Asian Journal of Civil Engineering (2021) 22:1281–1299
https://doi.org/10.1007/s42107-021-00381-0

ORIGINAL PAPER

Using AHP to prioritize the corruption risk practices in the Iraqi construction sector

Semaa Hazim Najim Alani[1] · Ahmed Mohammed Raoof Mahjoob[1]

Received: 20 February 2021 / Accepted: 14 June 2021 / Published online: 26 June 2021

Abstract
Corruption is an old phenomenon, but what is new is the increase in its scale and its diversified methods. Both advanced and developing countries have suffered to the point where corruption threatens to degrade communities and interrupt the progress of economic development. There are common issues in corruption, which is defined as the illegal obtainment of money, and the problem of corruption has been exacerbated by state institutions' dealings with private-sector companies through contracts. The major aim of this study is to assess the practices of corruption that represent risks in the Iraqi construction sector. The analytic hierarchy process (AHP) was used to develop multi-criteria decision-making support models to compare the major factors and risk categories to discern those with the greatest negative effect on construction projects and then to specify the optimal actions for the prevention of such practices. A set of corruption practices were extracted through reviewing the literature from previous studies, the reports of the Federal Board of Supreme Audit (FBSA) in Iraq and interviews with experts and decision-makers in the FBSA. The corruption practices were evaluated using a form prepared to suit the AHP methodology and enforcement steps have been simplified through Super Decisions software, which was available for its fulfillment. The AHP analysis showed that the construction stage is the primary stage for corruption practices, followed by the tendering stage and then the design stage. This paper suggests preventive actions for practices at each stage of a construction project in Iraq, and it recommends multiple strategies to eliminate corruption.

Keywords Corruption risk · Corruption practices · AHP · Preventive actions

Introduction

Corruption is defined as fraudulent actions conducted by individuals in positions of authority, including government officials, managers, and others, for achieving a personal gain. Recent investigations by the International Transparency Organization indicated that the construction industry is considered the most corrupt due to the rapid development of international construction markets. In terms of engineering or construction businesses, the categories of parties who may participate in corrupt actions consist of company owners, government officials, investors, responsible technical staff, lenders, equipment and material suppliers, and regulatory or permit agencies (Zou, 2006). Also, corruption can happen in any phase of a project, such as during initiation, planning, design, bidding and construction, as well as ongoing operation and maintenance (Tabish & Jha, 2012). Some examples of corruption are deception or fraud, unlawful political dealings, and accepting and offering bribes as well as inappropriate gifts.

In this study, the practices of corruption covered in previous studies and reviews of the reports of the Federal Board of Supreme Audit (FBSA) in Iraq will be utilized and identify the parties involved in corruption in every stage of the construction process to assess them by using analytic hierarchy process (AHP) analysis. The research will suggest a set of preventive actions to cease or reduce such practices.

✉ Semaa Hazim Najim Alani
s.najim0901@coeng.uobaghdad.edu.iq

Ahmed Mohammed Raoof Mahjoob
ahmed.mahjoob@coeng.uobaghdad.edu.iq

[1] Civil Engineering Department, Construction Project Management, University of Baghdad, Baghdad, Iraq

Literature review

Corruption is an agreement formed between two entities who decide to act in a corrupt manner. In the last 10 years, there has been growing attention to corruption in the construction industry. Furthermore, various studies have been carried out and reported on regarding the forms of corruption found in construction. Corruption can be defined as a social phenomenon that is deeply rooted in mankind's history. It is considered to be comparable to other crime types that happen in the procurement of works via local authorities and governments because of the massive amounts of money involved in each transaction as well as the complexity involved in monitoring project expenditure (Zou, 2006). In addition, corruption is a significant issue in social and economic development (Foster et al., 2012). Corruption can have another definition according to Okafor (2013) who states specifying that "corruption was sociologically, any behavior or act which contravenes societal approved standards and negatively valued via a number of individuals in society". Corruption has been ranked 5th amongst the top problems in the country following unemployment, low incomes, poverty, and high prices (USAID, 2014). "Risk" and "Corruption" are naturally-associated concepts. Yet, the disciplines related to anti-corruption and risk management are farther apart than what is already considered. There is a lack of risk management literature which addresses the corruption risks (World Bank, 2013). Institution representatives require considering the implementation of effective corruption risk management (CRM) due to the fact that this approach has been considered as the most effective tool of prevention for the minimization of corruption in different countries. CRM is a management process that assists in the identification of structural weaknesses that may facilitate corruption, provides a model for all employees to participate in the identification of treatments and risk factors, and embeds corruption prevention in a well-established governance framework (Johnsøn, 2015). For the purpose of making the institutions have the ability to effectively managing its risks of corruption, the risks have to be identified at first and after that, analyzed with the use of a process of the risk assessment. In the case of correctly performing and using it, the CRM may be a sufficient preventive and proactive tool in a fight against corruption in all of the (private or public) institutions (Škrbec, 2016). Corruption risks constitute a broad risk category, just as corruption is a broad concept encompassing many different behaviors. A study conducted by Jong et al. (2009) suggested 12 corruption types in the construction sector: nepotism, negligence, unfair and dishonest conduct, kickbacks, bid-rigging, fraud, bribery, collusion, embezzlement, conflict of interest, extortion, and front companies. Olufemi et al. (2013) revealed seven corrupt practices concerning the construction sector in Nigeria; bribery was the most common, followed by cover pricing, fraudulent invoices, and false claims. Shakantu (2006) reported that the major sources of corrupt activities are contractors, clients, and state institutions. Therefore, there is a need to ensure that clients and government officials understand their responsibilities and roles as being transparent, impartial, and accountable to the public. Plaček et al. (2019) investigated the risk of individual and systemic corruption at the municipal level in the Czech Republic and Bulgaria. They did so by employing the corruption risk, which is based on the traditional fault mode and effect analysis (FMEA) method that is used mostly in manufacturing. The model considers corruption as a personal choice, and its implementation revealed considerable differences in the risk of corruption in Bulgaria. The public's normative attitude toward corruption, the general public's lack of involvement, and the lack of a range of safeguards are all factors that contribute to these disparities. Shan et al. (2017) found that immorality was the most prominent underlying cause contributing to corruption in China's public construction sector, followed by opacity, unfairness, procedural violation, and contractual violation. Nag (2015) studied and proposed steps to combat corruption in the Indian public procurement sector. Corruption can occur at any level and in every phase of a construction project, including project conception, planning and design, bidding and construction and operation and maintenance (Bowen et al., 2007; Tabish & Jha, 2011). Mazigo (2014) examined the corruption causes in public procurement construction in Tanzania to assess public procurement construction processes and the major corruption types in each stage, identify the major corruption causes, and suggest measures to eradicate corruption in public construction procurement in the Manyara region. Various strategies have been presented to combat corruption in the construction industry. Developing leadership, enforcing rules, laws, and sanction systems, establishing training and education, transparency mechanisms, ethical standards, project governance, and leveraging audit and information technology are some of the most widely supported strategies (And & Onder, 2012; Bowen et al., 2007; Kenny, 2012; Plaček et al., 2019; Shan et al., 2020; Sohail & Cavill, 2008; Tabish & Jha, 2012; Zou, 2006). Furthermore, a number of construction industry associations, non-governmental organizations, and international organizations have made significant efforts to combat corruption in the construction industry. The American Society of Civil Engineers advocated a zero-tolerance approach for construction businesses in the United States (Crist, 2009). Corruption risks differ across the phases of the project cycle and different tools are useful for the identification, assessment, and mitigation of those risks. Using the AHP approach, this study evaluates the likelihood of corruption risk in the Iraqi construction sector.

An analytical approach to measuring the intangible components of technological innovation in a building is described by Skibniewski and Chao (1992). The method employed the AHP, which combined both positive and negative evaluation variables into a single framework.

The procedures include creating comparison matrices, testing pairwise comparison consistency, and aggregating the eigenvectors for the matrices to get a final result. The importance of the AHP technique as a communication tool for group discussion is discussed, as well as the sources of information for evaluation, utilizing the AHP technique.

On the basis of their objectives, expertise, and knowledge of each situation, the AHP assists decision-makers to identify and set priorities. Feelings and intuitive judgments are seen to be more indicative of human thinking and behavior than what we say. The AHP framework integrates our sentiments, intuitions, and logic so that we can map out complex situations as we see them. It mirrors how humans actually deal with problems in a simple intuitive way, but it improves and accelerates the process by giving an organized method for decision-making (Wind & Saaty, 1980).

