



Research paper

Factors affecting time and cost trade-off in multiple construction projects

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Abstract: Cash is one of the most critical resources of a construction company that determines survival. Cash-flow management is essential for contractors, as lack of cash resources is one of the leading causes of bankruptcy in the construction industry, compared to most other sectors. The purpose of this paper is to identify factors affecting time and cost trade-off in multiple construction projects in Iraq. After reviewing a wide range of literature to determine the most common elements, a questionnaire is distributed to owners, consultants, supervising engineers, and contractors engaged in construction projects. The results of the questionnaire were analyzed using the relative importance index, arithmetic mean and standard deviation. The respondents namely assured Seventeen most essential factors; payments delay from client, progress payment due period, payment conditions, advanced payment, project delay, inaccurate project scheduling, variation orders, project duration, inaccurate project duration, profit, risk margin, project cost, cash flow forecasts, retentions percentage, estimating errors, materials cost, equipment cost, and labour cost.

Keywords: trade-off, construction projects, cash flow, relative importance index

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1. Introduction

The importance of financial management in construction management has long been recognized. The construction industry, on the other hand, has the highest rate of insolvency in any sector of the economy. Many construction businesses fail due to poor financial management, particularly a lack of focus on cash flow forecasting. Where's the cash? This is an all-too-common question in the construction sector, and even profitable construction firms can run into cash flow issues. Lack of cash flow control has been a major contributor to the industry's high rate of insolvencies for years; as a result, it is a topic that all contractors should consider seriously. Simply said, contractors go out of business because they run out of cash, not because they don't have enough work. Cash flow is one of the most important tools for regulating a company's cash flow by determining the cash in and cash out in a project and clearly presenting the possible outcomes with a time effect [1]. Many studies have been carried out to study essential factors that influence the cash flow of construction projects. No attempts have been found to investigate factors affecting time and cost trade-off in multiple construction projects. To enable the concerned government agencies to trade-off effectively, it is necessary to understand the most important factors influencing multiple construction projects and analyze using the relative importance index (RII) method.

2. Research objectives

- Identify factors that effect on time and cost trade-off in multiple construction projects.
- Analysis factors time and cost trade-off using relative importance index.

3. Research methodology

The following procedures were used in this study:

- A literature review was conducted to cover previous studies on the construction projects time and cost trade-off. According to this analysis, a variety of factors are likely to influence the time and cost trade-off.
- Based on the factors that have already been identified. Owners, consultants, supervising engineers, and contractors in the private and public sectors were surveyed to determine the most important factors affecting time and cost trade-off in construction projects in Iraq.
- The relative importance index, arithmetic mean, and standard deviation were used to analyze these factors.

4. Literature review

The Cash Flow Risk Index (CFRI) development process was investigated to quantify the impact of risks on a project's cash flow from the owner's perspective. To that end, the study looked through the literature to find risk factors that could affect a construction projects cash

flow and found 44 of them. The study also used a Delphi exercise to validate and consolidate these factors to create a CFRI, reducing the number of factors from 44 to 36 [2]. conducted research into the various factors that affect project cash flow and their impact on cash flow. Mobilization advance, project margin, retention, contractor credit arrangements with labour, material, plant and equipment suppliers, and other subcontractors, delay, no delay in payment variation risk, and material cost variances are among these factors [3]. identified the factors influencing the cash flow through the questionnaires and interviews of 105 construction companies listed on the Vietnam stock exchange. Analysis results, the study finds six main categories of factors affecting the cash flow of construction companies. They are macro environment; construction period; payables and receivables; construction cost; retention; loan payment, and tax [4]. In Ghana, the researcher looked into the cash flow factors that influence the profitability of construction projects. After that, principal component analysis narrowed down the factors to the most important ones. Wages of labour and staff, progress payment duration, bank interest rate, and replacement of defective works were all significant variables selected from rotated and component score matrixes [5]. introduced an appropriate and straightforward Bayesian Belief Networks (BBNs)-based probabilistic cash flow forecasting model on avoiding contractor bankruptcy by considering influence diagrams and risk factors that affect a project [6]. studied assessing the contractor cash flows effect on the delivery of projects in Nigeria. The study findings show that delay payment, delay in settling claims, loan repayment, consultant instruction, and change in interest rate are the main factors affecting cash flow on projects delivery in Nigeria [7] identified the main factors affecting two of several financial keys that influence the contractor cash flow. The values of the financing cost and the maximum capital requirements for any construction project are these two keys. This research looks at a unique type of construction project. It is important to note that both the financing cost and the maximum capital requirements can significantly impact the project progress and the contractor profit [8]. The research presented in this paper focuses on identifying and assessing the effects of several factors on cash flow forecasting. Based on the factors identified, a stochastic model was developed by integrating AHP with simulation. Results show that change of progress, payment duration, financial position, project delay, improper planning and management, inability to manage change orders, and the number of claims these factors contributed very high percentages on cash flow risk compared with the other factors [9]. This study as a first step in a knowledge-based expert system (KBES) modelling of construction cash flow to incorporate risk and uncertainties, identified and assessed the risk factors responsible for the variation in construction cash flow profiles. Results showed that the major risk factors involved in cash flow forecasting relate to changes in the design or specifications, contract conditions pertaining to cash inflow, interim valuations and certificates and construction programming issues such as inclement weather [10].

