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

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

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

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1 Introduction

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

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

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

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

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

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

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

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

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

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

2 Literature review

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

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

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

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

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

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

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

3.3 Case representation

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

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

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

3.3.1 The causes of dispute

The causes of international construction disputes are recognized from different perspectives and divided into different categories. For example, the common sources of disputes in Sino-Foreign joint venture construction projects have been identified from the perspective of contract, culture, and legality [14]; the major constructional dispute 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 Word 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.

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

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

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

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

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

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

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

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

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

Where α and β are the lower and upper bounds of the range respectively, which can be calculated through:

$$\alpha = \begin{cases} Min_1^m\ p_{ij} & \left(if\ p_{0j} > Min_1^m\ p_{ij}\right) \\ p_{0j} & \left(if\ p_{0j} \leqslant Min_1^m\ p_{ij}\right) \end{cases} \tag{4}$$

$$\beta = \begin{cases} Max_1^m\ p_{ij} & \left(if\ p_{0j} < Max_1^m\ p_{ij}\right) \\ p_{0j} & \left(if\ p_{0j} \geqslant Max_1^m\ p_{ij}\right) \end{cases} \tag{5}$$

3.4.2 Hybrid similarity measurement

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

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

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

3.5 Reuse and retention

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

<Insert Table 8 here>

(1) Dispute resolution methods

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

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

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

i. “A claim under the contract”, which means the claim event is specified under a particular provision of the contract, subject applicable law.

ii. “A claim arising out of or in connection with the contract”, which means the remedy for dispute is not designated in the contract, and the claimant needs to invoke a provision of the law to obtain a remedy.

iii. “A claim under the principles of the applicable law”, which means a claim arising under the application of the principles of the law, either by the parties to the contract or against third parties.

iv. “A claim arising out of the principle of *quantum meruit*”, which is based on the principle that an individual has the right to be paid a reasonable remuneration for work done.

v. “A claim for *ex gratia* payment”, which is not raised by virtue of a contractual entitlement, but out of the owner’s kindness to maintain the goodwill necessary to complete the project successfully.

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

(3) Outcome of the dispute settlement

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

4 Model application

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

<Insert Table 9 here>

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

<Insert Table 10 here>

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

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

(2) *Contract terms- or law-based referenced in the dispute resolution*. The basis of the contract referencing in case Z_1 is consistent with the clause of the FIDIC contract concerning "Delayed drawings or instructions"[2],

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

<Insert Table 11 here>

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

5 Conclusions and recommendations

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

[2] "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".

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

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

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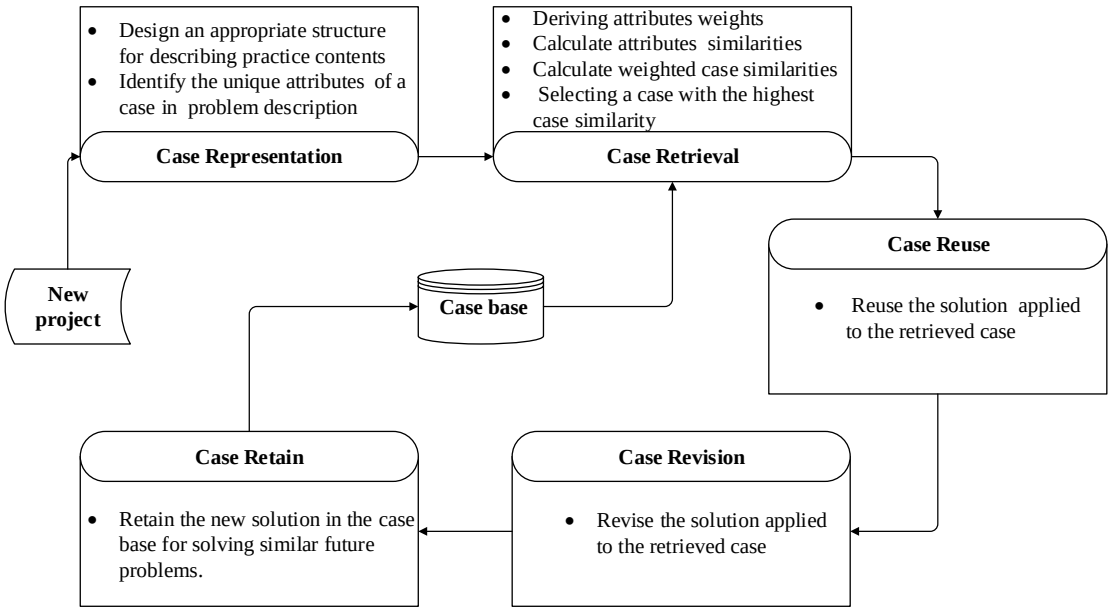

