Available online at www.CivileJournal.org

Civil Engineering Journal

(E-ISSN: 2476-3055; ISSN: 2676-6957)

Vol. 7, No. 07, July, 2021

Structural Equation Modelling (SEM) Approach On Inappropriate Construction Equipment Delay Factors

B. Indhu [1, 2*], K. Yogeswari [3]

[1] *Research Scholar, B. S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India.*

[2] *Assistant Professor, Department of Civil Engineering, SRM Institute of Science and Technology (SRMIST), Chennai, India.*

[3] *Associate Professor, B.S. Abdur Rahman Crescent Institute of Science and Technology, Chennai, India.*

Received 26 February 2021; Revised 15 May 2021; Accepted 27 May 2021; Published 01 July 2021

Abstract

The advancement of construction equipment is a trend in the construction industry, with numerous benefits. However, using inappropriate construction equipment causes delays in construction projects, affecting the firm's reputation. A number of research studies on overall delay have been conducted globally. Even so, there is a lack of research on construction delays caused by inappropriate construction equipment. The aim of this paper is to investigate the inappropriate construction equipment delay factors and their effects on the firm's reputation. Based on the issues identified in the focus group interviews and the literature survey, a questionnaire survey was conducted to assess the impact of these factors on the progress of Indian construction projects. The primary constraint was that all 300 responses were collected in person from construction professionals to avoid lethargic responses that could skew the results. Pearson correlation coefficients were used to determine the positive strength of each factor's relationship. A t-test was used to see if there was a significant difference between the respondents' firm categories. Structural Equation Modeling (SEM) was used to validate the effective relationship between the causes of delays due to inappropriate construction equipment and its impact on company's reputation. All of the factors examined by the SEM analysis evidenced that the inappropriate construction equipment factors are correlated among themselves and combined to impact the reputation of the company. Recommendations are made to overcome the inappropriate equipment delay factors.

Keywords: Inappropriate Equipment; Management; Inventory; Equipment Selection; Equipment Replacement; Construction Delay.

1. Introduction

In fact, delays are one of the most common problems in the construction industry [1]. Only if the project is completed within the projected timeline, meets the basic quality standards, and meets the client's expectations is it considered satisfactory [2]. Despite several resources assisting the construction industry, construction project delays continue [3, 4]. Investigating the causes of delays is essential to enhancing the construction industry's efficiency [5, 6]. For years, researchers all over the world and in their own country have been studying the causes and consequences of delays in construction projects in a variety of protocols. The crisis discovered in various countries by various scholars varies from country to country; in time, it varies from project to project [7].

According to global research, one of the most important factors influencing the success of building projects over the last decade has been delays caused by the use of ineffective on-site equipment [3]. Massive equipment usage has

* Corresponding author: indhub@srmist.edu.in

http://dx.doi.org/10.28991/cej-2021-03091717

recently begun as a result of the need to complete building projects as soon as possible; however, effective equipment planning, budgeting, optimization, and use of emerging modelling techniques are woefully inadequate. Construction equipment preparation and scheduling must be carefully considered, because improper on-site equipment affects not only the operation or the overall project duration, but also the project cost [8] in the current trend, innovations in the construction sector can be demonstrated by the availability of a diverse range of specialised equipment on the market, each with a unique design feature, making it difficult to select suitable equipment with advantageous characteristics from a diverse range of alternatives available [9]. The SEM is a multivariate statistical technique for analysing the relationships in a model between latent variables (causes of delay) and observed variables (effects of delay) [10]. SEM can quantify the comprehensive relationships between investigated factors and has a high potential to solve experience-oriented problems in the construction industry [11]. It is essential to understand the relationship between the causes and effects of delays in order to make effective decisions to reduce project completion delays and avoid the firm's reputation being negatively affected.

Various studies have used different ranking methods to investigate the factors influencing delay in Indian construction projects. The effects of delay have also been investigated. However, there has been no research into validating those factors versus effects using Structural Equation Modeling. This is the research's gap. This study identifies the factors influencing inappropriate construction equipment as well as the factors influencing firm reputation in India. The study's novelty is satisfied by using SEM to validate the relationship between the factors influencing inappropriate construction management and their impact on the firm's reputation.

2. Past Studies

The first step in controlling the delay is determining the source of the delay [12]. With the rapid development of infrastructure, the task of on-site machinery and equipment is critical to achieving efficiency and productivity. This decision is made by matching the equipment in the fleet to the task at hand.

2.1. Improper Equipment Selection

Improperly chosen construction equipment can stymie progress, incur unnecessary costs, and pose significant safety risks, making equipment selection a critical stage in execution and planning [13]. The proper construction equipment must be chosen in order to meet the estimated costs, quality, and duration of the construction project, as well as to ensure the active participation of both the individual construction union and the entire construction industry. [14, 15]. Nonetheless, given the complicated financial circumstances and the project's total failure, this selection problem necessitates locating and selecting the best version [16]. Unavailability of replacement parts for imported equipment [17]; disposal of equipment for potential projects affecting the economy, lack of service support for imported equipment, unsuitable climatic conditions for certain equipment, and lack of a prior record of equipment verification were all issues related to inappropriate on-site equipment [18, 19].

2.2. Improper Inventory Management

Spare parts are required to ensure the critical equipment's operation. The nature of the requirement necessitates the procurement of spare parts. To reduce the financial and commercial costs of downtime, both equipment dealers and service providers must stock spare parts in their inventories [20]. Inadequate inventory planning of spare parts by the project manager due to a lack of awareness and negligence causes inconvenience when the need for onsite equipment arises. Improper procurement management, which results in the non-availability of spare parts when needed, is one of the most common causes of project delays and should be taken seriously [21]. In that case, preventive maintenance must be performed on the available equipment in order to track the inventory requirement in advance [22]. Improper procurement management causes include: Non-stocking of imported spare parts; Equipment idleness due to importing of spare parts; Inadequate installation: Non-tracking of equipment availability and Utilisation study [4, 23, 24].

