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

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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
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-stock 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.

| Design Problem |
|----------------|
| Aim - To analyse and validate the impact of delay on reputation of the firm caused by inappropriate construction equipment |

Research Question

- How to list the factors causing delay due to inappropriate construction equipment?
- How to analyze the factors causing delay?
- How to validate the factors causing delay and its impact on reputation of the firm?

Research Methodology

- Extraction of Delay Causes and framing Questionnaire
- Questionnaire survey
- Statistical Analysis
  1. To measure the strength of the positive relationship within the factors using Pearson's correlation coefficient
  2. To measure if there is any significance difference between the category of firms using t-test.

Analysis Methods

1. Listing of various factors causing delay due to inappropriate construction equipment.
2. Listing of factors affecting loss of reputation of the firm
3. Analysis of strength of the relationship between causes and impacts on reputation of the firm
4. Validating the correlation among each delay causes and its impacts on reputation of the firm

Research Contribution

Possible recommendations to overcome delay

Conclusion
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                         |                                 |
| 16     | Cost overrun                                              | Effects of Delay                |
| 17     | Negative social impact                                    |                                 |
| 18     | Disputes and litigation                                   | Loss of the firm’s reputation   |
| 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 | Frequency | Percent |
|--------------------------|-----------|---------|
| Contractor               | 36        | 12      |
| Equipment Dealer         | 6         | 2       |
| Equipment Operator       | 18        | 6       |
| Engineers                | 123       | 41      |
| Project Managers         | 69        | 23      |
| Others                   | 48        | 16      |

| Experience in years | Frequency | Percent |
|---------------------|-----------|---------|
| 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  | Frequency | Percent |
|----------------------|-----------|---------|
| Residential          | 210       | 70      |
| Road                 | 9         | 3       |
| Commercial           | 81        | 27      |

| Delay in the current Project (%) | Frequency | Percent |
|----------------------------------|-----------|---------|
| 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 Mean  | SD | Private Mean | SD | 9.39   | 0.350 |
| Improper Inventory Management                         | 14.44            | 2.886 | 13.75 | 3.193 | 0.507 | 0.613 |
| Non-replacement of Equipment                          | 13.86            | 3.343 | 13.40 | 4.627 | 0.279 | 0.738 |
| 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).

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 (R²=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’ (R²=0.57), ‘Non-replacement of equipment’ (R²=0.72) and ‘Improper equipment selection’ (R²=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.
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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