Innovations

Iron-triangle framework and the efficient management of public building projects in Nigeria

Fayomi, Fidelis Olukayode*
Department of Building Technology, Abraham Adesanya Polytechnic, Ijebu Igbo, Nigeria
Onifade, M.K**
Department of Mechanical Engineering,
Bells University of Technology, Ota
Adeoye, A.B***
Department of Management Technology,
Bells University of Technology, Ota

Corresponding Author: **Fayomi, Fidelis Olukayode***

Abstract
The project management techniques and practices over the years have not been able to proffer adequate solutions to the pattern of project underperformance trending within the Building sector of the construction industry. Multi-dimensional unsatisfactory project completion states have characterised the delivery of most Public projects due to failure factors affecting expected outcomes. Quality deficiencies, delay/time overrun and cost overrun have become inherent attributes of most Public building projects in developing countries as revealed by literature. Three hundred and two (302) closed and open-ended questionnaires were randomly distributed to the selected population for the study comprising professionals in the building construction industry in the Ogun State. Pearson Correlation analysis was utilised in testing whether there is a significant relationship between the variables while the effects of the framework for managing public building projects' success was tested with Regression analyses. Statistical Package for Social Sciences (SPSS) version 22 aided in carrying out the analyses. The results revealed that the Iron-Triangle-based framework is 'very high in effectiveness for all the areas identified since REIs are within 0.80-1.00. The closeness of the values to each other also shows that there is little difference in the effectiveness of using the Iron Triangle to accomplish success in the delivery of Public building projects and that the effects of the application of the Iron-Triangle framework on the success of public building projects in the study area were statistically significant F (1, 299) = 394.423; p (.000) < .01. The significance value, 0.000 is less than 0.01.0. The model summary results are statistically significant in predicting the effects of the application of the Iron-Triangle framework on the success of public building projects in the study area. This result classified causes of building projects failure to range between Most prevalent, Moderate prevalent to Least prevalent and, also confirms the 'very high effectiveness of the application of Iron-Triangle as a tool for managing triple-constraints (Time, Cost, and Quality/Scope) to achieve project success in Public building projects production in the study area and States with similar characteristics.

Keywords*: 1.Building production, 2.Iron-Triangle framework, 3.Project management, 4.Public building projects, 5.Triple-constraints.*

Introduction

Buildings are recognised as one of life's essentials since they not only give shelter but also a comfortable, conducive, healthy, and secure enclosed space where people can engage in a variety of activities, including social interactions. (Ogunbayo, Ajao, Alagbe, Ogundipe, Tunji-Olayemi, & Ogunde, 2018). The motivation of stakeholders in achieving appropriate, sufficient, and cheap building delivery is strongly correlated with addressing security demands and the socioeconomic status of people. To ensure effective service delivery and maximised economic advantage, buildings are vital components of human activity that must be preserved. (Gouda, Abdallah, & Marzouk, 2020).

Building production is a staged process that uses both professionals and non-professionals from a wide range of disciplines, each with their expertise and goals. This is a blatant sign that this industry has a tremendous financial impact on the overall economy. The building industry is a driving force behind economic and infrastructure expansion, as shown by the successes documented, while failure, project abandonment, and collapse indicate dire consequences for the country's economy. (Nwachukwu & Emoh, 2011). According to Pinter and Punder (2013), success requires the accomplishment of objectives during each stage of the building production process and activities. Failure, on the other hand, is falling short of the goals set for the project. Long-standing project management practices often define project success as projects that are delivered on schedule, under budget, and with high quality. Additionally, the project ought to give the client the highest level of satisfaction possible. (Nwachukwu & Emoh, 2011).

The effectiveness of the project management techniques used and the skill of the project managers in charge of the project delivery are key factors in finding a solution to problems with building project production management, project abandonment, and project failure. Compliance with the techniques for controlling project schedule, cost, and quality restrictions in project delivery is another aspect of efficient project management. These management restraints make up the "triple limitation," "iron triangle," or "triple constraint" collection of restraints. (Chiguru, 2019; Gomes & Romão, 2016; Omondi, 2017; Vides, Pertuz & Diaz, 2021). Building projects must be executed with success in mind because they frequently require significant financial outlays, failure or abandonment of the project could result in crippling effects on investors' or project financiers' financial capacities, and constant use of limited resources could result in the closure of windows to viable sources of alternative funding, which would be an opportunity cost. The client may have no other expectations for the future than the success of the project, with the project serving as their sole hope. (Nwachukwu & Emoh, 2011). For the majority of governments, end users, and communities, a building project's success is a crucial concern. (Ramlee, Tammy, Rajar, Ainumir, Abdul Karim, Chan, & Mohd Nasir, 2016). To ensure successful project delivery, the project team must carefully monitor, control, and balance the problems resulting from project restrictions. (Chiguru, 2019). Time, Cost, and Quality trade-offs will ensure that projects are completed (Tabish & Jha, 2018). Deficiencies in Projects delivery, abandonment, and collapse have turned out to be frequent occurrences in developing countries like Nigeria causing a huge degree of severity and concerns with significant negative devastating impacts on their growing economies (Akande *et al*., 2018*)*. It is important to dwell on this problem because building projects exhibit problems that differ from those encountered within other types of procedural production activities. The challenges entrapped in project scheduling, coordination, and controlling are very enormous and quite complex in large projects which tend to require vigorous and careful scheduling and monitoring to attain successful completion of such projects on time and at a judicious cost (Anyanwu, 2012).

