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Construction Project Delay Factors of Public Universities in Ethiopia: A Structural Equation Modeling Approach

Abenet Yohannes Hailu [a++*], Ismael Mohammed [a#], Dereje Alemu [b++] and Anley Gesese [c++]

[a] *Department of Accounting and Finance, Jigjiga University, Ethiopia.*
[b] *Department of Mathematics, Jigjiga University, Ethiopia.*
[c] *Department of Physics, Jigjiga University, Ethiopia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study aimed to identify causes of construction projects delay in Public Universities in Ethiopia.
Study Design: This was a cross-sectional survey using quantitative method.
Place and Duration of Study: Jigjiga, Haromaya, Dire Dewa and Kibrdhar universties between April and September 2022.

[++] *Assistant Professor;*
[#] *Lecturer;*
**Corresponding author: E-mail: abenetyohannes@gmail.com;*

Methodology: This study identified project delay factors and modelled the Partial Least Square Structural Equation (PLS-SEM) model. a structured questionnaire used to collect data from contractors, consultants and clients. Data were analyzed using SmartPLS4 software.

Results: The findings show that Clients, Contractors, Consultants, Materials, and Labor related factors significantly affect delayed projects. Labour-related factors had the greatest impact on construction delay, while the external factor had an insignificant effect on project delay. The overall model had 73.1% explanatory power. These findings might support practitioners and decision-makers to focus on potential construction delay factors that might occur in their current or future projects.

Keywords: Construction project; structural equation modelling; time overrun; SmartPLS.

1. INTRODUCTION

“As in most developing countries, Ethiopia's construction industry has significantly contributed to the economy’s growth through infrastructure development” [1]. It also enjoyed a large portion of the country's scarce funds. With a 72.2 percent share of industrial output, the construction industry grew by 6.6% in 2021, with the construction of roads, railroads, dams, and housing playing a significant role [2]. Almost two million individuals are working in construction, both permanently and temporarily [3]. Over the past two decades, the nation has seen a rapid growth of infrastructure development, particularly in the public sector, as public universities and other public entities invest in new projects. However, with this rapid increase in infrastructure projects, delays in the construction process are becoming more common, and this is a major problem for the nation. Delays are a key aspect in the overall performance of any construction project since they raise the cost of the project. Completing a project on time benefits all the parties involved, like the Consultant, Client and Contractor [4,5]. Therefore it’s necessary to identify the factors responsible for schedule delays in construction projects [6]. “A delay, according to Zack [7], is the time overrun either beyond the completion date indicated in the contract or beyond the date agreed upon by the parties for the delivery of the project”. Delays can also be caused by any "act or event" that makes it take longer than expected to meet the contract's terms. It's a global problem, it seems, for construction projects to run behind schedule [8].

“Time is a constituent component of a company's plan to perform a task or project. There is a strong relationship between project scope, time, and conditions. Any change in the areas mentioned above affects the project's overall performance” [9]. The owner and the construction company both lose money due to delays. If the contractor is too busy working on current projects, the owner will lose out on potential income while using the projects, and the contractor will have to pay more to keep the contract in place. Delays in building highways, flyovers, and other structures have a negative impact on the population at large. Overrunning the budget is almost inevitable if the project's timeline runs long. Time is a scarce resource that must be carefully monitored and planned for prior to the project's launch [10]. “Delay and its consequences are considered one of the supreme adverse factors in the Ethiopian construction industry” [11].

Generally speaking, a construction project is considered a success if it is finished on time, within budget, with the agreed-upon quality, in accordance with the specifications, and to the satisfaction of all parties involved. Additionally, projects have been evaluated based on their usefulness, contractors' profits, the lack of claims and litigation, and occupants' satisfaction with the building's "fitness for purpose." [6]. “Many public building construction projects in Ethiopia suffer delays; only 8.25% of projects were finished on the originally targeted completion date, and the remaining 91.75% were delayed 352% of their contractual time” [11]. “Construction project delays also result in conflicts and mistrust among concerned parties (designer, contractor worker, and consultant)” [12].

Researchers have made a number of efforts to identify the various factors that cause delays in such projects in different countries and for projects of different natures. Khona et al. [13], has shortlisted a number of factors and grouped them into nine major categories –Consultant related factors, contractor-related factors, Design related factors, equipment-related factors, External related factors, labour-related factors, Material related factors, owner-related factors and Project-related factors among those, identified ones that affect the most were payment to contractors, transparency in contract awarding, proper vendor selection, effective planning [14] in his research “to identify the causes and effects of delays on construction delivery time identified a lack of working capital finance, frequent design changes, ineffective communication practices, and slow decision-making as the ones affecting the most”. Khona et al. [13] in their research “blamed frequent changes in client requirements and poor contractor selection for causing project delays. In general, conflicts between involved parties, ineffective procurement strategies, working capital issues, sluggish decision-making, and frequent changes in user requirements are the factors highlighted in a number of research efforts carried out to identify common delay-causing factors in projects”.

According to Yahya and Al-Emad [15], Construction delay is defined as completing a project later than the time stipulated and agreed upon by the involved individuals or parties. Delays in construction projects are now considered the norm. According to Emeka [16], the top twenty reasons of construction project delays are also classed as non-excusable delays, which a client will not tolerate. These delays also result in significant damages and losses for the company. Time overruns are a significant issue for civil engineering development projects in Ethiopia. These delays affect every project stage, from planning to execution to final inspection, and can cost anywhere from 13 per cent to 183 per cent of the original contract. The percentage of the total contract cost at completion attributable to time and cost overruns varies from 1% to 47% [17]. To improve higher education accessibility, the Ethiopian government has allocated its scarce financial resources to expand public universities and equip them with the necessary facilities and infrastructure. However, completing projects at the allocated cost and time becomes difficult.

Time overrun affecting construction project progress; It reduces the profit, which leads to enormous losses and leaves the project in complex situations. Construction time is one of the peak success criteria for a project throughout its lifecycle and is of serious concern to those involved in the construction industry [18]. The government has allocated an additional 44.3 billion Br from its budget to prop up 290 poorly planned and managed public projects. The recent audit also revealed that 32 projects had been delayed for more than five years due to poor project management, 54 projects remain suspended for up to five years, 208 projects are delayed by a year to three years, and 75 projects are suspended between a half year and 12 months. In addition, 16 other public projects that commenced work without feasibility studies were terminated after spending 246.6 million Birr [19]. As to the researchers’ knowledge and available literature, there are no adequate empirical studies about the causes of construction projects delay in higher public universities in Ethiopia. Therefore, this study intends to determine the current determinant factors of time overrun of construction projects in selected public universities.

