Study of material supply critical factors affecting the construction industry in Mongolia

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ABSTRACT

Material cost is almost 50-60% of most construction projects. In recent years, the price of building materials and the supply has decreased, directly affecting the construction cost. This study aims to identify the main factors supply of materials affecting the construction industry in Mongolia. A quantitative approach was adopted in carrying out the research. The target population included civil engineering companies in Ulaanbaatar, Mongolia. In the survey, stakeholders of construction projects, such as clients, contractors, designers, consulting service companies, and construction material suppliers of various construction projects, were targeted for the survey. A total of 90 respondents were surveyed. The respondents were a mix of CEOs, consultant engineers, field engineers, project managers, architects, and budgeters. Descriptive statistics (measures of central tendency) and the Relative Importance Index (RII) were used to analyze the data. The most significant factors identified were a shortage of materials, building materials quality, economic instability, pandemic situation, mistakes during construction, and financial difficulties of the owner.

Keywords: *Construction sector, Material critical factor, Relative Importance Index (RII), construction project*

1. INTRODUCTION

One of the critical sectors that create the infrastructure of any country is the construction sector. Thirty-two percent of Mongolia's citizens live in rural areas and 68 percent in cities. Also, 48 percent of the population lives in Ulaanbaatar capital city (NSM, Population annual report, 2022). Furthermore, 77.3 percent of the capital's population lives in apartments, while 22.5 percent live in suburban areas. This situation shows the need to improve the infrastructure in the capital, raise the population's standard of living, and reduce air pollution. There are also many problems facing the construction industry in Mongolia.

On the other hand, it adversely affected construction cost overrun, delay, and project quality. Mongolia is a developing country in Asia, like Malaysia, Indonesia, Thailand, Pakistan, and Vietnam. Mongolia's resource sector contributes nearly 90% of exports and more than 20% of the gross domestic product. About 90% of total exports, primarily minerals in raw form, go to the People's Republic of China.

Currently, in our country, economic growth is low, and industrial development is poor, which causes the lack of construction materials, price increases, transportation costs unstable, lack of experience in project type, and unpredictable weather conditions.

The cost of materials is a significant part of the project's total cost, and in our country, it accounts for 50-60% of the construction budget. Materials supply chain management in construction refers to managing the flow of materials from suppliers to construction sites to ensure that the necessary materials are available at the right time and in the right quantities. The materials supply chain in construction typically involves several stages, including procurement, transportation, storage, and delivery. Effective management of each stage requires careful planning, coordination, monitoring, and appropriate tools and technologies, such as inventory management systems, automated tracking systems, and supply chain analytics.

This study aims to identify the main factors supply of materials affecting the construction industry in Mongolia. Materials management covers integrated coordination of the materials-related functions such as

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takeoff, purchase, speed up, transport, receive, warehouse, and distribution [3]. If not properly managed at the site, materials can lead to termination or even suspension of a project, which is why it is the most critical part of a project and needs serious attention [2].

2. PREVIOUS STUDY

Recently, researchers have studied and proposed several factors that directly or indirectly affect the successful implementation of construction projects. Those proposed factors are converted into survey questionnaires to collect information from construction project stakeholders.

Studies such as Battula, Namburu, and Kone 2020 [4] and Kamaruddeen, Sung, and Wahi 2020 [5] have considered CSCM as a suitable method for improving profit, reducing time and cost, and increasing efficiency in the construction industry.

Battula, Namburu, and Kone 2020, developed 27 questionnaires and analyzed the data using the RII method to investigate the factors influencing SCM in the construction industry, as well as to identify the barriers to SCM implementation in the current construction industry. CSCM in the construction industry can significantly improve owner and stakeholder value and reduce overall costs [6].

O. Omolayo, O.-A. Bamitale Dorcas (2019), identified the most important factors in the implementation of construction projects using quantitative analysis methods in their study. Based on results, six (6) most severe factors of construction cost overrun were identified as: risk and uncertainty related factors, lack of financial power by clients, weak regulation and control, project fraud and corruption, variation of price, and indiscriminate change in design [7].

Z. M. Jusoh and N. Kasim 2017, identified 8 groups 47 influential factors affecting the materials management. These are (1) site conditions; (2) on-site planning and coordination; (3) management; (4) materials; (5) supplier or manufacturer error; (6) transportation; (7) contractual; and (8) government intervention [8].