Previous research has shown that private and public construction projects are barely delivered on time, cost, quality, and material specification expectations. In less than a few months of completion of buildings or rehabilitation, these commissioned Infrastructures become decrepit despite the colossal funds expended on their delivery. The collapse of building facilities, some even during construction in Nigeria can best be ascribed as a holistic financial loss likened to a project investor dramatically burying his life savings in a dug hole hence, staving off alternative venture opportunities (Onifade, Afolabi, &

Omogbolahan, 2017). An example of managerial failure in project delivery was exhibited in the recent collapse of a twenty-one-storey building under construction at Ikoyi, Lagos Nigeria recorded at the end of the year 2021.

Deficiencies in the delivery of projects in Nigeria emanate from several issues. For instance, deficient project planning, incompetency, inapposite application of planning procedure, scant apprehension of critical factors for project planning and project success index have been highlighted (Akande *et al*., 2018).

Considering the foregoing, it can be said that the knowledge of how to use the triple-constraints model and other frameworks to efficiently manage projects is very relevant in these days of incessant building delivery failures. However, there may be the need to further look into factors that pre-disposes projects to fail to know how specific frameworks could be used to solve the perennial challenges in the industry. From a literature point of view, project success factors for the construction Industry (Bakr, 2018; Gunduz & Yahya, 2018; Kalwane & Waghmare, 2016; Ramlee *et al*., 2015; Ribeiro, Paiva, Varajão, & Dominguez, 2013) and building in particular (Alvani *et al*., 2014; Belay *et al*., 2017; Patel *et al*., 2016) predominantly outside Nigeria; project failure factors (Nzekwe, Oladejo, & Emoh, 2015; Osuizugbo, 2019) in Nigeria; and factors of both success and failure (Oviasogie, Ikudayisi, & Olufolajimi, 2020) have been investigated. This is an indication that little or none of the studies have been dedicated to the causes of building project failure and their effects on public building project delivery in Nigeria. Similarly, the effects of such failures in public building projects are huge. Failure specific to major stakeholders has not received wide coverage from the available evidence as far as building project is concerned in recent times in Nigeria. Some others addressed the triple constraints/iron triangle framework of project management (Demirkesen & Ozorhon, 2017; El-Maaty *et al*., 2017; Lehtonen, 2014); and other frameworks or methodologies such as building information modelling (Liao, Teo, & Ton, 2017; Olawumi & Chan, 2019), Agile Quality Management Framework (Ahmed & Mohammed, 2018), M-TOPSIS method (Pinter & Pšunder, 2013) and general frameworks (Chan, Scott, & Lam, 2002; Jugdev, Perkins, & Walker, 2013). This shows that very few studies have compared the contributions of the frameworks of project management to the prevention of project failure although some studies have examined some individually outside Nigeria. The factors affecting triple constraints in the UK and Nigerian construction Industry (Ebiloma & Rimtip, 2019) and other countries (Chiguru, 2019) have been examined. On the other hand, the effect of triple constraints/iron triangle framework on projects in construction is very scantly (Nakhleh, 2019; Rugenyi & Bwisa, 2016) even as very few studies were found to have been conducted to assess the effects of project management techniques/methods/practices on project delivery in Nigeria (Onifade *et al*., 2017) and other countries (Alotaibi, 2019; Abdulla & Al-Hashimi, 2019; Haron *et al*., 2017).

Literature Review and Theory

2.1 Concept of Project

It is crucial to highlight the differences in the two words' definitions to distinguish between the ideas of projects and project management. A project is, in the simplest terms possible, any series of actions or succession of occurrences that involves merging various resources to achieve a specific objective. (Nwachukwu & Emoh, 2011). A project can be thought of as the realisation of a specific aim, which entails a concatenation of sequential tasks and activities that consume resources. It has to be finished by the specified deadline and start and end dates (Rosli, 2017). A project is frequently explained by key performance indicators (KPIs), which provide crucial data and chart a route for the desired project conclusion. In a similar line, identified critical success factors (CSFs) are major prerequisites for project success and co-established (Bjerkensjö & Khalaf, 2021).

Project Management

The process of managing the necessary series of tasks to accomplish particular project goals can be referred to as project management. Utilising available resources and investigating current organisational structures aims to maximise the benefits of collaborative contributions such as strategies, tools, and procedures without adversely affecting obstacles or impediments to the organisation's regular operations (Rosli, 2017). Project management is a clever management technique designed to accomplish defined goals within predetermined time and financial constraints by making the most use of available resources (Onifade *et al,* 2017). The project must be completed on schedule, within budget, and per technical specifications (Vides, Pertuz & Díaz, 2021). By carefully choosing, coordinating, planning, budgeting, and monitoring the actions of all the many professionals and non-professionals involved during the development process, project management involves the appropriate amortisation of the collection of activities of all those people (Nwachukwu & Emoh, 2011). A project is only considered successful if its goals have been met including delivery within the anticipated timeframe, cost or budget, and quality (scope) that meets the client's requirements (Kerzner & Balack, 2010; Neyestani, 2016). When the triple restriction technique is used correctly in project management, it significantly increases the likelihood that the project will be completed successfully, meeting the needs of all stakeholders, on schedule, and within the budget that has been set aside for it. This is especially true during the project's crucial planning stage (Vides, Pertuz, & Díaz, 2021).