2. LITERATURE REVIEW

Delay is an incident that extends the time required to accomplish all or a portion of a project [20]. If an extension of time is granted, a delay may also be described as the time that elapses after the original contract deadline has passed. Time elapsed past the completion date stipulated in the contract is the delay examined here; whether or not more time has been granted is irrelevant.

Several factors can cause delays in construction projects, some of which are related to political instability, economic instability, cultural differences, climate, security, and infrastructure [21]. The common causes of delays in road construction projects in developing countries include Lack of proper planning and project management, insufficient funding and financial mismanagement, poor quality of materials and equipment, delays in securing permits and environmental clearances, labor shortages, and low productivity, unforseen site conditions, and natural disasters [22,23]. Lack of clear communication and coordination among project stakeholders: This can lead to misunderstandings and disputes that can slow down the progress of the project [24]. Lack of available labor or skilled workers: Skilled workers may be in high demand, which can result in delays due to the inability to find enough workers to complete the project [25]. Unanticipated changes in project scope can cause delays, as they often require re-planning and re-scheduling of work [26]. Adverse weather conditions can disrupt construction activities and cause delays [27]. These are just a few of the many factors that can contribute to delays in construction projects. Project managers need to identify and address these factors in order to minimize the risk of delays and ensure the successful completion of the project.

Project delay is a global problem [8]; it has far-reaching consequences for countries' economies [28]. Whenever there is a time overrun (delay), the parties to the building contract are forced to grapple with a wide range of intricate problems that are of paramount importance. These concerns relate to the right to recover delay fees or the obligation to extend the project with the ensuing right to recover costs for schedule revisions under the contract. People start wondering what went wrong when there is a delay, and arguments and lawsuits often follow as parties try to assign blame [29].

Several studies [30] show that the construction sector around the world regularly has setbacks that prevent them from completing their projects on time. As Sanders and Eagles put it, a delay is "an incident that causes extended time to finish all or part of a project" [31]. A number of issues have been identified as the root cause of the construction project's ongoing delay. It can be broken down into two groups, those within the organization (client, Contractor, consultant) and those outside the organization [32]. Several researchers [33–35] have emphasized the need for early detection of construction delays and the development of effective solutions to these problems. It is difficult to study and classify delays because of the many activities involved in each construction project, as noted by Sweis et al. [36], who believe that delays occur in all sizes and types of construction projects, from the simplest to the most complicated. Numerous investigations have been done, and numerous causes related to the construction project have been found [35,37]. Extreme weather, resource scarcity, financial difficulties for public organizations and contractors, ineffective contract management, material shortages, and insufficient resources are all examples of such factors.

Problems with delays in the Egyptian building industry were explored by Amer [38]. According to the research, the following are the most common causes of building delays in Egypt: poor contract administration, unrealistic timetables, insufficient client funding, payment delays, design changes during construction, and a lack of cement and steel, to name a few. The problem has been proven to be just as pressing in Arab nations. According to research done in Saudi Arabia's construction business [39], major building projects often run behind schedule due to misunderstandings between contractors, builders, and clients. The factors were broken down into nine categories: money, resources, contracts, governments, people, plans, machinery, and the natural world. These reasons were later applied by Aibinu and Al-Lawati [40] to update the list of delay causes in the Egyptian construction industry. They also underlined the value of consultants and owner payments in minimizing project delays for major building endeavours.

2.1 Client-Related Factors

Several studies have pinpointed causes of delay that are directly related to the client. Clients experience a loss of income, decreased productivity, continued reliance on in-house assets, and a dearth of resources available for rent when building projects run behind schedule [41]. According to research done in Lebanon [42], clients worry primarily about money. [43] Research on building initiatives in Malaysia. Extending the idea presented by Mezher and Tawil [42], they provided survey proof that financial issues are the primary cause of construction project delays. Customers look to the lead contractor to absorb schedule risk and pay any associated penalties [44]. Late or nonpayment to contractors by clients is the primary cause of delay in Saudi Arabian construction projects, according to multiple studies [45–48]. Customers' requests for modifications are another major cause of building delays [39]. It has been found that obtaining client approval is a leading cause of construction project delays [45]. As reported Al-Khalil and Al-Ghafly [46], it has been discovered that client decisions are the leading cause of delays in the building industry. The client's lack of technical knowledge is the root cause of the decision-making bottleneck. According to research [49,50]. Based on the literature above, the following hypothesis was formed for this investigation:

Hypothesis 1: Client-related factors have a significant effect on project delay.

2.2 Contractor-Related Factors

Several studies by different academics pinpointed causes of delay that were directly or indirectly connected to contractors. Contractor incompetence in planning, site management, and experience are identified as primary sources of delay [8]. The main causes of delay include contractors' financial problems, subcontractors' problems, and the quality of the contractors' work [49,50]. To the same extent, Frimpong and Oluwoye [30] has shown that issues associated with the contractor significantly contribute due slippage. Poor site management, subcontractors, inadequate planning, methodologies employed for construction, and insufficient contractor expertise are some of the primary concerns noted by Odeh and Battaineh [35] in their writing about contractor-related delaying factors. Rework due to errors, poor communication and organization, ineffective project planning and scheduling, improper construction method implementation, insufficient contractor work, frequent change of subcontractors, poor technical staff qualification, and site deployment are all reported as significant factors contributing to project failure [51]. Following a thorough review of the literature, the following hypothesis has been developed for the objectives of this inquiry.

Hypothesis 2: Contractor-related factors have a significant effect on project delay.

2.3 Consultant-Related Factors

Only a few studies have focused on consultants. It has been apparent, however, that consultants often struggle to deal with new projects because of a lack of knowledge and a lengthy review process for design papers [52]. It is common for contractors and clients to blame the delay on the consultancy firms, saying they now have smaller labour than before. Based on prior [6,49,50], According to the consultant's report, the primary causes of a delay are the contractors' lack of preparation, the contractors' poor site management, the client's failure to pay for finished work, and a lack of necessary equipment and materials. Drawing alterations, inefficient consultants, drawing preparation and approval, improper site investigation, contract management, slow response and inspection—these are some of the most common issues that occur from consultants in Pakistan's construction industry [41]. According to research conducted by Kenny and Vanissorn [53], consultants would benefit from being informed about the site condition and construction procedures in advance of the design process. The following hypothesis has been advanced in light of the foregoing discussion:

Hypothesis 3: consultant related factors have a significant effect on project delay.

