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*Published in:*  
Automation in Construction

*DOI:*  
[10.1016/j.autcon.2018.11.006](https://doi.org/10.1016/j.autcon.2018.11.006)

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*Recommended citation(APA):*  
Liu, J., Li, H., Skitmore, M., & Zhang, Y. (2019). Experience mining based on case-based reasoning for dispute settlement of international construction projects. *Automation in Construction*, 97, 181-191.  
<https://doi.org/10.1016/j.autcon.2018.11.006>

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1 **Experience Mining Based on Case-Based Reasoning for Dispute Settlement of**  
2 **International Construction Projects**

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9 **Abstract:** Considering the experience-orientation of the construction industry, the  
10 valuable experience of similar historical cases is important reference to resolve new  
11 problems, while research concerning this issue in dispute settlement is still relatively  
12 scarce. The objectives of this study are to (1) propose a pragmatic method for generating  
13 dispute settlement for international construction projects based on Case-Based  
14 Reasoning (CBR); and (2) validate the CBR model by a specific dispute case. To  
15 achieve the research objectives, successful historical cases are collected, and attributes  
16 that influence dispute-related problems are derived. A two-step refinement process is  
17 then conducted to extract similar cases. Finally, a dispute case in Ethiopia is used to  
18 demonstrate the application of developed model. This innovative dispute settlement  
19 model enriches the theoretical framework in the field of experience mining for decision  
20 maker, and the selected experiences provide an effective reference to resolve new  
21 dispute problems and reduce the transaction costs of dispute settlement.

22 **Keywords:** Dispute settlement; Case-Based Reasoning (CBR); Causes of disputes;  
23 Project attributes; Host country attributes; Similarity measure.

## 24 **1 Introduction**

25 International construction involves not only the uncertainties peculiar to international  
26 transaction but also all the risk common to domestic construction projects [32,50].  
27 Furthermore, international construction projects are more vulnerable to disputes  
28 resulting from such factors as different contracts, cultural background, languages, and  
29 technical standards [32,55]. Hence, disputes have been one of the main factors  
30 preventing the successful completion of international construction projects [10].

31 Generally, negotiation, mediation, arbitration, and litigation are common Alternative  
32 Dispute Resolution (ADR) approaches when disputes arise in international construction  
33 projects. These have been very important in dispute management, and are likely  
34 continue to be the most common and recognized method of resolving construction  
35 disputes. However, they are also well recognized as being highly costly [22,41], not  
36 only in terms of the amount paid out in the final settlement, but also the transaction  
37 costs involved in the dispute-solving process[49], which usually include lawyers' fees,  
38 arbitration/mediation/court fees, consultant and expert witness costs, and expenditure  
39 in searching for information[52]. In many cases, the transaction costs involved may  
40 even exceed the amount paid out in the final settlement. Therefore, it is important to  
41 establish a more effective system that can reduce the transaction costs invested in the  
42 process of dispute settlement.

43 With the experience-oriented construction industry, the knowledge and judgments of  
44 past experiences are key factors to resolving problems that may reoccur, which suggests  
45 that the successful dispute management practices adopted in prior projects can be  
46 applied in new projects, especially for more complex international construction projects  
47 [17]. It is beneficial to reduce lawyers' fees, consultant and expert witness costs, cost of  
48 collecting related information, etc., as much as possible. However, existing studies

49 mainly concentrate on the selection of ADR methods [7,19-21,24,32,37], the causes of  
50 disputes [10,23,61,64], and such factors affecting dispute settlement as culture  
51 [6,33,34,62] and trust [38].

52 Objective and quantitative management based on actual data is required to support  
53 more practical and effective dispute management. One approach is Case-Based  
54 Reasoning (CBR), which is a methodology that retrieves valuable experiences from  
55 historical cases as references for decision-maker to solve similar problems [4,40,60].  
56 This can be used for construction work as, despite the unique features of each project,  
57 the methods and procedures used to solve problems are similar [46]. The CBR  
58 technique has been applied in a wide range of experience-intensive problems due to  
59 such advantages as its suitability for solving complex and unstructured problems, and  
60 convenience in updating the knowledge database [67].

61 Moreover, according to the ARCADIS' 2017 *Global Construction Dispute Report:*  
62 *Avoiding the Same Pitfalls*, the 2017 top five most common causes of construction  
63 disputes throughout North America, the United Kingdom, Continental Europe, the  
64 Middle East, and Asia are consistent with those in 2016. This means that a huge amount  
65 of historical data is available to enable similar cases to be identified, and ensuring the  
66 feasibility of the CBR method in dispute management.

67 In response, this study aims to establish a dispute settlement model for international  
68 construction projects based on the CBR method, mining the successful experience in  
69 historical dispute settlement cases.

70 The process to conduct the research is as follows. Firstly, a literature review of  
71 research methods used to generate construction dispute resolution strategies is carried  
72 out. Next, the CBR-based dispute settlement model is built (i.e., establishing the case  
73 base, case representation, extracting the attributes and computation of weight, retrieving

74 similar cases, reuse, and retention). Finally, a text case is selected to demonstrate the  
75 application of the model.

76 This innovative dispute settlement model enriches the theoretical framework in the  
77 field of experience mining for decision makers, and the selected experiences provide  
78 an effective reference for resolving new dispute problems and reducing the transaction  
79 costs involved .

## 80 **2 Literature review**

81 Research methods used to generate construction dispute resolution strategies can be  
82 classified into three sections.

83 (1) *Survey-based methods*: based on interview or questionnaire surveys to explore the  
84 dispute settlement mechanism. For example, questionnaire surveys combine with  
85 interviews have been used to recognize problem in the area of disputes and dispute  
86 resolution practices of Chinese international projects [13] and Sino-Foreign joint  
87 ventures [14]; a questionnaire survey conducted to identify and analyze the  
88 transaction costs hidid in the process of project dispute resolution [52]; also an  
89 interview survey used to develop a selection model for dispute resolution method  
90 for international projects [12].

91 (2) *Empirical studies*: the most common empirical research method used in dispute  
92 related issues is Structural Equation Modeling (SEM), mainly to verify a single  
93 factor, such as the influence of culture [6,33,34,62] and trust [38] on dispute  
94 management - proposing corresponding dispute resolution strategies - and studying  
95 conflict management style [62,66] and ADR method [7,53] to provide suggestions  
96 concerning the selection of ADR methods *depending on the specific dispute*  
97 *situation*.

