KEC Conference 2024
ISSN: 3021-940X (Print) DOI: https://doi.org/10.3126/injet.v1i2.66688

Evaluating the Alignment between Intended Project Durations and Standard Time Cost Models: A Comparative Analysis in Basic Hospital Construction Projects in Nepal

Diksha Dahal[1] *, Subash Kumar Bhattarai[2], Ronald Shrestha[3], Pratik Khanal[4], Sagar Acharya[5]

[1]*Research Scholar, Department of Civil Engineering, Kathmandu Engineering College, Nepal. drdahal49@gmail.com*
[2]*Visiting Faculty-Construction Management, Department of Civil Engineering, Kathmandu Engineering College and Department of Civil Engineering, Himalaya College of Engineering, Nepal. subashkbhattarai@gmail.com*
[3]*Graduate Student, Department of Construction Management, California State University, Fresno, United States of America. stharonaldo753@gmail.com*
[4]*Research Scholar, Department of Civil Engineering, Himalaya College of Engineering, Nepal. khanalpratik55@gmail.com*
[5]*Research Scholar, Department of Civil Engineering, Himalaya College of Engineering, Nepal. sasagar617@gmail.com*

Abstract

This study examines the congruence between the intended projected duration expressed in bidding documents for basic hospital construction projects and Nepal's time cost model specific to health building projects. Through a comparative analysis approach, data from bidding documents and the time cost model equation were analyzed to identify disparities or alignments. The findings reveal moderate to strong positive correlations between the intended project completion time and the time calculated from costs, with variations in correlation strength depending on the specific variables used for cost estimation. The study highlights the need for refining cost estimation methods, enhancing training and capacity building, regular calibration of time-cost models, and further research to improve project management practices in the Nepalese construction industry.

Keywords: Health buildings, Basic hospital construction, Time-cost model, Comparative analysis

1. Introduction

Unrealistic timelines and budgets have been identified as significant factors impacting effective contract management practices in construction (Sah & Bhattarai, 2021). Nepal's construction sector is pivotal for the nation's development, particularly in providing essential infrastructure like hospitals. (Mishra, 2018) sheds light on the frequent occurrences of time and expense overruns in Nepali building projects, often arising from disparities in expected project durations set by employers. These disparities can result in delays and cost overruns, emphasizing the critical need for precise project management procedures and realistic project estimations.

Nepal's construction sector is critical to the country's growth, notably in terms of providing necessary infrastructure such as hospitals. Effective project management procedures, including accurate project length estimates, are critical to the successful completion of construction projects. In Nepal in most of the cases it has been observed that the expected duration of the project is expressed using the experiences for the past project and employer's judgmental process. However, inconsistencies between expected project durations established by employers' results in delays and cost overruns. According to (Mishra, 2018), time and expense overruns are becoming a common occurrence in Nepali building projects.

The government of Nepal in the fiscal year 2077/078 B.S and 2078/79 B.S has planned and sanctioned the budget for planning, designing, and implementing different types of primary level/ basic hospitals in two

*Corresponding Author

hundred fifty-nine and three hundred ninety-six local levels across the country respectively (GON/MoHP, 2023). Municipalities and rural municipalities across the country are implementing the health infrastructure project as sanctioned and budgeted by the Ministry of Health and Population (GON/MoHP, 2023). Basic hospitals are of three types 5-bedded, 10-bedded, and 15-bedded. Local levels are accountable and responsible to implement the basic hospitals under their jurisdiction. Local levels are entirely new entities for the planning, designing, and execution of health infrastructure. Local levels prepared the hospital building design, drawings, cost estimates, determining project duration, construction, and contract management through their own technical personnel or through the mobilization of the consultant. In Nepal, a study done by (Mishra, 2020) recommended the time cost model for expressing duration of the health building project with an equation, $T = 487.5 \times (C/79.96)^{0.293}$ (time (T) is expressed in days and cost (C) in million NRs).

Where, T represents the variable that we want to calculate or determine, C represents another variable that influences the value of T, the expression (C/79.96) represents the ratio of C to a constant value (79.96 in this case), and the exponent 0.293 indicates the degree to which the ratio (C/79.96) affects the value of T.

Therefore, this research aims to assess the congruence between intended projected duration expressed in bidding document of basic hospital construction with Nepal's time cost model for health building.

1.1 Objective of the study

The overall objective of the study is to evaluate the congruence between the intended projected duration, as outlined in the bidding documents for basic hospital construction projects, and Nepal's time cost model specific to health building projects. However, the specific objectives of the research are:

- To calculate the costs of the hospital building projects using the information provided in bid security amount, experience, and annual construction turnover
- To determine the project duration of hospital buildings utilizing a standard time-cost model, incorporating costs derived from bid security amount, experience, and annual construction turnover
- To determine the correlation between the Intended project completion time utilizing a standard time-cost model, incorporating costs derived from bid security amount, experience, and annual construction turnover.

1.3 Scope and Limitation of Study

The study focuses specifically on basic hospital construction projects within the context of Nepal's construction industry. The assessment considered parameters related to both project duration and cost, with a particular emphasis on aligning the intended duration expressed in bidding documents with the estimates provided by Nepal's time cost model. The study employed a comparative analysis approach to assess the congruence between the intended projected duration and the time cost model. Data from bidding documents and the time cost model equation has been analyzed to identify any disparities or alignments. The data that has been extracted from the bidding documents are the employer's intended completion time of the project. Similarly, regarding the approximate cost estimates of the project, value of bid security amount, value of average annual construction turnover and value of specific experiences were considered. Hence, the variables that have been taken from the bidding documents are time and cost.