The AHP methodology is based on the eigenvalues and eigenvectors mathematical theory. Special computer programs can be employed to put it into practice. It provides a method for generating approximation criteria weights and finding consistency criteria. When the number of objects being compared grows, pairwise comparison of criteria given in the AHP technique becomes more difficult. It proposes an algorithm and determines preliminary weight estimations by comparing one criterion with the others to address the problem (Podvezko, 2009). The AHP is used for analyzing qualifying issues through a quantitative analytical method. It is a multi-rule decision-making procedure that is straightforward, adaptable, and pragmatic. It primarily applies to the bidding stage. The implementation of the AHP approach in the risk management of engineering projects is examined in depth. Furthermore, Wen-Ying (2009) describes its significance and the issues to be addressed throughout AHP risk management implementation. The AHP approach organizes quantitative and qualitative components into hierarchies by combining them. It calculates dominant priority by comparing pairs of homogenous components that have a common criterion or feature. In order to extend the approach, non-homogeneous elements can also be clustered. Parallel hierarchies (for both benefits and costs) and solitary hierarchies have been used in AHP applications for projecting and planning resource allocation (Mota-Sanchez, 2010). Saaty (2008) indicated that the AHP enables decision-makers to structure complex problems in a simple hierarchy and evaluate many qualitative and quantitative factors systematically within multiple conflicting criteria. The AHP analysis is considered one of the key approaches to break down decision-making problems into many levels to form a hierarchy with unidirectional hierarchical relations.

The most significant problem with the AHP, which is also associated with other methods of decision making, is its capability of using the judgments of the private individual as a focus for the qualitative side (Dyer & Forman, 1990; Sevkli et al., 2007). The AHP used the principle of hierarchic composition to derive a combination of the priorities of the alternative, comprising of a number of criteria from the priorities that concern each one of the criteria. It includes the multiplication of each one of the priorities of the alternative through the prioritization of its matching criterion and the addition of overall criteria for obtaining the general priority of the alternative, which can be considered as the simplest method for composing the priorities. The additive method with the use of limiting priority powers instead of a judgment matrix is crucial for composition in the case where feedback and dependence have been taken into consideration in the decision-making (Saaty & Hu, 1998). The AHP approach is based upon mathematical tools for the processing of the personal subjective preferences of an expert or several experts on pairs of relevant factors that have been formulated into a comparative matrix that assesses and analyzes the decisions (Saaty & Vargas, 1991). Al Barqouni (2015) assessed the risk factors that a contractor may encounter during construction projects in the Gaza Strip by using the AHP. This compared the main risk categories and factors to find the most effective and those that negatively impact construction projects, and then identified the optimal preventive actions in relation to these factors. Tofan and Breesam (2018) revealed 15 key performance indicators (KPIs), divided into five categories (perspectives, financial, customer, internal business, and learning and growth), for construction companies in Iraq by using the fuzzy analytic hierarchy process (FAHP) technique to obtain the weights related to each KPI. Atanasova-Pacemska et al. (2014) noted that the AHP method is recommended for use in the selection process by tenders in public procurement and the European Union, and it is already included in some of the laws and regulations of many Union member countries. The AHP implementation stages can be simplified, according to Al-Harbi (2001), by using Expert Choice professional software, which is commercially available and was developed for implementing the AHP for prepublication criteria and contractors desiring to prequalify for a project. During the bidding and construction phases of construction projects in Egypt and Saudi Arabia, the AHP was used to normalize uncertainty estimates and rank risks by the likelihood of their occurrences. The responses were used to complete a pairwise analysis of risk parameters using the AHP approach and Expert Choice software. The findings demonstrated that project stakeholders regard financial risk as the most likely occurrence of construction projects. After financial risk, design risk was ranked as the second most likely occurrence. Political and construction risks were ranked third and fourth, respectively (Eskander, 2018).

Decision modeling was completed using multi-criteria decision software called Super Decisions, based on the AHP methodology and developed by Thomas L. Saaty using the weighting-ranking approach in evaluation and choice mode. According to Baby (2013), the super decisions software is a basic, easy-to-use application for building decision models with dependencies and feedback, as well as computing conclusions through utilizing the AHP's super matrices.

Problem statement

The effects of corrupt inclinations in the construction industry in Iraq are cause for serious concern to all, as this propensity has become the norm in every area of the economy. Corruption is systemic, as its tendencies manifest in every sector of the economy, including the construction industry, leading to the frequent collapse of buildings and associated loss of life and property, poor-quality project delivery, and the abandonment of projects. It is difficult to prevent financial and administrative corruption cases that occur at all stages of the project in light of the audit methods used because the methods do not ensure that the financial statements are free of errors and the corruption cannot be easily detected in compliance with audit standards. This study will help prevent corruption practices by identifying and prioritizing those found in the project-management stages by using the AHP method, which will help to emphasize the high damage ranking.

Research objectives

The following are the objectives of this research:

- To develop a decision support model based on the AHP for the proposed preventive actions for corruption risk practices.
- To prioritize corruption risk practices to determine the riskiest practices, which should be focused on.
- To provide the most practical suggestions and recommendations by applying the developed models, targeting the optimal preventive actions in risk management that aim to improve the performance of government institutes in this field.

Research methodology

The methodology used in this research is as follows:

(A) Review previous studies of related topics and examine FBSA reports on construction projects in Iraq.
(B) Identify the corruption risk practices in each stage of a construction project.
(C) Identify the practices that affect construction projects in Iraq by using interviews and discussions with experts on the FBSA staff (with more than 15 years of experience) to reach a consensus on the hierarchy of their evaluation synthesis.
(D) Analyze the impact of corruption risk practices by deriving the possibility of their incidences in the AHP framework, which will assist to accentuate the high degree of risks. Also, the decision-maker can rely on sound judgment and experts' preferences for particular occurrences when using the AHP technique, which allows for relative-scaled comparisons at all levels of the hierarchies of the many factors involved (pairwise comparisons). When comparing two or more corruption risk practices, this reduces uncertainty by ensuring that the approach produces accurate ratings for the most serious threat.
(E) Develop various strategies for combatting corruption risk practices and propose preventive action for each corruption practice for construction projects in Iraq.

Figure 1 shows the methodology of the research.

The goal of this paper is to prioritize corruption risk practices using the AHP, which is a more practical tool than the traditional statistical method for analyzing this type of knowledge because the concept of pairwise comparison is the key foundation of the AHP, which reveals the dependent relationship between the studied factors. This model should provide users with an efficient mechanism that aids in identifying corruption risk practices and determines actions that may help avoid these practices.

Identification of corruption risk practices in the construction sector in Iraq

The corruption risk practices in each stage of a construction project in Iraq were collected and grouped as shown in Table 1. The following corruption risk practices are under study.

Qualitative analysis using AHP methodology

One analytical method is usually proposed to solve such a complicated issue; this is the AHP that was proposed by Wind and Saaty (1980) and Saaty (1990). The AHP provides decision-makers with the ability to structure a complicated issue by utilizing a simple hierarchy and periodically evaluating numerous qualitative and quantitative factors under multiple conflicting criteria. The AHP can be described as

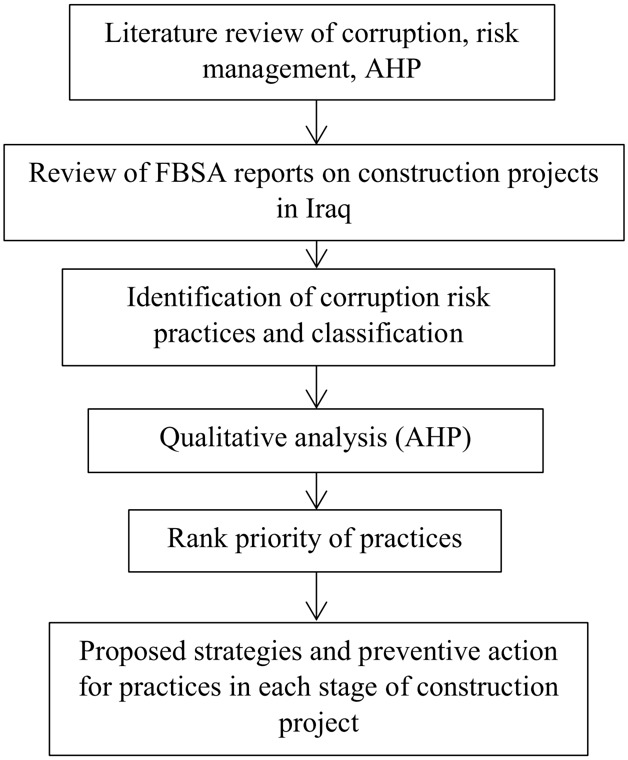

Fig. 1 Flowchart of the research methodology

one of the most common techniques for breaking down a decision-making problem into a number of levels for the purpose of forming a hierarchy with unidirectional hierarchical relations between the levels. The hierarchy's top level is the fundamental aim of a decision problem. The lower levels represent the intangible and the tangible criteria and sub-criteria, which contribute to the aim. The lowest level is produced by alternatives for the evaluation of criteria. The procedure for modeling for the ease of interpretation can be represented as follows.

In the first stage, pairwise comparisons and relative weight calculations are performed. The pairwise element comparisons in each of the levels are carried out with regard to their relative significance toward the control criterion. Saaty proposed a 1–9 scale in the case of the comparison of two elements, as can be seen from Table 2. For instance, number 9 signifies a greater importance compared to the other elements and 8 signifies that it is between "very strong importance" and "extremely important."