2.3. Non-Replacement of Equipment

The equipment is subject to normal wear and tear due to its age. They may not be replaced on time, however, due to financial constraints [25]. Failure to replace equipment on time results in low productivity and equipment efficiency [3, 26–28]. Advances in the construction industry cause equipment obsolescence [7, 29]. Inadequate equipment is another factor affecting the construction project's progress. Equipment cannot be replaced due to insufficient payment [30–32].

2.4. Loss of the Firm’s Reputation

Delays have a negative impact on project delivery, resulting in late project completion and operation, which contributes to the company's reputation being harmed [33- 35]. The critical effects of the delay examined in relation to the Relative Importance Index (RII) in the Ethiopian construction industry rank termination of the contract as the third

most important factor contributing to the Loss of the firm's reputation [7]. The study conducted in the South African construction industry discovered five major effects of the delay; among the five outcomes, low quality of work and conflicts contributed to the Loss of the firm's reputation [28]. Another Tanzanian study on the causes and effects of construction project delays identified the negative social impact as the third most critical factor that tends to lead to the company's reputation being harmed [36]. Cost overruns are another critical effect of delay, contributing to the firm's reputation loss [37, 38]. Frequent construction delays cause disagreements and litigation, affecting the firm's reputation [39].

The literature review revealed that, while equipment is available on-site, it is ineffective and inefficient, reducing productivity. When needed, imported spare parts are not in stock. The inability to obtain imported spare parts also contributes to equipment idleness. The three main factors affecting delay due to inapt equipment are an improper selection of the right equipment, improper inventory management and non-replacement of equipment on time. Equipment is also not replaced when needed due to a lack of funds. Cost overruns, negative social impact, disputes, and litigation are all negative effects of delays caused by the use of inappropriate equipment on the job site. All of these consequences result in the firm's reputation being affected.

3. Research Methodology

Figure 1 depicts the study's research design. To document the practical issues occurring on the construction site, a focus group interview was conducted by arranging personal interviews with twenty-six plant and machinery procurement managers. The factors were gathered from focus group interviews as well as the literature, and a questionnaire was created. A questionnaire survey was conducted, and 300 samples were obtained from various construction professionals. SPSS tools were used to analyse their questionnaire responses. Pearson correlation coefficient analysis was performed to determine the strength of correlation within the delay factors. The t-test was used to determine the impact of firm's reputation loss. To investigate the relationship between the two types of firms, the t-test was used. SEM analysis was performed to validate the positive relationship between the factors and their impact on the firm's reputation. Based on the findings, recommendations are made to address the factors causing the delay.