The scope is limited to basic hospital construction projects and may not encompass other types of construction projects. Additionally, the study focuses on the congruence between intended project duration and the time cost model, without delving into other aspects of project management or construction planning. The study also assumed the employer's cost estimates based on the provided bid security amount, annual construction turn-over and specific experience.

1.4 Significance of Study

The findings of the study aim to provide insights into the accuracy and reliability of project duration estimation practices within the Nepalese construction industry. The results may have implications for

enhancing project management practices, optimizing resource allocation, and improving project outcomes in the context of basic hospital construction projects in Nepal.

2. Literature Review

(Bromilow, 1974) developed the foundational Time-Cost Model, which gives a way for predicting the ideal project length given a budget or cost restriction. The approach stresses the trade-off between project length and cost, allowing project managers to make more informed decisions about project scheduling and resource allocation.

The equation derived by Bromilow can be represented as follows: $T = K * C^B$ (Equation 1)

Where, T = construction time (in days), C= estimated cost of project (in million dollars), K= a constant describing the general level of time performance, B= a constant describing how the time performance was affected by project size as measured by cost.

Application of Bromilow's Time-Cost Model.

There has been various research on the applicability of Bromilow's Time-Cost Model. Some of the notable global and local research are:

2.1 International perspective:

(Liu, 2017) investigated the practical applicability of Bromilow's time-cost model to building project management. It explored the model's effectiveness in optimizing project timetables and resource allocation. The findings indicate that, while Bromilow's model gives useful insights, its applicability may be impacted by project complexity and unpredictability.

(Abdullah, 2018) reviewed the various time-cost trade-off models, including Bromilow's model, in construction projects. It assessed the performance of the models in terms of project length and cost optimization, as well as aspects that may affect their practical applicability. The review discussed Bromilow's model's merits and drawbacks, as well as ideas for practical implementation.

(Javadian, 2014) studied critically to assess Bromilow's time-cost model and other time-cost trade-off models in the context of construction projects. It evaluated the models' assumptions and limits, as well as their practical application. The findings emphasized the importance of carefully considering project-specific elements when using Bromilow's model to ensure its efficacy in practice.

(Aminbakhsh, 2016) comprehensively reviewed the applicability of time cost model and examined the obstacles and opportunities connected with applying Bromilow's model to optimize project schedules and resource allocation, as well as insights into its practical application. The review helps to improve our understanding of the factors that influence the efficacy of Bromilow's model in practice.

2.2 National perspective:

Assessment of time–cost model of public health buildings in Nepal: This study evaluates the time-cost model for public health buildings in Nepal. It investigated the accuracy and reliability of time-cost model forecasts in health-building projects. The findings showed the importance of calibrating and refining the time-cost model to increase its accuracy in predicting project durations and costs. This study also investigated the use of time-cost models for health buildings in Nepal. It investigated the factors that influence project length and cost in the context of health building projects. The study offers insights on optimizing project schedules and resource allocation to obtain cost-effective project results. The study recommended the recommended the time cost model for expressing duration of the health building project with an equation,

$$T = 487.5 \times (C/79.96)^{0.293}$$ (time is expressed in days and cost in million NRs) (Mishra, 2020) .

(Chaulagain, 2018) examined the factors affecting time and cost overruns in public construction projects in Nepal. It identifies factors such as inadequate project planning, delays in decision-making, and poor contract

management as significant contributors to overruns. The findings underscore the importance of effective project management practices to mitigate time and cost overruns.

(Acharya, 2017) investigated the factors causing time overruns in infrastructure projects in Nepal. It identifies factors such as delays in land acquisition, changes in project scope, and adverse weather conditions as key contributors to time overruns. The study emphasizes the importance of proactive risk management and effective coordination among project stakeholders to minimize time overruns.

These studies offer valuable insights into the factors influencing time and cost management in building projects both globally and within the specific context of Nepal. They highlight the importance of effective project planning, resource allocation, and risk management in achieving successful project outcomes.

3 Methodology

3.1 Research Design

To evaluate the congruence between the intended projected duration, as outlined in the bidding documents for basic hospital construction projects, and Nepal's time cost model specific to health building projects, various literature, and articles (published as well as unpublished) were reviewed. The primary data were collected from online sources and secondary data to published research.