The second step is the comparison of criteria or sub criteria. As soon as the issue has been decomposed and the hierarchy has been created, the process of the prioritization begins determining relative criteria significance. The criteria have been pairwise compared based on their degrees of influence, in particular the criteria in the higher level in each one of the levels. In the AHP, a number of the pairwise comparisons are based upon a standardized scale of comparison across nine levels (Albayrak & Erensal, 2004**)**.

Let $C=\{Cj| \ j=1, 2, \ldots, n\}$ be the group of the criteria. The pairwise comparison result on the n criteria may be summarized in $(n \times n)$ matrix of evaluation A, where each one of the elements a_{ij} $(i, j=1, 2, \ldots, n)$ represents the quotient of criteria weights. Such pairwise comparisons may be seen by the square and the reciprocal matrix (Eq. 1).

$$A = (a_{ij})_{n \times n} = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ a_{n1} & a_{n2} & a_{nn} \end{bmatrix}. \quad (1)$$

In the final step, each one of the matrices undergoes normalization, and relative weight values are estimated. The right eigenvector presents relative weight values (w) that correspond to the maximal eigenvalue $(\lambda_{\max})$ as:

$$A_w = \lambda_{\max} \cdot w. \quad (2)$$

In the case of the complete consistency of pairwise comparisons, the matrix A has a rank of 1 and $\lambda_{\max}=n$. In such a case, the weight values may be obtained through the normalization of any row or column of (Albayrak & Erensal, 2004; Borajee & Yakchali, 2011; Wang & Yang, 2007). It must be taken into consideration that the output quality of the AHP has been associated with the consistency of the judgments of the pairwise comparisons. Consistency has been identified by the relation between A entries: $a_{jk} \times a_{ij} = a_{ik}$ (Dağdeviren et al., 2009). The consistency index (CI) may be computed with the use of the equation below (Saaty, 2008):

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}. \quad (3)$$

Utilizing a final consistency ratio (CR) may result in a conclusion on whether evaluations have sufficient consistency. CR is computed as a ratio of CI and random index (RI), as can be seen from Eq. (4). The value 0.10 represents the acceptable upper limit for the CR. In situations where the final CR is higher than this number, the process of evaluation has to be repeated for the purpose of improving consistency (Borajee & Yakchali, 2011).

CR has to be $\leq 5\%$ for $n=3$; $\leq 9\%$ for $n=4$; and $\leq 10\%$ for $n>4$. Values of the RI are listed in Table 3.

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}. \quad (4)$$

Table 1 The corruption risk practices in each stage of a construction project

ID	The corruption risk practices at the planning stage, committed by the client and contractor
CRP1	Using political influence (Adnan et al., 2012; Erasmus, 2013; Gates, 2014; Hadiwattege et al., 2000; Kasimu & Kolawole, 2015)
CRP2	Bribing to obtain planning permission (Akinsola & Omolayo, 2013)
CRP3	Collusion between contractors and public officers (Adnan et al., 2012; Gates, 2014; Jong et al., 2009)
CRP4	Overstating or tailoring the project requirements to suit a certain bidder (Akinsola & Omolayo, 2013)
CRP5	Greed of contractor and public officer (Bowen et al., 2012; Brown & Loosemore, 2015; Hadiwattege et al., 2000; Jong et al., 2009)
CRP6	Misuse of power in granting the project
CRP7	Avoidance of taxes and fees (Davis, 2004; OECD, 2016)
CRP8	Cover pricing
CRP9	A specific method being used to implement the project without adhering to the controls and issued instructions, helping manipulation and fraud in calculating costs and setting prices
CRP10	There being a choice of projects that directly impacts solving a specific crisis or benefiting a citizen
CRP11	A service project (not an investment) being included in the investment budget table, and it being considered an explicit violation
ID	**The corruption risk practices at the design stage, committed by the client and consultant**
CRP1	Manipulation of tender evaluation (Bowen et al., 2012; Brown & Loosemore, 2015; Davis, 2004; Fukuyama, 2005; Hadiwattege et al., 2000; Kolawole, 2015; OECD, 2016)
CRP2	Collusion between tenderer and public officer
CRP3	Culture of bribes (Adnan et al., 2012; Brown & Loosemore, 2015; Hadiwattege et al., 2000; Jong et al., 2009; OECD, 2016)
CRP4	Conflict of interest and lack of integrity (Bowen et al., 2012; Brown & Loosemore, 2015; Hadiwattege et al., 2000; Keifer & Effenberger, 1967)
CPR5	Altering the project's timing to suit vested interests (Sohail & Cavill, 2008)
CRP6	Corrupted selection of consultants in terms of feasibility studies and the preparation of specifications/bid documents (Tabish & Jha, 2012)
CPR7	Manipulating the project design to benefit certain consultants, contractors or suppliers as well as other private parties (Sohail & Cavill, 2008)
CPR8	The contracts with the design company not including penalty conditions in case of errors in the designs; thus, the designing party does not bear any liability for errors occurring during execution the works
ID	**The corruption risk practices at the tendering stage, committed by the contractor and client**
CRP1	Bribery for obtaining contracts (Akinsola & Omolayo, 2013)
CRP2	Leaking of information to a preferential bidder (Fukuyama, 2005; Gates, 2014; Hawkins, 2013; Shan et al., 2015)
CRP3	Production of a fraudulent timesheet
CRP4	The legal affair department being lax in taking action
CRP5	Collusion between companies or between public officials and bidders
CRP6	Officials taking percentages on government contracts
CRP7	Politicians' influencing the choice of contractor or the nature of the contract (Sohail & Cavill, 2006)
CRP8	Political parties levying large rents on international businesses in return for government contracts (Sohail & Cavill, 2008)
CRP9	Lack of competitive/inequitable contract practices
ID	**The corruption risk practices at the construction stage, committed by the client, contractor or consultant**
CPR1	Change order manipulation (Bowen et al., 2012; Gates, 2014; Hadiwattege et al., 2000; Jong et al., 2009)
CPR2	Collusion between contractors and officers (Bowen et al., 2012; Gates, 2014; Hadiwattege et al., 2000; Jong et al., 2009)
CRP3	Manipulation of the bills of quantities
CRP4	Non-implementation
CRP5	Concealing substandard work
CRP6	Deviations, particularly in especially high-value and high-rated items, not being adequately verified and monitored
CRP7	Site supervisors neglecting their duty by taking bribes from contractors
CRP8	The concealment of bribes
CRP9	Exaggerated or false claims against contractors for reducing or containing payments
CRP10	The departments in charge of counting, control and interiority in following up on spent loans being ineffective
CRP11	Violation of the instructions in the federal budget for purchasing (Al-Frijawy et al., 2018)
CRP12	Cheap or substituted materials (Jong et al., 2009; Keifer & Effenberger, 1967; Kolawole, 2015)

Table 1 (continued)

ID	The corruption risk practices at the construction stage, committed by the client, contractor or consultant
CRP13	The investor paying the salaries of the resident engineer and department employees, thus creating an agreement relationship between the investor and the resident engineer department when carrying out the work
CRP14	Fake certification of a supervision company (Brown & Loosemore, 2015; Davis, 2004; Kolawole, 2015; OECD, 2016)
CRP15	The owner of the project laying the foundation stone for the project twice, indicating the exploitation of the project for advertising purposes
CRP16	Baseless complaints from a contractor to obtain an unfair increase in the contract prices
CRP17	Bias in selection of a subcontractor (Bowen et al., 2012; Davis, 2004; Keifer & Effenberger, 1967)
CRP18	Changing the sub-contract party following the receipt of a bribe
ID	**The corruption risk practices at the operation and maintenance stage, committed by the contractor and client**
CRP1	Bribing for winning operation & maintenance (O&M) contracts/personnel appointments
CRP2	Corruption increases costs, meaning a lack of resources for O&M
CRP3	Manipulation of invoices (Chan & Owusu, 2017; Davis, 2004)
CRP4	Intense competition between maintenance contractors (Bowen et al., 2012; Brown & Loosemore, 2015)
CRP5	Collusion between contractors (Brown & Loosemore, 2015; Gates, 2014; Jong et al., 2009)
CRP6	Corruption in procurement related to spare parts and equipment
CRP7	Siphoning off supplies to the market
CRP8	Preference in promotions/hiring
CRP9	Illegal workers

Table 2 Pairwise scale of comparison Saaty (1996) and Dağdeviren et al. (2009)

Intensity of importance	Definitions	Explanation
1	Equally important	Two activities have equal contributions to an objective
3	Moderately important	Judgment and experience slightly favor one activity over the other
5	Very important	Judgment and experience strongly favor one activity over the other
7	Very strong or demonstrated importance	One of the activities is very strongly favored compared to the other; its dominance is shown in the practice
9	Extremely important	The evidence that favors one of the activities over the other is of the maximal possible affirmation order
2,4,6,8	For compromises amongst the values above	In some of the cases, one requires the numerical interpolation of a compromise judgment due to the fact that there are not any suitable words that can describe it

Table 3 Values of the RI (Saaty & Vargas, 1991)

N	1	2	3	4	5	6	7	8	9	10
RI	0.0	0.0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Implementing qualitative analysis (AHP) steps to rank corruption risk practices according to multi-criteria weights

The qualitative risk analysis will be performed as follows:

1. Specifying the hierarchy structure of the corruption risk practices model, which is divided into three levels as a goal (priority arrangement for corruption risk practices), main criteria (comparison between construction project stages) and sub-criteria (comparison between corruption risk practices in each stage of a construction project), as shown in Fig. 2.
2. The researcher conducted an interview and discussion with experts with over 15 years of experience auditing construction projects in Iraq in a group decision-making process. The details of respondents are presented in Table 4.