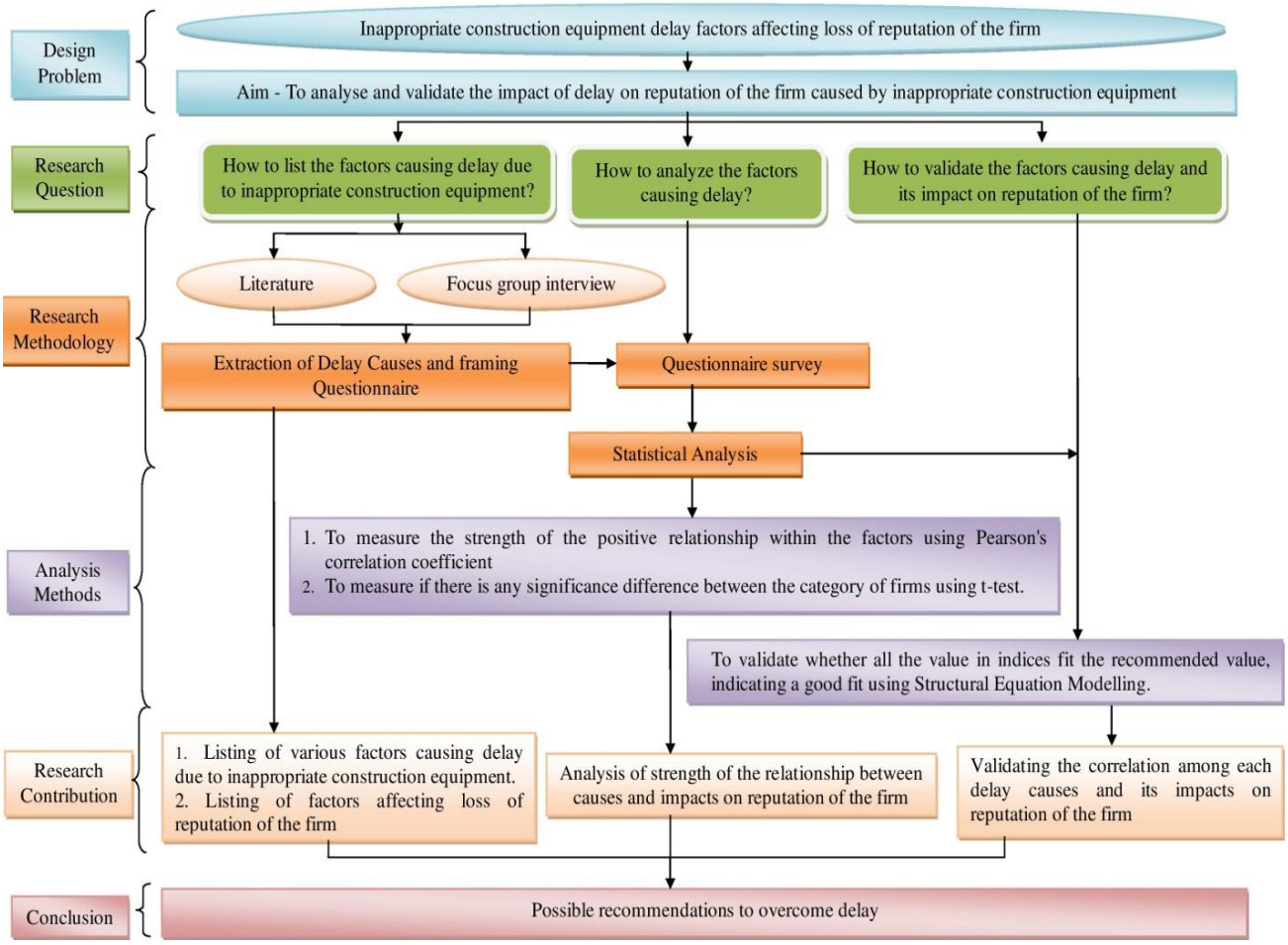

Figure 1. Research Design

4. Data Collection

A focus group interview was conducted with twenty-six plant and machinery procurement managers to elicit current factors of inappropriate construction equipment delay. Individual interviews were set up with each of the experts, and the causes and effects of construction project obstruction due to inappropriate construction equipment were explored. In a questionnaire, the questions based on the causes and effects of delay identified in the focus group interview and literature survey were divided into four sections. Two senior academicians and one industry expert reviewed the questionnaire design. The reviews were checked and edited as needed. The revised questionnaire was distributed to respondents. 300 responses were gathered. The responses for the surveys were collected in person from each respondent using the company's or individual's authorized facsimile.

The responses were analysed using multivariate statistical techniques. On a 5-point Likert scale, the questionnaire responses were received. Table 1 categorises the causes of delay due to inappropriate construction equipment identified through focus group interviews and a literature review as three major factors: Improper inventory management; Non-replacement of equipment and Improper equipment selection. The causes grouped under Improper inventory management are: (1) Non-stocking of imported spare parts (2) Equipment idleness due to importing of spare parts (3) Inadequate installation and (4) Non-tracking of equipment availability and utilization study. The causes grouped under Non-replacement of equipment are: (5) Normal wear for age (6) Low efficiency of equipment (7) Obsolescence i.e. outdated equipment and (8) Inadequacy i.e. Outdated product design. The causes grouped under Improper equipment selection are: (9) Improper size selection leading to workspace constraints (10) Non-availability of spare parts for imported equipment (11) Demand of trained operators for specialised equipment (12) Useless for future projects affecting economy (13) Lack of service support for imported equipment (14) Unsuitable climatic conditions and (15) Lack of past performance analysis. Also, the effects of delay with respect to Loss of the firm's reputation are categorised as: (16) Cost overrun; (17) Negative social impact; (18) Disputes and litigation; (19) Poor quality of work and (20) Termination of contract.

Table 1. Causes and Effects of delay

Sl. No	Causes of Delay	Key Factor
1	Non-stocking of imported spare parts.	Improper Inventory Management
2	Equipment idleness due to importing of spare parts.	
3	Inadequate installation	
4	Non-tracking of equipment availability and utilisation study	
5	Normal wear for age	Non-replacement of equipment
6	Low efficiency of equipment	
7	Obsolescence i.e. outdated equipment	
8	Inadequacy i.e. outdated product design	
9	Improper size selection leading to workspace constraints	Improper equipment selection
10	Non-availability of spare parts for imported equipment	
11	Demand of trained operators for specialized equipment	
12	Useless for future projects affecting the economy	
13	Lack of service support for imported equipment	
14	Do not go well with the climatic conditions	
15	Lack of past performance analysis	
	Effects of Delay	
16	Cost overrun	Loss of the firm's reputation
17	Negative social impact	
18	Disputes and litigation	
19	Poor quality of work	
20	Termination of contract	

Since this study was conducted for Indian Context, the sample was collected from various parts of India as given in Table 2.

Table 2. Study Area Locations

Sl. No	Districts	State / Union Territory	No of respondents
1	Chennai	Tamilnadu	54
2	Cochin	Kerala	20
3	Bhopal	Madhya Pradesh	42
4	Ahmedabad	Gujarat	29
5	Portblair	A & N Islands	35
6	Hyderabad	Telangana	20
7	Bangalore	Karnataka	30
8	Mumbai	Maharashtra	44
9	Kolkata	West Bengal	10
10	Amaravathi	Andra Pradesh	16
Total			**300**

The sample was gathered from construction experts who have worked with construction equipment in the past and in current projects. The frequency of the samples concerning the Category of the firm, Designation of the surveyors, Experience in years, Type of the current project and delay in the current project is given in Table 3. Private firms have a higher response rate than individual firms because private firms have all designations and employees with varying levels of experience. However, individual company has a limited number of employees.

Table 3. Frequency distribution of the collected samples

Category of firm	Frequency	Percent
Private	237	79
Individual	63	21
Designation of Surveyors		
Contractor	36	12
Equipment Dealer	6	2
Equipment Operator	18	6
Engineers	123	41
Project Managers	69	23
Others	48	16
Experience in years		
Up to 5	120	40
6–10	84	28
11–15	39	13
16–20	27	9
Above 20	30	10
Type of the project		
Residential	210	70
Road	9	3
Commercial	81	27
Delay in the current Project (%)		
No delay	144	48
6–10	45	15
11–15	57	19
16–20	48	16
Above 20	6	2
Total	300	100

5. Factor Analysis

A t-test was used to see if there was any significant difference between the Categories of firms in terms of Inappropriate equipment delay causes. Table 4 shows the results. Because the effects of delay in this study are on the 'Reputation of the firm,' a t-test is used to determine whether or not there is a significant difference between the two categories of the firm. As a result, because the P-value is greater than 0.05, there is no significant difference between

the Mean and SD of the Category of Firms for the factors of 'Improper inventory management', 'Non-replacement of equipment', and 'Improper equipment selection'. Whether it is an individual firm or a private firm, they all have a similar level of experience with the equipment. It has been observed that both face similar equipment-related issues, which cause construction work to be delayed.

