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Estimation of the Overall risk in Residential Building in Egypt

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Abstract— The success of any project depends on the careful risk assessment. Unfortunately, most residential projects suffer from many risks leading to an increase in cost and the total duration of the project, especially in developing countries. The summation of risk factors method depends on the number of risk factors. This study aims to predict an alternative method for overall risks. To achieve this goal, it was necessary to assess the risk factors individually first, then applied the proposed method. Through a review of the literature, 46 risk factors were identified which considered the most important risk factors in residential projects. A structured questionnaire was prepared to determine the likelihood of occurring of these risk factors and their impact on both the schedule and the cost of projects. Two hundred valid questionnaires were received from experts in the field of risk management. SPSS software was used to analyze the data. The proposed method uses the independent events theory and the process of combinations to estimate the potential range of the overall risk. Thus, this study can be considered as the basis of optimizing the overall risk analysis.

Index Terms— Independent events; overall risk; residential buildings; risk assessment.

1 Introduction

A risk is an unsure event or condition, but if it happens, it features a positive or negative impact on project objectives [1]. If these risks don't handle properly, it will result in excesses within the schedule and cost of the project [2]. Hallowell et al. considered that the risks represent threats to the project's success, thus, the utilization of good risk management is essential to the success of the project [3]. Understanding the risks can mitigate their effects if they have negative effects or increase their usefulness if they have a positive impact. Analysis of all risks takes an extended time and excess cost [4]. Hence, the project manager should concentrate on the main risks [5]. Early risk identification helps to cut back the impact of the risks and provide a contingency reserve. Construction projects in Egypt have suffered from overruns in cost and time because of unforeseen events, especially after the recent political and economic events.

2 Literature review

Numerous researchers studied the risk management processes including identifying risk factors, risk assessment individually risks or assessing the overall risk value as a percentage of contract size. Wu et al. presented a risk assessment model to classify the overall risk based on 18 risk factors classified into four major groups using the Delphi technique [6]. The most serious factors are fund's difficulties, lack of a clear division of responsibilities and obligations, lack of operational experience, lack of supplies and material defects. According to the model, the overall risk level of Photovoltaic Poverty Alleviation Projects in China was relatively high. After a literature review and interviews with experts, Kishan et al. identified 47 risk factors at construction projects as the most important factors in India [7]. Tipili and Ilyasu defined and evaluate the likelihood and impact of risk factors on Nigerian construction projects using a questionnaire technique. Fifty questionnaires were received from the experts. The cost risks and time-related risks have the greatest impact on the project, while the environmental risk factors can be considered low risks [8]. The references for identified risk factors were shown in table (1).

TABLE 1
The List of Risk Factors

ID	Description	Source
F1	Payments delayed by the owner	[4], [7], [9]
F2	Unmanaged cash flow	[10]
F3	Inflation	[7], [11]
F4	Swinging exchange rates	[7], [12]
F5	Exchange taxes rate	[12], [13]
F6	The exchange price of fuel	[12]
F7	Building material price increase	[11]
F8	Changing labor costs	[11]
F9	Change in the price of the equipment	[12]
C1	Different actual quantities	[7], [11]
C2	Use of faulty material	[7]
C3	Problem in quality control and quality assurance	[14], [15], [16]
C4	Undocumented orders to change	[17], [18]
C5	Differing site conditions	[19]
C6	On-site material damage	[12], [13]
C7	Loss of equipment productivity	[12]
C8	Surveying work errors	[12]
C9	Lack of workers skills	[20], [21], [22]
E1	Unfavorable weather	[19], [23], [24]
E2	Difficulty in site access	[7]
E3	Catastrophes	[7], [11]
P1	New laws or regulatory acts	[22], [25]
P2	Unstable security conditions	[7]
P3	Corruption/ bribery	[22], [26]