Building Project

The building industry is vital to a country's economy. A geographical entity's economic viability is generally shown by the presence of physical infrastructures and prominent buildings like roads, skyscrapers, bridges, and other types of construction (Roshana & Akintola, 2002). Given that physical structures are required for engaging in substantial economic activity, it is only logical to draw the conclusion that they promote economic expansion. Buildings are still important since they are essential to the development of any sort of urbanisation. They serve as the key component for informing residents that development and growth are occurring in their neighbourhood (Gouda *et al*., 2020). Building development is an excellent example of a project, while there are projects in every area of human endeavour (Nwachukwu & Emoh, 2011).

Several people with a variety of interests who are passionate about them are involved in construction projects, one of which is a building project. This could be the cause of the many performance measures that are based on the interests of the various parties involved in construction projects. When carrying out capital-intensive or public projects, all industry participants need to make wise use of resources to achieve maximum success. The outcomes of adopting the traditional methods of project management have been reported as being poor, which highlights the need for meticulousness when carrying out building projects. The relationships between the stakeholders, including the customer, contractors, and consultants, have thus become tainted as a result of improper management. Because they do not get the benefits of project management's improved procurement process, clients are constantly on the losing end (Vides *et al*., 2021).

Project Success

Project success is relative, making it challenging to express in a few words, yet being every project manager's ambition and ultimate goal (Pinter & Pšunder, 2013). Due to its ambiguous nature, project success has been defined differently by many organisations and individuals.

There is consensus among experts on what constitutes project success and how it may be measured, despite the complexity and diverse definitions (Fernando *et al*., 2015). In general, experts think that a project's success might be either long- or short-term. This has been used to refer to both efficacy and efficiency (Abdulla & Al-Hashimi, 2019).

Projects are generally started to maximise organisational profit. Results-driven organisational performance comes before this. Making such a profit is followed by actions focused on increasing profits, fostering growth, and improving market positioning (Fernando, Thorpe, Panuwatwanich, &

Goh, 2015). Project managers are focused on one goal, which is how to complete the task. They consider a project to be successful when all deadlines are reached, the budget is met, and the expected parameters are properly satisfied. When the client is pleased with the finished product, some project managers consider that to be the pinnacle of success. Intriguingly, while adopting this attitude may aid in task completion by saving money, time, and other resources, it may also result in disappointment if other unanticipated reasons prevent the project from being completed promptly (Gomes & Romão, 2016; Shenhar, Dvir, Levy, & Maltz, 2001).

Project Failure

The concept of project failure as the antithesis of the idea of success in project management will become clear with a knowledge of project success as stated above. When managerial expertise is not used to achieve goals and objectives, projects fail. This does not imply that the project was not finished; rather, it refers to the precise moment at which the project was declared finished. There are also the following issues to think about: Is there a time or money overage? Have the defined quality requirements been met? Will it hold up to the test of time? Can you utilize the project's potential to the fullest? Are your clients and end users content and satisfied? Can a client insist on working with the same team if the client suggests starting a new project? The project is deemed successful if the responses to the aforementioned questions are satisfactory; otherwise, it is deemed unsuccessful (Nwachukwu & Emoh, 2011). Certain stakeholders, particularly project users and some individual owners, define a failed project as one that was either not completed, had a constructed dam project that failed within a short period, or had a completed construction project that collapsed. Imagine that a road project failed a few months after it was finished. (Dim, Okorocha, & Okoduwa, 2018). In addition, the existence of a crucial success component that was essentially unknown contributed to the high rate of project failures. The input into the project management process, which can directly or indirectly contribute to the project's success, is a crucial success factor (Belay, Alemayehu, & Assefa, 2016).

Theoretical Review

2.2.1 Resource-Based View (RBV)

The work of Penrose in the 20th century served as the inspiration for the Resource-Based View (RBV) of the firm (1959). The project imagined the company as a group of productive people and physical resources and an administrative organisation. Carla (2006) asserts that the firm can benefit from a range of services from both its material and human resources. Depending on how the firms envision using them, the same resources can be used in various ways. Because of this, businesses are knowledge repositories because there is a strong connection between the knowledge that individuals within the organisation possess and the services gained from the resources. Although the foundations of the resource-based view can be linked to an earlier study, Birger Nienhüserfelt is credited with developing the RBV in his article Resource-Based View of the Firm from 1984 (Nwankwere, 2017). Resources are varied among organisations, and this heterogeneity can be sustained over time, which is a crucial presumption on which the RBV of the firm is built (Nwankwere, 2017). He further claimed that strategists have discovered four empirical indicators indicating businesses' resources or VRIN resources can produce sustainable competitive advantage. A resource would be considered valuable if it could enhance and raise the value that the company is providing to its clients; this could be done by either improving its capacity to stand out or be distinctive or by lowering the price of the goods or services. When just one or a small number of businesses can afford to purchase a resource, it is considered uncommon.

