PROJECT PERFORMANCE DIAGNOSTICS: A MODEL FOR ASSESSING CONSTRUCTION PROJECT PERFORMANCE IN NIGERIA.

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Acknowledgement

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Declaration

I declare that this thesis represents my own work carried out by me, except where due acknowledgement has been made in the text, and that it has not been submitted either in part or full for any other award than the degree of Doctor of Philosophy in Built Environment, University of Salford, Manchester, UK. Materials from other sources have been duly acknowledged and referenced in line with ethical standards.

Signed: WASIU ADENIRAN BELLO

Signature ....

Date ....

Dedication

Dedicated

To my Children –

AbdulRahmah, Najat, Maryam, ’A’ishat & Zainab

To my well wishers,

And

To my Loved Ones

LIST OF ABBREVIATIONS

AVE:	Average Variance Extracted
BIM:	Building Information Modelling
CFA:	Confirmatory Factor Analysis
CSF:	Critical Success Factor
DSS:	Decision Support System
FM:	Facility Management
JCT:	Joint Contract Tribunal
KPI:	Key Performance Indicator
PPD:	Project Performance Diagnostics
PPDM:	Project Performance Diagnostics Model
PPP:	Public-Private-Partnership
SD:	System Dynamics
SPSS:	Statistical Package for Social Sciences
UK:	United Kingdom

ABSTRACT

Construction Projects are notorious for demonstrating poor performance and under achievement as usually indicated by project objectives. Project managers in the construction industry are faced with many research suggestions in literatures to improve performance but there are confusion in the implementation of these recommendations. These could be attributed to dearth of literatures that comprehensively treat critical success factors; CSFs as drivers of key performance indicators; KPIs for assessing construction project performance. KPIs are measure of indication of the workings of CSFs for project performance thus, both are present on projects and useful in exploring the underlying dynamic structure of complexity inherent in construction projects. The study determine CSFs for KPIs of cost, time, quality and health/safety which were used to develop a dynamic Project Performance Diagnostic Model which gives feedback for improved decision making in the context of diagnosing project performance in the Nigeria construction industry.

This research tends not to discard the positivism or interpretivism philosophical stance by being pragmatic. Pragmatism argues that the most important determinant of epistemology, ontology and axiology adopted on research is determined by appropriately answering particular research question thus, this research adopted the pragmatism philosophy. The research process involves different phases with quantitative-qualitative research technique corresponding to the two respective ends of the positivist-constructivist paradigm continuum. The data for this research were collected through interviews of focus expert group and survey questionnaire in a form of data generation triangulation. Results of the qualitative aspect were used to develop a questionnaire, which was analysed using statistical techniques including factor analyses. The CSFs of KPIs so analysed were used to develop PPDM system dynamic based model to simulate

the interplay and effects of different CSF components for aiding decision making of project managers.

The research suggests that Cost as a key performance indicator has the most overriding impact on construction project performance with three components. The three dimensions to Cost performance indicator are Contractor's Management Capacity, Client's Commitment to Progress of Project, and Economic Environment of Project Estimate. Time performance indicator would impact performance in four different dimensions identified as Design Team Commitment to Project Management Outcomes, Capacity of Contractor for Project Management, Construction Resource Management, and External Factors. Quality performance indicator discovered three-component dimensions labelled Project Communication Management with Design and Workforce, Contractor Capacity for Resource Management on Quality Objective, and Project Manager's Competence on Information Coordination and Construction Method. There are two dimensions that impact Health and Safety performance indicator which are Effective Finance of Site Management for Health Safety Implementation and Capacity of Contractor for Project Management and Safety Programme. These different components of KPIs were used for the development of a dynamic Project Performance Diagnostic Model. The study emphasized the importance of contractor to cost performance and the design team commitment to time performance with the underlying relationship of the CSFs in predicting the KPIs.

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

The complicated nature of construction projects has challenged researchers in the construction industry to research, design and develop models and mechanisms to ameliorate the situation and to solving the complexity associated with construction works. Several reports have demonstrated poor performance of construction projects (Davis, Ledbetter and Buratti, 1989; Georgy, Chang and Walsh, 2000; Nitihamyong and Skibniewski, 2006) and under achievement (Carpenter, 1981; Egan, 1998). According to Reichelt and Lyneis (1999) projects are notorious for failing to achieve cost and schedule budgets, in spite of considerable effort over the years toward improving project management for successful performance. There had been lamentations on performance of projects among countries as evidenced by number of failure being reported on construction project performance.

This is even more pronounced in developing countries including Nigeria where there have been clamour for improved performance. This is clear in the Vision 2020 National Technical Working Group Report (2009) in which Government seek for initiatives to review the existing order to improve decision making in reducing failure in performances for improved industry efficiency. According to the Ministry of Budget & National Planning (2017) the general economic performance in Nigeria had been seriously undermined by deplorable infrastructure, corruption and mismanagement of public finances. Ojeifo and Alegbeleye (2015) lamented peculiarity of the Nigeria nation describing it as parochial and primordial attitude toward change in comparison with other emerging economies like Malaysia, Ghana, and South Africa which had successfully adopted a new public management concept. Ahmadu, Aminu and Tukur, (2005) have also lamented the gap in evidenced based research in the Nigeria performance environment. This would mean assessing the Nigeria situation in consideration of its peculiarities to improving project performance relative to what operates in other economies of the world.

Measurement of progressive project performance is very important in predicting the outcome of construction project whether success or failure. Omran, AbdulRahman & Pakir (2012a) submitted that the success of a construction project is dependent on its performance. This performance is measured based on timely completion, expected quality standard, within cost estimates and client satisfaction. Failure to fulfil the project objectives within budget and on time is quite common (Fleming and Koppelman, 2002; Ford and Sterman, 2003; Jung and Kang, 2007) and the two common terms used in measuring performance of construction projects are Critical Success Factors, CSF (Omran, *et. al.*, 2012a) and Key Performance Indicators, KPI (Mahmoud & Scott, 2002).

This two concepts are not clearly explained by many research works available to the industry while these are two different concepts researchers used them interchangeably or misconstrue their individual meanings altogether going by criticisms among researchers as could be established in the works of Jaafari (2007); Humphreys, Mian, and Sidwell (2004); Mian, Sherman, Humphreys and Sidwell (2004); and Tsoukas (2005). There had been arguments as regards the definition of CSFs. The distinct clarification of CSFs and KPIs were not ascertained in these researches yet they are not mutually exclusive rather the CSFs drive the KPI which measures the quantum of the achievement of the CSFs for construction project performance as established in this research. This clarification is being propagated for the stakeholders in the industry and Nigeria in the particular instance for this research.

According to BSC Designer Team (2013) CSFs are the critical issues that decide the success of an organization whose high performance or success is important and these are actually the steps taken to succeed while KPIs on the other hand only indicate what the success rate or level is and thus are defined as the tools to measure performance. However, the ultimate means of measuring project success is through the satisfaction of the project client (Leong, *et. al*, 2014). Achieving client satisfaction depends on how well the projects perform against other key performance indicators such as cost, time and quality (Idrus, *et. al*, 2011). Wanberg, Harper, Hallowell and Rajendran (2013) emphasised the establishment of the project cost, quality, safety, and duration as the four critical elements that contribute to project success.

The assessment of project performance using the critical success factors approach has attracted various classifications of such construction performance enhancing factors. Such groups are: Project management factors, project procedures or procurement factors, project-related factors, project participants or human related factors and external factors (Chan, *et. al.*, 2004; Gudiene, *et. al.* 2013b). Critical factors were also grouped as contractor factors, project manager factors, design team factors, client factors and, materials factors (Omran, *et. al.,* 2012b. Using the CSFs, project performance depends on how well these groups interact to bring about project success (Chan, *et. al.*, 2004).

Measurement of project performance with the key performance indicators approach has recorded various classifications but, the most popular and widely accepted in the construction industry around the world is the classification of the UK KPI working group (Mahmoud & Scott, 2002). The approach here is to determine the success of construction project using key performance indicators such as; cost, time, quality, health and safety, client satisfaction, productivity and, environmental impacts (Babu, 2015). The success of a construction project, using the KPI approach is determined by how well construction projects fare against the aforementioned indicators especially cost, time and quality (Chan, 2003; Omran, *et. al.*, 2012a) and health and safety. Shibani & Arumugam (2015) concluded that certain critical success factors are essential for theperformance of construction projects and these factors also affect the budget, quality and time objectives of project performance. This raise a question on what determines performance and what does the project objectives measure?

The aforementioned approaches assume that a project is controlled once each factor element of the project is understood, this assertion failed to understand the relationship between the factors as they affect the individual objectives and the project performance. According to Rodrigues and Bowers (1996) experience suggests that the interrelationships between the project's components are more complex than is suggested by the traditional work breakdown structure of project network. The emphasis of complexity of construction project is a common knowledge in the industry requiring a concerted effort to resolve. Reichelt and Lyneis (1999) argued that the failure to improve project performance results majorly from models which do not treat projects as the complex dynamic systems which they are including Amaratunga, Sarshar, and Baldry, (2002); Chan and Chan (2004); Tsoukas (2005); Du Plessis and Hoole (2006); Meng, (2011); and the UTS-Helmsman(2016) and thus there is a dearth of research in developing project performance models that captures the dynamics of construction projects. Tupenaite, Kanapeckiene and Naimaviciene (2008) emphasised that construction projects have been more complicated, dynamic with interactive scenario that constantly requires Project managers to speed-up reflective decision-makings on time.

Dynamic modelling of complex systems usually addresses the behaviour of the systems over time. Abi-Karam (2006) in his paper corroborated with Nitihamyong and Skibniewski (2006) that construction industry is fragmented due to its multidisciplinary/organizational nature that relates to the under-achievement of the industry. This would include the concern on the different background of the stakeholders involved in delivery process of construction project. Poon (2004) asserted that the situation is generally two-folds: the inefficient construction process and the temporary organizational management structure. Managing the fragmented construction process coupled with the temporary organisational process requires the study of the underlying factors within the structure to improve achievement of success in project performance.

The success of a construction project depends on a number of factors, such as project participants, the competence of project managers, and the abilities of key project members. Construction project decision makers are always concerned about those terms that are used to indicate their performance including budget, schedule, quality, and health and safety which are the outcome of the process and the management structure. A construction project is considered successful if it is handed over to the client on time, within the budget and to the required quality standards (Takim and Akintoye, 2003). Indeed, a project control effort is devoted to ensuring that the actual cost does not deviate from the planned cost and that the project is completed on schedule.

Construction administrators and managers are involved in daily decision making on scheduling and budget control for project performance. Many times decision making are poorly implemented and its impact overlooked due to non challant of project leaders. In Nigeria, construction professionals are usually unwary to adopt scientific models that could improve performance as reported in the works of Bello & Odusami (2008, 2012) as they are glued to the conventional thump rule in the administration of construction contract. Failure to take certain decisions perhaps due to oversight automatically affects the general performance of a construction project thus; there is limit to what an individual can process within mental model to achieving performance coupled with the misconstrued understanding of CSFs and KPIs and the dynamics of their relationship.

Factors that affect decision making are crucial to the planned success of a project thus, understanding critical success factors and their relationship with key performance indicators is a gap in the construction project research and this would enhance decision making particularly on feedback. The effect and interrelationship of these factors are very important in making conclusion on a particular decision to be made. System dynamics as a tool would be appropriated for investigating the interconnected issues of a system due to its ability in providing a holistic view of the system. In their work Bajracharya, Pradhan and Shrestha (2008) posited that the modelling framework provided by system dynamics allowed the integration of the social and ecological processes in order to understand behaviour of complex mountain ecosystem.

Just as a manager modifies the recommended optimal decisions to take care of real life exigencies, a system dynamics model treats optimal decisions as desired values of policy variables and modifies them in the light of local constraints to obtain realistic values of policy variables (Mahanty and Mohapatra, 1994). This research therefore aims to provide a System Dynamic Project Diagnostic Model which will help project managers check feedback on performance of their projects and implement timely corrective action during the duration of the construction phases of building projects in Nigeria.

1.2 Statement of the Research Problem

The description of construction projects has been characterised with complexity factors owing to the uncertainties and interdependencies among these factors requires adequate treatment of the dynamics of these complex factors for better understanding of project performance. According to Kim, Han, Kim, and Park (2009) construction projects are affected by complex and dynamic factors or variables that are interrelated in a complex system that critically affect project success. In Nigeria, construction professionals are usually unwary to adopt scientific models that could improve performance as reported in the works of as they are glued to the conventional thump rule in the administration of construction contract (Bello & Odusami; 2008, 2012). This cannot continue as construction projects become more complex and dynamic. General performance of a construction project is affected due to an oversight or failure to take certain decisions and thus; there is limit to what an individual can process within mental model to achieving performance coupled with the misconstrued understanding of CSFs and KPIs and the dynamics of their relationship.

Project performance could mean different things to different people whether in terms of function, aesthetics, attractiveness, profit, sustainability or satisfaction. The list could be endless based on different requirements and objectives. The requirements of construction clients are hinged to the following four key factors: Time, Cost, Quality and Safety Performance. Poon (2004) asserted that inefficient design and construction process are usually criticized as some of the main causes of poor performance, due to fragmentation. Successful project delivery requires the concerted effort of the project team to carry out the various project activities, but it is the project manager who is responsible for orchestrating the whole construction process (Bayliss, 2002).

