APWEN Journal of Engineering, Science and Technology
ISSN: 2714-2396, Volume 9 Issue 1

MEDIATING EFFECT OF PROJECT PLANNING ON INVENTORY MANAGEMENT AND CONSTRUCTION PROJECT TIME OVERRUN

I. M. Adamu[1]*, M. B. Idris[2] and S. Abdullahi[3]

[1] Department of Mechanical Engineering, Kaduna State University, Kaduna, Nigeria
[2] Department of Business Administration, Kaduna State University, Kaduna, Nigeria
[3] Department of Civil and Environmental Engineering, Air Force Institute of Technology, Kaduna, Nigeria

Corresponding email: abrahimi1122@gmail.com

Received Date 24 April 2026 Accepted Date 19 May 2026 Published Date 16 June 2026

Abstract. Persistent time overrun affect construction project delivery in Nigeria attributable to poor project planning and improper inventory management which cripple delivery schedules and lead to stakeholder discontent. This underscores an urgent need to examine how inventory management and project planning jointly influence construction delivery timelines. Accordingly, this study investigated the relationship between project planning, inventory management and poor time performance of construction projects in Nigeria. The study utilized Partial Least Squares Structural Equation Modelling (PLS-SEM) built in SmartPLS 4.0 software to analyse primary data obtained from a survey of 429 construction stakeholders. Findings indicate that project planning and inventory management explain 78.9% of the variance in construction project time overrun, with effective project planning (β=0.790, t=32.211, $p<0.05$) and good inventory management practice (β=0.146, t=5.174, $p<0.05$) significantly reducing construction project time overrun. Project planning was found to provide an important mediating mechanism for the two constructs (inventory management and delivery time overrun), strengthening the effect of inventory management on construction project time overrun reduction (β=0.435, t=17.389, $p<0.05$). This outcome could be linked to incorporation of project planning practices such as adequate resource forecasting and allocation, proper scope definition, reasonable activity duration and effective risk planning; which permit effective team member engagement, improve effective project stakeholder control to promote schedule compliance, lead to adequate contingency planning and permit reasonable deadlines from authorities. The study recommends institutionalizing robust project planning systems, improving forecasting and resource allocation, and enhancing competencies in risk planning and scope management to reduce construction project time overrun. The study's outcomes provide critical insights to project managers, policymakers, construction firms and government agencies, stressing that integrating sound project planning with adequate and proactive inventory management are essential for achieving on-time project delivery.
.

Keywords: effective project planning, inventory management, digitalization, on-time project delivery, construction projects.

1. Introduction

Construction project management is characterized by intricacies emanating from shifting stakeholder expectations, planning, supply chain disruptions and globalization; leading to poor time performance of projects, cash flow problems and client dissatisfaction [1]. These complexities and challenges have driven the construction sector to be increasingly shaped by emerging technologies that influence planning, construction, maintenance, demolition, management and logistics, with growing adoption of computers, automated tools, machinery, and other intelligent devices [2]. Project planning and scheduling have emerged as vital tools for handling time and resource intricacies amid the dynamic environments and complex network of structures within modern construction project management [3].

Ministries, Departments and Agencies (MDAs) in Nigeria begin important project procurements such as hospitals, roads and schools towards the end of financial year without adequate planning, which lead to delayed actualization of projects, erode public trust and undermine government projects [4]. Additionally, [5] reported that project delivery in Nigeria's construction industry is seriously affected by poor time performance and time overrun, where 56,000 uncompleted construction projects exist across six geopolitical zones of the country. Moreover, [6] recognized the presence of many uncompleted constituency projects in Nigeria. These delayed delivery of construction projects in Nigeria were resounded by [7], who noted suboptimal schedule adherence on TETFund projects in Nigerian tertiary institutions, while [8] reported that 86% of assessed TETFund projects in Nigeria's tertiary institutions recorded time overruns ranging from 66% to 860%, with an average of 199%. Inadequate contractor performance and poor resource allocation were identified by [9] as major contributing factors to poor time performance of construction projects. [10] reported the influence of construction supply chain and procurement, into which inventory management befalls as critical to project success with [11] stressing the need for strategic foresight, effective inventory management and adaptability in projects.

Inventory management is a systematic approach which plan, acquire, store, move and control materials in store or transit in order to optimize resource allocation and usage [12]. [13] stated that a critical aspect of construction project management is inventory management, whose poor management could be severe to project delivery success, as it consumes more than half of the total construction project capital investment. [14] noted that effective inventory management is crucial in sustaining firm competitiveness and improving logistics systems with increasing supply chain complexity, while [12] stated that poor inventory management can result in project time overruns, cost overruns and reduced performance. Addressing inventory management challenges and complexities requires adoption of advanced inventory management systems and technologies such as just-in-time delivery, demand forecasting and tracking technologies [11]. [12] while assessing inventory management practices on building construction projects in Jimma Town of Ethiopia noted ABC Analysis and Reorder Point (ROP) as techniques employed for inventory management. However, [15] reported Just-in-Time (JIT), Vendor Managed Inventory (VMI), Material Requirement Planning (MRP) and Economic Order Quantity (EOQ) as techniques employed for inventory management in Kenya; while investigating inventory management practices and supply chain performance of construction firms in Nairobi. Neither of the two studies presented: [12] and [15] nor previous studies had effectively used the combined inventory management techniques (Just-in-Time: JIT, Vendor Managed Inventory: VMI, Material Requirement Planning: MRP, Economic Order Quantity: EOQ, ABC Analysis and Reorder Point; ROP) to investigate the effect of inventory management on other constructs such as project planning and project delivery time overrun in the Nigerian construction sector to the best knowledge of the authors, coupled with the fact that the two studies reported: [12] [15] were not done in Nigeria. This presents a variable inclusion and geographic gap, as a study that combined the two separately reported and utilized inventory management techniques with other constructs such as project planning and construction project delivery time overrun could provide more insight and understanding of inventory management effect on construction project success, which is what this study seeks to achieve.

Project planning is a critical component of project management and a key determinant of project success [16]. Yet, while examining project delivery in the United Arab Emirates, [9] identified core project planning elements as: scope definition, risk planning, activity durations, team involvement, contingency planning, deadlines from authorities, and effectiveness of stakeholder control, but found that they did not positively influence project outcomes in the UAE oil and gas construction sector. In contrast, [7] noted that late procurement of materials resulting from ineffective project planning was a primary cause of delay on TETFund projects in Nigeria, and therefore advocated for effective project planning. Similarly, [17] opined that changes to project scope, whether big or small, have positive and negative impacts on overall scope and project success and might lead to project failure. Effective scope definition, risk planning and realistic activity duration estimation can mitigate delays, enhance collaboration and optimize inventory management, ultimately reducing time overrun [17] [18] [19]. The construction sector continues to face significant challenges, including time overruns driven by uncertainties and poor project scope definition that directly affect project cost and schedule [17] [18]. [20] stated that pressure to start delivering projects lead teams to skimp on planning; creating a fragile foundation that fractures under pressure. Despite these understandings, a gap exists (geographic and variable inclusion), as highlighted above, when it comes to understanding the mediating effect of project planning on inventory management and construction project time overrun. This mediation (project planning on inventory management and construction project time overrun) has not been investigated and reported in literature, which is what this study seeks to achieve in Nigeria using the following alternative hypotheses developed in line with the study objectives.

Hypothesis 1: Inventory management significantly reduces construction project time overrun

Hypothesis 2: Project planning significantly affect inventory management of construction projects

Hypothesis 3: Project planning significantly affect construction project delivery time overrun

Hypothesis 4: Project planning mediation exist between inventory management and construction project time overrun

2. Literature Review

2.1 Empirical Literature

2.1.1 Inventory management and project time overrun

Available empirical literature on construction inventory management indicate observable contradictions. [21] and [15] reported reasonable gains from lean prefabrication and EOQ, VMI, JIT in China and Kenya respectively, research from Pakistan and UAE by [22] and [9] reported contractors' performance, resource allocation and multi-stakeholder factors overtaking inventory management in driving time overruns. Reports of contested findings were given by [11] on a study conducted in Coastal Karnataka of India which indicated that supply chain disruptions and material cost dictate inventory management practice selection more than technical consideration, indicating that JIT could increase risk in uncertain supply chains despite its success in normal conditions. Limitations observed in the studies rallied around absence of longitudinal designs that separate causal effects or test digital tools such as BIM and blockchain. Geographically, evidences are more in UAE, China, Ethiopia, Kenya and Pakistan than Nigeria, with each portraying distinct domain conditions with lean integration and off-site construction more in China, while stakeholder dependent and buffer-heavy methodologies found in East Africa and South Asia. As such, utilisation of inventory management practice relies on matching institutional conditions with project delivery method and local supplier reliability, leaving a gap for empirical evaluation and incorporation of digital tools like Building Information Modelling (BIM), Internet of things (IoT), Radio Frequency Identification (RFI) and Artificial Intelligence in developing countries to drive effective inventory management and project success [23]. These outcomes justify further evaluation of the relationship between inventory management and construction project time overrun to provide better understanding of the relationship.

