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Original Article

A Statistical Approach on Optimizing the Effects of Cost overrun in Construction Project

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Abstract - *Generally acknowledged when the building project is finished within budget, it is the one determined to judge its success. Due to various economic conditions, this is frequently more difficult in developing nations, where financial challenges are just one reason for poor project execution. This Research examined the factors that affect the profit and lead to cost overruns on construction projects. To get a better knowledge of the problem and the numerous methods that were taken to analyze it, an in-depth examination of regional and worldwide publications was carried out. Data was collected from Tamil Nadu, India's delta district, to illustrate cost-overrun factors. A Chi-Square analysis model and Multinominal logistic regression were used for data analysis to evaluate the relationships of project estimating contract prices cost overruns and developing prediction models for estimating cost overrun that leads to a better economy. The most important finding proved that every model construct significantly increases the probability of budget overruns. This suggests that the model could generalize the factors contributing to budget overruns when constructing projects. Identifying these elements would make improving project cost performance easier for the construction industry.*

Keywords *- Cost overrun, Exceeding budget, Profitability, Construction budget.*

1. Introduction

The construction industry is fundamental to the nation's economy and essential for physical development. Better project performance improves the economic value of construction management. The Cost, time, and quality determine the successful completion of a construction project. Cost overrun plays a serious role in the construction budget of every project. [9] Cost overrun refers to the difference between market price and budget costs for a construction project. It occurs when the market price exceeds the budgeted Cost. [7, 8] According to the inflation rate, many factors play a role in cost overrun. The major things are Men, Materials and Machinery. [2, 17] In every year, approximately, inflation increased by 6% in the Indian economy. [29] For this Research, data were collected from the construction sites in the Delta region of Tamil Nadu, such as Thanjavur, Thiruvarur, Kumbakonam, Nagapattinam and Karaikal, for better understanding of cash flow in construction. Cash flow in construction management comes from engineers and every part of the construction sector. [1, 5] On the other hand, maintaining the cash flow in every direction in construction increases profit using some methods and techniques. [3, 40] Controlling the weather or predicting unexpected problems on every site is impossible. Rather than that, there are few chances to control how these factors impact the project. Lack of time management also significantly impacts exceeding budget, such as labour wage hikes and material price hikes in the market. The majority of Research in India was only concentrated on Cost overrun, not on increasing profit. The maximum amount of Research from the beginning is only focused on controlling Cost overrun because of a lack of focus on predicting and increasing the profit percentage of construction project's budgets. The expected profit of the project was clashed by some important unexpected reason. The study mainly focuses on the reason for the loss and cost overrun of the project, which were analyzed, and valid causes were predicted.

2. Literature Review

The Research focuses on Cost overrun in construction, but the overall profit margin of construction has not profited as per every engineer's expectation. [5, 6] Because the construction sector's economy only determines the short period, most projects move over the years. [28] Cost overrun is the predominant issue that affects the project process and reduces the profit margin. [10, 39] Cost overrun commonly affects the nation's economic growth, leading to financial losses and reducing the growth of the construction industry. [13, 16]The inflation rate is one of the most important causes of global cost overruns in construction projects. [28] The construction industry has defected due to the inflation rate's