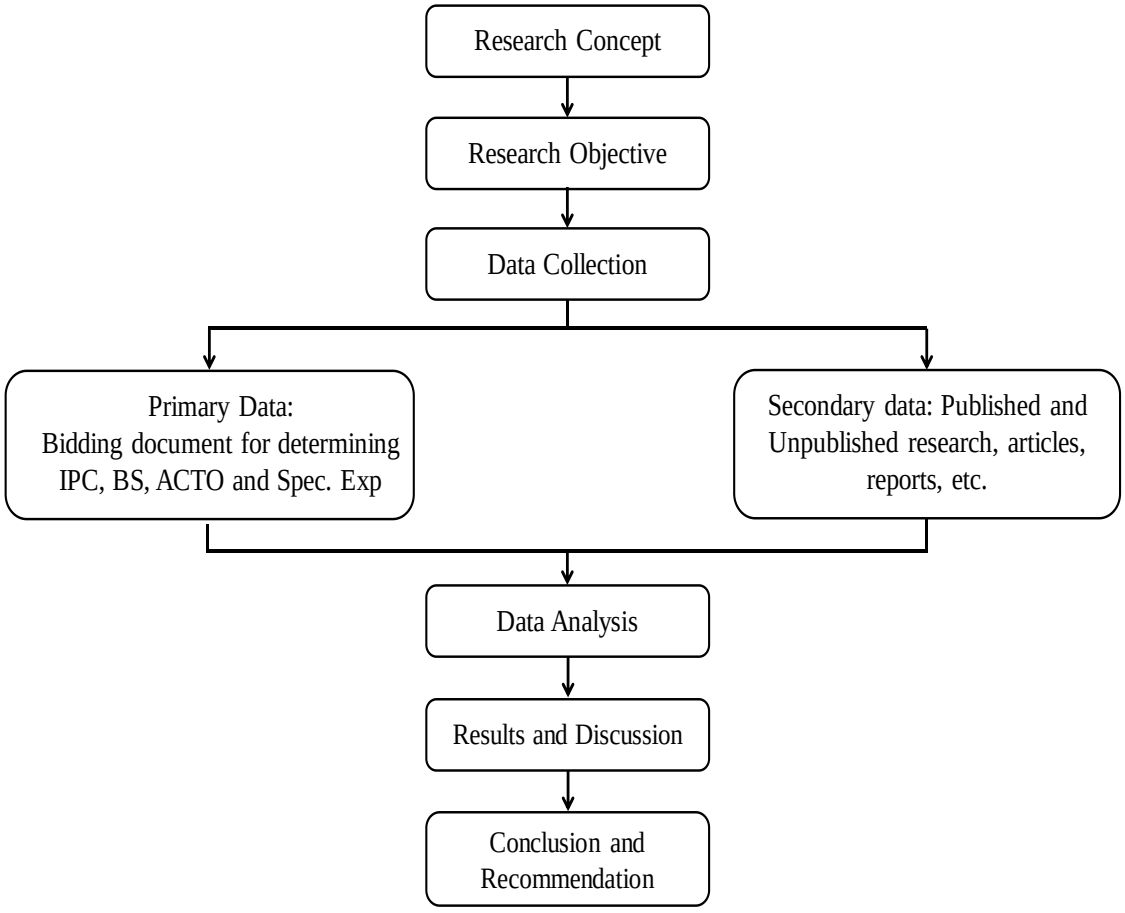

Figure 1. Research Flow chart

3.2 Research Approach

For the comparative analysis in evaluating the congruence between the intended projected duration, as outlined in the bidding documents for basic hospital construction projects, a quantitative approach was used.

3.3 Study Area and population and sample size

The study focuses on hospital projects in Nepal, particularly those falling under the jurisdiction of local levels. To determine the sample size, an observation was conducted to identify projects tendered through the bolpatra.gov.np portal during the fiscal years 2077/78 to 2080/81. A total of 85 hospital buildings were tendered through this portal within the specified timeframe, constituting the population size for our study. From this population, a purposive sampling approach was employed to select hospitals with capacities of 5 beds, 10 beds, and 15 beds, as indicated in the tender notices published on bolpatra.gov.np. This method ensures that the selected sample represents a diverse range of hospital sizes, allowing for comprehensive analysis and insights into the implementation of basic hospital projects across Nepal's local levels.

3.4 Sample Size for study

From a total of 85 hospital projects, the sample size has been determined using Cochran equation as given below. To calculate sample size with 90% confidence level and confidence interval of 10 has been used. For a finite sample,

$$n_0 = \frac{Z^2pq}{e^2} = \frac{1.64^2 * 0.5 * 0.5}{0.10^2} = 67.24 \quad \text{(Equation 2)}$$

Where,

n_0 = Cochran's sample size recommendation

Z = Area of normal curve and its value is 1.64 for 90% confidence level.

e = Desired level of precision (Confidence interval) p = Estimated proportion of an attribute that is present in the population, and q is 1-p. Since the variability in the proportion is not known, therefore, maximum variability of 0.5 (i.e., p=q=0.5) is assumed.

The equation is modified as below if there is as smaller population as follows:

Where,

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} = \frac{67.24}{1 + \frac{(67.24 - 1)}{85}} = 37 \text{ (approximately),} \quad \text{(Equation 3)}$$

Where n = New Adjusted sample size

Among those 37 samples, Purposive sampling has been used to collect the samples. A purposive sampling is a non-random sampling technique where researchers deliberately select samples based on predetermined criteria that are relevant to the research objectives. In this case, the researcher has chosen to focus on hospitals of specific sizes (5-bedded, 10-bedded, and 15-bedded) within the study area.

The justification for this approach is that it allows for a focused examination of different hospital sizes, which may have varying characteristics and requirements. By selecting hospitals of different capacities, the study can capture a diverse range of experiences and factors that may influence the implementation and performance of basic hospital projects.

Table 1 indicates the distribution of sampled hospitals according to their bed capacity. Seven 5-bedded hospitals, ten 10-bedded hospitals, and twenty 15-bedded hospitals were selected, resulting in a total of 37 sampled hospitals.

Table 1. List of Projects under study

Types of Hospital	Number of Sample
5 Bedded	7
10 Bedded	10
15 Bedded	20
Total	37

This distribution ensures representation across different hospital sizes, allowing for a comprehensive analysis of the various factors affecting basic hospital projects in Nepal. While the sample size is limited, the purposive selection of hospitals based on bed capacity ensures relevance to the research objectives and provides valuable insights into the implementation of healthcare infrastructure projects in the region.

3.5 Methods of Data Collection

Primary data has been collected from bolpatra.gov.np. Bidding documents which have been published from different local levels are downloaded and required variables are collected. Whereas secondary data has been collected from published sources.

