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Construction Delay Analysis: Causes, Impacts, and Mitigation Strategies

Kwame B. O. Amoah*, George Okere, Abhijeet Deshpande

Civil, Architectural Engineering. & Construction Management, University of Cincinnati, Cincinnati, 45221, USA

Abstract This study investigates the leading causes and impact of construction project delays and outlines the delays in three main categories: Contractors' Delays, Owners' Delays, and External factors Delays. Construction projects are more intricate and associated with significant levels of risk owing to cost overruns. These situations frequently lead to delays, incomplete work, and unforeseen challenges. These delays prolong the project's duration, increase costs and stakeholder conflicts. This paper developed and tested a comprehensive conceptual model, describing the factors causing delays in different areas of construction projects and providing awareness of project management and construction practices. The research conducted an extensive data collection process with a designed survey distributed to owners, contractors, and subcontractors, totalling 314 participants across Ohio, USA. The data was collected using stratified sampling to ensure a representative sample. The authors examined the data utilizing ordinary least squares multiple regression. The findings have practical implications for the construction industry, indicating factors related to clients, design, procurement, funding source, and labor contributing to project delays. The grasp of these factors will aid the industry stakeholders in managing better and mitigating project delays, equipping teams with the skills to make informed decisions and enhance project outcomes.

Keywords Construction Delays, Causes of delay, Construction industry and Project management

1. Introduction

The AEC industry is one of the most critical industries contributing significantly to any nation's economic development. Construction contributes to economic growth by satisfying primary objectives, including employment creation, output generation, and income generation. The industry's impact is particularly pronounced in many countries, representing more than half of the national capital and up to 10% of the Gross National Product.

Project delays may be defined as additional time for construction projects beyond the original contracted timeline. As Construction projects have distinctive features such as fixed project timelines, complex processes, financial intensity, technology, and organizational complexity, any delay can result in cost overruns, time overruns, litigations, and project abandonment [38].

Delays may occur at any point in the project life cycle, from the Initiating/feasibility stage to planning, executing, monitoring, and controlling, and can persist until completion. These delays can directly or indirectly impact key project constraints like cost, schedule, scope, quality, and customer satisfaction.

* Corresponding author:
amoahkb@ucmail.uc.edu (Kwame B. O. Amoah)
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As the major parties (stakeholders) involved in the construction project, the owner, consultant, and contractor, are responsible for causing project delays, it's important to remember that other stakeholders outside the three primary parties can also contribute to project delays. Delays negatively impact contractors' and developers' businesses and raise building costs due to resource price escalation, economic recession, extreme weather, and political unrest. In some cases, more money is required to fund a project due to delays [24].

Delays can profoundly impact critical project constraints such as cost, schedule, scope, quality, and customer satisfaction [16]. Cost overruns occur when expenses exceed the budgeted expenditure, while schedule overruns happen when tasks or projects are not completed on time. Introducing or removing requirements can lead to scope creep, and failing to meet needs or acceptance criteria can negatively impact quality and customer satisfaction.

2. Literature Review

Past researchers have diligently identified construction project delay delays for years, exploring a multitude of factors contributing to these delay causes [24]. Aziz et al. [9] provided a comprehensive overview of delay factors, covering the owner and contractor, financing, contract, design, site conditions, labor, material, equipment, regulations,

scheduling, external factors, and contractual relations. Alsuliman et al. [7] examined different causes of delays at various levels in public construction projects to verify the magnitude of the delay. Assaf et al. [8] Further, risk factors in construction projects are classified into multiple categories depending on a defined criterion. Chalhoub et al. [11] also classified the causes of delays into five categories: owners, contractors, design, infrastructure, and social and external factors.

This section of the paper reviews the literature on causes of delay experienced by global construction-focused projects from the perspective of five categories: owner, contractor, material, equipment, labor, and external factors. As defined in Table 1, the summarized classifications are insights applied to real-world construction projects, making the research findings highly relevant and engaging.

2.1. Owner-Related Cause of Delays

Assaf et al. [8] found ten delays caused by the owners' perspective associated with large construction projects, traced to the owners' delayed progress payments and the many owners' teams' lack of project management skills. Wuala et al. [30] suggested poor fund allocation, variation in scope of work, slow decision-making, unrealistic deadlines, and site readiness as owner-related delay causes.

Alsuliman et al. [7] used a questionnaire-based technique to investigate the causes of delays at several stages of public building projects. The author found the bid awarding issue the most significant reason for the owner's major delay problems.