Previous researches on project performance mainly concentrated on critical success factors, CSFs or key performance indicators, KPIs for project performance without adequately treating CSFs as drivers for KPIs. Whereas most researches emphasized the assessment of performance on achieving project objectives which include time, cost, quality, and health and safety thus, the KPIs. It follows that reporting the performance of construction project performance would require the assessment of the key performance indicator in terms of cost, time, quality, and health and safety among others. This will be a veritable tool for project managers. There is need for a common platform in treating these concepts in the construction world and simplifying management for managers. Providing construction managers with information about and insight into the existing data so as to make decision more efficiently without interruption is a problem during the management of construction process.

The management of project by avoiding failure in time, budget, and other project objectives is paramount on the mind of the project manager. How to analyse the factors of successes and failures of finished projects and how to use the existing data to analyse patterns and feedbacks of underlying relationships for projects are the problems requiring research attention in the industry, thus modelling the CSFs that would enhance decision making for construction project performance.

Decision making is changing in construction due to the implementation of new technologies. Information Technology is now extensively used in the construction industry as a tool to reduce some of the problems generated particularly through simulations. According to Vanegas and Chinowsky (1996) during the project control phase, in order to take rectifying actions for any deviations in the performance, project managers often need timely analysis reports to measure and monitor construction performance and to assist in making long-term decisions. However, investigation indicated that there is inadequate systematic and automated evaluation and monitoring in construction projects. The problem to be investigated in this research is the performance of construction projects by assessing the CSFs measured by the KPIs in evaluating performance of construction projects and using the existing data to develop a system dynamic model as a diagnostic framework in order to effectively and efficiently practice decision making.

1.3 Need for the Research

Providing construction managers with information and insight into the existing data for efficient decision making without interruption is a problem during the management of construction process which eventually leads to performance failure. According to Chau, Cao, Anson and Zhang (2002) a decision support system is required to assist construction managers in monitoring the construction process in progress. In solving the problem, this research proposes a performance diagnostic framework for timely check within the dynamic of the construction process to assist and support project managers in taking timely decision in the management of the performance of the construction project.

Past studies had established that construction projects failed to keep to project objectives. Existing researches have not been able to exhaust the available research solutions to the problem of poor performance. Available research tools are yet to completely address the failure of the performance of construction projects. This is evident from lamentations on performance of projects from researches that are country specific with evidence of failure being reported on construction project performance. Developing countries including Nigeria have evidence of this with mismanagement and corruption report established on such failed projects. Therefore, many of these countries and particularly Nigeria clamour for improved performance (Ahmadu, et al., 2005; Bello & Odusami, 2008, 2012; National Technical Working Group Report, 2009; Ojeifo and Alegbeleye, 2015; and Budget & National Planning, 2017).

The economic recovery and growth plan for the country target among other objectives to Building a Globally Competitive Economy by Investing in infrastructure, Improving the business environment, and Promoting Digital-led growth (Budget & National Planning, 2017). This provides basis to fill the gap created in the study of performance in Nigeria by assessing the evidence based solution rather than theoretical rhetoric which might not fit into the Nigeria situation. The report of Ahmadu, et al., (2005) asserted that there is a yawning gap between theory and evidence in Nigeria. Government plan to improving business environment and promoting digital-led growth would require researches in this area to developing tools that could be used to assess performance which will be useful for project managers of construction facilities. To develop such tools, proper understanding of concepts and terms that will be used in the analyses and modelling of such tools must be established.

The current literature in construction project performance including the works of Humphreys, et al (2004); Mian, et al (2004); and Tsoukas (2005) have not been able to adequately treat the critical success factors as drivers of key performance indicators. The key performance indicators are elements to measure the workings of the CSFs whereas researchers either address CSFs directly for project performance without relating it to KPIs or misconstrue the CSFs as the same as KPI and thus, creating a cloudy situation in the solution that is being proffer to solving the problems in an industry having a complex dynamic system. This confusion was also criticised by Jaafari (2007).

Many researchers have not been able to address or popularise the dynamic complexity of construction industry using the system dynamic approach. How to analyse the successes and failures of finished projects and how to use the existing data to analyse patterns and feedbacks for projects are the problems facing the industry, thus modelling the CSFs for KPIs for construction project performance. Therefore, there is need to add to the body of literature to address the inadequacy in this regard and direct the consciousness of other researchers to getting the proper concept of CSFs and KPIs and using it to assessing construction project performance by adopting the System dynamics methodology. Analysed systems solve problem by determining criteria that influence the solution through the application of multicriteria decision-making methods. The nature of the problem being solved usually determines the criteria and their quantum and also influences the selection of mathematical methods (Sigitas and Trinkūniene, 2008) and or framework to be adopted.

A performance diagnostic framework will provide information for users to make decisions and do their jobs more effectively. A System Dynamic Project Performance Diagnostic Framework is therefore required and thus proposed as an interactive system that provides the inter-relationship and dependencies of critical success factors in the construction project delivery for the users to have easy access to decision models and data. The user is typically a manager or a professional staff. The system contains models that are used to analyze data through simulation for robust and reliable results.

1.4 Research Questions

In order to tackle the research problem, the following research questions are raised:

1. What are the key success factors having underlying measures that contribute to timely, safe, quality and cost-effective delivery of construction projects in Nigeria?
2. What underlying relationships exist to determine the component factors of CSFs for each KPIs in determining construction project performance?
3. How could project variables diagnose the construction process and predict project performance?
4. What project information model is appropriate for diagnosing construction project performance in terms of cost, time, quality, and health and safety?

1.5 Research Aim and Objectives

The aim of this study is to assess and model successes of finished projects and how to use the existing data to develop a framework based on information developed by actual performances during project executions.

1.5.1 Research Aim

To develop a System Dynamic Project Diagnostic Framework, primarily for improved decision making in the context of diagnosing/predicting construction project performance in the Nigeria construction industry.

1.5.2 Research Objectives

1. To investigate critical success factors (CSF) and underlying measures for key performance indicators (KPI) in terms of cost, time, quality and health/safety for construction project performance.
2. To establish component factors of CSFs with their underlying relationship for each KPIs (Cost, Time, Quality, and Health/Safety) for effective project performance.
3. To evaluate the dynamic interrelationship between project variables of CSFs for individual KPI for its suitability as model for construction project performance diagnostic for effective project delivery in Nigeria.
4. To develop and validate a System dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables.

1.6 Scope and Delimitation of the Study

The research was limited to the construction consultants' firm and construction managers who have records of their construction activities. Since there are several factors considered for the effective management of a construction projects, the factors considered for this research were those found in literature which were considered by construction participants that were interviewed. The extent of knowledge acquisition was limited by time constraint. It is important to note that the title reflect a broad concept but the focus is limited to the four popular key performance indicators for construction project performance including time, cost, quality, and health and safety.

The construction experience and professional judgment of the construction practitioners who supplied the relevant information can be relied upon and the judgment will be considered to be sound. It was assumed that data on original or initial project cost, schedule and quality which served as basis for developing models were prepared on sound professional logic and were accurate and reliable. Can we possibly model the performance of managers in the construction industry like we see the model analysis of football games in assessing the performance of teams? This is not impossible and of course the future to explore in construction project performance diagnosis.

1.7 Research Approach Methodology

Achieving the aim and objectives of the research requires the proper procedural application of research methodology. The researcher carried out a comprehensive review of literature in critical success factors and KPIs and System Dynamics in the construction industry to gather requisite knowledge. The use of techniques and tools for collecting and analysing data led to critical review of CSF, KPIs and System Dynamics and its models carried out to establish identified gap in the literature to form research question including the aim and objectives of the research.

The study involved the use of literature review, focus group discussions with experts and questionnaire survey for its data collection. Data analyses include statistical analysis with the aid of Statistical Packages for Social Scientists (SPSS) version 24 and dynamic relationship evaluation using a dynamic modelling tool called VENSIM. Figure 1.1 shows a methodological flow chart for the study. Appendix 1 presents a copy of the questionnaire used for data collection. Methodological approaches used in achieving each of thestudy's objectives are briefly explained in the following sub-sections.

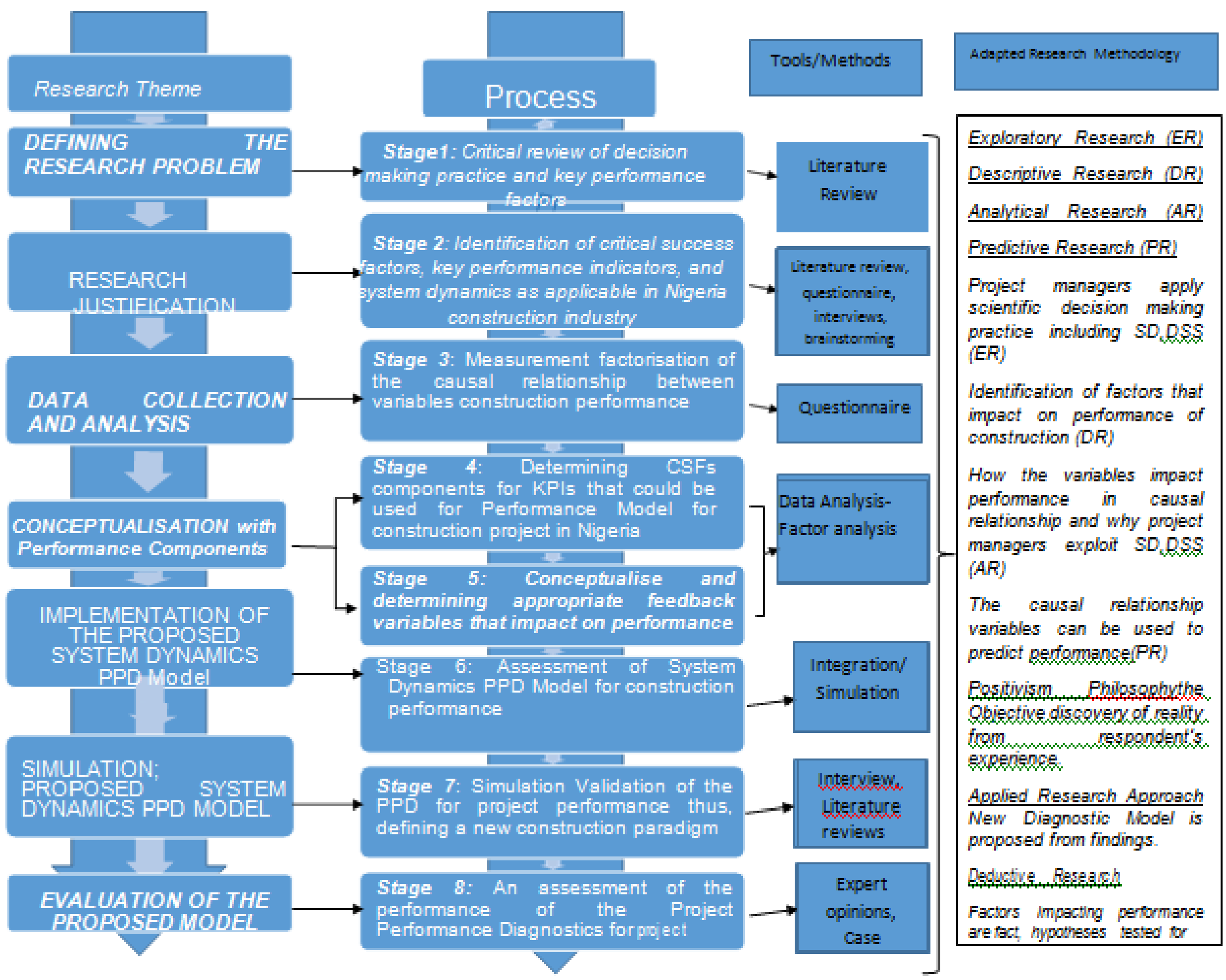


Figure 1. 1: Schematic Stage Breakdown of Research Design

The research design flow chart is broken down to different stages of clarity as developed for this research; illustrated in Figure 1.1. The figure itself depicts how the embedded processes that were carried out throughout this study overlap with the research themes in addition to the methods/tools engaged with each stage of the process. The figure also clarifies and demonstrates the research methodology after a comprehensive literature review about the research, adopted research philosophy, approach and method deployed in the study. The different stages are as discussed in the following section.

1.7.1 Research Approach Methodology: Objective One

To investigate critical success factors (CSF) and underlying measures for key performance indicators (KPI) in terms of cost, time, quality and health/safety for construction project performance.

The objective 1 was carried out by exploring CSFs in literatures most of which are addressing project directly and few ones from factor influencing performance of cost, time, quality, and health and safety as KPIs for project performance as conceptualized in this research. The process include:

1) Literature review of relevant literature to identify the critical success factors that enables performance to be achieved through the measure indicated by the KPIs for project performance

2) To achieve a comprehensive collection of the identified factors, a systematic review of literature style was employedwith effort to see to the classification of the CSFs under their individual KPIs which they drive.

3) Discussion with focus group of experts in the construction industry were carried out with the aim of confirming their understanding and agreement of the collected factors as being relevant to the Nigeria environment and the reasonableness of classification to the four KPIs considered in the research.

4) Design of questionnaire from the results of literature review and the interviews for subsequent survey. The questionnaire was pilot tested and administered.

5) The individual KPI of cost, time, quality, and health and safety were separately analysed with descriptivestatistics, reliability and Kruska walis analyses were carried out for the purpose determining the CSFs and data validation.

6) Factor analysis was carried out using SPSS version 24 in order to determine the underlying measures for key performance indicators.