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P4	Bureaucracy	[11]
L1	Difficulty obtaining licenses	[7]
L2	Resolutions on postponed labor disputes	[7]
L3	Legal conflicts between the parties	[7]
M1	Poor communication between the parties	[9], [15]
M2	Changes in methods of management	[7]
M3	The ambiguous planning	[7]
M4	Resource management	[7], [20]
M5	Work in multiple shifts	[12]
M6	Equipment unavailable / shortage	[9], [14] [18]
M7	Materials not available	[12], [15], [24]
M8	Shortage of labors available	[4], [7], [12]
M9	High bid competitiveness	[7]
M10	Poor communication between the offices and the site	[21], [26]
M11	Undefined scope of work	[7]
M12	Delay of material arrival	[11]
Ph1	Accidents according to poor safety	[7], [10]
Ph2	Security of equipment and material	[16], [26]
D1	Uncoordinated design	[17], [21]
D2	Delay in design	[11]
D3	Constructability of design	[11], [27]
D4	Change in design	[4], [7]

The overall risk of the project deals with the project as a single unit. (Practice standard for project risk management, 2009). Individual risk describes the impact of uncertainty on a specific activity or event, while overall project risk describes the impact of uncertainty on the project as a single unit and therefore the overall risk is considerably more than the summation of all individual risk factors within the project. It includes all sources of uncertainty in the project. If the overall risk is treated as a sum of individual risks, this means that risk management processes focus only on individual risks and fail to identify risks associated with the whole project [1], [28], [29]. Risk analysis can be performed through qualitative and quantitative methods. Quantitative methods such as Bayesian networks and artificial neural networks were used to estimate the total risk of the project. Although quantitative methods are more accurate, they require more time and cost than qualitative methods. Therefore, there is a continuing need to propose a new method for qualitatively estimating the overall project risk.

This paper identifies, evaluates and ranks the significant risks in the residential construction industry in Egypt. It proposes a method for estimating the overall risk of the project qualitatively if the risk factors are independent.

3 Methodology

The methodology of this research consists of Four parts. Part I is for identifying the risk factors. Part II is for analyzing each risk individually. Part III presents a computer program to rank the risk factors. Part IV is to estimate the overall risk. The research methodology is summarized in the chart shown in Figure (1).

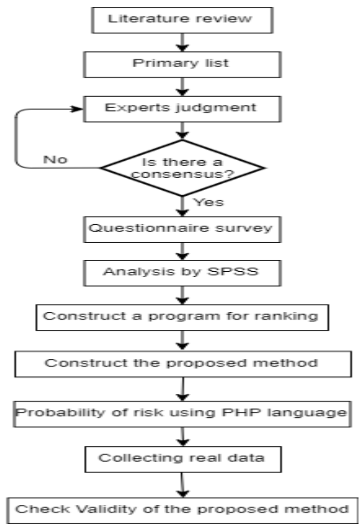

Figure 1. The methodology of research

4 Risk identification

The initial process of risk assessment in residential projects is identifying the risk factors. From reviewing previous literature, A list of 51 risk factors was identified as a preliminary questionnaire. A Delphi technique was applied to reach an agreement of experts. All experts have more than 15 years of experience in risk management. The list of 51 risk factors was sent to the experts and the experts' responses were reviewed and redistributed again to the experts for further comments. The number of repetitions is from three to five rounds, based on the degree of consensus the author is looking for (Haddad 2016). After four rounds the experts agreed on only 46 factors to form the final questionnaire. The risk factors were divided into eight main groups; financial risks (F), construction risks (C), environmental risks (E), political risks (P), legal risks (L), management risks (M), physical risks (PH), and design risks (D). The financial risk group includes nine factors; delayed owner payments, incompetent cash flow, inflation, exchange rate fluctuation, exchange tax rate, exchange fuel price, change of material price, change in labor costs, and change of equipment cost. Construction risk factors which affect during the execution of the construction works containing nine factors; actual quantities differ from the contract quantities, use of defective material, poor quality control, undocumented change orders, differing site conditions, damage of material on the site, loss of productivity, errors in surveying works, and lack of workers' skills. Environmental risk factors are the risks caused by nature including adverse weather conditions, difficulty to access the site, and natural catastrophes. Whereas, the political risks are the risks caused by political decisions or disruptions such as new governmental acts or legislation, unstable security circumstances, bribery/ corruption, and bureaucracy. The legal risks are primarily caused by a defective transaction or a claim. The legal risk factors include difficult to get permits, delayed labor dispute resolutions, and legal disputes during the construction between the parties.