The primary data utilized in this study are:

- Intended completion time of the project as mentioned in bidding document
- Bid security amount
- Required specific experience
- Annual construction turnover

Whereas secondary data is the time cost model of the health building project in Nepal

3.6 Data Analysis and interpretation

After collecting data from the primary sources, the variable required for the study has been extracted and evaluated to find out the congruence between the standard time cost model equations for health building. The variable that has been extracted from the bidding document is intended project completion time of the project as mentioned in **Special Conditions of Contract (SCC)** clause and regarding the cost as it has not been mentioned in the bidding document, researcher computed the costs based on the bid security amount, annual construction turn over and work experience. Therefore, the costs have been calculated for all three variables. After the computing the costs, the health building's time cost model has been tested and compared it with the intended project completion time to find whether it corelates or not. While evaluating the congruence, a correlation and repeated ANOVA test were performed to trace out the conclusion of the study.

4 Results and Discussions:

4.1 Calculation of Costs Estimates:

From the bidding document of the published basic hospital projects the employer's costs estimates have been calculated using the bid security amount, annual construction turnover and specific experience. The calculated cost estimates of the sample projects under study have been presented in the table below:

Table 2. Cost estimates of 5 bedded hospital taken from Bidding document

SN	Project under study	Cost estimates in Million as per:		
		Bid security (BS)	Annual Construction Turnover (ACTO)	Work experience
1	Project 1	68	37.81	68.75
2	Project 2	70	73.33	70
3	Project 3	63.33	58.57	60
4	Project 4	84	85.09	87.5
5	Project 5	55	58.3	58.13
6	Project 6	73.33	51.2	76.63
7	Project 7	56.67	31.31	60

Source: https://bolpatra.gov.np/egp/searchOpportunity (GoN, 2024)

Table 3. Cost estimates of 10 bedded hospital taken from Bidding document

SN	Project under study	Cost estimates in Million as per:		
		Bid security (BS)	Annual Construction Turnover (ACTO)	Work experience
1	Project 1	90.00	79.72	79.72
2	Project 2	76.67	79.49	79.38
3	Project 3	88.00	93.33	93.75
4	Project 4	93.33	94.67	93.75
5	Project 5	72.00	73.33	64.38
6	Project 6	112.00	120.00	112.50
7	Project 7	104.00	97.73	97.75
8	Project 8	120.00	117.33	116.88
9	Project 9	116.70	118.00	117.88
10	Project 10	120.00	118.00	56.25

Source: https://bolpatra.gov.np/egp/searchOpportunity (GoN, 2024)

Table 4. Cost estimates of 15 bedded hospital taken from Bidding document

SN	Project under study	Cost estimates in Million as per:		
		Bid security (BS) amount	Annual Construction Turnover (ACTO)	Work experience
1	Project 1	276.23	276.26	207.19
2	Project 2	156.67	173.07	173.00
3	Project 3	95.33	84.16	103.75
4	Project 4	200.00	266.81	177.50
5	Project 5	150.00	145.75	162.50
6	Project 6	155.00	265.94	169.28
7	Project 7	196.00	190.67	190.63
8	Project 8	197.46	197.45	197.45
9	Project 9	152.00	160.00	150.00
10	Project 10	140.00	146.67	137.50
11	Project 11	199.90	194.67	172.50
12	Project 12	155.00	156.00	155.00
13	Project 13	171.97	134.67	168.75
14	Project 14	180.00	180.00	180.00
15	Project 15	160.00	146.67	150.00
16	Project 16	52.00	53.00	50.00
17	Project 17	200.00	202.00	202.00
18	Project 18	196.00	188.79	181.25
19	Project 19	140.00	140.80	140.75
20	Project 20	172.00	293.33	150.00

Source: https://bolpatra.gov.np/egp/searchOpportunity (GoN, 2024)

After determining the cost estimates of the individual projects, the time required for completing these projects has been calculated by putting the value of cost of each hospital building in standard health building time cost model taken from the past research to determine whether the time deviates from intended project completion time of that project or not.

4.2 Calculation of time duration from each cost's estimates based on time cost model

The intended project completion time of each project as mentioned in the bidding documents and the time duration calculated from the standard model equation is presented in the table below.

Table 6. Time calculated from the standard time cost model for health building, T (days) = T = 487.5 × (C/79.96)^0.293- for 5 bedded hospitals

Project	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
1	455	465	392	467
2	730	469	476	469
3	605	456	445	449
4	609	495	497	501
5	548	437	445	445
6	730	476	428	482
7	456	441	393	449

Table 7. Time calculated from the standard time cost model for health building, T (days) = T = 487.5 × (C/79.96)^0.293 for 10 bedded hospitals

Project	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
1	730	505	488	488
2	730	486	487	487
3	730	502	511	511
4	730	511	513	511
5	730	473	476	458
6	1,095	539	550	539
7	730	527	518	518
8	730	550	546	545
9	730	545	547	547
10	730	550	547	440

Table 8. Time calculated from the standard time cost model for health building, T (days) = T = 487.5 × (C/79.96)^0.293 for 15 bedded hospitals

Project	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
1	1,095	702	702	645
2	730	594	612	612
3	720	514	495	527
4	913	638	694	616
5	760	587	582	601
6	910	592	694	608
7	730	634	629	629
8	365	636	636	636
9	730	589	598	587
10	730	575	583	572
11	730	638	633	611
12	730	592	593	592
13	730	611	568	607
14	730	619	619	619
15	730	598	583	587
16	1,095	429	433	425
17	730	638	640	640
18	608	634	628	620
19	730	575	576	576
20	730	611	714	587

4.3 Correlation between projects time duration

Based on the correlation matrix it has been observed that:

- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the BS is 0.63, indicating a moderate positive correlation.
- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the ACTO is 0.65, also indicating a moderate positive correlation.
- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from specific work experience is 0.6, again indicating a moderate positive correlation.