The research's practical implications for the industry centered on shedding light on several owner-related delay causes, including scope changes, communication, coordination, a prolonged change-order approval process, procurement inconsistency, and inadequate budget allocation. These findings can help mitigate construction project delays and cost overruns [11].

This literature review section identified six (6) significant causes of owner-related delays. These consist of financing difficulties, cash flow issues, progress payments, delivery of the project site, drawings/plan revision and approval process, and material selection.

2.2. Contractor’s Causes of Delay

Contractors are the primary culprit for many construction delays due to their oversight responsibility of project execution and management of the construction crew. Assaf et al. [8] studied points towards major financing problems for contractors, conflicts between the subcontractors and the general contractors, rework, disputes between the contractor, the consultant, or the owner, poor site management, supervision, poor communication/coordination, and unstructured planning. Additional challenges the contractors face include a need for precise construction methods, subcontractors delayed work, frequent changes of subcontractors, and delayed mobilization. Long et al. [31] attributed seventeen (17) causes of delay to the contractor, consisting of improper planning, bad team experience, lack of modern equipment, wrong time estimates, inconsistent cost estimates, poor site management, lack of defined monitoring/control procedure, poor labor relations, undefined construction methods, lack of funds, lack of training for the project teams, poor contract management, excessive overtime, material waste, lack of team requisite skills, absence of site inspection, and lack of competent subcontractors or vendors. Abdul-Rahman et al. [2] further identified delays such as poor supervision, conflicting construction methods, zero-project planning, consistent lack of funds during construction, and deficiencies and rework. Khatib et al. [27] defined general contractors, subcontractors, drawings/ specification discrepancies, wrong design interpretation, shortage of material & labor on site, and ignorance of price escalation procedure as primary delay factors.

This section of the literature review found 14 significant causes of delays attributed to contractors. The causes include: 1). the communication gap between contractors, owners, and designers; 2). ineffective planning and scheduling issues; 3). poor site management; 4). delayed mobilization; 5). conflicts between the contractor and other project participants; 6). implementing obsolete construction methods; 7). frequent changes to the project schedule; 8). faulty construction drawings; 9). incomplete engineer's estimate; 10). budget inaccuracies; 11). unstructured construction methods; 12). plan errors and omissions; 13). ambiguous specification; and 14). rework and lousy contractor experience. Delays impact the project schedule, work quality, cost, client satisfaction, and scope.

2.3. Material & Equipment-Related Causes of Delay

Construction delays have been recognized as a global challenge preventing timely material delivery, cost overrun, and project quality [17]. Material delivery and procurement are critical issues that must be controlled to avoid delays in construction project execution Indhu et al. [33]. & Madan et al. [32] investigated the essential factors related to the causes and effects of delays in construction projects, ranking materials delays as major delay issues from the contractors' and independent consultants' views. The relative importance of construction delays survey conducted by the study revealed that fluctuation of material prices and lack of preferred equipment are major delay factors. Madan et al. [26] extracted construction equipment delay caused by existing literature with a recommended approach to overcome the challenges [2], which involves a comprehensive risk management strategy and proactive communication with suppliers. The study outlined the sources of shortages, material availability, and origin.

2.4. Labor-Related Causes of Delay

Many labor delays resulted from labor shortages, low productivity, labor permits, and conflicts among the labor force [34]. Abbasi et al. [1] indicated that labor shortages, recruitment problems, and low performance are the causes

of labor-related delays. Fashina et al. [17] suggested a lack/shortage of laborers, labor strikes, personal conflicts between laborers, and lack of sufficient skilled labor as labor-related delays.

The literature in this section reveals a diverse range of causes of labor-related delays. The findings include labor strikes, personal conflicts between laborers, a lack of sufficient skilled labor, and high labor wages.

These delays could result in delayed or cancelled projects, lost/delayed revenue/payments, and damage to the business relationship between the owner, contractor, and subcontractor.