erratic behaviour every year-the Hike in building material prices was examined. [12, 29] Contractors are forced to compromise on quality when owners refuse to pay for higher project costs, which lowers project productivity when the material price may hike. [15, 24] It has been difficult for stakeholders to anticipate how the inflation rate will change over time, eventually leading to cost overruns in building projects. [14, 32]Some studies like Building information modelling for stakeholder management on construction megaprojects with a questionnaire survey were held with 204 responders such as contractors, clients, engineers and manufactures. The data was analyzed using Cronbach Alpha, and the ANOVA test using SPSS was considered. [44] Many difficulties arise in construction in developing nations, such as poor contractor performance brought on by a lack of resources and qualifications. [25] In public procurements, the lowest bid criterion holds legal force. Nevertheless, contractors take advantage of the gaps in the bid process management system. [18, 19] Labour wages are an essential requirement fosurvival and success; this is the most significant and fundamental component affecting stress and the worker. [25, 30] The highest stress level comes from labourers' poor wages. [22] The absence of accurate information regarding the "value" and "cost of the sustainable construction industry" prevents developers and clients from making the best choices regarding sustainability. [21, 23] Cost overrun should be remembered that achieving "sustainability goals" does not stop with completing the building design. [14, 28] Even though this may cause projects to achieve varying degrees of cost reduction, it was thought to be vital to offer each construction project a certain amount of autonomy to determine their standard progress towards cost-efficiency and propose successful activities. [27, 33] A regression analysis was performed to determine the connections between the project's contract prices and cost overruns, creating forecast models for estimating cost overruns. [31, 34] Regression models were formulated to predict project cost overruns. [35, 37] The cost overruns for projects rise in construction with the contract prices. [11, 38] A quantitative questionnaire survey with 124 respondents was performed, and data was analyzed using multiple linear regression using SPSS. These results identified key factors such as stakeholder's decision, competence trust, intuitive trust, honesty, integrity and communication. [43] In Malaysia, a quantitative survey was held with 250 construction professionals using a questionnaire. According to SPSS, the top barriers to safety in construction sites are limitations in automation BIM adaptation for safety at construction sites. Difficulties in change and lack of safety knowledge. [41] A quantitative questionnaire survey was performed. The data was analyzed using Kolmogorov-Smirnov, Cronbach's Alpha, Kasier-Meyer-Olkin, and Bartlett's sphericity test, which is SPSS. [42] A questionnaire survey was conducted with clients, consultants, and contractors. The collected data was tested by Kruskal Wallis, Normality mean Rank, and Cronbach Alpha using SPSS. The highest affecting factor is the cash flow problems faced by contractors. [45]

