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Risk assessment Model for Residential Construction Projects

Mohamed Fergany*[1], Mohamed Badawy [2], and Omar El-Nawawy[3]
[1]Post-graduated Student, Department of Structural Engineering, Faculty of Engineering, Ain-Shams University, Cairo, Egypt.
[2]Associate Professor, Department of Structural Engineering, Faculty of Engineering, Ain-Shams University, Cairo, Egypt, https://orcid.org/0000-0002-0672-4929.
[3]Professor, Department of Structural Engineering, Faculty of Engineering, Ain-Shams University, Cairo, Egypt

الملخص

مشاريع المباني السكنية في مصر تحمل الكثير من المخاطر. تهدف هذه الورقة إلى تقييم وترتيب عوامل الخطر المتعلقة بالمشاريع السكنية في مصر بعد الأحداث الاقتصادية الأخيرة. تم تحديد ستة وأربعين عوامل الخطر من خلال مراجعة الآداب السابقة. تم إعداد استبيان لهذه المخاطر لتقييمها وتحديد احتمالها وتأثيرها على كل من وقت وتكلفة المشروع. تم الاستجابة لعدد ٢٠٠ استبيان وبعد ذلك تم عمل تحليل احصائي لهذه الاستبيانات باستخدام برنامج اس بي اس اس . من نموذج تقييم المخاطر ، وجدنا أن المشروعات السكنية عبارة عن مشاريع محفوفة بالمخاطر وأن متوسط تصنيفها من حيث تقييم المخاطر هو متوسط المستوى ، مما يدل على الحاجة إلى تنفيذ عملية إدارة المخاطر اثناء تنفيذ هذه المشاريع و خاصة بعد الأحداث الاقتصادية الأخيرة في مصر. أظهرت دراسة أن أهم خمسة عوامل خطر في المشاريع السكنية هي (تغيير سعر صرف العملة ، تغيير سعر الوقود، تغيير تكلفة العمالة ، تأخير توريد المواد ، والتغيير في التصميم).

تعد هذه الدراسة مهمة جدًا لصناعات البناء باعتبارها ركيزة أساسية لتقدير مثالي لتكاليف المخاطرة (التكلفة الحدية لاستخدامها في ظروف غير متوقعة) حتى تتمكن الشركات من المنافسة في مجال صناعة البناء والتشييد.

Abstract

Residential projects in Egypt carry a lot of risks. This paper aims to assess and rank the risk factors related to residential projects in Egypt after the recent economic events. Forty-six risk factors are identified by reviewing previous literatures. A questionnaire was prepared for these risks to assess them and determine their probability and impact on both the time and cost of the project. A total of 200 questionnaires were responded, and then a statistical analysis of these questionnaires was conducted using SPSS. From the risk assessment model we found that residential projects are risky projects and its average rating is medium level, which indicates the need to carry out the risk management process, especially after the recent economic events in Egypt. Ranking study showed us that the five most important risk factors in residential projects are (exchange rate fluctuation, exchange fuel price, change of labor cost, material delivery delay, and change in design). This study is very important to the construction industries as a basic substrate for an optimal estimation of risk costs (marginal cost to be used in unexpected circumstances) so that firms are able to compete in the construction industry.

Key words: Risk Identification; Risk Assessment; Residential Projects.

1. INTRODUCTION

Construction projects face many risks. A risk is an uncertain event or condition that if it occurs, has a positive or negative effect on project objectives (Project Management Institute 2008). These risks if not handled properly, will lead to excesses in time and cost of the project (Smith 2006). Hallowel et al. (2012) considered that the risks represent threats to the success of the project. Hence, using the good management of

these risks is critical to the success of the project executives. Understanding the risks helps us to mitigate their effects if they have negative effects or increase their usefulness if they have a positive effect. So, the main risks must be focused as much as possible (Barber et al. 2005). Identifying all the risks takes a long time and leads to counterproductive (El-Sayegh 2008). Early risk identification helps us to reduce the impact of the risks and provide a contingency cost. After identifying project risks, a risk assessment process should be carried out which is considered the most difficult process in risk management (Thomas et al. 2006). The risk assessment process is evaluating and ranking the potential risks hence the project manager can determine the important ones (Hashemi et al. 2013). Any construction company usually try to be competitive and offer the best price to the investor, therefore construction companies must analyze the most common risk factors and estimate the impact of them based on the opportunities and threats caused by these risks.