2.5. Externally Related Causes of Delay

This literature review presents a comprehensive overview of the various external factors that can lead to construction project delays. Previous researchers have identified multiple factors, including political instabilities, project locations, and geological conditions [11]. Aibinu et al. [5] conclude that price escalation, inclement weather, labor disputes, worker strikes, strict regulations, permits bureaucracy, civil unrest, and acts of God consecutively affect projects. Assaf et al. [8] pointed out relevant external-related delay factors such as unstable soil conditions, difficulties securing permits, differing geotechnical conditions, site utility issues, and social aspects. Additionally, traffic control challenges and accidents on site are crucial factors. Assaf et al. [8], & also pinpoint legal disputes, severe delay penalties, materials shortages, and delays in unique manufacturing materials. Ling et al. [30] defined external delays as natural risks, including weather and geological systems, political risks, wars, civil disorder, and strained industrial relations. Olawale et al. [35] traced external delay sources with unpredictable weather conditions, heavy dependence on imported mate-rials, inflation, deficient regulation, control, and unstable government policies. This comprehensive review underscores the need for a thorough understanding of the topic to effectively manage and mitigate construction project delays.

The literature in this section points to ten significant causes of delays in the external category. These delays were: 1. unpredictable weather conditions/natural calamities; 2. political/social unrest; 3. differing site conditions or concealed conditions; 4. delay in getting permits and acquisitions (Environmental, Land, utilities, govt approvals); 5 subsurface condition effects; occurrence of an accident during construction; 6. intervention by outside agencies; utility service providers delays; and 7. lack of defined final inspection and certified completion certificates.

As mentioned above, the delays directly impact the project schedule, cost, quality, planning, and execution phases. These delays could result in delayed or cancelled projects, lost/delayed revenue/payments, and damage to the business relationship between the owner, contractor, and subcon-tractor.

2.6. Mitigation Plan: Owner-Caused Delays

The Mitigation plan conducted by the construction companies focused on improving the current process, adopting new technologies, and providing necessary training. This emphasis on training is critical to ensuring the project's success. Six recommendations could help mitigate these delays: 1. Owners should ensure appropriate funding sanctions are received in advance. This proactive approach to funding reassures stakeholders and prepares them for the project's financial demands; 2—team up with more than one financial institution; 3. Undergo proper training on decision-making, communication, financial management, and adopting alternative approaches; 4. The owner must guarantee that limited changes are made during the construction phase and that negative impacts associated with missing essential items are prevented; 5. [36] Ismai et al. [36] posit that all change order requests must support the quality of the work, scope, and cost. The owner should promptly pay interim certificates within the specified time to avoid interest penalty provisions, promote project progress, and guarantee project completion on time [16].

2.7. Mitigation Plan: Material & Equipment Caused Delays

The Mitigation plan carried out by various construction companies mainly focused on improving the current process, adapting new technologies, and providing necessary training. Eight recommendations could help mitigate these delays: 1. Encourage collaboration between the client, contractor, and design team. Abdul-Rahman et al. [2]; 2. peer reviews and Building Information Modeling (BIM) are great ways to detect design flaws; 3. advanced technologies can reduce the impacts of labor disruption; 4. Incorporating design-build (DB) methods and Integrated Project Delivery (IPD) structured to promote the contractor's early participation in projects; 5. during the pre-contract and bidding periods, contractors should pay close attention to the specifications and aim to bid on jobs with a competitive edge. Muhwezi et at. [37]; 6. to prevent companies from a shortage of funds during the execution of the works, contractors must preplan sufficient cash flow and refrain from allocating limited project funds to non-project activities; 7. contractors should ensure enough experience for the desired task, assign qualified project teams, and adequately define their building methods; and 8. the contractor must ensure adequate planning and work schedule, site management, and job-site monitoring to keep an eye on essential operations and keep projects on time and within budget. Amoah et al. [29] developed a BIM-based integrated approach that promoted vital decisions in construction projects' early design and planning phases utilizing effective information exchange for collaboration. The exchange framework system accessed data automatically and seamlessly without the manual effort of a specific project team to reduce project delays.

2.8. Mitigation Plan: Labor-Caused Delays

The mitigation plan, which is central to refining the current process through comprehensive training, could be further fortified by five key recommendations. These include

1—the implementation of specified contracts with labor to provide a clear framework for work; 2. High-level conflict resolution training focuses on empowering supervisors to mediate issues effectively [12]; 3—enhancing training requirements for construction workers and on-site training for new employees' access; 4. Improve hourly wages and bonus structures to provide better incentives [28], and 5—regularly conduct site meetings to foster communication and address issues promptly.