2.4 Material-Related Factors

The quality of the Material used is also crucial in a building. Researchers have spent a lot of time trying to pin down what is causing delays in the construction sector, and they keep coming up with one thing: materials. The most significant cause of construction delay is usually the late arrival of necessary materials [54]. The quality of materials and the shortage of Materials during the execution of projects are the key variables responsible for delaying a project [8,49]. According to research [55], the most time-consuming part of the construction process is choosing the appropriate materials. Materials shortages and late deliveries are two major reasons for delay [36]. Aibinu and Jagboro [56] Material management issues were found to be the primary cause of the project's late start. Thus the following hypothesis has been proposed:

Hypothesis 4: Material-related factors have a significant effect on project delay.

Meditating variable:

Hypothesis 4A: Material-related factors indirectly affects Project delay through the Contractor factor.

2.5 Labour-Related Factors

Today, a shortage of available workers is a significant issue in the building sector [57]. Reasons for this issue are widespread [58]. An increase in labour is said to be the root cause of skilled labour shortages [59]. Insufficient availability of skilled, semi-skilled, and unskilled labour also contributes to building project delays [36]. Similarly, out of a total of twenty-eight potential bottlenecks, the supply of workers in Malaysia was ranked seventh [8]. This demonstrates the significance of factors connected to labour in prolonging the completion of a building project. According to Wei [51], direct construction workers are critical to the success of any construction project and its timely completion. A study by Assaf and Al-Hejji [60] reported that building project delays are caused by a lack of labour, unskilled labour, foreign labour, a low productivity level, and personal conflicts among labourers. Following a review of the existing literature, the following working hypothesis has been developed for this investigation:

Hypothesis 5: labour related factors have a significant effect on project delay.

Meditating variables:

Hypothesis 5A: labour related factors indirectly affect Project delay through the Client factor.

Hypothesis 5B: labour related factors indirectly affect Project delay through the consultant factor.

Hypothesis 5C: labour related factors indirectly affect Project delay through the Contractor factor.

2.6 External Factors

Any building project in Nigeria is susceptible to setbacks caused by forces beyond its control [8]. They list weather, rule and regulation changes, neighbour issues, and unanticipated site circumstances as examples of external influences [41]. Natural catastrophes, unforeseen site circumstances, organizational shifts, new rules and regulations, disagreements, and problems with neighbours are reported to be the most important and highly ranked variables in Pakistan's building business. To that end, [6] noted that weather, regulatory changes, conflicts with neighbours, and unforeseen site circumstances are the primary external variables responsible for construction delays in Saudi Arabia. There are eight external factors that, according to Wei [51], can delay a building project. The effects of the subsurface and ground conditions (soil, high water table, etc.), obtaining licenses from the municipality, effects of weather on construction activities, traffic control and restriction at a job site, accidents during construction, changes to government guidelines and rules, provision of services from utilities (such as water, electricity, telephone, etc.), and final audit and certificating are the most important external factors, in his opinion. The resulting hypothesis is that:

Hypothesis 6: External-related factors have a significant effect on project delay.

Meditating variable:

Hypothesis 6A: External-related factors *indirectly affects Project delay through the Contractor factor.*

Hypothesis 6B: *External factor indirectly affects Project delay through the Client factor.*

2.7 Effects of Construction Project Delay

When construction projects are delayed, the effects often negatively affect the stakeholders. Research conducted by Aibinu and Jagboro [56] showed the effects of the delay in the construction industry of Nigeria. They discovered five possible common effects that arise in most countries due to the delay. These effects were:

• Cost overruns
• Time overruns
• Disputes
• Arbitration and litigation and
• Total abandonment of the project

3. MATERIAL AND METHODS

The current study's research methodology has implemented a questionnaire survey to test the conceptual model of project delay factors in the construction projects of higher public institutions. An extensive literature review was carried out along with the interaction between construction practitioners through a pilot study to identify indicators for six latent constructs influencing Project delay. The questionnaire is framed and then distributed to clients, contractors and consultants working on construction projects at Haromaya, Dire Dewa, Jigjiga and Kibredehar Universities. The questionnaire for the survey consists of two parts; the first part is designed to gather information on the organization’s profile and the respondent's personal information. The second part of the questionnaire includes 53 statements under seven constructs, i.e., the client (CL), Contractor (CN), consultant (CS), Labour (LA), materials (MT), External (EX) and project delay (PD). Each statement is designed to elicit the respondents’ opinions on the different attributes in the context of causes of project delay using a 5-point Likert scale, with point 1 representing very little effect, point 2 representing little effect, 3 point representing average effect, 4 point representing high effect and point 5 representing very high effect. This approach enables the evaluation of the respondent’s perception regarding the causes of project delay. The indicators gathered from the literature review provide the hypothetical basis for developing the conceptual model as shown in Fig. 1 using partial least square SEM. By using [61] Samling's method, a 300 sample was determined. A relative proportion of respondents was selected from each university. A questionnaire was distributed to 300 respondents and got the filled questionnaire back from 296 respondents at a response rate of about 98%. Most of the respondents are working with clients (50%) organizations, followed by contractors (35%) and consultants (15%). The analysis used 296 completed questionnaire sets which is sufficiently based on [62] rule of thumb for the sample size required in PLS-SEM Statistical investigation and analysis of this research are based on component-based partial least squares structural equation modelling. There are two types of assessment carried out in the conceptual model - Assessment of the outer measurement model and Assessment of the inner structural model. The analysis and validity of the model are carried out using smart PLS v.4 software [63].

The conceptual framework of this study is based on an extensive review of construction delay literature; a structural equation model using a component-based Partial Least Squares (PLS) approach is constructed by setting up twelve hypotheses with 53 attributes, as shown in Table 1 for seven factors such as client (CL), Contractor (CN), consultant (CS), Labour (LA) materials (MT), External (EX) and project delay. The literature review provided the theoretical basis to develop the conceptual model. The framework is analyzed by partial least squares structural equation modelling, which focuses on predicting and explaining target constructs. The estimation procedure for PLS-SEM is an ordinary least square regression-based method rather than the maximum likelihood estimation procedure for covariance-based SEM. PLS-SEM uses available data to estimate the path relationships in the model with the objective of minimizing error terms of the endogenous constructs. It estimates coefficients that maximize the R^2 values of the endogenous constructs. Using this framework of factors and dimensions of project delay, a hypothetical diagram of the structural model is presented in Fig. 1. The arrow represents the direction of hypothesized influences in the structural model.

