2023

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Available at: https://doi.org/10.58491/2735-4202.3047

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ORIGINAL STUDY

Evaluation of the Risk Factors Impacting the Cost Overruns in the Construction of Roads in Egypt During the COVID-19 Pandemic

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Abstract

Cost overruns are a common problem in the global construction industry, which affects the development of road construction, particularly in developing countries. Moreover, many risk factors in road construction might result in project cost overruns, particularly during COVID-19. So, the research aimed to look into the new risk variables' severity when a coronavirus infection was present. The primary goal of the study is to identify the most important risk variables affecting the construction of roads in Egypt, especially during COVID-19 to lessen the likelihood and impact of those risks. The likelihood and effects of the identified risks were determined by conducting a questionnaire survey on a set of 11 risk categories made up of 162 risks. The study's findings also indicate that the excessive and illegal loads on the roads, the fluctuating value of the Egyptian pound, and the accruing interest on loans to the contractor as a result of the work interruption caused by the coronavirus are the high-risk factors that have the greatest impact on cost overruns for road projects. In addition, the cost matrix has also been used to display risk factor levels as a road map for responding quickly to high risks.

Keywords: Cost overruns, Qualitative risk analysis, Risk breakdown structures, Road projects

1. Introduction

Cost overruns are a frequent issue in the world's construction sector, which has an impact on the growth of road construction, especially in emerging nations (Donaldson, 2018). Moreover, several road construction risk factors could cause project cost overruns, especially during COVID-19. As far as we know, no previous research has investigated the effect of the coronavirus on the cost overruns in the construction of roads in Egypt. Therefore, a broad range of risk factors was examined in the study to demonstrate how severe its impacts were, particularly during COVID-19. In addition, risk breakdown structures [RBS] have separated the risk factors into eleven groups. The RBS in the study includes operational, equipment, and the effects of the coronavirus, as well as contract, design, material, owner, labor, contractor, and consultant. The research methodology starts with a comprehensive literature review to provide a list of the main risk factors. A final risk factor list also includes the factors that experts added especially during COVID-19. Therefore, the primary goal of this article is to identify the most important risk variables affecting the construction of roads in Egypt, especially during COVID-19 to lessen the likelihood and impact of those risks. The likelihood and effects of the identified risks were determined by conducting a questionnaire survey on a set of 11 risk categories made up of 162 risks. The cost matrix has also been employed as a tool for displaying the levels of risk factors, and as a result, it may be utilized to develop a road map for generating speedy responses for high risks.
2. Literature review

Cost overruns are seen as an event or disturbance that pushes the project's cost over the budget. It may also result in estimates of time and cost that are incorrect. It can also be brought on by the absence of a thorough strategy to risk management. Project risk management refers to the procedures used in risk management planning, identification, analysis, responses, and project monitoring and control (Project Management, 2017). And, the goal of project risk management [RM] is to identify and prioritize risks that are likely to take place, focus on providing guidelines for risk response, and direct and manage project risks by raising the possibility and impact of the occurrence of favorable events (opportunities) and reducing the likelihood and impact of the occurrence of unfavorable events (threats) to the project (Borge, 2002). However, several projects are not prepared to manage risk because most firms’ current project management methods do not take into account the expanding demands for risk management (Smith et al., 2014). There are several severe constraints to risk management methods used in project management. These constraints contain: A) the amount of time needed to use risk management techniques; B) Collecting input estimations and evaluating likelihood might be difficult; C) Organizational and individual reluctance to change D) inability to comprehend and evaluate results of risk management methods (Leung et al., 1998). The risk breakdown structures (RBS) can be used as a checklist to ensure that all risk sources are covered during risk identification, which speeds up the process. The RBS also offers a categorization of the discovered risks according to their sources, enabling the project team to give some risk sources more focus than others as they are more frequent in the project.

The size of the project, the expansion of the project’s scope, inflation, the amount of time required to finish the project, the incompleteness of initial engineering and quantity surveys, external delays, the complexity of administrative structures, and the lack of management staff experience are the causes that lead to cost escalation. Also, the factors that contribute to cost escalation are project location, project specifics, environmental mitigation costs, work halts, strikes, bid expiration, stress from the local government, and political turbulence (Schexnayder et al., 2003). Mansfield showed that ineffective contract management, poor planning, faulty estimating, and general price fluctuations are the main causes of cost escalation (Mansfield et al., 1994).

Cost overruns affect the development of road construction, particularly in developing countries. Moreover, many risk factors in road construction might result in project cost overruns. Cost overruns can happen for a variety of reasons on different kinds of projects. If project costs end up being higher than anticipated, the funding profile would no longer be compatible with the demands of the budget. The consequences would be negative, especially for developing nations whose prosperity is measured in large part by how well they succeed in providing infrastructure through the construction industry, particularly on road construction projects, which make up a significant portion of the business (Kaliba et al., 2009). Most developing economies also deal with this issue; it does not only affect wealthy nations (Ahmed et al., 2002). Cost escalation is the phrase used to describe the increase in the sum of money needed to build a road project above and beyond the initially planned amount. Cost escalation happens when real expenses are higher than originally anticipated values. Schexnayder looked at some of the factors that contribute to cost growth and divided them into two categories: Uncontrollable and restraining factors (Schexnayder et al., 2003). Other investigations determined that issues including delays in land acquisition, unanticipated difficulties with the supply of raw materials, and illegal encroachment on land even during project implementation were to blame for the cost (Datta, 2002; Flyvbjerg et al., 2002).

To give stakeholders tools for risk identification, many researchers studied the factors that contribute to risks in the construction sector. Ehsan and Mirza illustrated risk factors common to the construction business, including time pressure, resource availability, history, design complexity, experience, management stability, and team size. Ehsan and Mirza categorize construction risks into technical, logistical, management, environmental, financial, and sociopolitical categories (Ehsan et al., 2010). On the other hand, technical, logistical, management, environmental, economic, social, and political risks were categorized as construction risks by Ehsan and Mirza (Tang et al., 2007). Yasser and Mostafa used fault tree analysis to pinpoint the primary factor causing building project delays (Gamal and Abd Elrazek, 2020). Additionally, inefficiencies in risk management lead to schedule and expense overruns (Raftery, 2003). Numerous studies have concentrated on creating approaches that take the effects of uncertainty on project cost overruns into account (Ammar et al., 2022; Leu et al., 2023; Osama et al., 2023; Vivek and Rao, 2022).
The primary goal of the study is to identify the most important risk variables affecting the construction of roads in Egypt, especially during COVID-19 to lessen the likelihood and impact of those risks. Therefore, the study has created a framework that will enable organizations to take the following actions in order to manage the risk factors that lead to cost overruns in Egyptian road projects: A framework contain: stage I: risk identification, stage II: risk assessment (evaluate risk factors in road construction projects and identify the biggest ones); Thorough involved literature review on risk management in relation to roads conducted in order to develop a questionnaire. Additionally, this list was expanded with the help of experts to include all potential risk factors for road construction projects. Also, it outlines the risks by surveying a panel of experts from various construction sectors using a questionnaire. Furthermore, Fig. 1 depicts the process of risk analysis for the attributes that affect the construction of roads in Egypt. The qualitative risk analysis was used to identify the high-risk factors for each category, followed by the cost matrix was employed to establish the different levels of risk for each category. After that, a risk response plan has been identified as an appropriate action for high-risk factors. Moreover, different scenarios have been chosen as a strategy for figuring out the best action for risks.

3. Research methodology

The suggested study analyses each identified risk and uses interviews and pre-structured questionnaires on a set of 11 risk categories made up of 162 risks to elicit the specific risk with as much expert opinion as possible. The cost matrix has also been employed as a tool for displaying the levels of risk factors, and as a result, it may be utilized to develop a road map for generating speedy responses for high risks. This can be done by taking the following actions.

(1) The research technique begins with a thorough literature analysis to give a prime risk factors list. This list was then supplemented with experience to produce a final risk factor list that encompasses all potential risks during road building.

(2) A brainstorming-directed questionnaire has been used to solicit the most prevalent risks facing road projects in Egypt. The impacts of each risk and its likelihood have been suggested by experts.