2.2.2 Theory of Constraints

Dr Goldratt first developed the Theory of Constraints (TOC) in his book The Goal, which is a general management philosophy. Any manageable system is only able to accomplish its objectives within a specific environment, where there is always at least one limitation in reality, according to the idea behind this title. A constraint is simply the point at which a project or job does not function as intended (Bhagdewani, Kanase, & Shinde, 2017). The core principles of TOC were first stated by Goldratt, one

of the co-founders of the organisation. Each system has at least one restriction that prevents it from performing better with its objective. The system should produce its greatest output when that constraint is used to its full potential. Maximum use of non-constrained resources does not enhance output; instead, it just generates wasteful inventory (Skorkovský & Linhart, 2014). The theory, which is a type of systems thinking, contends that each complex system, at any one time, frequently only has one aspect or limitation that prevents it from achieving more of its goal. Exploiting the limitation and adjusting scheduling and resource consumption are necessary (Rugenyi, 2015).

Construction constraint problems can be solved using the Theory of Constraints, albeit this approach is just starting to gain acceptance. The TOC suggests five tactical methods to locate and eliminate the main restriction in the system. A particularly efficient way to get rid of the time restrictions related to buffer management in TOC is to use Critical Chain Project Management (CCPM). To construct time buffers, buffer management involves adjusting activity time estimations while taking into account human behaviour (Mishra, 2020). The Theory of Constraints (TOC) can be used to find, eliminate, and enhance internal capacity. Subordination additionally denotes making sure that resources are accessible in a specific project context. Theory constraints (TOC) application can improve the standard of management and organisational performance (Vasudevan, 2021).

2.2.3 Resources Dependency Theory

A Resource Dependence Perspective by Jeffrey Pfeffer and Gerald Salancik, published in 1978, marked the beginning of Resource Dependency Theory (RDT), which at the time was largely accepted in Anglo-American discourse (Nienhüser, 2008). Emerson (1962) has previously proposed this idea, according to Chen (2015), but recent research using it has led to a widespread acceptance of the theory in the fields of organisational theory and strategic management.

The links between resources and business decisions are explained by RDT. Resources and their application are the main ideas. It is fundamentally necessary to link resources, their utilisation to produce outputs, and the relationship between outputs and the success or survival of the organisation (Narayana, 2015). An organisation's dependency on resources owned by other organisations in its environment, namely suppliers, shareholders, unions, competitors, governmental authorities, and other stakeholders, is explained and managed by resource dependence theory (RDT), a scientific method (Reiss, 2012; Ayse, 2014).

According to Nienhüser (2008), a fundamental tenet of Resource Reliance Theory (RDT) is that "organisational decisions and actions can be explained depending on the specific dependency situation" and that "dependence on 'essential' and important resources influences the actions of organisations." When a resource is necessary—even in very modest quantities—an organisation will struggle to carry out its operations if it is not on hand. Subcontractors, for instance, while also increasing the reliance of other organisations on their resources, such as project skills In relationships between organisations and stakeholders, control of essential resources is viewed as the source of power since it enables the controller to impose financial requirements on other organisations that depend on access to the resource (Ulrich & Barney, 1984 as cited in Parker, et al., 2015).

2.2.4 Theory of Triple Constraints

The three restrictions come from the definition of a project, which is an endeavour undertaken temporarily by a group of people to produce a particular good, service, or outcome (PMI, 2015). A project is often deemed successful if it meets its objectives per its acceptance criteria and does so within the stipulated timeframe and budget (APM, 2015). These criteria provide a focus on specific traits found in a typical project organisation. In other words, there are only so many resources available to do all of the tasks in existence. Due to the scarcity created by this, we are subject to the triple restrictions of having to fulfil deadlines, staying within budget, and performing at least as well as expected (Dobson, 2004; Rugenyi & Bwisa, 2016).

According to the theory of the triple constraint: (1) The triple constraint is a balance between the three interdependent project elements of scope, time, and cost as a function of the project's higher purpose; and (2) The cause and effect of new or changing triple constraint requirements are constantly negotiated

throughout all phases of a project. (3) The three fundamental links between the triple constraints imply that at least one of the variables must be restricted (otherwise, there is no baseline for planning) and that at least one of the variables must be exploitable (otherwise, quality may be impacted) (Wyngaad, Pretorius, & Pretorius, 2012 as cited in Rugenyi & Bwisa, 2016).

2.2.5 Discussion of Applicable Theories

TOC, RBV and RDT are important theories to project management as they provide insight into how project managers (and other key stakeholders) can increase the chances of project success by managing project constraints, utilising internal resources and strategic assets and reducing dependencies and uncertainties Parker, *et al*., 2015)**.** As a result, they serve as the foundation for this study because they are all crucial to the effective administration of an organisation or project.