Table 1. Identification of indicators for project delay

Constru	Cod	Description of Indicators for Project	Reference
Client Related Factors	CL1	Delay in handing over the site to the contractor	[8], [30], [35], [50], [51], [64]
	CL2	Delay in release of mobilization advance	
	CL3	Lack of issuing of necessary instructions and approvals	
	CL4	Extra work apart from the scope	
	CL5	Delay in the testing of materials and approvals	
	CL6	Actual site conditions differ from the design condition	
	CL7	Lack of communication and teamwork	
	CL8	Delay in approval of variation orders and interim payments	
	CL9	Owners' cash flow problem	
	CL10	Lack of ability of decision making	
Contractors Related Factors	CN1	Lack of professional engineers and other technical staff	[39], [41]–[48], [64]
	CN2	Cash flow problem	
	CN3	Lack of resources	
	CN4	Poor planning and scheduling	
	CN5	Poor communication, coordination, and teamwork with other parties	
	CN6	Actual site condition differing with specifications and drawings	
	CN7	Difference between actual and BOQ's quantities	
	CN8	Increase the amount of rework	
	CN9	Inadequate construction experience	
	CN10	Conflicts between the contactor and other parties	
Consultants Related Factors	CS1	Less experience in construction work	[6], [41], [52], [53], [64]
	CS2	Delay in issuing instructions and approvals	
	CS3	Lack of communication with the contractor's technical and other staff	
	CS4	Delay in the evaluation of interim payment and variation orders	
	CS5	By issuing wrong instructions, an increase in rework	

Constru	Cod	Description of Indicators for Project	Reference
	CS6	Delay in inspection and testing	
	CS7	Late approval of shop drawings	
	CS8	Delay in informing scope growth of the owner	
	CS9	Conflicts between site engineer and contractor	
	CS10	Lack of maintenance and follow-up contract documentation	
Labour Related Factors	LA1	Scarcity of Skilled Labour	[6], [8], [36], [51], [57]–[59], [64]
	LA2	Lack of supervision and not assigning specific work to each labour	
	LA3	Mismanagement of labour	
	LA4	Labour laws and regulations	
	LA5	Idling of labour	
Materials Related Factors	MT1	Approval of required quality of Material	[8], [36], [54]–[56], [64]
	MT2	Actual transported Material deferring with approved quality	
	MT3	Scarcity of Material	
	MT4	Less a transportation facility to transport Material	
	MT5	Increase in the price of Material	
	MT6	Lack of additional stocks of Material	
	MT7	Protection of Material from the weather until it uses for the construction	
	MT8	Procurement delay in special kinds of Material	
External Related Factors	EX1	Natural disasters	[6], [8], [41], [51], [64]
	EX2	Weather condition	
	EX3	Strikes	
	EX4	Violations of acts, rules and regulations of other organizations	
	EX5	Changes in government regulation and laws	
Project Delay	PD1	Time Overrun	[8], [30], [35], [50], [51], [64]
	PD2	Poor quality	
	PD3	Delay of other projects related to the main one.	
	PD4	Litigation and court case	
	PD5	Dispute between parties	

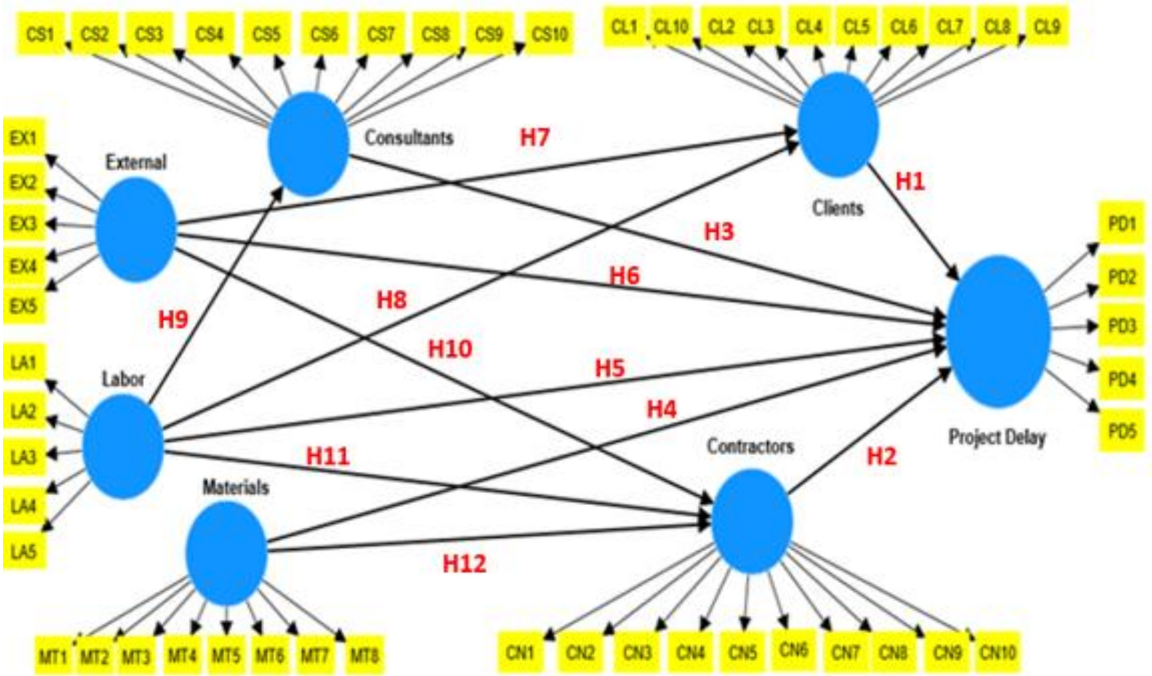

Fig. 1. Initial Conceptual PLS SEM Model for Project Delay

4. RESULTS AND DISCUSSION

4.1 Assessments on Measurement Model

In assessing reflective measurement models, the first step is to examine the reliability of indicators by determining how much of the indicator's variance can be attributed to its construct. This is done by calculating the indicator loading, which is the square of the bivariate correlation between the indicator and the construct. Adequate reliability is indicated by indicator loadings of at least 0.708, which means the construct accounts for over half of the variance in the indicator. However, in social science research, indicator loadings tend to be lower, especially when using newly designed scales. Therefore, researchers should consider other criteria of reliability and validity before eliminating indicators with loadings below 0.70. [65]. Additionally, the impact on content validity, or how well the measure captures all aspects of a particular construct, should also be taken into account. Indicators with loadings below 0.40 should be routinely dropped from the measurement model, but those between 0.40 and 0.708 should only be removed if it improves internal consistency reliability or convergent validity [54].