Zeb et al. identified the factors affecting materials management from the respondents' opinions about the materials management of contractors and subcontractors in developing countries. Strength of index familiarity, frequencies and agreements were computed through the technique of Relative Importance index (RII). Ranking carried out through the Likert's Scale and top five factors were identified. According to the researchers, inadequate on-site warehouse space and material management by contractors and subcontractors were identified as the essential factor observed in the analysis [2].

The literature review indicates that obtaining critical factors influencing the supply of construction materials will help construction project professionals to optimize projects and minimize problems that may arise during project implementation.

3. MATERIAL AND METHOD

3.1. Study area

Study areas were selected in Ulaanbaatar for this research. The choice of locations was based on commercial viability, social status, economic considerations, and area accessibility which provide opportunities for diverse industries like construction, consulting, manufacturing, agriculture, telecom, marketing, legal, health, and technological advancement.

3.2. Data source

In this study, data were collected from construction professionals by questionnaire. All collected data were analyzed using IBM SPSS Statistics 21 developer software, and descriptive, Ranking, severity analysis, reliability statistics, factor analysis, and Pearson correlations were performed on the characteristics of the respondents.

A total of 90 engineers and technical staff of construction companies in Ulaanbaatar, Mongolia, including clients, contractors, designers, and consulting service companies, participated in the survey. Survey was limited to the building projects.

The research methodology was conducted through a literature review and data collection through paper and electronic questionnaires [9]. The literature review aimed to understand better the factors affecting the supply of construction materials in construction projects. It surveyed owners/clients, consultants, contractors, site engineers, project managers, and subcontractors and revealed the factors affecting the supply of construction materials. The respondents expressed their opinion on the importance level of each indicator on a five-point Likert scale ranging from 1 (very low important) to 5 (very high important). The survey was carried out from June 2022 to December 2022.

The questionnaire has two main parts; the first contains general information about the respondents. The second part has five groups: A, B, C, D, and E. Here: Owners-related factor in group A, Materials-related factor in group B, Contactors-related factor in group C, External-related factors in group D, and Projects-related factor in group E.

The gathered data were ranked using the Relative Importance Index (RII) method and statistical tools to determine the factors contributing to this lack of supply and demand.

3.3. Relative importance index and Severity

The RII method was adopted in this study to determine the relative importance of significant factors affecting the supply of construction materials. RII value ranges from 0 to 1 [10]. The higher the RII value more significant the impact or frequency of occurrence of the variables. RII is calculated for each factor as in the equation below:

$$RII = \frac{\Sigma W}{A \cdot N} \quad (1)$$

$$RII = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \quad (2)$$

$$0 \le RII \le 1 \quad (3)$$

Where W = weighting given to by respondents (ranging from 1 to 5); A = highest weight (i.e., 5 in this case), and N = the total number of respondents.
n_1 − Number of respondents for Not very important
n_2 − Number of respondents for Not important
n_3 − Number of respondents for Moderately important
n_4 − Number of respondents for Important
n_5 − Number of respondents for Very important

The level of importance was used to interpret the RII values obtained as follows: high importance (RII = 0.8-1), high-medium importance (RII = 0.6-0.8), medium importance (RII = 0.4-0.6), medium-low importance (RII = 0.2-0.4) and low importance (RII = 0-0.2) [7].

The severity index (I) was calculated to interpret the degree of severity effect of the identified factors influencing material supply.

$$I = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \cdot 100\% \quad (4)$$

The severity index was categorized into five levels:
- 0-49% - no severe
- 50-69% - fairly severe
- 70-74% - moderately severe
- 75-79% - severe
- 80-100% - the most severe

4. PREVIOUS

4.1. Relative importance index and Severity

Study areas were selected in Ulaanbaatar for this research. The choice of locations was based on commercial viability, social status, economic considerations, and area accessibility which provide opportunities for diverse industries like construction, consulting, manufacturing, agriculture, telecom, marketing, legal, health, and technological advancement.

The descriptive statistics, such as mean, standard deviation, minimum, maximum, skewness, and kurtosis, were determined from the collected data, as shown in Table 1. The results showed that the standard deviation values were 3.372 to 4.808, indicating that the collected data were good quality.

Table 1. Descriptive statistics

	N	*Min*	*Max*	*Mean*	*Std. Deviation*
A. Owners related factor	*90*	*7.00*	*30.00*	*24.15*	*4.80849*
B. Materials related factor	*90*	*8.00*	*35.00*	*29.44*	*4.75492*
C. Contractors related factor	*90*	*9.00*	*25.00*	*19.95*	*3.81573*
D. External related factor	*90*	*17.00*	*55.00*	*43.44*	*7.36544*
E. Projects related factor	*90*	*4.00*	*20.00*	*15.23*	*3.37223*

The general information of the surveyed respondents is shown in Table 2. Furthermore, 56.7% of the surveyed organizations have worked in the construction industry for over ten years, and 44.4% implement 3-4 projects yearly.