Time, money (budget), scope, and quality are just a few of the constraints that exist at every step of a project, along with other elements like risks and resource availability. As a result, it is crucial to apply the TOC to project management since managing critical constraints can reduce delays, which increases the likelihood that the project will be completed on schedule, within budget, and by scope and quality requirements. The TOC technique encourages project managers to identify constraints at each stage of the project and apply methods to overcome these constraints because it is a process of continuous improvement. A final evaluation of the project and documentation of "lessons learned" are undertaken during the closing phase, which may also include a general evaluation of how constraints were managed throughout the project life cycle (Parker *et al*., 2015).

As it focuses on the utilisation and deployment of a firm's resources and the development of strategic assets for obtaining a competitive advantage, the RBV approach is crucial to project management. According to RBV, project management also has intangible resources, which might include invisible assets, tacit knowledge, and special capabilities, routines, and procedures. Tangible resources include common project management methodologies, tools, standards, and practices (Jugdev, 2004; Mathur, Jugdev, & Fung, 2013). Some authors have discovered that using only conventional, well-known tools and procedures does not necessarily result in project success (Ekundayo *et al*., 2013). According to Shenhar and Dvir (2007) (as cited in Parker *et al*., 2015), modern projects are more uncertain, complex, and subject to change as a result of the dynamic business environment. This contrasts with the traditional approach, which is based on a fixed, predictable, and most often simple model. Therefore, to handle the majority of modern projects successfully, project managers need to have additional skills and abilities.

2.3 Review of Empirical Studies

Sibiya, Aigbavboa, and Thwala (2015) studied the key performance indicators of construction projects using the South African construction industry as a case study. The research looked into the KPIs for the most important building projects in South Africa's Gauteng province. Professionals who were randomly chosen as the target population for the survey, including architects, quantity surveyors, electrical engineers, mechanical engineers, structural engineers, civil engineers, construction managers, project managers, and construction project managers, completed questionnaire surveys to gather the study's primary data. The survey results were analysed, and the findings showed that the most important KPIs for construction projects are profitability, construction time, project management, risk management, material ordering, handling, and management, quality assurance, client satisfaction (product), safety, time predictability (project, design, construction), productivity, and client satisfaction (service).

To better understand the elements that affect the success and failure of construction projects in the Nigerian construction industry, Oviasogie *et al.,* (2020) produced empirical information on these aspects as they relate to building projects. To identify the most important success and failure criteria in connection to projects within the construction industry, the study employed the Mean Item Score (MIS). The timely disbursement of payments, the availability of resources, and the competence of contractors are the most important factors in a project's success; on the other hand, insufficient equipment and

manpower, poor pay, and a lack of professionalism were deemed to be the most harmful factors in a project's performance.

In Nigeria, Osuizugbo (2019) looked at project failure factors (PFFs) that affect the design and construction phase of building projects. A questionnaire with 28 identified characteristics was utilised in a survey design to gather information from three groups of respondents (professionals in the construction industry, contractors, and clients). The most PFFs were identified using the mean score, relative importance index, and mean score average method, and the agreement between the categories of respondents on the most crucial PFFs was examined using Spearman's rank correlation. To ascertain whether the mean scores among the various groups of respondents were statistically significant, a one-way analysis of variance was also carried out. According to the survey, the top five PFFs are culture or ethical misalignment, unclear scope and goals, subpar monitoring and tracking, mistakes in design, and subpar expectation management. The comprehension of PFFs, it was determined, would benefit all interested parties in the building industry and increase the success of construction projects.

The impact of project management techniques on projects' success in Saudi Arabia was assessed by Alotaibi (2019). The study was based on information gathered via surveys and interviews with some of the more seasoned PMs at significant contracting firms (Grade 1, Grade 2, and Grade 3) in the Riyadh region of the country. Two phases made up the study. Twelve PMs from grade 1 and grade 2 contractors participated in phase one's qualitative survey, which included interviews, and 276 PMs from grade 1, 2, and 3 contractors participated in phase two's quantitative survey, which included a questionnaire. Based on the type of data gathered, both statistical and thematic analysis was conducted. It was determined that even if there are many causes of cost overruns and project failures, the adoption and application of project management practices should increase perceptions of project success, lower the number of project failures, and enhance the industry as a whole.

Ebiloma and Rimtip (2019) investigated the factors that affect the success and failure of PMM usage in the UK and Nigerian construction industries to address the challenges in project management and promote the use of modern methodologies in the construction industry as a result of the underutilization of Modern PMMs, such as PMBOK, APMBOK, and PRINCE2, in the Nigerian construction industry. Telephone and in-person interviews were conducted to gather information about the practices in the Nigerian and British construction industries. Four senior project managers from the Nigerian construction sector and two senior project managers from the UK's construction sector are among the participants. The participants identified several issues that prevent the adoption of PMMs and lower the success rate of the methodologies, including the nature of contracts in the nation, lack of understanding of PMM, a poor emphasis on management, societal ideologies (resistance to change), and difficulties enforcing policies. The quality of education and training received by professionals in the construction sector in the UK, as well as communication among those professionals, were evaluated. According to the study's findings, the Nigerian construction industry would eventually embrace PMMs if it is encouraged to hire qualified specialists and has an effective oversight plan from the government and the construction sector.