2.1.2 Project planning and inventory management

Research reported that inventory management can improve time performance of construction projects under certain planning conditions. [14] reported that utilizing decision support systems coupled with real-time visibility enhance responsiveness and lead to waste reduction through Just-in-time (JIT) and Vendor Managed Inventory (VMI), while [24] linked poor project planning to ineffective inventory management outcomes like slow moving stock and high minimum order quantities. However, [25] observed that the gains of project planning and inventory management rely on incorporation of digital technologies such as BIM and RFID. The criticality of scope definition over other project planning proxies was stressed by [26], who observed that poor scope definition negatively correlate with inventory management and project delivery time. [27] and [34] contested this where they emphasized effectiveness of stakeholder control and team engagement through on-time identification, conflict resolution and participatory decision making as mechanisms which reduce delays by aligning inventory requirements. The points of contention on risk planning, activity durations and contingency planning were reported by [28] who opined that Risk Management Planning has to do with iterative risk allocation, with [29] and [30] disagreeing on method of contingency estimation, contrasting resilience curves with fuzzy and expert judgement methods. Deadline from authorities impose external pressure which interacts with these proxies but rarely modelled. Observed limitations in these studies were underrepresentation of small contractors and reliance on case studies, expert judgements and conceptual frameworks with small large-scale empirical testing. These outcomes justify further evaluation of the relationship between project planning and inventory management to provide better understanding of the relationship.

2.1.3 Project planning and project time overrun

Contradictions and contested findings exist in literature on project planning and time overrun revolving around which proxies drive desired outcomes. [17] saw scope definition as most important since unplanned scope creep and poor scope definition seriously affect schedule and cost. However, [31] contested the mechanism by stressing that only on-time identification of critical, unhealthy and unplanned changes through benchmarking, what-if-analysis, expert judgement, brainstorming and lessons learned reduce rework and lead to timely project delivery. Contradictions abound risk and contingency planning where [32] and [33] argued that real-time tools, structured frameworks and inclusive stakeholder risk discussions mitigate budget threats and delays. There was disagreement between [29] and [30] on risk estimation methods where they contrasted fuzzy methods and expert judgements with activity risk capacity and disruption recovery profiles-based resilience curves. Divergent views exist on team involvement and activity duration where [19] emphasized the need for realistic scheduling, team trust and WBS/CPM alignment to anticipate time overruns, with [18] advocating for Naive Bayes, and Machine Learning (ML) models using historical data not traditional estimation methods which fail under uncertainty. [27] [34] and [35] argued that stakeholder control is mostly linked to project planning success but diverge on how it operates considering timely identification, conflict resolution, participatory decision making and dynamic management of competing resources, while identifying the outcome influencing capabilities of deadline from authorities through regulatory compliance. Important limitations from the studies suggest over reliance on conceptual frameworks, expert judgement, small sample size with few large-scale empirical validations, and fragmented evidence on digital integration despite [23] identifying gaps in linking planning platforms with field operations, and [36] advocating for drone improved data collection and usage without clearer proof of project delivery delay reduction. These outcomes justify further evaluation of the relationship between project planning and delivery time overrun to provide better understanding of the relationship.

2.1.4 Project planning as mediator

There are mixed findings and contradictions in literature around drivers of effective project performance in the construction sector. According to [37], client competencies, project team commitment and contractor competencies are the strongest predictors of project performance based on a study conducted on fifty-three (53) public sector projects where analysis was done using regression and factor analysis. However, [38] tilted towards project management functions such as planning where the authors identified clear scope understanding among the most important factors in a study conducted at Malaysia’s public universities. [9] noted that project planning does not improve delivery performance of construction projects in UAE oil and Gas sector, while [7] noted late procurement resulting from ineffective project planning as a major cause of time overrun on TETFund projects in Nigeria. Similarly, [17] opined that changes to project scope, whether big or small, have positive and negative impacts on overall scope and project success and might lead to project failure, while [17] [18] [19] stated that project planning proxies such as effective scope definition, risk planning and realistic activity duration estimation can mitigate delays, enhance collaboration and optimize inventory management, ultimately reducing time overrun. [39] reported experienced multidisciplinary teams, rapid conflict resolution, comprehensive managerial actions, positive attitudes and consistent funding as drivers of effective project performance in Vietnam. [40] tilted towards team structure, knowledge sharing, resource allocation and risk allocation as drivers of effective project performance in a study conducted in Malaysia. It could be observed from these reviews that contradiction exist, and none of these studies examined inventory management directly but highlighted scope definition, deadline from authorities, risk planning, realistic activity durations as mechanisms through which inventory management practices such as MRP, EOQ, ROP, JIT and VMI could affect scheduled delivery of projects, suggesting an indirect path to improving inventory management through planning to reduce construction project time overrun. Key limitations of these studies rallied around surveys and interviews of small samples of respondents of between 53 and 260 without testing mediation pathways. As such, this study examined whether project planning mediates the relationship between inventory management and construction project time overrun in Nigeria.

2.2 Value Addition in the Research

Examining the mediating effect of project planning on inventory management and construction project time overrun, which this research put to focus bridged an important knowledge gap on project and construction management literature. Actionable insights were provided in line with the research outcome to improve construction project delivery by reducing delays and project abandonment through appropriate planning and effective inventory management. The research outcome is expected to improve planning, inventory management and policy initiatives tailored to the Nigeria's construction sector unique needs, where construction project delivery delay affect project success and economic growth.

2.3 Theoretical Framework

This paper presents the mediating effect of project planning on inventory management and construction project time overrun in the Nigeria's construction industry. The study utilized Dynamic Capability Theory (DCT) and Resource-Based Theory (RBT) to back its theoretical framework. The work looked at how effective planning; having scope definition, activity duration estimation, risk planning, contingency planning, team involvement, stakeholder control and deadlines from authorities as proxies that affect inventory management methods: JIT, MRP, VMI, ABC Analysis and ROP, and construction project time overrun (resource allocation and contractor's performance). The theoretical framework is presented as Figure 1 which maps the study constructs relationship to guide strategies for reducing project delivery delay in Nigeria. The postulates of the selected underpinning theories (RBT and DCT) are presented below.

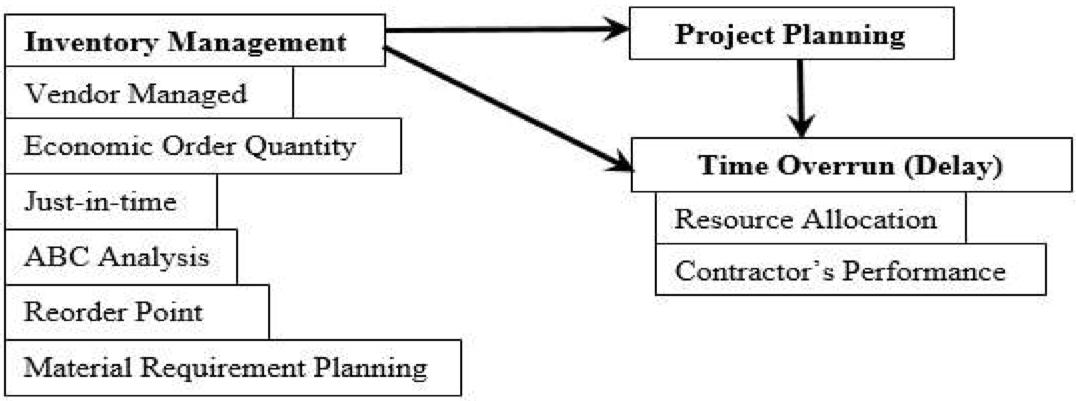

Figure 1: Theoretical Framework

2.3.1 Resource based theory

Resource-Based Theory (RBT) proposed by [41] states that a firm can use its internal resources to achieve sustainable competitive advantage. The theory offers a framework applicable in analyzing how construction firms can deploy their internal resources through effective inventory management to achieve sustainable competitive advantage [11], as inventory are internal resources used by organizations to achieve their objectives. This study deployed RBT to examine how construction firms or organizations in Nigeria can effectively harness and utilize its valuable, inimitable, rare and non-substitutable resources to improve inventory management, strengthen construction project delivery and reduce delays.

2.3.2 Dynamic capability theory

Dynamic Capability Theory (DCT) states that firms can achieve sustainable competitive advantage by utilizing their ability to sense opportunities and threats, seize opportunities and reconfigure resources to adapt to changing environments that can be volatile or uncertain [42]. This theory finds application in the construction sector as construction firm musts effectively adapt and respond to changing conditions [11]. The study presented herein investigates how construction firms in Nigeria can build dynamic capabilities in project planning and inventory management to improve supply chain resilience and project performance.