Table 3. shows the results of the index of the relative importance factors affecting material supply in construction projects in Ulaanbaatar, Mongolia. The factors are ranked in descending order of importance. According to the survey results, the shortage of materials was ranked the highest of the total factors. The mean of this factor was "4.51" while RII was "0.902".

Along with this, there are border closures and embargoes, quality of materials, fluctuation in the price of raw materials, instability economic, incorrect planning, widespread pandemic, customs difficulties, late delivery of materials and equipment, lack of financial power of the client and mistakes during construction. Out of the thirty-three factors, the first eighteen were considered to have a high level of importance. In contrast, the remaining fifteen factors were regarded as having a high-medium level of importance.

4.2. Factor analysis

Factor analysis is a collection of methods used to examine how underlying constructs influence the responses on several measured variables. This is generally divided into two categories: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is used for checking dimensionality and is often used in the early stages of research to gather information about the interrelationships among a set of variables [11].

It determines the factor structure of a construct based on the relationship between variables and checks reliability based on data. It is the most common method used to reduce data, which is used to select questions related to the construct validity, dimensions, and concepts of the newly developed instrument.

The "factor loading" of EFA, or the correlation coefficient of variables (items), is one of the first essential indicators. A factor loading of 0.30 or greater is sufficient to show that the item is strongly correlated with the factor. In other words, the factor loading coefficient decides whether the item will remain or be removed [12].

Table 2. Summary of characteristics of respondents

Category	Classification	Frequency	Percent %
Type of organization	Contractor	37	41.1
	Owner	24	26.7
	Investor	3	3.3
	Architect-engineer	9	10.0
	Consultant	5	5.6
	Subcontractor	5	5.6
	Vendor	7	7.8
	Total	90	100
Position of respondents	General director	11	12.2
	CEO	9	10.0
	Engineer	13	14.4
	Project director	2	2.2
	Project manager	9	10.0
	Site engineer	22	24.4
	Architect	3	3.3
	Quantity surveyor	8	8.9
	Other	13	14.4
	Total	90	100
Professional Degree	Consulting engineer	10	11.1
	Professional Engineer	30	33.3
	Professional estimator	9	10.0
	Professional architect	2	2.2
	Not degree	39	43.3
	Total	90	100
Work experience in the construction sector	1 to 2 years	10	11.1
	3 to 5 years	16	17.8
	6 to 10 years	25	27.8
	11 to 15 years	23	25.6
	16 years above	16	17.8
	Total	90	100
Respondent's type of project	Residential building	51	56.7
	Office building	8	8.9
	Industrial building	9	10.0
	Commercial and trade building	3	3.3
	Other	19	21.1
	Total	90	100

Table 3. Factors Influencing materials supply in the construction of Ranking

Code	Factor	Mean	RII	Severity (%)	Rank
B2	Shortage of materials	4.51	0.902	90.22	1
D9	Border closures and embargoes	4.46	0.891	89.11	2
B1	Quality of materials	4.44	0.889	88.89	3
B3	Fluctuation in the price of raw materials	4.42	0.884	88.44	4
D5	Instability economic	4.40	0.880	88.00	5
C4	Incorrect planning	4.36	0.871	87.11	6
D10	Widespread pandemic	4.33	0.867	86.67	7
D1	Customs difficulties	4.31	0.862	86.22	8
B4	Late delivery of materials and equipment	4.27	0.853	85.33	9
A1	Lack of financial power of the client	4.24	0.849	84.89	10
C5	Mistakes during construction	4.18	0.836	83.56	11
C1	Management and organization in construction site	4.14	0.829	82.89	12
B7	Logistics issues	4.12	0.824	82.44	13
A2	Management organization	4.09	0.818	81.78	14
A3	Information flow	4.08	0.816	81.56	15
C3	Contractors financial difficulties	4.08	0.816	81.56	15
D6	Coordination of the parties involved in the project	4.03	0.807	80.67	17
A5	Change in design	3.99	0.798	79.78	18
E4	Project stakeholder management, lack of information	3.98	0.796	79.56	19
A4	Poor project management	3.94	0.789	78.89	20
D11	Problems of neighboring countries	3.94	0.789	78.89	20
D8	Inappropriate government policies	3.89	0.778	77.78	22
E3	Project risk and uncertainty	3.88	0.776	77.56	23
B6	Materials ordering process	3.87	0.773	77.33	24
A6	Change in contract	3.81	0.762	76.22	25
B5	Storage standards of Material	3.81	0.762	76.22	25
D3	Poor communication of vendors	3.76	0.751	75.11	27
E2	Project Specification	3.71	0.742	74.22	28
E1	Project location	3.67	0.733	73.33	29
D4	Design code and standard changes in the project	3.64	0.729	72.89	30
D2	Unpredictable weather condition	3.62	0.724	72.44	31
C2	Inappropriate software for materials record	3.60	0.720	72.00	32
D7	Social and cultural impacts	3.06	0.611	61.11	33