5. Questionnaire survey

The relative importance of causes and effects of time and cost trade-off in multiple construction projects was assessed using a questionnaire developed by clients, consultants, and contractors. The survey was split into two sections. The first part of the survey asked for information about the respondents' backgrounds. The second section of the survey

focused on time and cost trade-offs in construction projects. The fifty-seven leading factors for time and cost trade-off are classified into five categories; Contractual aspects, financial aspects, bidding aspects, execution aspects, and external factors. A small pilot study was conducted with 5 consultants, 10 clients, and 5 contractors before the questionnaire was distributed. The primary goal of the pilot study was to ensure that the questionnaire was accurate in capturing the relevant factors influential in Iraq. All respondents agreed that the questionnaire did an excellent job capturing the factors that influence the time-cost trade-off.

6. Characteristics of the respondents

A total of (86) out of (120) distributed questionnaire forms were collected, forming a response rate of (71.66%). The respondents consist of (4) Owner, (18) Consultants, (29) Supervising Engineers and (35) Contractors, as shown in Fig. 1.

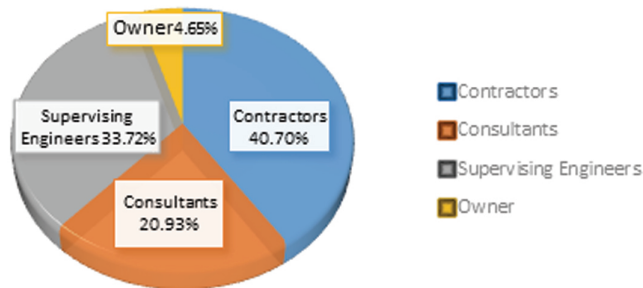


Fig. 1. Affiliation percentages of respondents

Table 1 shows education degrees of the respondents, where results show that (6.98%) of them hold a (PhD) degree, (23.26%) have an (MSc) degree, (66.28%) hold a (BSc) degree, (2.33%) hold a (Diploma) degree, and (1.16%) hold an (Other) degree.

Table 1. Respondents of education degrees

Education degree	No.	Percentage
PhD	6	6.98%
MSc	20	23.26%
BSc	57	66.28%
Diploma	2	2.33%
Others	1	1.16%

The percentages of respondents with experience, with (4) having (<6) years of experience, (10) having (6–10) years of experience, and (72) having more as shown in Fig. 2.

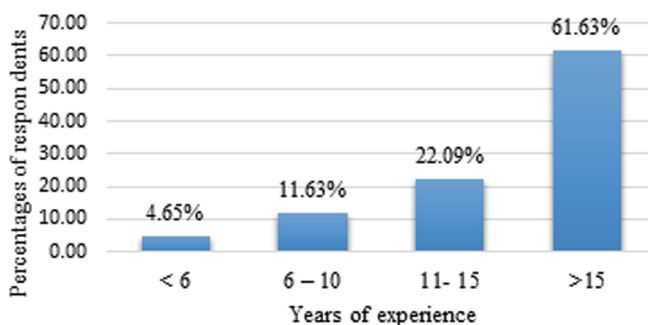


Fig. 2. Affiliation percentages of respondents

Table 2 shows the engineering specialization field of the contractors where some of them have more than one-field, e.g. civil and highway.

Table 2. Contractors engineering specialization

Engineering Specialization	No.	Percentage
Civil Engineer	22	62.86%
Mechanical Engineer	1	2.86%
Highways Engineer	6	17.14%
Architectural Engineer	3	8.57%
Electric Engineer	2	5.71%
Chemical Engineer	1	2.86%

The contractors' fields of practice are listed in Table 3. According to the results, building construction is the most common area of practice.