98 (3) *Document analysis*: mainly including literature review and text analysis. For  
99 instance, a review of current different methodologies in preventing or resolving  
100 construction disputes, for giving the reader an overview of their strengths and  
101 weaknesses[[37,44](#)]; the development of an analytical framework for choosing  
102 dispute resolution methods, suggesting expected risks involved should be  
103 considered when using specific dispute resolution methods [[32](#)]; and suggestions of  
104 the means by which payment problems could be mitigated through document  
105 analysis [[56](#)].

106 However, although these three types of methods have made a significant contribution  
107 to resolving construction dispute from different perspectives, existing methods do have  
108 some practical limitations. For example, the efficacy of survey-based approaches is  
109 limited due to the subjectivity of expert judgments [[48](#)], and may lack depth because of  
110 respondent scruples. Similarly, document analysis mainly combs and compares existing  
111 dispute settlement methods, making their selection difficult in specific cases, while the  
112 empirical studies can only verify the factors affecting dispute resolutions and lack the  
113 ability to help identify more systematic resolution strategies.

114 Considering the limitations in existing dispute settlement methods, therefore, it is  
115 necessary to conduct further research that addresses dispute problems from a new  
116 perspective. CBR, as a decision support system based on the psychological theory of  
117 human reasoning [[18](#)], has been progressively used for project management [[17,40](#)]. Its  
118 main purpose is to hold a minimum amount of information relating to past (historical)  
119 project disputes in a single, well-structured, repository so that many relevant aspects to  
120 a similar new (target) project situation are easily identified and retrieved for  
121 consideration before taking decisions and also enabling all sources of a particular  
122 dispute to be analyzed simultaneously [[15](#)].

123 Moreover, CBR has also been applied in previous studies relating to dispute  
124 management. For example, text mining techniques have been used to retrieve similar  
125 cases for the ADR of construction accidents [28]; and a hybrid Artificial Neural  
126 Network and CBR model has been developed to solve potential lawsuit problems  
127 caused by construction projects change orders [16]. However, these focus on domestic  
128 construction projects, which are different from international construction projects,  
129 leaving the application of CBR in the dispute management of international construction  
130 project yet to be explored.

### 131 **3 Method formulation**

#### 132 **3.1 Research design**

133 Classical CBR system applications involve the five distinct phases of case  
134 representation, retrieval, reuse, revision, and retention adapted by Aamodt and Plaza  
135 [68]. The main function of each step shown in Fig. 1 [16,29,40,43,60].

136 **<Insert Fig. 1 here>**

137 Previous successful cases were collected from related project databases, references,  
138 the WeChat Official Account and website. The attributes that influence dispute-related  
139 problems were subsequently derived. For similar or even identical cases, the dispute  
140 resolution strategies may vary widely if the dispute causes are different. Considering  
141 this, a two-step refinement process was then conducted to retrieve similar cases,  
142 comprising:

143 Step one: historical practices are extracted from the databases by judging whether the  
144 *cause of dispute* in each case is similar to that of the text case.

145 Step two: the most similar cases whose *project features* match the target case are  
146 retrieved. In this process, the analytic hierarchy process (AHP) is used to determine the

147 feature weights. The relationship between these derived causes and the extracted  
148 attributes is shown in Fig. 2.

149 **<Insert Fig. 2 here>**

150 Shen et al.'s [58] hybrid methods are then used to measure their similarity by  
151 considering the different project features having different value formats.

152 Finally, the developed model is validated by comparing the output data of the  
153 retrieved cases with that of the test case.

### 154 **3.2 Collection of historical construction dispute cases**

155 The basis of a CBR model is to collect appropriate cases [46]. Hence, a variety of  
156 dispute-related cases are required at the initial stage of model development.  
157 Accordingly, the available practices containing more detailed dispute-related project  
158 information were collected. The sources of historical cases mainly include:

- 159 • Cases obtained from investigation and survey;
- 160 • The China Case Center for Professional Degrees Education;
- 161 • Cases in publication references, such as *International Project Contracting &*  
162 *Labour Service* and the *Journal of International Economic Cooperation*;
- 163 • Cases from the *WeChat* official account relating to international engineering,  
164 including International Project Contracting and Investment (Wechat ID: EPC-BOT-  
165 PPP), International Labor Services and Overseas Projects (Wechat ID: GJLWYJ),  
166 One Belt and One Road High Ginseng (Wechat ID: BR project).
- 167 • Cases from websites: the Ministry of Commerce of the People's Republic of China,  
168 China International Economic Cooperation Association, China Association of  
169 International Engineering Consultants, China International Contractors Association,  
170 CGGT, British and Irish Legal Information Institute.



171 111 cases were collected, and the basic case information was organized into “Project  
172 type”, “The location of the project (host country) ”, “Causes of disputes”, and noting  
173 the “Source of the case” and the “Website” where further case information can be  
174 obtained.

### 175 **3.3 Case representation**

176 The purpose of the case representation is to define the format of case storage. It is  
177 considered that a historical case which can be important reference to solve future  
178 problems should include three components (1) a description of the problem, (2) the  
179 strategy adopted to address the problem, and (3) the outcome of the response strategy  
180 [60]. Component (1) aims to describe the problem and understand its context.  
181 Considering these three elements and the specificity of international construction  
182 dispute problems, the case here is represented in the form of the three-tuple.

183 **Case= [the causes of the dispute; the attributes related to the dispute; the dispute**  
184 **response strategy]**

185 where ‘the causes of dispute’ are used to describe the causes leading to disputes in  
186 international construction projects; ‘the attributes related to dispute’ are used to describe  
187 the dispute-related characteristics of the project including the attributes of the project  
188 and the host country; and the ‘dispute response strategy’ as the output of retrieved  
189 similar case is used to describe the dispute settlement.

#### 190 ***3.3.1 The causes of dispute***

191 The causes of international construction disputes are recognized from different  
192 perspectives and divided into different categories. For example, the common sources of  
193 disputes in Sino-Foreign joint venture construction projects have been identified from  
194 the perspective of contract, culture, and legality [14]; the major constructional dispute  
195 causes have been divided into seven components of owner, contractor, design, contract,

196 human behavior, project, and external factors related [10]; and a similar framework of  
197 dispute causes was developed by [64]. Moreover, by analyzing the FIDIC contract  
198 documents, supplemented by literature reviews, and expert interviews [64], 30 factors  
199 of dispute management in international construction projects have been identified from  
200 the perspectives of contract and construction [23]. However, these studies mainly derive  
201 the most common causes of dispute, and the item is recapitulative. A comprehensive  
202 identification of dispute causes is necessary to retrieve the more similar case. By  
203 summarizing dispute information in the database and the dispute causes in the literature,  
204 37 causes are identified and categorized here into “Owner-related”, “Contractor-  
205 related”, “Contract-related” and “External” factors (Table 1) after repeated discussion  
206 with experts and practitioners.