1.7.2 Research Approach Methodology: Objective two

To establish component factors of CSFs with their underlying relationship for each KPIs (Cost, Time, Quality, and Health/Safety) for effective project performance.

Extensive review of literature on CSFs and KPIs as they determine performance of construction projects were carried out with series of focus group discussions used for achieving objective one and through the use of the designed questionnaire. The process of achieving specific objective are as follows:

1) Questionnaires were distributed to solicit the opinion of practitioners and managers on typical project they manage as a case study data.

2) The questionnaires were analysed with the aid of SPSS 24 using various data screening techniques, reliabilityanalysis, Kruskal Wallis test and descriptive statistics.

3) Factor analysis was used to confirm the underlying relationship of the CSFs for KPIs with their different components as discovered from the factor analysis for project performance.

1.7.3 Research Approach Methodology: Objective Three

To evaluate the dynamic interrelationship between project variables of CSFs for individual KPI for its suitability as model for construction project performance diagnostic for effective project delivery in Nigeria

This objective was fulfilled by identifying the factors that were grouped under each components of CSF for KPIs of cost, time, quality, and health and safety. This resulted in each components having their sub-group of the unit CSF as determinedby factor analysis. The process is as follows:

1) Factor analysis were carried which ensure that only relevant factors that hang together were retained for further analysis. The factor analysis has component loading for each of the items. The individual loadings were subsequently used for the weightings of the CSFs under their components for KPIs' measure for project performance.

2) Based on the confirmatory factor analysis, dynamic relationship between all the CSFs for KPIs was modelled with VENSIM System Dynamic softwareModelling tool. This provided a user interface with loop diagram for stock and flow mathematical representation developed by the interaction of the components of KPIs for project performance. user to carry out simulation a graphical cause and effect diagrams, representing the interplayof various waste preventive measures.

3) The impacts of the interplay of the interdependencies and interactions of the components of KPIs for assessing performance were run with simulation to understand their stock and flow validity to generate feedback and thus useful for the proposed model. This is subsequently used for developing the model for diagnosing project performance.

1.7.4 Research Approach Methodology: Objective four

To develop and validate a System dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables.

As an overarching objective, this was achieved by building on previous objectives. The

following steps were involved:

1. The stock and flow diagram developed with the relevant CSFs which were analysed reliable and suitable for the KPI components was loaded with the CSF variables weighted by the component loadings for simulation as quantitative analysis of the System Dynamic Model - PPDM. Necessary checks to validate the model and its units were carried out before running the simulation using Vensim software. The model simulation was successfully run and confirmed okay.

2. A case study of a building project construction at completion was used to obtain data on theadoption rate of the different critical success factors for key performance indicators for project performance.

3. Relationships between various elements of the model were represented through mathematical equation modelling, which enhances simulation of the dynamic impacts of the different CSFs as they impact one another in the performance model.

4. The four different KPIs considered in this research which were included on the model were isolated individually (one after the other) to simulate their causalinfluences on the whole system. The overall impact of different key performance indicators and or individual CSF were easily observed from the

graphical presentation of results of the simulation. This provides information on decision making on the performance of construction project.

1.8 Significance of the Study

Previous studies on success factors for construction project performance have been carried out at unitary level expressing a relatively narrow idea on the subject of construction performance while success factors of performance indicators are dynamic and multiplicity in nature. This study contributes to existing body of knowledge by building on existing studies, using System Dynamic Modelling, to determine interplay between various CSFs for KPI measures to determine performance of construction project. Project managers seek to find construction research models and systems on how to make effective decisions and forecast the performance of a project with a view of ensuring certainty in the success of construction projects. They are under pressure to meet deadlines for client satisfaction, without sacrificing cost or quality under conditions of uncertainty and complex dynamic systems of construction projects.

Complexity of construction projects is treated as dynamic system considering the interdependencies between the system components as well as the intra-dependencies between the elements within the components. Every country of the world must be involved as the pace to bridge the gap between the developed and the less developed countries is geometric and not arithmetic in its progression. The application of IT in the construction industry mainly involves planning, monitoring, reporting and similar managerial functions that, in unison, support effective decision-making due to versatility of computers. The vast topic of IT includes general artificial intelligence systems, knowledge-based systems, intelligent decision-support systems, and the ever-popular Internet, which are fields that are continually growing independently, but proportionately with each other. The ever-growing attention given to information resources suggests that better management of these resources become critical to project success.

The successful performance of construction projects is the main concern of managing a project whereas the degree of varying impacts or dynamics critically influence the effectiveness of management. Therefore, managers of construction projects need to understand both the degree of dynamics project success factors for the key performance indicators for effective overall project performance. The need to propose a diagnostic framework in the Nigeria construction industry is novel, and considering the importance of construction performance, project and construction managers require such a system for improving their decision making. The government also clamour for tools to improve performance. Therefore, it is essential to wave flag informing practitioners particularly in Nigeria that there is a way of doing things – 'a new angle' – of tackling management of construction projects. The project performance diagnostics is an attempt to simplify the analysing process and to reduce the time needed in thought process, understanding project dynamics and preparing precise reports. The study will be of benefit to the consultants and client organisations including contractors and other parties involved in construction projects. The proposed framework will assist a decision maker (e.g. project manager) in determining a better management plan in order to satisfactorily complete a construction project.

1.9 Structure of the Thesis

The thesis is structured into seven chapters to explore the Critical Success Factors (CSFs) that determine Key Performance Indicators (KPIs) and thereby conceptualizing a model for assessing or diagnosing construction project performance following the objectives in this dissertation. The main objective of this research is to identify the CSFs for KPI in construction projects in Nigeria. For this reason, this dissertation is divided in different chapters, as follows:

Chapter 1; Introduction: This chapter introduces the research title with its underlying background of the idea of the knowledge that is being explored in this dissertation. Thus, the research problem, research questions, aim and objectives, scope of the research, significance of the research and the structure adopted in this thesis are discussed.

Chapter 2; Construction Project Performance - a Literature Review: This is a review of literature in construction project performance generally and particularly in Nigeria by looking at literature with a view to establish existing knowledge and develop variables for this research. Therefore, literatures in construction performance were discussed with their critical success factors. The first objective of the dissertation was achieved through these literature reviews with expert panels that are well grounded in Nigeria construction experience as per the research methodology.

Chapter 3, The Dynamics of Construction Project Performance: Factors and Indicators – a second literature review chapter: This chapter explores further the CSFs and KPIs as they are established from literature to clarify their underlying misconceptions and relationship. By exploring relationship between the factors, the need to review literature on complexity of construction projects as requiring system Dynamics as a tool to resolving the construction complexity is explored.

Chapter 4; Research Paradigm and Methodology, this chapter explain the flow of thought and philosophical stance of the researcher in the establishment of the research concept – being in its truth as approached by the researcher in this research. The chapter provides the research design, research paradigm, approaches, strategies, research methodology, data collection and analyses methods.

Chapter 5, Analyses of Critical Success factors influence on Key Performance Indicators: This chapter presents the analyses of responses and findings from the questionnaire survey to establishing the critical success factors for Key Performance Indicators. Important underlying hypotheses were analyzed in establishing the CSFs for the four KPIs considered in this dissertation that subsequently drive the Project Performance Diagnostic Model.

Chapter 6, Project Performance diagnostics: A System Dynamics Model. This Chapter presents the conceptualization of the System Dynamics Model for the Project Performance Diagnostics tool for the construction industry from the Nigeria perspective as established in the research. It includes the loop diagram of Stock and flow simulation models for the diagnostic tool.

Chapter 7, Project Performance diagnostics: A System Dynamics Model. This provides the final output of the research process with summary and conclusion of the journey so far. Specific mention of significant contributions of the research is discussed for clarity and knowledge propagation.

CHAPTER TWO
CONSTRUCTION PROJECT PERFORMANCE

2.1 Overview of the Chapter

This chapter presents the review of literatures on construction project performance. The focus of the chapter is on identifying the significance of the construction industry in terms of its contribution to the economy especially, the Nigerian economy, the processes involved in construction project delivery, factors determining project performance and evaluating relationships between project performance indicators. Also, the conceptual framework for this research is presented with the theoretical background and introduction to system dynamics with its application to construction project management.

2.2 Significance of the Construction Industry

The role of the construction industry in the growth of nations' economies across the world is very crucial. It is an industry characterised with unique and diverse products ranging from civil engineering infrastructures such as bridges, dams, roads, sea ports, amongst others; residential, commercial and public buildings such as houses, retail facilities, blocks of offices, religious buildings, educational institutions; and private projects for private clients (Sibiya, Aigbavboa & Thwala, 2014). The construction industry is therefore, a sector of both developing and developed economies which transforms various resources into constructed facilities, through planning, design, construction, maintenance and repair, operation, and management in general (Isa, Jimoh & Achuenu, 2013) The importance of the facilities or construction industry products in achieving national development cannot be over-emphasised as construction projects house all other activities of the economy such as the provision of the buildings for security exchange commission, banking sectors, court of laws, etc. The unique and project-specific environments in which the construction industry participants like the clients, investors, and contractors operate determine the quality of outputs of the industry.

Major participants in the construction industry are the architects, engineers (civil, mechanical, electrical, acoustic, etc.), cost consultants, management consultants, contractors, subcontractors, construction materials suppliers, clients and users. Depending on the complexity and the contractual arrangement employed on a project, the services of some auxiliary professionals such as lawyers, building finance and insurance agencies, real estate brokers, land developers, etc., are usually required (Isa, *et. al.*, 2013).

The importance of the construction sector in terms of its contribution to national economies is easily noticed and measured with its contribution to national GDP and employment prospects. The contribution to the GDP in the European Union is about 10% while the percentage of labour employed by the industry in the United States of America rose from 7.30% to 8.10% from 2000 to 2006 as revealed in the Statistical Abstract of the U.S. for the year 2007 (Vilnius, 2008). With an estimated figure of 111 million labours employed worldwide as at 1998, approximately 28% of all industrial employment, the construction industry is widely regarded as the world's largest industrial employer. Its annual output worldwide stands at approximately 10% of global GNP, of which 30% is generated in Europe, 22% created in the United States and 21% in Japan (Vilinus, 2008). Africa was responsible for 2.99% (20962 million Dollars) of the contribution of the construction industry to global output (ILO, 2001). With 1.56% and 1.80% contribution to GDP for 2010 and 2013 respectively, the contribution of the construction industry to the Nigerian economy stood at 8^{th} position among the twelve economic sectors considered (Adeagbo, 2013).

2.3 Construction Industry and the Nigeria Economy

"When the construction industry prospers everything prospers." (Haseeb, Lu, Bibi, Dyian & Rabbani, 2011). That is a French dictum which attests to the importance of the construction industry and its contribution to national economies. The prosperity of the industry spells boom for national and international economies as well as the industry participants such as contractors, workers, financiers, designers, etc. The economic impacts of construction industry on national economies can be well felt with increased number of successful projects. A project is said to be successful if the desired objectives set for the project are met within time and budget constraints with minimal or no adverse health, safety and environmental impacts (Haseeb, *et. al.*, 2011). Therefore, all parameters to enhance cost performance should be put in place in other to improve the industry's contribution to GDP. Since independence, the Nigerian economy has remained narrow, weak and externally-oriented with dependency on primary production activities of agriculture and mining of mainly crude oil and gas. These two sectors of the economy accounts for about 65% of the GDP, over 80% of Nigerian government proceeds, over 90%.of foreign exchange earnings and 75% of employment (NBS, 2011).

Organized building practice in Nigeria began in the 1930s with significant construction activities being handled through direct labour by the Public Works Department (PWD) and the Royal Army Engineers which was later transformed into the Nigerian Army Engineers (Mbamli and Okotie, 2012). Despite the abundance availability of various mineral resources in Nigeria, a larger percentage of Nigeria's GDP is still derived from crude oil. This has been one of the major reasons behind the country's failure to develop to expected potential hence, the incessant drop in economic growth and development experienced in the country (Isa, *et. al.*, 2013). According to Mbamli and Okotie (2012) Nigeria's independence in 1960 and oil boom of the 1970s increased construction activities such that most available construction organizations were "over-stressed". The problem of high time and cost overruns, low quality and abandonment surfaced and was attributed to poor project conception, careless planning and poor execution. Main causes of cost overruns in Nigeria according to the works of Mansfield, et al., 1994; Elinwa and Buba, 1993; and Okpala and Aniekwu, 1988 include Shortage of materials, Finance and payment for completed works, Poor contract management, Price Fluctuations, Fraudulent practices, Cost of materials, High cost of machineries, Inaccurate estimates leading to delays, Lack of geotechnical studies before starting the construction and delays caused by the involvement of complicated rules.

The contributions of the manufacturing and construction sectors of the Nigerian economy, which have been said to have greater potential for generation of employment opportunities and sustainable foreign exchange earnings and government revenues, account for meagre 4.14 and 2.00% of gross output respectively. This is an indication that the construction sector of the Nigerian economy is still battling with challenges hindering it from reaching its full potential which consequently, limits its contribution to the national gross output (Oluwakiyesi, 2011). The small percentage of foreign exchange earnings and government revenues attributed to the construction industry in Nigeria is not a true reflection of the potential or contributory capacity of the industry to the economic development of the country.