Kaiser–Meyer–Olkin (KMO) and Bartlett's test

In factor analysis, the sample size should be sufficient, and the variables should be correlated in the correlation matrix. The following two tests verify this condition.

- If the KMO test statistic exceeds 0.5, the sample size is sufficient for factor analysis.
- The variables are linearly related if the Bartlett test statistic is less than Sig<0.05.

In this study, the KMO test statistic was 0.810, indicating sufficient samples for factor analysis. (Table 4.) Furthermore, Bartlett's test statistic is highly significant (P\0.001), indicating the suitability of data processing employing factor analysis procedure [13].

Communalities

The proportion of a variable's variance explained by a factor was calculated by determining the communalities [14]. When evaluating 33 variables, the extraction communalities values are higher than 0.4, which indicates that the variables fit well with the factor solution. However, three items (item #A1, #C3, and #D7) in the initial data illustrate a variance lower than 0.4 to any of the factors. Therefore, these three items are excluded from the sample. (Table 5.)

Table 4. KMO and Bartlett's test of input variables

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.810
Bartlett's Test of Sphericity	Approx. Chi-Square	1896.061
	df	435
	Sig.	.000

Eigenvalues

The Eigen value is the sum of squares of all variables of each factor. An eigenvalue greater than one is considered significant, indicating that more common variance than unique variance is explained by that factor [15]. Table 6 lists the eigenvalues associated with each linear component (factor) after extraction. The first four components explain more than 61.43% of the variance. Since factor analysis is mainly used for data reduction, the minimum number of factors that explain more than 61.43% of the variance, thus the first four factors were selected.

Component matrix

Factor loading values communicate the relationship of each variable to the underlying factors. The variables with large loadings values > 0.40 indicate that they represent the factor. (Table 7.)

Table 5. Communalities-output variables

Communalities	Initial	Extraction
A2	1.000	.590
A3	1.000	.548
A4	1.000	.475
A5	1.000	.685
A6	1.000	.672
B1	1.000	.452
B2	1.000	.581
B3	1.000	.578
B4	1.000	.684
B5	1.000	.772
B6	1.000	.779
B7	1.000	.722
C1	1.000	.680
C2	1.000	.636
C4	1.000	.601
C5	1.000	.555
D1	1.000	.644
D2	1.000	.427
D3	1.000	.596
D4	1.000	.557
D5	1.000	.477
D6	1.000	.695
D8	1.000	.639
D9	1.000	.706
D10	1.000	.816
D11	1.000	.518
E1	1.000	.442
E2	1.000	.589
E3	1.000	.707
E4	1.000	.606

Table 6. Total variance explained of output variables

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	11.2	37.405	37.405	11.22	37.405	37.405	6.119	20.398	20.39
2	3.18	10.612	48.017	3.184	10.612	48.017	4.220	14.066	34.46
3	2.14	7.155	55.173	2.147	7.155	55.173	4.212	14.039	48.50
4	1.87	6.258	61.431	1.877	6.258	61.431	3.879	12.929	61.43
5	1.40	4.670	66.101						
6	1.08	3.601	69.702						
7	1.01	3.385	73.087						
8	.877	2.924	76.011						
9	.763	2.545	78.556						
10	.642	2.139	80.696						
11	.595	1.983	82.678						
12	.549	1.830	84.508						
13	.504	1.679	86.187						
14	.475	1.583	87.770						
15	.431	1.438	89.208						
16	.407	1.358	90.566						
17	.378	1.260	91.826						
18	.329	1.098	92.924						
19	.304	1.015	93.938						
20	.283	.943	94.882						
21	.253	.844	95.726						
22	.235	.783	96.509						
23	.231	.769	97.279						
24	.215	.718	97.996						
25	.152	.507	98.503						
26	.134	.445	98.948						
27	.099	.331	99.279						
28	.087	.292	99.571						
29	.077	.255	99.826						
30	.052	.174	100.00						