2.3.3 Mapping underpinning theories with developed hypotheses

This section tries to map adopted theories (RBT and DCT) to developed hypotheses to enable prediction of likely outcome based on the respective theoretical formulations as follows:

Hypothesis 1: Inventory management significantly reduces construction project time overrun

RBT considers inventory as valuable resource whose effective usage and right deployment through effective inventory management are essential in achieving sustainable competitive advantage [11]. The right deployment of the right inventory management practice at the right time ensures materials required for construction arrive where needed at the right time, which is expected to reduce workers idle time, avoid costly rush orders and reduce rework and waste. By eliminating material related stoppages, effective inventory management directly cuts construction project time overrun. Therefore, it is expected that the study's first alternative hypothesis which states that inventory management significantly reduces construction project time overrun will be supported based on RBT.

Hypothesis 2: Project planning significantly affect inventory management of construction projects

Based on Dynamic Capability Theory (DCT), project planning could be seen as the ability of project conceiving and implementing bodies to reconfigure and integrate resources to achieve sustainable competitive advantage, as DCT is all about sensing and seizing opportunities, resource reconfiguring and adapting to changing environments [42]. Planning aids accurate and effective scope definition, identification of needed resources and informing project teams when and where materials are needed based on existing or revised plans [19]. [19] stated that planning is not a one-time event but a progressive process that continues throughout a project life cycle; planning with the level of detail needed to achieve and immediate horizon while maintaining strategic visibility for the remaining aspect is an effective strategy in projects. As such, when clear plans and effective communication are combined, precise inventory decisions are made, which lead to reduction in over-stocking and over ordering, reduces execution stoppages and eliminate to a large extent mismatched delivery. Therefore, as planning is a dynamic capability [19], it is expected that the study's second alternative hypothesis which states that project planning significantly affect inventory management of construction projects will be supported based on DCT.

Hypothesis 3: Project planning significantly affect construction project delivery time overrun

[19] stated that planning is not a one-time event but a progressive process that continues throughout a project life cycle; planning with the level of detail needed to achieve and immediate horizon while maintaining strategic visibility for the remaining aspect is an effective strategy in projects. Based on Dynamic Capability Theory (DCT), project planning could be seen as the ability of project conceiving and implementing bodies to identify, reconfigure and integrate resources such as people, information, inventory and financing to achieve sustainable competitive advantage [42]. Since effective project planning creates realistic schedules, clarifies scope and enables fast decisions which aligns project team and prevent or reduce reworks and stoppages. Therefore, as planning is a dynamic capability [19], it is expected that the study's third alternative hypothesis which states that project planning significantly affect construction project delivery time overrun will be supported based on DCT.

Hypothesis 4: Project planning mediation exist between inventory management and construction project time overrun

Integrating Dynamic Capability Theory (DCT) with Resource-Based Theory (RBT) can effectively explain the study's fourth alternative hypothesis which states that project planning mediation exist between inventory management and construction project time overrun. This is because RBT can adequately explain inventory management as inventories are internal resource in organizations, whose effective deployment, usage and management can lead to competitive advantage [11] [41], while DCT properly explain project planning as a dynamic capability which creates and reconfigure scope, schedule and deploys inventory management, leading to effective inventory sourcing and utilization [19]. As such, it could be said that inventory management can decrease construction project time overrun through effective project planning. Therefore, as planning is a dynamic capability [19], and inventory management resource based [41], it is expected that the study's fourth alternative hypothesis which states that project planning mediation exist between inventory management and construction project time overrun will be supported based on a combination of RBT and DCT.

3. Methodology

3.1 Research Design, Sample Size and Sampling Techniques

This research utilized survey design which collected primary data in 2025 through cross-sectional survey of construction project stakeholder in Nigeria (contactors, clients, developers, project managers and suppliers), administered using convenience sampling via online survey with responses obtained totaling 429 in number; where 174, 128, 81, 34 and 12 were contactors, project managers, clients, suppliers and developers respectively. Initially, a pilot study was conducted after expert review of the adapted questionnaire to establish its reliability by obtaining fifty (50) responses from the study respondents utilizing the adapted questionnaire administered online using convenience sampling to determine its reliability. The questionnaire's constructs used in the study were adopted from [9] [12] and [15]. The project planning construct was unidimensional having seven items adopted from [9], while the construction project time overrun construct whose elements were: contractor's performance and resource allocation were unidimensional each having five items each adopted from [9]. The inventory management construct had six dimensions having Vendor Managed Inventory (VMI), Economic Order Quantity (EOQ), Just-in-Time (JIT), Material Requirement Planning (MRP), ABC Analysis (ABC) and Reorder Point (REP) as elements, with the five elements having two items each except VMI which had three items. The VMI, EOQ, JIT, MRP elements were adopted from [15], while the ABC and REP elements were adopted from [12].

3.2 Instrument Validation and Method of Data Analysis

The data obtained from the pilot survey was analysed with the aid of PLS-SEM using PLS 4.0 software to obtain Composite Reliability (CR) values for the main study constructs: project planning, inventory management and construction project time overrun. Further, validation of the data obtained for the study constructs and proxies was done using item loadings, Composite Reliability (CR), Average Variance Extracted (AVE) and Heterotrait-Monotrait (HTMT) ratio as required by [43] [44] for measurement model. Assessment of the structural model was done using PLS-SEM, covering additional model validation and hypothesis testing according to [43] [44]. These enabled evaluation of the mediating effect of project planning on inventory management and construction project time overrun in Nigeria, with the results obtained presented in Tables 1-8 and Figures 2-6.

4. Results and Discussion

4.1 Pilot Test

The results of pilot test using Composite Reliability (CR) analysis according to [43] [45] were presented in Table 1. The CR values obtained for the study constructs were 0.924, 0.689 and 0.723 for project planning, inventory management and construction project time overrun respectively, all within the range of 0.60 to 0.95 threshold specified by [43] [45]. Therefore, the reliability of the construct in the pilot study were in the order of project planning, inventory management and construction project time overrun. This shows that the questionnaire is adequate for utilization in the main study.

Table 1: Pilot Test Composite Reliability

Construct	Project Planning	Inventory Management	Time Overrun (Delay)
Composite Reliability	0.924	0.689	0.723

4.2 Category of Respondents

The groupings of the study respondents are presented in Figure 2, which indicates that 2.80%, 7.93%, 18.88%, 29.84% and 40.56% of the respondents were Developers, Suppliers, Clients, Project Managers and Contractors respectively. This shows a wide spread in the responses received, which are within the main stakeholders in the Nigerian construction industry. Therefore, it could be concluded that this study obtained responses that are widely spread and from very important stakeholder in the Nigeria's construction sector.

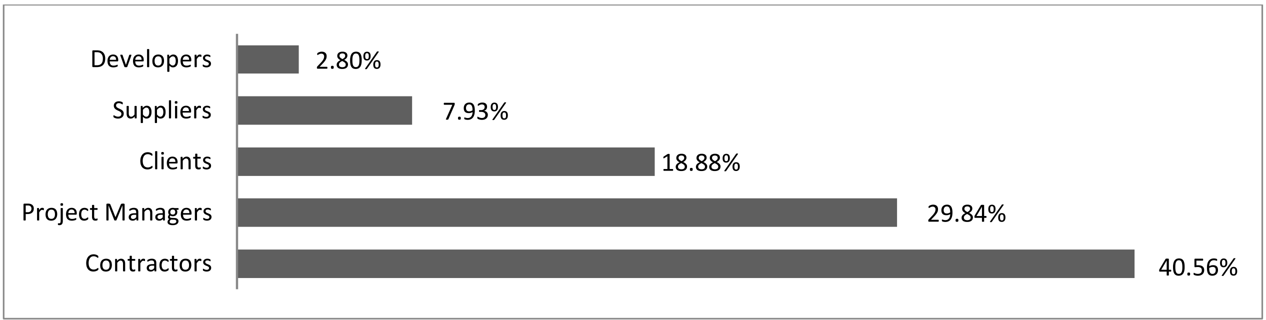

Figure 2: Category of respondents

4.3 Experience of Respondents

The construction project related experience of the study respondents is provided in Figure 3, which shows that 29.60%, 27.50%, 25.64% and 17.25% of the respondents have construction project related experience of more than 15 years, between 11 to 15 years, between 6 to 10 years and less than 5 years. This shows that 82.75% of the study respondents have 6 and above years of experience, which indicates that the study respondents have adequate experience to respond to the research questionnaire.