Table 5 and Fig. 3 show that 50% of respondents had 16–20 years' experience, 25% had 25–28 and 25% had 30–36.

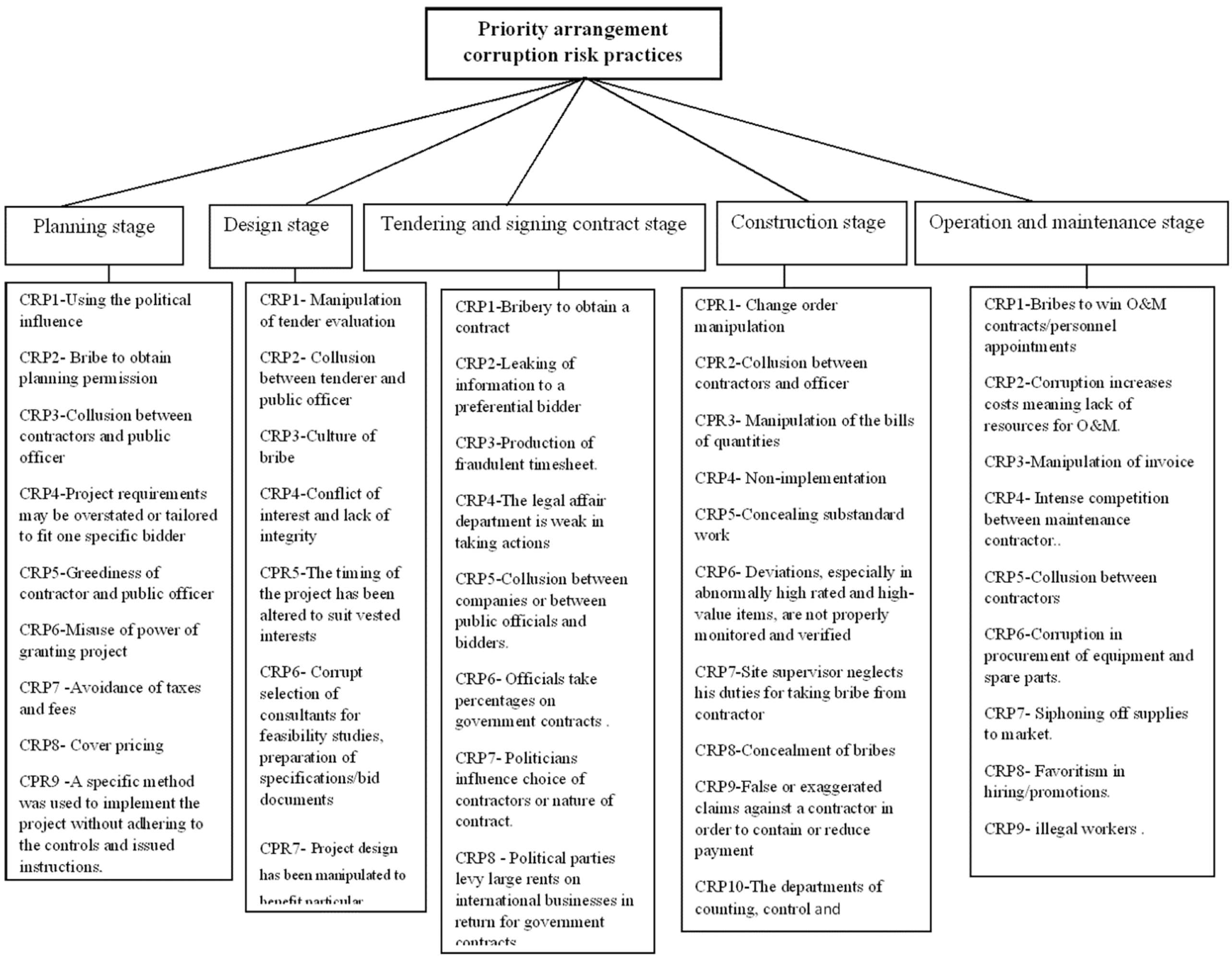

Fig. 2 The hierarchy structure of the corruption risk practices model

Table 6 and Fig. 4 illustrate that 58% of respondents studied law, 33% studied civil engineering and 9% studied electrical engineering.

Table 7 and Fig. 5 show that 92% of respondents had a B.Sc. degree and 8% of respondents had an M.Sc.

Table 8 and Fig. 6 demonstrate that 42% of respondents were legal consultants, 17% were senior legal advisors, 33% were chief senior engineers and 8% of respondents were assistant chief engineers.

3. Pairwise comparisons were made with FBSA staff experts to reach a consensus on the hierarchy of their evaluation synthesis by using the AHP form.
4. The pairwise comparisons generated in the previous stage were organized and put into a square matrix where the diagonal elements are equal to 1.0. The criterion in the ith row will be better than the criterion in the jth column if the element (i, j) is more than 1.0. If the value of the element (i, j) is less than

1.0, the criterion in the *j*th column will be better than that in the *i*th row since the element (*j*, *i*) of the matrix is the reciprocal of the (*i*, *j*). Table 9 shows the AHP matrix for prioritization of the stages of a construction project in which corruption practices are most frequent.

5. The column entries matrix is normalized to find the eigenvector, dividing each value of the column (*j*) by the sum of the column, as shown below.

Criteria	Priority vector (eigenvector) X
PS	0.068637
DS	0.169815
TS	0.183717
CS	0.519427
O&MS	0.058405

Criteria	PS	DS	TS	CS	O&MS
PS	1	0.33333333	0.2	0.142857143	2
DS	3	1	1	0.2	4
TS	5	1	1	0.333333333	2
CS	7	5	3	1	7
O&MS	0.5	0.25	0.5	0.142857143	1
Column sums	16.5	7.58333333	5.7	1.819047619	16

Normalised columns →

Normalized pairwise values are calculated by dividing each value by the sum of its column. The weights (priority vector) are calculated by averaging all the elements in the row.

Criteria	PS	DS	TS	CS	O&MS
PS	0.060606061	0.043956044	0.035087719	0.078534031	0.125
DS	0.181818182	0.131868132	0.175438596	0.109947644	0.25
TS	0.303030303	0.131868132	0.175438596	0.183246073	0.125
CS	0.424242424	0.65934066	0.526315789	0.54973822	0.4375
O&MS	0.03030303	0.032967033	0.087719298	0.078534031	0.0625
Column sums	1	1	1	1	1

Row average →

6. Calculating the lambda max (λ_{max}), which is used to determine the CI and the CR, each value in the pairwise comparison matrix is multiplied by the criteria value. The weighted sum value is calculated by taking the sum

of each value in the row, and then the weighted sum value is divided by criteria weights to calculate their ratios as follows:

Matrix (A) × Priority vector (X)

$$\begin{Bmatrix} 0.068636771 & 0.056604836 & 0.036743324 & 0.074203917 & 0.116809357 \\ 0.205910313 & 0.169814511 & 0.183716621 & 0.103885484 & 0.233618714 \\ 0.343183855 & 0.16981451 & 0.183716621 & 0.173142473 & 0.116809357 \\ 0.480457397 & 0.849072554 & 0.551149863 & 0.519427419 & 0.40883275 \\ 0.034318385 & 0.042453628 & 0.09185831 & 0.074203917 & 0.058404679 \end{Bmatrix} =$$

$$\overset{AX}{\begin{Bmatrix} 0.352998206 \\ 0.896945643 \\ 0.986666817 \\ 2.808939983 \\ 0.301238919 \end{Bmatrix}} = \overset{AX/X}{\begin{Bmatrix} 5.142989693 \\ 5.281914003 \\ 5.370590922 \\ 5.407762243 \\ 5.157787466 \end{Bmatrix}}$$

The lambda max (eigenvalue) is calculated by taking the average of all ratios (AX/A).

$\lambda_{max} = 5.272209$.

Consistency index (CI) is calculated by Eq. (3).

CI = 0.0680522.

Consistency ratio (CR) is calculated by Eq. (4).

Random index (RI) = 1.12, as given in Table 3.

CR = 0.0607609.

CR < 0.1 indicates sufficient consistency for decision.