Management risks are related to the decisions that are taken by the project managers and the decision-makers containing poor communication between parties, changes in management ways, ambiguous planning due to project complexity, resource management, work more than one shift, unavailable /shortage of equipment, unavailable materials, unavailable /shortage labours, high competition in bids, poor communications between the head office and site office, undefined scope of working, and delay in material delivery. Physical risks may cause a loss or harm, even without contacts such as poor safety procedures, insecurity of material and equipment. Design risk factors related to the design of the project, including uncoordinated design, delay in the design, constructability of design, and change in design.

5 Qualitative risk analysis individually

The questionnaire consists of three parts, the first part of the questionnaire related to the respondents' data. The second part comprises three groups for the probability of the risk factor, the impact on the cost of the project and the impact on the schedule of the project. The probability scale and the impact scale in the questionnaire were split into five different classifications, namely; very low, low, medium, high, and very high. To standardize the experts' view on the risk variables, the probabilities, and the impacts were described in the table (2). The third part is to ask the respondent about the number of risk factors that occurs in the project.

The questionnaire was circulated to 230 professional experts and only 200 questionnaires were received at a response rate of 87%. A qualitative risk analysis was performed using SPSS software as a statistical program to evaluate the results of the questionnaire. For each risk, the relative importance index (RII) was calculated using equation (1).

$$RII = \frac{\sum_{i=1}^{N} P*I}{N} \quad (1)$$

Where RII represents the relative importance index, P represents the likelihood of occurrence, "I" represents to the bigger of the impact on time or cost, and N represents the number of the respondents to the questionnaire.

TABLE 2
PROBABILITY/ IMPACT MATRIX

		Impact				
		Very Low	Low	Medium	High	Very high
Probability	V high	0.05	0.09	0.18	0.36	0.72
	High	0.04	0.07	0.14	0.28	0.56
	Medium	0.03	0.05	0.10	0.20	0.40
	Low	0.02	0.03	0.06	0.12	0.24
	V Low	0.01	0.01	0.02	0.04	0.08

TABLE 3
RISK CATEGORY

Risk category	Low	Medium	High
RII	< 0.05	0.05 –0.17	> 0.17

The classifications of risk factors were shown in table (3) according to the relative importance index. The risk probability, impact on project cost, impact on the project schedule, risk category, and risk ranking for each risk factor were shown in table (4).

TABLE 4
THE RISK ASSESSMENT REGISTER

ID	Prob.	Impact		RII	Category	Rank
		Cost	Cost			
F1	0.57	0.36	0.36	0.23	High	10
F2	0.53	0.41	0.41	0.22	High	11
F3	0.59	0.46	0.46	0.27	High	6
F4	0.68	0.53	0.53	0.36	High	1
F5	0.56	0.38	0.38	0.21	High	12
F6	0.65	0.5	0.5	0.33	High	2
F7	0.54	0.33	0.33	0.18	High	15
F8	0.65	0.47	0.47	0.31	High	3
F9	0.55	0.36	0.36	0.20	High	13
C1	0.53	0.4	0.4	0.21	High	12
C2	0.44	0.31	0.31	0.16	Medium	17
C3	0.49	0.32	0.32	0.16	Medium	17
C4	0.47	0.35	0.35	0.17	Medium	16
C5	0.4	0.36	0.36	0.15	Medium	18
C6	0.41	0.36	0.36	0.15	Medium	18
C7	0.49	0.3	0.3	0.20	High	13
C8	0.39	0.36	0.36	0.21	High	12
C9	0.52	0.32	0.32	0.26	High	7
E1	0.4	0.21	0.21	0.10	Medium	20
E2	0.45	N	N	0.10	Medium	20
E3	0.29	0.39	0.39	0.15	Medium	18
P1	0.43	0.3	0.3	0.14	Medium	19
P2	0.47	0.38	0.38	0.19	High	14
P3	0.56	0.39	0.39	0.22	High	11
P4	0.59	0.35	0.35	0.25	High	8
L1	0.5	0.33	0.33	0.21	High	12
L2	0.39	0.21	0.21	0.08	Medium	21
L3	0.41	0.27	0.27	0.15	Medium	18
M1	0.42	N	N	0.17	Medium	16
M2	0.47	0.29	0.29	0.18	High	14
M3	0.43	0.33	0.33	0.20	High	13
M4	0.5	0.33	0.33	0.20	High	13
M5	0.5	0.31	0.31	0.19	High	14
M6	0.46	N	N	0.23	High	10
M7	0.47	N	N	0.24	High	9
M8	0.47	N	N	0.24	High	9
M9	0.55	0.3	0.3	0.17	Medium	31
M10	0.47	N	N	0.20	High	13
M11	0.39	0.32	0.32	0.16	Medium	17
M12	0.52	0.36	0.36	0.30	High	4
Ph1	0.49	0.34	0.34	0.17	Medium	16
Ph2	0.5	0.3	0.3	0.16	Medium	17
D1	0.54	0.46	0.46	0.25	High	8
D2	0.52	N	N	0.25	High	8
D3	0.54	0.31	0.31	0.20	High	13
D4	0.55	0.41	0.41	0.28	High	5