In 2015, Nzekwe *et al*. investigated project failure as a recurrent problem in Nigeria's Anambra State. According to research, project failure has turned into a common occurrence for construction projects in developing nations. Project abandonment is just one way this shows up; other ways include structural flaws that cause buildings to collapse, extended project delivery times, cost overruns, and unhappy clients. To reduce the high rate of project failure, the objective of this research was to critically analyse the elements that may cause project failure in Anambra State, Southeast Nigeria. One hundred (100) project experts with a minimum of five years of experience were surveyed to gather the primary data for the study. To get their thoughts on the causes of the project's failure, structured questionnaires based on the Likert-5-Point Scale of Responses were employed, and secondary data came from a survey of the literature. The Statistical Package for Social Sciences was used to create the required statistical tools for

the analysis of the results (version 16.0). The analysis demonstrates that project failure rates are high (p = 0.000), and the cost of materials is the main contributing factor in the study area.

Anyanwu (2012) undertook the study to determine how project management and the project manager are all capable of meeting the demand for preventing the occurrences of building and infrastructure collapse in Nigeria. The project manager position in the building construction industry should be held by a professional with the necessary expertise and training in the project management body of knowledge, it was discovered after examining the various parts that makeup project management in the industry. Project management is a vehicle with which project managers can achieve successful building project delivery.

3.0 Methodology

A descriptive study is one in which variables that may be connected are assessed for a predetermined population at a certain period. The research design used in the study was descriptive. It may be applied to preliminary and exploratory investigations to enable data collection, summarisation, presentation, and interpretation for the aim of clarity (Orodho, 2003). This study also involves a description of variables, the study of associations among them as well as predicting the influence among some of them. Thus, the choice of this design is to assess the effectiveness of the application of the Iron-Triangle framework for managing public building project delivery**.**

3.1 Sampling Procedure

The study involved a multistage sampling procedure. The first stage involved the purposive selection of the building construction projects in Ogun State, being the focus of this study. The second stage involved the identification and stratification of the target respondents according to their profession, i.e., Civil Engineer, Builder, Architect, Project Manager, Quantity Surveyor Estate Manager, and others (see Table 4.1). The third stage involves a convenience sampling of the respondents. The respondents were conveniently selected for the sharing of the research instrument online. This can be regarded as a census sampling procedure since the entire identified professionals were part of the study.

Table 3.1: Population/Sample Size

Areas of Specialisation	**Population/Sample Size**
Project management	76
Civil engineering	72
Architecture	39
Building	62
Quantity Surveying	27
Estate management	24
Others	1
Total	302

Source: Field Study, 2022

3.2 Method of Data Collection

Data collection is important for providing answers to questions raised in the study and for objectives to be achieved. Data for this study were mainly primary and were retrieved with the aid of a questionnaire designed for the purpose. The questionnaire consists of closed-ended and open-ended questions. This

includes both pre-set questions that respondents must answer in a specific order and using pre-established response alternatives, as well as open-ended questions that allow respondents to express their opinions. Five components make up the questionnaire. While Section A gathered demographic data on the respondents, Sections B through F focused on the research variables and objectives: Causes of building project failure; Effects of factors of public building project failure on the major stakeholders; Frameworks in existence for the management of building projects; and the assessment of the Effectiveness of the Adaptation of Iron-Triangle based framework to management of public building projects delivery in order of appearance in each of section B to Section E respectively. Data from Section A were measured on a nominal scale. Those in Sections B to E comprised questions measured at ordinal levels using 5-points Likert scale items in addition to the open-ended. The type and description of the data collected are presented in Table 3.2. An online version of the questionnaire was designed for easy sharing and collection of data from the respondents.

3.3 Method of Data Analysis

The summary of the statistical tools employed to achieve the objectives and hypotheses of the study is displayed in Table 3.4. The analyses of the demographic data are purely descriptive (frequency and percentage distributions presented in tables). The causes of building project failure (objective one) depended on the mean score and percentage distribution for analyses. The consequences of public building project failure on the major stakeholders were analysed using the Mean score (SI) (objective two). The frameworks for managing the production of building projects (objective three) were also evaluated using the Relative Importance Index (RII) while the adapt an Iron-Triangle-based framework for the management of public building projects was examined using the percentage and Relative Effectiveness Index (REI). Pearson Correlation analysis was also utilised in testing whether there is a significant relationship between public building project success and the strategies mitigating failures (hypothesis one) while the effect of a framework for the management of public building on project success was tested with Regression analyses. Statistical Package for Social Sciences (SPSS) version 22 aided in carrying out the a for ementioned analyses.