3. Research Methodology

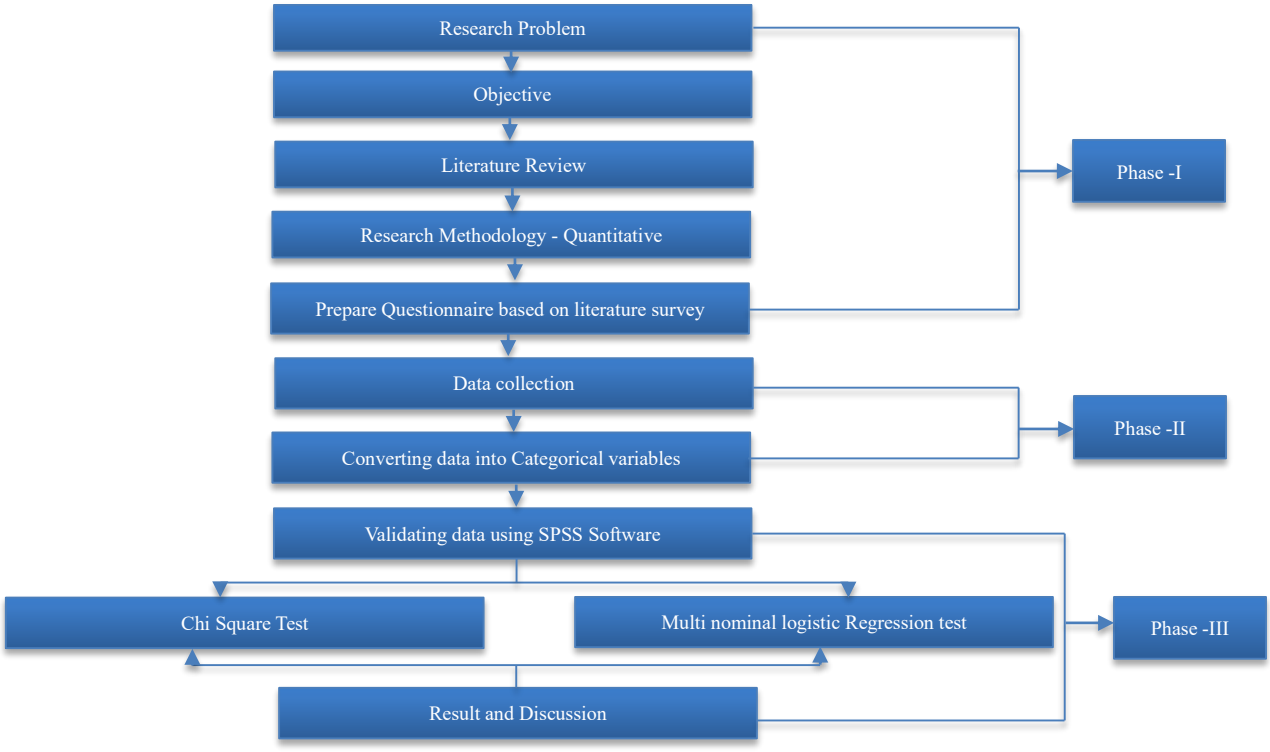

Fig. 1 Framework of a methodology to optimize cost-overrun

Based on this literature review, a structured framework has been curated to optimize the cost-overrun. From the framework, the methodology of the Research was classified into three phases. In the first phase, a structured questionnaire was prepared based on the literature review. In the second phase, the collected data was labelled and associated by using categorical encoding to identify the key factors of cost overrun. Moreover, in the final phase of the statistical approach, the Chi-Square test is implemented in the Statistical Package of Social Science software (SPSS-26) to determine the importance of Cost overrun in the construction industry.

3.1. Data Collection

A structured questionnaire was prepared based on the research objective and literature review to analyze the cost-overrun in the construction budget, unexpected loss in the construction project, and Preparedness for cost-overrun.

Figure 2 shows the types of respondents who collected the data using the cluster sampling method.

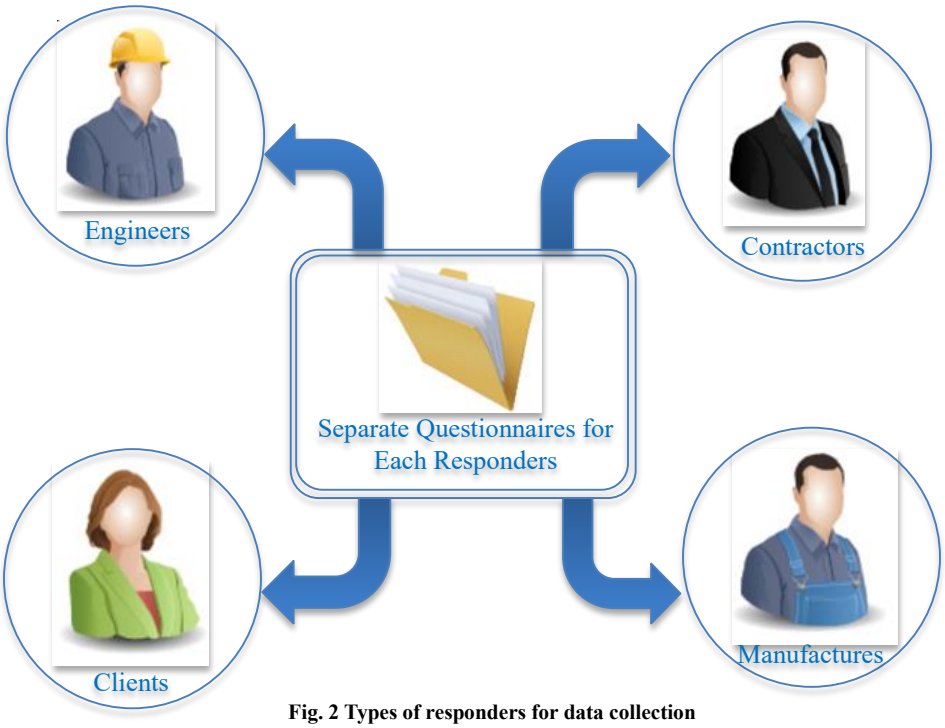

Fig. 2 Types of responders for data collection

RQ1. How can skilled and unskilled labourers manage the Hike in wages?
RQ2. How do we manage sudden losses like climate change or accidents?
RQ3. Is there any chance you can buy material from a wholesaler?
RQ4. Is there any extra discount from a wholesaler or retailer especially?
RQ5. How do we get the extra profit margin in gross profit?
RQ6. What was the average percentage of profit they got for the total pro?
RQ7. How much would it cost if you directly undertake the project?
RQ8. Does the climate have an impact on production?
RQ9. Are there any changes in labour when the price of raw material rise?
RQ10. If the labourers are in demand, it should affect?
RQ11. Bargaining from the retailer and customer may have an impact on manufacturing.
RQ12. How do we handle unexpected difficulties caused by climate change?
RQ13. As site clearance is difficult, how should the issue be resolved?
RQ14. How do you face unfortunate accidents that may occur on the site?
RQ15. How to tackle the problem of weather changes like sudden rainfall.
RQ16. In case any accident may happen in transporting the material after buying means, how to solve it?
RQ17. How do we face any material breaks in transportation or on-site?
RQ18. If a loss occurs, who will pay an extra amount that exceeds the budget?
RQ19. In case any accident may occur, will you get any responsibility?
RQ20. How will you check if the material is of first quality or not?