(3) The risk factors (RF) can be divided into several categories based on their attributes and kind. As a result, it can create RBS, which is a component of the risk management plan. A stratified classification of risks and the establishment of a nomenclature for characterizing project risks are based on the hierarchical risk breakdown structure that has been created. With the use of the HRBS, risks can be divided into those that are concerned with the control of the sources of risk factors.

(4) Finding the mean after obtaining the total probabilities for each risk from the questionnaires has been employed to calculate the value of probability. Additionally, the same approach can be used to determine the impact.

(5) Prioritizing identified risks based on risk score estimations created by calculating the cost impact and evaluating the probability of occurrence.

(6) Examining the prospective responses offered by experts to risks and selecting the most appropriate response even as a corrective or preventive action.

Moreover, the risk category is included in the risk management plan. Whereas, the risk can be categorized using the risk breakdown structure (RBS) based on its attributes. As well, it displays a hierarchical chart that divides the project risks into higher-level and lower-level groups. As a result, the
study divided the risks related to Egyptian road construction into eleven groups. These groups contain consultant, design, equipment, material, owner, contract, contractor, labor, external (corona virus effects), external (others), and operational. This phase is useful for figuring out the total risk factors (RF) associated with road projects. And, it has been created before risk identification. The risk of breakdown structure has been shown in Fig. 2. They perform qualitative risk analysis process analyses and prioritize project risks based on the characteristics of each individually identified risk. The perform qualitative risk analysis process examines and ranks the characteristics of individual risks before prioritizing them according to those characteristics (Guide, 2001). Its objective is to rate and categorize the identified risks according to their impact (I) and probability of occurrence (P) to conduct a further study or take appropriate action. Consequently, high-priority risks in terms of threats are thought to be a key emphasis of the plan risk response process. Also, the following steps ought to be part of the analytical process: A subjective risk probability (P) value has been created using a scale from 0 to 1. In addition to producing a risk impact (I) on a scale, the standard impact evaluation approach for cost impacts is also produced, as illustrated in Table 1. Finding the mean after obtaining the total probabilities for each risk from the questionnaires has been employed to calculate the value of probability. Additionally, the same approach can be used to determine the impact. To get the risk score (RS), multiply the probability (P) by the impact (I). Following the risk score values assigned to each risk, risks are ranked and prioritized (RR). Using the likelihood and impact matrix presented in Table 2 (Guide, 2001), the risk factors have been categorized into high (H), moderate (M), and low (L) risks. The selection of high and moderate risks follows to get a response action.

4. Data collection

Making a sample questionnaire is the first step in the data collection and questionnaire design procedures. A pilot study was carried out on Egyptian

Table 1. Standard of risk impact (Guide, 2001).

<table>
<thead>
<tr>
<th>Impact scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability scales</td>
</tr>
<tr>
<td>Project Objectives</td>
</tr>
<tr>
<td>Probability scales</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Insignificant cost increase</td>
</tr>
</tbody>
</table>

Table 2. Probability and impact matrix (Guide, 2001).

<table>
<thead>
<tr>
<th>P</th>
<th>Probability and Impact Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90</td>
<td>0.05</td>
</tr>
<tr>
<td>0.70</td>
<td>0.04</td>
</tr>
<tr>
<td>0.50</td>
<td>0.03</td>
</tr>
<tr>
<td>0.30</td>
<td>0.02</td>
</tr>
<tr>
<td>0.10</td>
<td>0.01</td>
</tr>
</tbody>
</table>

1 Very low | Low/0.10 | Moderate/0.20 | High/0.40 | Very high/0.80 |
construction companies using an interview and a questionnaire to determine the risks contributing to cost overruns in the construction of the road projects in Egypt, especially during COVID-19. For this study, different factors have been used in choosing respondents, like the number of experience years [above 15: 15%, between 11 and 15: 15%, between 5 and 10: 58.33%, under 5 experience years: 11.67%]. Additionally, the respondents were chosen from a variety of work types to obtain realistic responses to the risk factors associated with Egypt’s road construction projects. Where, they were represented (28.33% owners, 58.33% contractors, and 13.33% owners). In addition, the total number of responders who contributed to the study is sixteen practitioners. Consequently, a wide range of construction professionals is included. In the pilot survey, every question was based on an interview. A skilled interviewer interacts with the participants and offers definitions as needed to help with questionnaire responses. The following categories of responders were created based on the role of the companies (consultant, contractor and owner). The study made an effort to include the majority of the experience spectrum, from junior to expert. The information was received from 60 experts [see Fig. 3]. Furthermore, 162 risk factors are broken down into eleven primary categories. Also, Tables 3-13 breaks down each group into many risk factors. Compute risk ranking concerning category (RRC) and risk ranking for total risk factors (RRT).

5. Reliability analysis

The random sample was determined using Eq. (1) by (Hogg et al., 2009) in order to obtain a demonstration sample of the targeted participants. Where (n) refers to a limited sample size, (m) to an unlimited population sample size, and (N) to the largest population sample size that is currently available.

$$n = \frac{m}{1 + \left(\frac{m-1}{N}\right)}$$

Eq(1)
Due to the lack of specific information or data regarding the owners, contractors, consultants, managers, and site engineers of road construction companies, the owner, contractors, and consulting firms are chosen. Hence, 600 specialists from various companies are the estimated total number of experts. Equation No. (2) is used to calculate the m value, and Z is the statistical value used to represent the used confidence level. Z can be different according to the level of confidence, where Z is equal to 1.645, which represents a 90% confidence level. It can be 1.96, which represents a 95% confidence level.

### Table 3. Analysis of risk factors (Consultant).

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cons. 1</td>
<td>The owner's meddling with the consultant's decisions</td>
<td>0.451</td>
<td>0.215</td>
<td>0.097</td>
<td>Moderate</td>
<td>3</td>
<td>92</td>
<td>MIT.</td>
</tr>
<tr>
<td>Cons. 2</td>
<td>Conflicts between the designer and the consultant</td>
<td>0.375</td>
<td>0.205</td>
<td>0.077</td>
<td>Moderate</td>
<td>4</td>
<td>122</td>
<td>MIT.</td>
</tr>
<tr>
<td>Cons. 3</td>
<td>The contractor's tardiness in responding to questions</td>
<td>0.318</td>
<td>0.201</td>
<td>0.064</td>
<td>Moderate</td>
<td>10</td>
<td>143</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 4</td>
<td>The oversight team's lack of experience</td>
<td>0.431</td>
<td>0.250</td>
<td>0.108</td>
<td>Moderate</td>
<td>1</td>
<td>75</td>
<td>MIT.</td>
</tr>
<tr>
<td>Cons. 5</td>
<td>Rigidity in supervision</td>
<td>0.438</td>
<td>0.243</td>
<td>0.106</td>
<td>Moderate</td>
<td>2</td>
<td>80</td>
<td>MIT.</td>
</tr>
<tr>
<td>Cons. 6</td>
<td>System weaknesses in the consultant office's documentation</td>
<td>0.358</td>
<td>0.193</td>
<td>0.069</td>
<td>Moderate</td>
<td>9</td>
<td>133</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 7</td>
<td>Lack of Quality Control/Assurance</td>
<td>0.280</td>
<td>0.210</td>
<td>0.059</td>
<td>Low</td>
<td>13</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td>Cons. 8</td>
<td>The oversight team is only present temporarily on the project</td>
<td>0.210</td>
<td>0.169</td>
<td>0.035</td>
<td>Low</td>
<td>16</td>
<td>162</td>
<td></td>
</tr>
<tr>
<td>Cons. 9</td>
<td>Disregard for the project timetable and failure to follow it</td>
<td>0.305</td>
<td>0.196</td>
<td>0.060</td>
<td>Low</td>
<td>12</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Cons. 10</td>
<td>Delay in the approval of amendments while the work is being done</td>
<td>0.321</td>
<td>0.228</td>
<td>0.073</td>
<td>Moderate</td>
<td>5</td>
<td>127</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 11</td>
<td>Taking too long to examine and approve the design documentation</td>
<td>0.319</td>
<td>0.227</td>
<td>0.072</td>
<td>Moderate</td>
<td>6</td>
<td>128</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 12</td>
<td>The design documents are being examined and approved too slowly</td>
<td>0.291</td>
<td>0.246</td>
<td>0.072</td>
<td>Moderate</td>
<td>7</td>
<td>129</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 13</td>
<td>Taking too long to approve the material samples</td>
<td>0.272</td>
<td>0.229</td>
<td>0.062</td>
<td>Moderate</td>
<td>11</td>
<td>145</td>
<td>AV.</td>
</tr>
<tr>
<td>Cons. 14</td>
<td>Incorrect or insufficient soil assessment</td>
<td>0.257</td>
<td>0.279</td>
<td>0.072</td>
<td>Moderate</td>
<td>8</td>
<td>130</td>
<td>MIT.</td>
</tr>
<tr>
<td>Cons. 15</td>
<td>The schedule is not being updated regularly</td>
<td>0.319</td>
<td>0.177</td>
<td>0.056</td>
<td>Low</td>
<td>14</td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Cons. 16</td>
<td>Lack of a date given in the notice to proceed</td>
<td>0.280</td>
<td>0.160</td>
<td>0.045</td>
<td>Low</td>
<td>15</td>
<td>160</td>
<td></td>
</tr>
</tbody>
</table>
confidence level. On the other hand, the values of $Z$ can reach 2.575 to represent a high confidence level with a percentage of 99%. $P$ represented the calculated population proportion, while ($e$) represented the point estimate sampling error.