The reliability of the data in the questionnaire was calculated using SPSS software. Cronbach's Alpha can be calculated using equation (2). The Cronbach's Alpha was 0.914, this represents the high reliability of the measuring tools. The error variance can be calculated using equation (3). Hence, there is a 0.16 error variance in the values. It also shows a high degree of inner consistency regarding the gathered data [30].

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$$\alpha = \frac{N*c}{v+(N-1)*c} \quad (2)$$

$$EV = 1 - \alpha^2 \quad (3)$$

Where α represents the Cronbach's Alpha, N represents the number of respondents, c represents the average covariance between item-pairs, v represents the average variance, and EV represents the error variance.

6 RISK ASSESSMENT PROGRAM

It is better to use software that helps the risk team to assess and rank the risk factors, hence, this study proposes a program to help to evaluate the risks hence can contribute to the development of risk assessment and management. The user can identify potential risks using the proposed program by clicking the mouse on the potential risk from the "Home" window and the user can also deselect the factor by reselecting the same risk factor. After completing the selection of all potential risks, the user presses on the "Process" button to perform the assessment.

The program automatically displays the first risk factor's probability values and its impact on project cost and time, which were obtained from the results of the questionnaire from this research. If these values are appropriate for the project conditions, the user clicks "Next" to the next factor; otherwise, the user clicks "Default" to change the probability and impact values to fit the project conditions and then clicks "Next" to the next factor. This process continues until all identified risk factors have been reviewed. After determining the likelihood and impact of all risks, the program will calculate the risk score using equation (4). Each risk factor is classified into one of three categories; high, medium and low. The user clicks on the "Ranking" button, the program selects the category of each factor and ranks all risk factors in descending order according to the risk score. The ranking of factors as illustrated in figure (2).

$$R = P * I \quad (4)$$

Where R represents the risk score, P represents the likelihood of occurrence, and "I" represents the bigger of the impact on time or cost.


Back Home

#	Risk factor	Probability	Cost impact	Time impact	Risk Score	Risk Category
1	swining exchange rate	0.68	0.53		0.36	High
2	Changing labor cost	0.65	0.47		0.31	High
3	Change in design and redesign	0.55	0.41	0.5	0.28	High
4	Bureaucracy	0.59	0.35	0.42	0.25	High
5	Delay of material arrival	0.52	0.36	0.48	0.25	High
6	Not coordination design	0.54	0.46	0.46	0.25	High
7	Delay in design	0.52		0.49	0.25	High

Figure 2. Risk ranking

7 A PROPOSED METHOD FOR ESTIMATING THE OVERALL RISK

The proposed method considers the risk factors as independent factors. If the probability of occurrence of event A does not affect the probability of occurrence of event B and vice versa, then the two events A and B are independent. The probability of occurring both events together can be calculated as shown by equation (5). Both events have an impact on time or cost of the project, hence the impact of both events together can be calculated using equation (6). Hence, the risk score (RS) can be calculated using equation (7) [31].

$$P(A \cap B) = P(A) * P(B) \quad (5)$$

$$I(A \cap B) = I(A) + I(B) \quad (6)$$

$$RS(A \cap B) = P(A \cap B) * I(A \cap B) \quad (7)$$

If N is the total number of mutually independent events and K is any sub-collection of events from all events N, hence, the probability, impact, and risk can be expressed using equations (8), (9) and (10).