Table 4. t-Test Category of firm

Inappropriate equipment delay causes	Category of firm				T value	P value
	Individual		Private			
	Mean	SD	Mean	SD		
Improper Inventory Management	14.44	2.886	13.75	3.193	0.939	0.350
Non-replacement of Equipment	13.86	3.343	13.40	4.627	0.507	0.613
Improper equipment selection	24.44	5.448	24.80	3.365	0.279	0.781

Table 5. Pearson Correlation Coefficient among Inappropriate equipment delay causes

Inappropriate equipment delay causes	Improper Inventory Management	Non-replacement of Equipment	Improper equipment selection
Improper Inventory Management	1	0.705**	0.589**
Non-replacement of Equipment	-	1	0.642**
Improper equipment selection	-	-	1

Table 5 shows the linear relationship between the three factors of causes of delay with each other. (**) Denotes significant at 1% level The Spearman's rank correlation coefficient ranges from +1 to -1. Where +1 denotes a perfect positive relationship, -1 denotes a perfect negative relationship, and values close to zero denote little or no correlation [40]. The correlation coefficient between Inappropriate equipment delay Causes on 'Improper inventory management' and 'Non-replacement of equipment' is (0.705), indicating a 70.5 percent positive relationship between 'Improper inventory management' and 'Non-replacement of equipment' and is significant at the 1% level. The correlation coefficient (0.642) between factors of causes of delay on 'Non Replacement of equipment' and 'Improper equipment selection' shows 64.2 percent of positive relationships between 'Non Replacement of equipment' and 'Improper equipment selection' and is significant at the 1% level. The coefficients in the preceding two cases were greater than 0.6, indicating a high correlation coefficient. Because the correlation coefficient (0.589) between 'Improper inventory management' and 'Improper equipment selection' is less than 0.6, it shows only 58.9 percent of a positive relationship, indicating a medium-correlation relationship [11].

Table 6. Mean and SD of Factors affecting delay due to Improper inventory management

Factors affecting delay due to Improper inventory management	Mean	SD
a. Non - stocking of imported spare parts.	4.044	0.944
b. Equipment idleness due to importing of spare parts.	3.860	0.909
c. Inadequate installation	3.584	0.976
d. Non-tracking of equipment availability and utilization study	3.540	1.039

According to the mean score in Table 6, the main factor affecting project delay due to 'Improper inventory management' is 'Non-stocking of imported spare parts' (4.044), followed by 'Equipment idleness due to importing spare parts' (3.860), 'Non-tracking of equipment availability and utilisation study' (3.540), and 'Inadequate installation' (3.584) are the least important factors.

Table 7. Mean and SD of Factors affecting delay due to non-replacement of equipments

Factors affecting delay due to non-replacement of equipments	Mean	SD
a. Normal wear for age	3.900	0.951
b. Low efficiency of equipment	3.734	0.987
c. Obsolescence i.e. outdated equipments	3.656	1.004
d. Inadequacy i.e. Outdated product design	3.576	1.098

The main factor affecting the delay in the project based on the mean score mentioned in the Table 7 due to 'Non-replacement of equipment's are 'Normal wear for age' (3.900), followed by 'Low efficiency of equipment' (3.734). The least factors affecting the delay are 'Inadequacy i.e. Outdated product design' (3.576), followed by 'Obsolescence i.e. outdated equipment's' (3.576).

Table 8. Mean and SD of Factors affecting delay due to Improper equipment selection

Factors affecting delay due to Improper equipment selection	Mean	SD
a. Improper size selection leading to workspace constraints	3.816	1.043
b. Non availability of spare parts for imported equipments	3.714	0.981
c. Demand of trained operators for specialized equipments	3.742	0.951
d. Useless for future projects affecting economy	3.494	1.030
e. Lack of service support for imported equipments	3.642	0.963
f. Do not go well with the climatic condition	3.510	1.073
g. Lack of past performance analysis	3.624	1.016

According to the mean score in Table 8, The most important factor influencing the delay in projects due to 'Improper equipment selection' are 'Improper size selection leading to workspace constraints' (3.816), which is followed by the 'Demand of trained operators for specialized equipment' (3.742), 'Non-availability of spare parts for imported equipment' (3.714) and so on. The least important factor affecting the delay of the project is 'Useless for future projects affecting economy' (3.494) followed by 'Do not go well with the climatic condition' (3.510), 'Lack of past performance analysis' (3.624) and so on.

Table 9. Mean and SD of Factors affecting Loss of the firm's reputation of the firm

Factors affecting delay due to Loss of the firm's reputation of the firm	Mean	SD
Cost overrun	3.766	1.011
Negative social impact	3.506	1.090
Disputes and litigation	3.764	0.980
Poor quality of work	3.620	1.109
Termination of contract	3.650	0.972

According to the mean score in Table 9, the most important factors affecting Loss of the firm's reputation of the firm are 'Cost overrun' (3.766), which is followed by 'Disputes and litigation' (3.764). The least factor affecting is 'Negative social impact' (3.506) followed by 'Poor quality of work' (3.620).

6. Structural Equation Modelling Results

Structural Equation Modelling describes how closely the factors of Inappropriate equipment delay, namely 'Improper inventory management', 'Non-replacement of equipment', and 'Improper equipment selection', are correlated with one another and have an impact on the company's reputation as shown in Figure 2.