$$m = \frac{z^2 x P (1 - P)}{e^2}$$

Eq (2)

To acquire the necessary sample size (Sincich et al., 2001), proposed using 0.50 as a cautious
estimate for P. Z is equal to (1.645) at the 90% level of confidence, and the m infinite sample size is roughly equivalent to:

\[ m = \frac{(1.645^2) \times 0.5 \times (1 - 0.5)}{0.1^2} = 67.65 \]

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P Value</th>
<th>I Value</th>
<th>RS Value</th>
<th>Risk Case</th>
<th>RRC Value</th>
<th>RRT Value</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The daily inspection report should be submitted periodically to project managers to keep them informed of the condition of the equipment to take quick actions for fixing the equipment.</td>
</tr>
<tr>
<td>Equ. 1</td>
<td>Lack of spare parts and frequent equipment failures</td>
<td>0.442</td>
<td>0.306</td>
<td>0.135</td>
<td>Moderate 5</td>
<td>35 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 2</td>
<td>Low equipment productivity and efficiency</td>
<td>0.431</td>
<td>0.285</td>
<td>0.123</td>
<td>Moderate 7</td>
<td>53 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 3</td>
<td>Delays in equipment repair</td>
<td>0.477</td>
<td>0.306</td>
<td>0.146</td>
<td>Moderate 3</td>
<td>29 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 4</td>
<td>The company doesn’t investigate the technical state of the equipment or its suitable distribution following work requirements.</td>
<td>0.453</td>
<td>0.274</td>
<td>0.124</td>
<td>Moderate 6</td>
<td>50 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 5</td>
<td>Insufficient equipment</td>
<td>0.467</td>
<td>0.292</td>
<td>0.136</td>
<td>Moderate 4</td>
<td>34 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 6</td>
<td>Moving equipment can be difficult, whether it’s to locations for routine maintenance or to work on another area of the project.</td>
<td>0.420</td>
<td>0.245</td>
<td>0.103</td>
<td>Moderate 10</td>
<td>86 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 7</td>
<td>The carelessness in obtaining or renewing the equipment’s license</td>
<td>0.397</td>
<td>0.216</td>
<td>0.086</td>
<td>Moderate 12</td>
<td>106 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 8</td>
<td>A lack of modern mechanical equipment</td>
<td>0.520</td>
<td>0.283</td>
<td>0.147</td>
<td>Moderate 2</td>
<td>24 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 9</td>
<td>The site of the asphalt mixer and the crushers are far apart from the project.</td>
<td>0.372</td>
<td>0.320</td>
<td>0.119</td>
<td>Moderate 8</td>
<td>58 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 10</td>
<td>Lack of technical and engineering expertise in asphalt mixers and crushers</td>
<td>0.401</td>
<td>0.251</td>
<td>0.101</td>
<td>Moderate 11</td>
<td>89 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 11</td>
<td>Equipment distribution issue</td>
<td>0.442</td>
<td>0.236</td>
<td>0.104</td>
<td>Moderate 9</td>
<td>84 MIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equ. 12</td>
<td>Using outdated equipment with low productivity rates and neglecting routine maintenance on this equipment</td>
<td>0.509</td>
<td>0.329</td>
<td>0.168</td>
<td>Moderate 1</td>
<td>12 MIT.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Analysis of risk factors (Equipment).
<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matr. 1</td>
<td>Vendor materials don't adhere to the requirements</td>
<td>0.419</td>
<td>0.359</td>
<td>0.150</td>
<td>Moderate</td>
<td>2</td>
<td>20</td>
<td>AV.</td>
</tr>
<tr>
<td></td>
<td>Matr. 2</td>
<td>0.347</td>
<td>0.270</td>
<td>0.094</td>
<td>Moderate</td>
<td>10</td>
<td>97</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 3</td>
<td>0.284</td>
<td>0.275</td>
<td>0.078</td>
<td>Moderate</td>
<td>12</td>
<td>121</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 4</td>
<td>0.342</td>
<td>0.220</td>
<td>0.075</td>
<td>Moderate</td>
<td>13</td>
<td>125</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 5</td>
<td>0.382</td>
<td>0.303</td>
<td>0.116</td>
<td>Moderate</td>
<td>6</td>
<td>62</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 6</td>
<td>0.533</td>
<td>0.380</td>
<td>0.202</td>
<td>High</td>
<td>1</td>
<td>5</td>
<td>ACC.</td>
</tr>
<tr>
<td></td>
<td>Matr. 7</td>
<td>0.404</td>
<td>0.306</td>
<td>0.124</td>
<td>Moderate</td>
<td>4</td>
<td>52</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 8</td>
<td>0.371</td>
<td>0.259</td>
<td>0.096</td>
<td>Moderate</td>
<td>9</td>
<td>93</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 9</td>
<td>0.405</td>
<td>0.282</td>
<td>0.114</td>
<td>Moderate</td>
<td>7</td>
<td>65</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 10</td>
<td>0.406</td>
<td>0.330</td>
<td>0.134</td>
<td>Moderate</td>
<td>3</td>
<td>37</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 11</td>
<td>0.357</td>
<td>0.337</td>
<td>0.120</td>
<td>Moderate</td>
<td>5</td>
<td>57</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 12</td>
<td>0.351</td>
<td>0.225</td>
<td>0.079</td>
<td>Moderate</td>
<td>11</td>
<td>118</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td>Matr. 13</td>
<td>0.357</td>
<td>0.286</td>
<td>0.102</td>
<td>Moderate</td>
<td>8</td>
<td>87</td>
<td>MIT.</td>
</tr>
</tbody>
</table>

