85 | 5.25 | 0.54 | 7.46 | 0.33 | 8.00 | 0.23 | 8.26 | 0.19 |
| *CP2* | *Resource sharing* | | | | | | | | | | |
| CP2c | Perceived partners' satisfaction scores by using Likert scale | 3.32 | 1.10 | 5.41 | 0.77 | 7.20 | 0.48 | 8.19 | 0.12 | 9.07 | 0.05 |
| *CP3* | *Cost reduction* | | | | | | | | | | |
| CP3a | Cost saving resulting from innovation expressed as a proportion of total project cost | 10.55% | 0.47 | 25.72% | 0.39 | 47.51% | 0.24 | 75.60% | 0.14 | 88.00% | 0.10 |
| *CP4* | *Technology acquisition* | | | | | | | | | | |
| CP4b | Perceived partners' satisfaction scores by using Likert scale | 1.22 | 1.06 | 3.28 | 0.66 | 5.75 | 0.50 | 7.41 | 0.20 | 8.91 | 0.07 |
| *CP5* | *Facilitating internationalization* | | | | | | | | | | |
| CP5c | Perceived partners' satisfaction scores by using Likert scale | 3.10 | 0.53 | 4.83 | 0.41 | 6.67 | 0.37 | 8.25 | 0.15 | 9.04 | 0.10 |
| *CP6* | *Enhancing competitiveness* | | | | | | | | | | |
| CP6a | International projects secured expressed as a proportion of the total number of projects per year | 15.20% | 0.63 | 22.38% | 0.50 | 25.02% | 0.35 | 30.50% | 0.17 | 47.29% | 0.11 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *CP7* | *Creating long-term relationships* | | | | | | | | | | |
| CP7c | Perceived partners' satisfaction scores by using Likert scale | 1.72 | 1.02 | 3.47 | 0.78 | 6.20 | 0.59 | 7.05 | 0.40 | 7.54 | 0.26 |
| *CP8* | *Acquisition of managerial skills* | | | | | | | | | | |
| CP8b | Perceived partners' satisfaction scores by using Likert scale | 1.22 | 1.06 | 3.28 | 0.66 | 5.75 | 0.50 | 7.41 | 0.20 | 8.91 | 0.07 |
| *CP9* | *Reputation* | | | | | | | | | | |
| CP9c | Perceived partners' satisfaction scores by using Likert scale | 1.89 | 0.43 | 3.27 | 0.36 | 5.29 | 0.25 | 7.77 | 0.14 | 8.33 | 0.10 |
| *CP10* | *Communication, learning, and development* | | | | | | | | | | |
| CP10c | Perceived partners' satisfaction scores by using Likert scale | 2.02 | 0.60 | 4.00 | 0.52 | 6.85 | 0.37 | 8.21 | 0.17 | 9.56 | 0.09 |
| *CP11* | *Market share* | | | | | | | | | | |
| CP11a | Perceived partners' satisfaction scores by using Likert scale | 1.10 | 0.55 | 3.15 | 0.31 | 5.44 | 0.28 | 7.73 | 0.18 | 8.72 | 0.13 |
| *PM1* | *Effective strategic control* | | | | | | | | | | |