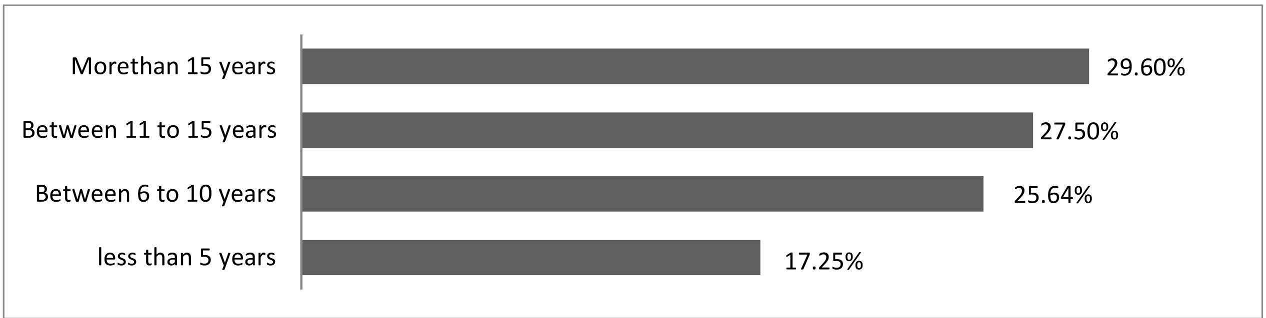

Figure 3: Construction project related experience of respondents

4.4 Measurement Model Assessment

4.4.1 Measurement model individual item reliability Analysis

Figure 4 presents measurement model for the study which shows outer loadings for each items of the study constructs. The reliability of each item was evaluated using outer loadings in line with [43]. Outcome of item loadings after analysis as presented in Table 2 and Figure 4 indicates that most item loadings exceeded the 0.5 minimum threshold proposed by [43] [40], except items JIT2 and RA2 which were removed due to low indicator outer loadings in line with [38] [45]. Items retained in the measurement model were 28 out of 30 with outer loadings ranging from 0.579 to 1.000 consistent with [40]. This confirms reliability of the indicators retained.

4.4.2 Analysis of internal consistency reliability

Composite Reliability (CR) was used to examine the internal consistency reliability of the study constructs in line with [43] [45]. Results of CR test are presented in Table 2, which show CR values ranging from 0.725 to 0.924 for the retained items which define the study constructs: project planning, inventory management and construction project time overrun. The CR values obtained (0.725 to 0.924) fall within the 0.60–0.95 acceptable CR threshold [43] [45]. Just-in-time presented an issue caused by deleting item JIT2 according to [43] [45], which came out with low loading of 0.08. This outcome signifies a possible misunderstanding or non-familiarity with JIT concept by the study respondents. A value of 0.725 was obtained as CR of MRP inventory management method, which is close to but still greater than the minimum acceptable threshold of 0.60 proposed by [46] for composite reliability. However, [46] stated that in a situation where internal consistency reliability is in doubt due to CR value obtained, exploring further to determine Average Variance Extracted (AVE), whose value should be 0.5 or higher is the next process for establish internal consistency reliability. As presented in Table 2, the AVE value obtained for MRP is 0.58 which is greater than 0.5. Thus, this established an acceptable internal consistency reliability for MRP in line with [46].

4.4.3 Analysis of convergent validity

Average Variance Extracted (AVE) was used to examine convergent validity of the study constructs in line with [45]. Table 2 presents values of AVE obtained for the study constructs which were in the range of 0.580 to 0.888, exceeding the minimum acceptable value of 0.5 proposed by [45]. This indicates acceptable convergent validity for most of the constructs. Just-in-time presented an issue caused by deleting item JIT2 according to [43] [45], which came out with low loading of 0.08. This outcome signifies a possible misunderstanding, non-familiarity or limited application of JIT concept by the study respondents.

4.4.4 Discriminant validity analysis

Heterotrait-Monotrait (HTMT) ratio was used to assess discriminant validity of the constructs and their elements in line [47], who proposed conservative and liberal maximum values of 0.85 and 0.90 for HTMT. The outcome of discriminant validity test for the study constructs was presented in Table 3, which shows computed HTMT values ranging from 0.204 to 0.840, falling below the respective conservative and liberal maximum values of 0.85 and 0.90 [47]. Therefore, indicating a satisfactory discriminant validity for the study constructs using the maximum liberal value of 0.90.

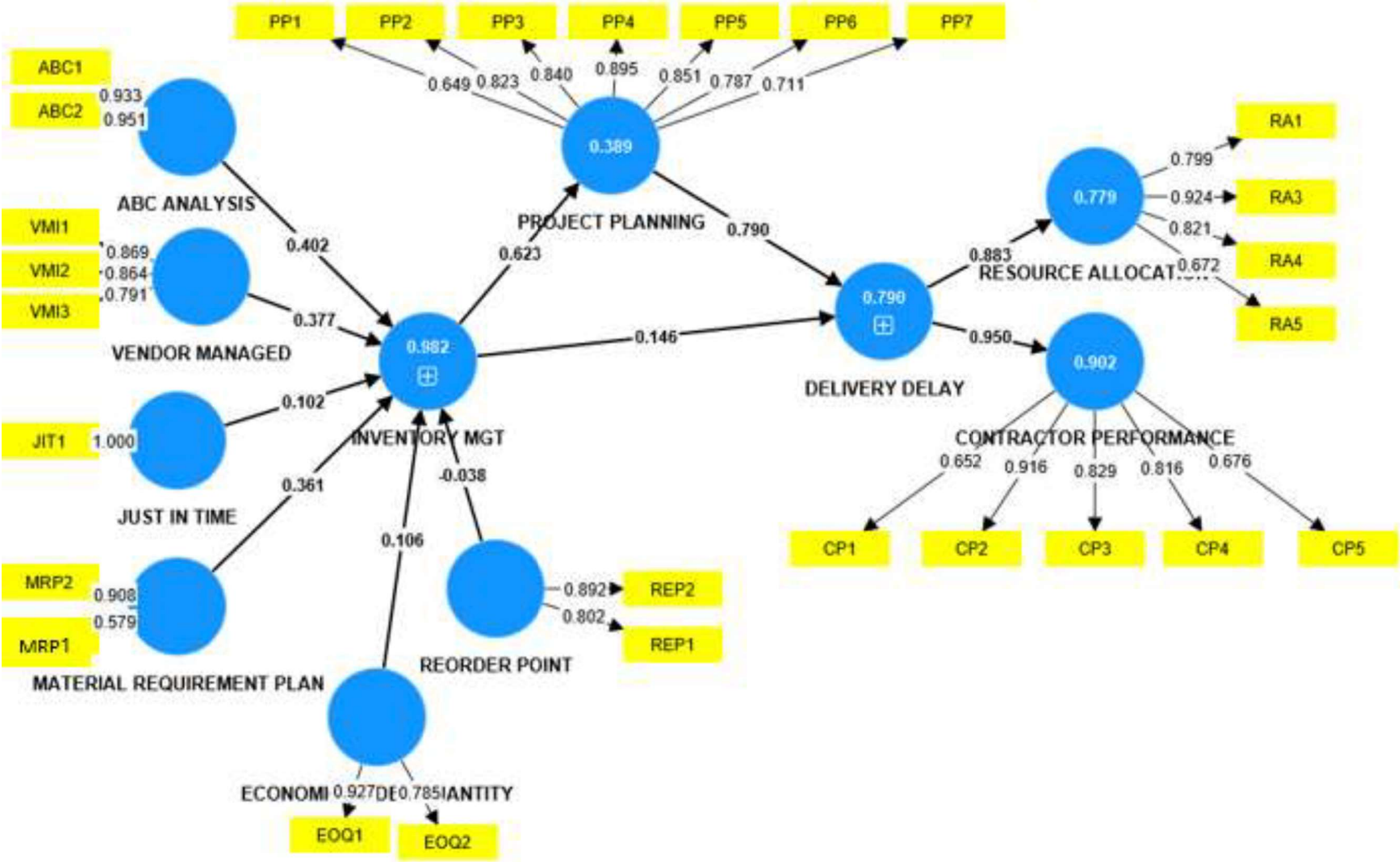

Figure 4: Measurement Model

Table 2: Measurement Model

Constructs	Items	Loadings	CR	AVE
Project Planning	PP1	0.649	0.924	0.637
	PP2	0.823		
	PP3	0.840		
	PP4	0.895		
	PP5	0.851		
	PP6	0.787		
	PP7	0.711		
Project Time Overrun: Delay (Contractor's Performance: CP & Resource Allocation: RA)	CP1	0.652	0.863	0.615
	CP2	0.916		
	CP3	0.829		
	CP4	0.816		
	CP5	0.676		
	RA1	0.799	0.882	0.655
	RA3	0.924		
	RA4	0.821		
	RA5	0.672		
Inventory Management (Vendor Managed: VMI, Just in Time: JIT, Economic Order Quantity: EOQ, Materials Requirement Planning: MRP, Reorder Point: REP, ABC Analysis: ABC	ABC1	0.933	0.940	0.888
	ABC2	0.951		
	VMI1	0.869	0.879	0.709
	VMI2	0.864		
	VMI3	0.791		
	MRP1	0.579	0.725	0.580
	MRP2	0.908		
	EOQ1	0.927	0.848	0.737
	EOQ2	0.785		
	JIT1	1.000		
	REP1	0.802	0.836	0.719
	REP2	0.892		

Source: Smart PLS extract (2026)

Table 3: Discriminant Validity using Heterotait-Monotrait Ratio (HTMT)