Initially, the overall sample was assessed, and the outer loadings of items such as LA1, CS1, CS2, CS9, EX1, EX3 and EX5 were less than 0.5. Hence, to improve Composite Reliability (CR) and Cronbach's alpha (α) > a 0.7 value and to make the latent variable correlation as per the rule demonstrated by Fornell and Larcker [66], the items having factor loadings smaller than 0.5 were discarded. Next, the outer measurement model is assessed for convergent validity. The measure of internal consistency is convergent validity, which is estimated to ensure that indicators assumed to measure each factor measure them and not measure another factor. In the partial least squares path modelling, three tests can be used to determine the convergent validity of the measured constructs, i.e., Cronbach's alpha, Composite Reliability Scores (CR), and Average Variance Extracted (AVE).

In the final iteration, running the PLS algorithm in Smart PLS software (Version 4) resulted in Cronbach's alpha and Composite Reliability Score (CR) values higher than the recommended value of 0.7. the Average variance extracted (AVE) was also higher than 0.5, as suggested by the researchers [29,40,67] and confirming the adequate reliability and convergent validity of the outer measurement model. The results for reliability and Convergent validity, along with the factor loadings, are presented in Table 2. The result of indicators' reliabilities and Average Variance Extracted (AVE) after the elimination of indicators with low correlation values is shown in Fig. 2. Once the iteration process is completed, the final model is checked for discriminant validity. Discriminant validity indicates the extent to which the given factor is different from other factors. Three measures are used for assessing it, i.e., the Fornell-Larcker criterion, Cross loadings test, and Heterotrait-Monotrait Ratio (HTMT) values [65].

Where each indicator loading is higher for its construct than for any other construct and each of the constructs or latent variables loads highest with its indicators or assigned items, it can be generalized that the indicators of the latent variable or construct are discriminant of each other [68]. Table 3 reports on the cross-loadings of all the items. It is observed that all the factors' loadings are greater than their cross-loadings, which is a sign of discriminant validity.

Discriminant validity was also tested using the criteria suggested by Fornell and Larcker and Heterotrait-Monotrait Ratio (HTMT) method. The discriminant validity at the construct level is assessed by the Fornell-Larcker criterion and suggests that an enabler shares more variance with its assigned indicators than with any factors. The correlation matrix of the factors in which main diagonals are the square root of the average variance extracted (AVE). The results indicate that the square root of AVE is greater than the correlation value of the construct shared on other constructs. all the Heterotrait-Monotrait Ratio (HTMT) values also did not exceed the 0.9 threshold which indicates the presence of discriminant validity. The implication is that the various latent variables are distinct and different from each other. The result of both methods is reported in Table 3. The construct measures in the measurement model are confirmed as reliable and valid; the next step is to assess the structural model results.

Table 2. Construct reliability and validity

Construct	Code	First iteration				Final iteration			
		Outer loading	Alpha	CR	AVE	Outer loading	Alpha	CR	AVE
Clients	CL1	0.80	0.94	0.95	0.64	0.80	0.94	0.95	0.64
	CL2	0.84				0.84			
	CL3	0.86				0.86			
	CL4	0.88				0.88			
	CL5	0.87				0.87			
	CL6	0.81				0.81			
	CL7	0.80				0.80			
	CL8	0.72				0.72			
	CL9	0.68				0.68			
	CL10	0.69				0.69			
Contractor	CN1	0.69	0.92	0.93	0.57	0.69	0.92	0.93	0.57
	CN2	0.73				0.73			
	CN3	0.80				0.80			
	CN4	0.85				0.85			
	CN5	0.85				0.85			
	CN6	0.84				0.84			
	CN7	0.78				0.78			
	CN8	0.73				0.73			
	CN9	0.65				0.65			
	CN10	0.61				0.61			
Consultants	CS1	0.47	0.91	0.93	0.57	Omitted	0.93	0.95	0.72
	CS2	0.52				Omitted			
	CS3	0.74				0.71			
	CS4	0.84				0.84			
	CS5	0.93				0.95			
	CS6	0.86				0.89			
	CS7	0.91				0.93			
	CS8	0.78				0.77			
	CS9	0.50				Omitted			
	CS10	0.79				0.81			
Labour	LA1	-0.08	0.79	0.87	0.64	Omitted	0.92	0.94	0.80
	LA2	0.88				0.88			
	LA3	0.94				0.94			
	LA4	0.92				0.92			
	LA5	0.85				0.85			
Materials	MT1	0.83	0.92	0.93	0.63	0.83	0.92	0.93	0.63
	MT2	0.87				0.87			
	MT3	0.86				0.86			
	MT4	0.83				0.83			
	MT5	0.74				0.74			
	MT6	0.78				0.78			
	MT7	0.67				0.67			
	MT8	0.75				0.75			
External	EX1	-0.64	-0.71	0.00	0.52	Omitted	0.71	0.87	0.77
	EX2	0.88				0.92			
	EX3	-0.64				Omitted			
	EX4	0.85				0.84			
	EX5	-0.54				Omitted			
Delay	PD1	0.72	0.91	0.93	0.74	0.72	0.91	0.93	0.73
	PD2	0.89				0.89			
	PD3	0.93				0.93			
	PD4	0.90				0.90			
	PD5	0.83				0.83			