$$P\left(\bigcap_{j=1}^{k} E_{ij}\right) = \prod_{j=1}^{k} P\left(E_{ij}\right) \quad (8)$$

$$I\left(\bigcap_{j=1}^{k} E_{ij}\right) = \sum_{j=1}^{k} P\left(E_{ij}\right) \quad (9)$$

$$RS\left(\bigcap_{j=1}^{k} E_{ij}\right) = P\left(\bigcap_{j=1}^{k} E_{ij}\right) * I\left(\bigcap_{j=1}^{k} E_{ij}\right) \quad (10)$$

More than 95% of respondents agreed that the maximum number of risks occurring in the project does not exceed three. The number of possible combinations (NC) of the number of "r" events extracted from a set of "n" events without repetition or substitution can be estimated using equation (11). The total number of factors in this research was 46, so if only one risk factor occurred, there were 46 trials. If two risk factors occur together, the number of trials is 1035 wherein the case of three factors, the number of trials is 15180, hence the total of all trials is 16261. The programming language (PHP) was used, for all trials that could be performed, depending on the occurrence of one, two or three risk factors and the maximum value of the potential risk score was 0.455 as was shown in Figure (3).

$$NC = nCr = \frac{n!}{r!*(n-r)!} \quad (11)$$

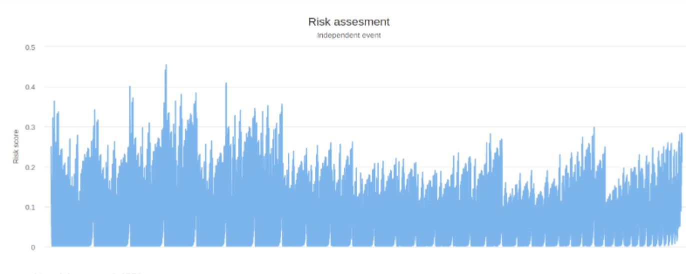

Figure 3. The possible cases of risk factors

The expected potential risk categories according to the permutations and combinations are presented in Table 5. The risk-scoring category between 10% and 15% has the highest probability with 41.97%, followed by the risk-scoring category of 15% to 20% with 30.35%. A detailed study of 17 residential projects was conducted to determine the actual risk as a percentage of the contract size. The results of a study of 17 projects show that the most real risk scores occur in the category (10% -15%) by 64.70%, which matches the results of the proposed method. Comparing the results of the proposed method with the actual results, it was found that the cumulative probability of expected risk is approximately equal to the cumulative probability of actual risk as shown in Figure 4, which indicates the effectiveness of the proposed risk assessment method.

TABLE 5

THE EXPECTED AND ACTUAL RISK SCORE

Risk score	Expected	Actual
0 - 5	0	0
5 – 10	12.80	0
10 – 15	41.97	64.70
15 – 20	30.35	11.80
20 – 25	11.00	11.70
25 – 30	3.00	11.80
30 – 35	0.70	0
35 - 40	0.20	0
40 – 45	0.02	0
45 - 50	0.01	0