The key stakeholders in the construction industry in Nigeria are clients, professional consultants and contractors (Patience, 2008). The public sector constitutes the major client of the construction industry in Nigeria, and the traditional approach in this sector is to handle building design and construction in two separate phases and by two separate teams – the design and construction teams. The design team usually consist of consultant such as architect, quantity surveyor, structural engineer and services engineer (electrical and mechanical). The construction team, on the other hand, usually consists of a major constructor and a number of sub-contractors who are selected on the basis of lump sum competitive tender, undertaken after completion of most of the design activities. (Babatunde, Opawole and Ujaddughe, 2010, Mbamli and Okotie, 2012, Isa, Jimoh and Achuenu, 2013). Therefore, effort directed at growing the construction in Nigeria is, by implication, an effort to grow the national economy as a whole.

2.4 The Construction Project Delivery Process

Procurement is a combination of activities undertaken by a client in bringing about the construction or refurbishment of construction projects. Effective procurement method is usually preceded by devising a project strategy, which involves weighing up the benefits, risks and financial constraints which might confront the project execution and, which eventually will be reflected in the choice of contractual arrangements. In every project, time, cost, and quality performance, among other criteria, in relation to both design and construction of the building, are usually top on the list of considerations in choosing a procurement method. (JCT, 2011). Although every construction project is unique in its own way, the set of procurement methods chosen from, in executing them, remain the same.

The Joint Contract Tribunal (JCT) (2011) divided construction procurement into three (3) broad options namely: Traditional Procurement (Conventional Procurement), Design and Build Procurement, and Management Procurement

2.4.1 Traditional Procurement

Generally, the pre-contract stage of construction project comprises of the conception of the project, development of the project brief, selection of project designers/consultants to advice and prepare contract documents (e.g. architectural drawings, bills of quantities, conditions of contract, etc.) from the project brief and calling for tender from interested contractors (Brook, 2004). The contract stage is simply the actual construction of the project and its commissioning. This is usually termed the traditional method of procurement.

The traditional method of project delivery is divided into five (5) detailed stages: Project conception, design, tender, construction and, commissioning. At the project conception stage, construction projects activities start with client's decision to build. The client, which can be an individual or a corporate organisation, on deciding to invest on a construction project, employs the services of a lead consultant which may be the architect, civil engineer or project manager depending on the scale and type of the proposed project, and discusses the proposals with the lead consultant and subsequently, assemble the design team (Cartlidge, 2009).

What happens at the design stage is simply the preparation of all contract documents, necessary to call for bids from interested contractors, by the appointed designers. Such documents include architectural drawings, engineering drawings, bills of quantities, conditions of contract, specifications, etc. in accordance with the brief submitted by the project client (Cartlidge, 2009).

The next stage on the procurement route, tendering, is mainly focused on the selection of the most qualified contractor to execute the project. This still remains one of the most critical issues to achieve successful project delivery (Bolpagni, 2013). Principles of 'equal treatment, the principle of non-discrimination, the principle of mutual recognition, the principle of proportionality and the principle of transparency' are usually taken serious in selecting contractor and the process involved can be outlined as follows:

- Tender specification preparation

- Invitation to the tender
- Submission of the tender documents by the bidders
- Evaluation of tenders
- Selection of contractor

After the contract has been awarded to the chosen contractor, what is left is for the contractor to move into site and commence actual construction activities with the aim of achieving success in terms of quality, cost, time and minimal health, safety and environmental adverse effects. Commissioning and handing over of the completed project is the last phase of construction project deliver process. A construction project can only be termed successful if the handing over is achieved without trading quality for timely completion or cost overruns (Idrus, Sogandi & Husin, 2011).

In Joint Contracts Tribunal Limited (JCT) practice note of 2011, Traditional method of procurement is mainly characterised by the separation of contracting firms from independent client consultant hence, the distinct separation of design process from construction. Also, full documentation is required before tender is invited from interested and qualified contractors.

Traditional method can be in three (3) types – lump sum, measurement and cost reimbursement methods. Irrespective of the type chosen on a construction project, the following are the general characteristics of traditional procurement method:

- Contractors awarded such contract are commonly appointed via competitive tendering processes and, although less common, by negotiation.

- Adequate time is required to prepare full documentation necessary for tendering processes.
- The client, through his appointed consultants, controls design in accordance with specified quality standards. The contractor is usually free from design responsibility.
- The separate and sequential processes of design and construction usually elongate the project duration.
- A clear but, adjustable in accordance with contractual provisions, budget for the project is usually known from the onset.
- Despite some levels of inflexibility that are usually experienced due to decision making before the commencement of works, changes and variations are still effected usually, at a price in terms of direct and related costs.
- Appointed consultants manage administrative issues relating to valuations, payments and other related post-contract management (JCT 2011).

The popular forms of traditional procurement contracts are:

2.4.1.1 Lump Sum Contract

This type of contract is used for both projects with or without quantities. The contract sum is determined before the commencement of construction work, which is executed by the contractor for as agreed fee. Drawings and firm bills of quantities are used to price contracts 'with quantities 'while those 'without quantities' are priced onthe basis of drawings and another document — usually a specification or work schedules (JCT, 2011).

2.4.1.2 Measurement Contract

In this type of contract, the contract sum is not finalised until the project is completely executed. The contract sum is reached by re-measurement of executed works and valued with previously agreed work rates. This type of contract is usually employed in situations where works cannot, for reasonable reasons, be measured accurately before tenders are invited. This arrangement is also, usually characterised with reasonably complete designs and; a clear and accurate picture of project requirements. There are two (2) variants of this contract one is based on drawings and bills of approximate quantities while the other one is based on drawings and schedule of rates or prices (JCT, 2011).

2.4.1.3 Cost Reimbursement Contracts

This is sometimes referred to as Cost-plus or Prime cost contract. The contract sum is arrived at by adding the prime (actual) costs of labour, plant, materials and other inputs to an amount, previously agreed to by parties to the contract, to cover overheads and profit. The added overheads and profit can be a fixed sum, a percentage, or on some other agreed reimbursement basis. This is a relatively high-risk option for client here the full extent of the work is not known or cannot be designed pre-tender, the use of this method rest on the presence of circumstances that make the adoption of other alternatives difficult (JCT, 2011).

2.4.2 Design and Build Procurement

The simplicity of contractual links between parties (client and contractor) to the main contract is a major advantage that makes this form of procurement attractive to clients (Brook, 2004). This is an arrangement of a project delivery system where both the design and construction of a project is made the responsibilities of a contractor for a fee, under a contract based on standards provided by the client (JCT, 2011). A single entity may perform all of the design and construction or it may subcontract to other companies and periodic maintenance is commissioned separately or performed by the client (Bolpagni, 2013). The main steps involved are:

- Defining the need to build and the scope of the work;
- Defining the client's requirements of the technical proposals;
- Selecting and inviting bidders to tender;
- The contractor or contractors preparing their technical, scheduled and price proposals;
- Selection and acceptance of a tender which then becomes a contract. A selection criterion, in addition to price, may be also the quality of the design solution (qualifications-based and/or cost-based);
- Design and construction of the building.

The various options of this procurement method available depend on the degree of inclusion of initial design in client's requirement. The three main (3) types of contracts under this procurement method are:

2.4.2.1 Packaged Deal or Turnkey Contract

This involves the appointment of a specialist construction firm by the client on a complete package, usually to some specific standard specification from a commercial firm. Drafting of special contract based on provider's standard terms is common in this type of arrangement (JCT, 2011).

2.4.2.2 Design and Build Contract

The contract documents for this type of arrangement are written with the contractor's design obligations relating to the whole of the works in mind. The fundamental difference between this contract type and traditional 'work and materials' contracts is in itsexplicit provision for contractor's design obligations. However, the wording used in describing the contracts which require a material level of design input from the contractor is often the same as in those which are used for a 'develop and construct' approach (JCT, 2011).

2.4.2.3 Contractor's design for specific elements only

Simply, unlike design and build contract, this is traditional 'work and materials' contract which include for limited design provision relating to an identified portion of the work (JCT, 2011).

2.4.3 Management Procurement

This is broadly divided into two:

2.4.3.1 Construction Management (CM)

In this procurement arrangement, the client still hires a design team to handle the design of the construction project and acontractor to construct but, another party, the construction manager, is hired to manage the overall project. Implementation of the construction is usually carried out either by several subcontractors or trade contractors, in contract with the client only but, under the supervision of the construction management. Contractually, the trade contractors are the client's risk (Brook, 2004; JCT, 2011

2.4.3.2 Management Contract

This involves a management contractor undertaking to manage the carrying out of the work through works contractors, who are contractually accountable to him. Although the administration and operation of the works contractors is the management contractor's responsibility, he is not liable for the consequences of any default by a works contractor so long as the management contractor is not in default with the particular requirements of the management contract (JCT, 2011; Bolpagni, 2013).

Whichever method is adopted between the two types of construction management, one advantage of the method is the opportunity to experience early starts on large-scale and complex projects (Brook, 2004).

The construction manager monitors of cost, time, quality, safety and other performance parameters of the project but does not take responsibilities for them while the management contractor is responsible for construction methods, quality and cost of constructed projects. The construction manager bares no risk while the management contractor bares risks associated with the delivery of the project (Bolpagni, 2013).

2.5 Performance of Construction Project

The success of a construction project depends on its performance, which is measured base on timely completion, within the budget, required quality standard and customer satisfaction (Omran, *et. al.,* 2012a). It is very uneasy to give an unambiguous judgement on the success or failure of a construction as not all the successful criteria are usually met. However, the determination of project success is largely dependent on who is measuring the success, to a contractor, profitability is a performance while clients and occupiers or users measures project success on absence of claims and litigations and fitness for purpose respectively (Takim & Akintoye, 2002). This means that a project termed successful by the contractor because of the desired profitability achieved while the same project may be termed failure by the client, due to cost overruns or delay or numerous litigations experienced during the course of executing the project. According to Chan (2003), cost, time and quality are the most important indicators to measure project success although, other performance indicators such as safety, functionality and satisfaction were said to be attracting increasing attention. The uncertainties in budgets, processes and technology that are being faced constantly in construction industry make it dynamic (Chan, et al., 2004). In light of the above quoted authors, it is safe to conclude that the concept of project performance depends on the perspective of the measurer among the project stakeholders. Generally, literatures review shows that construction project performance is measured under the following broad groups: cost, time, quality, health and safety, client satisfaction, environmental factors, productivity, people factors, regular and community satisfaction, and innovation and learning (Chan, 2003; Enshassi, Mohamed, & Abushaban, 2009; Omran, *et. al.*, 2012a; Abdul Rahman & Alzubi, 2015). The most important performance indicator on a project depends on the requirements of the client. Cost, time and quality performance are the major criteria of measuring project success as cost and time overrun on construction project is responsible for abandonment of most construction projects.

2.5.1 Success of construction projects

The outcome of construction project could either be success or failure and thus, once a project failed to achieve success then its outcome is failure. Therefore, project performance is measured on the prediction of project outcome whether success or failure (Omran, *et. al.,* 2012a). This performance is measured based on timely completion, expected quality standard, within cost estimates and client satisfaction (Chan, 2003; and Chan, et al., 2004). Baker, et al., 1983 considered that perceived performance should be the right criteria to measure success, instead of time, cost and quality. Achieving these three objectives determine project management success which is separated project product success (Van Der Westhuizen and Fitzgerald, 2005), therefore the combination of project management success and project product success determine the project success. It follows that an exclusive definition of project success does not exist as different person, different project team and company define project success to suit their requirement and thus, lack of a unique definition of project success (Pinto and Mantel, 1990; Chan, *et al.*,2004).

In this research, measuring project performance success has been based on appropriate criteria that are majorly embraced in the built environment from previous studies. Sanvido (1992) considered that cost, time and quality are an essential part of these objectives and therefore posited that success of a project is defined as meeting the objectives of the project for a given participant as each participant will have a different point of view. In the report of Chan (2003) in an attempt to develop a framework for measuring success of construction projects, carried out by reviewing eight (8) leading journals on project success, the contents of the 'golden/iron' triangle – cost, time and quality, were confirmed as the basic and the most important parameters to measure project success. It was, however established that other indicators such as safety, functionality, satisfaction, environmental performance, etc. are attracting increasing attention. Therefore, this research includes health and safety indicator as part of the objectives of project success.

2.5.2 Critical success factors for construction projects

There are many different factors that influence project performance to varying degrees, with certain factors more critical to a project's success than others. Critical success factors are linked to project success directly (Chan *et. al.*, 2004) yet, project success cannot be measured without key performance indicators such as cost, time, quality and, health and safety performance amongst others (Mahmoud & Scott, 2002; Enshassi, *et. al.*, 2009; Babu, 2015). According to Sanvido et al. (1992) focus on these key factors is important for project managers in order to make reasonable resource allocation.

Similarly, project management factors, project participants factors, project procurement factors and external factors all predict construction project performance in terms of cost, quality, time and, health and safety. This is supported by the frameworks of Chan, *et.al.*, (2004) and Forcada, *et. al.*, (2008). The Critical Success Factors (CSF) have been defined by many different authors and there is no unique way of defining this term (Hwang and Lim, 2012) due to the fact that various authors interpret success differently. Sanvido (1992) defined CSF as factors predicting success on projects. This means an area of project that is of concern and attention to achieving success as Takim & Akintoye (2002) posited that CSF are fundamental issues inherent in the project requiring day-to-day attention which must be maintained in order for team working to take place in an efficient and effective manner. Budget, schedule, and quality are the major goals in construction projects, CSF are those factors that determine the success of the achievement of these objectives (Chua, 1999; Kog, 2012). CSF are factors that have an influence in the achievement of the objectives of the projects. Therefore, in this research factors that determine the success of the achievement of schedule, budget, quality and health safety objectives of construction projects are the critical success factors.