Constructs	ABC	CP	DEL	EOQ	IMG	JIT	MRP	PP	REP	RA	VMI
ABC											
CP	0.652										
DEL	0.662	0.650									
EOQ	0.223	0.301	0.312								
IMG	0.829	0.729	0.712	0.704							
JIT	0.645	0.395	0.404	0.377	0.656						
MRP	0.767	0.840	0.766	0.682	0.506	0.527					
PP	0.511	0.802	0.750	0.382	0.690	0.371	0.783				
REP	0.317	0.422	0.383	0.633	0.807	0.204	0.756	0.329			
RA	0.751	0.824	0.797	0.265	0.716	0.386	0.779	0.617	0.457		
VMI	0.366	0.524	0.484	0.532	0.829	0.366	0.755	0.512	0.712	0.424	

Source: Smart PLS extract (2026), DEL = construction time overrun, IMG = inventory management

4.5 Structural Model Assessment

Bootstrap analysis using 5,000 samples and 429 cases was used to implement structural model analysis of the direct and mediating relationship of the study constructs in line with [45]. The latent variables relationship is presented in Figure 5

4.5.1 Direct relationships hypotheses test

Table 4 presents results of the direct and mediating hypothesis tests at 5% significance level. The results revealed a significant relationship between inventory management and construction project time overrun ($\beta = 0.146$, $t = 5.174$, $p < 0.05$). This indicates that effective inventory management practices can reduce project delays or time overruns, suggesting that improved inventory management is linked to decreased time overrun in construction projects. Similarly, Table 4 shows that inventory management is significantly related to project planning ($\beta = 0.623$, $t = 16.415$, $p < 0.05$). This implies that effective project planning enhances inventory management, enabling adequate scope definition, effective risk planning, reasonable activity duration, allow effective team member engagement, lead to adequate contingency planning, allow reasonable deadlines from authorities and increase effectiveness on project stakeholder control.

Project planning was found to exhibit a significant relationship with construction project time overrun ($\beta = 0.790$, $t = 32.211$, $p < 0.05$), indicating that effective project planning reduces time overrun through efficient resource forecasting and allocation, adequate scope definition, effective risk planning, reasonable activity duration, allow effective team member engagement, lead to adequate contingency planning, allow reasonable deadlines from authorities and increase effectiveness on project stakeholder control.

4.5.2 Hypotheses test for mediation relationship

Mediation occurs when a third variable intervenes in the direct relationship between two constructs [48]. The bootstrap method is recommended for testing mediation effects in PLS-SEM [40]. As shown in Table 4, results obtained indicate that project planning significantly mediates the relationship between inventory management and construction project time overrun ($\beta = 0.435$, $t = 17.389$, $p < 0.05$), highlighting the critical role of project planning in this relationship.

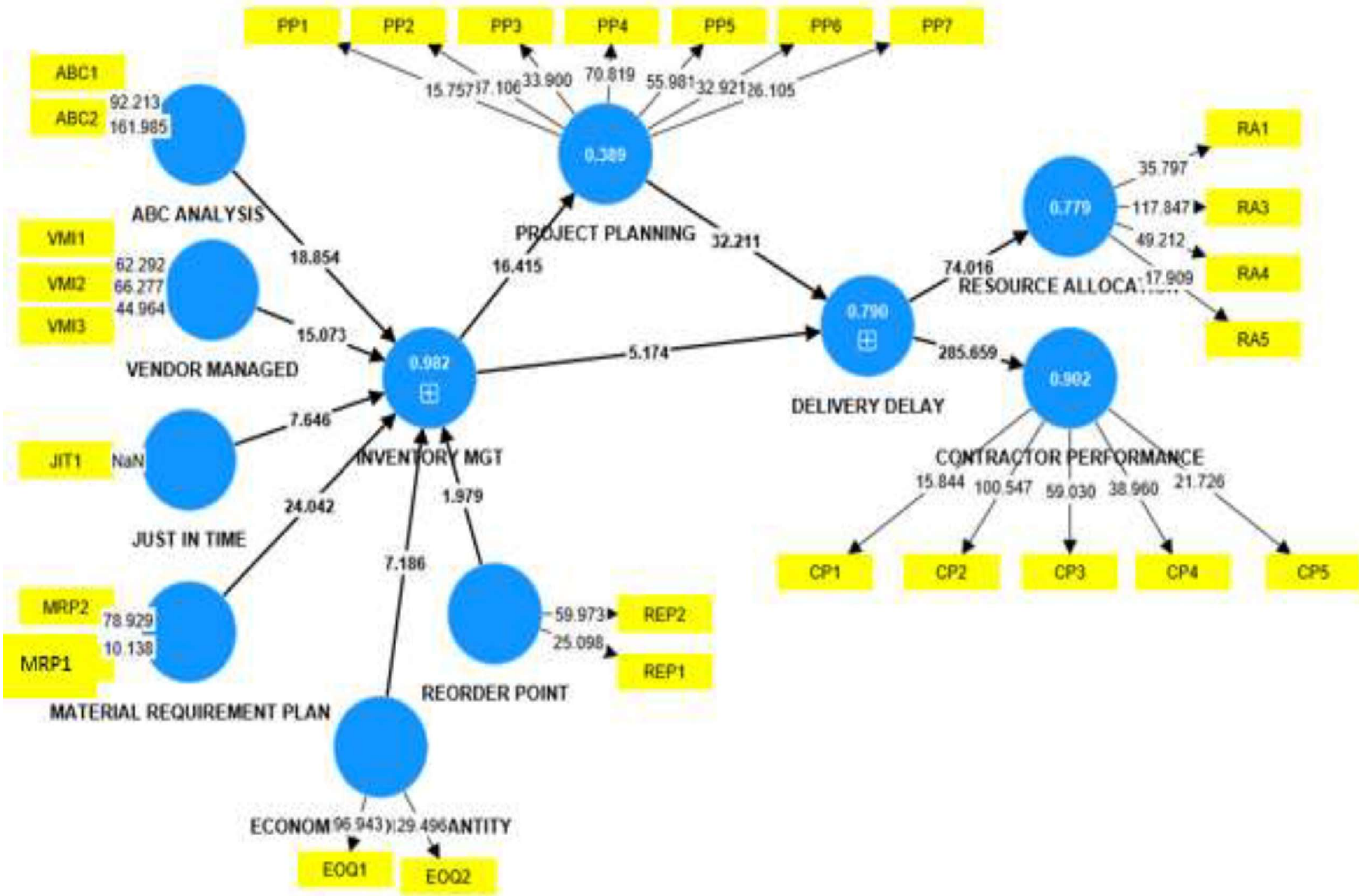

Figure 5: Structural model obtained using bootstrapping

Table 4: Hypothesis Test (Direct and Mediating Relationship)

Hypotheses	Relationship	Beta value	(STDEV)	t-value	95% confidence Interval Upper	lower	p-value	Findings
H1	INV MGT -> DELAY	0.146	0.028	5.174	0.205	0.094	0.001	Supported
H2	INV MGT -> PP	0.623	0.038	16.415	0.691	0.543	0.001	Supported
H3	PP -> DELAY	0.790	0.025	32.211	0.833	0.736	0.001	Supported
H4	INV MGT -> PP-> DELAY	0.435	0.025	17.389	0.482	0.384	0.001	Supported

Source: Smart PLS extract (2026)

This shows how project planning made the direct effect of inventory management on construction project time overrun to shift when it was introduced as a mediating construct between the two constructs. Furthermore, the significant direct (β = 0.146, t = 5.174, $p < 0.05$) and significant indirect (β = 0.435, t = 17.389, $p < 0.05$) relationships between these constructs signify that project planning exhibit partial complementary mediation between inventory management and construction project time overrun in line with [48].

4.5.3 Coefficient of determination: R-Squared

Results of Coefficient of Determination (R^2) test considering the effect of project planning and inventory management on construction project time overrun is presented in Table 5, whose value was found to be 0.789. This indicates that the two constructs (project planning and inventory management) explained 78.9% of variance in construction project time overrun. As proposed by [49]; substantial, moderate and weak exploratory power of constructs are detected when R^2 values obtained are 0.75, 0.50, and 0.25 respectively. This shows that the model developed and used in this study having R^2 value of 0.789 has substantial exploratory power in line with [45], and can adequately explain the relationship between these constructs (project planning, inventory management and construction project time overrun). Thus, implying that the included constructs (project planning, inventory management) significantly influence construction project time overrun.

Table 5: Construction Time Overrun R-Squared Value

Construct	R Square
Project Time Overrun (delay)	0.789

4.5.4 Effect size assessment: F-Squared

Table 6 present the results of effect size (f^2) assessment on the study constructs (inventory management, construction project time overrun and project planning), which shows that inventory management to construction project time overrun relationship has an effect size of 0.152, project planning to construction project time overrun relationship has effect size of 0.730, while inventory management to project planning relationship has effect size of 0.635. According to [50], values of effect size greater than 15 and not equal to 35 indicate medium effect size with those greater than or equal to 35 indicating large effect size. In line with the thresholds specified by [50], inventory management exhibit medium (0.152 > 15) and large (0.635 > 35) effect size on construction project time overrun and project planning respectively, while project planning has large (0.739 > 0.35) effect size on construction project time overrun. These outcomes suggest a mediation of project planning on inventory management and construction project time overrun, while showing the construct (project planning) is very important in determining the outcome of the other two constructs (inventory management and time overrun) on construction projects.