207 **<Insert Table 1 here>**

208 Construction disputes have their distinct nature and characteristics, and thus the  
209 sources of disputes vary from one project to another. We therefore not only need to  
210 identify the causes as fully as possible, but also the specific, convergent, and  
211 discriminant validity between each cause. To investigate the applicability for the  
212 problem, a questionnaire survey was carried out with subjects from international  
213 construction project teams. A five-point scale was used for each item to determine the  
214 likelihood of factors causing disputes, from 1 (very low) to 5 (very high). Using  
215 purposive sampling, 145 valid responses were collected based on all clauses in  
216 international construction projects. The average working experience of respondents is  
217 5.4 years, which is acceptable compared with the norm of 5-10 years for most  
218 questionnaire surveys concerning the cause of dispute [14][23]; 72 (50%) are from  
219 senior management, 44 (35%) middle management, such as state managers and general  
220 managers, with the remainder from the operational level.

221 **3.3.2 Data analysis**

222 Internal consistency reliability is the representation of composite reliability [36]. As  
223 Table 2 indicates, the Cronbach's alpha coefficient is 0.866 overall and 0.801, 0.817,  
224 0.823, and 0.788 for Owner-related, Contractor-related, Contract-related and External  
225 factors respectively, well above the 0.70 threshold [36] for acceptable reliability. For  
226 convergent and discriminant validity, all factor loadings should be greater than 0.7, with  
227 the Average Variance Extracted (AVE) exceed the recommend 0.5 threshold [31]. As  
228 shown in Table 2, these are complied with, each factor receiving the highest loading  
229 (above 0.772) on the corresponding grouping, which provides evidence of discriminant  
230 validity and suggests that the cause of disputes categories are different from each other.  
231 Moreover, the cumulative variance reaches up to 79.231%, which means two factor  
232 groupings explain 79.231% of the variance, higher than the recommended guideline of  
233 60% [9].

234 **<Insert Table 2 here>**

235 **3.3.3 Attributes related to disputes**

236 Each international project related to different and specific contexts is commonly  
237 described by multiple project features. However, the factors having a critical impact on  
238 the dispute problem have yet to be investigated. This description involves the specific  
239 attribute or ontology of a case, and the minimum amount of information used to define  
240 each case should provide effective learning to users [60].

241 To achieve this aim, feature extraction comprises two steps: collecting variables from  
242 the database and literature; and extracting attributes linked to dispute problems. For the  
243 latter, the attributes were extracted from 11 experts, comprising 3 senior managers, 4  
244 project managers, 2 contract managers, and 2 engineers – this being regarded as a  
245 practical way to choose the attributes [47,67]. This provided 13 international project

246 features divided into two categories (project related- and host country related- attributes)  
247 systematically organized as illustrated in Fig. 3.

248 **<Insert Fig. 3 here>**

249 (1) Project attributes

250 It is well established that project type, contract type, project delivery method,  
251 duration, project scale, and the location of the project are related to both international  
252 and domestic construction project disputes [16,18,27,51]. Moreover, the phase of  
253 dispute occurrence influences the management of the dispute case [18]. Similarly, the  
254 type of owner relates to ownership structure: private, public, state or state-owned, or a  
255 combination of the above; when the owner is a state or state-owned, it is more likely to  
256 face the problem of internal politics during the dispute settlement [39].

257 (2) Host country attributes

258 Cultural differences have been a major factor affecting international construction  
259 project disputes, such as in the selection of dispute resolution methods [33,34,53]. The  
260 “Degree of cultural difference” is usually measured by the Hofstede 6-D model, which  
261 divides culture into 6 dimensions of power distance, individualist, masculinity,  
262 uncertainty avoidance, long-term orientation, and indulgence - each indicator having a  
263 score between 0 and 100. Here, we score “Degree of cultural difference” as the mean  
264 value of the six indicators. In addition, corruption is defined as the misuse of public  
265 power for private benefit [69], and the Corruption Perceptions Index (CPI) published  
266 by Transparency International - annually ranking countries by their perceived levels of  
267 corruption. As defined by the World Bank, “Government effectiveness” is used to  
268 measure the competence of the bureaucracy, and the quality of public service delivery  
269 reflects the host country’s governance indicators; “Regulatory quality” captures  
270 perceptions of the ability of the government to formulate and implement sound policies

271 and regulations that permit and promote private sector development; and the “Rule of  
272 law” is defined as the situation in which the laws of a country are obeyed by everyone.  
273 The three kinds of data can be obtained from Word Bank Open Data.

274 It is considered that the value formats of the input attributes mainly include crisp  
275 symbol, crisp number, interval number, and a fuzzy linguistic variable [[17](#),[58](#),[59](#)]. In  
276 our study, the Dispute-related features of international construction projects are  
277 summarized as just “Crisp symbol” and “Crisp number”, as shown in Table 3. The  
278 “Crisp symbol” is used to express terms with such definite meanings as expressing the  
279 attribute “Project delivery method” by “EPC”, “DBB”, “BOT”, and “Other”; while a  
280 “Crisp number” is used to describe a certain value, such as the “Duration” of the project.

281 **<Insert Table 3 here>**

#### 282 ***3.3.4 Weight computation***

283 In CBR, a similar case is represented as several attributes, and the reliability of the  
284 derived outcomes relies on the attribute weights and similarities [[1](#)]. Therefore, the CBR  
285 system requires the attribute weights and similarities to be precisely calculated  
286 [[1](#),[25](#),[48](#)]. An AHP is adopted to determine the attribute weights based on the above  
287 attribute extraction. AHP is suited to reflecting expert opinions, site experiences, and  
288 examining the relative importance of interrelated and complex attributes [[57](#)]; it has  
289 been the most commonly used method of weight computation [[17](#)][[48](#)][[67](#)]. The AHP  
290 survey was conducted with 15 international construction experts. Their selection is  
291 based on their (1) having over five years experiences with international construction  
292 projects; (2) having a good understanding of ADR and litigation processes; or (3) being  
293 accredited mediators/arbitrators of recognized professional bodies.