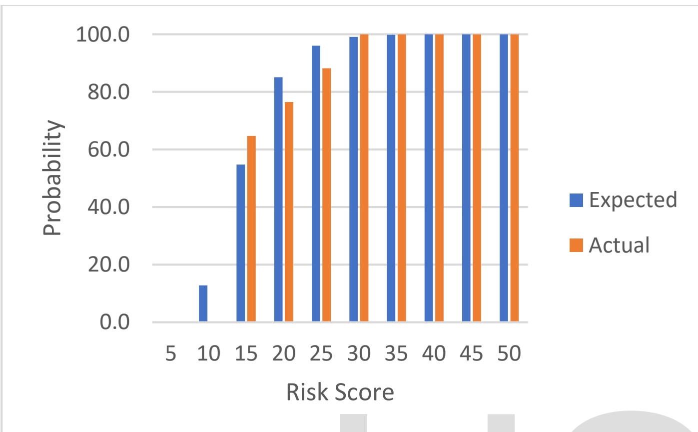

Figure 4. The cumulative probability of risk score

8 DISCUSSION

The analysis of the results of the questionnaire show that the most important risk factors in housing projects in Egypt are the swinging in exchange rates, fuel price change, change in labor costs, delays in the arrival of materials and changes in design. The most important factor is the change in the exchange rate, which is a logical conclusion, given the recent economic events in Egypt and it was ranked second in the study of Alkhalidy in Egypt [32]. The factor of the fuel price change is ranked second, in this study, which is a logical result as Egypt has seen a substantial increase in fuel prices in recent years, increasing the overall project costs. This risk factor ranks 41st at the study of Jayasudha et al. [33]. The change in labor cost factor was ranked third, in this research, which has a direct impact on the cost of construction projects in Egypt, where the salaries in the construction industries in Egypt were rising as a result of high living costs. It should be noted that this factor ranks first in the risk factors assessed in the research of Elbarkouky [34].

Delays in the delivery of raw materials by suppliers negatively affect the project schedule, which may affect the overall cost. Therefore, the factor of the arrival of materials came in fourth place while this factor came second in the study of Karim et al. [35]. This result makes sense as this factor is affected depending on the trade conditions and unique business recovery from time to time as well as from one country to another. The factor of change in design was ranked fifth in this study, this factor may cause a great delay in the scheduling and loss of money if it occurs during implementation and this factor was ranked fourth according to Eskander [36] and second in the study of Jayasudha & Vidivelli [33].

TABLE 6
COMPARISON OF RISK RANKING

Risk Factors	This study	Alkhalidy [32]	Eskander [36]	Karim et al. [35]
Delayed owner payments	10	____	____	11
Unmanaged cash flow	11	5	2	5
Inflation	6	10	____	____
Exchange taxes rate	12	____	24	____
Swinging Exchange rate	1	2	____	____
Actual quantities differ from the contract Quantities	12	____	____	4
Differing site conditions	18	4	30	____
Loss of productivity of equipment	13	25	____	____
Errors on surveying works	12	8	____	____
Quality control and quality assurance problems	17	____	7	____
Lack of workers skills	7	27	____	____
Difficulty to access the site	20	____	33	____
Catastrophes (floods, earthquakes, fire)	18	____	36	____
Adverse weather conditions	20	29	32	13
Difficulty to get permits	12	19	9	15
New governmental acts or legislations	19	11	35	8
Delayed labor disputes resolutions	21	____	11	____
Unstable security circumstances (Invasions)	14	1	____	____
The occurrence of accidents because of poor safety procedures	16	____	____	10
Bribery/corruption	11	22	____	____
Bureaucracy	8	____	____	8
Poor communication between involved Parties	16	34	____	____
Unavailable /shortage labors	9	16	19	
Poor communications between the home and field offices	13	34	____	____
Undefined scope of working	17	____	____	11
Availability of material	9	____	12	1
Shortage of equipment	10	____	____	3
Material delivery delay	4	7		2
Redesign and change in design	5	____	4	____
Not coordinated design	8	____	____	22

The ranking of risk factors, according to the results of this research with the corresponding ranking of factors in the previous researches were illustrated in the table (6). The results were compared with the results of the research of Alkhalidy [32] in Egypt, the research of Eskander [36] for projects in Saudi Arabia, and the research of Karim et al. [35] for projects in Malaysia.

9 Conclusion

Construction companies are interested in managing risk factors affecting the cost and time of the project. This study presents a risk register for assessing the risks in residential projects in Egypt under the current economic conditions. It also presents a computer model to help the user to assess the risk factors and rank them according to their risk score. The most important risk factors in residential projects in Egypt were swinging exchange rates, exchange price of fuel, changing labor costs, delay of material arrival, change in design and redesign.

One of the most common methods of determining the overall risk of a project is the summation method, which is estimated based on the total risks for the factors identified in the project. The greater the number of risk factors, the higher the total value, so the summation method is not a good method to estimate the overall risk or compare risks in different projects. This paper proposes a new method to estimate the overall risk qualitatively. The proposed method assumes that all risk factors are independent factors. The overall risk of a project equal to the maximum of the risk scores through all computations of risk factors in the project. The results showed that the most likely degree of risk is placed in the category of (10% -15%).

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