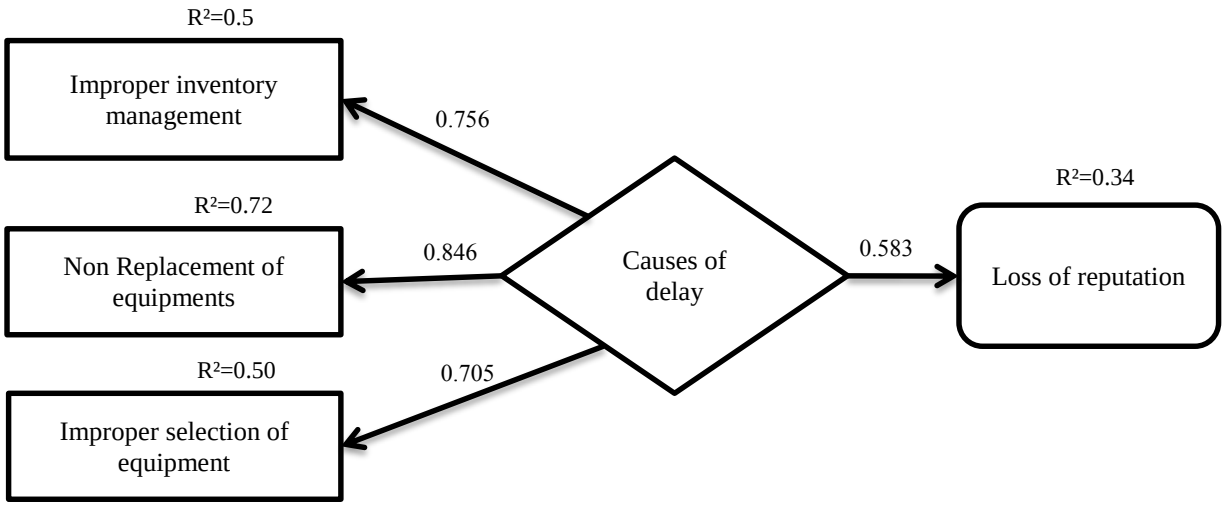

Figure 2. Structural equation model based on standardised coefficient on Inappropriate equipment delay causes

Table 10. Inappropriate equipment delay causes in the Structural Equation Model Analysis

Inappropriate equipment delay causes	Unstandardised coefficient (B)	Standard Error of B	Standardised coefficient	t value	P value
Improper inventory Management	2.241	0.124	0.756	18.142	<0.001**
Non-replacement of equipment	2.651	0.127	0.846	20.922	<0.001**
Improper equipment selection	3.418	0.206	0.705	16.624	<0.001**
Loss of the firm's reputation	3.083	0.234	0.583	13.157	<0.001**

Table 10 shows that (**) indicates significant at the 1% level. The most significant cause is an unstandardized coefficient of 'Improper equipment selection (3.418), followed by 'Non-replacement of equipment' (2.651) and 'Improper inventory management' (2.241). The coefficient of 'Loss of the firm's reputation' (3.083) indicates that the causes of inappropriate equipment have a positive impact on it.A standardized coefficient's purpose is to assess the relative contribution of a predictor variable and an actual variable [41]. 'Improper inventory management' is associated with causes of delay (B = 0.756, p-value 0.001); 'Non-replacement of equipment' is associated with causes of delay (B = 0.846, p-value 0.001); 'Improper equipment selection' is associated with causes of delay (B = 0.705, p-value 0.001); and causes of delay are associated with 'Loss of the firm's reputation' (B = 0.583, p-value 0.001). There is no such thing as a negative coefficient. In this study, all three causes of Inappropriate equipment delay are shown to have an impact on the firm's reputation.

Table 11. Model fit summary of Structural Equation Model

Indices	Value	Suggested by Hair et al. (2010) [42]
Chi-square value/DF	2.091	<3.00
GFI	0.979	> 0.959
AGFI	0.937	> 0.90
NFI	0.970	> 0.990
CFI	0.972	> 0.955
RMR	0.066	< 0.08
RMSEA	0.039	< 0.08

According to Table 11, the Goodness of Fit Index (GFI) value (0.979) and Adjusted Goodness of Fit Index (AGFI) value (0.937) are greater than 0.959 and 0.9, indicating a good fit. It is found that the calculated Normed Fit Index (NFI) value (0.970) and Comparative Fit Index (CFI) value (0.972) indicate that it is a perfect fit, as do the Root Mean Square Residuals (RMR) value (0.066) and Root Mean Square Error of Approximation (RMSEA) value (0.039).6.

7. Discussion

According to a Taiwanese study, SEM quantifies the strength of relationship in both observed and construct variables. Using SEM, they have identified how the causes of delay are related to one another and how they're being combined to impact the effects of delay. The SEM validated this study by demonstrating the impact of Inappropriate equipment delay causes among themselves and on the firm's reputation (R^2=0.34). A study in Ghana examined the effects of delay, 'Cost overrun (Rank =1),' Litigation (Rank =3), Contract termination (Rank =6). and 'Increased Portfolio of Non-Performant Projects (Rank=7)' contributing to the factor of 'Loss of firm's reputation' in this study [43]. A study in Iran ranked 'Cost overrun (Rank=2), Disputes (Rank=3), and Litigation (Rank=6) among the consequences of delay. The Inappropriate equipment delay causes are influenced by 'Improper inventory Management' (R^2=0.57), 'Non-replacement of equipment' (R^2=0.72) and 'Improper equipment selection' (R^2=0.50). According to this study, the causes of delays caused by inappropriate equipment are linked. A study in Hargeisa found that 'Low efficiency of equipment' ranks third in the delay factor related to equipment, contributing to the factor 'Non replacement of equipment' [44, 45]. In support of the factor 'Improper equipment selection,' a recent Malaysian study ranked 'Improper or insufficient plant and equipment selection' 17th in overall causes of delay [46]. Among the overall causes of delay, 'Equipment unavailability' ranks eighth in Benin and nineteenth in Oman, contributing to the factor 'Improper Inventory Management.' [47-48]. Previous researchers have also used simple tools such as regression, which are insufficiently accurate due to co-linearity and multi-co-linearity effects [27]. The key strength is that the research findings demonstrated that absolute fit indices fit the sample data and reveal that the proposed model has an acceptable fit by satisfying the recommended values [36].