Table 3. Contractors field of practice

Field of Practice	No.	Percentage
Building construction	21	60.00%
Highways/Bridges construction	8	22.86 %
Water Supply/Sewerage	4	11.43%
Electrical network	1	2.86 %
Irrigation system	1	2.86%

7. Analyse the questionnaire

The questionnaire form was designed using the 5-point Likert's scale to obtain the answer to each question. The relative importance of time and cost trade-off factors is calculated according to [11]. Who used the relative importance index (RII) for such purpose. For each factor in the questionnaire, a five-point Likert scale ranging from (1 = not important) to (5 = very highly important) is used and transformed into a relative importance index (RII) using Eq. (7.1). On the other hand, using the statistical analysis of the questionnaire data by calculating the arithmetic mean and standard deviation according to Eq. (7.2) and (7.3), respectively.

$$(7.1) \quad \text{RII} = \left(\frac{\sum W}{A \times N} \right)$$

where: W – the respondents' weight, which ranges from 1 to 5, A – the respondents' highest weight (for each factor), and N – the total number of respondents, which is equal to (86).

$$(7.2) \quad M = \frac{\sum_{i=1}^K x_i \times f_i}{N}$$

$$(7.3) \quad S = \sqrt{\frac{\sum_{i=1}^K (x_i - M)^2 \times \frac{f_i}{\sum_{i=1}^k f_i}}{N}}$$

where: S – standard deviation, M – mean, x_i – weight value for factor, f_i – number of frequencies, and N – the total number of respondents.

Table 4 shows the relative importance index, mean (M) and standard deviation (S.D) values for (57) factors, as well as their final screening and ranking based on the questionnaire results.

Table 4. Ranking and RII for all factors

No.	Factor	1	2	3	4	5	RII	Mean	St. dev	Rank	Category
		no	very low	medium	high	very high					
1	Project cost	3	5	24	35	19	0.744	3.721	0.990	11	Contractual
2	Project duration	3	5	19	41	18	0.753	3.767	0.966	8	Contractual
3	Payment conditions	0	1	15	46	24	0.816	4.081	0.707	3	Contractual
4	Advanced payment	0	3	21	37	25	0.795	3.977	0.826	4	Contractual
5	Progress payment due period	0	0	14	39	33	0.844	4.221	0.710	2	Contractual

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Table 4 – Continued from previous page

No.	Factor	1	2	3	4	5	RII	Mean	St. dev	Rank	Category
		no	very low	medium	high	very high					
6	Retentions percentage	2	8	30	27	19	0.723	3.616	1.008	13	Contractual
7	Retentions ceiling	1	10	36	35	4	0.672	3.360	0.796	24	Contractual
8	Retentions release	1	9	42	24	10	0.677	3.384	0.870	22	Contractual
9	Financial status	5	10	35	23	13	0.667	3.337	1.058	26	Financial
10	Repayment of loans	3	8	39	26	10	0.674	3.372	0.934	23	Financial
11	Taxes withholdings	5	17	25	26	13	0.658	3.291	1.126	28	Financial
12	Insurance withholdings	12	19	33	12	10	0.574	2.872	1.176	53	Financial
13	Sub-contractors cost	6	13	28	27	12	0.660	3.302	1.107	27	Financial
14	Payment arrangement for sub-contractors	3	6	39	28	10	0.684	3.419	0.913	19	Financial
15	Materials cost	5	7	24	33	17	0.716	3.581	1.079	15	Financial
16	Payment arrangement for materials	2	8	32	39	5	0.686	3.430	0.834	18	Financial
17	Labour cost	4	8	25	36	13	0.707	3.535	1.014	17	Financial
18	Payment arrangement for labour	5	9	30	31	11	0.679	3.395	1.032	21	Financial
19	Equipment cost	6	8	25	27	20	0.709	3.547	1.155	16	Financial
20	Payment arrangement for equipment	3	11	30	32	10	0.681	3.407	0.975	20	Financial
21	Staff wages	7	9	37	19	14	0.656	3.279	1.113	29	Financial
22	Difficult design	9	18	26	20	13	0.623	3.116	1.212	43	Bidding
23	Poor design	10	10	30	19	17	0.653	3.267	1.241	30	Bidding
24	Incomplete design	12	14	23	19	18	0.640	3.198	1.327	36	Bidding
25	Inaccurate bid items	9	8	31	20	18	0.670	3.349	1.215	25	Bidding
26	Estimating errors	4	6	29	28	19	0.721	3.605	1.055	14	Bidding
27	Inaccurate project duration	3	4	26	31	22	0.751	3.756	1.005	9	Bidding
28	Inaccurate project scheduling	1	4	28	27	26	0.770	3.849	0.952	6	Bidding
29	Overheads	7	14	43	16	6	0.600	3.000	0.982	51	Bidding
30	Overheads allocation	7	13	45	16	5	0.598	2.988	0.952	52	Bidding
31	Profit and risk margin	0	4	34	28	20	0.749	3.744	0.870	10	Bidding
32	Margin allocation	3	7	53	18	5	0.635	3.174	0.800	38	Bidding