During the development of the project cost, the project manager must take the risks provision into consideration, which is a marginal cost to cover project threats after mitigation. Eldosouky et al. (2014), and Moselhi & Salah (2012) have presented methods for estimating the risk and the contingency reserve. On the other hands, usually, there is usually a difference between the planned cost of risk and the real state cost of risk incurred because of some of the different circumstances of the project that were not considered. In Egypt, residential projects have exceeded their cost and time because of so-called unforeseen events especially after the recent political and economic events experienced by Egypt.

This paper identifies, assesses, and ranks the significant risks in the residential construction industry in Egypt under the view of the new economic conditions that have occurred in the last 5 years.

2. RISK IDENTIFICATION

The first step in risk assessment is to identify risks in residential projects by reviewing previous literature. A list of 51 risk factors were presented to the experts as a pre-questionnaire to be agreed on only 46 factors to be assessed in the final questionnaire. Table 1 presents the identified risk factors with their references. The risk is divided into seven main groups namely; 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).

Financial risk is the risk that involves a financial change to firms as (delayed owner payments, unmanaged cash flow, inflation, exchange rate fluctuation, exchange taxes rate, exchange fuel price, construction material price hike, a change of labor cost, and change in the price of equipment required). Construction risk is the risk incurred during the execution of the construction works as (actual quantities differ from the contract Quantities, use of defective material, quality control, and quality assurance problems, undocumented change orders, differing site conditions, damage of material on site, loss of productivity of equipment, errors on surveying works, lack of workers skills). Environmental risk is the risk caused by nature as (adverse weather conditions, difficulty to access the site, catastrophes (floods, earthquakes, fire)). Political risk is the risk caused by political decisions or disruptions as (new governmental acts or legislation, unstable security circumstances, bribery/corruption, bureaucracy).

Legal risk is primarily caused by a defective transaction or a claim as (difficulty to get permits, delayed labor disputes resolutions, legal disputes during the construction among the parties of the contract). Management risk is Risk related to decisions taken by project managers and decision makers as (poor communication between involved Parties, changes in management ways, ambiguous planning due to project Complexity, resource management, work in more than one shift, unavailable /shortage of equipment, unavailable materials, unavailable /shortage labours, high competition in bids, poor communications between the home and field offices, the undefined scope of working, material delivery delay (steel, bricks...). physical risks, risks may cause a loss or harm with or without contact as (the occurrence of accidents because of poor safety procedures, Security of material and equipment)
Design risks is the risk related to the designs of the projects as (not coordinated design, delay in design, constructability of design, redesign and change in design).

Table 1. Summary of Risks Suggested by Literatures

Risk	Description	Source
1	Delayed owner payments	Kishan et al. (2014), El-Sayegh (2008), and Odeh and Battanieh (2002)
2	Unmanaged cash flow	Kishan et al. (2014), A. I. Abd-Eltawab (2018)
3	Inflation	Kishan et al. (2014), Ogunsanmi (2016)
4	Exchange rate fluctuation	Kishan et al. (2014), Aziz (2013)
5	Exchange taxes rate	Aziz (2013)
6	Exchange fuel price	Aziz. (2013)
7	Construction material price hike	Ogunsanmi (2016)
8	The increase in labor cost	Ogunsanmi (2016)
9	Change in price of equipment required	Aziz (2013)
10	Actual quantities differ from the contract Quantities	Kishan et al. (2014), Ogunsanmi (2016)
11	Use of defective material	Kishan et al. (2014)
12	Quality control and quality assurance problems	Khoder et al. (2019), El-Sayegh (2008), Tang et al. (2007) and Zayed et al. (2008))
13	Undocumented change orders	Kishan et al. (2014), Hashemi et al. (2013), Choudhry and Iqbal (2012), Tran and Molenaar (2013), and Hastak and Shaked (2000)
14	Differing site conditions	Reilly and Arrigoni (2005), WSDOT (2013), and Hashemi et al. (2013), Abdallah (2019)
15	Damage of material on site	Aziz (2013)
16	Loss of productivity of equipment	Aziz (2013)
17	Errors on surveying works	Aziz (2013)
18	Lack of workers skills	Tang et al. (2007), Hashemi et al. (2013), and Chan et al. (2010), Ghada et al. (2016)
19	Adverse weather conditions	Creedy et al. (2010), Alarcon et al. (2010), El-Sayegh (2008), Odeh and Battanieh (2002), Chan et al. (2010), and Zayed et al. (2008), Ghada et al. (2016), Abdallah (2019), Aziz (2018)
20	Difficulty to access the site (very far)	Kishan et al. (2014)
21	Catastrophes (floods, earthquakes, fire	Kishan et al. (2014), Ogunsanmi (2016)
22	New governmental acts or legislation	Kishan et al. (2014), Zoysa and Russell