The questionnaire was distributed to the Manufacturer, Engineer, Contractor, labour, and Client. These respondents were given valid answers from every part of the construction site. This Research, 220 data samples were collected across the Delta Region of Tamil Nadu, India, such as Thanjavur, Thiruvarur, Nagapattinam, Kumbakonam and Karaikal. A cluster sampling approach was employed to select respondents.

3.2. Justifying Geographical Focus

The purpose of choosing the delta district region in Tamil Nadu, India, was that paint and steel costs are lower in Nagapattinam, Thiruvarur district, and Karaikal district regions. Also, the availability of course aggregates is easy in the Tanjore district region because of the stone quarry in the same area near Pudukkottai. Compared to Nagapattinam, the Karaikal district area price is aggregated, and the fine aggregate price is lower in Thanjavur and Thiruvarur Region. Steel and paint prices are high here. Compared to Karaikal, Nagapatinam's reason for production. So, every area was analyzed, and the sample was chosen through cluster sampling. However, overall, Research was adopted to make the availability of raw materials easy.

3.3. Sample Size

The data collection in the survey process was chosen using cluster sampling. The purpose of choosing cluster sampling was to ensure that the population of respondents was very high. The target area was around six districts in Tamilnadu. Cluster sampling was called collecting the responders randomly in the target area by considering sample size.

The sample of every responder was 85 numbers, so there are different types of respondents. So, a survey of people may provide the data for validation. The four types of respondents are engineering contractor manufacturer clients, so the sample size was 340.

3.4. Data Analysis

3.4.1. Chi-Square Analysis

The Chi-square test is a statistical method often used in quantitative Research, particularly for analyzing categorical data. This test analyses if any significant association occurs between two categorical variables.

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

- χ^2 = Chi-square statistic
- O_i = Observed frequency for each category (actual data from the sample)
- E_i= Expected frequency for each category (what would be expected if there were no relationship between variables)
- $\sum$ =the overall categories of the variables.

3.4.2. Multinominal Logistic Regression Analysis

Multinomial logistic regression analysis is a statistical method used for categorical variables in quantitative Research to predict the probability of dependent variables in a categorical range with more than two possible outcome processes.

- A set of input features: $\boldsymbol{x}$ E R^d
- A categorical target variable: y E {1,2,3,…, K} where *K* is the number of classes
- The model of probability that y = *k* given x

$$P(y = k|x) = \frac{exp(w_k^T x)}{\sum_{j=1}^{k} exp(w_j^T x)}$$

Where:

- w_k E R^d is the parameter vector for class k
- *x* E R^d is the input vector

Log-Likelihood Function

- The data set of N example $\{(x^{(i)},y^{(i)})\}^N_{i=1}$
- The log-likelihood ratio

$$l(w) = \sum_{i=1}^{N} log\ P\ (y^{(i)}\ |x^{(i)})$$

By using the Softmax model:

$$l(w) = \sum_{i=1}^{N} \log \frac{exp(w_{y^{(i)}}^T x)}{\sum_{j=1}^{k} exp(w_j^T x^{(i)})}$$

$$= \sum_{i=1}^{N} \left(w_{y^{(i)}}^T - log \sum_{j=1}^{N} exp(w_j^T x^{(i)}) \right)$$

4. Results and Discussion:

4.1. Chi-Square Test

The chi-square test was predominantly conducted on three major causes of cost overrun. They were cost-overrun in construction budget, unexpected loss in construction project and Preparedness for cost-overrun.

Here, a statistical approach was used to identify the factors. A Chi-square test was executed at an alpha (<0.05) noted since most of the factors asymptotic significance was lesser than 0.05. This shows that the result of the Chi-square was less than 0.05.

The implication of this result is embedded in the fact that there are some differences of opinion between the respondents and in the valuation of these factors. The null hypothesis was accepted at a *p*-value lesser than 0.05. Therefore, there are most of the similarities in opinions of the manufacturers, engineers, contractors, and clients as regards the impact of cost-overrun in the construction projects.