Table 3.2: Method of Data Analysis

S/N	Objective	**Tool**	**Formula**	**Description**
A	Objective One	Percentage distributions; Mean Score	$\frac{\sum W}{N}$	**W is the weight that respondents assigned to each question, and N is the overall number of respondents.**
B	Objective Two	Percentage distributions; Mean Score. Correlation Analysis	$\frac{\sum W}{N}$	**W is the weight that respondents assigned to each question, and N is the overall number of respondents.**

C	Objective Three	Relative Important Index (RII)	$\frac{\sum W}{A * N}$	**W is for the weights of respondents (1-not important) to (5-very important) assigned to each risk; A stands for the greatest weight (in this example, 5); and N stands for the total number of respondents. The RII value is in the 0 to 1 range (0 not included). The more significant the questionnaire item, the higher the RII number should be.**
D	Objective Four	Relative Effectiveness Index (REI)	$\frac{\sum W}{A * N}$	**W represents the respondents' weighting of each risk (1-not important) to 5 (extremely important); A represents the maximum weight (in this example, 5); and N is the total number of respondents. The REI value is between 0 and 1. (0 not included). The effectiveness of a questionnaire item increases with REI value.**
E	Hypothesis One	Correlation Analysis		
F	Hypothesis Two	Multiple Regression		r= Regression coefficient y= Dependent variable x= Independent variable

3.4 Model Specification

The multiple regression equations below will be used to establish the dependency relationship between variables in the study based on the stated hypothesis.

Hypothesis Two: Effect of **a f**ramework for the management of public building projects and project success

$$Y = f(X) \quad (1)$$

$$Y = \beta_0 + \beta\ X\ + e$$

Where:

$Y = Project\ Success$

X = Framework for the management of building projects

β_0= Constant

β = $Coefficients$

4.0 Discussion of Findings

Discussion of Findings

Based on the demand of objective one, the dominant causes of building project failure are non-compliance with project specifications; inadequacy of project specifications; lack of detailed project work breakdown and project plan; the dearth of required training, technical competence and experience; and inability to track progress and requirements can cause project failure. These factors are generally related to specific construction skills for employees. They also illustrate the need for the right leadership to drive project implementation. This corroborates the findings in Ojima, Ojo and Nanven (2019) in part. According to the authors, encouraging the use of qualified professionals will ensure good management practices and eventually the adoption of project management methodologies, which will result in the success of the project, in addition to an effective supervision plan from the government and the construction industry with pertinent policies. Osuizugbo (2020) also noted a lack of professionalism, a significant proportion of inexperienced workers, and a lack of expertise in the building industry. This shows the importance of up-to-date training, both in-house and otherwise. The purpose is to expose employees to the developments in the industry and improve the process of using new approaches to achieving project objectives. According to Anyanwu (2012), a professional with training in the project management body of knowledge should hold the role of the project manager in the building construction business. Supporting this assertion, the greatest significant success elements, according to Belay *et al*. (2017), are the project manager's leadership abilities, the decision-making process' efficacy, and project monitoring. Relatively, the availability of skilled labour has also been identified as an important factor (Bakr, 2018). Other factors identified as complementary to averting project failure in terms of providing leadership and skills for the project include the adequacy of plans and specification, safety, project planning, quality control and assurance, technology transfer, technical approval authorities, risk identification & allocation, among others (Patel, *et al*., 2016).

On the other hand, the causes with low impact include non-application of formal methods and strategies in project management; ineffective communication during project execution; ineffective communication at all levels; key staff exiting the project and/or company during project execution; and cultural differences in global projects. These causes seem to relate to how workers are being done and the necessary ingredients for project effectiveness. Non-application of formal methods and strategies in project management; and ineffective communication still require appropriate leadership to plan for and implement during the project life. This supports the view expressed in Anyanwu (2012) that project management requires the use of certain methodologies. It also includes communication management among other knowledge management areas (PMI, 2013). Bakr (2018) also supports the fact that the flow of information among parties is one of the factors that influence the construction project's success.

The consequences of public building project failures among stakeholders were the focus of objective two. The findings of this study on the consequences of project failures include cost overrun on building projects, time overrun in building projects, and lack of satisfactory project expectations from the end users. From all indications, dashing off the hope of workers on building projects, dispute, arbitration and litigation, and project abandonment are not unlikely, but are the least common causes. Linking the causes of failures to the consequences, blight of value for project fund, negative environmental impacts on the community, cost overrun on building projects, time overrun in building projects, and dash in hope of workers on building projects are significantly related to each of the three categories of causes of project failures in the study area. Overruns are a common phenomenon in the construction industry for which Oluseye (2017) identified their factors as underlying issues in public building infrastructure in Sub-Saharan Africa. The author pointed out that project overruns can have a detrimental impact on project procurement as well as society at large, including a waste of limited resources, disagreements and litigation, an increase in cost and schedule delays, a bad reputation among the public, and project abandonment. This means a dispute, arbitration and litigation, and project abandonment are not common consequences, but likely to be the aftermath of other consequences. The implication is that, in

one way or the other, causes that are not well-attended early on in the project might degenerate into later consequences.