| PM1a | Percentage of partners' personnel in top management level | 20.32% | 1.85 | 48.55% | 0.62 | 60.12% | 0.46 | 87.05% | 0.22 | 90.80% | 0.18 |
| *PM2* | *Effective operational control* | | | | | | | | | | |
| PM2a | Percentage of partners' personnel in key functional and operational areas | 15.37% | 1.20 | 35.48% | 1.01 | 56.24% | 0.65 | 74.00% | 0.48 | 85.55% | 0.25 |
| *PM3* | *Effective organizational control* | | | | | | | | | | |
| PM3a | Percentage of partners' personnel in managing the ICJV organization | 20.37% | 1.52 | 31.48% | 1.21 | 66.24% | 0.55 | 75.39% | 0.35 | 90.54% | 0.14 |
| *PS1* | *Overall satisfaction* | 2.52 | 1.03 | 3.67 | 0.80 | 5.50 | 0.58 | 7.09 | 0.31 | 9.30 | 0.20 |
| PS1a | Perceived partners' satisfaction scores by using Likert scale | | | | | | | | | | |
| *PS2* | *Stability of the ICJV* | | | | | | | | | | |
| PS2b | Perceived partners' satisfaction scores by using Likert scale | 1.04 | 0.75 | 3.43 | 0.51 | 5.52 | 0.25 | 7.28 | 0.17 | 8.14 | 0.11 |
| *SP1* | *Sustainable job creation* | | | | | | | | | | |
| SP1a | Number of local workforces employed expressed as a proportion of the total workforce | 11.07% | 0.61 | 27.55% | 0.47 | 51.53 | 0.37 | 82.00% | 0.23 | 85.05% | 0.10 |
| *SP2* | *Stakeholder engagement* | | | | | | | | | | |
| SP2c | Perceived partners' satisfaction scores by using Likert scale | 1.15 | 0.46 | 4.12 | 0.30 | 6.01 | 0.17 | 8.58 | 0.12 | 9.15 | 0.08 |
| *SP3* | *Social reporting* | | | | | | | | | | |
| SP3b | Perceived partners' satisfaction scores by using Likert scale | 2.93 | 1.20 | 3.98 | 0.82 | 5.67 | 0.51 | 7.11 | 0.30 | 8.66 | 0.25 |
| *SP4* | *Avoidance of material wastage* | | | | | | | | | | |
| SP4a | Percentage of material wastes produce per month | 73.54% | 1.31 | 21.72% | 0.56 | 13.36% | 0.32 | 7.42% | 0.15 | 2.50% | 0.10 |
| *SP5* | *Pollution reduction* | | | | | | | | | | |
| SP5a | Percentage of pollutants (i.e. water, noise, air) produce per month | 73.54% | 1.31 | 21.72% | 0.56 | 13.36% | 0.32 | 7.42% | 0.15 | 2.50% | 0.10 |
| *SP6* | *Environmental compliance* | | | | | | | | | | |
| SP6b | Perceived partners' satisfaction scores by using Likert scale | 2.12 | 1.60 | 3.76 | 0.52 | 5.85 | 0.27 | 7.40 | 0.14 | 8.19 | 0.04 |