Fig. 1. The CBR process.

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

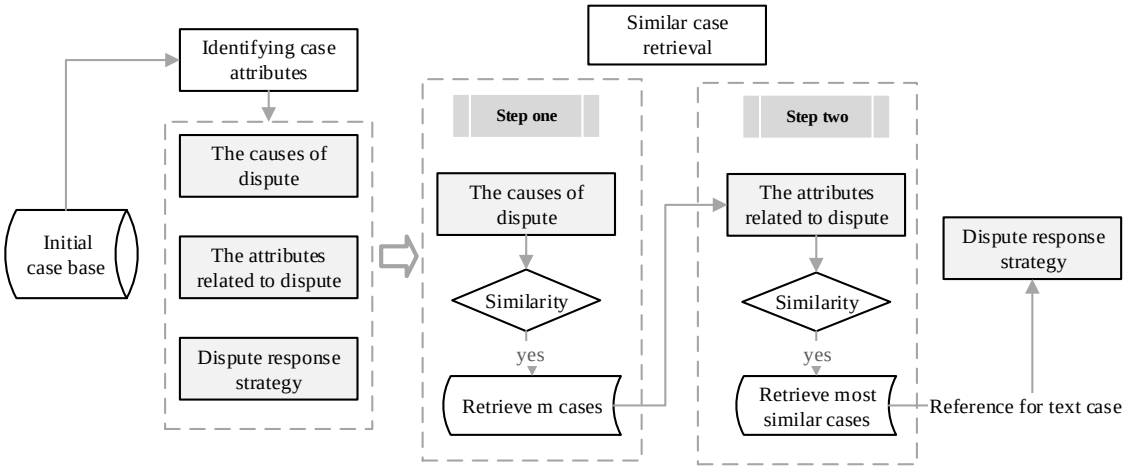

Fig. 2. The two-step refinement process conducted to retrieve similar cases

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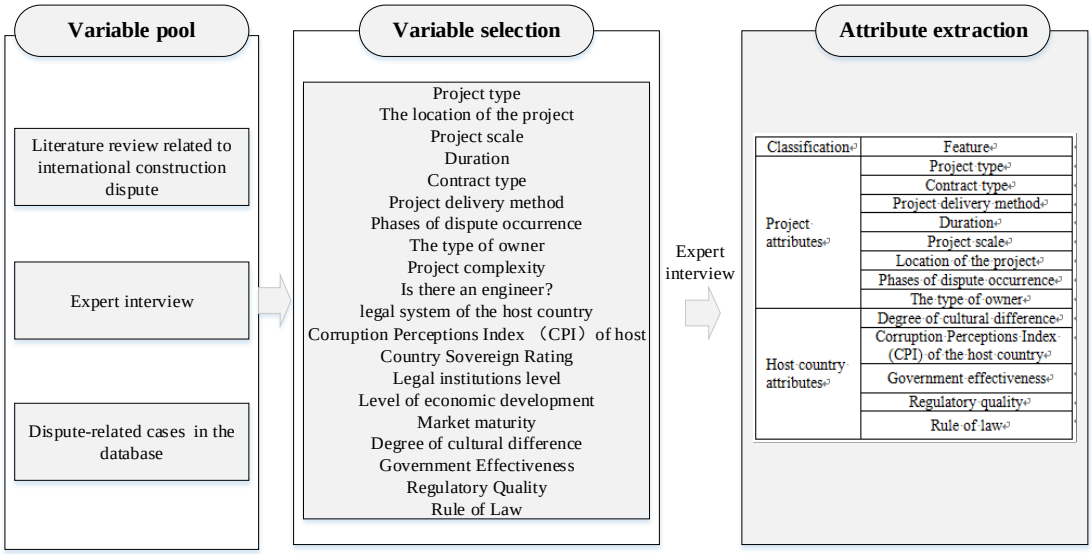