Table 10 presents the weight for first-level criteria, second-level sub-criteria and risk parameter final weight. Super decisions software was used in the process of analyzing AHP answers.

Discussion of the results of the AHP corruption risk practices analysis

The results and findings from the risk analysis study showed that the construction stage was the primary stage for the occurrence of corruption practices, with a likelihood of 0.519427. Among the risks of the practice at this stage, according to the priority, concealing substandard work was 0.0534; this result was compatible with the findings (Sohail & Cavill, 2008) that happened at this stage. Collusion between contractors was 0.05093 and ranked as the second most significant fraudulent causative factor at this stage in Iraq. This result was compatible with findings (Saim et al., 2018), referring to the frequency of the factors and was ranked fourth as a major fraudulent causative factor in this stage. Non-implementation was 0.04673, and this result was in line with other findings (Sohail & Cavill, 2008). Change order manipulation had a value of 0.04187; this result was compatible with findings (Saim et al., 2018) and was ranked as the fourth among the major fraudulent causative factors. Deviations, especially in abnormally high-rated and high-value items not being properly monitored and verified, had a value of 0.04088; this result corresponded with other findings (Shan et al., 2015) and was ranked as the eighth in terms of severity, scored at 3.6 in a construction project in China. Site supervisors neglecting their duties by taking bribes from a contractor was 0.04019; this result was in line with other findings (Shan et al., 2015, 2018) and was ranked as the second in terms of severity, and scored at 3.97 in China's construction project. The second major stage was that of tendering and signing contracts, with a likelihood of 0.183717. Among the practice risks in this stage, bribery to obtain a contract was 0.0351 and ranked as five by using the relative corruption index scored 0.45 of fraudulent practices in the construction industry in Nigeria (Akinsola & Omolayo, 2013) and a similar system from the UK. Officials taking percentages on government contracts was 0.02606, which corresponds to other findings (Sohail & Cavill, 2008). Leaking of information to a preferential bidder had a value of 0.02572, ranked as five by using the

Table 4 The details of respondents for corruption risk practices

Rank	Job position	Academic degree	Educational background	Factional rank	Years of experience	Highest-cost project managed
1	Manager of the violation follow-up section	B.Sc	Law	Legal consultant	30	More than $150 million
2	Manager of the legal department	B.Sc	Law	Legal consultant	30	More than $150 million
3	Manager in the legal department	B.Sc	Law	Legal consultant	25	More than $150 million
4	Manager in the violation follow-up section	B.Sc	Law	Senior legal advisor	20	More than $150 million
5	Chairman of the specialized authority for Water Resources Affairs	B.Sc	Civil engineering	Chief senior engineer	18	More than $150 million
6	Chairman of the engineering authority	B.Sc	Electrical engineering	Chief senior engineer	36	More than $150 million
7	Chairman of the specialized authority for Oil Affairs	B.Sc	Civil engineering	Chief senior engineer	19	More than $150 million
8	Authority member	B.Sc	Civil engineering	Asst. chief engineer	16	More than $150 million
9	An employee in the violation follow-up section	M.Sc	Law	Senior legal advisor	16	More than $150 million
10	Authority member	B.Sc	Civil engineering	Chief senior engineer	17	More than $150 million
11	Manager of the administrative investigation department	B.Sc	Law	Legal consultant	26	More than $150 million
12	Manager of the lawsuits department	B.Sc	Law	Legal consultant	28	$11–50 million

Table 5 Experience of the respondents

No	Experience	No. of resonance	%
1	16–20 years	6	50
2	25–28 years	3	25
3	30–36 years	3	25
	Total	12	100

Table 6 Educational background of the respondents

No	Educational background	No. of resonance	%
1	Law	7	59
2	Civil engineering	4	33
3	Electrical engineering	1	8
	Total	12	100

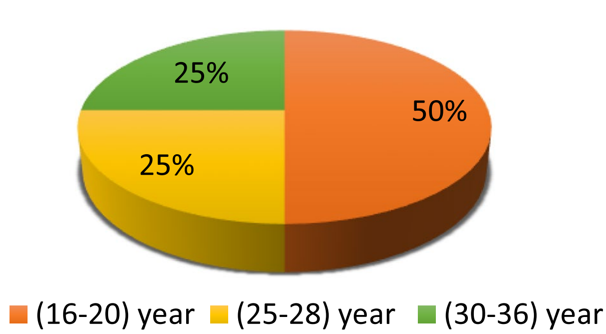

Fig. 3 Experience of the respondents

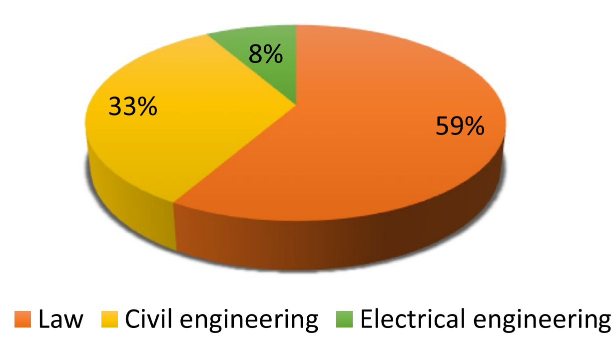

Fig. 4 Educational background of the respondents

Table 7 Academic degree of respondents

No	Academic degree	No. of resonance	%
1	B.Sc	11	92
2	M.Sc	1	8
	Total	12	100

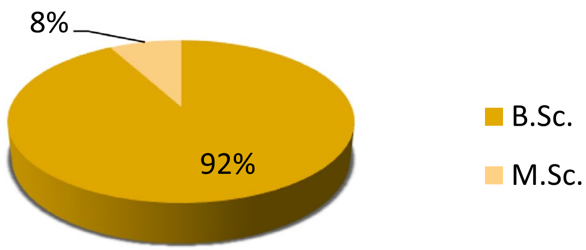

Fig. 5 Academic degree of respondents

Table 8 Factional rank of respondents

No	Factional rank	No. of resonance	%
1	Legal consultant	5	42
2	Senior legal advisor	2	17
3	Chief senior engineer	4	33
4	Asst. chief engineer	1	8
	Total	12	100

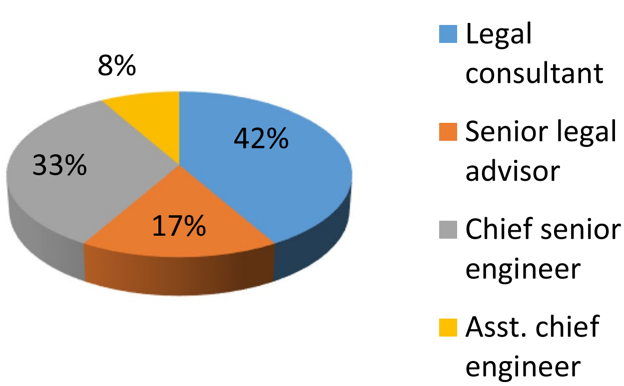

Fig. 6 Factional rank of respondents

relative corruption index scored at 0.45 of fraudulent practices in the construction industry in Nigeria (Akinsola & Omolayo, 2013), ranked as twenty with a mean score of 3.49 (Shan et al., 2018), and ranked as fourth in terms of severity, scored at 3.73 (Shan et al., 2015) in the construction project in China. Politicians' influencing the choice of contractor or the nature of the contract was rated as 0.02537, while collusion between companies or public officials and bidders was 0.02071. This latter result is compatible with other findings (Saim et al., 2018) and was ranked as the primary fraudulent causative factor at this stage. Political parties levying large rents on international businesses in return for government contracts had a value of 0.01902 and this correlates with the findings (Sohail & Cavill, 2008). At the third level of likelihood of practice was the design stage, with a value of 0.169815. Among the risk practices at this stage, manipulation of tender evaluation was 0.0432; this result is in line with other findings (Saim et al., 2018) and was ranked the second greatest factor, with findings (Zou, 2006) (Tabish & Jha, 2012), and was ranked sixteenth with a mean score of 3.67 in the construction project in China according to Shan et al. (2018). Collusion between tenderer and public officer was 0.02919, corresponding with other findings (Saim et al., 2018), and was ranked as the major fraudulent causative factor at this stage. The timing of the project being altered to suit vested interests was rated 0.02721, which correlates with other findings (Sohail & Cavill, 2008). Conflict of interest and lack of integrity was 0.02379; this result was in line with other findings (Saim et al., 2018) and was ranked as the fourth most significant fraudulent causative factor. The culture of bribes was 0.01672; this result aligned with other findings (Saim et al., 2018) and was ranked as the third major fraudulent causative factor. The corrupt selection of consultants for feasibility studies, the preparation of specifications/bid documents and project design being manipulated to benefit particular suppliers, consultants, contractors and other private parties was valued at 0.01183. This result was in line with other findings (Shan et al., 2018) and was ranked as collusive practice number ten in the construction project in China. The fourth stage of likelihood, at 0.068637, was the planning stage. Among the risk practices in this stage, using political influence was 0.01458, with a result that correlated with other findings (Saim et al., 2018) and ranked as the first major fraudulent causative factor. Collusion between contractors and public officers was valued at 0.00925, which was consistent with other findings (Saim et al., 2018) and was ranked as the third fraudulent causative factor. Project requirements being overstated or tailored to fit one specific bidder was 0.00838; this result was in line with other findings (Shan et al., 2018) and was ranked as the third collusive practice in the construction project in China. Bribing to obtain planning permission was valued at 0.00692 and was scored 0.44 by using the corruption relative index and ranked as six of fraudulent practices in the construction industry in Nigeria (Akinsola & Omolayo, 2013). The greediness of contractors and public officers was 0.00582 and misuse of power in granting projects was 0.00577. The fifth stage of likelihood, valued at 0.058405, was the operation and maintenance stage. Among the risk practices at this stage, bribes to win O&M contracts and personnel appointments were 0.01285, and this result was in line with a rating of very corrupt in the system based in