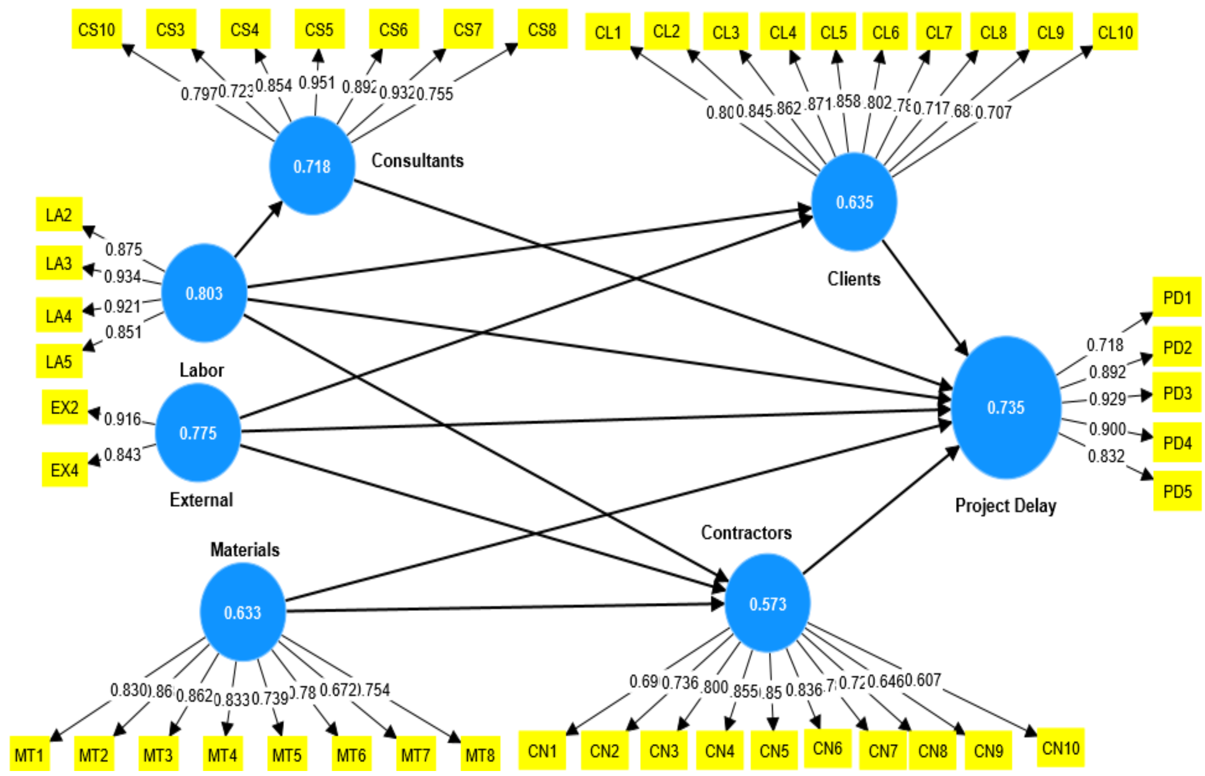

Fig. 2. Final PLS Path model for project delay

4.2 Evaluation of the Structural Model

The construct measures in the measurement model are confirmed as reliable and valid, and the next step is to assess the structural model results. This involves examining the model's predictive capabilities and the relationships between the constructs. For assessing the inner structural model, the criterion checked is multicollinearity assessment, T-statistic value and Path coefficient (*p*-value), Effect size, and Predictive relevance of the model.

4.2.1 Multicollinearity

In structural models, it is essential to check whether any significant level of collinearity exists between predictor or explanatory variables. Tolerance values below 0.2 and VIF values above 5 in PLS-SEM suggest the possibility of collinearity [62]. Tolerance or VIF guidelines may suggest deleting constructs, combining predictors into a single construct, or developing higher-order constructs if collinearity is detected. As shown in Table 4, all VIF values are below 5, indicating no collinearity issues. That latent variables are independent of each other, and that change in one does not affect the other variables and vice versa.

4.2.2 Estimation of Path Coefficients (β) and T-statistics

Computing path coefficients in PLS path models allows for testing of the structural model and relevance of the hypothesis (p-value). Partial least squares path models do not require normally distributed data and are measured by the squared multiple correlations (R2) between each latent endogenous variable and the dependent and independent variables. The bootstrapping method is used to determine the significance of the hypothesis [68]. Bootstrapping procedure using 5,000 sub-samples was performed to estimate the significance of the path coefficients. Table 5 shows the hypothesized path coefficient values along with the T- statistics (bootstrap) values. The relationship between Clients and Project Delay is significant with $\beta = 0.291$, and T-value = 6.341 has a direct positive significant influence on Project Delay at the 5% significance level. This indicates that a 100-point change in Clients will bring about 29.1-point changes in Project Delay. The Contractor factor changes directly to the Project Delay factor with a coefficient of 0.277. This indicates that a 100-point change in contractor will bring about 27.7-point changes in Project Delay.

Table 3. Cross-loading test for discriminant validity

	Clients	Contractors	Consultants	Labour	Materials	External	Project Delay
CL1	0.796						
CL2	0.841						
CL3	0.862						
CL4	0.875						
CL5	0.866						
CL6	0.812						
CL7	0.798						
CL8	0.72						
CL9	0.68						
CL10	0.693						
CN1		0.688					
CN2		0.734					
CN3		0.798					
CN4		0.854					
CN5		0.848					
CN6		0.836					
CN7		0.782					
CN8		0.726					
CN9		0.646					
CN10		0.611					
CS3			0.712				
CS4			0.844				
CS5			0.947				
CS6			0.886				
CS7			0.934				
CS8			0.767				
CS10			0.809				
LA2				0.877			
LA3				0.935			
LA4				0.92			
LA5				0.849			
MT1					0.83		
MT2					0.868		
MT3					0.862		
MT4					0.833		
MT5					0.74		
MT6					0.784		
MT7					0.672		
MT8					0.753		
EX2						0.917	
EX4						0.842	
PD1							0.718
PD2							0.891
PD3							0.929
PD4							0.900
PD5							0.832

The relationship between Consultants and Project Delay is significant, with β = 0.195, and T-value = 4.739 at the 5% significance level has a direct positive significant influence on Project Delay. This indicates that a 100-point change in consultants will bring about 19.5 -point changes in Project Delay. The relationship between Labour and Project Delay is significant with β = 0.337, and T-value = 9.095 (Table value is 1.96 at the 5% significance level) has a direct positive significant influence on Project Delay. The Labour factor changes in direct proportion to the Project Delay factor with a coefficient of 0.337. This indicates that a 100-point change in labour will bring about 33.7-point changes in Project Delay. The relationship between Materials and Project Delay is significant with β = 0.133 and T-value = 2.963 (Table value is 1.96 at the 5% level of significance level direct positive significant influence on Project Delay. The Materials factor changes directly to the Project Delay factor with a coefficient of 0.133. This indicates that a 100-point change in Materials will bring about 13.3-point changes in Project Delay. The model analysis results revealed that the entire hypothesis in the path model of Project Delay is significant except for three hypothetical paths. Table 6 shows that the effect of the External factor on Project Delay, Clients, and Contractors is insignificant at the 5% significance level and with β = 0.045, 0.073 and 0.104, respectively. The Beta values of each path in the conceptual model were compared, and it was found that the hypothetical path Labour -> Project Delay has a higher path coefficient of 0.337, which indicates that Labour-related factors have a significant effect on Project Delay.

4.2.3 Model's explanatory power

R^2 is a measure of the model's explanatory power, representing the variance explained in each endogenous construct [69]. In PLS path models, the squared correlation values of 0.67, 0.33 and 0.19 are considered substantial, moderate and weak, respectively [68]. The R^2 value for contractor, consultant and Client latent endogenous constructs, as shown in Fig. 3, is below the threshold value of 0.19, and the values are Weak. Whereas the constructs project delay with the squared correlation values of 0.731 has a substantial value. This indicates that the model is well-fitted, given that it is beyond the acceptable threshold of 0.5.