2.5.3 Critical success factors for construction projects in Nigeria

Researchers in Nigeria have published research work on Critical Success Factors as identified by different authors but it was discovered that there are dearth of literature in CSFs for construction projects generally except few literature work available mostly for PPP projects. This research work has identified CSFs related to construction project and sees how they were adaptable for this research. The study of Ihuah, Kakulu, and Eaton (2014) reveals that 22 Critical Project Management Success Factors (CPMSF) are essential for the achievement of sustainable social (public) housing estates' delivery/provision in Nigeria. These relate to: the project managers' performance; the organisation that owns the development project; the characteristics of the team members; and the external project environment. Ogwuleeka, (2011) highlighted some critical success factors influencing project performance in Nigeria. The top six significant factors were identified to include;

objective management, management of design, technical factors, top management support, risk management and financial support. Surprisingly, some factors like community engagement, legal factors, mutual relationship, and environmental factors were considered least critical to project success, even though they are taken seriously especially in the new era where collaboration, sustainability and green building are gaining ground in the construction industry. Also, Akintoye et al., (2003) identified some critical success factors for projects procured using the private finance initiative namely; detailed risk allocation, commitment towards project duration and cost, technical innovation and technology transfer and accountability.

Nevertheless, the factors identified by most of the authors displayed a significant difference in their understanding of critical success factors. For instance, the obvious difference in the CSFs identified by Nzekwe et al., (2015), Ofori, (2013), and Amade et al., (2015) for successful implementation of public project in Anambra, developing countries, and Imo respectively as illustrated in Table 1.

Table 2. 1: Critical Success Factors by various authors for Nigeria Construction Industry

S/N	AUTHORS	Identified Critical Success factors
1	Nzekwe et al, (2015)	Ability to handle unexpected crises/situation
		Availability of the required technology and expertise
		The provision of appropriate network to all key actors in project implementation,
		Selection and training of necessary personnel
		A detailed and accurate specification of individual action steps

S/N	AUTHORS	Identified Critical Success factors
2	Ofori, (2013)	Recognized finance availability Communication coordination and commitment Competence and experience of stakeholder /project team Planning Teamwork Top management support
3	Amade et al., (2015)	Component 1: a. Effective Procurement Method b. Provision of Adequate Finance c. Strong Monitoring & Evaluation System d. Political Risks-External Factors e. Realistic Schedule and Cost Estimate f. Contractor's ability to manage the design Component 2: a. Training, Development and Motivation of Team Members b. Effective Communication Management c. Effective Project Planning Scheduling and Budgeting d. Project Manager's Competence and Decision Making Skills Component 3:

S/N	AUTHORS	Identified Critical Success factors
		a. Adequate Planning b. Adequate Team Selection Component 4: a. Leadership Skills of the Project Manager b. Effective Stakeholders Management Component 5: a. Weather Conditions Component 6: a. Effective Coordination of Project Activities
4	Ogwueleka A. (2011).	Nature & market condition, Stakeholder management, Project organization Stable frame work condition, Technical Factors, Management of design, Interface towards surrounding projects , Financial support, Legal factors, Environmental factors, Mutual relationship, Commitment of participants, Skills acquisition and availability of manpower, Innovative concept, Community engagement, Risk management

Ihuah et al, 2014 included in their list factors such as land issues, effective housing policy implementation, housing project ownership, and top management support which were also mentioned as a critical success factor by some other authors (Nwakanma *et. al.*, 2008; Ugwu and Kumaraswamy (2006); and Ogwueleka (2011). The CSFs for construction projects could be related to this but by reviewing the housing concepts to read project. Success of a project is deemed to be associated with adequate project fund and resources (Ihuah et al, 2014; Ogwueleka, 2011; and Dada and Oladokun, 2013). Ihuah et al (2014) considered adequate project monitoring and feedback to be part of critical factors that determine success of a project. However, Nwakanma et al (2008), and Ugwu and Kumaraswamy (2006) subscribed to the notion that end user involvement/inclusion cannot be overemphasized in the course of a project. This is important in that specifications of a project will be adequately satisfied if the consumers of the project are involved in the course of the project. Project manager/leader authority is a factor to be reckoned with for a successful project execution. It is critical for project managers who want to attain success to have realistic costing and time estimates (Ihuah et al, 2014; Ugwu and Kumaraswamy, 2006; Ogwueleka, 2011; and Famakin et al, 2014), as well as constant assessment of building materials and their non-static cost. Every successful project must have a mission and goal (Ihuah et al, 2014; and Nwakanma et al, 2008). Clarification of a project goal facilitates better understanding of the project (Ihuah et al, 2014; and Ugwu and Kumaraswamy, 2006), thereby leading to its success.

Composition of a project team is as important as providing the team members with adequate information about the project (Ihuah et al, 2014; Ugwu and Kumaraswamy, 2006; and Ogwueleka, 2011). Adequate project planning and control will always put into consideration the weather condition as well as the project site condition and other risks that need to be professionally managed (Ihuah et al, 2014; Ogwueleka, 2011; and Famakin et al, 2014) in order to attain success.

Furthermore, since every project is targeted towards satisfying certain needs, project ability to solve problems is derived from clear requirement specification (Nwakanma, 2008; and Ugwu and Kumaraswamy, 2006)) and realistic schedule set for the project execution (Ihuah et al, 2014, and Ogwueleka, 2011). It is of great importance in project management to put in place appropriate hardware and software technologies (Ugwu and Kumaraswamy, 2006). The need for providing these technologies calls for competence of the in-house team in the area of information technology coupled with development of the team understanding of construction processes and the business environment which is not likely to be separated from the cultural composition of the environment. The consequent result of this effort is the ease of use in respect with the project in question thus; successful project managers have the responsibility of standardizing process of operation so that problems will not occur in case of change management at the organizational level (Ugwu and Kumaraswamy, 2006). Process standardization is connected with evolutionary development which has its role to play in return on investment made in the project. Outsourcing part of the project being done may not be overlooked if success is to be attained at the end of the project (Ugwu and Kumaraswamy, 2006). This is because, outsourcing allows for gaining competence of partners and other stake holders in the supply chain as well as creating standard platforms for integration and communication which are instrumental to company turnover (Ugwu and Kumaraswamy, 2006; and Ogwueleka, 2011), gaining interpersonal skills (Ugwu and Kumaraswamy), and achieving objective management (Ogwueleka, 2011).

It is understood that it is critical for a project success to establish interface between the project and other surrounding projects, ensure adequate financial support, and factor in legal and general environmental issues that can affect the project execution (Ogwueleka, 2011). Mutual relationship among team members and between the project and the purpose for its execution, and commitment of participants skills acquisition and availability of manpower, and coming up with innovative concept in respect with project execution (Ogwueleka, 2011) are factors that bear a lot on the success of a project.

It is absurd to disconnect a successful project from its economic viability (Dada and Oladokun, 2013; and Famakin et al, 2014) and reliable contractual arrangements (Ogwueleka, 2011; Dada and Oladokun, 2013; and Famakin et al, 2014) that would showcase the project's multi-benefits objectives whose achievement is dependent on good governance, competitive procurement processes, transparency in the procurement process, as well as technology transfer (Famakin et al, 2014) which is mostly manifested in outsourcing and other interrelationship processes.

In summary, the critical success factors and the key performance indicator in the Nigeria construction industry is similar with construction sector all over the world with few differences. Research conducted by Musa, et al., (2015) in Nigeria also established that there is a significant relationship between CSFs (Economic factors, social factors and political factors) with the success criteria. Although the CFSs identified by the authors varied due to the difference in focus (whether successful implementation of projects, procurement routes, or successful provision of shelter and infrastructures) most of the factors identified were based on the objective of the situation they were being considered which confirms its relationship with the KPIs. In lieu of these differences, the CSFs are identified to include management factors, economic factors, stakeholder's factors, political factors, project/ social factors, and legal factors. However, the KPIs identified were of reasonable similarities.

2.6 Theoretical Background to the Study

Measurement of progressive project performance is very important in predicting the outcome of construction project whether success or failure. Omran, *et. al.,* (2012a) submitted that the success of a construction project is dependent on its performance. This performance is measured based on timely completion, expected quality standard, within cost estimates and client satisfaction. Many other researchers have researched into various other performance indicators for construction projects and have identified, in addition with cost, quality, time and client satisfaction, the following: regular and community satisfaction, health and safety and environmental factors (Chan, 2003; Enshassi, *et. al.,* 2009; Dawood, Sikka, Marasini & Dean, 2006; Alumbugu, Abdulazeez, Saidu, Ola-awo & Tsado, 2015). Despite the identification of these key performance indicators, there exist records of poor performance of construction project in literatures (Omran, *et. al.*, 2012a; Sibiya, *et. al.*, 2014; Gudiene, Ramelyte, and Banaitis, 2013a).

Getting to achieve the above-mentioned performance indicators required continuous monitoring and evaluation of the construction processes (Kamau & Mohamed, 2015). Ability to predict the outcome of an event before it starts or while it is on-going on construction sites will help in preparing adequately for anticipated difficulties and ultimately, achieve success (Elattar, 2009). However, construction is dynamic in nature, that is, uncertainties and risk associated with construction business vary with every construction project (Gudiene, *et.al.*, 2013a), thereby making key performance indicators vary from project to project (Alumbugu, *et. al.*, 2015).

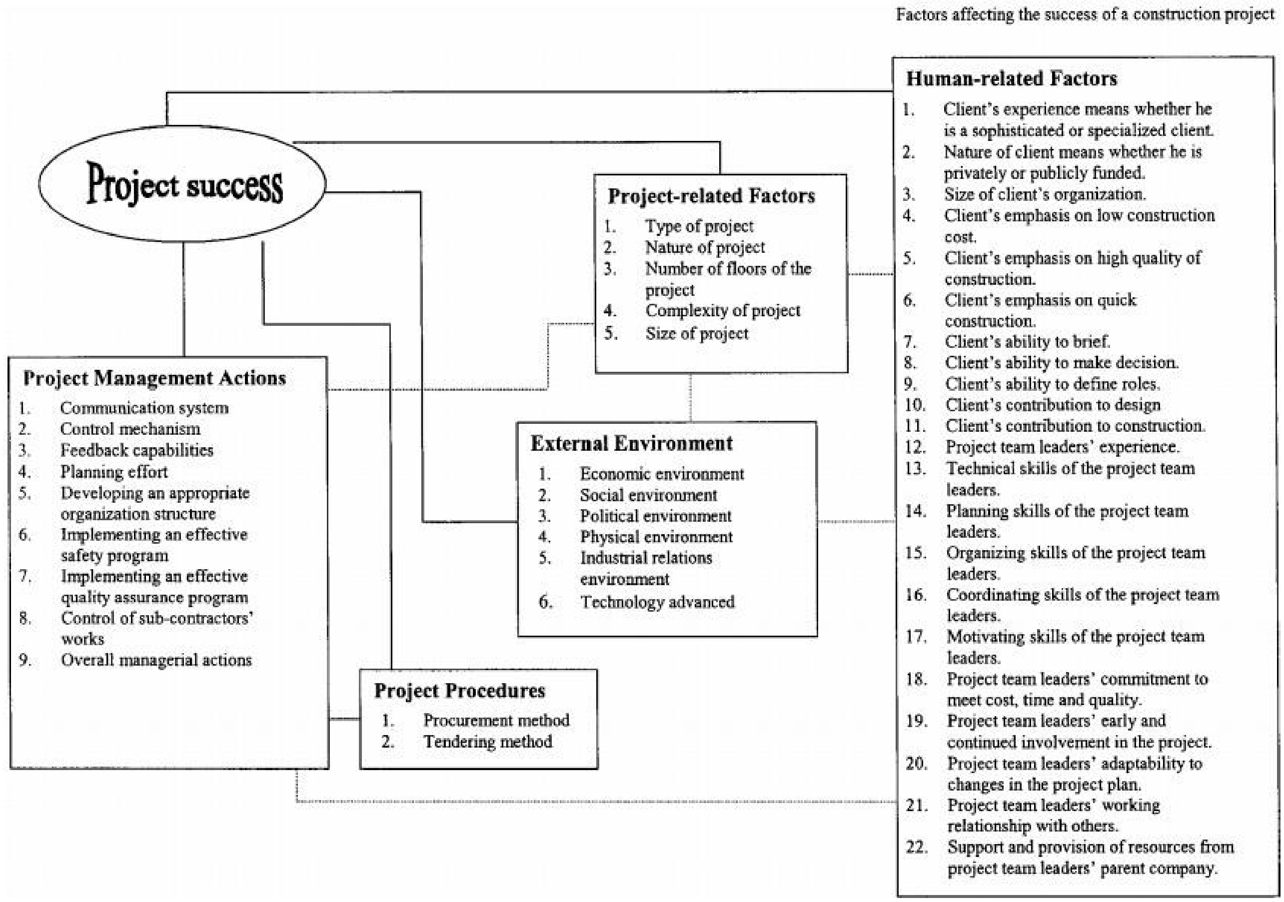


Figure 2. 1: New conceptual framework for factors affecting project success
Source: Chan et. al.(2004)

Chan *et.al*. (2004) present a framework showing the relationship between various project critical success factors and project success (Figure 2.1). All the critical success factors groups namely: human-related, project management, project procedures, project-related and external factors have direct impacts on the success of construction projects. The dotted lines that connect factor groups indicate the relationship between factor groups. Human-related factors group is impacted on or has impact on project management factors, project-related factors, and external environment factors with the exception of project procedure factors. Also, project management actions are determined by the project procedures and project management factors adopted on construction projects while project-related and human related factors are influenced by external environmental factors. Project related factors influence human-related factors, external environment, and project management factors. There exists no relationship between project related factors and project procedures factors (Chan *et. al.*, 2004). This is in contrast with the findings of Ogunsanmi (2013) which links effects of factors of procurement method, such as variation order, to project- related success factors. Disputes arising from procurement factors could lead to cost and time overrun thereby, altering the goals and/or outcome of construction projects. However, the framework did not show how the various critical success factors groups predict the key performance indicators of construction projects.