In the evaluation of frameworks for managing building projects, Iron Triangle Method, Extreme Project Management/Megaproject (XPM), Building Information Modelling Framework (BIM), Projects Integration Sustainable Methods (PRISM), and Prince 2 are the most important and common in usage in the study area relative to others, whilst Critical Path Method (CPM), Critical Chain Project Management (CCPM), Agile and Waterfall are the least important set of frameworks. This is consistent with the findings of Abdulla and Al-Hashimi (2019), who discovered that applied Project Management Models (PMMs) have a greater impact on project success than comprehensive PMMs. Similarly to this, Olawumi and Chan (2019) noted that the building information modelling and project information management (BIM-PIMF) framework for construction projects has the propensity to enhance information channels and make it simpler to integrate technological innovations into construction processes while enhancing the technical proficiency of project staff. In contrast to these results, Silva, Pérez, and Puentes (2018) found no statistically significant link between the use of project management approaches and the effectiveness of the projects. Due to the inconsistent findings, Al-Hajj and Zraunig (2018) argued that the level of training, timeliness, and level of implementation attained by practitioners all affect the impact of project management tools and methods on project success. Thus, the human factor is very germane. Another study found that using project management tools was less variable than using risk management tools and information communication technology support tools (Jugdev *et al*., 2013). It can be inferred that; the effectiveness of project management methodologies may depend on other support tools and strategies like mastery of their use through training of employees that will use them and effective strategies for communication information from the framework to project stakeholders since not all stakeholders are not required to capacity to use them.

The use of an iron-triangle-based framework is ‘very high in effectiveness in all the areas identified. Specifically, it has significant effectiveness for time management, initiation of fund disbursement patterns, resource allocation and application to different stages of the project lifecycle. The least effective adaptation areas include managing materials mobilisation/ stocking of materials, total quality control management and scheduling of materials in building projects. Although client engagement and acceptance have become more significant in recent years, Ribeiro *et al*. (2013) began by stating that the conventional elements of cost, time, and quality are still the most crucial for determining the success of a project. In support of this claim, Haron *et al.* (2017) suggested that in addition to the traditional iron triangle's view of time, cost, and quality, new and emerging criteria like customer satisfaction, the project team's competency, and the performance of subcontractors/suppliers are becoming measures of success.

Project success is positively and significantly correlated with each of the following: Triangle Method, Extreme Project Management/Megaproject (XPM), Building Information Modelling Framework (BIM), Prince 2, and Projects Integration Sustainable Methods on the test of hypothesis one (PRISM). Hence, the frameworks tend to improve the chances of the successful delivery of projects in the study area. On the other hand, project success is not significantly related to Hybrid (of the waterfall and agile) and Agile, but negative and significantly related to Critical Path Method (CPM) and Waterfall, Total Quality Management (TQM), and Critical Chain Project Management (CCPM). Both Hybrid (of waterfall and agile) and Agile are not likely to contribute significantly to project success in the study area while the remaining frameworks do not achieve the required results without using them alongside other modern ones. Olateju *et al.* (2011) noted that the high cost of implementation of projects in public sector organisations as well as the lack of in-depth knowledge of PM tools and methodologies are both problems. This may inhibit the ability to achieve the required results. As stated initially, the skills of employees may need improvement to get the best out of their usage.

Lastly, the application of the iron-triangle framework has a significant effect on public building project success in the study area. This refutes the conclusion made by Mellado, Lou, and Becerra (2020) that

there is no harmonious relationship between the definition of performance and the conventional iron triangle of "cost-time-quality," although it was also noted that the iron triangle is still the preferred method of performance analysis despite being ineffective. The use of iron triangles is not likely to go into extinction so soon. This is because even most of the modern frameworks and tools operate based on these three constraints although they have other criteria for managing project success like sustainability.

5.0 Concluding Remarks

The causes of project failure range from moderate prevalence to most prevalent. Generally, the most prevalent is the inadequacy of project specifications; and lack of detailed project work breakdown and project plan while the least prevalent are cultural differences in global projects. Effects of project failure are also from 'moderate' to 'very high in the study area although cost overrun, time overrun and lack of satisfactory project expectations from end users are more common ones.

Iron Triangle framework has proven to be an important tool in the hand of the professionals in the study area just as Extreme Project Management/Megaproject, Building Information Modelling Framework, and Projects Integration Sustainable Methods have also been deployed to very great extents.

The effectiveness of the application of the Iron-Triangle-based framework for the management of public building projects in the study area is 'very high' especially, in the initiation of fund disbursement patterns, resource allocation, and usage at different stages of the project lifecycle.

Recommendations

Based on the findings from the study, the following recommendations are made.

i. Adequate time and effort must be put into the initiation phase of building projects in the study area to detailed project specifications, and work breakdown to arrive at a project plan free from ambiguities.
ii. Project participants should be encouraged to use the Iron Triangle framework, Extreme Project Management/Megaproject, Building Information Modelling Framework, and Projects Integration Sustainable Methods to achieve more effective and efficient management of different aspects of building project delivery.
iii. Given the effectiveness of the application of the Iron-Triangle-based framework for the management of public building projects in the study area, professionals should be encouraged to use it in different aspects of a project most especially those with lower effectiveness such as managing materials mobilisation/stocking of materials, total quality control management in building projects, and scheduling of materials.

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Corresponding Email: ***kay1fayomi@yahoo.com***