The inspection of the samples of the materials should be done before the execution.
The procurement department inside the organization should expand the vendor list by evaluating others.
Procedures for storing the materials should be included in the quality plan. And, the project should follow up on all instructions to maintain the materials from damage.
The design should be early to reduce the time for calculating the quantity. And, the creation of quantity survey teams should be at the beginning of the project to expedite the calculation of quantity and hence submit the material order.
The specification and the design should be submitted early in the project.
Accept [Contingency reserve] creation of the construction methods as a part of the studies of the project.
Inspection report for the materials.
Agreement with the subcontractor to supply the required quantity.
Provide a means for quickly transporting the fabrication materials.
Quality control work to prevent the mud and the project manager returns the matter to the designer to re-design according to the surrounding conditions.
Hire a quality assurance specialist for the project to perform an audit periodically on the project.
The experimental tests should be created to confirm the validity.
<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own. 1</td>
<td>The owner's financial situation is precarious.</td>
<td>0.260</td>
<td>0.259</td>
<td>0.067</td>
<td>Moderate</td>
<td>16</td>
<td>136</td>
<td>AV.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The contract should be mentioned the progress payment procedures and determine the steps in case of delaying the invoice payment.</td>
</tr>
<tr>
<td>Own. 2</td>
<td>The progress payment delay</td>
<td>0.412</td>
<td>0.257</td>
<td>0.106</td>
<td>Moderate</td>
<td>8</td>
<td>81</td>
<td>AV.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The contract should be mentioned the progress payment procedures and determine the steps in case of delaying the invoice payment.</td>
</tr>
<tr>
<td>Own. 3</td>
<td>There aren't any incentives for the contractor to finish earlier.</td>
<td>0.353</td>
<td>0.167</td>
<td>0.059</td>
<td>Low</td>
<td>19</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own. 4</td>
<td>Choosing the contractor with the lowest bid regardless of whether they have the skills necessary to execute the project on schedule and to the acceptable standard</td>
<td>0.509</td>
<td>0.280</td>
<td>0.142</td>
<td>Moderate</td>
<td>2</td>
<td>30</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The organization's policy should be to increase the percentage of technical experience for awarding the tender.</td>
</tr>
<tr>
<td>Own. 5</td>
<td>The timeline is not reasonable in light of the contract's requirements.</td>
<td>0.424</td>
<td>0.207</td>
<td>0.088</td>
<td>Moderate</td>
<td>10</td>
<td>103</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Organize meetings periodically with contractors to provide all requirements and measure the progress of the project.</td>
</tr>
<tr>
<td>Own. 6</td>
<td>Ineffective delay penalties</td>
<td>0.277</td>
<td>0.194</td>
<td>0.054</td>
<td>Low</td>
<td>21</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td>Own. 7</td>
<td>Lack of strict adherence to the contract terms by the owner</td>
<td>0.289</td>
<td>0.235</td>
<td>0.068</td>
<td>Moderate</td>
<td>14</td>
<td>134</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Increasing the penalty values to commit to the terms of a contract.</td>
</tr>
<tr>
<td>Own. 8</td>
<td>Increasing the amount of work being executed because there weren't enough studies done before beginning the project</td>
<td>0.337</td>
<td>0.297</td>
<td>0.100</td>
<td>Moderate</td>
<td>9</td>
<td>90</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The study of the project should take time during the project life cycle and should be involved as a part of the schedule.</td>
</tr>
<tr>
<td>Own. 9</td>
<td>Increased changes to project plans throughout implementation as a result of the study's flaws</td>
<td>0.446</td>
<td>0.327</td>
<td>0.146</td>
<td>Moderate</td>
<td>1</td>
<td>28</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The studies of the project should be introduced early in the project to mitigate changes in the project.</td>
</tr>
<tr>
<td>Own. 10</td>
<td>Project managers change frequently</td>
<td>0.330</td>
<td>0.172</td>
<td>0.057</td>
<td>Low</td>
<td>20</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>Own. 11</td>
<td>Many requests for changes from the owner during the execution</td>
<td>0.424</td>
<td>0.305</td>
<td>0.129</td>
<td>Moderate</td>
<td>4</td>
<td>46</td>
<td>MIT.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The studies of the project should be introduced early in the project to mitigate changes in the project.</td>
</tr>
<tr>
<td>Own. 12</td>
<td>Scope creep refers to the addition of things or works that are not specified in the contract.</td>
<td>0.430</td>
<td>0.309</td>
<td>0.133</td>
<td>Moderate</td>
<td>3</td>
<td>38</td>
<td>AV.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contract terms should prevent scope creep.</td>
</tr>
<tr>
<td>Own. 13</td>
<td>The owner and other partners don't communicate well enough</td>
<td>0.263</td>
<td>0.203</td>
<td>0.053</td>
<td>Low</td>
<td>22</td>
<td>157</td>
<td></td>
</tr>
</tbody>
</table>

(continued on next page)
The above equation indicates that the required minimum sample size is 60.

6. Total risk score

The risk rating (RR) has been established using the risk score (RS). However, the total risk score (TRS) for each primary risk category has been determined as the total of all risk scores for that category divided by the number (n) of risk factors in each category. In descending order, the following risk categories were given the highest priority: operational, external (coronavirus effects), external (others), contract, equipment, material, contractor, design, owner, labor, and consultant, with TRS of 0.212, 0.147, 0.139, 0.125, 0.124, 0.114, 0.103, 0.099, 0.089, 0.082, and 0.070, respectively, as shown in Fig. 4. In conclusion, the biggest influences on cost overruns of road projects are operational risk and external risk brought on by the impact of the coronavirus.

Therefore, the following are the high-risk factors that impact the project cost: Excessive and illegal
loads on the roadways being used [RR = 1], Float Egyptian currency [RR = 2], Accruing interest on loans to the contractor as a result of the Corona pandemic work interruption [RR = 3], The inflation rate and how it affects price increases [RR = 4], Increased costs for materials [RR = 5], Due to the shutdown, supplies have been delayed and stopped [RR = 6], Increasing taxation [RR = 7], Pipeline, electrical, and instrumentation cables interfering with the paths of the roads [RR = 8], Difficulty getting money from banks in foreign currencies to pay for products that are unavailable in Egypt [RR = 9], The modification of the lending financial strategy [RR = 10].

7. Risk response plan

The goal of the risk response planning phase is to provide choices and specify appropriate measures to address threats, reduce them, and explore opportunities while taking into account the importance of individual and global risks to the project. An overview of the risk response strategies created for the project risks, as well as the monitoring and control of the identified risks, are shown in Tables 3–13.

The low risks are ignored and the total number of low risks is 16 risk. Only high and moderate risks are expected to necessitate a response, and each risk should have a solution to maximize risk response efforts. Threats can be handled in four different ways; Avoidance (AV.): removing the threat by removing its source; mitigation (MIT.): lowering the risk score by minimizing its likelihood of happening and/or effect; transference (TR.): transferring the risk package to a different party by subcontracting or purchasing insurance who is better equipped to manage the risk; Acceptance (ACC.): applying contingency reserves. Tables 3–13 demonstrates that the project management team prepared the appropriate risk responses in some circumstances to guard against the likelihood of a delay in the initial risk response or an unexpected outcome. As a result, 20 avoidance strategies, 89 mitigation plans, 2 transference plans, and 35 acceptance plans were created.

8. Cost matrix

Cost matrices can be used to display the various risk levels (high, medium, and low). As illustrated in
Table 9. Analysis of risk factors (Contractor).