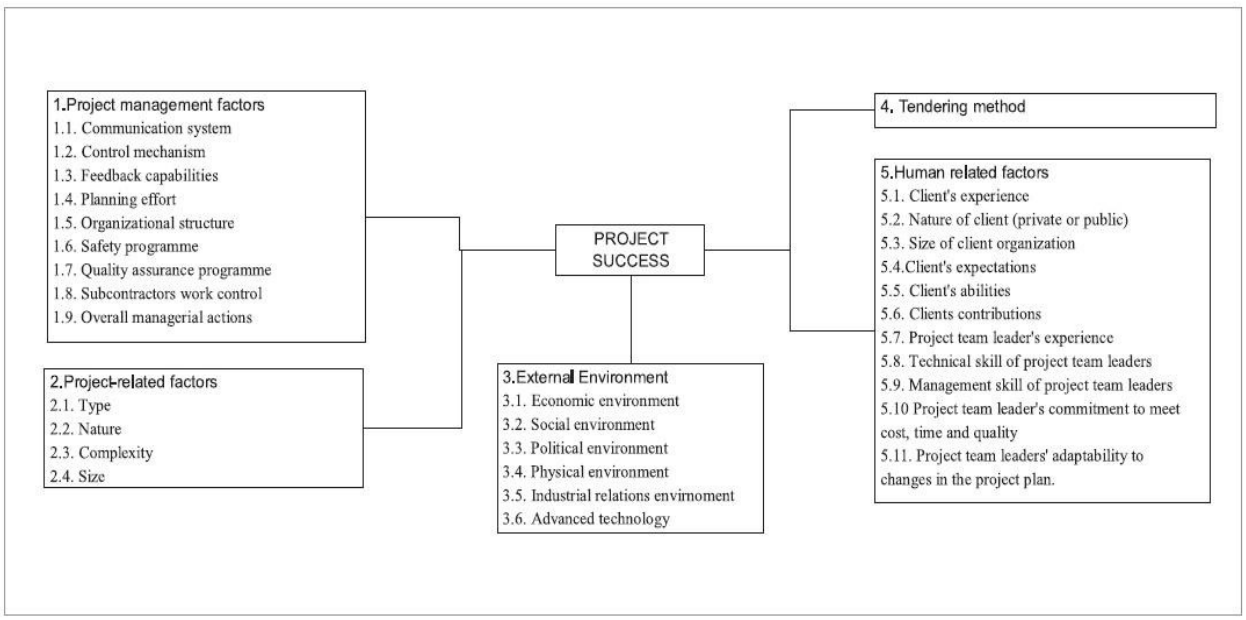


Figure 2. 2: Framework for critical success factors and variables
Source: Forcada, et. al.(2008)

Forcada, Casals, Gangolelss, Roca and Fuertes (2008) came up with a framework (Figure 2.2) that looks almost, alike to that of Chan *et al,* (2004).

Unlike the framework of Figure 2.1, external environmental factors are only related to project success with no relationship with other success factors group although, there exist significant and direct relationships between project management and project-related factors as well as between tendering method and human related factors with all factors group having relationship with project success. With the external environment directly affecting project success only, it can be inferred that the authors believed that external environmental factors such as economic, social, political and physical environments amongst others can affect the outcome and performance of construction projects with no other factors group having no influence on the effect brought by the external environmental factors.

A typical example is the increase in the prices of building materials as a result of drop in the value of Naira in foreign exchange market against the Dollar - the major currency of exchange internationally and in Nigeria. Although, the price increase will definitely alter cost estimates for construction projects that are on-going but, reversing or putting up measures to return the purchasing power of the Naira cannot be achieved by parties to construction projects but can only adjust to accommodate the changes brought about by the economic situations.

Physical environmental factors like earthquake or flooding can adversely affect the progress or eventually frustrate the execution of construction projects. Earthquake and similar natural occurrences do affect project outcome yet, project participants cannot do anything to curtail the effects of such disaster. Client's experience or procurement method adopted for such projects; for instance, do not influence earthquake or flooding.

The dynamism of construction projects requires continuous development of diagnostic or analytic model to measure the performance to keep the projects under control in terms of cost, time, quality and other previously identified success indicators. The focus of this thesis is to develop a model or system that can assess performance of construction project. Effective measurement of performance indicators, through critical success factors, will enhance the chances of identifying potential problems that may hinder the success of such projects. Early identification will enhance quick and effective solution and control of the problems.

2.7 Project Performance Indicators Reviewed from the Literature

The efforts of Takim and Akintoye (2002) were directed towards dividing the key performance indicators, identified by the UK working group on key performance indicators, into three orientations: procurement, process and result orientations. The performance indicators put forward by the UK working group are: construction cost, construction time, cost predictability, time predictability, defects, client satisfaction with the product and client satisfaction with the service; and three company performance indicators, namely: safety, profitability and productivity. This is also in agreement with the research of Mahmoud and Scott (2002).

In the report of Chan (2003) in an attempt to develop a framework for measuring success of construction projects, carried out by reviewing eight (8) leading journals on project success, the contents of the 'golden/iron' triangle – cost, time and quality, were confirmed as the basic and the most important parameters to measure project success. It was, however established that other indicators such as safety, functionality, satisfaction, environmental performance, etc. are attracting increasing attention. Mian, Sherman, Humphreys, and Sidwell (2004) adopted the term 'project health check' to describe the performance indicators of construction projects. Unsurprisingly, cost, time and quality with safety, environment and, stakeholders' value are the six (6) most critical performance measures confirmed as parameters used in assessing projects health.

The focus of Jha and Iyer (2006) was on quality performance of construction projects. The authors pointed out the importance of quality performance as a measure of project performance by stating the repercussions that are usually associated with poor quality. Repercussions stated are loss in productivity; additional expenditure by way of rework and repair; loss of reputation, leading to loss in market share; and eventually being put out of business. The research was concluded with the identification of critical success factors that specifically aid construction quality performance.

The focus of the research of Dawood, *et. al.,* (2006) was on 4D planning of construction projects. The most significant performance indicators identified in this research are: time, safety, client satisfaction, planning efficiency, and communication. Planning efficiency and communication are the new indicators identified in this research while cost and quality that have been established as key parameters in measuring project success by previous researchers were missing out. The inclusion of planning efficiency and communication and exclusion of cost and quality as performance indicators could be as a result of the focus of the research being on 4D planning as against construction project success which has been the focus of other researchers.In addition to cost, quality, time, safety, effectiveness, and stakeholders' satisfaction, two (2) other performance indicators were identified by Toor and Ogunlana (2009). The two (2) Performance indicators added by the researchers are efficient use of resources and reduced conflicts and disputes. Findings of the research indicate that the traditional measures of the iron triangle (on-time, under-budget and according to specifications) are no more applicable to measuring performance on large public sector development projects. Enshassi, *et. al.,* (2009) revealed cost, time, quality, productivity, client satisfaction, regular and community satisfaction, people, health and safety, innovation and learning and, environment as major groups of construction performance indicators in accordance with their relative importance indices ranking. Among these ten (10) groups, a total of sixty-one (61) key performance indicators were distributed.

Odusami, *et.al.* (2010) referred to the key performance indicators as quality performance indicators and were divided into two (2) broad groups – corporate and project levels. Human resource management topped the rank of the performance indicators at the project level, which is the focus of this study, while risk management came last on the log. Other quality performance indicators as rated from second to eighth on the list are: scope management, cost management, integration management, time management, procurement management, quality management and, communication management.

The development and prioritizing of key performance indicators for construction projects was viewed from the perspective of client in the study of Idrus, *et. al.,* (2011). Quality of finished project was rated first followed by construction cost and construction time respectively completing the traditional 'iron triangle' of measuring project success. Other performance criteria, in order of their ranking from fourth to eleventh, are: occupational health and safety, labour dependency, contractor's project management, quality of coordination by construction team, contractor's capacity of manpower, construction flexibility, environment friendliness and level of technology.

Mutual trust between project partners, guaranteed maximum price value, time required for the settlement of final project account and, contractor's involvement in project design were identified by Chan and Chan (2012), in addition to three (3) other indicators that have been identified by other researchers – time performance, magnitude of disputes and conflicts and, client satisfaction on the quality of completed work. The focus of their research was on target cost contracts.

Vyas and Kulkarni (2013) identified Cost on-time completion, resource management, quality control, percent complete, earned man-hours, lost time accounting and punch or snag list as key performance indicators of construction projects. In the research of Yeung, Chan, Chan, Chiang and Yang (2013), safety performance was rated as the most important indicator with cost, time and quality performance ranking second, third and fourth respectively. Other indicators in accordance with their ranks are: client's satisfaction, effectiveness of communication, end user's satisfaction, effectiveness of planning, functionality and, environmental performance. Langston (2013) stated scope also referred to as quality or standard, cost, time, risk and stakeholders' satisfaction as the key performance indicators of construction projects using 3D integration model. Wu and Sun (2013) introduced project loading and project resource to the list of existing performance measures. Other performance indicators identified in their research are: time, quality, cost, environmental and safety. Sibiya, *et. al.,* (2015) categorised key performance indicators of construction projects in the South African construction industry as: construction time, profitability, project management, material ordering, handling and management, risk management, quality assurance, client satisfaction (product), safety, time predictability (project, design, construction), productivity and, client satisfaction (service). Alumbugu, *et. al.,* (2015) agreed with the 'iron triangle' as the most important criteria for measuring project performance.

2.8 Performance Indicators for Construction Project

Generally, performance of construction project is predicted and measured with previously established critical success factors for the project (Takim & Akintoye, 2002). The UK KPI working group (2000) stated the following as the seven main groups of organization's key performance indicators, they are: time, cost, quality, client satisfaction, client changes, business performance and, health and safety.

Seven (7) out of the ten (10) key performance indicators developed by the UK KPI working group in 2002 are meant for measuring project performance while the remaining three (3) measures company performance (Mahmoud & Scott, 2002). The seven (7) KPIs that are related to project performance are: client satisfaction (product), client satisfaction (service), defects (quality), predictability of cost, predictability of time, construction time and construction cost. Safety, profitability and productivity make up the list of the three indicators that measure company performance.

Measuring project success in terms of cost is simply the ability to complete the project within the estimated budget. Criteria for measuring cost performance on construction projects are: market share of organization, liquidity of organization, cashflow of project, profit rate of project, overhead percentage of project, project design cost, material and equipment cost, project labour cost, project overtime cost, motivation cost, cost of rework, cost of variation orders, waste rate of materials, regular project budget update, cost control system, escalation of material prices and, differentiation of currency prices (Enshassi, *et.al.*, 2009; Auma, 2014; Babu, 2015). How events like disputes and conflicts, change in client/project specifications and other unforeseen events are managed determines the cost performance on construction projects as these are likely to lead to exceeding the target or budget for the project (Chan & Chan, 2012).

Time is defined as the duration for completing the project. This is determined based on the time the client is scheduled to put the building to use. Criteria for measuring time performance on construction projects are: site preparation time, percentage of orders delivered late, time needed to implement variation orders, time needed to rectify defects, average delay in claim approval, average delay in payment from owner to contractor, unavailability of resources as planned through project duration and, average delay because of closures leading to materials shortage (Enshassi, *et. al.*, 2009; Babu, 2015). In the construction industry, quality of construction projects is the ability of the end products to satisfy the needs for which the projects were undertaken. Quality is measured with the aesthetics, stability and comfort derived as defined at the project conception stage.

Project manager's competence; top management support and their competence; interaction between project participants; owners' competence; and monitoring and feedback by project participants were identified as factors having positive contributions to construction projects quality performance (Jha & Iyer, 2006). The findings of Jha and Iyer (2006) affirmed the importance of 'human element rather than machinery' and 'good communication among people' on project success. Other criteria for measuring quality performance of construction projects are: conformance to specification, unavailability of personals with high experience and qualification, quality of equipment and raw materials in project, participation of managerial levels with decision-making, quality assessment system in organization and, quality training/meeting (Enshassi, *et.al.,*2009; Babu, 2015).

The measurement of project success using health and safety is mainly focused on the degree to which construction projects are executed with limited injuries and health hazards to personnel directly and indirectly involved with the projects. Measurement of project success in terms of health and safety performance is usually based on the following criteria: application of health and safety factors in organization, easiness to reach the site (location of project), reportable accidents rate in project and, assurance rate of project (Enshassi, *et. al.*, 2009; Babu, 2015).

The client, corporate, government or individual, should be satisfied with the outcome of a project. This factor is related with other performance factors as it is determined by how well a project performs in terms of other performance criteria. Client satisfaction cannot be separated from the quality of services rendered by project participants, the quality of the product of the services rendered, timely completion as stipulated in contract documents, as well as performance in terms of cost. Idrus, *et. al.* (2011) submitted that quality of finished project, construction cost and construction time are the criteria given high priority by clients in measuring the performance of a construction project.