Risk	Description	Source
		(2003) and Chan et al. (2010)
23	Unstable security circumstances (Invasions)	Kishan et al. (2014)
24	Bribery/corruption	Hashemi et al. (2013), El-Sayegh (2008), Choudhry and Iqbal (2012), and Chan et al. (2010)
25	Bureaucracy	Ogunsanmi (2016)
26	Difficulty to get permits	Kishan et al. (2014), and Odeh and Battanieh (2002)
27	Delayed labor disputes resolutions	Kishan et al. (2014)
28	Legal disputes during the construction Phase among the parties of the contract	Kishan et al. (2014)
29	Poor communication between involved Parties	Kishan et al. (2014), Tang et al. (2007), Kartam and Kartam (2001), Odeh and Battanieh (2002)
30	Changes in management ways	Kishan et al. (2014)
31	Ambiguous planning due to project Complexity	Kishan et al. (2014)
32	Resource management	Kishan et al. (2014)
33	work in more than one shift	Aziz (2013)
34	Unavailable /shortage of equipment	Khoder et al. (2019), Odeh and Battanieh (2002), Hashemi et al. (2013), Chan et al. (2011), Hastak and Shaked (2000), and Zayed et al. (2008)
35	Unavailable materials	Kishan et al. (2014), Alarcon et al. (2011), Tang et al. (2007), Aziz (2018),
36	Unavailable /shortage labors	Kishan et al. (2014), El-Sayegh (2008), Aziz (2018)
37	High competition in bids	Kishan et al. (2014)
38	Poor communications between the home and field offices	Hashemi et al. (2013), Choudhry and Iqbal (2013), and Tran and Molenaar (2014)
39	The undefined scope of working	Kishan et al. (2014)
40	Material delivery delay (steel, bricks...)	Ogunsanmi, O. E. (2016)
41	The occurrence of accidents because of poor safety procedures	Kishan et al. (2014), A. I. Abd-Eltawab (2018)
42	Security of material and equipment	Kishan et al. (2014), Tang et al. (2007), Choudhry and Iqbal (2013), and Zayed et al. (2008)
43	Not coordinated design (structural, architectural, electrical…)	Kishan et al. (2014), Hashemi et al. (2013), Choudhry and Iqbal (2013), and Tran and Molenaar (2014)
44	Delay in design	Ogunsanmi (2016)
45	Constructability of design	Tsai & Yang (2010), Ogunsanmi (2016)
46	Redesign and change in design	Kishan et al. (2014), El-Sayegh (2018)

3. RISK ASSESSMENT MODEL

A model for project risk assessment was built using statistical analysis by SPSS software to analyze the results collected from the questionnaire that was distributed for 230 experts and only 200 experts were. The model evaluates 46 risk factors for residential projects. This model contains an assessment of the probability, the impact for project cost, the impact for project time, risk category, and risk ranking. Table (4) shows the project risk assessment model. The identified risks are placed in a questionnaire and

then evaluated form experts' perceptions of residential projects in Egypt. The first part of the questionnaire was about the general information of the respondents. The second part consists of three groups; the probability of occurrence of the risk factor, the impact of this factor on project cost, and the impact on the project schedule. The questionnaire was distributed for 230 experts and only 200 experts were responded with the respondent rate of 87%. The scale was divided into five categories namely; very low, low, medium, high, and very high. To standardize the opinion of the experts in assessing the risk factors, the probability, and the impact were defined in the table (3). The relative importance index (RII) for each risk was calculated using equation (1) (Ghada et al. 2016).