Table 9 Values in the pairwise comparisons matrix in the stages of construction project

Stage of project	Planning stage	Design stage	Tendering stage	Construction stage	Maintenance and operation stage
Planning stage	**1**	1/3	1/5	1/7	2
Design stage	3	**1**	1	1/5	4
Tendering stage	5	1	**1**	1/3	2
Construction stage	7	5	3	**1**	7
Maintenance and operation stage	0.5	0.25	0.5	1/7	**1**

the construction industry in Nigeria (Akinsola & Omolayo, 2013) and in the UK. Corruption increasing costs, meaning a lack of resources for O&M, scored 0.0117, and this result corresponded with other findings (Sohail & Cavill, 2008). Manipulation of invoices was rated 0.00834; this result was in line with other findings (Saim et al., 2018) and was ranked the second most important fraudulent causative factor. Corruption in the procurement of equipment and spare parts was 0.00563, and this result corresponded with other findings (Sohail & Cavill, 2008). The practice of illegal workers was valued at 0.00505; this result was ranked as the first collusive practice with a relative corruption index scored at 0.58 in construction projects in Nigeria (Akinsola & Omolayo, 2013). Preference in hiring and promotions was 0.00416, and this result was in line with other findings (Sohail & Cavill, 2008).

Strategies to combat corruption risk practices

The respondents suggested six strategies to combat corruption risk practices:

(a) Implementing an electronic governance system in institutions; in other words, using information and communication technologies (such as the internet) that can transform relationships with citizens, businesses, and branches of the government. These technologies enable institutions to serve various purposes, such as improving government service provision to citizens, increasing interaction with the business sector and the construction industry, and enhancing the efficiency of government administration, resulting in reduced corruption, increased transparency, increased income or reduced costs.

(b) Developing the necessary legal procedures to strengthen the rule of law and improve the capacity of organizational bodies to implement anti-corruption measures.

(c) Strengthening the role of regulatory agencies to ensure the establishment of procedures for coordination and cooperation between them.

(d) Enhancing internal control procedures in all state departments to enhance the administration's ability to control and reduce the risks of collusion and fraud in the construction sector.

(e) Simplification and rationalization of administrative procedures and periodical self-evaluation of institutions.

(f) Promotion of public education, transparency, and integrity, as well as a focus on the importance of implementing a workplace code of conduct and uncovering financial interests.

This research provides preventive action for each practice in each stage of a construction project. This is illustrated in Tables 11, 12, 13, 14 and 15 below.

Conclusion

Administrative and financial corruption in the construction sector is a longstanding phenomenon that has affected the administrative system since the establishment of the Iraqi state. It has increased during the past 3 decades due to wars and economic sanctions imposed on Iraq. The most corrupt practices in the construction sector are a culture of bribery, which affects all project stages. This research recommends that organizations must comply with ISO 37001. In 2013, ISO created a project committee to create ISO 37001. The committee comprised experts from the participating and observing countries, including Iraq, which is an anti-bribery management system (ABMS) standard. It was published in October 2016. It describes a number of anti-bribery rules and procedures that institutions should use to help prevent bribery as well as identify and resolve any bribery that happens**.** The primary stage in which corruption appears is the

Table 10 In each stage of a construction project, each corruption practice is given a local weight, a final weight and a rank

Stage of project	The stage criteria weight	Sub-criteria	Sub-criteria local weight	Sub-criteria final weight	Rank
Planning stage	0.068637	CRP1	0.21241	0.01458	1
		CRP2	0.10083	0.00692	4
		CRP3	0.13474	0.00925	2
		CRP4	0.12207	0.00838	3
		CRP5	0.08480	0.00582	5
		CRP6	0.08404	0.00577	6
		CRP7	0.05606	0.00385	8
		CRP8	0.04432	0.00304	10
		CRP9	0.07718	0.00530	7
		CRP10	0.04613	0.00317	9
		CRP11	0.03742	0.00257	11
Design stage	0.169815	CRP1	0.25441	0.04320	1
		CRP2	0.17191	0.02919	2
		CRP3	0.09845	0.01672	5
		CRP4	0.14008	0.02379	4
		CRP5	0.16021	0.02721	3
		CRP6	0.06965	0.01183	6
		CRP7	0.06965	0.01183	6
		CRP8	0.03564	0.00605	7
Tendering stage	0.183717	CRP1	0.19104	0.03510	1
		CRP2	0.13999	0.02572	3
		CRP3	0.06983	0.01283	7
		CRP4	0.06113	0.01123	8
		CRP5	0.11274	0.02071	5
		CRP6	0.14184	0.02606	2
		CRP7	0.13807	0.02537	4
		CRP8	0.10354	0.01902	6
		CRP9	0.04182	0.00768	9
Construction stage	0.519427	CRP1	0.0806	0.04187	4
		CRP2	0.09805	0.05093	2
		CRP3	0.07686	0.03992	7
		CRP4	0.08997	0.04673	3
		CRP5	0.10281	0.05340	1
		CRP6	0.07871	0.04088	5
		CRP7	0.07738	0.04019	6
		CRP8	0.0676	0.03511	8
		CRP9	0.04713	0.02448	9
		CPR10	0.03455	0.01795	10
		CRP11	0.03365	0.01748	13
		CRP12	0.03373	0.01752	12
		CRP13	0.03138	0.01630	14
		CRP14	0.02493	0.01295	16
		CRP15	0.03418	0.01775	11
		CRP16	0.02766	0.01437	17
		CRP17	0.03041	0.01580	15
		CRP18	0.03041	0.01580	15

Table 10 (continued)

Stage of project	The stage criteria weight	Sub-criteria	Sub-criteria local weight	Sub-criteria final weight	Rank
O&M stage	0.058405	CRP1	0.22003	0.01285	1
		CRP2	0.2004	0.01170	2
		CRP3	0.14274	0.00834	3
		CRP4	0.05874	0.00343	8
		CRP5	0.06806	0.00398	7
		CRP6	0.09632	0.00563	4
		CRP7	0.056	0.00327	9
		CRP8	0.07129	0.00416	6
		CRP9	0.08643	0.00505	5
Summation	1			1	

Table11 Preventive action against corruption risk practices at the planning stage

Rank	ID	The corruption risk practices at the planning stage	Preventive action
1	CRP1	Using political influence	Project owners implement integrity pact and transparency
2	CRP3	Collusion between contractors and public officers	Examining former projects to identify suspicious or unusual relations between the public officer and the contractor
3	CRP4	Overstating or tailoring the project requirements to suit a certain bidder	Project owners implement integrity pact and transparency
4	CRP2	Bribing to obtain planning permission	The role of internal control should be improved
5	CRP5	Greed of contractor and public officer	The role of internal control should be improved
6	CRP6	Misuse of power in granting the project	Project owners implement integrity pact during the planning stage
7	CRP8	A specific method being used to implement the project without adhering to the controls and issued instructions, helping manipulation and fraud in calculating costs and setting prices	Project owners implement and adhere to the controls and issued instructions when executing the project
8	CRP7	Avoiding fees and taxes	Checking cases when adequate fees were paid to the land occupants with a pre-agreed amount of money or in kind. The checking is necessary for both parties—the land occupants and the developer on their agreement and the transaction of the actual fee history
9	CRP10	There being a choice of projects that have no direct impact on solving a specific crisis or benefiting a citizen	Project owners implement integrity pact during the planning stage
10	CRP8	Cover pricing	Project owners implement integrity pact during the planning stage
11	CRP11	A service project (not an investment) being included in the investment budget table, and it being considered an explicit violation	Project owners implement integrity pact and transparency

construction stage. This is followed by the tendering stage, which is an important stage when the work is assigned to the selected company, then the design stage, the planning stage, and the operation and maintenance stage. Most of the corruption is committed by government institutions (the public sector) in the client's locality due to the corruption of government officials and working employees, which leads to lax internal control in institutions and to not applying the principles of transparency and integrity when executing the work. This research recommends applying the principle of electronic governance to eliminate corruption risk practices along with periodically changing employees or officials and