Table 7. Rotated component matrix of output variables

	Component			
	1	2	3	4
D6	.750			
A2	.735			
C1	.733			
A3	.708			
D4	.703			
A4	.676			
A6	.674			
E4	.580			
D3	.532			
D5	.516			
D2	.472			
D10		.858		
D9		.795		
D1		.742		
D11		.679		
B2		.656		
E3			.694	
A5			.666	
E1			.651	
D8			.648	
E2			.631	
C2			.535	
C5			.525	
B6				.803
B3				.729
B5				.696
B4				.659
B7				.593
C4				.470
B1				.449

Reliability analysis

Reliability analysis is a statistical technique used to evaluate the consistency and stability of a measurement instrument or test over time, across different raters, or under varying conditions. Internal consistency was estimated using a coefficient of Cronbach’s alpha [16].

George and Mallery (2003) provide the following rules of thumb: “> 0.9 – Excellent, > 0.8 – Good, > 0.7 – Acceptable, > 0.6 – Questionable, > 0.5 – Poor, and < 0.5 – Unacceptable” [17].

Cronbach's alpha for each of the four factors is exhibited in Table 8.

A description of factors-output valuables is illustrated in Table 9.

Table 8. Data outcome of factors reliability statistics

Factors	Cronbach's Alpha	N of Items
Management-related factors	.872	10
Project-related factors	.891	11
External-related factors	.851	5
Materials-related factors	.848	6
Total	.940	33

Table 9. Description of factors-output valuables

Factors	Factors name	Loading variables
Factor 1	Management related factor	Coordination of the parties involved in the project Management organization Management and organization in construction site Information flow Design code and standard changes in the project Poor project management Change in contract Project stakeholder management, lack of information Poor communication of vendors Instability economic Unpredictable weather condition
Factor 2	External related factor	Widespread pandemic Border closures and embargo Customs difficulties Problems of neighboring countries Shortage of materials
Factor 3	Project related factor	Project risk and uncertainty Change in design Project location Inappropriate government policies Project Specification Inappropriate software for materials record Mistakes during construction
Factor 4	Material related factor	Materials ordering process Fluctuation in the price of raw materials Storage standards of Material Late delivery of materials and equipment Logistics issues Incorrect planning Quality of materials

Correlation

In Table 10, the correlation matrix displays sufficient correlations to explain the application of factor analysis. The correlation matrix shows that there are all factors whose inter-correlations are > 0.3 between the variables, and it can be concluded that the hypothesized factor model is suitable.

Table 10. Correlation matrix between four factors of output variables

		F1	F2	F3	F4
F1	Pearson Correlation	1.00	.727**	.430**	.476**
	Sig. (2-tailed)		.000	.000	.000
F2	Pearson Correlation	.727**	1.00	.413**	.556**
	Sig. (2-tailed)	.000		.000	.000
F3	Pearson Correlation	.430**	.413**	1.00	.503**
	Sig. (2-tailed)	.000	.000		.000
F4	Pearson Correlation	.476**	.556**	.503**	1.00
	Sig. (2-tailed)	.000	.000	.000	

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

CONCLUSION

This study aimed to determine the critical factors affecting the material supply in construction projects in Ulaanbaatar, Mongolia.

According to the research, the shortage of materials was ranked the highest of the total factors. Along with this, there are border closures and embargoes, quality of materials, fluctuation in the price of raw materials, instability economic, incorrect planning, widespread pandemic, customs difficulties, late delivery of materials and equipment, lack of financial power of the client, and mistakes during construction. Out of the thirty-three factors, the first eighteen were considered high levels of importance. In contrast, the remaining fifteen factors had a high- medium significance. This study revealed that Mongolia is a landlocked country, which makes the supply of construction materials a critical issue. Furthermore, among the main factors affecting the supply of construction materials, the impact of the Covid pandemic is ranked in the top ten.

Pearson correlation tests result in no significant stakeholder disagreements regarding ranking these causes. Factor analysis is employed to group them as principal factors. With the factor analysis technique, 4 factors are extracted: Management-related factors, Project-related factors, External-related factors, and Materials-related factors.

In the future, there is a need for research to create practical models that evaluate construction supply chain management suitable for Mongolia's situation.

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