Table 6: Effect size: F-Squared

Construct	F-squared (Delay)	Effect Size	F-squared (PP)	Effect Size
Inventory Management	0.152	Medium	0.635	Large
Project Planning (PP)	0.730	Large		

4.5.5 Assessment of predictive relevance: Q-Squared

The predictive relevance (Q^2) values obtained through blindfolding, presented in Table 7, demonstrate the study's developed model's predictive capability. Values of predictive relevance obtained for construction project time overrun (0.415) and project planning (0.235) are both greater than zero, confirming predictive relevance [45]. This indicates that the model developed and used in the study has sound structural validity and predictive power.

Table 7: Predictive relevance on endogenous variables: Q-squared

Construct	SSO	SSE	Q^2 (=1-SSE/SSO)
Project Time Overrun (Delay)	6848.000	4008.626	0.415
Project Planning (PP)	2996.000	2292.623	0.235

4.6 Importance Performance Map Analysis

Importance-Performance Map Analysis (IPMA) identifies areas for improvement by comparing the importance and performance of constructs [43]. As shown in Figure 6 and Table 8, project planning has the highest importance (0.790) among the major study constructs in influencing construction project time overrun, followed by inventory management (0.639). However, inventory management (69.211%) exceeded project planning (67.287%) in terms of performance. Overall, considering the all the indicators, ABC analysis was found to exhibit the highest performance with just-in-time having the lowest as shown in Figure 6. In line with the IPMA outcome and considering the major constructs (project planning and inventory management), project planning was found to be critical with importance of 0.790 yet underperforming (performance: 67.287%). As such, stakeholders in the construction sector should prioritizing improving their project planning capabilities and strategies to improve their performance and reduce construction project delivery delay. The managerial implications for this finding suggest the need for construction project managers and other stakeholders to redirect resources towards pre-construction planning, scope control improvement, stakeholder alignment, adequate risk planning and scheduling. Therefore, construction project stakeholders should prioritize enhancing their project planning capabilities and strategies to improve their performance and reduce construction project time overrun. Private organizations, government agencies and regulatory bodies should establish appropriate planning frameworks and incentivize project planning. As project planning is dynamic in nature [19], construction projects stakeholders need to develop dynamic capabilities to meet changing project and planning needs. Monitoring compliance with established project plans and possible changes approved by relevant authorities is also necessary to ensure project planning yielded desired outcome. Addressing this gap will boost inventory management effectiveness and reduce construction project time overruns more than when other study constructs are improved directly.

Table 8: Unstandardized Importance of the Constructs

Construct	Importance	Performance
Inventory Management	0.639	69.211
Project Planning	0.790	67.287

Journal of Engineering, Science and Technology
ISSN: 2714-2396, Volume 9 Issue 1

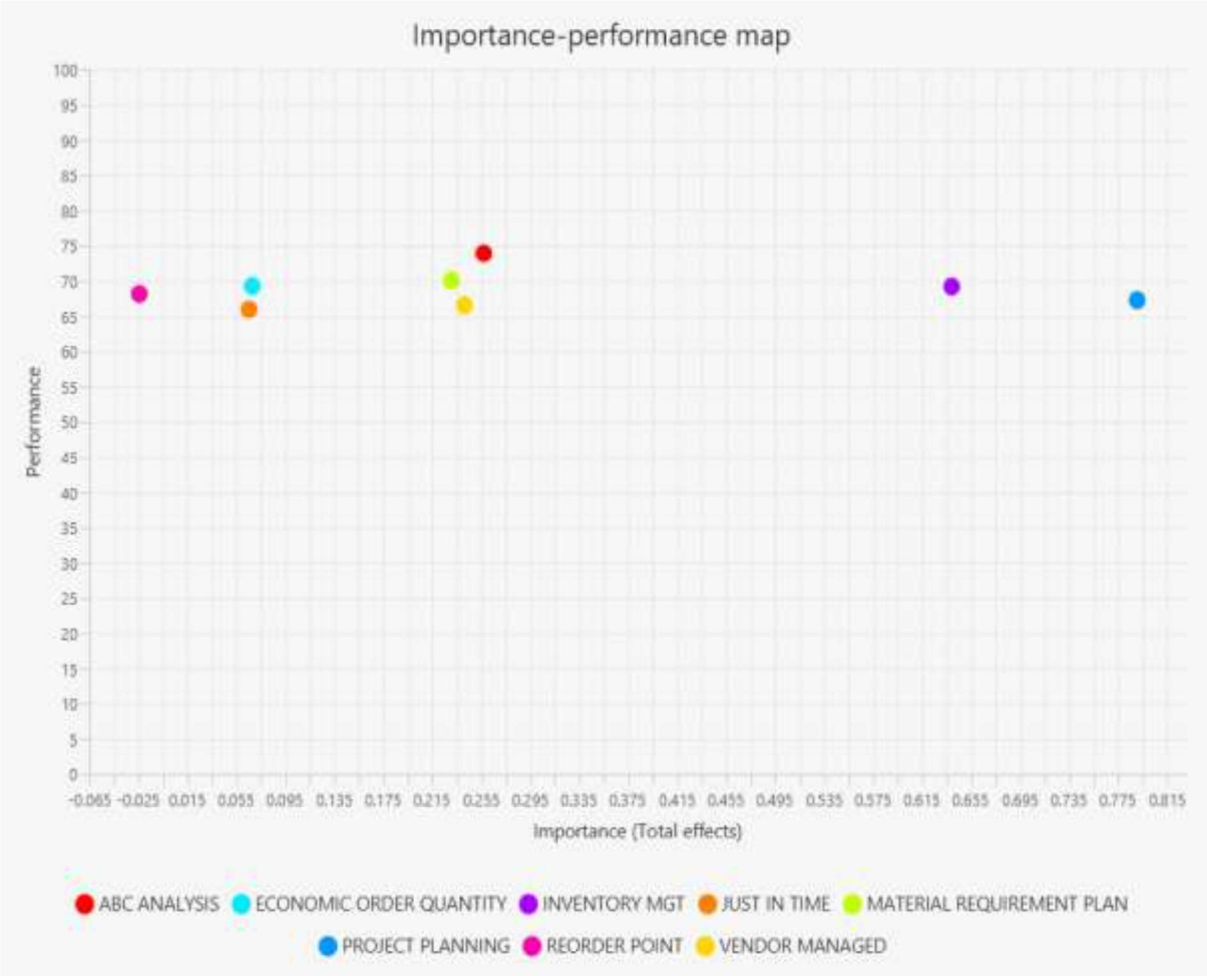

Figure 6: Importance - Performance Map

4.7 Discussion of Hypotheses Findings

4.7.1 Inventory management and project time overrun

Outcome of the first hypothesis test revealed that inventory management positively and significantly influences construction project time overrun in Nigeria. This outcome conformed to global evidence which suggests that effective inventory management is pivotal to achieving project success, where inventory management techniques such as MRP, ROP, ABC Analysis, VMI, JIT and EOQ improved the performance of supply chains by influencing reliability, cost, flexibility and asset utilization [12] [15]. The influence of material cost on project performance is severe [11] while contractors performance and resource allocation affect timely delivery of projects [9]. Material related issues still drive project delivery delay, while lean methodologies like JIT improving project outcomes, both of which need strategies that are context specific [21] [22]. In Nigeria, construction time overrun remains critical, with 56,000 uncompleted projects [5] and poor TETFund schedule performance [7], late constituency projects delivery [6], and late procurement and project planning [4]. Therefore, the Nigerian government and its Ministries, Departments and Agencies (MDAs), construction firms and organizations should integrate proven inventory management techniques, adopt Building Information Modelling (BIM) and blockchain technology for transparent planning and procurement, digitalise processes and embed inventory metrics into risk and contractor evaluations to reduce project delivery time overrun. This outcome aligns with Resource-based Theory (RBT) which suggest that organizations can use their internal resources that are valuable, inimitable, rare and non-substitutable to achieve sustainable competitive advantage as digitalisation, BIM, blockchain and proven inventory management techniques are internal resources that are valuable, inimitable, rare, non-substitutable and very important in achieving project success.