4.2.4 Effect size f^2

The effect size measures each predictor construct on the dependent construct. When an independent construct is omitted from the model, the PLS path model measures the changes in squared correlation values. It determines whether the omitted independent construct has a substantive effect on the value of the dependent construct. The formula for calculating effect size f^2 [68] is given by the following equation.

$$f^2 = \frac{R^2\ included - R^2 excluded}{1 - R^2\ included} \quad (1)$$

Table 4. Fornell-Larcker criterion & HTMT

	Clients	Consultants	Contractors	External	Labour	Materials	Project Delay
Clients	***0.797***	0.643	0.190	0.086	0.302	0.683	0.693
Consultants	0.613	***0.847***	0.190	0.048	0.308	0.525	0.629
Contractors	0.234	0.208	***0.757***	0.110	0.266	0.263	0.508
External	0.060	-0.017	0.088	***0.880***	0.064	0.060	0.077
Labour	0.281	0.285	0.264	-0.052	***0.896***	0.359	0.648
Materials	0.643	0.499	0.292	-0.026	0.330	***0.795***	0.642
Project Delay	0.654	0.591	0.516	0.062	0.590	0.608	**0.857**

Note: diagonal and vitalized are the square root of Ave. below the diagonal elements are the correlation between the construct's values. Above the diagonal elements are the HTMT values

Table 5. Multicollinearity assessment

	Clients	Consultants	*Contractors*	External	Labour	Materials	Project Delay
Clients			1.740				2.144
Consultants	1.000						1.680
Contractors							1.149
External	1.000		1.014				1.028
Labour		1.000	1.136				1.191
Materials			1.788				1.871

Table 6. Hypothesis testing

Hypothetical Path	Standardized Beta	T-Statistics	P values	Inference
Clients -> Project Delay	0.291	6.341	0.000	Supported
Contractors -> Project Delay	0.277	8.217	0.000	Supported
Consultants -> Project Delay	0.195	4.739	0.000	Supported
Materials -> Project Delay	0.133	2.963	0.003	Supported
Labour -> Project Delay	0.337	9.095	0.000	Supported
External -> Project Delay	0.045	1.436	0.151	Not supported
External -> Clients	0.073	1.166	0.244	Not supported
Labour -> Clients	0.288	5.176	0.000	Supported
Labour -> Consultants	0.285	5.084	0.000	Supported
External -> Contractors	0.104	1.790	0.073	Not supported
Materials -> Contractors	0.229	3.710	0.000	Supported
Labour -> Contractors	0.193	3.498	0.000	Supported

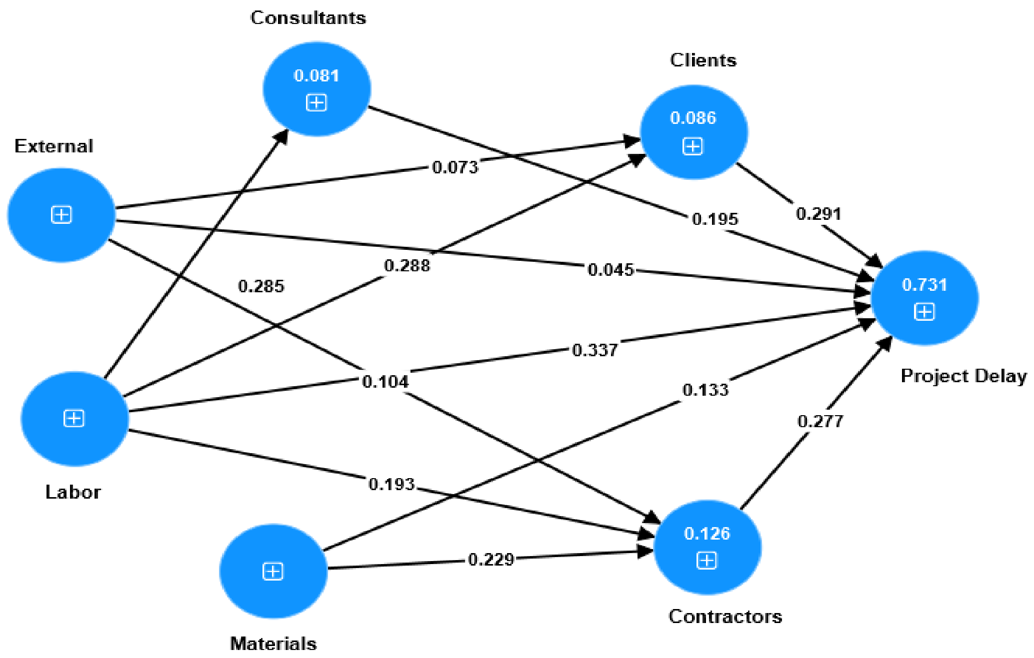

Fig. 3. Measuring the value of R^2

The effect of predictor independent construct is large at the structural level if f^2 is 0.35, and it is medium if f^2 is 0.15, and small if f^2 is 0.02 (Cohen, 1988), and the results and inference are tabulated in Table 7.

4.2.5 Model's predictive relevance

Calculating Q^2 statistics indicates the quality of the partial least squares path model. The model can predict the future by reproducing the observed values in a controlled environment through blindfolding procedures [70]. If Q^2 in a structural equation model is larger than zero, then the model has predictive relevance; otherwise, the model is not predictively meaningful. Small (0.02), medium (0.15), and big (0.35) values imply that an exogenous construct has a small, medium, or large predictive relevance for a chosen endogenous construct, respectively. In the developed PLS Path model, Cross validated redundancy approach is applied to predict the omitted data points. The q^2 effect size for the predictive relevance of the model and inference are tabulated in Table 8. In the path model, the predictive relevance q^2 effect size of Project Delay has a value of 0.471, indicating that the Project Delay construct has large predictive relevance. The results and inference are tabulated in Table 8.