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor</td>
<td>Co. 1 Difficulties with the contractor’s financial funding</td>
<td>0.513</td>
<td>0.293</td>
<td>0.150</td>
<td>Moderate 1</td>
<td>19</td>
<td>MIT.</td>
<td>Studying the situation of the finances for the contractors as a part of the tendering documents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 2 Lack of managerial ability</td>
<td>0.414</td>
<td>0.299</td>
<td>0.124</td>
<td>Moderate 4</td>
<td>51</td>
<td>MIT.</td>
<td>The PMO [project management office] in the organization can interfere in the decision in case of a weakness in the owner’s ability to manage the project.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 3 Contractor experience is insufficient</td>
<td>0.395</td>
<td>0.308</td>
<td>0.122</td>
<td>Moderate 5</td>
<td>54</td>
<td>MIT.</td>
<td>Requirements for tendering should add the previous experience of the contractors.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 4 Contractors’ incorrect price to win the bid</td>
<td>0.359</td>
<td>0.306</td>
<td>0.110</td>
<td>Moderate 9</td>
<td>70</td>
<td>MIT.</td>
<td>Studying the cost baseline from the owner to confirm that the contractor can achieve the project.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 5 Contractor’s breach of contract</td>
<td>0.359</td>
<td>0.229</td>
<td>0.082</td>
<td>Moderate 21</td>
<td>113</td>
<td>MIT.</td>
<td>Increasing the penalty values in the terms of a contract</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 6 Technical personnel shortage</td>
<td>0.394</td>
<td>0.266</td>
<td>0.105</td>
<td>Moderate 14</td>
<td>82</td>
<td>MIT.</td>
<td>Hire specialists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 7 Project management offices (PMO) are absent</td>
<td>0.517</td>
<td>0.251</td>
<td>0.130</td>
<td>Moderate 3</td>
<td>44</td>
<td>AV.</td>
<td>Creating the PMO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 8 The deficiencies in engineering departments’ training</td>
<td>0.521</td>
<td>0.266</td>
<td>0.138</td>
<td>Moderate 2</td>
<td>31</td>
<td>MIT.</td>
<td>Training plan for each project</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 9 The pre-handover inspection was inadequate and the contractor review was inadequate</td>
<td>0.414</td>
<td>0.221</td>
<td>0.091</td>
<td>Moderate 18</td>
<td>98</td>
<td>MIT.</td>
<td>A site visit should be a commitment for all partners.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 10 Rework brought on by improperly completed work</td>
<td>0.400</td>
<td>0.269</td>
<td>0.108</td>
<td>Moderate 11</td>
<td>76</td>
<td>MIT.</td>
<td>A quality assurance specialist should be included in the organization breakdown structure of the project.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 11 Improper scheduling of the project</td>
<td>0.431</td>
<td>0.252</td>
<td>0.109</td>
<td>Moderate 10</td>
<td>73</td>
<td>MIT.</td>
<td>The meetings for creating the schedule between all partners should be done at the beginning of the project to create the proper schedule.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 12 Failure to establish priorities following the schedule</td>
<td>0.426</td>
<td>0.251</td>
<td>0.107</td>
<td>Moderate 12</td>
<td>77</td>
<td>MIT.</td>
<td>Increasing the role of the planning department inside the project for adherence to the schedule</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 13 Not predicting productivity, not monitoring the daily rates of implementation, and not comparing them to what is necessary per the plan</td>
<td>0.329</td>
<td>0.255</td>
<td>0.084</td>
<td>Moderate 20</td>
<td>109</td>
<td>MIT.</td>
<td>Increasing the role of the planning department inside the project for monitoring and controlling the project</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Co. 14 The contractor’s delay in generating shop drawings and material samples</td>
<td>0.343</td>
<td>0.187</td>
<td>0.064</td>
<td>Moderate 25</td>
<td>142</td>
<td>MIT.</td>
<td>It should include the duration cycle of the submittal process for approving the shop drawing and material samples in the schedule</td>
<td></td>
</tr>
</tbody>
</table>

(continued on next page)
Figs. 5–15, the curves can be used to determine the different risk levels [high, medium, low]. All points above the HR-curve are high risks. And the points between HR-curve and MR-curve is the medium risks. Finally, we neglect that the points under MR-curve are low risks. Additionally, it can be regarded as a useful tool for identifying the primary risk so that immediate action can be taken for the priority risks. Therefore, it could be the next step after determining the risk score.

A visual basic program for an Excel spreadsheet was created to construct the cost matrix for all risk categories. And, it can be used as a tool to update the risk score periodically to measure the highest and lowest risk during the project life cycle. It helps expedite the appropriate action during the execution of the project.

**Co. 15** Incorrect construction techniques 0.430 0.274 0.118 Moderate 7 61 MIT. Hire specialists

**Co. 16** Lack of High-Technology 0.484 0.245 0.119 Moderate 6 59 MIT.

**Co. 17** Delay in resource mobilization 0.394 0.254 0.100 Moderate 16 91 MIT.

**Co. 18** The failure to adhere to the project’s safety regulations and guidelines 0.496 0.189 0.094 Moderate 17 96 MIT.

**Co. 19** Disadvantages of extra and night work (poor quality - work fatigue, lack of workers incentives) 0.454 0.230 0.104 Moderate 15 83 ACC.

**Co. 20** Conflicts between subcontractors when the program is being carried out, as well as their lack of cooperation to adhere to the planned schedule's sequence 0.379 0.208 0.079 Moderate 22 120 MIT.

**Co. 21** Subcontractors on the work site are not coordinated enough 0.354 0.199 0.070 Moderate 23 132 MIT.

**Co. 22** Delay in the subcontractor's work 0.399 0.267 0.106 Moderate 13 78 MIT.

**Co. 23** Untrustworthy subcontractor 0.341 0.195 0.067 Moderate 24 137 MIT.

**Co. 24** Subcontractors are frequently changed because of their poor performance 0.401 0.288 0.116 Moderate 8 63 MIT.

**Co. 25** Difficulty in directing a sub-contractor 0.382 0.224 0.085 Moderate 19 108 MIT.

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>0.274</td>
<td>0.118</td>
<td>Moderate</td>
<td>7</td>
<td>61</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 16</td>
<td>Lack of High-Technology</td>
<td>0.484</td>
<td>0.245</td>
<td>0.119</td>
<td>Moderate</td>
<td>6</td>
<td>59</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 17</td>
<td>Delay in resource mobilization</td>
<td>0.394</td>
<td>0.254</td>
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<td>Moderate</td>
<td>16</td>
<td>91</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 18</td>
<td>The failure to adhere to the project's safety regulations and guidelines</td>
<td>0.496</td>
<td>0.189</td>
<td>0.094</td>
<td>Moderate</td>
<td>17</td>
<td>96</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 19</td>
<td>Disadvantages of extra and night work (poor quality - work fatigue, lack of workers incentives)</td>
<td>0.454</td>
<td>0.230</td>
<td>0.104</td>
<td>Moderate</td>
<td>15</td>
<td>83</td>
<td>ACC.</td>
<td></td>
</tr>
<tr>
<td>Co. 20</td>
<td>Conflicts between subcontractors when the program is being carried out, as well as their lack of cooperation to adhere to the planned schedule's sequence</td>
<td>0.379</td>
<td>0.208</td>
<td>0.079</td>
<td>Moderate</td>
<td>22</td>
<td>120</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 21</td>
<td>Subcontractors on the work site are not coordinated enough</td>
<td>0.354</td>
<td>0.199</td>
<td>0.070</td>
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<td>23</td>
<td>132</td>
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<td></td>
</tr>
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<td>Co. 22</td>
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<td>0.399</td>
<td>0.267</td>
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<td>13</td>
<td>78</td>
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<td></td>
</tr>
<tr>
<td>Co. 23</td>
<td>Untrustworthy subcontractor</td>
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<td>0.195</td>
<td>0.067</td>
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<td>137</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 24</td>
<td>Subcontractors are frequently changed because of their poor performance</td>
<td>0.401</td>
<td>0.288</td>
<td>0.116</td>
<td>Moderate</td>
<td>8</td>
<td>63</td>
<td>MIT.</td>
<td></td>
</tr>
<tr>
<td>Co. 25</td>
<td>Difficulty in directing a sub-contractor</td>
<td>0.382</td>
<td>0.224</td>
<td>0.085</td>
<td>Moderate</td>
<td>19</td>
<td>108</td>
<td>MIT.</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5 Graph presents a level of risk factors for the consultant category which medium risks are (Cons. 1, Cons. 2, Cons. 3, Cons. 4, Cons. 5, Cons. 6, Cons. 10, Cons. 11, Cons. 12, Cons. 13, and Cons. 14).

Fig. 6 Graph presents a level of risk factors for the design category which medium risks are Desn. 1, Desn. 2, Desn. 3, Desn. 4, Desn. 7, Desn. 8, Desn. 9, Desn. 10, Desn. 11, Desn. 12, Desn. 13, and Desn. 14.

Fig. 7 Graph presents a level of risk factors for the equipment category which medium risks are Equ. 1, Equ. 2, Equ. 3, Equ. 4, Equ. 5, Equ. 6, Equ. 7, Equ. 8, Equ. 9, Equ. 10, Equ. 11, and Equ. 12.)
Table 10. Analysis of risk factors (Labor).