Table12 Preventive action against corruption risk practices at the design stage

Rank	ID	The corruption risk practices at the design stage	Preventive action
1	CRP1	Manipulation of tender evaluation	Auditing procedures should be initiated on the work of the committees
2	CRP2	Collusion between tenderer and public officer	Examine former projects to identify suspicious or unusual relations between the public officer and the tenderer
3	CPR5	The project timing being changed to suit vested interests	The role of internal control should be improved
4	CRP4	Conflict of interests and lack of integrity	Transparency and integrity pact is implemented via the project owners
5	CRP3	Culture of bribes	Transparency and integrity pact is implemented via the project owners
6	CRP6	Corrupt selection related to consultants for feasibility studies and the preparation of specifications/bid documents	The role of internal control should be improved
6	CRP7	Project design being altered to benefit specific suppliers, contractors or consultants as well as other private parties	The role of internal control should be improved
7	CRP8	The design contracts and the designing company not including penalty conditions for the designing party in case of errors in the designs; thus, the designing party does not bear any offense liability for errors that appear during the works	The role of legal procedures should be improved when concluding contracts

Table13 Preventive action against corruption risk practices at the tendering stage

Rank	ID	The corruption risk practices at the tendering stage	Preventive action
1	CRP1	Bribery to obtain a contract	Project owners implementing transparency and integrity pact
2	CRP6	Officials taking a certain percentage on the government contracts	The project owner should apply the principle of transparency and integrity
3	CRP2	Leaking of information to a preferential bidder	Auditing procedures should be initiated on the work of bid-analysis committees
4	CRP7	Politicians influencing the contract nature of the contractor choice	The project owner should apply the principle of transparency and integrity
5	CRP5	Collusions between companies or between bidders and public officials	Examine previous projects to identify suspicious or uncommon relations between the public officer and the bidder
6	CRP8	Political parties levying large rents on international businesses in return for government contracts	The project owner should apply the principle of transparency and integrity
7	CRP3	Production of a fraudulent timesheet	Auditing procedures should be initiated on the work of committees
8	CRP4	The legal affair department being lax in taking actions	The role of legal procedures should be improved
9	CRP9	Lack of competitive/inequitable contract practices	The role of internal control should be improved

monitoring their working behavior within the institution. The corruption risk practices for the construction sector, as assessed using the AHP and provided in this research, are of very high importance for anti-corruption institutions, industry professionals, and policymakers to aid the formulation of anti-corruption measures. This also constitutes an element of vital data that is required by both the construction industry and academic researchers for instigating further studies and informing the proposition and development of novel anti-corruption measures, helping to lower the corruption rate in the short term and, hopefully, eliminate it entirely in the long term.

Table14 Preventive action against corruption risk practices at the construction stage

Rank	ID	The corruption risk practices at the construction stage	Preventive action
1	CRP5	Concealing substandard work	Auditing procedures should be initiated on the work of the committees
2	CRP2	Collusion between contractors and officer	The project owner should apply the principle of transparency and integrity
3	CRP4	Non-implementation	Auditing procedures should be initiated on the work of bid-analysis committees should select the best bid
4	CRP1	Change order manipulation	Auditing procedures should be initiated on the work of the committees
5	CRP6	Deviations, particularly in unusually high-value and high-rated items, not being suitably verified and monitored	The entity supervising the work must submit a monthly work progress schedule and the project owner must monitor the work continuously
6	CRP7	Site supervisors neglecting their duty by taking bribes from the contractor	Examine the previous projects to identify suspicious or uncommon relationships between the contractor and the on-site supervision company
7	CRP3	Manipulation of the bills of quantities	Auditing procedures should be initiated on the work of the committees
8	CRP8	Concealment of bribes	Auditing procedures should be initiated on the work of the committees or the disclosure of involvement in corruption, and these should be referred to the judiciary
9	CRP9	Exaggerated or false claims against a contractor for reducing or withholding payment	The role of internal control should be improved
10	CRP10	The departments of counting, control and interiority in the following up of the spent loans being inadequate	Change the employees working in the control department periodically and monitor their working behavior
11	CRP15	The project owner laying the foundation stone for the project twice, indicating the exploitation of the project for advertising purposes	The project owner should apply the principle of transparency and integrity
12	CRP12	Cheap or substituted materials	The executive committees should open sub-stores in the worksites, done in a way that ensures the regular input and output of materials; they then return the surplus materials to the main warehouses
13	CRP11	Violation of the instructions in the federal budget for purchasing	The officials should commit to following the instructions in the federal budget for purchasing
14	CRP13	The investor paying the salaries of the resident engineer and department employees, thus creating an agreement relationship between the investor and the resident engineer department when carrying out the work	The role of internal control should be improved for disclosure about involvement in corruption, and this should be referred to the judiciary
15	CRP17	Bias in the selection of a subcontractor	Non-encouragement of contractors to sell the works referred to them to subcontractors and setting penal regulations against this
15	CRP18	Changing the subcontractor after receiving bribes	Non-encouragement of contractors to sell the works referred to them to subcontractors and setting penal regulations against this
16	CRP14	Fake certification of the supervision company	Auditing procedures should be initiated on the work of committees
17	CRP16	Baseless complaints from contractors as an approach for obtaining an unjustified increase in the contract prices	The role of legal procedures should be improved

Table15 Preventive action against corruption risk practices at the operation and maintenance stage

Rank	ID	The corruption risk practices at the operation and maintenance stage	Preventive action
1	CRP1	Bribes for winning O&M contracts/personnel appointments	Project owners implement transparency and integrity pact
2	CRP2	Corruption increases costs, meaning a lack of resources for O&M	The role of internal control should be improved
3	CRP3	Manipulation of invoices	Auditing procedures should be initiated on the work of the committees
4	CRP6	Corruption in the procurement of equipment and spare parts	The role of internal control should be improved
5	CRP9	Intense competition between maintenance contractors	The role of internal control should be improved for disclosure about involvement in corruption, and this should be referred to the judiciary
6	CRP8	Favoritism in hiring/promotions	The project owner should apply the principle of transparency and integrity
7	CRP5	Collusion between contractors	The role of internal control should be improved
8	CRP4	Illegal workers	The entity supervising the work must monitor workflow
9	CRP7	Siphoning off supplies to the market	Auditing procedures should be initiated on the work of the purchasing committees

Acknowledgements This paper was produced in cooperation with the Department of Civil Engineering, University of Baghdad.

References

Adnan, H., Kassim, A., & Chong, H. Y. (2012). Success factors on joint venture projects for Indigenuous bumiputera contractors in Malaysia. *Journal of Applied Sciences Research, 8*, 4113–4125.

Akinsola, O. E., & Omolayo, O. H. (2013). Corruption and fraud in the Nigerian construction sector. The transformation of the building industry-possibilities and realities. *43 Rd Annual General Meeting and Conference of Nigeria Institute of Building Held at Conference Centre On*, *26*

Al Barqouni, H. M. (2015). Application of analytic hierarchy process (AHP) in risk assessment for construction building projects. A Thesis Submitted in Partial Fulfillment of Requirements for the Degree of Master in Construction Management, The Islamic University. Gaza

Albayrak, E., & Erensal, Y. C. (2004). Using analytic hierarchy process (AHP) to improve human performance: an application of multiple criteria decision making problem. *Journal of Intelligent Manufacturing, 15*(4), 491–503.

Al-Frijawy, J., Militaru, C., & Ali, M. H. (2018). The phenomenon of the spread of administrative and financial corruption in Iraq despite the multiplicity of oversight bodies. *American Scientific Research Journal for Engineering Technology, and Sciences (ASRJETS), 49*(1), 8–18.

Al-Harbi, K. M. A. S. (2001). Application of the AHP in project management. *International Journal of Project Management, 19*(1), 19–27.

Atanasova-Pacemska, T., Lapevski, M., & Timovski, R. (2014). Analytical hierarchical process (AHP) method application in the process of selection and evaluation

Baby, S. (2013). AHP modeling for multi-criteria decision-making and to optimise strategies for protecting coastal landscape resources. *International Journal of Innovation, Management and Technology, 4*(2), 218.

Borajee, M., & Yakchali, S. H. (2011). Using the AHP-ELECTRE III integrated method in a competitive profile matrix. *International Conference on Financial Management and Economics* (pp. 68–72)

Bowen, P., Edwards, P., & Cattell, K. (2012). Corruption in the South African construction industry: A mixed methods study. *Proceedings of 28th Annual ARCOM Conference (Ed. Smith, SD)*, (pp. 521–531)

Bowen, P., Pearl, R., & Akintoye, A. (2007). Professional ethics in the South African construction industry. *Building Research and Information, 35*(2), 189–205.

Brown, J., & Loosemore, M. (2015). Behavioural factors influencing corrupt action in the Australian construction industry. *Engineering, Construction and Architectural Management*, *22*(4), 372–389.

Chan, A. P. C., & Owusu, E. K. (2017). Corruption forms in the construction industry: literature review. *Journal of Construction Engineering and Management, 143*(8), 4017057.