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

Where (RII) is the relative importance index, (P) is the probability of occurrence, (I) is the bigger impact on cost or time, and (N) is several respondents to the questionnaire. Table (2) shows the risk categories according to the relative importance index.

Table (2) The Relative important index

		Impact				
		Very Low (0.05)	**Low (0.1)**	**Medium (0.2)**	**High (0.4)**	**Very high (0.8)**
Probability	Very high (0.9)	0.05	0.09	0.18	0.36	0.72
	High (0.7)	0.04	0.07	0.14	0.28	0.56
	Medium (0.5)	0.03	0.05	0.10	0.20	0.40
	Low (0.3)	0.02	0.03	0.06	0.12	0.24
	Very Low (0.1)	0.01	0.01	0.02	0.04	0.08

Table (3) Risk category

Risk category	Low	Medium	High
Relative important index	<= 0.05	0.05 - 23	> 23

Table 4. The risk assessment

I.D	Risk factors	Probability	Cost impact	Time impact	RII	Risk Category	Ranking
F1	Delayed owner payments	0.57	0.36	0.41	0.23	High	10
F2	Unmanaged cash flow	*0.53*	0.41	0.42	0.22	Medium	11
F3	Inflation	*0.59*	0.46	N	0.27	Medium	6
F4	Exchange rate fluctuation	0.68	0.53	N	0.36	High	1
F5	Exchange taxes rate	0.56	0.38	N	0.21	Medium	12
F6	Exchange fuel price	0.65	0.5	N	0.33	High	2
F7	Construction material price hike	0.54	0.33	N	0.18	Medium	15
F8	Change of labor cost	0.65	0.47	N	0.31	High	3
F9	Change in price of equipment required	0.55	0.36	N	0.20	Medium	13

I.D	Risk factors	Probability	Cost impact	Time impact	RII	Risk Category	Ranking
C1	Actual quantities differ from the contract Quantities	0.53	0.4	0.28	0.21	Medium	12
C2	Use of defective material	0.44	0.31	0.36	0.16	Medium	17
C3	Quality control and quality assurance problems	0.49	0.32	0.3	0.16	Medium	17
C4	Undocumented change orders	0.47	0.35	0.37	0.17	Medium	16
C5	Differing site conditions	0.4	0.36	0.37	0.15	Medium	18
C6	Damage of material on site	0.41	0.36	0.36	0.15	Medium	18
C7	Loss of productivity of equipment	0.49	0.3	0.41	0.20	Medium	13
C8	Errors on surveying works	0.39	0.36	0.53	0.21	Medium	12
C9	Lack of workers skills	0.52	0.32	0,5	0.26	Medium	7
E1	Adverse weather conditions	0.4	0.21	0.26	0.10	Medium	20
E2	Difficulty to access the site	0.45	N	0.22	0.10	Medium	20
E3	Catastrophes (floods, earthquakes, fire)	0.29	0.39	0.5	0.15	Medium	18
P1	New governmental legislations	0.43	0.3	0.33	0.14	Medium	19
P2	Unstable security circumstances	0.47	0.38	0.41	0.19	Medium	14
P3	Bribery/corruption	0.56	0.39	0.34	0.22	Medium	11
P4	Bureaucracy	0.59	0.35	0.42	0.25	Medium	8
L1	Difficulty to get permits	0.5	0.33	0.41	0.21	Medium	12
L2	Delayed labor disputes resolutions	0.39	0.21	0.21	0.08	Medium	21
L3	Legal disputes during the construction Phase among the parties of the contract	0.41	0.27	0.37	0.15	Medium	18
M1	Poor communication between involved Parties	0.42	N	0.4	0.17	Medium	16
M2	Changes in management ways	0.47	0.29	0.39	0.18	Medium	14
M3	Ambiguous planning due to project complexity	0.43	0.33	0.46	0.20	Medium	13
M4	Resource management	0.5	0.33	0.4	0.20	Medium	13
M5	work in more than one shift	0.5	0.31	0.37	0.19	Medium	14
M6	Shortage of equipment	0.46	N	0.49	0.23	Medium	10
M7	Unavailable materials	0.47	N	0.51	0.24	High	9
	Unavailable labors	0.47	N	0.5	0.24	High	9
M8	High competition in bids	0.55	0.3	N	0.17	Medium	31