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>Lbr. 1</td>
<td>inadequate labor supply, especially skilled labor for the contractor</td>
<td>0.424</td>
<td>0.297</td>
<td>0.126</td>
<td>Moderate</td>
<td>2</td>
<td>48 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 2</td>
<td>Labor is lost as a result of resignation, especially among highly skilled professionals, technicians, or engineers.</td>
<td>0.457</td>
<td>0.276</td>
<td>0.126</td>
<td>Moderate</td>
<td>1</td>
<td>47 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 3</td>
<td>Personal disputes, strikes, and labor disputes</td>
<td>0.313</td>
<td>0.184</td>
<td>0.058</td>
<td>Low</td>
<td>14</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 4</td>
<td>The conflict between the staff team and the labor</td>
<td>0.309</td>
<td>0.172</td>
<td>0.053</td>
<td>Low</td>
<td>16</td>
<td>158</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 5</td>
<td>Working without commitment and sincerity</td>
<td>0.325</td>
<td>0.205</td>
<td>0.066</td>
<td>Moderate</td>
<td>11</td>
<td>138 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 6</td>
<td>Workplace ethics-contradictory behavioral risks</td>
<td>0.250</td>
<td>0.145</td>
<td>0.036</td>
<td>Low</td>
<td>18</td>
<td>161</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 7</td>
<td>Wages fluctuate and salaries not being paid on time</td>
<td>0.383</td>
<td>0.245</td>
<td>0.094</td>
<td>Moderate</td>
<td>6</td>
<td>95 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 8</td>
<td>lack of motivation for employees to complete tasks on time</td>
<td>0.473</td>
<td>0.240</td>
<td>0.113</td>
<td>Moderate</td>
<td>4</td>
<td>66 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 9</td>
<td>Low labors morale</td>
<td>0.424</td>
<td>0.211</td>
<td>0.090</td>
<td>Moderate</td>
<td>8</td>
<td>101 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 10</td>
<td>Low labor productivity</td>
<td>0.402</td>
<td>0.288</td>
<td>0.115</td>
<td>Moderate</td>
<td>3</td>
<td>64 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 11</td>
<td>The absence of assessments to choose the best labor for the project</td>
<td>0.421</td>
<td>0.258</td>
<td>0.109</td>
<td>Moderate</td>
<td>5</td>
<td>74 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 12</td>
<td>Discriminatory behavior among project participants</td>
<td>0.442</td>
<td>0.202</td>
<td>0.089</td>
<td>Moderate</td>
<td>9</td>
<td>102 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 13</td>
<td>The conflict between decisions made differently in the work</td>
<td>0.395</td>
<td>0.207</td>
<td>0.082</td>
<td>Moderate</td>
<td>10</td>
<td>114 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 14</td>
<td>The laborers' late arrival at the work site</td>
<td>0.317</td>
<td>0.208</td>
<td>0.066</td>
<td>Moderate</td>
<td>12</td>
<td>139 MIT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 15</td>
<td>Workplace injuries and accidents for labor</td>
<td>0.251</td>
<td>0.180</td>
<td>0.045</td>
<td>Low</td>
<td>17</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 16</td>
<td>The medical issues for labor</td>
<td>0.330</td>
<td>0.199</td>
<td>0.066</td>
<td>Moderate</td>
<td>13</td>
<td>140 TR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 17</td>
<td>Work fatigue may result from long hours at the work.</td>
<td>0.420</td>
<td>0.217</td>
<td>0.091</td>
<td>Moderate</td>
<td>7</td>
<td>99 ACC.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbr. 18</td>
<td>Absenteeism</td>
<td>0.303</td>
<td>0.183</td>
<td>0.055</td>
<td>Low</td>
<td>15</td>
<td>155</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 8** Graph presents a level of risk factors for the material category which medium risks are Matr. 1, Matr. 2, Matr. 3, Matr. 4, Matr. 5, Matr. 7, Matr. 8, Matr. 9, Matr. 10, Matr. 11, Matr. 12, and Matr. 13, and high risk is Matr. 6.

**Fig. 9** Graph presents a level of risk factors for the owner category which medium risks are Own. 1, Own. 2, Own. 4, Own. 5, Own. 7, Own. 8, Own. 9, Own. 11, Own. 12, Own. 14, Own. 15, Own. 16, Own. 17, Own. 18, Own. 19, Own. 20, Own. 21, and Own. 22.

**Fig. 10** Graph presents a level of risk factors for the contract category which medium risks are Cntr. 1, Cntr. 2, Cntr. 3, Cntr. 4, Cntr. 5, Cntr. 6, and Cntr. 7.

**Fig. 11** Presents a level of risk factors for the contractor category which medium risks are Co. 1, Co. 2, Co. 3, Co. 4, Co. 5, Co. 6, Co. 7, Co. 8, Co. 9, Co. 10, Co. 11, Co. 12, Co. 13, Co. 14, Co. 15, Co. 16,
Table 11. Analysis of risk factors (External [corona virus effects]).

<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>External (corona virus effects)</td>
<td>TRS = 0.147</td>
<td>0.404</td>
<td>0.321</td>
<td>0.130</td>
<td>Moderate</td>
<td>9</td>
<td>45</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 1</td>
<td>The effects of corona virus on productivity decline and cessation</td>
<td>0.440</td>
<td>0.339</td>
<td>0.149</td>
<td>Moderate</td>
<td>3</td>
<td>22</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 2</td>
<td>The corona pandemic has forced the suspension of numerous projects.</td>
<td>0.463</td>
<td>0.318</td>
<td>0.147</td>
<td>Moderate</td>
<td>4</td>
<td>25</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 3</td>
<td>Reduction of employment for both the owner and the contractor to 50%, as decided by the Council of Ministers Government legislation is constantly being changed</td>
<td>0.447</td>
<td>0.306</td>
<td>0.137</td>
<td>Moderate</td>
<td>5</td>
<td>33</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 4</td>
<td>Due to the shutdown, supplies have been delayed and stopped</td>
<td>0.523</td>
<td>0.383</td>
<td>0.200</td>
<td>High</td>
<td>2</td>
<td>6</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 5</td>
<td>Difficulty performing work tasks in light of the Corona pandemic</td>
<td>0.456</td>
<td>0.285</td>
<td>0.130</td>
<td>Moderate</td>
<td>8</td>
<td>43</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 6</td>
<td>The regular absence from work, whether brought on by health issues, transportation challenges, a fear of being fined for violating a curfew, etc. (during the Corona pandemic)</td>
<td>0.472</td>
<td>0.277</td>
<td>0.131</td>
<td>Moderate</td>
<td>7</td>
<td>42</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 7</td>
<td>Employees have low morale and poor health as a result of the work site's seclusion as a result of the Corona outbreak.</td>
<td>0.426</td>
<td>0.257</td>
<td>0.109</td>
<td>Moderate</td>
<td>11</td>
<td>71</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 8</td>
<td>Workers’ incapacity to take proactive steps to stop the spread of the Corona virus and infection, as well as their lack of desire in doing so</td>
<td>0.571</td>
<td>0.231</td>
<td>0.132</td>
<td>Moderate</td>
<td>6</td>
<td>39</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 9</td>
<td>Owner's hesitation in making decisions amid the corona pandemic</td>
<td>0.472</td>
<td>0.256</td>
<td>0.121</td>
<td>Moderate</td>
<td>10</td>
<td>56</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exc. 10</td>
<td>Accruing interest on loans to the contractor as a result of the Corona pandemic’s work interruption</td>
<td>0.542</td>
<td>0.433</td>
<td>0.255</td>
<td>High</td>
<td>1</td>
<td>3</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
</tbody>
</table>

Fig. 12 Presents a level of risk factors for the labor category which medium risks are Lbr. 1, Lbr. 2, Lbr. 5, Lbr. 7, Lbr. 8, Lbr. 9, Lbr. 10, Lbr. 11, Lbr. 12, Lbr. 13, Lbr. 14, Lbr. 16, and Lbr. 17.

Fig. 13 Presents a level of risk factors for the external (corona virus) category which medium risks are Exc. 1, Exc. 2, Exc. 3, Exc. 4, Exc. 6, Exc. 7, Exc. 8, Exc. 9, and Exc. 10. In addition, the high risks are Exc. 5, and Exc. 11.