4.1.1. Cost-Overrun in Construction Budget

Table 1 presents a Chi-square analysis of cost-overrun in the construction budget. The factors with Chi-square values were Managing sudden loss (.000), Weather impact on production (.020), Difficulties in weather change (.004), Unfortunate accident (.002), problem of weather changes (.001) and Responsibility for accident (.004). These factors were interpreted with the dependent variable, such as increasing the gross profitability of construction projects. The degree of freedom was 4, and the asymptotic significance was less than 0.05, except for Weather impact on production (.020). So, it justifies that weather changes, like sudden rainfall, would not significantly impact production, which would not lead to cost-overrun. The following graph represents the cost-overrun in the construction budget.

Table 1. Chi-Square test for cost-overrun in construction budget

S. No	Question	Parameters	Chi-Square	Df	Sig.
1.	Q2	To manage sudden loss	24.963	4	.000
2.	Q8	Weather impact on production	11.622	4	.020
3.	Q12	Difficulties in weather change	15.522	4	.004
4.	Q14	Unfortunate accident	16.705	4	.002
5.	Q15	The problem of weather change	18.105	4	.001
6.	Q19	Responsibility for accident	15.377	4	.004

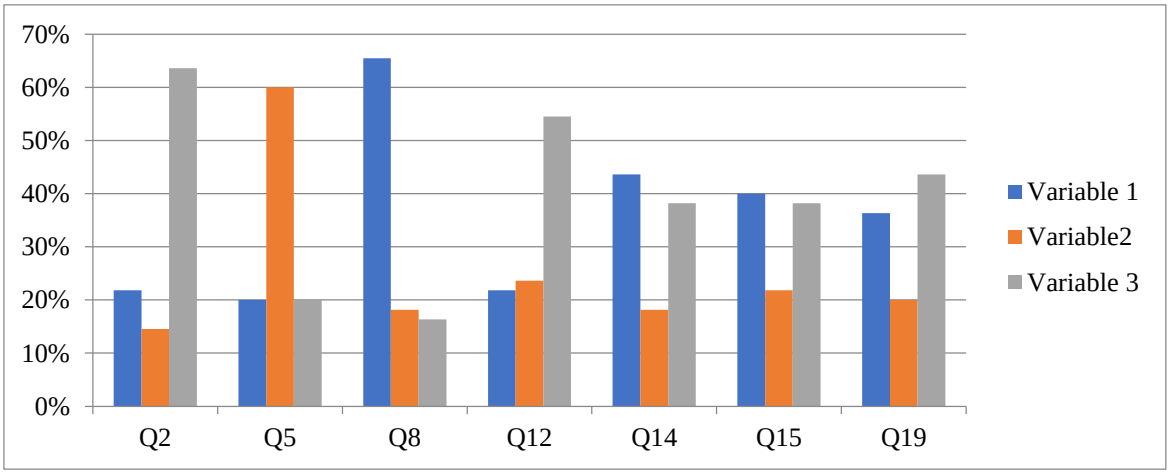

Fig. 3 Percentage of respondents for cost-overrun in the construction budget

By analyzing the above factors of cost-overrun in the construction budget, Figure 3 shows that the engineer had to increase the gross profitability of the project. In case of sudden losses may happen, like weather changes or accidents, the engineer has rescheduled the days. From the manufacturer's perspective, if the weather changes impact raw material production, they have to create a fine balance between productivity and quality of material. If the contractor has to handle unexpected difficulties due to weather, they should allocate the alternative work to labourers without climatic changes.

To tackle problems like sudden rainfall, the contractor should reschedule the same work for another day. At some point, the contractor has to face unfortunate accidents that may occur on the site; they have to accept the fact, which leads to reduced profit. In that case, the client has to take full responsibility when the accident occurs. This result shows the significant value that creates an impact to increase gross profitability; the engineer had to do extra work for a higher profit margin.

4.1.2. Unexpected Loss in Construction Project

Table 2 represents the Chi-square evaluation of unexpected loss in construction projects. The factors with Chi-square values were a Hike in labour wages (.000), Changes in labour wages when raw materials rise (.008), Labour demand was reduced profit (.001), Accidents when transporting the material (.021), material broken in transport (.002) and Exceed planned budget (.002). The average profit percentage of an engineer was set as a dependent variable, and these factors were analyzed. The degree of freedom was 4, and the asymptotic significance was less than 0.05, except for the accident factor when transporting material (.021). Because accidents while transporting materials are inevitable. So, the engineer has to prepare extra material to compensate for the loss.