I.D	Risk factors	Probability	Cost impact	Time impact	RII	Risk Category	Ranking
M9	Poor communications between the home and field offices	0.47	N	0.42	0.20	Medium	13
M10	Undefined scope of working	0.39	0.32	0.41	0.16	High	17
M11	Material delivery delay	0.52	0.36	0.48	0.30	High	4
M12	The occurrence of accidents because of poor safety procedures	0.49	0.34	0.3	0.17	Medium	16
Ph1	Security of material and equipment	0.5	0.3	0.32	0.16	Medium	17
Ph2	Not coordinated design	0.54	0.46	0.46	0.25	High	8
D1	Delay in design	0.52	N	0.49	0.25	High	8
D2	Constructability of design	0.54	0.31	0.37	0.20	Medium	13
D3	Redesign and change in design	0.55	0.41	0.5	0.28	High	5
D4							

4. RELIABILITY OF RESULTS

The reliability of the values in the questionnaire was measured by SPSS software to ascertain their realness. The results were obtained that (Cronbach's Alpha = 0.914), which reflects high reliability of the measuring instruments. Furthermore, it indicates high level level of internal consistency with respect to the data collected.

5. ANOVA TEST

The ANOVA test was applied to determine whether the results would change with years of experience or not. The results showed significant values greater than (0.05), which proved that there is no difference in mean values regarding the years of experience of the respondents.

6. STUDY OF RISK FACTOR RANKING

According to the questionnaire, the five most important risk factors in residential projects are (exchange rate fluctuation, exchange fuel price, change of labor cost, material delivery delay, and change in design, these significant factor are from two main groups (financial risk, and design risk). Amongst these, exchange rate fluctuation, is the most important factor that is placed at rank 1in this study, and it is a very logical result in light of the recent economic events witnessed by Egypt, this events have increased the probability of occurrence and the impact of this factor, this factor is placed at rank 6 out of 25 risk factors in the study conducted by (Bing, Li, et al. 1999), and it is also ranked 16th in the study conducted by (Chan et al. 2010), and it is also ranked 32 in the study of (El-Sayegh, Sameh Monir 2008).

Exchange fuel price, this factor is placed at rank 2 in our study, this is a logical result as Egypt has witnessed a significant increase in the price of fuel at recent times, which affected the price of raw materials and transfers, which affects the total cost of the project.
Increase of labor cost, this factor comes in the third rank in this study, which directly affects the cost of construction projects in Egypt. As a result of high prices in living, there is a rise in the salaries of labors of the construction industries in Egypt.
It is worth mentioning that the risk factor of price change has the rank 17 in the study conducted by (Chan et al. 2010), and has the rank 1 at the study of (El-Sayegh, Sameh Monir 2008), also has the rank 7 at the study of (Creedy 2010).

Materials delivery delay, this factor comes in the fourth rank, as a result of suppliers delay in the supply of raw materials, which may adversely affect the project schedule, which would affect the total cost. It is worth mentioned that this factor occupies rank 4 in the study of (El-Sayegh, Sameh Monir 2008), and the second rank at the study of (Karim et al. 2012). This is a logical result as this factor affected by the conditions of trade, and the recovery of the market trade, and the recovery of the market that different from time to time, and from country to country.
Change in design, this factor comes in the fifth rank in this study, this factor can cause big delay in schedule, and loss in cost if it occurs during implementation. This factor comes in the rank 2 in the study of (Jayasudha 2016), has the rank 32 in the study of (Chan 2010), also has the rank 1 in the study of (Creedy 2010).

7. CONCLUSION

The current economic conditions in Egypt and price fluctuations forced many construction companies to pay attention to managing the risks affecting the time and cost of the project as one of the methods used to avoid the increase in time and cost of the project. Several previous studies have been interested in identifying potential risk factors and evaluating the likelihood of occurrence and impact on time or cost. As a result of the recent economic conditions in Egypt, it is necessary to reassess the likelihood and impact of these risks. This study presents a risk assessment model for residential projects in Egypt under the recent economic conditions. This model assesses the probability of the occurrence and impact of these factors on both the time and cost of the project and the ranking of these factors according to the risk score from the largest to the least by using the statistical method and Including 200 experts in residential projects.
This study is an introduction to estimating potential risks in residential projects in Egypt, which makes it easy to estimate them for marginal cost of the project.

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