Fig. 14 Presents a level of risk factors for the external (others) category which medium risks are Exo. 1, Exo. 2, Exo. 3, Exo. 4, Exo. 6, Exo. 7, Exo. 8, Exo. 9, Exo. 10, Exo. 11, Exo. 16, Exo. 17, Exo. 18, Exo. 19, Exo. 21, and Exo. 22. In addition, the high risks are Exo. 5, Exo. 12, Exo. 13, Exo. 14, Exo. 15, and Exo. 20.

Fig. 15 Graph presents a level of risk factors operational category which medium risks are Opt. 2. And, the high risk is Opt. 1.

9. Discussion, analysis, and practical implications

Only medium and high risk situations are addressed in a risk response plan, which should
<table>
<thead>
<tr>
<th>Risk Code</th>
<th>Risk Factor</th>
<th>P</th>
<th>I</th>
<th>RS</th>
<th>Risk Case</th>
<th>RRC</th>
<th>RRT</th>
<th>Risk Response Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exo. 1</td>
<td>The challenge of seizing land that is in the way of roadways</td>
<td>0.492</td>
<td>0.281</td>
<td>0.138</td>
<td>Moderate</td>
<td>11</td>
<td>32</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 2</td>
<td>When the road pathways of different parties cross, there are complicated</td>
<td>0.560</td>
<td>0.303</td>
<td>0.170</td>
<td>Moderate</td>
<td>7</td>
<td>11</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td></td>
<td>and numerous procedures. (Antiquities-Electricity-Roads-Water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exo. 3</td>
<td>Many industrial challenges (military installations - mosques - houses -etc.)</td>
<td>0.343</td>
<td>0.240</td>
<td>0.083</td>
<td>Moderate</td>
<td>20</td>
<td>111</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 4</td>
<td>Site’s remote location</td>
<td>0.433</td>
<td>0.345</td>
<td>0.149</td>
<td>Moderate</td>
<td>8</td>
<td>21</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 5</td>
<td>Pipeline, electrical, and instrumentation cables interfering with the</td>
<td>0.561</td>
<td>0.332</td>
<td>0.186</td>
<td>High</td>
<td>4</td>
<td>8</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td></td>
<td>paths of the roads</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exo. 6</td>
<td>The challenge of getting work permits</td>
<td>0.469</td>
<td>0.281</td>
<td>0.132</td>
<td>Moderate</td>
<td>13</td>
<td>41</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 7</td>
<td>It is challenging to pinpoint the facilities along the project’s path</td>
<td>0.528</td>
<td>0.250</td>
<td>0.132</td>
<td>Moderate</td>
<td>12</td>
<td>40</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td></td>
<td>with high accuracy because there is no map of them.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exo. 8</td>
<td>The climate effects such as wind, rain</td>
<td>0.357</td>
<td>0.233</td>
<td>0.083</td>
<td>Moderate</td>
<td>19</td>
<td>110</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 9</td>
<td>Utilities not being available on-site (such as water, electricity,</td>
<td>0.435</td>
<td>0.272</td>
<td>0.118</td>
<td>Moderate</td>
<td>15</td>
<td>60</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td></td>
<td>telephone, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exo. 10</td>
<td>The alterations to government laws and legislation</td>
<td>0.351</td>
<td>0.246</td>
<td>0.086</td>
<td>Moderate</td>
<td>18</td>
<td>105</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 11</td>
<td>Exchange rate fluctuations</td>
<td>0.444</td>
<td>0.333</td>
<td>0.148</td>
<td>Moderate</td>
<td>9</td>
<td>23</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 12</td>
<td>Float Egyptian currency</td>
<td>0.564</td>
<td>0.422</td>
<td>0.238</td>
<td>High</td>
<td>1</td>
<td>2</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 13</td>
<td>Difficulty getting money from banks in foreign currencies to pay for</td>
<td>0.506</td>
<td>0.360</td>
<td>0.182</td>
<td>High</td>
<td>5</td>
<td>9</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td></td>
<td>products that are unavailable in Egypt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exo. 14</td>
<td>The modification of the lending financial strategy</td>
<td>0.491</td>
<td>0.368</td>
<td>0.180</td>
<td>High</td>
<td>6</td>
<td>10</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 15</td>
<td>Increasing taxation</td>
<td>0.531</td>
<td>0.367</td>
<td>0.195</td>
<td>High</td>
<td>3</td>
<td>7</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 16</td>
<td>Revolution, strikes, war, and closed regions</td>
<td>0.315</td>
<td>0.277</td>
<td>0.087</td>
<td>Moderate</td>
<td>17</td>
<td>104</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 17</td>
<td>Natural disasters (torrents, earthquakes, etc.)</td>
<td>0.248</td>
<td>0.307</td>
<td>0.076</td>
<td>Moderate</td>
<td>21</td>
<td>124</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 18</td>
<td>Accidents during implementation</td>
<td>0.331</td>
<td>0.228</td>
<td>0.075</td>
<td>Moderate</td>
<td>22</td>
<td>126</td>
<td>TR. Medical insurance</td>
</tr>
<tr>
<td>Exo. 19</td>
<td>Implementation is challenging due to traffic (maintenance projects)</td>
<td>0.469</td>
<td>0.227</td>
<td>0.106</td>
<td>Moderate</td>
<td>16</td>
<td>79</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
<tr>
<td>Exo. 20</td>
<td>The inflation rate and how it affects price increases</td>
<td>0.534</td>
<td>0.393</td>
<td>0.210</td>
<td>High</td>
<td>2</td>
<td>4</td>
<td>ACC. Accept [contingency reserve]</td>
</tr>
</tbody>
</table>

(continued on next page)
include [avoid, mitigation, transfer, or accept] options and a description of the strategy to be used. On the other hand, the risk factors for a consultant, design, equipment, material, owner, contract, contractor, labor, external (corona virus effects), external (others), and operational can be categorized according to the risk response plan, which can help the decision-makers in choosing suitable risk response plan strategies. It can be sorted as follows:

For consultant: the risk response plan for a contractor can be divided into different strategies [avoidance for six factors (Cons. 3, Cons. 6, Cons. 10, Cons. 11, Cons. 12, and Cons. 13), mitigation for five factors (Cons. 1, Cons. 2, Cons.4, Cons. 5, and Cons. 14)]. Therefore, the main solution for facing risk factors of a consultant is avoidance and mitigation which can be represented 54.55% and 45.45%, respectively of the other risk response plans.

For design: the risk response plan for a contractor can be divided into different strategies [avoidance for six factors (Desn. 3, Desn. 8, Desn. 9, Desn. 10, Desn. 11, and Desn. 14), mitigation for six factors (Desn. 1, Desn. 2, Desn. 4, Desn. 7, Desn. 12, and Desn. 13)]. Therefore, the main solution for facing risk factors of design is avoidance and mitigation which can be represented 50% of the other risk response plans.

For equipment: the risk response plan for a contractor can be divided into different strategies [mitigation for twelve factors from (Equ. 1: Equ. 12)]. Therefore, the main solution for facing risk factors of equipment is mitigation which can be represented 100% of the other risk response plans.

For the material: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Matr. 1), mitigation for eleven factors from (Matr. 2: Matr. 5) and from (Matr. 7: Matr. 13), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of material is mitigation which can be represented 84.62% of the other risk response plans.

For the owner: the risk response plan for a contractor can be divided into different strategies [avoidance for three factors (Own. 1, Own. 2, and Own. 12), mitigation for fifteen factors Own. 4, Own. 5, Own. 7, Own.8, Own.9, Own.11, and from (Own. 14: Own. 22)]. Therefore, the main solution for facing risk factors of the owner is mitigation which can be represented 83.33% of the other risk response plans.

For the contract: the risk response plan for a contractor can be divided into different strategies [avoidance for two factors (Cntr. 6, and Cntr. 7), mitigation for five factors from (Cntr. 1: Cntr. 5)]. Therefore, the main solution for facing risk factors of the contract is mitigation which can be represented 71.43% of the other risk response plans.