Table 9. Correlation between indented project completion time and time estimates for 5-bedded hospital

	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
Intended Project completion time as per Bidding document in days	1	0.63	0.65	0.6
Time calculated from costs taken from BS amount	0.63	1	0.4	0.99
Time calculated from costs taken from ACTO	0.65	0.4	1	0.35
Time calculated from costs taken from Specific Work Experience	0.6	0.99	0.35	1

Table 10. Correlation between indented project completion time and time estimates for 10-bedded hospital

	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
Intended Project completion time as per Bidding document in days	1	0.17	0.52	0.29
Time calculated from costs taken from BS amount	0.17	1	0.89	0.47
Time calculated from costs taken from ACTO	0.52	0.89	1	0.55
Time calculated from costs taken from Specific Work Experience	0.29	0.47	0.55	1

The correlation coefficients between the other variables are as follows:

- Between time calculated from costs taken from BS amount and time calculated from costs taken from ACTO: 0.4 (indicating a weak positive correlation).
- Between time calculated from costs taken from BS amount and time calculated from costs taken from specific work experience: 0.99 (indicating a strong positive correlation).
- Between time calculated from costs taken from ACTO and time calculated from costs taken from specific work experience: 0.35 (indicating a weak positive correlation).

Overall, there is a moderate to strong positive correlation between the intended project completion time and the time calculated from costs, regardless of the source of cost data. However, the correlation between times calculated from costs taken from ACTO and specific work experience is weaker compared to the other variables.

Based on the correlation matrix it has been observed that:

- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the BS amount is 0.17, indicating a weak positive correlation.
- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the ACTO is 0.52, indicating a moderate positive correlation.

- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from specific work experience is 0.29, indicating a weak positive correlation.

Table 11. Correlation between indented project completion time and time estimates for 15-bedded hospital

	Intended Project completion time as per Bidding document in days	Time calculated from costs taken from BS amount	Time calculated from costs taken from ACTO	Time calculated from costs taken from Specific Work Experience
Intended Project completion time as per Bidding document in days	1	-0.03	0.12	-0.04
Time calculated from costs taken from BS amount	-0.03	1	0.77	0.88
Time calculated from costs taken from ACTO	0.12	0.77	1	0.69
Time calculated from costs taken from Specific Work Experience	-0.04	0.88	0.69	1

The correlation coefficients between the other variables are as follows:

- Between time calculated from costs taken from BS amount and time calculated from costs taken from ACTO: 0.89 (indicating a strong positive correlation).
- Between time calculated from costs taken from BS amount and time calculated from costs taken from specific work experience: 0.47 (indicating a moderate positive correlation).
- Between time calculated from costs taken from ACTO and time calculated from costs taken from specific work experience: 0.55 (indicating a moderate positive correlation).

Overall, there is a positive correlation between the intended project completion time and the time calculated from costs, with varying degrees of strength depending on the source of cost data. The strongest correlation is observed between time calculated from costs taken from the Bid Security Amount and time calculated from costs taken from the Annual Construction Turn Over.

Based on the correlation matrix it has been observed that:

- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the BS amount is approximately -0.03, indicating a very weak negative correlation.
- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from the ACTO is approximately 0.12, indicating a very weak positive correlation.
- The correlation coefficient between the intended project completion time as per the bidding document and the time calculated from costs taken from specific work experience is approximately -0.04, indicating a very weak negative correlation.

The correlation coefficients between the other variables are as follows:

- Between time calculated from costs taken from BS amount and time calculated from costs taken from ACTO: approximately 0.77, indicating a moderate positive correlation.
- Between time calculated from costs taken from BS amount and time calculated from costs taken from specific work experience: approximately 0.88, indicating a strong positive correlation.
- Between time calculated from costs taken from ACTO and time calculated from costs taken from specific work experience: approximately 0.69, indicating a moderate positive correlation.

Overall, there is a very weak correlation between the intended project completion time as per the bidding document and the time calculated from costs, regardless of the source of cost data. However, there are moderate to strong positive correlations between the time calculated from costs taken from the BS and the ACTO, as well as between these two and the time calculated from specific work experience.

4.4 Test of Hypothesis for all three categories of hospital projects

A Kruskal-Walli's test is a non-parametric test used to compare three or more groups on a continuous ordinal outcome. It's often used when the assumptions of a one-way ANOVA (e.g., normality, equal variances) are not met. Here the 4 categories of the independent variables are intended project completion time, costs estimate calculated from bid security amount, costs estimate calculated from annual construction turn over and cost estimate calculated from specific work experience as mentioned in the bidding document.

Table 12. Hypothesis assumptions

Null hypothesis	Alternative hypothesis
There is no difference between the 4 categories of the independent variable in terms of the dependent variable .	There is a difference between the 4 categories of the independent variable in terms of the dependent variable .

Kruskal-Wallis Test for 5 bedded hospitals

A Kruskal-Walli's test showed that there was a significant difference between the categories of the independent variable with respect to the dependent variable , p=.023. Thus, with the available data, the null hypothesis was rejected.