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No.	Factor	1	2	3	4	5	RII	Mean	St. dev	Rank	Category
		no	very low	medium	high	very high					
33	Renting vs. buying equipment	10	13	33	24	6	0.607	3.035	1.089	48	Bidding
34	What to sub-contract	10	17	37	19	3	0.572	2.860	1.008	54	Bidding
35	Cash flow forecasts	2	4	30	34	16	0.735	3.674	0.913	12	Bidding
36	Project delay	3	5	16	36	26	0.779	3.895	1.018	5	Execution
37	Payments delay from client	0	3	6	28	49	0.886	4.430	0.775	1	Execution
38	over/under measurement by the client	7	13	32	21	13	0.647	3.233	1.134	33	Execution
39	sub-contractors over/under measurement	8	19	29	23	7	0.605	3.023	1.095	49	Execution
40	Material shortage	20	11	10	27	18	0.628	3.140	1.488	41	Execution
41	Equipment shortage	18	9	19	22	18	0.630	3.151	1.427	40	Execution
42	Labour shortage	19	9	22	19	17	0.614	3.070	1.421	46	Execution
43	Sub-contractor shortage	18	13	26	22	7	0.570	2.849	1.251	55	Execution
44	Poor performance by the consultant	15	17	17	23	14	0.609	3.047	1.354	47	Execution
45	Poor project management by the owner staff	11	9	32	26	8	0.626	3.128	1.135	42	Execution
46	Poor project management by the contractor staff	10	9	34	23	10	0.633	3.163	1.136	39	Execution
47	Defective work	6	8	42	18	12	0.651	3.256	1.042	31	Execution
48	Variation orders	1	5	28	29	23	0.758	3.791	0.947	7	Execution
49	Claims settlement	7	6	44	22	7	0.637	3.186	0.976	37	Execution
50	Contractor/owner disputes resolution	7	8	40	19	12	0.649	3.244	1.073	32	Execution
51	Relation with owner	10	14	29	14	19	0.642	3.209	1.284	35	Execution
52	Relation with consultant	13	14	32	13	14	0.602	3.012	1.260	50	Execution
53	Inflation and price escalation	14	12	24	23	13	0.621	3.105	1.293	44	External

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No.	Factor	1	2	3	4	5	RII	Mean	St. dev	Rank	Category
		no	very low	medium	high	very high					
54	Currency exchange rates	11	16	28	16	15	0.619	3.093	1.261	45	External
55	Banks interest variation	11	12	24	25	14	0.644	3.221	1.250	34	External
56	Weather conditions	13	20	31	14	8	0.563	2.814	1.163	57	External
57	Accidents and theft/lost	15	18	28	16	9	0.567	2.837	1.226	56	External

According to Table 5, the factors that contribute most to time and cost trade-off were:

- Contractual aspects: progress payment due period, payment conditions, advanced payment, project duration, project cost, and retentions percentage.
- Financial aspects: materials cost, equipment cost, and labour cost.
- Bidding aspects: inaccurate project scheduling, inaccurate project duration, profit and risk margin, cash flow forecasts, and estimating errors.
- Execution aspects: payments delay from client, project delay, and variation orders.

Table 5. RII for all categories

Categories	RII
Contractual aspects	0.753
Financial aspects	0.673
Bidding aspects	0.667
Execution aspects	0.657
External factors	0.603

8. Spearman's correlation

The nonparametric test Spearman's rank correlation is used. Nonparametric tests, also known as distribution-free tests, are a type of nonparametric test. These tests appear to have the benefit of not requiring the assumption of normality or variance homogeneity. They compare medians rather than means, so if the data contains one or two outliers, their impact is minimized. The Spearman's Correlation is used in this study. Correlation is a measure of the strength and direction of a relationship between different categories of factors. This study is used to demonstrate the degree of agreement among the other categories. The correlation coefficient ranges from +1 to -1, with +1 denoting a perfect positive relationship (agreement) and -1 denoting a perfect negative relationship (disagreement). As a result,

sample correlation estimates close to unity in magnitude imply a strong correlation, whereas values near zero imply little or no correlation. Eq. (8.1) is used to measure and compare the association between categories for time and cost trade-off in multiple construction projects using the Spearman's rank correlation coefficient (r) [12]:

$$(8.1) \quad r = 1 - \left(\frac{6 \sum d^2}{n^3 - n} \right)$$

where: r – the Spearman rank correlation coefficient between categories, d – the difference between the variables' ranks for each factor, and n – the number of rank pairs

Table 6 shows the results of the spearman rank correlation coefficient between categories in the questionnaire. It is found that there is relatively good agreement between categories for time and cost trade-off. Spearman rank correlation coefficient values were within (0.792–0.910), a high degree of agreement.