Note: CV = Coefficient of variance; ME = Mean expectation

**Table 10.** Quantitative ranges of determinants

| | Performance levels | | | | |
|---|---|---|---|---|---|
| Code | Poor | Average | Good | Very good | Excellent |
| PP1a | <-4.24% | -4.24% – 0.47% | 0.47% – 2.54% | 2.54% – 4.54% | >4.54% |
| PP2a | <-5.43% | -5.43% – 1.18% | 1.18% – 6.98% | 6.98% – 12.54% | >12.54% |
| PP3a | >7.10% | 2.31% – 7.10% | 1.00% – 2.31% | 0.50% – 1.00% | <0.50% |
| PP4a | <3.19 | 3.19 – 5.59 | 5.59 – 7.56 | 7.56 – 8.63 | >8.63 |
| PP5a | >8.85% | 4.10% – 8.85% | 1.47% – 4.10% | 0.34% – 1.47% | <0.34% |
| PP6b | >18.03% | 8.30% – 18.03% | 3.45% – 8.30% | 0.90% – 3.45% | <0.90% |
| PP7a | <28.80% | 28.80% – 41.97% | 41.97% – 59.83% | 59.83% – 80.22% | >80.22% |
| PP8a | >51.55% | 28.82% – 51.55% | 16.70% – 28.82% | 7.58% – 16.70% | <7.58% |
| CP1b | <4.18 | 4.18 – 6.36 | 6.36 – 7.73 | 7.73 – 8.13 | >8.13 |
| CP2c | <4.37 | 4.37 – 6.31 | 6.31 – 7.70 | 7.70 – 8.63 | >8.63 |
| CP3a | <18.14% | 18.14 – 36.62% | 36.62% – 61.56% | 61.56% – 81.80% | >81.80% |
| CP4b | <2.25 | 2.25 – 4.52 | 4.52 – 6.58 | 6.58 – 8.16 | >8.16 |
| CP5c | <3.97 | 3.97 – 5.75 | 5.75 – 7.46 | 7.46 – 8.65 | >8.65 |
| CP6a | <18.79% | 18.79% – 23.70% | 23.70% – 27.76% | 27.76% – 38.90% | >38.90% |
| CP7c | <2.60 | 2.60 – 4.84 | 4.84 – 6.63 | 6.63 – 7.30 | >7.30 |
| CP8b | <2.25 | 2.25 – 4.52 | 4.52 – 6.58 | 6.58 – 8.16 | >8.16 |
| CP9c | <2.58 | 2.58 – 4.28 | 4.28 – 6.53 | 6.53 – 8.05 | >8.05 |
| CP10c | <3.01 | 3.01 – 5.43 | 5.43 – 7.53 | 7.53 – 8.89 | >8.89 |
| CP11a | <2.13 | 2.13 – 4.30 | 4.30 – 6.59 | 6.59 – 8.23 | >8.23 |
| PM1a | <34.44% | 34.44% – 54.34% | 54.34% – 73.59% | 73.59% – 88.93% | >88.93% |
| PM2a | <25.45% | 25.45% – 45.86% | 45.86% – 65.12% | 65.12% – 79.78% | >79.78% |
| PM3a | <25.93% | 25.93% – 48.86% | 48.86% – 70.82% | 70.82% – 82.97% | >82.97% |
| PS1a | <3.10 | 3.10 – 4.59 | 4.59 – 6.30 | 6.30 – 8.20 | >8.20 |
| PS2b | <2.24 | 2.24 – 4.48 | 4.48 – 6.40 | 6.40 – 7.71 | >7.71 |
| SP1a | <19.31% | 19.31% – 39.54% | 39.54% – 66.77% | 66.77% – 83.53% | >83.53% |
| SP2c | <2.64 | 2.64 – 5.07 | 5.07 – 7.30 | 7.30 – 8.87 | >8.87 |
| SP3b | <3.46 | 3.46 – 4.83 | 4.83 – 6.39 | 6.39 – 7.89 | >7.89 |
| SP4a | >47.63% | 17.54% – 47.63% | 10.39% – 17.54% | 4.96% – 10.39% | <4.96% |
| SP5a | >47.63% | 17.54% – 47.63% | 10.39% – 17.54% | 4.96% – 10.39% | <4.96% |
| SP6b | <2.94 | 2.94 – 4.81 | 4.81 – 6.63 | 6.63 – 7.80 | >7.80 |

## Appendix I. Fuzzy Extent Analytical Hierarchy Process (FEAHP) and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) techniques

### *Procedure for the FEAHP technique*

Based on the conversion rule defined in Table 1, the linguistic terms assigned to each PI were transformed to triangular fuzzy numbers (TFNs). The maximum and minimum value of participant opinions are used as the two terminal points of TFNs. The geometric mean is taken as the membership degree of TFNs to obtain the statistical unbiased effect. A TFN is expressed by ($\alpha_i$, $\delta_i$, $\gamma_i$) where $\alpha_i$, $\delta_i$, and $\gamma_i$ denote the lower, modal and upper values, respectively. The first step is to compile and convert the linguistic terms into the TFN (see Table 2), Eqs. (1) and (2) are used:

$$E_i(\lambda) = (\alpha_i, \delta_i, \gamma_i),\ i = 1, 2, \ldots, n \quad (1)$$

$$A_i(\lambda) = (\alpha_{iA}, \delta_{iA}, \gamma_{iA}) = (\min(B_{ijA}), Gm, \max(B_{ijA}))\quad i = 1, 2, \ldots, n \quad (2)$$

where $E_i(\lambda)$ represents the TFN response of participant $i$ for PI $\lambda$, $A_i(\lambda)$ is the accumulation of the responses of all participants for PI $\lambda$. On the other hand, $\min(B_{ijA})$, $Gm$, and $\max(B_{ijA})$, indicate the minimum evaluation value, the geometric mean of all evaluation values, and the maximum evaluation value, respectively.