Table 7. Effect size f^2

Dependent construct	Independent construct	R^2 (included)	R^2 (excluded)	Effect size	Inference
Project Delay	Clients	0.731	0.692	0.146	Small effect
Project Delay	Contractors	0.731	0.662	0.258	Medium effect
Project Delay	Consultants	0.731	0.709	0.083	Small effect
Project Delay	Materials	0.731	0.721	0.038	Small effect
Project Delay	Labour	0.731	0.646	0.317	Medium effect
Project Delay	External	0.731	0.729	0.009	No effect
Clients	External	0.086	0.081	0.006	No effect
Clients	Labour	0.086	0.003	0.091	Small effect
Consultants	Labour	0.081	0	0.088	Small effect
Contractors	External	0.126	0.117	0.011	No effect
Contractors	Materials	0.126	0.077	0.057	Small effect
Contractors	Labour	0.126	0.097	0.034	Small effect

Table 8. Predictive relevance of the model

	Q^2predict	Inference
Clients	0.070	Small predictive relevance
Consultants	0.073	Small predictive relevance
Contractors	0.103	Small predictive relevance
Project Delay	0.471	large predictive relevance

Table 9. Mediating effects of the construct in the path model

Construct	Mediating construct	Direct effect	Indirect effect	Total effect	t-value	P values
Clients -> Project Delay		0.291		0.291	6.341	0.000
Consultants -> Project Delay		0.195		0.195	4.739	0.000
Contractors -> Project Delay		0.277		0.277	8.217	0.000
External -> Clients		0.073		0.073	1.166	0.244
External -> Contractors		0.104		0.104	1.790	0.073
External -> Project Delay	Clients, Contractors	0.045	0.050	0.095	2.383	0.017
Labour -> Clients		0.288		0.288	5.176	0.000
Labour -> Consultants		0.285		0.285	5.084	0.000
Labour -> Contractors		0.193		0.193	3.498	0.000
Labour -> Project Delay	Contractors, Consultants, Clients	0.337	0.193	0.530	10.799	0.000
Materials -> Contractors		0.229		0.229	3.710	0.000
Materials -> Project Delay	Contractors	0.133	0.063	0.197	4.345	0.000

4.3 Mediating Effects

In this study, the indirect effects of the construct through two or more mediating constructs are investigated in addition to the direct effect of the construct. In the PLS path model, the Labour construct has a direct effect on project delay and an indirect effect through the mediating constructs of Contractors, Consultants, and Clients, for which total effects are estimated by summing up direct and indirect effects. The result of mediating effect in the path model is presented in Table 9. The findings indicate that labour (0.530) has the strongest total effect on project delay, followed by Clients (0.291) having a strong total effect on the project delay.

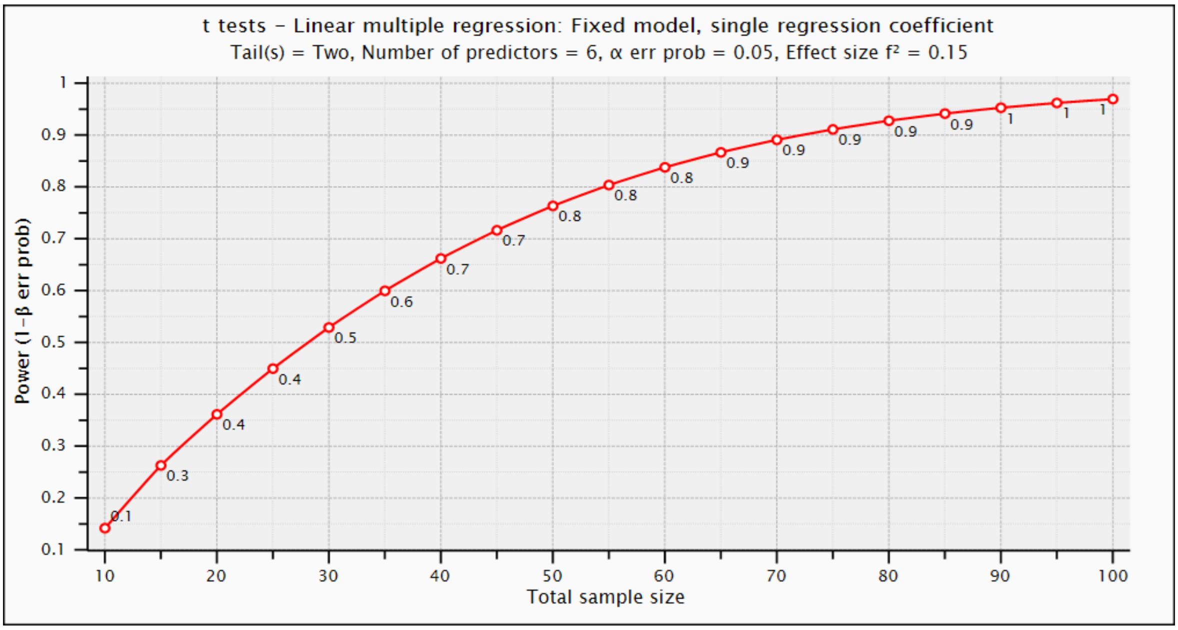

Fig. 4. Power analysis model graph

4.4 Power Analysis

The power analysis (1-β) test was used to evaluate the reliability of the parameters of the model with the sample size used for the analysis [60]. The general acceptance for an appropriate model is at least 0.80, as suggested by [63]. In order to calculate the power of a model, the following parameters are needed: the significance level (α), the sample size (N), and the effect size (ES) of the population.Using G-power analysis 3.1.9.7 [71], the parameters taken as input for the study are Sample size (N) as 296, level of significance as 5%, and effect size (ES) as 0.15. The power has achieved 100% with a sample size of 89, as shown in Fig. 4. Hence, from the power analysis, it is evident that the sample size used in this study is sufficient for achieving adequate power.

5. CONCLUSION

This study has examined 49 factors contributing to construction projects' delay in selected public universities' using PLS-SEM modelling in SmartPLS software. The developed PLS-SEM path model, comprised of these factors in 6 groups which contribute to construction delay, is to show a graphical representation of relationships of construction delay factors. Assessment of the model found that in the outer model, all the manifests in the model are reliable and valid. For the inner model, it was found that the labour and client group is the most dominant path with β-values of 0.337 and 0.291, respectively. In contrast, an external factor has an insignificant impact on the construction delay with a β-value of 0.016. Finally, the overall model has a high explaining power ability to generalize the model for construction projects in selected higher public universities in Ethiopia. These findings might support practitioners and decision-makers to focus on potential construction delay factors that might occur in their current or future projects. Further studies on project delay factors in Ethiopia could expand the geographic coverage to include more regions and cities to gain a wider perspective of the issue. Additionally, the following variables could be included to provide a more comprehensive understanding: Political instability and corruption, financial management practices, Insufficient stakeholder involvement and communication, and cultural barriers. Incorporating these variables in the study design can help to provide a more in-depth analysis of the project delay factors in Ethiopia and inform better policies and practices for project management.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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