691
692 **Fig. 3.** The attribute extraction process

693 **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
Contract-related factors	Different interpretations of the contract provisions	17
	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
	Disagreement on payment method caused by variation of quantities	28
External factors	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
	Force majeure 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

694

695 **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%		

696

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/ ender 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 *Hofstede Insights*)
	Corruption Perceptions Index (CPI) of the host country	Crisp number	(Come from *WIKIPEDIA*)
	Government effectiveness	Crisp number	(Come from *World Bank Open Data*)
	Regulatory quality	Crisp number	(Come from *World Bank Open Data*)
	Rule of law	Crisp number	(Come from *World Bank Open Data*)

699 **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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701

702 **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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704

705 **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				

706

707 **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

708

709 **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.

710

711 **Table 9.** Project Z_0 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		

712

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

Attributes	Case								
	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8
C_1	Transportation	Transportation	Transportation	Water supply	Power	Industrial plant	Industrial plant	Transportation	Other
C_2	Unit price	Unit price	Lump sum	Lump sum	Lump sum	Lump sum	Unit price	Unit price	Unit price
C_3	DBB	DBB	EPC	EPC	EPC	EPC	EPC	DBB	DBB
C_4	36 months	33 months	32 months	60 months	66 months	33 months	56 months	63 months	24 months
C_5	51.69 million	17.13 million	447 million	159 million	200 million	270 million	100 million	180 million	31.8 million
C_6	Africa (Ethiopia)	Africa (Tanzania)	Eastern Europe (Poland)	Africa (Algeria)	Latin America (Ecuador)	Eastern Europe (Hungary)	Other (Guyana)	Africa (Morocco)	Africa (Uganda)
C_7	Construction	Construction	Construction	Construction	Construction	Construction	Construction	Construction	Construction
C_8	Public	Public	Public	Public	State‐owned company	Private	State-owned company	Public	Public
C_9	52.5	42.83	58.67	—	54	64.17	—	46	—
C_{10}	34	32	62	34	31	48	34	37	25
C_{11}	-0.42	-0.66	0.83	-0.48	-0.47	0.53	-0.23	-0.07	-0.5
C_{12}	-1.07	-0.33	1.05	-1.28	-1.01	0.75	-0.53	-0.13	-0.22
C_{13}	-0.47	-0.4	0.84	-0.77	-1.06	0.5	-0.62	-0.07	-0.39

714

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

Attributions	Weights	Case							
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8
C_1	0.027	1	1	0	0	0	0	1	0
C_2	0.036	1	0	0	0	0	1	1	1
C_3	0.132	1	0	0	0	0	0	1	1
C_4	0.270	0.929	0.905	0.429	0.286	0.929	0.524	0.357	0.714
C_5	0.062	0.92	0.08	0.75	0.655	0.492	0.888	0.702	0.954
C_6	0.057	1	0	1	0	0	0	1	1
C_7	0.110	1	1	1	1	1	1	1	1
C_8	0.056	1	1	1	0	0	0	1	1
C_9	0.018	0.547	0.711	0	0.93	0.453	0	0.695	0
C_{10}	0.014	0.946	0.243	0	0.919	0.622	1	0.919	0.757
C_{11}	0.080	0.839	0.161	0.96	0.966	0.362	0.872	0.765	0.765
C_{12}	0.057	0.682	0.09	0.91	0.974	0.219	0.768	0.597	0.635
C_{13}	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

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

717