294 Firstly, the “Attribute criteria weights” between “Project attributes” and “Host  
295 country attributes” are determined by experts. Then, the “Project attributes” (C1-C8)

296 and “Host country attributes” (C9-C13) weights are calculated. The attribute weights  
297 were obtained through the AHP process as shown in Tables 4 to 6, with a Consistency  
298 Ratio (CR) value of less than 0.1 [3,5].

299 **<Insert Table 4-6 here>**

300 Based on the above analysis process, the integrated attribute weights are obtained for  
301 the similarity calculation below as shown in Table 7.

302 **<Insert Table 7 here>**

### 303 **3.4 Retrieval**

304 Retrieval is a process of searching and determining the most similar and relevant case  
305 or cases [60]. For this purpose, the degree of similarity between text case and storage  
306 case should be measured [58].

#### 307 **3.4.1 Similarity measure**

308 Various similarity or distance measures have been adopted in CBR systems. A typical  
309 method for calculating similarity is the distance-based method; and the most commonly  
310 used is Euclidean Distance [1], which is the ordinary distance of the line segment  
311 connecting two points in Euclidean space [2,42,48]. Euclidean distance is more suitable  
312 for the similarity measure of quantified attributes. The “Crisp symbol” is used to  
313 express terms with definite meanings, such as the attribute “Contract type” being  
314 expressed by “Lump sum”, “Unit price”, and “Cost plus fee”, as it is difficult to quantify  
315 the “Contract type” and calculate the ordinary distance of line segment connecting  
316 “Lump sum” and “Unit price” in Euclidean space. Due to different project features  
317 having different value formats, Shen et al.’s [58] hybrid methods are used to measure  
318 their similarities.

319 In establishing similarity measures, the following basic information is defined.

320  $Z = \{Z_1, Z_2, \dots, Z_m\}$  is a set of historical construction dispute cases,  $Z_i$  denotes the  
 321  $i_{th}$  case,  $i \in M(1, 2, \dots, m)$ ;  $Z_0$  is used to represent the text case.  
 322  $C = (C_1, C_2, \dots, C_{13})$  is an international construction project attributes set, and  $C_j$   
 323 expresses the value of the  $j_{th}$  attribute,  $j \in N(1, 2, \dots, 13)$ ;  $\vec{W} = (w_1, w_2, \dots, w_{13})^T$   
 324 denotes the vector of weighting values of the 13 attributes, subject to  $\sum_{j \in N} w_j = 1$  and  $0 \leq$   
 325  $w_j \leq 1$ , where  $w_j$  denotes the weighting values of attribute  $C_j$ .

326  $\vec{P}_i = (p_{i1}, p_{i2}, \dots, p_{i13})^T$  denotes the vector of international construction projects  
 327 attribute values, where  $p_{ij}$  express the value of the attribute  $C_j$  in referring to the  
 328 historical construction dispute case  $Z_i$ ;  $\vec{P}_0 = (p_{01}, p_{02}, \dots, p_{013})^T$  denotes the vector of  
 329 international construction projects attribute values, where  $p_{0j}$  is defined as the value  
 330 of attribute  $C_j$  in refereeing to the text case  $Z_0$ .

331 (1) For attributes with a *crisp symbol*, for example the project type and contract type,  
 332 the similarity between the target and historical cases can be measured by judging  
 333 whether they have same value or not [[1,26,29,30,45,59,60](#)]. According to the above  
 334 definition of a crisp symbol, the similarity between  $Z_i$  and  $Z_0$  denoted as  $S1_i(Z_i, Z_0)$   
 335 can be measured in regard to attribute  $C_j$ , by judging whether the value of the crisp  
 336 symbol carried by  $Z_i$  is the same as that carried by  $Z_0$ :

$$337 \quad S1_i(Z_i, Z_0) = \begin{cases} 1 & \text{if } p_{0j} = p_{ij} \\ 0 & \text{if } p_{0j} \neq p_{ij} \end{cases} \quad i \in M, j \in N \quad (1)$$

338 (2) For attributes with a *crisp number*, such as Duration, Project scale, the similarity  
 339 between the text and storage cases can be obtained through calculating the distance  
 340 between the values of the two crisp numbers [[11,35,58,59,63](#)]. Hence, the similarity

341 between  $Z_i$  and  $Z_0$  denoted as  $S2_i(Z_i, Z_0)$  can be measured in regard to attribute  $C_j$ ,  
 342 by calculating the distance between the values of the two crisp numbers:

$$343 \quad S2_i(Z_i, Z_0) = 1 - D(p_{ij}, p_{0j}), i \in M, j \in N \quad (2)$$

344 Where  $D(p_{ij}, p_{0j})$  is used to measure the Humming distance between  $p_{ij}$  and  $p_{0j}$ ,  
 345 and  $D(p_{ij}, p_{0j})$  can be calculated through:

$$346 \quad D(p_{ij}, p_{0j}) = \frac{|p_{ij} - p_{0j}|}{\beta - \alpha}, \quad p_{ij}, p_{0j} \in [\alpha, \beta] \quad i \in M, j \in N \quad (3)$$

347 Where  $\alpha$  and  $\beta$  are the lower and upper bounds of the range respectively,  
 348 which can be calculated through:

$$349 \quad \alpha = \begin{cases} \text{Min}_1^m p_{ij} & (\text{if } p_{0j} > \text{Min}_1^m p_{ij}) \\ p_{0j} & (\text{if } p_{0j} \leq \text{Min}_1^m p_{ij}) \end{cases} \quad (4)$$

$$350 \quad \beta = \begin{cases} \text{Max}_1^m p_{ij} & (\text{if } p_{0j} < \text{Max}_1^m p_{ij}) \\ p_{0j} & (\text{if } p_{0j} \geq \text{Max}_1^m p_{ij}) \end{cases} \quad (5)$$

### 351 **3.4.2 Hybrid similarity measurement**

352 The formulas above-mentioned are used to calculate the similarity between  $Z_i$  and  
 353  $Z_0$  when individual attribute  $C_j$  is considered. For retrieving the most similar  
 354 construction dispute cases compared with the target one, the degree of similarity in  
 355 regard to various projects attributes  $C_j$  should be integrated into a hybrid similarity  
 356 measurement. This integrated measurement is used to express the general similarity  
 357 level between  $Z_i$  and  $Z_0$ , denoted as  $S(Z_0, Z_i)$ .

$$358 \quad S(Z_0, Z_i) = \sum_{j=1}^{13} w_j S_j(Z_0, Z_i) \quad (6)$$

359 where  $w_j$  is the weighting value computed by the AHP process above.