Table 1. Linguistic variables and TFNs scale of PI for the significant weight

| Linguistic variables | TFN assigned | TFN reciprocal scale |
|---|---|---|
| Not important (NI)/Not realized (NR) | (0,0,1) | (1,0,0) |
| Least important (LI)/Least realized (LR) | (0,1,3) | (1/3,1,0) |
| Fairly important (FI)/Fairly realized (FR) | (1,3,5) | (1/5,1/3,1) |
| Moderate (M)/Moderate (M) | (3,5,7) | (1/7,1/5,1/3) |
| Important (I)/Realized (R) | (5,7,9) | (1/9,1/7,1/5) |
| Very important (VI)/Highly realized (HR) | (7,9,10) | (1/7,1/9,1/10) |
| Most important (MI)/Most realized (MR) | (9,10,10) | (1/10,1/10,1/9) |

The second step is to compute fuzzy extent synthetic value ($S_i$), which is defined as:

$$S_i = \sum_{j=1}^{n} M_{g_i}^{j} \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} \quad (3)$$

Where $\sum_{j=1}^{n} M_{g_i}^{j}$ denotes the fuzzy addition operation of m degree analysis value, and $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]$ represents the fuzzy addition operation of $M_{g_i}^{j}$ ($j$ = 1, 2, 3, …., $m$) value.

Afterward, the degree of possibility of $M_2 = (a_2, m_2, \gamma_2) \geq M_1\ (a_1, m_1, \gamma_1)$ is then defined. The highest point of intersection $D$ between $\mu_{M_1}$ and $\mu_{M_2}$ as depicted in Fig. 7 needs to be computed using the following expression:

$$\begin{cases} 1, & if\ m_2 > m_1 \\ 0, & if\ l_1 > u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise,} \end{cases} \quad (4)$$

The next step is priority weight calculation, which is given as:

$$W' = (d'(A_1),\ d'(A_2), \ldots, d'(A_n))^T \quad (5)$$

where $d'(A_i) = d(A_i)/\sum_{j=1}^{n} d(A_i)$, $d(A_i) = \min V_{(M_i \geq M_k)}$, and $\sum_{j=1}^{n} d'(A_i) = 1$. The defuzzified weight $W$ is used for further calculations.

***Procedure for the FTOPSIS Technique***

The first step is the aggregation of fuzzy rating calculation from the linguistic terms' ratings as established before using the transformation rule depicted in Table 1. The second step is developing normalized fuzzy rated decision matrix. By employing linear scale transformation, the combined fuzzy weights of different criteria scales are converted into an equivalent scale. The normalized fuzzy decision matrix is given by $\tilde{R}$ where:

$$\tilde{R} = [r_{ij}]_{mxn} i = 1, 2, 3, \ldots, m \text{ and } j = 1, 2, 3, \ldots, n \quad (6)$$

where $r_{ij} = \left(\frac{x_{1ij}}{x^*_{3j}}, \frac{x_{2ij}}{x^*_{3j}}, \frac{x_{3ij}}{x^*_{3j}}\right)$, $x^*_{3j} = \max x_{3ij}$, or $r_{ij} = \left(\frac{x^-_{1j}}{x_{3ij}}, \frac{x^-_{1j}}{x_{2ij}}, \frac{x^-_{1j}}{x_{1ij}}\right)$, $x^-_{1j} = \min x_{1ij}$

The third step is the incorporation of weights into the decision matrix. This created using the normalized matrix. Assuming $\tilde{V}$ denotes the weighted fuzzy normalized matrix, then it will be determined by using the expression below.

$$\tilde{V} = [v_{ij}]_{mxn} i = 1, 2, 3, \ldots, m \text{ and } j = 1, 2, 3, \ldots, n \quad (7)$$

where, $\tilde{V}_{ij} = \tilde{r}_{ij}$ x $w_j$, and $w_j$ denotes the normalized weight vector obtained from the previous calculations.