7.1. Recommendations

Although not all the causes of equipment delay can be completely eliminated, but actions can be taken to reduce the maximum delay by considering the following recommendations as balanced inventory must be maintained to overcome both zero stock to avoid non-availability of the equipment at the right time and to avoid excessive stock, which increases the cost for storing excess spare parts than required; the people in-charge employed for a particular type of project have to be well experienced in the field of interest. Change in type of project takes time for them to get adapted to, leading to improper planning for availing the right choice of equipment. The person in-charge must be aware of the working conditions and production rate of equipment required for the project and should be able to make a proper selection of equipment; downtime of equipment has to be reduced by detecting and diagnosing the fault during maintenance; quick replacement of equipment with respect to deterioration (normal wear and tear), obsolescence (outdated equipment) and inadequacy (change in product design) has to be ensured.

8. Conclusion

Through focus group interviews and a literature review, this study systematically investigated the reasons for the delay caused by the use of Inappropriate construction equipment on the job site. Through focus group interviews and a literature review, fifteen causes of delay due to Inappropriate equipment usage were identified and classified into three major factors: 'Improper inventory management', 'Non-replacement of equipment', and 'Improper equipment selection'. 'Improper equipment selection'. The following were the consequences of the delay: 'Cost overruns; Negative social impact; Disputes and Litigation; Poor quality of work; and Contract termination, resulting in the firm's reputation being negatively affected. These factors were framed as questions and distributed to various construction professionals under various categories, such as firm category, surveyor designation, experience in years, type of current project, and delay in current project. The SEM demonstrated that the indices' values perfectly fit the suggested value, indicating a positive relationship between Inappropriate equipment delay causes and 'Loss of the firm's reputation' factor. Using SEM, the factor 'Improper equipment selection' is reported to be the most sensitive factor causing delay, followed by 'Non Replacement of Equipment' and 'Improper Inventory Management.' As a result, in order to avoid a loss of the firm's reputation, projects must be delivered on time by increasing productivity on-site by using appropriate equipment.

Limitations

- This study is limited to inappropriate construction equipment factors alone, despite the fact that there are numerous other causes of construction equipment delay due to the fact that 'Inappropriate construction equipment' factor itself has numerous causes. There are various other effects of delay, but in this study, only the 'Loss of the firm's reputation' has been thoroughly researched because this issue itself afflicts the development of the country in a large scale
- Because India is such a large country, only a few states have been surveyed.

Future Scope

Future research can be improved by overcoming the study's limitations and investigating other causes and effects of equipment delay. The sample size can also be increased by covering a large section of the population on a mass scale.

9. Declarations

9.1. Author Contributions

B.I.: Research Design, Conducted questionnaires survey, Analysed and interpreted the data; writing—original draft preparation; K.Y.: Conducted focus group interview; Analysed and interpreted the data. All authors have read and agreed to the published version of the manuscript.

9.2. Data Availability Statement

The data presented in this study are available in article.

9.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

9.4. Conflicts of Interest

The authors declare no conflict of interest.

10. References

[1] Mahamid, Ibrahim, Amund Bruland, and Nabil Dmaidi. "Causes of Delay in Road Construction Projects." Journal of Management in Engineering 28, no. 3 (July 2012): 300–310. doi:10.1061/(asce)me.1943-5479.0000096.

[2] Chan, Daniel W.M., and Mohan M. Kumaraswam. "Reasons for Delay in Civil Engineering Projects – the Case of Hong Kong." HKIE Transactions 2, no. 3 (January 1995): 1–8. doi:10.1080/1023697x.1995.10667685.

[3] Enshassi, Adnan, Sherif Mohamed, and Saleh Abushaban. "Factors Affecting The Performance Of Construction Projects In The Gaza Strip." Journal Of Civil Engineering And Management 15, no. 3 (June 30, 2009): 269–280. doi:10.3846/1392-3730.2009.15.269-280.

[4] Głuszak, Michał, and Agnieszka Leśniak. "Construction Delays in Clients Opinion – Multivariate Statistical Analysis." Procedia Engineering 123 (2015): 182–189. doi:10.1016/j.proeng.2015.10.075.

[5] Abdul Kadir, M.R., W.P. Lee, M.S. Jaafar, S.M. Sapuan, and A.A.A. Ali. "Factors Affecting Construction Labour Productivity for Malaysian Residential Projects." Structural Survey 23, no. 1 (February 2005): 42–54. doi:10.1108/02630800510586907.

[6] Alaghbari, Wa'el, Mohd. Razali A. Kadir, Azizah Salim, and Ernawati. "The Significant Factors Causing Delay of Building Construction Projects in Malaysia." Engineering, Construction and Architectural Management 14, no. 2 (March 6, 2007): 192–206. doi:10.1108/09699980710731308.

[7] Gebrehiwet, Tsegay, and Hanbin Luo. "Analysis of Delay Impact on Construction Project Based on RII and Correlation Coefficient: Empirical Study." Procedia Engineering 196 (2017): 366–374. doi:10.1016/j.proeng.2017.07.212.

[8] Gurcanli, G. Emre, Harun Turkoglu, and Senem Bilir. "Heavy Equipment Scheduling for Horizontal Construction Projects." Procedia Engineering 182 (2017): 265–273. doi:10.1016/j.proeng.2017.03.189.

[9] Prasad, Kanika, Edmundas Kazimieras Zavadskas, and Shankar Chakraborty. "A Software Prototype for Material Handling Equipment Selection for Construction Sites." Automation in Construction 57 (September 2015): 120–131. doi:10.1016/j.autcon.2015.06.001.

[10] Sambasivan, Murali, T.J. Deepak, Ali Nasoor Salim, and Venishri Ponniah. "Analysis of Delays in Tanzanian Construction Industry." Engineering, Construction and Architectural Management 24, no. 2 (March 20, 2017): 308–325. doi:10.1108/ecam-09-2015-0145.

[11] Yang, Jyh-Bin, and Shen-Fen Ou. "Using Structural Equation Modeling to Analyze Relationships among Key Causes of Delay in Construction." Canadian Journal of Civil Engineering 35, no. 4 (April 2008): 321–332. doi:10.1139/l07-101.