360 **3.5 Reuse and retention**

361 The analysis of case reuse and retention is conducted based on the retrieval of similar  
362 cases. The solution that was applied to solve the dispute problem in the similar retrieved  
363 case comprises the alternative approach for the target case. Because of the repeatedly  
364 storage and reusing of each case, the results become increasingly accurate. After  
365 extracting the similar results, an interview with the experienced practitioners will be  
366 conducted to evaluate the outcomes of each solution, then the new case with a  
367 correspondingly modified solution is retained and accumulated in the case base for  
368 future reference [17,30,65]. The outputs of a similar retrieved case have three parts as  
369 shown in Table 8.

370 **<Insert Table 8 here>**

371 (1) Dispute resolution methods

372 ADR techniques have gained popularity as providing means of managing  
373 construction conflicts and disputes, and such ADRs as negotiation, mediation,  
374 arbitration, litigation, and dispute review boards [7,10,34] are incorporated into the  
375 standard form of project contracts as a designated means of avoiding or resolving any  
376 disputes. Each method has advantages and disadvantages in addressing the international  
377 construction dispute problem. However, it is a complicated decision of which dispute  
378 resolution methods to adopt for an international construction dispute problem because  
379 of differences in cultural, political, economic factors, etc., compared with domestic  
380 projects [32]. Therefore, the dispute resolution methods used in other successful  
381 dispute-settled cases provides valuable information for decision makers

382 (2) Contract-terms or law-basis referenced in dispute resolution

383 A dispute is accompanied by a claim. There are five categories of claim in FIDIC [8]:

- 384 i. “A claim under the contract”, which means the claim event is specified under  
385 a particular provision of the contract, subject applicable law.
- 386 ii. “A claim arising out of or in connection with the contract”, which means the  
387 remedy for dispute is not designated in the contract, and the claimant needs  
388 to invoke a provision of the law to obtain a remedy.
- 389 iii. “A claim under the principles of the applicable law”, which means a claim  
390 arising under the application of the principles of the law, either by the parties  
391 to the contract or against third parties.
- 392 iv. “A claim arising out of the principle of *quantum meruit*”, which is based on  
393 the principle that an individual has the right to be paid a reasonable  
394 remuneration for work done.
- 395 v. “A claim for *ex gratia* payment”, which is not raised by virtue of a contractual  
396 entitlement, but out of the owner’s kindness to maintain the goodwill  
397 necessary to complete the project successfully.

398 Therefore, the contract terms or laws used to settle a dispute in similar cases may  
399 provide an important reference for a new dispute problem.

### 400 (3) Outcome of the dispute settlement

401 The most usual outcome of a dispute settlement is the assertion of an entitlement to  
402 payment (such as prolongation and acceleration costs) or time (such as avoiding a  
403 penalty for delays). Calculating the claim for indemnity of construction project cost and  
404 time accurately involves considering the cause of the dispute, the features of the project,  
405 and the circumstance of the host country. Therefore, the claimed expense and duration  
406 of a successful dispute-settled case provides a worthy reference for a new dispute  
407 problem.

#### 408 **4 Model application**

409 The originality of the research is in applying the CBR system to the dispute  
410 management of international construction projects. Establishing a three-tuple form for  
411 case representation, 37 causes of dispute, and 13 international project features  
412 organized into project- and host country-attributes are identified. The “Dispute  
413 resolution method”, “Contract terms or law-based references”, and “Outcome of the  
414 dispute resolution” are main references for the text case. To demonstrate the application  
415 of the model, we select an international construction project in Ethiopia as an example,  
416 denoted by  $Z_0$ . The project faces the problem of “the design drawing provided by the  
417 owner is delayed”, which can be classified as reason “Schedule delay caused by the  
418 owner”. The project attributes are shown in Table 9.

419 **<Insert Table 9 here>**

420 By comparing the same cause of dispute, eight similar practices are retrieved from  
421 the case database; their details are summarized in Table10.

422 **<Insert Table 10 here>**

423 The similarity computation results concerning all the project features are shown in  
424 Table 11. It can be concluded that  $Z_1$  is chosen as the most similar case, as its global  
425 similarity of 0.934 is far above the other cases. The output of case  $Z_1$  is

426 (1) *Dispute resolution methods*. The dispute resolution method in case  $Z_1$  is negotiation,  
427 an efficient and often effective dispute-resolution technique, especially in countries  
428 with a lower level of governance.

429 (2) *Contract terms- or law-based referenced in the dispute resolution.* The basis of the  
430 contract referencing in case  $Z_1$  is consistent with the clause of the FIDIC contract  
431 concerning “Delayed drawings or instructions”<sup>2</sup>,

432 (3) *Outcome of the dispute resolution.* Considering the actual time delay and cost, the  
433 contractor in case  $Z_1$  obtained 30 “sunshine working days” extension. There is a  
434 demarcation between the rainy and dry season in most African countries; the  
435 number of sunshine working days during the year is less than that of working days,  
436 especially for transportation projects, which are implemented outdoors.

437 **<Insert Table 11 here>**

438 A dispute resolution plan for the target case  $Z_0$  can now be preliminary schemed  
439 through the above analysis. Negotiation is the preferred method. According to the  
440 provisions of the FIDIC contract “Delayed drawings or instruction”, an extension of  
441 sunshine working days for delay, and payment of cost plus a reasonable profit is  
442 expected - the exact claim amount and extension of time to be determined by the actual  
443 time delay and cost.

## 444 **5 Conclusions and recommendations**

445 Considering the experience-oriented nature of the construction industry, this study  
446 provides a new perspective to resolve international construction disputes using the CBR  
447 method. Previous cases are collected from such sources as related project databases,  
448 references, and the WeChat Official Account and Website. 37 causes of dispute are  
449 identified, categorized into owner-related, contractor-related, contract-related, and  
450 external factors; and 13 international project features, systematically organized into

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<sup>2</sup> “If the contractor suffers delay, and/or incurs cost as a result of a failure of the engineer to issue the notified drawing or instruction within a time which is reasonable and is specified in the notice with supporting details, the contractor has the right to request an extension of time for any such delay, and payment of any such cost, plus reasonable profit”.

451 project- and host country- related attributes. The most similar case is retrieved through  
452 a hybrid similarity measure. The outputs of the similar retrieved case are mainly in three  
453 parts: (1) the dispute resolution method; (2) the contract-terms or law-basis referenced  
454 in the dispute resolution; and (3) the outcome of the dispute settlement. Finally, an  
455 international construction project of Ethiopia is selected as an example, and the scheme  
456 of dispute settlement for the test case is derived. Hence, the CBR dispute settlement  
457 model considers the causes, factors, and ADR together, which provides an effective  
458 reference in resolving new dispute problem and reducing the transaction costs involved.