4.7.2 Project planning and inventory management

Outcome of the second hypothesis test confirms that effective project planning plays a crucial role in inventory management by enabling adequate scope definition, appropriate risk planning, reasonable activity durations, team engagement, contingency planning, realistic deadlines, and stakeholder control. This is supported by evidence that optimal inventory levels depend on careful planning and control [24], whereas ineffective planning leads to high minimum order quantities, large batch sizes, and slow-moving stock [24]. A well-defined scope is central to success and allows stakeholders to accurately determine inventory needs with shared expectations [26], with scope management considered more critical than any other project knowledge area [26]. Risk Management Plans (RMP) identify hazards, quantify risks, and implement preventive measures from design to construction [28], though inadequate risk assessment often occurs due to deadline pressure [32]. Contingency planning requires resilience-based forecasts, expert judgment, fuzzy methods, and scenario planning to address disruptions [29] [30]. Effective stakeholder engagement through early identification, communication, participatory decision-making, and conflict resolution enhances completion rates and cost efficiency [27] [34]. Digital tools such as BIM, RFID, IoT, and AI analytics improve real-time visibility and inventory control [23] [36]. Planning capabilities and BIM are valuable, inimitable resources that drive efficiency, aligning with resource-based theory, while reconfiguring planning and stakeholder processes to respond to disruptions aligns with dynamic capability theory. Therefore, effective project planning directly strengthens inventory management, with construction firm's adoption of BIM-enabled planning frameworks, conceiving and formalizing risk management plans, having contingency plans and stock reserves when necessary, guided by effective forecast facilitated by BIM, RFID, IoT, and AI analytics and material requirement plan, and implementing dynamic stakeholder management to optimize inventory outcomes.

4.7.3 Project planning and project time overrun

The third hypothesis test found that effective project planning significantly reduces construction project time overrun or delay, and this is strongly supported by literature. Effective risk management is fundamental to project success, as uncertainties threaten objectives, timelines, and budgets, making risk identification, assessment, and response paramount [33]. Early stakeholder engagement aligns goals and improves outcomes, with active involvement in risk discussions reducing surprises [32] [27] [24]. Project scope is the base of key planning processes including cost, schedule, and Work Breakdown Structure (WBS); poor scope definition directly affects cost and schedule, while scope creep is a main cause of delay and failure [17]. Managing predefined changes, using expert judgment, lessons learned, benchmarking, brainstorming and what-if analysis helps discover potential scope changes and mitigate risks [17]. Enhancing scope quality adds control and reduces rework, over-cost, and time overrun [17]. Time management through defining activities, sequencing, duration estimation, and schedule control is essential for success, while realistic scheduling with WBS and critical path analysis prevents delays [19]. Contingency planning using resilience curves, expert judgment, fuzzy methods and scenario planning accounts for disruption impacts on resources and schedules [29] [30]. Digital analytical and surveillance tools including Support Vector Regression (SVR), machine and deep learning models, Unmanned Aerial Vehicles (UAVs), Internet of Things (IoT), Radio Frequency Identification (RFID), and Artificial Intelligence (AI) analytics enable accurate duration estimates, effective planning and real-time monitoring [18] [23] [36]. From the resource-based theory perspective, structured planning frameworks, Building Information Modelling (BIM), and advanced risk tools represent valuable, rare, and inimitable resources that give construction firms a competitive advantage by reducing delays, while dynamic capability theory explains how firms reconfigure their planning, risk, scope, and stakeholder processes to sense uncertainties, seize digital opportunities, and transform operations to maintain schedule performance; thus, effective project planning directly reduces time overrun by integrating risk management, scope control, realistic scheduling, contingency planning, and stakeholder engagement. Therefore, it is recommended that construction firms institutionalize structured risk frameworks, adopt digital planning and monitoring tools such as BIM, Unmanned Aerial Vehicles (UAVs), and Machine and Deep Learning (ML & DL) forecasting, formalize scope change management, establish resilience-based contingency reserves, and implement dynamic stakeholder management to enhance schedule adherence and minimize delays.

4.7.4 Project planning significantly mediates the effect of inventory management on construction project time overruns

Outcome of direct and mediating hypothesis test on the study constructs (project planning, inventory management and construction project time overrun) revealed that project planning significantly mediates the relationship between inventory management and construction project time overrun in Nigeria. This is as such because sound project planning improves the beneficial impact of inventory management in reducing construction project time overrun through appropriate planning, scheduling and stakeholder management, which align with resource-based and dynamic capability theories. The study outcome indicate that effective project planning is very important in translating inventory management practices into timely delivery of construction projects. These findings offer an important approach to reducing construction project delivery delays in Nigeria.

5. Conclusion, Recommendations, Limitations and Future Research

5.1 Conclusion

This study investigates the mediating effect of project planning on inventory management and construction project time overrun in Nigeria. The study provides detailed analysis of how innovatory management, project planning and construction project delivery delay are related. Findings revealed that project planning and inventory management affect construction project time overrun. The study identified robust planning methodologies such as adequate resource forecasting and allocation, estimation of realistic activity durations, clear scope definition and effective risk planning; which permit effective team member engagement, improve effective project stakeholder control and promote schedule compliance, leading to adequate contingency planning and permitting reasonable deadlines from authorities; as drivers of appropriate project planning. Furthermore, appropriate inventory management emanating from effective project planning was found to improve timely delivery of construction projects. Project planning was found to be an important mediator between inventory management and construction project time overrun offering improved inventory performance which lead to timely project completion. Outcomes of the study aligned with resource based and dynamic capability theories which suggest the need for organizations to utilize their important resources and develop dynamic capabilities to achieve sustainable competitive advantage.

5.2 Recommendations and Policy Direction

Construction firms in Nigeria should institutionalize comprehensive project planning to strengthen inventory management and reduce construction time overrun. This requires embedding practices such as adequate scope definition, resource forecasting and allocation, effective risk planning and reasonable activity duration into project lifecycles, while investing in Building Information Modelling (BIM), Unmanned Aerial Vehicles (UAVs), Machine Learning (ML) and Deep Learning (DL) forecasting to support real-time planning and data-driven decision-making. Project managers should build competencies that allow effective team member engagement, lead to adequate contingency planning, permit reasonable deadlines from authorities and increase effectiveness on project stakeholder control to translate inventory management into timely construction project delivery. The need for policymakers to promote training, capacity building programmes and adoption of frameworks that improve project planning in the line of risk planning and resource allocation, integrated digital planning systems and platforms and scope management is suggested. Regulatory bodies and government need to develop guidelines and standards that promote effective project planning and inventory management. Government, construction organizations and other project stakeholders should support research and development on project planning and inventory management.

5.3 Limitations of the Study

The study identified convenience sampling, single country focus and the single item JIT construct obtained as limitations.

5.4 Suggestions for Future Research

Future research could look at various or integrated national context and examine the influence of digital technology adoption and forecasting in the use of Unmanned Aerial Vehicles (UAVs), Building Information Modelling (BIM), deep and machine learning, Radio Frequency Identification (RFID) and Near Field Communication (NFC) on inventory management and project planning. Looking at how project planning affects some project performance constructs such as quality assurance, occupational safety and cost control could unravel some mysteries. Investigating the effect of organizational culture on inventory management and project planning could give better insights into the interplay between these constructs and identify some project management and project planning challenges. The influence of project planning on green construction practices and environmental sustainability is worth looking at. Developing and validating integrated Project Planning and Inventory Management (PPIM) frameworks for mega projects having complex logistics is another research direction. Finally, the effect of public procurement policies and approval cycles on accuracy of planning and project delivery delays in government-funded projects could be investigated.

References

[1] Rehan, A., Thorpe, D., Heravi, A., 2024. A framework for leadership practices and communication in the context of the construction sector. *Project Leadership and Society, 5, 100142*, pp. 1-13. https://doi.org/10.1016/j.plas.2024.100142.

[2] Gorecki, J., Bojarowicz, E., Bizon-Gorecka, J., Zaman, U. and Keles, A. E., 2022. Leadership models in era of new technological challenges in construction projects. *PLUS ON, 17 (12)*, pp. 1-25, e0278847.

[3] Peng, J and Chen, C., 2026. Deep learning and heuristic exploration for risk-aware scheduling in construction projects. *Automation in Construction, 187, 106957,* pp. 1-13.

[4] BPP., 2025. BPP sets stricter measures to check procurement delays by MDAs. An interview with Director-General of Bureau for Public Procurement. *Business day News Paper* of January 13, 2025, Nigeria, pp. 6.

[5] Makun, M. J. and Ganiyu, G. B., 2019. Causes and Effects of Delay on Building Projects in Abuja. *In 1st International Conference on Collaboration for Sustainable Development in the Built Environment*. Held at Faculty of Environmental Sciences, University of Ilorin, Nigeria, pp. 583 – 594. Available online.

[6] BPP., 2026. BPP rolls out community-based system to track constituency projects. An interview with Director-General of Bureau for Public Procurement. *Business day News Paper* of January 20, 2026, Nigeria, pp. 6.

[7] Mukhtar, M. M., Abdussalam, D. & Mustapha, M. M., 2021. Factors affecting time performance of tertiary education trust fund construction projects in North-East, Nigeria. *Arid Zone Journal of Engineering, Technology & Environment, 17(3)*, pp. 335-346.

[8] Aghimien, D. and Aigbavboa, C., 2018. Performance of selected funding schemes used in delivering educational buildings in Nigeria. *In International Conference on Industrial Engineering and Operations Management*. Held in Washington DC, USA, pp. 108-119. Available online.