Table 2. Chi-Square test for loss in construction project

S. No	Question	Parameters	Chi-Square	df	Sig.
1.	Q1	Hike in labour wages	24.417	4	.000
2.	Q9	Changes in labour wages when raw materials rise	13.717	4	.008
3.	Q10	Labour demand was reduced profit	18.326	4	.001
4.	Q16	Accident when transporting the Material	11.578	4	.021
5.	Q17	Material broken in transport	17.507	4	.002
6.	Q18	Exceed planned budget	17.248	4	.002

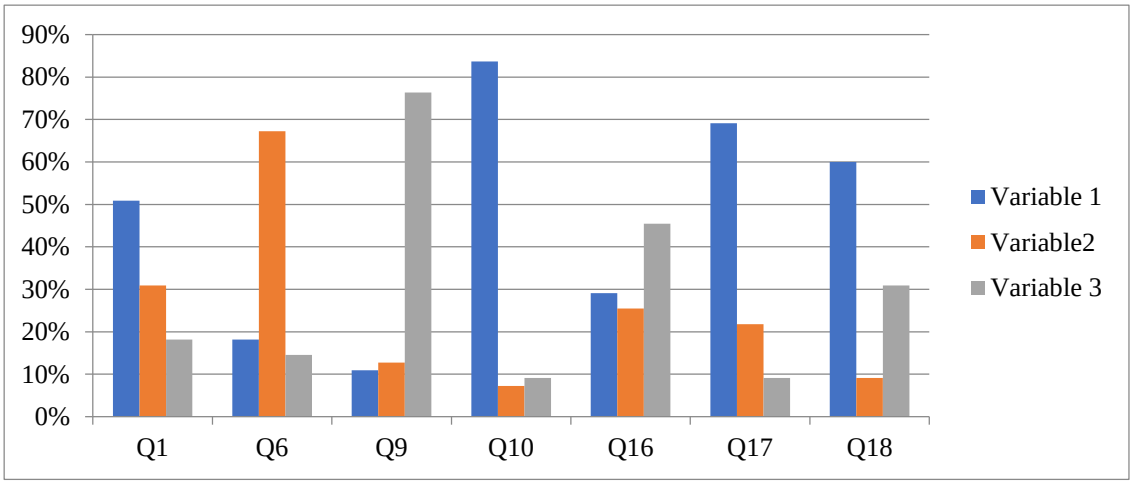

Fig. 4 Percentage of respondents for unexpected loss in construction project

Figure 4 shows that the engineer has to set the average profit percentage of the construction project based on the following factors of unexpected loss in a construction project. To manage the salary hike of skilled and unskilled labour, the engineer had to provide the same wages as in the market. Similarly, from the manufacturer's side, there were no changes in labour quantity and salary when the price of raw material increased. However, the manufacturers' productivity was affected if labourers were in demand. If any accident occurs while transporting the material, the contractor will not take any responsibility because it is the engineer's Responsibility to manage their labour and material. From the client's side, the engineer has to take responsibility and compensate for their profit if the budget is exceeded. Therefore, by facing this unexpected loss in the construction project, the engineers can get 10% as the average profit percentage in the total project.

4.1.3. Preparedness of Cost-Overrun

Table 3 represents the Chi-square result of Preparedness for cost-overrun. The factors with Chi-square values were Buying material from the wholesaler (.013), Extra Discount (.053), Bargaining affects manufacturing (.007), Difficulties in site clearance (.092) and Checking first quality materials (.086). These factors were analyzed with a dependent variable, which was the direct profit of an engineer. The degree of freedom was 4, and the asymptotic significance was less than 0.05; here, the factor bargaining affects manufacturing (.007) is approximately related to the significance. This states that Bargaining for an extra discount to the market seller would be a better way because they already provide good rates for engineers in the name of regular customers, and providing a few discounts doesn't affect the manufacturer.

Table 3. Chi-Square test for Preparedness for cost-overrun

S. No	Question	Parameters	Chi-Square	Df	Sig.
1.	Q3	Buying material from wholesalers	12.677	4	.013
2.	Q4	Extra Discount	9.362	4	.053
3.	Q11	Bargaining affects manufacturing	14.026	4	.007
4.	Q13	Difficulties in site clearance	7.998	4	.092
5.	Q20	Checking first-quality materials	8.155	4	.086