459 Two limitations of the study are apparent. Firstly, the data for the historical cases are  
460 mainly from public data in the WeChat official account or Website, which may be  
461 incomplete to some extent. For example, the Hofstede measure of cultural difference  
462 can result in some countries appearing to have no cultural difference when such a  
463 difference really exists. Secondly, 13 international project related- and host country  
464 related-attributes are recognized, but the relationship between the attributes is not  
465 considered in this study, such as the Corruption Perceptions Index and Government  
466 Effectiveness, the Regulatory Quality, and Rule of Law. Future research is needed to  
467 investigate the correlation between the attributes and also expand the attributes involved,  
468 such as the attitudes and preferences of both parties when addressing disputes. In  
469 addition, we establish the dispute settlement model based on the classical CBR system  
470 adapted by [Aamodt and Plaza \(1994\)](#) [68] and utilize one case to apply the proposed  
471 model. So in the follow research, some methodological innovation will be explored and  
472 more test cases will be needed to prove effectiveness or validity of the suggested model.  
473 Moreover, CBR provides a suitable approach to solving such complex construction  
474 management problems as risk management and future research would benefit from  
475 widening the application of CBR in such areas.

476 **Acknowledgements**

477 The work described in this paper was supported by the Humanities and Social Sciences

478 Planning Fund from the Ministry of Education of China (Project No. 16YJA630031).

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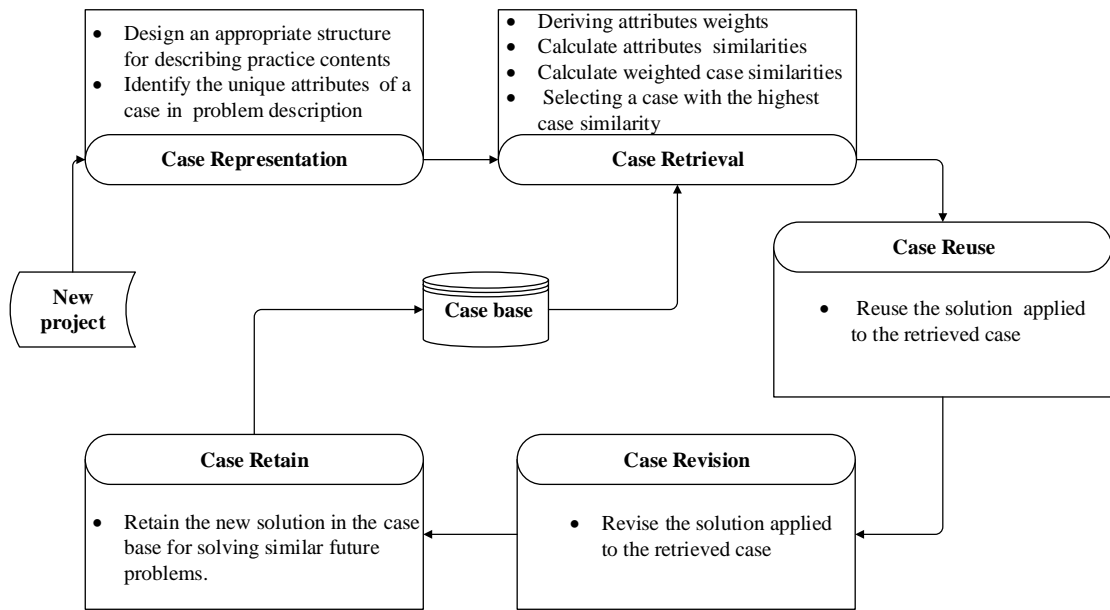
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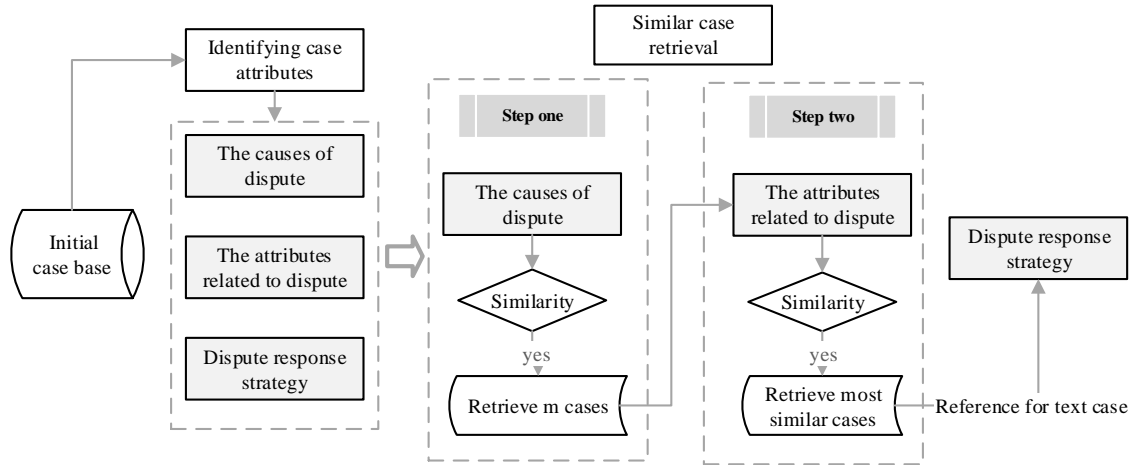
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**Fig. 1.** The CBR process.