[9] Al Kaabi, M. S., 2021. Factors influencing timely completion of construction projects in the oil industry in the united arab emirates-an exploratory study. A dissertation submitted for the award of the Degree of Doctor of Business Administration, Department of Business Administration, Aberystwyth University, United Kingdom. pp. 1-126

[10] Jin, R., Zou, Y., Gidado, K., Ashton, P. and Painting, N., 2019. Scientometric analysis of BIM-based research in construction engineering and management. *Engineering. Construction & Architectural Management, 26(8),* pp.1750–1776, https://doi.org/10.1108/ECAM-08-2018-0350

[11] Shriharsha, Jagadeesha, B. P. and Sumukh, H., 2025. Investigating the mediating roles of inventory management and supply chain disruption factors in logistics performance – An evidence from the construction industry from Coastal Karnataka, India. *Results in Engineering, 26, 104822*, pp. 1-14.

[12] Muhammed, F.U., 2021. Assessment of inventory management practices on building construction projects: A case of Jimma town. Master of science degree thesis in construction management and engineering submitted to school of graduate studies and Department of Civil and Environmental Engineering, Jimma Institute of Technology, Ethiopia, pp. 1-10.

[13] Munyaka, J.B. and Yadavalli V.S.S., 2022. Inventory Management Concepts and Implementations: A Systematic Review. *South African Journal of Industrial Engineering, 33(2)*, pp. 15-36.

[14] Silva, A., Silva, M. and Ferreira, A. C., 2025. Inventory Management and its influence on the supply of high-value products: Case study evidence. *Logistics, 9 (1)*, pp. 1-19.

[15] Joseph, C. H., 2018. Inventory management practices and supply chain performance of construction firms in Nairobi. *MBA project, Department of management science, University of Nairobi, Kenya.* pp.1-66

[16] Khan, S., Saher, N. and Yunis, M. S., 2019. Project planning, project success and project risk. ` *Global Social Sciences Review (GSSR)*, *14(1)*, pp. 219 - 225.

[17] Althiyabi, T. and Qureshi, R., 2021. Predefined project scope changes and its causes for project success. *International Journal of Software Engineering & Applications, 12 (2)*, pp. 45-56.

[18] Selvam, G., Kamalanandhini, M., Velpandian, M. and Shah, S.. 2024. Duration and resource constraint prediction models for construction projects using regression machine learning method. *Engineering, Construction and Architectural Management*, *32 (9*), pp. 5743-5763.

[19] Oburu, A. O., 2020. Effective project time management. *International Academic Journal of Information Sciences and Project Management, 3(6)*, pp. 47-55.

[20] PMBOK., 2025. *The comprehensive practitioners guide*. Eight Edition, Project Management Body of Knowledge, Project Management Institute, pp.1-26

[21] Xing, W., Hao, J. L., Qian, L., Tam, V. W. Y. and Sikora, K. S., 2021. Implementing lean construction techniques and management methods in Chinese projects: A case study in Suzhou, China. *Journal of Cleaner Production, 286, 124944*, pp.1-16

[22] Rashid, Y., 2020. Analysis of Delay Factors and their Effects on Construction Projects. *Management Sciences Letters*, *10 (6)*, pp. 1197 – 1204.

[23] Radman, K., Jelodar, M. B. and Lovreglio, R., 2026. A digital monitoring, delay detection and visualization framework for construction projects: RealCONs. *Automation in Construction, 183,106781*, pp. 1-21.

[24] Hänninen., 2024. Improving inventory management efficiency: the impact of optimisation. Master's thesis in Industrial Engineering and Management, Lappeenranta–Lahti University of Technology LUT, Tarkastaja, pp. 1-82.

[25] Gangani, R., Bhavsar, A. & Modi R., 2018. A critical review on Building Information Modelling (BIM) – based dynamic inventory control for material management in construction industry. *IJCRT Journal, 6(2)*, pp. 2320-2882.

[26] Mwangi, L. W. and Yusuf, M., 2022. Project scope management and successful implementation of infrastructural health program in Nairobi county. *International Journal of Management and Commerce Innovations, 10 (1)*, pp. 140 – 148.

[27] Tor, M. A., Gambo, M., and Ogedengbe, F. A., 2025. Effect of Stakeholder Engagement Strategies on the Timely Completion of Construction Projects in North-Central Nigeria: A Conceptual and Theoretical Perspective. *Pakistan Journal of Life and Social Sciences*, *23 (1)*, pp. 7595 – 7607.

[28] Zhang, Y., 2024. Application of risk management plan to technical risks in metro construction: Case study of the Grand Paris Express project. *Tunnelling and Underground Space Technology, 147, 105716,* pp. 1-14

[29] Vegas-Fernández, Fernando. 2022. Project risk costs: Estimation overruns caused when using only expected value for contingency calculations. *Journal of Management in Engineering, 38 (5), 04022037,* pp. 1-8. https://doi.org/10.1061/(ASCE)ME.1943-5479.0001064.

[30] Zarghami, S. A., 2024. Resilience to disruptions: a missing piece of contingency planning in projects. *International Journal of Production Research, 62 (17)*, pp. 6029-6045.

[31] Sharma, R., Sohi, A., Hertogh, M. and Deketh, J., 2017. Controlling the uncontrolled by noticing the unnoticed. In *International Conference on Computer Sciences and Information Technologies (CSIT)*, Ukraine, *IEEE.* pp. 106-112.

[32] Khan, R., 2025. The role of risk management in project success: A comprehensive study of project management practices. *Texila International Journal of Management, 6 (1)*, pp. 1-7.

[33] PMI., 2019. *The Standard for Risk Management in Portfolios, Programs, and Projects*. Project Management Institute, pp. 10

[34] Swain, A. Rout, S., 2022. An empirical investigation to fill up knowledge gaps from earlier studies on stakeholder management in the construction industry. *Journal of Nonlinear Analysis and Optimization, 13 (2)*, pp. 339-349.

[35] Liu, L., Rahbarimanesh, A., Abadi, M. & Wang, K., 2024. Stakeholder management in construction projects: A systematic literature review. In 8th *BUiD Doctoral Research Conference,* University of Manchester, pp. 347-358.

[36] Choi, H. -W., Kim, H. -J., Kim, S. -K., & Na, W. S., 2023. An overview of drone applications in the construction industry. *Drones, 7(8),* pp. 515 - 510

[37] Chan, A.P.C., Ho, D.C.K., and Tam, C.M, 2001. Design and Build Project Success Factors: Multivariate Analysis. *Journal of Construction Engineering and Management. 127 (2)*, pp. 93–100.

[38] Adnan, H., Bachik, F., Supardi, A. and Marhani, M.A, 2012. Success Factors of Design and Build Projects in Public Universities-review under responsibility of Centre for Environment-Behaviour Studies (cE-Bs), Faculty of Architecture, Planning & Surveying, Universiti Teknologi MARA, Malaysia. *Procedia-Social and Behavioural Sciences*, *35 (2)*, pp. 170–179.

[39] Dang, C.N. and Le-Hoai, L, 2016. Critical success factors for implementation process of design-build projects in Vietnam. *Journal of Engineering Design and Technology, 14 (1)*, pp. 17–32.

[40] Lee, Z.P., Rahman, R.A. and Doh, S.I., 2021. Critical success factors for implementing design-build: Analysing Malaysian public projects. *Journal of Engineering Design and Technology, 20 (5)*, pp. 1041–1056.

[41] Barney, J., 1991. Firm resources and sustained competitive advantage. *Journal of management*, *17 (1)*, pp. 99–120, https://doi.org/10.1177/014920639101700108.

[42] Teece, D., 2012. Dynamic capabilities: Routines versus entrepreneurial action. *Journal of Management Studies*, *49(8)*, pp. 1395–1401. https://doi.org/10.1111/j.1467-6486.2012.01080.x

[43] Hair, J. F., Sarstedt, M., Ringle, C. M. and Gudergan, S. P., 2023. *Advanced Issues in Partial Least Squares Structural Equation Modeling*. Second Edition, SAGE Publications Inc., pp. 1-256.

[44] Henseler, J., Ringle, C. M. and Sarstedt, M., 2016. Testing measurement invariance of composites using partial least squares. *International Marketing Review*, *33*(3), pp. 405–431.

[45] Hair, J. F., Jr, Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G., 2014. Partial Least Squares Structuralequation Modeling (PLS-SEM): An Emerging Tool in Business Research. *European Business Review, 26(2),* pp. 106-121.

[46] Bagozzi, R. P., and Yi, Y., 1988. On the Evaluation of Structural Equation Models. *Journal of the Academy of Marketing Science, 16*(*1)*, pp. 74-94.

[47] Henseler, J., Ringle, C. M., and Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science,* 4*3(1)*, pp. 115-135.

[48] Zhao, X., Lynch, J. G and Chen, Q., 2010. Reconsidering Barron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research. 37(2*). pp. 197 - 206
[49] Hair, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M., 2021. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM).* Third Edition., SAGE Publications, Inc., pp. 1-384.
[50] Cohen, J., 1988. Statistical Power Analysis. *Current Directions in Psychological Science, 1*(3), pp. 98-101.