The fourth step is the computation of PIS ($A^+$) and NIS ($A^-$). This is performed based on the weighted decision matrix and are computed as follows:

$$A^+ = (\tilde{v}_1^+, \tilde{v}_j^+, , , \ldots \tilde{v}_n^+), \text{where } \tilde{v}_j^+ = \max_i \{x_{3ij}\} \quad (8)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_j^-, , , \ldots \tilde{v}_n^-), \text{where } \tilde{v}_j^- = \min_i \{x_{1ij}\} \quad (9)$$

The fifth step is calculating the distance of the evaluation alternatives from PIS and NIS. The Euclidean distance formula is utilized to determine the separation measures. The Eqs. are:

$$d(\tilde{X}, \tilde{Y}) = \sqrt{\frac{1}{3}[(v_1 - w_1)^2 + (v_2 - w_2)^2 + (v_3 - w_3)^2]} \quad (10)$$

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^+), \; i = 1, 2, \ldots, m; \; j = 1, 2, \ldots n \quad (11)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^-), \; i = 1, 2, \ldots, m; \; j = 1, 2, \ldots n \quad (12)$$

where $d_i^+$ is the distance between the PIS and each weighted matrix; and $d_i^-$ is the distance between the NIS and each weighted matrix. The last step is determining the relative performance measures values and rank base on the closeness coefficient ($CC_i$). Thus, the closer the $CC_i$ gets to 1 the better the evaluation alternative.

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (13)$$

**Appendix II. Average Mean Scores of Determinants**

| Code | Performance determinants | Importance | Measurability | Obtainability | Mean scores |
|---|---|---|---|---|---|
| | *Completing the project within budgeted cost* | | | | |
| PP1a | Variation of actual project cost expressed as a proportion of final agreed project cost | 6.29 | 6.65 | 6.41 | 6.45* |
| PP1b | Subjective evaluation by using a Likert scale (e.g., within budget, on budget, or overrun budget) | 6.00 | 4.88 | 4.82 | 5.23 |
| | *Completing the project within estimated schedule* | | | | |
| PP2a | Variation of actual completion schedule expressed as a proportion of final agreed completion schedule | 6.41 | 6.29 | 6.47 | 6.39* |
| PP2b | Subjective evaluation by using a Likert scale (e.g., ahead of schedule, on time, or behind schedule) | 6.59 | 4.76 | 5.00 | 5.45 |
| | *Achieving the required quality* | | | | |
| PP3a | Cost of rework expressed as a proportion of total project cost | 5.76 | 6.35 | 6.53 | 6.21* |
| PP3b | Average number of nonconformance reports produced per month | 5.71 | 6.29 | 5.53 | 5.84 |
| PP3c | Perceived customers' satisfaction scores by using Likert scale | 6.53 | 4.71 | 4.71 | 5.32 |
| | *Client satisfaction* | | | | |
| PP4a | Perceived client satisfaction with services including project schedule, cost, quality of work, etc. procedures by using Likert scale | 6.65 | 5.29 | 5.00 | 5.65* |
| | *Good safety performance* | | | | |
| PP5a | Number of accidents expressed as a proportion of the total number of workers | 6.59 | 5.82 | 5.76 | 6.06* |
| PP5b | Number of days lost expressed as a proportion of yearly average of workers | 6.18 | 6.00 | 5.94 | 6.04 |
| PP5c | Perceived partners' satisfaction scores by using Likert scale | 6.47 | 4.41 | 4.65 | 5.18 |
| | *Dispute resolution* | | | | |
| PP6a | Number of disputes, and the resolution cost per year | 6.41 | 6.41 | 5.59 | 6.14 |
| PP6b | Dispute resolution cost expressed as a proportion of original contract cost | 6.35 | 6.71 | 6.24 | 6.43* |
| PP6c | Average duration for settling disputes | 5.88 | 5.06 | 5.35 | 5.43 |
| PP6d | Subjective evaluation by using a Likert scale | 5.82 | 4.94 | 5.18 | 5.31 |
| | *Profitability* | | | | |
| PP7a | Percentage of revenue earned for the work performed as against the cost incurred | 6.82 | 6.65 | 5.94 | 6.47* |
| PP7b | Subjective evaluation by using a Likert scale | 5.47 | 5.41 | 5.24 | 5.37 |
| | *Ethics in management* | | | | |
| PP8a | Cost of management expressed as a proportion of total project cost | 6.35 | 6.29 | 6.24 | 6.29* |
| PP8b | Perceived partners' satisfaction scores by using Likert scale | 5.53 | 5.82 | 5.24 | 5.53 |
| | *Sharing of risks equitably* | | | | |
| CP1a | Number of risks borne by a partner expressed as proportion of the total risk on the project | 6.12 | 4.88 | 5.24 | 5.41 |
| CP1b | Perceived partners' satisfaction scores by using Likert scale | 6.71 | 5.71 | 5.65 | 6.02* |
| | *Resource sharing* | | | | |
| CP2a | Percentage ratio of resources provided by each partner to the total volume of work to be completed | 6.53 | 6.18 | 5.12 | 5.94 |