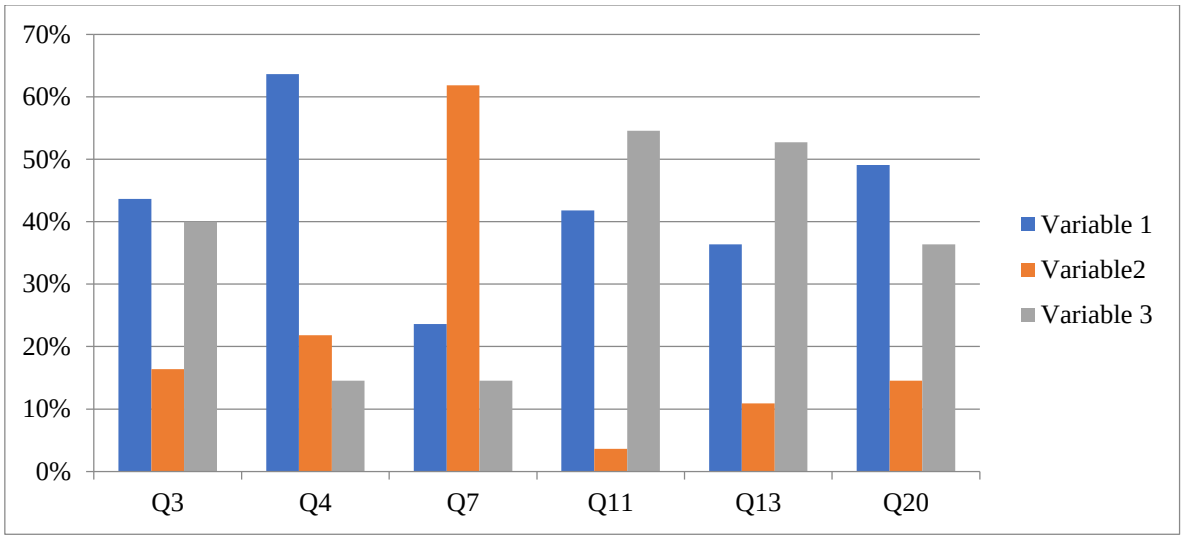

Fig. 5 Percentage of respondents for Preparedness of cost-overrun

This graphical representation shows the factor that exhibits Preparedness for cost-overrun. In this case, Figure 5 shows that the engineer has to determine the higher profit margin by directly controlling the project. Engineers could buy materials from wholesalers to increase profits if the project is large. Especially if the engineer becomes a regular customer, the wholesaler and retailer would provide an extra discount.

On the other hand, it will slightly affect the manufacturing profit between the retailer and customer from the manufacturer's perspective. If the site clearance is difficult, the contractor should solve the issue by taking legal action; if the problem is bigger, it may lead to loss. If the client suspects the material may be of first quality, they can confirm it by obtaining a test result from a consultancy lab. Hence, this significant value figures for an engineer to determine 10% as a common profit by directly controlling the project.

4.2. Multinominal Logistic Regression Test

Multinominal logistic regression is a statistical analyzing method used to predict the probability of categorical variables for data analysis in quantitative Research

4.2.1. Cost-Overrun in Construction Budget

Table 4 shows the representation of the regression test for Cost overrun in construction projects. The likelihood ratio of regression values is to manage the sudden loss (.000), weather impact on production (.004), difficulties in weather change (.002), Responsibility for the accident (.001), Unfortunate accident (.008) and the problem of weather change (.049). These factors were interpreted with the dependent variable as ways to increase the gross profitability of construction projects. This states that unfortunate accidents and problems with weather change were inevitable. In this case, the engineer should forecast the schedule and complete the construction project.

Table 4. Regression test for cost-overrun in construction budget

S. No	Question	Parameters	Regression likelihood ratio	Df	Sig.
1.	Q2	To manage sudden loss	64.131	4	.000
2.	Q8	Weather impact on production	44.112	4	.004
3.	Q12	Difficulties in weather change	45.332	4	.002
4.	Q14	Unfortunate accident	42.467	4	.008
5.	Q15	The problem of weather change	38.162	4	.049
6.	Q19	Responsibility for accident	46.953	4	.001

4.2.2. Unexpected Loss in Construction Project

Table 5 represents the regression test for loss in construction projects. The likelihood ratio of regression values is a Hike in labour wages (.005), changes in labour wages when raw materials rise (.043), labour demand was reduced profit (.208), accident when transporting the material (.000), material broken in transport (.006) and exceed planned budget (.000). The average profit percentage of an engineer was set as a dependent variable and analyze these factor. This shows that exceeding the planned budget will not affect the loss because the engineer will do elevation work to compensate for the loss. Accidents when transporting materials do not affect the construction profit because engineers have to pre-schedule the materials to avoid losses in construction projects.