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Source : Adapted from Aamodt and Plaza [68] and Jin et al. [43]

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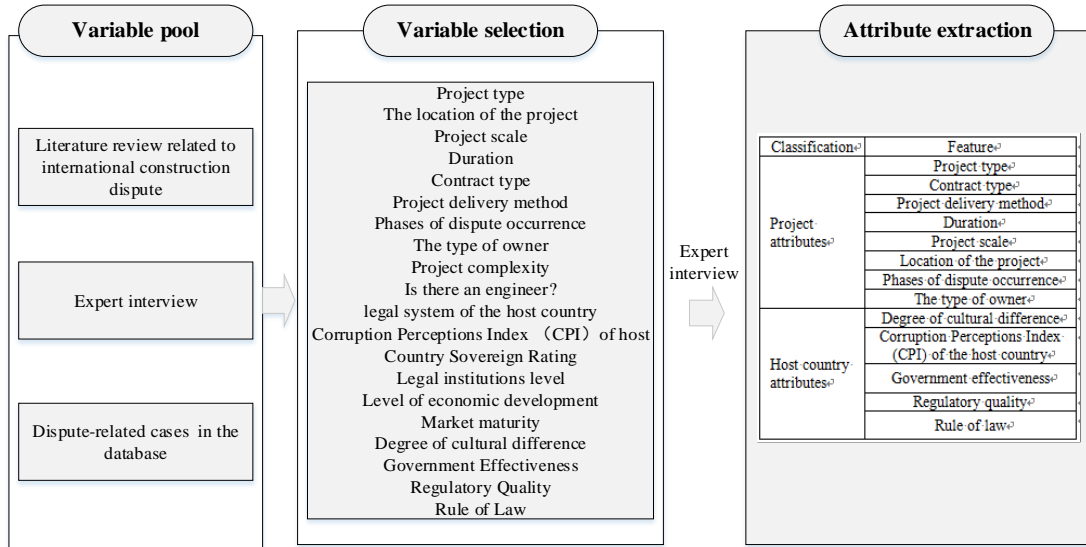
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Fig. 2. The two-step refinement process conducted to retrieve similar cases

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**Fig. 3.** The attribute extraction process



**Table 1.** Causes of international construction project disputes

Category	Item	No.
Owner-related factors	Payment delay	1
	Schedule delay caused by the owner	2
	Change in quantity of items during execution caused by the owner	3
	Ambiguous project scope or change of project scope or unclear boundaries of work	4
	Unrealistic expectations or demands and variations issued by the owner during the course of the project	5
	Acceleration	6
	Design errors or inferior quality of design	7
	Information provided by the owner incorrect/incomplete or lack reasonable interpretation	8
	Late construction site possession	9
Contractor-related factors	Unfamiliarity with project geographical condition	10
	Quality problem of works	11
	Delay in work progress	12
	The engineer not notified of the time delay or the engineer disapproved the time delay	13
	Financial failure of the contractor	14
	Failure to obtain written confirmation of instructions from the engineer	15
	Failure to fully understand the relevant local laws at the time of tender	16
	Different interpretations of the contract provisions	17
Contract-related factors	Unclear contract terms concerning adjustment of the contract price caused by provisional sums	18
	Unclear contract terms concerning the adjustment of approximate quantities	19
	Unclear payment conditions for returning retention money	20
	Unclear method to reduce the delay damages	21
	Unclear definition and types of defects	22
	Unreasonable risk allocation in the contract	23
	Failure to consider or calculate accurately the additional expense of actual work at the time of tender and estimation	24
	Failure to examine contract conditions at the time of tender	25
	Ambiguous liability limit for using or keeping materials and equipment provided by the employer	26
	Disagreement over the quantity of compensation for construction costs and time when a claim occurs	27
External factors	Disagreement on payment method caused by variation of quantities	28
	Fluctuation of foreign exchange rates	29
	Economic fluctuations	30
	Fluctuation of tax rate	31
	Monetary restrictions such as restriction on fund repatriations	32
	Changes in laws and regulations	33
	The legal system incompatible with the dispute resolution procedures in the contract	34
	Country security problems, language barriers, different cultural traditions, and religious backgrounds	35
	<i>Force majeure</i> such as weather, war, revolution, and civil disorder	36
	Differences in construction standards, technical specifications, and codes, such as regulations and standards for construction practices and methods	37

**Table 2.** Measurement Model Evaluation

Construct	Construct indicators	Factor loading	Indicator reliability	CR	AVE
Owner-related factors	Cause 1	0.889	0.774	0.801	0.610
	Cause 2	0.875	0.756		
	Cause 3	0.799	0.684		
	Cause 4	0.787	0.671		
	Cause 5	0.845	0.717		
	Cause 6	0.801	0.699		
	Cause 7	0.817	0.701		
	Cause 8	0.901	0.798		
	Cause 9	0.779	0.685		
Contractor-related factors	Cause 10	0.825	0.744	0.817	0.614
	Cause 11	0.802	0.732		
	Cause 12	0.784	0.677		
	Cause 13	0.856	0.746		
	Cause 14	0.772	0.663		
	Cause 15	0.791	0.687		
	Cause 16	0.884	0.789		
Contract-related factors	Cause 17	0.807	0.712	0.823	0.636
	Cause 18	0.778	0.689		
	Cause19	0.796	0.694		
	Cause 20	0.884	0.773		
	Cause 21	0.843	0.738		
	Cause 22	0.776	0.679		
	Cause 23	0.911	0.806		
	Cause 24	0.857	0.766		
	Cause25	0.867	0.769		
	Cause26	0.882	0.774		
	Cause27	0.797	0.678		
Cause28	0.811	0.703			
External factors	Cause29	0.824	0.719	0.788	0.664
	Cause30	0.869	0.755		
	Cause31	0.754	0.645		
	Cause32	0.740	0.633		
	Cause33	0.832	0.723		
	Cause34	0.801	0.688		
	Cause35	0.844	0.712		
	Cause36	0.768	0.628		
Cause37	0.796	0.629			
Cumulative variance (%)			79.231%		

**Table 3.** Dispute-related features of international construction projects

Classification	Feature	Format of feature value	Description of features
Project attributes	Project type	Crisp symbol	General building/ Oil and gas/ Transportation/ Power/Water supply/ Industrial plant/ Other
	Contract type	Crisp symbol	Lump sum/ Unit price/Cost plus fee
	Project delivery method	Crisp symbol	EPC/DBB/ BOT/Other
	Duration	Crisp number	Months
	Project scale	Crisp number	\$
	Location of the project	Crisp symbol	North America/Latin America/Eastern Europe/Western Europe/Southeast/Asia/ Africa/Oceania and Pacific Islands/Other
	Phases of dispute occurrence	Crisp symbol	Planning and design/ tender and Procurement/Construction/Inspection/ Operation and maintenance
	The type of owner	Crisp symbol	Private/Public/State or state-owned/ A combination of the above
Host country attributes	Degree of cultural difference	Crisp number	__(Come from <i>Hofstede Insights</i> )
	Corruption Perceptions Index (CPI) of the host country	Crisp number	__(Come from <i>WIKIPEDIA</i> )
	Government effectiveness	Crisp number	__(Come from <i>World Bank Open Data</i> )
	Regulatory quality	Crisp number	__(Come from <i>World Bank Open Data</i> )
	Rule of law	Crisp number	__(Come from <i>World Bank Open Data</i> )