| | | | | | |
|---|---|---|---|---|---|
| CP2b | Number of resources provided by each partner expressed as a proportion of the total number resources required | 5.59 | 5.35 | 4.88 | 5.27 |
| CP2c | Perceived partners' satisfaction scores by using Likert scale | 5.88 | 6.06 | 6.00 | 5.98* |
| | *Cost reduction* | | | | |
| CP3a | Cost saving resulting from innovation expressed as a proportion of total project cost | 6.29 | 5.94 | 6.06 | 6.10* |
| CP3b | Subjective evaluation by using a Likert scale | 5.88 | 5.35 | 5.06 | 5.43 |
| | *Technology acquisition* | | | | |
| CP4a | Number of technology forms obtained, and the ease of application | 6.12 | 5.24 | 5.24 | 5.53 |
| CP4b | Perceived partners' satisfaction scores by using Likert scale | 6.41 | 6.12 | 5.88 | 6.14* |
| | *Facilitating internationalization* | | | | |
| CP5a | Number of visits to partners' home country per year | 5.76 | 5.59 | 5.12 | 5.49 |
| CP5b | Number of international networks obtained after completion of ICJV project | 5.65 | 6.06 | 5.24 | 5.65 |
| CP5c | Perceived partners' satisfaction scores by using Likert scale | 5.76 | 6.12 | 6.12 | 6.00* |
| | *Enhancing competitiveness* | | | | |
| CP6a | International projects secured expressed as a proportion of the total number of projects per year | 5.82 | 6.29 | 6.24 | 6.12* |
| CP6b | Imitation attempts by competitors | 5.82 | 4.65 | 4.94 | 5.14 |
| CP6c | Perceived partners' satisfaction scores by using Likert scale | 6.00 | 5.12 | 4.59 | 5.24 |
| | *Creating long-term relationships* | | | | |
| CP7a | Frequency of parties engaging in other projects | 6.35 | 4.59 | 4.59 | 5.18 |
| CP7b | Frequency of meeting partners' expectation | 6.47 | 5.18 | 4.76 | 5.47 |
| CP7c | Perceived partners' satisfaction scores by using Likert scale | 5.94 | 6.47 | 5.76 | 6.06* |
| | *Acquisition of managerial skills* | | | | |
| CP8a | Number of managerial skills acquired and the ease of implementation (e.g., innovative construction techniques, management strategies, etc.) | 5.82 | 4.82 | 4.18 | 4.94 |
| CP8b | Perceived partners' satisfaction scores by using Likert scale | 6.35 | 6.18 | 5.76 | 6.10* |
| | *Reputation* | | | | |
| CP9a | Number of additional projects secured during the ICJV project execution | 6.41 | 6.00 | 5.35 | 5.92 |
| CP9b | Ratio of commendations to the number of complaints by the client | 5.76 | 5.12 | 5.18 | 5.35 |
| CP9c | Perceived partners' satisfaction scores by using Likert scale | 6.06 | 6.35 | 5.41 | 5.94* |
| | *Communication, learning, and development* | | | | |
| CP10a | Variation of the number of formal letters and emails sent between parties per months against the number with previous similar projects | 5.82 | 5.53 | 4.59 | 5.31 |
| CP10b | Number of formal and informal days training provided in skills development related to construction management | 5.94 | 5.53 | 5.53 | 5.67 |
| CP10c | Perceived partners' satisfaction scores by using Likert scale | 6.35 | 6.00 | 5.24 | 5.86* |
| | *Market share* | | | | |
| CP11a | Number of projects secured (local and/or foreign market) compared with the previous year | 6.29 | 5.47 | 5.47 | 5.74 |
| CP11b | Perceived partners' satisfaction scores by using Likert scale | 6.53 | 5.94 | 6.24 | 6.24* |
| | *Effective strategic control* | | | | |