Table 13. Post Hoc Test for 5-Bedded Hospital

	Test Statistic	Std. Error	Std. Test Statistic	p	Adj. p
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from BS amount	8.86	4.39	2.02	.044	.262
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO	13.29	4.39	3.03	.002	.015
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from Specific Work Experience	7.57	4.39	1.72	.085	.508
Time calculated from costs taken from BS amount - Time calculated from costs taken from ACTO	4.43	4.39	1.01	.313	1
Time calculated from costs taken from BS amount - Time calculated from costs taken from Specific Work Experience	-1.29	4.39	-0.29	.77	1
Time calculated from costs taken from ACTO - Time calculated from costs taken from Specific Work Experience	-5.71	4.39	-1.3	.193	1

Adj. p: Values adjusted with Bonferroni correction.

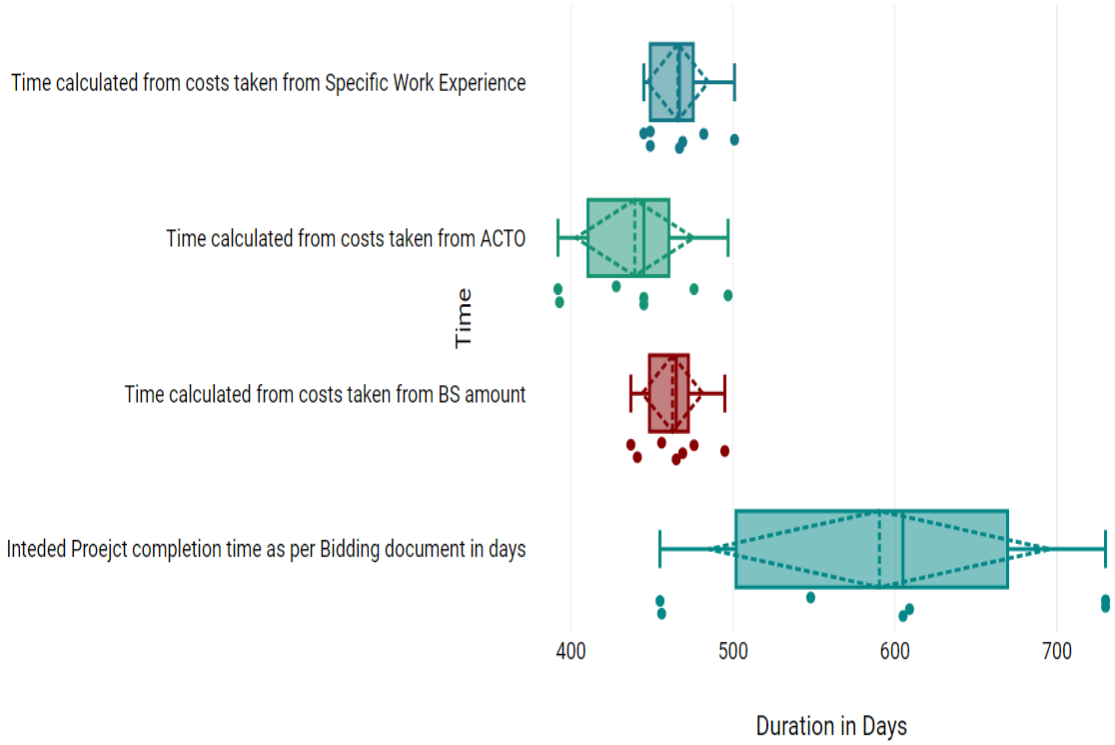

Figure 2. Box plot of time duration for 5 bedded hospital

Post hoc Test

The Kruskal-Walli's test showed that there was a significant difference. A Dunn-Bonferroni test was used to compare the groups in pairs to find out which was significantly different.

The Dunn-Bonferroni test showed that the pairwise group comparison of Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO has an adjusted p-value of less than 0.05, and thus, based on the available data, it can be assumed that the two groups were significantly different from each other.

Kruskal-Wallis Test for 10 bedded hospitals

A Kruskal-Walli's test showed that there was a significant difference between the categories of the independent variable with respect to the dependent variable , p=<.001. Thus, with the available data, the null hypothesis was rejected.