2.9. Delay Mitigation Plan: External Factors Caused Delays

The Mitigation plan conducted by the companies mainly focused on improving the current processes and providing requisite training when necessary. The recommendation for the seven mitigation strategies outlined could help reduce the delays. These mitigation strategies include avoiding lengthening the intended execution time throughout the litigation process; project stakeholders should collaborate to resolve significant disagreements throughout execution [36]; 2. all stakeholders should ensure sufficient planning to account for unforeseen events that could lengthen the building process, raise costs, and result in property damage. The risks of unforeseen delays should be insured to help defray the financial impact of the project; 3. leveraging weather generation Modeling techniques to contribute to understanding weather impacts construction projects. This insight could inform the project managers' initiation of comprehensive mitigation strategies; 4. define a lasting plan for site-specific weather prediction impact on the construction and scheduling process 5. provide clear and visible mitigation techniques to all project team members; 6. reach out to the labor crew to define measures for productivity; and 7. define apparent reporting authority among the project stakeholders with clear responsibilities.

3. Research Method

The authors designed an online survey to gather primary data. This study used a stratified sampling method to collect data from General Contractors, Owners, and subcontracting firms in Ohio, USA. The authors included respondents from various educational backgrounds, ages, and experience levels, ensuring a comprehensive and inclusive representation. The authors outlined measures enhancing the external validity of the research. The authors collected data through an online survey. The study spanned from November 2022 to August 2023. The respondents were assured of the strict confidentiality of their replies and the non-disclosure of their identities, respecting their privacy. A total of 420 surveys were gathered, and after filtering for missing or unfit entries, the survey identified 301 valid data points. We rigorously tested for non-response bias by comparing the first 75 respondents with the last respondents. The authors found no statistical difference between these two groups, further bolstering confidence in the study's findings.

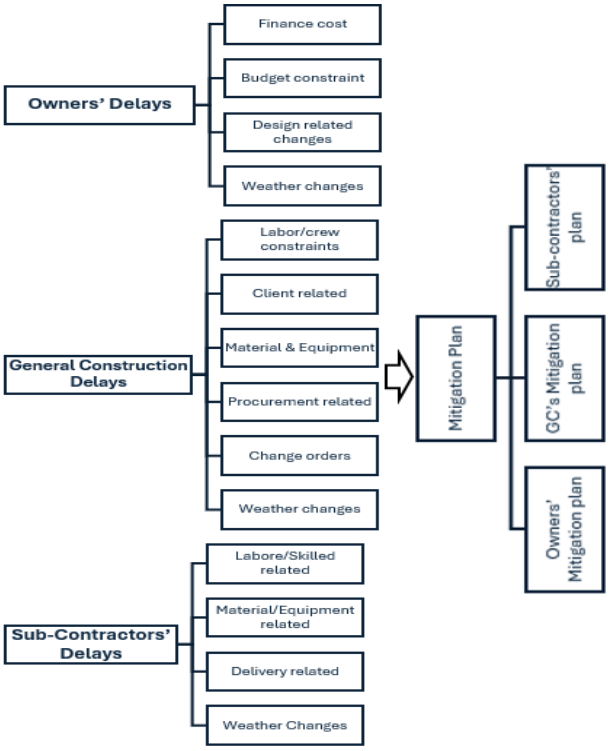

Figure 1. Conceptual model for the methodology of delay classification & mitigation plan

4. Discussion

The research objective was to identify the factors contributing to delays in construction projects. The authors developed a conceptual model and tested it with data collected from 420 respondents involved in construction projects. The theorized relationships were tested with regression analysis after verifying the survey instrument's psychometric features.

The findings highlight three critical sources of delays in construction projects: general/subcontractors, owners, and external factors. The results, as perceived by contractors, subcontractors, and owners, are significantly traced to construction project delays. The study further indicates that addressing owner-related factors can lead to a substantial reduction in delays. The paper underscores further the design-related impact factors on project schedules and the positive association of procurement-related factors with delays in the completion of construction projects. This finding aligns with previous studies - underscoring the significant funding-related impact factors on project schedules. The funding further pointed to Owners' finances and budgets as the most critical factors causing delays in construction projects. Several studies have found that inadequate funding and delay in sanctioning required finance to delay successfully implementing projects. The last finding of this study was the positive association of labor-related problems with delays in the completion of construction projects from both general and subcontractor points. Ohio's state occasionally experiences labor shortages, resulting in undue delays. Overall, the

findings reveal that all variables identified significantly contribute to construction delays in Ohio.