[12] Jalili, Mohamad Hadi, and Martin Skitmore. "A Framework to Predict Time and Cost Risks Based on Project Factors." Civil Engineering Journal 4, no. 11 (November 30, 2018): 2738. doi:10.28991/cej-03091195.

[13] Jahr, Katrin, and André Borrmann. "Semi-Automated Site Equipment Selection and Configuration through Formal Knowledge Representation and Inference." Advanced Engineering Informatics 38 (October 2018): 488–500. doi:10.1016/j.aei.2018.08.015.

[14] Sweis, G., R. Sweis, A. Abu Hammad, and A. Shboul. "Delays in Construction Projects: The Case of Jordan." International Journal of Project Management 26, no. 6 (August 2008): 665–674. doi:10.1016/j.ijproman.2007.09.009.

[15] Temiz, I., and G. Calis. "Selection of Construction Equipment by Using Multi-Criteria Decision Making Methods." Procedia Engineering 196 (2017): 286–293. doi:10.1016/j.proeng.2017.07.201.

[16] Tuskaeva, Zalina, and Gevork Aslanov. "Software Product Development for the Construction Equipment Selection." Procedia Engineering 165 (2016): 1184–1191. doi:10.1016/j.proeng.2016.11.837.

[17] Kadry, Mohamed, Hesham Osman, and Maged Georgy. "Causes of Construction Delays in Countries with High Geopolitical Risks." Journal of Construction Engineering and Management 143, no. 2 (February 2017): 04016095. doi:10.1061/(asce)co.1943-7862.0001222.

[18] Mahamid, Ibrahim. "Factors Contributing to Poor Performance in Construction Projects: Studies of Saudi Arabia." Australian Journal of Multi-Disciplinary Engineering 12, no. 1 (January 2016): 27–38. doi:10.1080/14488388.2016.1243034.

[19] Sharma S. C., Construction Equipment and Management, Sixth. Delhi: Khanna Book Publishing Co (P) Ltd., (1998).

[20] Turrini, Laura, and Joern Meissner. "Spare Parts Inventory Management: New Evidence from Distribution Fitting." European Journal of Operational Research 273, no. 1 (February 2019): 118–130. doi:10.1016/j.ejor.2017.09.039.

[21] Doloi, Hemanta, Anil Sawhney, K.C. Iyer, and Sameer Rentala. "Analysing Factors Affecting Delays in Indian Construction Projects." International Journal of Project Management 30, no. 4 (May 2012): 479–489. doi:10.1016/j.ijproman.2011.10.004.

[22] Poppe, Joeri, Rob J.I. Basten, Robert N. Boute, and Marc Lambrecht. "Inventory Management Under Various Maintenance Policies. A Numerical Study in Close Collaboration with an OEM." SSRN Electronic Journal (2016). doi:10.2139/ssrn.2873416.

[23] Aziz, Remon F., and Asmaa A. Abdel-Hakam. "Exploring Delay Causes of Road Construction Projects in Egypt." Alexandria Engineering Journal 55, no. 2 (June 2016): 1515–1539. doi:10.1016/j.aej.2016.03.006.

[24] Santoso, Djoen San, and Sothy Soeng. "Analyzing Delays of Road Construction Projects in Cambodia: Causes and Effects." Journal of Management in Engineering 32, no. 6 (November 2016): 05016020. doi:10.1061/(asce)me.1943-5479.0000467.

[25] Lopes, Rodrigo S., Cristiano A.V. Cavalcante, and Marcelo H. Alencar. "Delay-Time Inspection Model with Dimensioning Maintenance Teams: A Study of a Company Leasing Construction Equipment." Computers & Industrial Engineering 88 (October 2015): 341–349. doi:10.1016/j.cie.2015.07.00

[26] Aziz, Remon Fayek. "Ranking of Delay Factors in Construction Projects after Egyptian Revolution." Alexandria Engineering Journal 52, no. 3 (September 2013): 387–406. doi:10.1016/j.aej.2013.03.002.

[27] Assaf, Sadi A., and Sadiq Al-Hejji. "Causes of Delay in Large Construction Projects." International Journal of Project Management 24, no. 4 (May 2006): 349–357. doi:10.1016/j.ijproman.2005.11.010.

[28] Oshungade, Oluwaseun O., and Deon Kruger. "A Comparative Study of Causes and Effects of Project Delays and Disruptions in Construction Projects in the South African Construction Industry." Journal of Construction Engineering and Project Management 7, no. 1 (March 1, 2017): 13–25. doi:10.6106/jcepm.2017.3.30.013.

[29] Ghoddousi, Parviz, and Mohammad Reza Hosseini. "A Survey of the Factors Affecting the Productivity of Construction Projects in Iran." Technological and Economic Development of Economy 18, no. 1 (April 10, 2012): 99–116. doi:10.3846/20294913.2012.661203.

[30] Chen, Gui-Xiang, Ming Shan, Albert P. C. Chan, Xu Liu, and Yi-Qing Zhao. "Investigating the Causes of Delay in Grain Bin Construction Projects: The Case of China." International Journal of Construction Management 19, no. 1 (July 27, 2017): 1–14. doi:10.1080/15623599.2017.1354514.

[31] Gunduz, Murat, Yasemin Nielsen, and Mustafa Ozdemir. "Fuzzy Assessment Model to Estimate the Probability of Delay in Turkish Construction Projects." Journal of Management in Engineering 31, no. 4 (July 2015): 04014055. doi:10.1061/(asce)me.1943-5479.0000261.

[32] Al-Khalil, Mohammed I., and Mohammed A. Al-Ghafly. "Important Causes of Delay in Public Utility Projects in Saudi Arabia." Construction Management and Economics 17, no. 5 (September 1999): 647–655. doi:10.1080/014461999371259.

[33] Cheong Yong, Yee, and Nur Emma Mustaffa. "Analysis of Factors Critical to Construction Project Success in Malaysia." Engineering, Construction and Architectural Management 19, no. 5 (August 31, 2012): 543–556. doi:10.1108/09699981211259612.