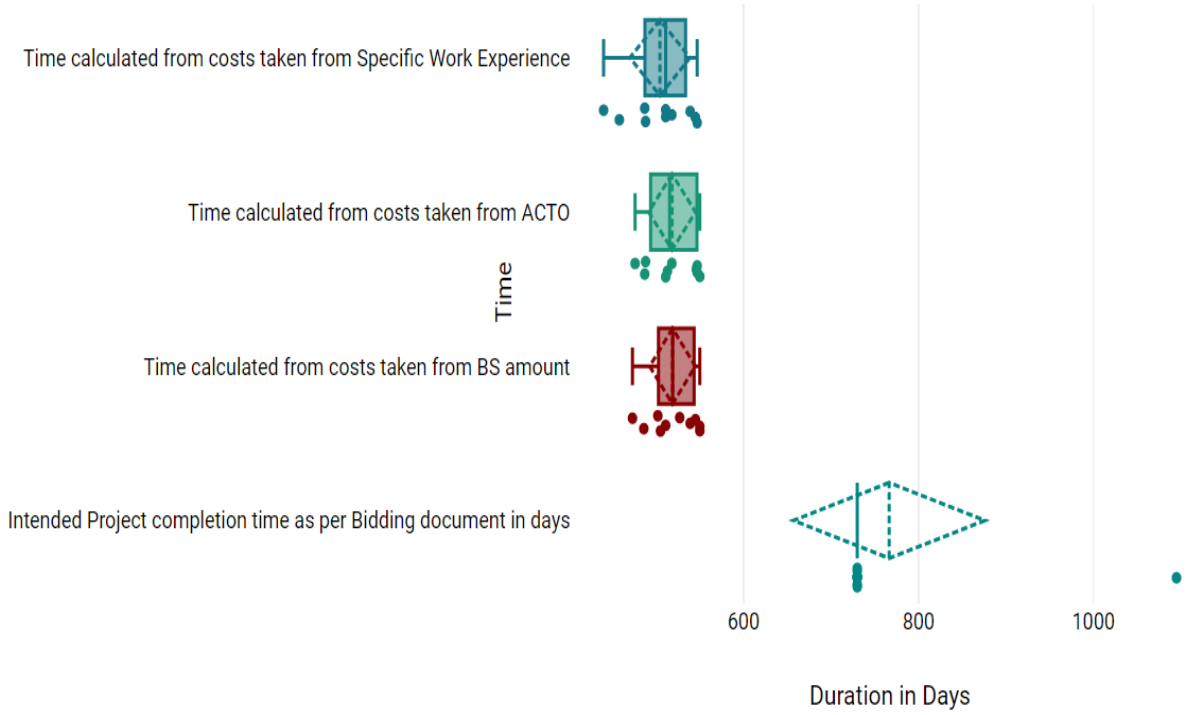

Figure 3. Box plot of time duration for 10 bedded hospital

Table 14. Post Hoc Test for 10-Bedded Hospital

	Test Statistic	Std. Error	Std. Test Statistic	p	Adj. p
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from BS amount	19.25	5.19	3.71	<.001	.001
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO	18.4	5.19	3.54	<.001	.002
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from Specific Work Experience	22.35	5.19	4.3	<.001	<.001
Time calculated from costs taken from BS amount - Time calculated from costs taken from ACTO	-0.85	5.19	-0.16	.87	1
Time calculated from costs taken from BS amount - Time calculated from costs taken from Specific Work Experience	3.1	5.19	0.6	.551	1
Time calculated from costs taken from ACTO - Time calculated from costs taken from Specific Work Experience	3.95	5.19	0.76	.447	1

Adj. p: Values adjusted with Bonferroni correction.

Post hoc Test

The Kruskal-Walli's test showed that there was a significant difference. A Dunn-Bonferroni test was used to compare the groups in pairs to find out which was significantly different.

The Dunn-Bonferroni test revealed that the pairwise group comparisons of Intended Project completion time as per Bidding document in days - Time calculated from costs taken from BS amount, Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO and Intended Project completion time as per Bidding document in days - Time calculated from costs taken from

Specific Work Experience have an adjusted p-value less than 0.05 and thus, based on the available data, it can be assumed that these groups were significantly different in pairs.

Kruskal-Wallis Test for 15 bedded hospitals

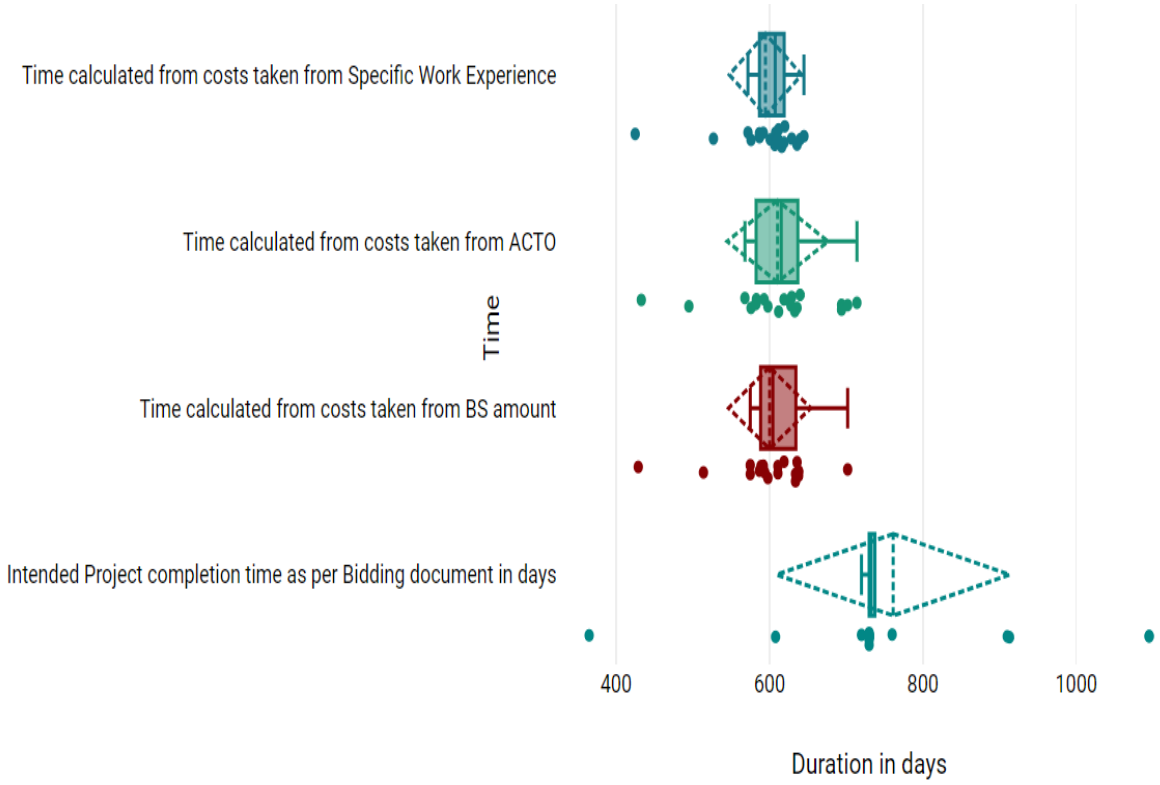

Figure 4. Box plot of time duration for 15 bedded hospital

A Kruskal-Walli's test showed that there was a significant difference between the categories of the independent variable with respect to the dependent variable , p=<.001. Thus, with the available data, the null hypothesis was rejected.