This means that satisfaction cannot be achieved if the project fails in, at least, in terms of quality, cost and time performance. According to Alumbugu, *et. al.*, (2015), the essence of quality, timely and budget-friendly project is to meet the needs of both the client and/or the end users. This is therefore, in contrast with the findings of other researchers (Dawood, *et. al.*, 2006; Chan, 2003) that usually place the 'iron-triangle' first in measuring construction performance. However, it should be pointed out that the findings of Alumbugu, *et. al.*, (2015) did not undermine the importance of quality, time and budget performance of construction projects as they still come out top on the list of key performance indicators tested for in the research rather, the findings showed that these three performance criteria and others can only be termed effective if client and/or users' expectations are met.

In accordance with the findings of Enshassi, *et. al.*, (2009), environmental performance of construction projects is of importance to clients, consultants and contractors in measuring project performance due to its relationship with productivity and time performance. This is a measure of the impacts of the project on its immediate environment; these include climatic conditions, noise level, air quality, etc. Project neighbours interests in environmental factors cannot be disregarded as they face most of the hardship, such as noise and dust, which may be brought up by the execution of the project.

Environmental performanceenhance sustainability and environmental friendliness of construction projects which lead to decline in construction costs and risks while, consequently, increasing profitability and chances of early repayment of loans obtained by client (if any) to execute such projects (Işik, Aladağ & Akkaya, 2012).

Productivity, another key performance indicator of construction project, is directly related to time performance of construction projects, this is because the more productive the resources deployed to the execution of a construction project the earlier it is completed. Combination of productive resources such as competent human resources and quality materials should also bring about quality project products or services, through improved coordination and motivation, thereby reducing additional costs that may be associated with reworks which translate to cost performance (Enshassi, *et. al.,* 2009).

Productivity on construction projects are positively affected by the potency of project management involved with the project. Effective team work and excellent leadership such as motivation, excellent communication skills, training, etc. can improve the productivity of construction workers on site (Omran, *et. al.*, 2012a).

Productivity performance on construction projects is predicted by sequencing of work according to schedule, relationship between project management and other project participants, number of project being executed by contractor in a year or concurrently, absenteeism rate of construction workers and complexity of the project involved (Babu, 2015).

The following section present a detailed analysis of cost, time, quality and, health and safety as means of measuring performance of construction project.

2.9 Key Performance Indicators: Cost, Time, Quality and, Health and Safety

Although, the measurement of construction project is largely based on seven (7) KPI groups (Mahmoud & Scott, 2002), various researchers have demonstrated the importance of cost, time, and quality as the most important of them all (Dawood, et al., 2006; Alumbugu, et al., 2015). Recent research works have shown that measurement of project performance cannot be adequately justified with these three (3) indicators alone (Shirouyehzad, Khodadadi-Karimvand & Dabestani, 2011) hence, the importance of health and safety on construction projects is gaining momentum in the research world (Chinda & Mohamed, 2007; Memon, *et., al.*, 2013) due to its effect on cost, quality and time performance (Enshassi, et. al., 2009; Babu, 2015).

2.9.1Cost

Cost performance is simply a measure of the degree to which general conditions promote the completion of a construction project within the estimated budget. It is measured by comparing current costs allocated for the work against budgeted costs allocated for the work in place, completed to date (Vyas & Kulkarni, 2013). Although cost is not limited to tender sum alone but includes all the cost incurred from inception to completion (Chan, 2003) but, events that leads to cost overrun or poor cost performance are usually associated with construction phase due to various uncertainties that characterise the phase of construction projects. Idrus, *et. al.* (2011) explained the importance of cost performance as a measure of project performance by linking it to client satisfaction. In measuring client satisfaction, delivery of desired quality project within estimated budgets and planned time are important.

In order to achieve good cost performance on a construction project a number of factors should be monitored, these factors determine project success in terms of cost. According to Enshassi, *et. al.*, 2009, stability of market prices of construction materials, differentiation of currency prices or strength of the foreign exchange market, cash flow of project, materials and equipment cost, and liquidity of organization top the list of factors that determine success of construction project cost wise.

A relatively stable market condition ensures that variation in prices of construction materials is limited thereby eliminating excessive cost that may be expended to offset fluctuation claims during the course of construction projects. The impact of foreign

Exchange market on the construction industry of import-depended economy like Nigeria is very enormous (Oyediran & Odeniyi, 2009). The authors put the average growth in the prices of construction materials to be four percent lower than the rate of depreciation of the Naira against its foreign counterparts. Over-dependence on importation of building materials to service the needs of the local construction industry put cost performance of construction projects in Nigeria at the mercy of the foreign exchange rates and market. Cash flow and liquidity of construction organization both have direct relationship with cost performance of construction projects. Cash flow from client to contractor determines the availability of funds, at the right time, for executing construction activities. Delay in the flow of cash and/or illiquid state of a contractor will only not delay the smooth running of construction sites and delivery of the project but, also lead to additional cost in terms of loss and/or expense (Nghiem *et. al.*, 2015).

An examination of these and other factors, such as, market share of organization, profit rate of project, overhead percentage of project, project design cost, project labour cost, project overtime cost, motivation cost, cost of rework, cost of variation orders, waste rate of materials, regular project budget update, cost control system and, escalation of material prices (Enshassi, *et. al.*, 2009) amongst others, identified as factors influencing cost performance of construction projects, shows that these factors are spread across various factor groups of construction critical success factors. Hence, project management factors such as cash flow of project, regular project budget update and cost control system (Omran, *et. al.,* 2012b; Sibiya, *et. al.*, 2014); procurement factors such as liquidity of organization (Divakar & Subramanian, 2009; Sweis, *et. al.*, 2014); project-participants factors such as cost of rework – caused by unqualified workforce and incompetent authority or supervision (Inayat, 2012); and external factors such as foreign exchange market which is caused by economic environment of construction projects (Chan, Scott & Chan, 2004) affect cost performance of construction projects (Babu, 2015).

A poorly performed project in terms of cost is easily identified with cost overruns and, causes attributed to its occurrence span across different groups namely: site-related; human-related; project-related and; technical issues (Shibani & Arumugam, 2015). The authors attributed delays of various kinds to cost overruns on construction projects. Such delays due to number of participants; land acquisitions; approval and disbursement of loan; procurement delay; delay in recruiting consultants; delay in hiring project staff; government procedures and; materials delivery.

Other causes of cost overruns: lack of safety measures on site; severe weather conditions; unanticipated ground conditions; antagonistic political conditions; unreasonable time schedule; non-accessibility of designs on time; amendments to works due to errors in design; amendments to works due to errors in execution; improper management and supervision; lack of skilled workers to operate special equipment; lack of proper coordination among project participants; regular change of contractors; clashes between owners and other parties; outdated construction methods; ineffective equipment; financial limitations of contractors and; other site related costs like labour costs, machinery costs and, transportation costs (Mahamid & Dmaidi, 2013; Shittu, Adamu, Mohammed, Suleiman, Isa, Ibrahim & Shehu, 2013; Shibani & Arumugam, 2015; Tejale, Khadenkar &Patil, 2015).

2.9.2 Time

Time performance is of great importance on construction projects especially, on commercial projects where the facility or building is to be subjected to let or rent to generate income for the client. A successful project, in terms of time performance, is completed as specified in the contract on or ahead of predetermined schedule (Dawood, Sikka, Marasini & Dean, 2006). A construction project that suffers delay in completion could lead to loss and/or extra expense to the client. This loss and/or expense could be in form of losing rent and other forms of income to be generated during the extra time expended on the project and delay in repayment of loan/credit facility obtained to finance the project. Delay in loan repayment thereby subjects client to pay additional interests on capital invested. Clients, consultants and contractors alike see time performance as major criteria for measuring project success (Alumbugu, Abdulazeez, Saidu, Ola-awo & Tsado, 2015) and was agreed to have impact on quality and cost of construction projects hence, concerted management efforts should be provided by stakeholders to achieve time performance on projects. Time performance is very important for construction projects to be completed on time, as the clients, users, stakeholders and the general public usually looks at project success from the macro view where their first criterion for project success appeared to be the completion time (Lim & Mohamed, 2000).

In achieving time performance on construction projects, emphasis should be on reducing average time loss to site closures, ensuring resources are available, prompt payment of valuations, reduction in the percentage of orders delivered late, proper planning of construction time, implementation of variation orders and average delay in claims approval (Babu, 2015).

Factors such as resources availability, payment of periodic valuation can be attributed to project-participants factors as these are offshoots of optimal utilisation of resources on construction sites (Omran, *et. al.*, 2012a). It takes the availability of skilful workers, experienced and competent project management team and, project managers to effectively manage the supply and quality control of construction materials in order to achieve optimal resources utilisation. Adequate planning of construction time is a function of the experience, competence and client's ability to make decision in conjunction with the commitment, competence and experience of project management team, project manager and the contractor's team (Chan, *et. al.*, 2004; Saqib, *et. al.*, 2008).

Although, proper project management practices like effective coordination and feedback capabilities (Sibiya, *et.al.*, 2014) can be instrumental in avoiding construction site closure yet, external factors especially physical factors such as flooding and earthquake may render all management efforts, in keeping construction sites running, useless (Chan, *et. al.*, 2004). Lots of time could be loss to physical factors beyond the control of the human factors of construction projects. Some projects could even, be completely frustrated depending on the degree of damage done by such natural disasters.

The procurement method adopted for a construction project affect performance especially, in terms of time. Procurement methods that give room for competition among established and new construction companies enhance project performance. Variation orders, for example, can lead to time overrun on construction projects as a result of disputes that do emanate from such orders (Ogunsanmi, 2013). Such disputes on variation orders are synonymous with traditional methods of procurement while other procurement methods such as turnkey and design and build has little of such bottlenecks to deal with due to their contractual arrangement. Time wasted in settling disputes and issues that result into disputes are drastically reduced in other forms of procurement other than the traditional means.

Leong, Zakuan, Mat Saman, Md. Ariff, and Tan (2014) argued the importance of time performance on measuring construction project performance by identifying it with client satisfaction, both as significantly effective in measurement of projects Quality Management System. The importance of client experience as a success factor in construction project was highlighted in the research of Kadiri and Shittu (2015) as top on the list of causes of time overrun from contractors' perspective was "lack of experience of client in construction". Other factors linked with time performance are: client's financial difficulties; inadequate fund allocation; incomplete drawings/details; slow decision making; inaccurate site investigations; monthly payment difficulties; client interference; delay of payment to suppliers/subcontractors; contractor's financial difficulties; poor and delayed designs; inaccurate cost estimates and; improper project planning and scheduling.

2.9.3 Quality

In conjunction with cost and time, quality become the third member of the three (3) most important performance indicators for construction projects popularly referred to as either 'iron triangle' or 'golden triangle'. The measurement of quality performance of a construction project is subjective in nature. It is the entirety of features required by a product or services to satisfy a given need and its ability to fit the purpose intended for buying the product or the service (Parfitt Sanvido, 1993) as cited in Chan (2003). However, irrespective of standard of a construction project product, quality vary from clients to clients as it may be viewed as the guarantee of a product that convince the clients or the end users to invest in it (Chan, 2003). The quality requirement of a construction project is spelt out in contract documents in graphical forms (such as in architectural drawings, engineering drawings, etc.) and written forms as it is found in specifications and bills of quantities. A proportion of information of quality standard desired for the project is also found in other supplementary documents such as variation orders. Hence, the quick and legal way to measure quality performance of a construction project is to compare the product with the specifications provided at the design stage and various variation orders issued during the course of the construction process.

Auma (2014) found out that qualification and experience of personnel, quality of materials and equipment used, conformance to specifications and quality assurance and follow up have influence of quality performance of construction projects. Clear and effective definitions of project specifications usually improve the chances of achieving quality project result. This means that there exists a direct and positive relationship between procurement procedures employed on construction project and quality performance (Jeptepkeny, 2015). What this implies is that quality performance of construction project is not achieved during construction phase alone but also, as a result of all efforts that have been put into the project, especially at design stage, before the construction phase is begun.

Quality is achieved when construction processes are carried out in conformance with specification, availability of experienced and qualified site personnel, quality of construction raw materials, active participation of management in decision making processes, quality assessment in construction organization and, quality training and meetings (Enshassi, *et.al.,*2009). It is the responsibility of the contractor's team to ensure constructions are executed in conformity with stated specifications by employing, training and deploying capable workers to the project (Omran, *et.al.,*2012b; Alvani, Bemanian & Huseinali, 2014). Effective decision making, quality assessment of construction works and ensuring that specified materials are used on project are the burdens of the project management team to bear (Saqib, *et. al.*, 2008; Tabish & Jha, 2011). Hence, quality of construction projects depends heavily on the availability and effectiveness of project- participants (sometimes referred to as human-related factors) and project management factors.

Poor quality in construction projects usually lead to rework, a crucial problem in the construction industries across the world (Mahamid, 2016). Top on the list of causes attributed to theseproblems are: poor communication between client and contractors, poor communication between client and consultants, use of materials of poor quality and, poor site management. Reworks are consequences of defects and, one of the major causes of defects is poor workmanship (Shittu, *et. al.*, 2013). Reasons given by the authors for occurence of defects on construction projects are poor management, complicated roles of subcontractors, competency and experience of labour, communication problems, unsuitable construction equipment, poor weather condition, available time and cost.