Crist, R. A. (2009). The ASCE committee of global principles for professional conduct. *Leadership and Management in Engineering, 9*(3), 144–146.

Dağdeviren, M., Yavuz, S., & Kılınç, N. (2009). Weapon selection using the AHP and TOPSIS methods under fuzzy environment. *Expert Systems with Applications, 36*(4), 8143–8151.

Davis, J. (2004). Corruption in public service delivery: experience from South Asia's water and sanitation sector. *World Development, 32*(1), 53–71.

De Jong, M., Henry, W. P., & Stansbury, N. (2009). Eliminating corruption in our engineering/construction industry. *Leadership and Management in Engineering, 9*(3), 105–111.

Dyer, R., & Forman, E. (1990). *Analytical approach to marketing decisions* (p. 496). Princeton.

Erasmus, J. (2013). *Understanding tender corruption* (pp. 1–17). Corruption Watch.

Eskander, R. F. A. (2018). Risk assessment influencing factors for Arabian construction projects using analytic hierarchy process. *Alexandria Engineering Journal, 57*(4), 4207–4218.

Foster, J. E., Horowitz, A. W., & Méndez, F. (2012). An axiomatic approach to the measurement of corruption: theory and applications. *The World Bank Economic Review, 26*(2), 217–235.

Fukuyama, F. (2005). Global corruption report: Corruption in construction and post-conflict reconstruction, transparency international. Auflage.

Gates, K. L. (2014). Biggest risk of corruption in the construction industry. *The Global Picture*, *11*, 1–4.

Gunduz, M., Onder, O. (2012). Fraud and corruption risk assessment in construction industry, *Las Vegas, Nevada USA*, September 11–13, 2012.
Hadiwattege, C., De Silva, L., & Pathirage, C. (2000). Corruption in Sri Lankan Construction Industry. *W107-Special Track 18th CIB World Building Congress May 2010 Salford, United Kingdom*, 141
Hawkins, J. (2013). How to note: Reducing corruption in infrastructure sectors. *Conference Paper*.
Johnsøn, J. (2015). The basics of corruption risk management: A framework for decision making and integration into the project cycles. *U4 Issue*, *11*(18), 1–23
Kasimu, M. A., & Kolawole, A. F. (2015). Appraisal of the impact of corruption on sustainable development in Nigerian Construction Industry. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)., 2*(10), 2834–2842.
Keifer, G., & Effenberger, F. (1967). Understanding tender corruption. *Angewandte Chemie International Edition, 6*(11), 951–952.
Kenny, C. (2012). Publishing construction contracts to improve efficiency and governance. *Proceedings of the Institution of Civil Engineers, 165*(5), 18–22.
Kolawole, A. F. (2015). Appraisal of the impact of corruption on sustainable development in Nigerian Construction Industry. *Journal of Multidisciplinary Engineering Science and Technology, 2*(10), 2834–2842.
Mazigo, D. (2014). "Causes of corruption in construction public procurement in Tanzania: A case of Manyara Region" *Dissertation Submitted in Partial Fulfillment of the Requirements for the Award of Master of Business Administration (Corporate Management) Degree of Mzumbe University*
Mota-Sanchez, F. (2010). Application of analytic hierarchy process in upstream risk assessment and project evaluations, Ph.D. Thesis, Texas A & M University
Nag, B. (2015). Combating corruption in Indian public procurement: some exploratory case Studies. *Journal of Institute of Public Enterprise, 38*(1/2), 1–34.
OECD. (2016). *Preventing corruption in public procurement*. OECD.
Okafor, E. E. (2013). Corruption and implications for industrial development in Nigeria. *Journal of Business Management, 7*(29), 2916–2924.
Olufemi, A., Fniob, E., & Omolayo, O. H. (2013). Corruption and fraud in the Nigerian construction sector" A paper presented at the Transformation of the Building Industry–Possibilities and Realities. *43rd Annual General Meeting and Conference of Nigerian Institute of Building Held at International Conference Centre on 26th–30th*
Plaček, M., Půček, M., & Ochrana, F. (2019). Identifying corruption risk: a comparison of Bulgaria and the Czech Republic. *Journal of Comparative Policy Analysis: Research and Practice, 21*(4), 366–384.
Podvezko, V. (2009). Application of AHP technique. *Journal of Business Economics and Management, 2*, 181–189.
Saaty, T. L. (1990). How to make a decision: the analytic hierarchy process. *European Journal of Operational Research, 48*(1), 9–26.
Saaty, T. L. (1996). *Decision making with dependence and feedback: The analytic network process, vol. 4922*. RWS Publications.
Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences, 1*(1), 83–98.
Saaty, T. L., & Hu, G. (1998). Ranking by eigenvector versus other methods in the analytic hierarchy process. *Applied Mathematics Letters, 11*(4), 121–125.
Saaty, T. L., & Vargas, L. G. (1991). *Prediction, projection and forecasting: Applications of the analytic hierarchy process in economics, finance politics, games and sports*. Kluwer Academic.
Saim, N. A. I. M., Rahman, I. A., & Ismail, M. F. (2018). Factors contributing to fraudulent practices in construction project life cycle. *International Journal of Engineering & Technology, 7*(3.20), 647–651.
Sevkli, M., Lenny Koh, S. C., Zaim, S., Demirbag, M., & Tatoglu, E. (2007). An application of data envelopment analytic hierarchy process for supplier selection: a case study of BEKO in Turkey. *International Journal of Production Research, 45*(9), 1973–2003.
Shakantu, W. (2006). Corruption in the construction industry: forms, susceptibility and possible solutions issues. *Civil Engineering Siviele Ingenieurswese, 2006*(7), 43–47.
Shan, M., Chan, A. P. C., Le, Y., Xia, B., & Hu, Y. (2015). Measuring corruption in public construction projects in China. *Journal of Professional Issues in Engineering Education and Practice, 141*(4), 5015001.
Shan, M., Le, Y., Chan, A., Hu, Y. (2020). Corruption in the public construction sector. ISBN 978-981-13-9550-5 (eBook). https://doi.org/10.1007/978-981-13-9550-5
Shan, M., Le, Y., Yiu, K. T., Chan, A. P., & Hu, Y. (2017). Investigating the underlying factors of corruption in the public construction sector: evidence from China. *Science and Engineering Ethics, 23*(6), 1643–1666.
Shan, M., Le, Y., Yiu, K. T. W., Chan, A. P. C., Hu, Y., & Zhou, Y. (2018). Assessing collusion risks in managing construction projects using artificial neural network. *Technological and Economic Development of Economy, 24*(5), 2003–2025. https://doi.org/10.3846/20294913.2017.1303648
Skibniewski, M. J., & Chao, L. C. (1992). Evaluation of advanced construction technology with AHP method. *Journal of Construction Engineering and Management, 118*(3), 577–593.
Škrbec J. (2016) "Corruption Risk Management" Addendum to the Risk Management Guidelines, handbook, this publication has been produced with the assistance of the European Union
Sohail, M., & Cavill, S. (2006). Corruption in construction projects. In: Serpell, A (Ed.), *Proceedings of the CIB W107 Construction in Developing Countries Symposium Construction in Developing Economies: New Issues and Challenges,* January, 18, 20
Sohail, M., & Cavill, S. (2008). Accountability to prevent corruption in construction projects. *Journal of Construction Engineering and Management, 134*(9), 729–738.
Tabish, S., & Jha, K. N. (2011). Analyses and evaluation of irregularities in public procurement in India. *Construction Management and Economics, 29*(3), 261–274.
Tabish, S. Z. S., & Jha, K. N. (2012). The impact of anti-corruption strategies on corruption free performance in public construction projects. *Construction Management and Economics, 30*(1), 21–35.
Tofan, A. S., & Breesam, H. K. (2018). Using the Fuzzy-AHP technique for determining the key performance indicators of public construction companies in Iraq. *International Journal of Civil Engineering and Technology, 9*(13), 1431–1445.
USAID. (2014). "Public Financial Management Risk Assessment Framework Manual" A mandatory Reference for ADS Chapter 20. https://www.usaid.gov/sites/default/files/documents/1868/220mae.pdf Accessed 28 Jul 2014.
Wang, J.-J., & Yang, D.-L. (2007). Using a hybrid multi-criteria decision aid method for information systems outsourcing. *Computers & Operations Research, 34*(12), 3691–3700.
Wen-Ying, L. I. (2009). Application of AHP analysis in risk management of engineering projects. *Journal Beijing University of Chemical Technology (social Sciences Edition), 1*, 46–48.
Wind, Y., & Saaty, T. L. (1980). Marketing applications of the analytic hierarchy process. *Management Science, 26*(7), 641–658.
World Bank. (2013). *World development report 2014: Risk and opportunity-managing risk for development*. The World Bank.
Zou, P. X. W. (2006). Strategies for minimizing corruption in the construction industry in China. *Journal of Construction in Developing Countries, 11*(2), 15–29.