Table 5. Regression test for loss in construction project

S. No	Question	Parameters	Regression likelihood ratio	Df	Sig.
1.	Q1	Hike in labour wages	45.476	4	.005
2.	Q9	Changes in labour wages when raw materials rise	40.595	4	.043
3.	Q10	Labour demand was reduced profit	36.629	4	.208
4.	Q16	Accident when transporting the Material	58.334	4	.000
5.	Q17	Material broken in transport	45.067	4	.006
6.	Q18	Exceed planned budget	55.724	4	.000

4.2.3. Preparedness of Cost Overrun

Table 6 illustrates the regression test for Preparedness for cost-overrun. The likelihood regression value was buying material for wholesaler (.014), extra discount (.042), Bargaining affects manufacturing (.000), difficulties in site clearance (.000) and checking first quality materials (.000). The factors were analyzed with a dependent variable such as the direct profit of an engineer. This indicates that buying material from wholesalers at an extra discount does not reduce cost overrun. Because the wholesaler has already sold the materials at the lowest market price, there is no possibility of an extra discount.

Table 6. Regression test for Preparedness for cost-overrun

S. No	Question	Parameters	Regression likelihood ratio	Df	Sig.
1.	Q3	Buying material from wholesalers	74.461	4	.014
2.	Q4	Extra Discount	71.936	4	.042
3.	Q11	Bargaining affects manufacturing	91.145	4	.000
4.	Q13	Difficulties in site clearance	86.446	4	.000
5.	Q20	Checking first-quality materials	99.101	4	.000

5. Conclusion

The statistical analysis of this survey was used by chi-square, which was the relationship between the question and the multinational logistic regression analysis validating the data set to be considered. The like-hood ratio test shows the significant value of regression. In this research study, every responding side played a role in the cash flow of the construction budget. Weather changes will affect the supply of materials and create demand, affecting the profit. Any accident on the construction site will lead to a huge cost and time loss. So, the engineer should accept the loss.

To prevent this, every engineer must follow the safety precautions the government recommends, even for small-scale construction sites. Ignoring safety leads to accepting the huge loss that happens by accident. On the other hand, rescheduling the other day will tackle the problem of weather changes like sudden rainfall. Delaying the work can reduce the Cost overrun only at the time of climatic changes and sudden losses like accident in construction site. In the construction industry, if labour wages increase, engineers must provide the same wages in the market for every labour. However, suppose the material is damaged by accident on the construction site. In that case, it will fall under labour's responsibility, and the Cost of the material price will be deducted from the labour wages. Rather than that, mostly engineers provide extra wages for extra work. In some cases, they provide food and accommodation apart from salary, which leads to cost overrun for the same construction project, which also reduces the profit margin. To control the Cost overrun from the manufacturer, the engineer could request an additional discount from them. The Bargaining is only applicable for bulk purchasing because, from the manufacturing unit, there are no changes in the quantity and salary of labourers when the price of raw material may increase. So, negotiation may be possible if there is a chance of buying material directly from the manufacturer. However, the wholesaler or retailer would not give the extra discount because they already provide a good rate in the name of regular customers, so they have good contact with other engineers for material price enquiries.

If the client has a product brand misconception, it automatically leads to cost overrun. So, clarifying the brand knowledge of the material to clients is the engineer's responsibility. This helps to resolve the misunderstandings clients have about material brands and unwanted expenditures on the names of brands. In a few areas, site clearance is difficult.

For this instance, a proper legal measure should be taken, but the lawyer allowance leads to cost escalation, negatively impacting the construction project. So before starting a project, make sure it is clear to reduce expenditure. The engineer should take full responsibility for the extra money for the other minor losses because the client did not take any responsibility. So, at each and every step of the cash flow engineer, the engineer had to make a proper decision

from manufacturer to client to tackle the situation of exceeding the budget on the construction site.

5.1. Future Research

Budget planning by using software like Building Information Modelling (BIM) would reduce the error of exceeding budgets and reduce cost overrun. To consider the inflation rate in the delta region, one should explore the relation between sustainability and cost-overrun by creating a benchmark for cost-overrun strategies and investigating manufacturing companies' influence on cost-overrun occurrence. Integrated Project Delivery (IPD) will greatly impact cost-overrun, increase productivity, and reduce waste.

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