[34] Oyegoke, Adekunle Sabitu, and Naseer Al Kiyumi. "The Causes, Impacts and Mitigations of Delay in Megaprojects in the Sultanate of Oman." Journal of Financial Management of Property and Construction 22, no. 3 (November 6, 2017): 286–302. doi:10.1108/jfmpc-11-2016-0052.

[35] Kongchasing, Nutchapongpol, and Gritsada Sua-Iam. "The Major Causes of Construction Delays Identified Using the Delphi Technique: Perspectives of Contractors and Consultants in Thailand." International Journal of Civil Engineering 19, no. 3 (October 10, 2020): 319–338. doi:10.1007/s40999-020-00575-8.

[36] Kikwasi, Geraldine. "Causes and Effects of Delays and Disruptions in Construction Projects in Tanzania." Australasian Journal of Construction Economics and Building - Conference Series 1, no. 2 (February 5, 2013): 52. doi:10.5130/ajceb-cs.v1i2.3166.

[37] Niazi, Ghulam Abbas, and Noel Painting. "Significant Factors Causing Cost Overruns in the Construction Industry in Afghanistan." Procedia Engineering 182 (2017): 510–517. doi:10.1016/j.proeng.2017.03.145.

[38] Mansfield, NR, OO Ugwu, and T Doran. "Causes of Delay and Cost Overruns in Nigerian Construction Projects." International Journal of Project Management 12, no. 4 (November 1994): 254–260. doi:10.1016/0263-7863(94)90050-7.

[39] Marzouk, Mohamed M., and Tarek I. El-Rasas. "Analyzing Delay Causes in Egyptian Construction Projects." Journal of Advanced Research 5, no. 1 (January 2014): 49–55. doi:10.1016/j.jare.2012.11.005.

[40] Mahdi, Ibrahim, and Ehab Soliman. "Significant and Top Ranked Delay Factors in Arabic Gulf Countries." International Journal of Construction Management 21, no. 2 (November 22, 2018): 167–180. doi:10.1080/15623599.2018.1512029.

[41] Chai, Chang Saar, and Aminah Md Yusof. "SEM Approach: Reclassifying Housing Delay in Malaysian Housing Industry." Journal of Economics, Business and Management 3, no. 3 (2015): 364–369. doi:10.7763/joebm.2015.v3.211.

[42] Black, William, and Barry J. Babin. "Multivariate Data Analysis: Its Approach, Evolution, and Impact." The Great Facilitator (2019): 121–130. doi:10.1007/978-3-030-06031-2_16.

[43] Amoatey, Charles Teye, Yaa Asabea Ameyaw, Ebenezer Adaku, and Samuel Famiyeh. "Analysing Delay Causes and Effects in Ghanaian State Housing Construction Projects." Edited by Professor Rolf A. Lundin and Dr Kjell Tryggestad. International Journal of Managing Projects in Business 8, no. 1 (January 5, 2015): 198–214. doi:10.1108/ijmpb-04-2014-0035.

[44] Bazanov, Vladimir Evgenievich. "Modeling of Management Processes of Construction Company Business for Increase in Its Competitive Stability." Civil Engineering Journal 5, no. 1 (January 27, 2019): 246. doi:10.28991/cej-2019-03091241.

[45] Fashina, Adebayo Adeboye, Mustafe Abdillahi Omar, Ahmed Abdullahi Sheikh, and Funke Folasade Fakunle. "Exploring the Significant Factors That Influence Delays in Construction Projects in Hargeisa." Heliyon 7, no. 4 (April 2021): e06826. doi:10.1016/j.heliyon.2021.e06826.

[46] Yap, Jeffrey Boon Hui, Pei Ling Goay, Yoke Bee Woon, and Martin Skitmore. "Revisiting Critical Delay Factors for Construction: Analysing Projects in Malaysia." Alexandria Engineering Journal 60, no. 1 (February 2021): 1717–1729. doi:10.1016/j.aej.2020.11.021.

[47] Akogbe, Romuald-Kokou T. M., Xin Feng, and Jing Zhou. "Importance and Ranking Evaluation of Delay Factors for Development Construction Projects in Benin." KSCE Journal of Civil Engineering 17, no. 6 (August 17, 2013): 1213–1222. doi:10.1007/s12205-013-0446-2.

[48] Al Mohsin, Mohammed A. Chasib, and Ali Alnuaimi. "A Comparative Study on Causes of Delay Incompletion of Construction Projects in Oman." Journal of Construction Engineering, Technology & Management 3, no. 1 (2013): 1-6.

Appendix I: Questionnaire Survey

Company Profile

Category of firm:

Type of current project:

Delay in the current project (%):

Respondent's Profile

Name of the Respondent:

Designation:

Experience:

Five Point Likert Scale

5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree

Table A1. Factors affecting delay due to Improper inventory management

Causes	4	3	2	1	0
a. Non-stocking of imported spare parts.					
b. Equipment idleness due to importing of spare parts.					
c. Inadequate installation					
d. Non-tracking of equipment availability and utilisation study					

Table A2. Factors affecting delay due to Non-replacement of equipment

Causes	4	3	2	1	0
a. Normal wear for age					
b. Low efficiency of equipment					
c. Obsolescence i.e. outdated equipment					
d. Inadequacy i.e. outdated product design					

Table A3. Factors affecting delay due to Improper equipment selection

Causes	4	3	2	1	0
h. Improper size selection leading to workspace constraints					
i. Non-availability of spare parts for imported equipment					
j. Demand of trained operators for specialised equipment					
k. Useless for future projects affecting the economy					
l. Lack of service support for imported equipment					
m. Do not go well with the climatic conditions					
n. Lack of past performance analysis					

Table A4. Factors affecting Loss of the firm's reputation of firm

Causes	4	3	2	1	0
Cost overrun					
Negative social impact					
Disputes and litigation					
Poor quality of work					
Termination of contract					

Place and Data: Signature with Company Seal