Table 6. Spearman rank correlation coefficient

Categories		Contractual aspects	Financial aspects	Bidding aspects	Execution aspects	External factors
Contractual aspects	Correlation coefficient	1.000	0.815**	0.841**	0.792**	0.802**
	Sig. (2-tailed)	–	0.000	0.000	0.000	0.000
	N	86	86	86	86	86
Financial aspects	Correlation coefficient	0.815**	1.000	0.926**	0.910**	0.926**
	Sig. (2-tailed)	0.000	–	0.000	0.000	0.000
	N	86	86	86	86	86
Bidding aspects	Correlation coefficient	0.841**	0.926**	1.000	0.855**	0.922**
	Sig. (2-tailed)	0.000	0.000	–	0.000	0.000
	N	86	86	86	86	86
Execution aspects	Correlation coefficient	0.792**	0.910**	0.855**	1.000	0.875**
	Sig. (2-tailed)	0.000	0.000	0.000	–	0.000
	N	86	86	86	86	86
External factors	Correlation coefficient	0.802**	0.926**	0.922**	0.875**	1.000
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	–
	N	86	86	86	86	86

**Correlation is significant at the 0.01 level (2-tailed).

9. Reliability and validity of results

Statistical tests were employed using SPSS version 26 to verify the reliability and validity of the questionnaire results to determine their consistency and the extent to which they genuinely represent the case in hand. When the reliability coefficient is more than (0.7), it is considered satisfactory. Greater internal consistency of data is achieved as much as the reliability coefficient is closer to (1). Truly representative data also means that the questionnaire form was suitably designed, and the study sample was appropriately selected. The Cronbach's coefficient (alpha) measure was used to check the reliability and validity of the results using Eq. (9.1) for the reliability test and Eq. (9.2) for the validity test. The values between (0.0) to (1.0) is considered as the normal range for Cronbach's coefficient (alpha) [13, 14].

$$(9.1) \quad \alpha = \frac{K}{K-1} \left[1 - \frac{\sum_{i=1}^K s_i^2}{s_t^2} \right]$$

$$(9.2) \quad V = \sqrt[3]{\alpha}$$

K is the number of items in a category, S_i^2 is the variance associated with the item (i), and S_t^2 is the variance associated with the sum of all (k) item scores.

Table 7 shows the results of reliability and validity tests for each category in the questionnaire. It is found that Cronbach's alpha values were within (0.776–0.914), which is high enough to assure reliability and validity.

Table 7. Reliability and Validity of each category

Categories	No. of items	Reliability	Validity
Contractual aspects	8	0.776	0.881
Financial aspects	13	0.898	0.948
Bidding aspects	14	0.869	0.932
Execution aspects	17	0.914	0.956
External factors	5	0.856	0.925

10. Research findings

- Progress payment due period: delay leads to a deficit in financing and making payments to suppliers, workers and sub-contractors.
- Payment conditions should suit the owner and the contractor to ensure timely due payment periods.

- Project duration and project cost: This is considered an important factor that needs attention because the project's duration is closely related to the financing elements that the project needs.
- Retentions percentage, materials cost, equipment cost, and labour cost: it has a direct impact on the cash flow needed for the project.
- Inaccurate project scheduling, inaccurate project duration, profit and risk margin, cash flow forecasts, and estimating errors, variation orders: this leads to delaying and overlapping activities and affects the project's time of completion, thus reducing the estimated profit margin.

11. Conclusions

As a result of the findings of this study, seventeen factors are said to be the most influential of time and cost trade-off in multiple construction projects according to expert opinions gathered through a questionnaire form directed to owners, consultants, supervising engineers and contractors engaged with construction projects in Iraq. These factors are payments delay from client, progress payment due period, payment conditions, advanced payment, project delay, inaccurate project scheduling, variation orders, project duration, inaccurate project duration, profit, risk margin, project cost, cash flow forecasts, retentions percentage, estimating errors, materials cost, equipment cost, and labour cost. Focusing and controlling these factors reduce their impact, facilitating time management and reducing the funding needed for the project. Both the owner and the contractor will have a good working environment if these aspects and factors are effectively managed. Both parties have a vested interest in improving project performance and, as a result, increasing profitability.

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