For the contractor: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Co. 7), mitigation for twenty-three factors from (Co.1:Co. 6), from (Co. 8:Co. 18), and from (Co. 20:Co. 25), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of contractor is mitigation which can be represented 92% of the other risk response plans.

For the material: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Matr. 1), mitigation for eleven factors from (Matr. 2: Matr. 5) and from (Matr. 7: Matr. 13), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of material is mitigation which can be represented 84.62% of the other risk response plans.

For the owner: the risk response plan for a contractor can be divided into different strategies [avoidance for three factors (Own. 1, Own. 2, and Own. 12), mitigation for fifteen factors Own. 4, Own. 5, Own. 7, Own.8, Own.9, Own.11, and from (Own. 14: Own. 22)]. Therefore, the main solution for facing risk factors of the owner is mitigation which can be represented 83.33% of the other risk response plans.

For the contract: the risk response plan for a contractor can be divided into different strategies [avoidance for two factors (Cntr. 6, and Cntr. 7), mitigation for five factors from (Cntr. 1: Cntr. 5)]. Therefore, the main solution for facing risk factors of the contract is mitigation which can be represented 71.43% of the other risk response plans.

For the contractor: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Co. 7), mitigation for twenty-three factors from (Co.1:Co. 6), from (Co. 8:Co. 18), and from (Co. 20:Co. 25), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of contractor is mitigation which can be represented 92% of the other risk response plans.

For the material: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Matr. 1), mitigation for eleven factors from (Matr. 2: Matr. 5) and from (Matr. 7: Matr. 13), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of material is mitigation which can be represented 84.62% of the other risk response plans.

For the owner: the risk response plan for a contractor can be divided into different strategies [avoidance for three factors (Own. 1, Own. 2, and Own. 12), mitigation for fifteen factors Own. 4, Own. 5, Own. 7, Own.8, Own.9, Own.11, and from (Own. 14: Own. 22)]. Therefore, the main solution for facing risk factors of the owner is mitigation which can be represented 83.33% of the other risk response plans.

For the contract: the risk response plan for a contractor can be divided into different strategies [avoidance for two factors (Cntr. 6, and Cntr. 7), mitigation for five factors from (Cntr. 1: Cntr. 5)]. Therefore, the main solution for facing risk factors of the contract is mitigation which can be represented 71.43% of the other risk response plans.

For the contractor: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Co. 7), mitigation for twenty-three factors from (Co.1:Co. 6), from (Co. 8:Co. 18), and from (Co. 20:Co. 25), and acceptance for one factor (Co. 19)]. Therefore, the main solution for facing risk factors of contractor is mitigation which can be represented 92% of the other risk response plans.
Fig. 4. Total risk score [TRS].

Fig. 5. Cost matrix for the categories of risk (Consultant).

Fig. 6. Cost matrix for the categories of risk (Design).
For labor: the risk response plan for a contractor can be divided into different strategies [mitigation for eleven factor (Lbr. 1, Lbr. 2, Lbr. 5, and from (Lbr. 7: Lbr. 14)), transferring for one factor (Lbr. 16), and acceptance for one factor (Lbr. 17)]. Therefore, the main solution for facing risk factors of labor is mitigation which can be represented 84.62% of the other risk response plans.

For external (corona virus effects): the risk response plan for a contractor can be divided into

Fig. 7. Cost matrix for the categories of risk (Equipment).

Fig. 8. Cost matrix for the categories of risk (Material).

Fig. 9. Cost matrix for the categories of risk (Owner).
different strategies [acceptance for eleven factor from (Exc. 1: Exc. 11)]. Therefore, the main solution for facing risk factors of external (corona virus effects) is acceptance which can be represented 100% of the other risk response plans.

For external (others): the risk response plan for a contractor can be divided into different strategies [transferring for one factor (Exo. 18), and acceptance for twenty-one factor from (Exo. 1: Exo. 17), and from (Exo. 19:Exo. 22)]. Therefore, the main solution
Fig. 13. Cost matrix for the categories of risk (External [corona virus effects]).

Fig. 14. Cost matrix for the categories of risk (External [others]).

Fig. 15. Cost matrix for the categories of risk (Operational).
for facing risk factors of external (others) is acceptance which can be represented 95.45% of the other risk response plans.

For operational: the risk response plan for a contractor can be divided into different strategies [avoidance for one factor (Opt. 1), and mitigation for one factor (Opt. 2)]. Therefore, the main solution for facing risk factors of operational is avoidance and mitigation which can be represented 50% of the other risk response plans.

10. Conclusions

Road construction is a challenging process with many crucial steps and risk variables that could cause cost overruns especially during COVID-19. Also, the impact of numerous risk factors exacerbated cost overruns in road construction as the COVID-19 epidemic spread throughout the world. Therefore, the study takes into account new unknown risk factors (corona virus impacts) and looks at the new level of risk factors due to it.

The analysis divided the risks connected to Egyptian road construction into eleven groups. It comprises design, consultant, owner, contractor, material, equipment, contract, labor risk, external (corona virus effects), external (others), and operational. Additionally, 162 risk variables are broken down into eleven major categories.

Overall, the research’s conclusions demonstrate that: Excessive and illegal loads on the roadways being used [RR = 1], Float Egyptian currency [RR = 2], Accruing interest on loans to the contractor as a result of the Corona pandemic’s work interruption [RR = 3], The inflation rate and how it affects price increases [RR = 4], Increased costs for materials [RR = 5], Due to the shutdown, supplies have been delayed and stopped [RR = 6], Increasing taxation [RR = 7], Pipeline, electrical, and instrumentation cables interfering with the paths of the roads [RR = 8], Difficulty getting money from banks in foreign currencies to pay for products that are unavailable in Egypt [RR = 9], The modification of the lending financial strategy [RR = 10].

In descending order with TRS, the following risk categories were given the highest priority: operation risk, external risk [Corona virus effects], external risk [Others], contract risk, equipment, material, contractor, design risk, owner, labor risk and consultant risk. In conclusion, the biggest influences on cost overruns of road projects are operational risk and external risk brought on by the impact of the corona virus.

A visual basic program for an Excel spreadsheet was created to construct the cost matrix for all risk categories. And, it can be used as a tool to update the risk score periodically to measure the highest and lowest risk during the project life cycle. In addition, the study focused on high and medium risk factors in putting a risk response plan and neglecting low risk to guide the organization in facing the risk factors. A risk response plan is only intended for medium and high risk by [avoid, mitigation, transfer, or accept] and describing the risk response plan for each risk.

Also, the study’s findings indicate that the excessive and illegal loads on the roads, the fluctuating value of the Egyptian pound, and the accruing interest on loans to the contractor as a result of the work interruption caused by the corona virus are the high-risk factors that have the greatest impact on cost overruns for road projects. In addition, the cost matrix has also been used to display risk factor levels as a road map for responding quickly to high risks.

Funding statement

No funds, grants, or other support was received.

Author contribution statement

We encourage authors to submit an author statement outlining their individual contributions to the paper using the relevant roles: 1. Conception or design of the work (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 2. Data collection and tools (Yasser A.S Gamal 50% - Mina Maged 50%). 3. Funding Acquisition: N/A. 4. Data analysis and interpretation (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 5. Investigation (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 6. Methodology (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 7. Project administration (Yasser A.S Gamal 35% - Elsayed Mohamed Abd Allah 35%– Mahmoud Enieb 30%). 8. Resources (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 9. Software (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 10. Supervision (Yasser A.S Gamal 35% - Elsayed Mohamed Abd Allah 35%- Mahmoud Enieb 30%). 11. Drafting the article (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30%- Mina Maged 20%- Mahmoud Enieb 20%). 12. Critical revision of the article (Yasser A.S
Gamal 30% - Elsayed Mohamed Abd Allah 30% - Mina Maged 20% - Mahmoud Enieb 20%).

13. Final approval of the version to be published (Yasser A.S Gamal 30% - Elsayed Mohamed Abd Allah 30% - Mina Maged 20% - Mahmoud Enieb 20%).

Conflict of interest

There are no conflicts of interest.

Acknowledgements

We appreciate all responders from different companies which work in construction of roads.

References