Post hoc Test

The Kruskal-Walli's test showed that there was a significant difference. A Dunn-Bonferroni test was used to compare the groups in pairs to find out which was significantly different.

The Dunn-Bonferroni test revealed that the pairwise group comparisons of Intended Project completion time as per Bidding document in days - Time calculated from costs taken from BS amount, Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO and Intended Project completion time as per Bidding document in days - Time calculated from costs taken from Specific Work Experience have an adjusted p-value less than 0.05 and thus, based on the available data, it can be assumed that these groups were significantly different in pairs.

Table 15. Post Hoc Test for 15-Bedded Hospital

	Test Statistic	Std. Error	Std. Test Statistic	p	Adj. p
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from BS amount	33.9	7.33	4.62	<.001	<.001
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from ACTO	31.87	7.33	4.35	<.001	<.001
Intended Project completion time as per Bidding document in days - Time calculated from costs taken from Specific Work Experience	36.12	7.33	4.93	<.001	<.001
Time calculated from costs taken from BS amount - Time calculated from costs taken from ACTO	-2.02	7.33	-0.28	.782	1
Time calculated from costs taken from BS amount - Time calculated from costs taken from Specific Work Experience	2.23	7.33	0.3	.762	1
Time calculated from costs taken from ACTO - Time calculated from costs taken from Specific Work Experience	4.25	7.33	0.58	.562	1

Adj. p: Values adjusted with Bonferroni correction.

5. Conclusion

The study aimed to assess the congruence between the intended projected duration expressed in bidding documents for basic hospital construction projects and Nepal's time cost model specific to health building projects. The findings reveal moderate to strong positive correlations between the intended project completion time and the time calculated from costs, regardless of the source of cost data. However, there are variations in the strength of correlation depending on the specific variables used for cost estimation.

Conclusion of Correlation test

In summary, the correlation analysis for the 5-bedded hospital indicates a moderate to strong positive correlation between the intended project completion time and the time calculated from costs, irrespective of the data source. Notably, the strongest correlation is observed between time calculated from costs sourced from the Bid Security Amount, and the Annual Construction Turn Over (ACTO).

For the 10-bedded hospital, the correlation between the intended project completion time and the time calculated from costs is positive, with varying strengths depending on the data source. The strongest correlation is found between time calculated from costs sourced from the Bill of Quantities and the ACTO.

In contrast, the correlation analysis for the 15-bedded hospital reveals very weak correlations between the intended project completion time and the time calculated from costs, regardless of the data source. However, moderate to strong positive correlations are observed between time calculated from costs sourced from the Bid Security Amount, and the ACTO, as well as between these two and the time calculated from specific work experience.

Overall, while the correlation between project completion time and cost calculations may vary, there is a consistent pattern of stronger correlations between the Bid Security Amount, and ACTO, suggesting their reliability in estimating project timelines.

Conclusion of Hypothesis test

Based on the hypothesis test results for the 5-bedded hospital, a significant difference was found among the groups according to the Kruskal-Walli's test. Further analysis using the Dunn-Bonferroni test revealed that the intended project completion time and the time calculated from costs taken from the ACTO were significantly different.

Similarly, for the 10-bedded hospital, the Kruskal-Walli's test indicated a significant difference among the groups. Post hoc testing with the Dunn-Bonferroni test confirmed significant differences in pairwise comparisons of intended project completion time with costs taken from the Bid Security Amount, ACTO, and Specific Work Experience.

Likewise, in the case of the 15-bedded hospital, significant differences were observed among the groups according to the Kruskal-Walli's test. Subsequent Dunn-Bonferroni tests highlighted significant differences in pairwise comparisons of intended project completion time with costs taken from the Bid Security Amount, ACTO, and Specific Work Experience.

Overall, the hypothesis tests across all three categories demonstrate significant differences between the intended project completion time and various cost calculation methods. These findings underscore the importance of considering different cost sources when estimating project timelines in hospital construction projects.

6. Recommendation

Time-cost models, such as Nepal's time cost model for health building projects, should be regularly calibrated and updated to reflect changing project dynamics and industry trends. This can help improve the accuracy of project duration predictions and enhance overall project management practices.

Future research should focus on validating the findings of this study across a broader range of construction projects in Nepal. Additionally, exploring the factors influencing discrepancies between intended project durations and time-cost model estimates can provide valuable insights for improving estimation practices.

7. Funding

The authors confirmed that has not received any financial support for this study's research, authorship, or publication.

8. Data Availability

Representative data analyzed during this study are included in the text. The detail dataset generated during and/or analyzed during the current study will be available on reasonable request.

9. Conflict of Interest

The authors declared no conflict of interest.

10. Acknowledgement

Authors would like to acknowledge the department of Civil Engineering of both Kathmandu Engineering College and Himalaya College of Engineering.

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