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**Table 4.** Attribute criteria weights obtained by AHP

	The attributes related to project	The attributes related to host country
Project attributes	1	3
Host country attributes	1/3	1
weight	0.750	0.250
CR	0.000<0.1	

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**Table 5.** Weights of project attributes obtained by AHP

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	1/2	1/4	1/5	1/4	1/2	1/4	1/2
C2	2	1	1/3	1/5	1/3	1/2	1/3	1/2
C3	4	3	1	1/5	3	2	3	3
C4	5	5	5	1	5	5	5	5
C5	4	3	1/3	1/5	1	1/2	1/3	2
C6	2	2	1/2	1/5	2	1	1/3	1/3
C7	4	3	1/3	1/5	3	3	1	3
C8	2	2	1/3	1/5	1/2	3	1/3	1
weight	0.036	0.048	0.177	0.360	0.082	0.076	0.146	0.075
CR	0.090<0.1							

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**Table 6.** Weights of host country attributes obtained by AHP

	C9	C10	C11	C12	C13
C9	5	1	5	3	1/2
C10	1	1/5	2	1/4	1/5
C11	1/2	1/5	1	1/5	1/4
C12	4	1/3	5	1	1
C13	5	2	4	1	1
weight	0.071	0.322	0.054	0.228	0.326
CR	0.075<0.1				

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**Table 7.** Integrated attribute weights obtained by AHP

Classification	Attributes	Attribute weights
Project attributes	Project type	0.027
	Contract type	0.036
	Project delivery method	0.132
	Duration	0.270
	Project scale	0.062
	The location of the project	0.057
	Phases of dispute occurrence	0.110
	The type of owner	0.056
Host country attributes	Degree of cultural difference	0.018
	Corruption Perceptions Index(CPI) of host country	0.014
	Government Effectiveness	0.080
	Regulatory Quality	0.057
	Rule of Law	0.082

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**Table 8.** The outputs of similar retrieved case

Outputs	Description
The dispute resolution methods	Negotiation, mediation, arbitration, litigation and other ADR et al.
The contract terms or laws basis referenced in dispute resolution	A particular provision of the contract or a provision of the applicable law et al.
The outcome of dispute resolution	The quantity of claim for loses and expenses and claim for extension of time et al.

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**Table 9.** Project Z<sub>0</sub> attributes

Attributes		Attributes	
Project type	Transportation	Degree of cultural difference	52.5
Contract type	Unit price	Corruption perceptions index(CPI) of host country	34
Project delivery method	DBB	Government effectiveness	-0.42
Duration	36 months	Regulatory quality	-1.07
Project scale	5.169 billion	Rule of law	-0.47
Phases of dispute occurrence	Construction		
The location of the project	Africa (Ethiopia)		
The type of owner	Public		

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**Table 10.** Project features of the historical and target cases.

Attribut es	Case								
	Z <sub>0</sub>	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Z <sub>5</sub>	Z <sub>6</sub>	Z <sub>7</sub>	Z <sub>8</sub>
C <sub>1</sub>	Transportation	Transportation	Transportation	Water supply	Power	Industrial plant	Industrial plant	Transportation	Other
C <sub>2</sub>	Unit price	Unit price	Lump sum	Lump sum	Lump sum	Lump sum	Unit price	Unit price	Unit price
C <sub>3</sub>	DBB	DBB	EPC	EPC	EPC	EPC	EPC	DBB	DBB
C <sub>4</sub>	36 months	33 months	32 months	60 months	66 months	33 months	56 months	63 months	24 months
C <sub>5</sub>	51.69 million	17.13 million	447 million	159 million	200 million	270 million	100 million	180 million	31.8 million
C <sub>6</sub>	Africa (Ethiopia)	Africa (Tanzania)	Eastern Europe (Poland)	Africa (Algeria)	Latin America (Ecuador)	Eastern Europe (Hungary)	Other (Guyana)	Africa (Morocco)	Africa (Uganda)
C <sub>7</sub>	Construction	Construction	Construction	Construction	Construction	Construction	Construction	Construction	Construction
C <sub>8</sub>	Public	Public	Public	Public	State - owned company	Private	State-owned company	Public	Public
C <sub>9</sub>	52.5	42.83	58.67	—	54	64.17	—	46	—
C <sub>10</sub>	34	32	62	34	31	48	34	37	25
C <sub>11</sub>	-0.42	-0.66	0.83	-0.48	-0.47	0.53	-0.23	-0.07	-0.5
C <sub>12</sub>	-1.07	-0.33	1.05	-1.28	-1.01	0.75	-0.53	-0.13	-0.22
C <sub>13</sub>	-0.47	-0.4	0.84	-0.77	-1.06	0.5	-0.62	-0.07	-0.39



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**Table 11.** Similarity results for each project feature.

Attributions	Weights	Case							
		Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Z <sub>5</sub>	Z <sub>6</sub>	Z <sub>7</sub>	Z <sub>8</sub>
C <sub>1</sub>	0.027	1	1	0	0	0	0	1	0
C <sub>2</sub>	0.036	1	0	0	0	0	1	1	1
C <sub>3</sub>	0.132	1	0	0	0	0	0	1	1
C <sub>4</sub>	0.270	0.929	0.905	0.429	0.286	0.929	0.524	0.357	0.714
C <sub>5</sub>	0.062	0.92	0.08	0.75	0.655	0.492	0.888	0.702	0.954
C <sub>6</sub>	0.057	1	0	1	0	0	0	1	1
C <sub>7</sub>	0.110	1	1	1	1	1	1	1	1
C <sub>8</sub>	0.056	1	1	1	0	0	0	1	1
C <sub>9</sub>	0.018	0.547	0.711	0	0.93	0.453	0	0.695	0
C <sub>10</sub>	0.014	0.946	0.243	0	0.919	0.622	1	0.919	0.757
C <sub>11</sub>	0.080	0.839	0.161	0.96	0.966	0.362	0.872	0.765	0.765
C <sub>12</sub>	0.057	0.682	0.09	0.91	0.974	0.219	0.768	0.597	0.635
C <sub>13</sub>	0.082	0.963	0.311	0.842	0.689	0.489	0.921	0.789	0.958
Global similarity		0.934	0.502	0.583	0.447	0.490	0.546	0.743	0.829

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Note: If the value of attribute  $C_j$  in the  $i_{th}$  case is default, this default value will be defined as 0.

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