4.1. Survey Demographic

The paper's demographic profile of the participants is defined. The study's sample was 74% male and 26% female participants, reflecting a diverse gender distribution. In total, 9.8% of the population is 18–24 years old, 37.3% are between 24-34 years, 33.7% are aged 35-44 years, and 19.2% are identified as above 45 years old. Out of all the responders, 76% were post-graduate, with a majority holding degrees in construction management, engineering, or related fields, while 24% had completed their graduation. 61.1% of the individuals belonged to the subcontractor group, while 32.9% were classified as contractors. In total, 67.9% possess work experience ranging from 6 to 10 years, while 13.6% have accumulated over 17 years of professional experience. Additionally, 24.7% possess less than five years of experience. A notable majority of respondents, 78.2%, have said that construction delays frequently lead to reduced project profit, contributing to substantial loss, as in Table 1, a concerning trend for the industry.

Table 1. Respondents' socio-demographic characteristics Papers

No.	Profiles	*n*= 420	%
1	***Gender***		
	• Male	311	74
	• Female	109	26
2	***Age***		
	• 18-24 years	41	9.8
	• 25-34 years	157	37.3
	• 35-44 years	142	33.7
	• Above 45 years	81	19.2
3	***Education***		
	• Undergraduate	302	72
	• Post-Graduate	92	22
	• Other	25	6
4	***Category***		
	• Owner/Client	80	19
	• General Contractor	134	32
	• Sub-contractor	206	49
5	***Experience***		
	• Less than 5 years	80	19
	• 6-10 years	121	28.8
	• Above 10 years	219	52.2
6	*Would Construction delays lead to the profit loss of successful companies into unprofitable ones?*		
	• Yes	357	85
	• No	24	5.6
	• Maybe	39	9.4

4.2. Sampling Test Adequacy

Several factors were meticulously examined and excluded from the research due to their lack of significance, as determined using a combination of factor analysis and multiple regression analysis. Table 2 displays KMO and Bartlett's test SPSS interpretation for evaluating the selection method. The sample appropriateness, as specified by KMO, should exceed 0.5. However, the study findings indicate that in this example, it is a remarkably high 0.842, underscoring the importance of this research. This information is thus highly significant and is presented. in Table 2.

Table 2. Bartlett's and KMO test

KMO sampling adequacy test	0.842
Bartlett Test	
Chi-square (Apx).	103652.121
df.	422
Sig.	00.00

4.3. Factor Analysis Confirmation

Adhering to the recommendations of Anderson and Gerbing (1988), the paper followed a two-step approach. In the first step, the authors checked the measurement model and performed Confirmatory factor analysis (CFA). The results of CFA are shown in Table 3 (See Appendix 1). As indicated in the table, all the constructs' reliability coefficients were well above the acceptable levels of 0.60. The factor loadings of indicators to all constructs were above 0.60. The loads ranged from 0.64 to 0.84. The average variance extracted estimate (AVE) for all the constructs exceeded acceptable levels of 0.50 (Hair et al., 2014). These statistics provide discriminant validity.

4.4. Practical Implications

The research findings from this study highlight the significant factors affecting construction project delays, which have several implications for the stakeholders executing and managing construction projects. Project managers play a crucial role in understanding and addressing these factors as they struggle daily to complete the projects on time. The research findings suggest that project managers should be aware that the projects are significantly affected by various vital factors. Understanding these delay factors is essential as it can help in better planning, resource allocation, and risk management, ultimately leading to timely project completion.

The need for more materials and other resources is a pressing issue in project delays. The research results underscore the urgency of addressing these issues, as they can guide the formulation of policies and initiatives to reduce delays in commercial projects. Table 4 in Appendix 2 summarises the results, reinforcing the importance of immediate action.

4.5. Future Study and Limitations

This study's limitations concern cross-sectional research based on the survey method, and hence, the innate concerns of familiar method bias and social appeal bias are inevitable. However, the authors conducted Harman's one-factor method

to address the common method bias. The paper found that a single factor accounted for less than 35% variance, suggesting that common method bias causes no problem. To address the social desirability problem, the authors assured respondents about the anonymity of the responses. The present study centered on an industry stakeholders' sample of respondents from Ohio State representing mid-western states. Future studies with a more significant sample of respondents from other geographical states are urgently needed to further our understanding of project delays and improve project management practices.

This study is a crucial starting point for further exploration into the relative contributions and implications of post-COVID-19-related project delays. Its findings are not only significant for the current state of project management but also pave the way for future research in this area, making it an engaging and interesting read for academic researchers and practitioners in project management and related fields.