| | | | | | |
|---|---|---|---|---|---|
| PM1a | Percentage of partners' personnel in top management level | 6.47 | 6.29 | 5.94 | 6.23* |
| PM1b | Determining the commitment level of partners in top positions by using Likert scale (e.g., low, average, or high) | 5.94 | 5.53 | 5.18 | 5.55 |
| | *Effective operational control* | | | | |
| PM2a | Percentage of partners' personnel in key functional and operational areas | 6.47 | 6.12 | 6.24 | 6.28* |
| PM2b | Determining the commitment level of partners in operational areas by using Likert scale (e.g., low, average, or high) | 6.24 | 5.12 | 4.65 | 5.34 |
| | *Effective organizational control* | | | | |
| PM3a | Percentage of partners' personnel in managing the ICJV organization | 6.24 | 6.06 | 5.59 | 5.96* |
| PM3b | Determining the commitment level of partners in the ICJV organization by using Likert scale (e.g., low, average, or high) | 5.94 | 4.94 | 5.00 | 5.29 |
| | *Overall satisfaction* | | | | |
| PS1a | Perceived partners' satisfaction scores by using Likert scale | 6.59 | 5.35 | 5.59 | 5.84* |
| | *Stability of the ICJV* | | | | |
| PS2a | Average duration for settling conflicts among partners | 5.71 | 5.29 | 4.82 | 5.27 |
| PS2b | Perceived partners' satisfaction scores by using Likert scale | 6.35 | 5.82 | 6.29 | 6.15* |
| | *Sustainable job creation* | | | | |
| SP1a | Number of local workforce employed expressed as a proportion of the total workforce | 6.41 | 6.18 | 6.00 | 6.20* |
| SP1b | Perceived partners' satisfaction scores by using Likert scale | 6.24 | 5.53 | 5.06 | 5.61 |
| | *Stakeholder engagement* | | | | |
| SP2a | Frequency of involving the local communities in the decision-making process during planning, design, and construction | 5.65 | 5.24 | 4.12 | 5.00 |
| SP2b | The attendance and contribution level of locals during decision-making | 6.18 | 5.59 | 4.53 | 5.43 |
| SP2c | Perceived partners' satisfaction scores by using Likert scale | 6.24 | 5.35 | 5.47 | 5.69* |
| | *Social reporting* | | | | |
| SP3a | Average number of times of providing project updates to the public per specific milestone | 5.76 | 4.94 | 4.94 | 5.21 |
| SP3b | Perceived partners' satisfaction scores by using Likert scale | 6.24 | 6.29 | 5.06 | 5.86* |
| | *Avoidance of material wastage* | | | | |
| SP4a | Percentage of material wastes produce per month | 6.65 | 5.94 | 5.71 | 6.10* |
| SP4b | Perceived partners' satisfaction scores by using Likert scale | 6.41 | 5.29 | 4.59 | 5.43 |
| | *Pollution reduction* | | | | |
| SP5a | Percentage of pollutants (i.e. water, noise, air) produce per month | 6.41 | 6.00 | 5.76 | 6.06* |
| SP5b | Perceived partners' satisfaction scores by using Likert scale | 5.94 | 5.18 | 4.94 | 5.35 |
| | *Environmental compliance* | | | | |
| SP6a | Summation of earned rating for each environmental indicator based on the measurement and the assigned priority according to local regulations and conditions | 6.25 | 5.41 | 4.65 | 5.44 |
| SP6b | Perceived partners' satisfaction scores by using Likert scale | 6.59 | 6.24 | 5.71 | 6.18* |

*Selected determinants for further analysis