5. Conclusions

This research, which delved into the primary causes and consequences of construction project delays, is significant for the construction industry. It categorizes the delays into three main groups: contractors' delays, Owners' Delays, and External factors.

Contractor delays are the most common and pose the most onerous construction delays. Moreover, owners' and material -related delays are regarded as a significant hazard. Labor/ equipment and external factor-related delays are the least essential categories of concern. These data are primarily from the pre-pandemic period. The literature analysis and survey results show the following variables and causes of construction project delays. The owners'/contractors' delays in assuring quick payment of interim certificates within the required period to avoid interest penalty requirements, encourage project progress, and ensure project completion on schedule are among the most prevalent difficulties raised by respondents. On the other hand, contractors must offer an appropriate and clear work schedule, a thorough site management plan, and monitoring of critical activities to ensure that projects are completed on time and within budget.

The continuous rise in material prices threatens construction enterprises' profit margins. Instead of stockpiling building supplies on-site, strategic techniques to address these difficulties should focus on producing the materials off-site and transporting them to the site as needed. Extensive usage of emerging technologies is also necessary to investigate project delivery system optimization. The industry must embrace the adoption of Building Information Modeling (BIM), Virtual Design & Construction (VDC), and other emerging technologies like Artificial intelligence (AI) at the most basic economic level since it is a more efficient and cost-effective means of planning and managing projects. This early technology adoption is essential to address supply chain issues and labor concerns and narrow the communication gaps for project planning and execution.

This study's contribution assists policymakers in developing policies to advance digital technology and address the significant concerns of industry players.

The research underscores the study's ongoing relevance in the current industry landscape.

Disclosure

All data, models, and code generated or used during the study appear in the submitted article. The author had no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendixes

Table 3. (Appendix 1). Factor analysis confirmation

Construction Delay Option	Cronbach's Alpha	Standardized loadings ($\lambda^2 yi$)	Reliability ($\lambda^2 yi$)	Variance (var (εi))	Average variance extracted estimate $\sum (\lambda^2 yi\ i)/ [(\lambda^2 yi) + (Var\ (\varepsilon i))]$
Owner/Client	0.812				0.71
Delays in payments		0.93	0.72	0.11	
Delays in site delivery		0.81	0.79	0.26	
Delays in rectifying errors in documentation		0.85	0.68	0.30	
Slow decision-making		0.83	0.71	0.27	
Limited Site supervision authority		0.82	0.69	0.31	
Design	0.825				0.71
Insufficient information		0.80	0.84	0.41	
Delayed delivery of design		0.84	0.82	0.32	
Reworks due to changes		0.92	0.96	0.18	
Communication gap		0.68	0.71	0.25	

Construction Delay Option	Cronbach's Alpha	Standardized loadings (λ^2yi)	Reliability (λ^2yi)	Variance (var (ξi))	Average variance extracted estimate $\sum (\lambda^2yi\ i)/ [(\lambda^2yi) + (Var\ (\xi i))]$
Procurement	0.821				0.71
Late ordering and delay in delivery		0.84	0.76	0.28	
Lack of skilled resources		0.79	0.88	0.32	
Transportation issues		0.89	0.66	0.34	
Low productivity		0.87	0.61	0.21	
Financial	0.831				0.68
Late payment		0.85	0.64	0.14	
Insufficient funds		0.93	0.71	0.18	
Poor forecasting		0.78	0.85	0.21	
Cost over runs		0.88	0.61	0.16	
Economy slowdown		0.86	0.77	0.6	
Labor	0.842				
Resources Shortage		0.78	0.62	0.37	
Skilled labor Shortage		0.86	0.78	0.42	
Unexpected strikes		0.35	0.46	0.24	
Low productivity		0.96	0.65	0.29	
Communication gaps		0.89	0.54	0.23	

Table 4. (Appendix 2). Results of regression analysis

Dependent variable	Owners, Contractors' and Subcontractors delays perception			
Independent variables →	**β**	**S. E**	**'t' Values**	**'p' values**
Owner/Client	0.393***	0.044	8.120	0.001
Design	0.438***	0.041	7.323	0.001
Procurement	0.393***	0.045	6.472	0.001
Finance	0. 379***	0.042	8.864	0.001
Labor	0.387***	0.043	9.862	0.001
R^2	0.781	0.042	8.453	0.001
Adj R^2	0.773			
F	64.958***			
df	6,287			
Note: ***p < 0.001				

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