2.9.4 Health and Safety

The degree to which the general conditions surrounding a construction project, promote the completion without major injuries or injuries to persons directly and indirectly connected to the project is a measure of health and safety performance of the project (Chan, 2003). Although, several researchers rated safety behind cost, quality and time (Dawood, *et.al.*, 2006; Alumbugu, *et.al.*, 2015) yet, its importance cannot be overlooked. An accident-free construction promotes on-time completion and eliminates claims from injured or dead site workers. This means that quality health and safety programme on construction sites ensures that time and cost overrun are reduced to the barest minimum. Accidents or injuries on construction sites can cause litigation and/or penalties or damages that may alter construction programmes thereby leading to delay in project delivery as well as addition to project costs in terms of compensations paid to injured workers or families of deceased workers, fines paid due to non-compliance with health and safety policies and extra interests on loan obtained to execute the projects due to time extension (Muhammad, Abdulateef & Ladi, 2015). This shows the direct relationship between cost performance and health and safety performance on construction projects. Also, productivity and quality can be adversely affected by the state of health and safety programme on construction sites. Accidents and/or injuries could lead to decline in morale of workers on site thereby reducing their productivity as well as commitment which could eventually lead to poor project outcome.

Application of health and safety factors in construction organization, safety of project location, reportable accident rate in project and assurance rate of project are success factors attributed to health and safety performance of construction project (Enshassi, *et. al.*, 2009).

Incorporation of health and safety policies into construction companies' cultures aids the ease of adopting effective safety programmes on construction sites. This depends on the organizational culture of the contracting organization and the monitoring and the authority traits of project management on construction projects. The use of defective personal protective equipment expose site workers to injuries and/or accidents that could be life threatening. Where productivity is prioritized above safety by both contractor and project management teams, such projects are subject to failure in terms of health and safety performance (Mashood, Mujtaba, Khan, Mubin, Shafique & Zahoor, 2014).

Safety of project location is a factor that can be categorised under the external success factors. Construction project location may be safe due to absence of civil unrest such as industrial actions, protests, commotion amongst others.

Flooding, earthquake and other natural events on construction sites and its environs could negatively affect the safety of construction projects, construction workers and, makes accessibility to the sites very difficult (Enshassi, *et. al.*, 2009). Assurance rate of success on construction projects is a function of multiple factors such as the competence of project participants, project complexity and effective project management practices such as training and organisation of workshops on safety practices on construction sites. Also, guiding against future reoccurrence of site accidents depend largely on the feedback got from the records of past accident therefore, keeping proper safety/accidents record is key to achieve successful project in terms of health and safety (Chan, *et.al.*, 2004). Therefore, it can be deduced that project-related, project management, project participants and external success factors predicts the health and safety performance of construction projects.

In achieving good results with health and safety performance on construction projects, factors found, in literatures, as important are: management support, teamwork, appropriate safety education and training, appropriate supervision, clear and realistic goals, safety equipment acquisition and maintenance, continuing participation of employees, safety meetings, delegation of authority and responsibilities, good communication, personal attitude, personal competency, sufficient resource allocation, effective enforcement scheme, program evaluation, personal motivation and, positive group norms (Shirouyehzad, et. al., 2011; Memon, *et. al.*, 2012).

2.10 Determining Factors for Construction project performance

Performance of construction projects is determined by a number of factors, some aiding on-time delivery while others causes delay or outright failure in the projects delivery. Enshassi, *et. al.,* (2009) categorized construction project performance factors into ten (10) broad groups namely: cost, time, quality, productivity, client satisfaction, regular and community satisfaction, people, health and safety, innovation and learning and, environmental factors. According to Auma (2014) major cost-related factors affecting the performance of construction projects are cost of equipment and materials, cost of variation orders, cost of rework and escalation of material prices. Time-related factors of construction project performance were identified as percentage of late delivery of orders, delay in claims approval and delay in payment of valuations to contractor. The quality performance of construction projects were hinged upon qualification and experience of staffs, quality of equipment and materials and conformance to specification while leadership factors to successful project performance are staffs' training and leaders' professional qualification. Therefore, Auma (2014) concluded that the major factors that determine construction project performance were cost, time management, quality management and leadership style adopted on construction site. However, it was revealed that cost overrun and delay in project delivery do not determine client satisfaction as clients were sometimes satisfied with the project. Muhammad, Abdulateef & Ladi (2015) researched into the importance of health and safety programme as a determinant of construction project performance. Although, proper implementation of health and safety policy on construction sites does come at a cost yet, it cannot be compared with the cost associated with its neglect, the delay it could cause and potential reduction in quality of the project output.

The extent to which construction projects are completely executed within or on stipulated time, established cost from inception, the expected quality standard and, level of satisfaction derived from the project outcome are used in measuring project performance according to Omran, *et. al.*, (2012a), and of course poor schedule, budget, safety performance, fair quality and client satisfaction were attributed to the poor performance of construction projects. To solve the problem of poor performance of construction projects, success factors put forward by researchers are: (1) project team leader experience, (2) planning effort, (3) adequacy of design and specification, (4) cost monitoring, and (5) leadership skills of project leader. Providing for the aforementioned five factors will help in eliminating disputes between parties to the construction contract, efficient planning, monitoring and control will help in planning for foreseen problems that may cause time and cost overrun as well as decrease in the expected quality of the project. According to Sibiya, *et. al.,* (2014), key performance indicators are used to measure project performance by simply comparing the actual performance of construction projects with their estimated performance in terms of effectiveness, efficiency, and quality of workmanship and products.

2.11 Summary of the Chapter

The role of the construction industry in the growth of nations' economies across the world is very crucial. The contribution of the construction industry to the Nigerian economy stood at 8th position among the twelve economic sectors considered by Adeagbo (2013). According to Mbamli and Okotie (2012) Nigeria's independence in 1960 and oil boom of the 1970s increased construction activities such that most available construction organizations were "over-stressed". The problem of high time and cost overruns, low quality and abandonment surfaced and was attributed to poor project conception, careless planning and poor execution. Effective procurement method is usually preceded by devising a project strategy, which involves weighing up the benefits, risks and financial constraints which might confront the project execution and, which eventually will be reflected in the choice of contractual arrangements. In every project, time, cost, and quality performance, among other criteria, in relation to both design and construction of the building, are usually top on the list of considerations in choosing a procurement method. (JCT, 2011). Measurement of progressive project performance is very important in predicting the outcome of construction project whether success or failure. Researchers have demonstrated the importance of cost, time and, quality as the most important KPIs but recent research works have shown the importance of health and safety as another key indicator in the assessment of the performance of construction projects.

CHAPTER THREE

THE DYNAMICS CONSTRUCTION PROJECT PERFORMANCE: FACTORS AND INDICATORS

3.1Overview

This chapter discusses the performance of construction in terms of performance indicators and the systematic review of literatures on critical success factors of construction project. The chapter contains the methodology adopted in the review, inclusion and exclusion criteria, review of critical success factors in construction project, performance indicators for cost, time, quality and health and safety, key performance indicators and performance forecasting variables.

3.2 Construction Project Performance

Measuring the performance of construction project is of great importance to project managers and clients (Idrus, *et. al.,* 2011) and, many researchers have studied this area over the decades. The two (2) common terms used in measuring performance of construction projects are critical success factors (Omran, *et. al.*, 2012a) and key performance indicators (Mahmoud & Scott, 2002).

However, the ultimate means of measuring project success is through the satisfaction of the project client (Leong, *et. al*, 2014). Achieving client satisfaction depends on how well the projects perform against other key performance indicators such as cost, time and quality (Idrus, *et. al*, 2011).

The measurement of project performance using the critical success factors approach has attracted various classifications of such construction performance enhancing factors. Such groups are: Project management factors, project procedures or procurement factors, project-related factors, project participants or human related factors and external factors (Chan, *et. al.*, 2004; Gudiene, *et. al.* 2013b). Critical factors group like contractor factors, project manager factors, design team factors, client factors and, materials factors are seen in the grouping of Omran, *et.al.,*2012b), while project-participants factors group was missing. However, project-participants factors are represented with the combine factors contained in contractor, project manager, design team and client factors. Using the CSFs, project performance depends on how well these groups interact to bring about project success (Chan, *et. al.*, 2004).

The measurement of project performance using the key performance indicators approach has attracted various classifications but, the most popular and widely accepted in the construction industry around the world is the classification of the UK KPI working group (Mahmoud & Scott, 2002).

Babu (2015) emphasised the approach to determine the success of construction project using key performance indicators such as; cost, time, quality, health and safety, client satisfaction, productivity and, environmental impacts. Other factors found in the literatures are innovation and learning, regular and community satisfaction, users' satisfaction and people's factors. The success of a construction project, using the KPIapproach is determined by how well construction projects fare against the aforementioned indicators especially cost, quality and, time (Chan, 2003; Omran, *et. al.*, 2012a). A project that surfers cost and time overrun with poor quality project output is a failed project (Shibani & Arumugam, 2015).

3.3 Critical Success Factors for Construction Projects

The success of construction projects is a function of how well the set success factors are met during the course of construction. In fact, critical success factors have great influences on success of construction projects (Baccarini & Collins, 2003).

A number of important factors that have been identified as critical to the success or failure due to lack of them are: experience of the project client, client's knowledge of construction processes/industry, client ability to define roles, ability to clearly state projects goals, project complexity, procurement method, competence of the project management team, project monitoring, control mechanisms employed on the project, support and commitment of top management and, external factors like economic factors, political and social factors and, climatic factors (Chan, et. al., 2004; Jha & Iyer, 2006; Omran, *et. al.,* 2012b; Sibiya, *et. al.*, 2014; Shibani & Arumugam, 2015).

To make a list with definite number of possible critical success factors for construction projects may not be ideal as every project is unique in its own way and, the critical success factors for every project depend on the complexity, type and mission of such projects. However, there have been various classifications by authors and, the classifications are presented in the next section.

3.4 Review of Critical Success Factors from Literatures

Determining success of building construction performance is a function of the perspective of who is defining it. Building construction success definition or criteria changes from project to project depending on projects participants, stakeholders, scope, size of project, available technology, owners' or clients' nature, amongst other factors (Saqib, Farooqui, & Lodi, 2008). Conversely, success criteria are often developed across the construction industry relating success to perception and expectation of clients, consultants and contractors.

A thorough review of the literature shows that critical success factors for construction projects were divided into groups. Chan, *et. al.,* (2004) divided the critical success factors of construction projects into five (5) major groups namely: project-related factors, procurement-related factors, project management factors, project participants- related factors and, external factors. Chinda and Mohamed (2007) put forward six (6) groups of different names on the safety of construction projects sites, the groups submitted with the research were: leadership, people, policy and strategy, partnership and resources, processes and goals. Leadership can be likened to the Project manager related factors; people can be equated with labour and labour productivity of the groupings of Chan, *et. al.* (2004). Saqib, *et.*

al. (2008) divided the factors into seven (7) groups with the addition of client-related factors, design team-related factors, contractor- related factors and, project manager-related factors as replacements for project participants-related factors and project-related factors in the groupings of Chan *et. al.* (2004) while, external factors group was renamed as business and work environment- related factors. Ika, Diallo and Thuillier, (2011) grouped the critical success factors under five (5) headings which are Monitoring factors, Coordination factors, Design factors, Training factors and Institutional environment. These groupings were peculiar to measuring the success of World Bank projects as that was the focus of the research.

From the research of Omran, *et. al.* (2012b), critical success factors for construction projects were divided into ten (10) groups namely: Project management factors, Procurement factors, Client factors, Contractor factors, Design team factors, Project manager factors, Work environment factors, Materials factor, Labour and productivity factors and External factors. Gudiene, *et. al.,* (2013b) also classified the critical success factors into seven (7) groups namely: external factors, institutional factors, project related factors, project management/team members related factors, project manager related factors, client related factors and, contractor related factors.

The groupings of Alias, Zawawi, Yusof & Aris (2014) was in accordance with that of Chan, *et. al.*, (2004) with procurement factors renamed as project procedures and project participants-related factors called human-related factors. Zahedi-Seresht, Akbarijokar, Khosravi, and Afshari (2014) identified construction success factors under a broad group called input factors. The factors grouped under this category cut across all other groups that have been found in literatures. Notable among the factors are: organizational sponsorship, project managers' competency, client organization, project operational environment and, organizational experience.Other researchers did not group the success factors in any manner but just extracted and tested for each as an individual factor (Jha &

Iyer, 2006; Abu Bakar, Abd Razak, Abdullah, Awang & Perumal, 2010; Varajão, Dominguez, Ribeiro & Paiva,2014; Nghiem, *et.al.*,2015; Wang, Yao, Wu& Jiang,2015).

3.4.1 Methodology of the Review

The methodology adopted in the review is termed systematic literature review. The key words searched on the Google search engine were 'critical success factors construction performance' and all downloadable literatures such as journal articles, PHD theses, working paper, conference proceedings, books, reports, etc., were downloaded. The total number of documents downloaded, relevant or irrelevant, to the subject matter was two hundred and thirty-five (235). The total number of pages displayed on the google search engine was twenty-four (24) with two hundred and forty (240) entries. A refined or repeated search which shows results omitted by the search engine on their level of relevance to the search key words displayed a total page number of fifty (50) with 'about 492 results'. Links displayed on pages 49 and 50 were inaccessible while repetition of results started from page eighteen (18).

3.4.2 Inclusion and Exclusion Criteria

The focus of this study is on the critical success factors of construction project performance. All literature materials retained or included in this review were included on the bases of their focus on building construction project performance only. A total number of sixty-five (65) literature materials from the available two hundred and forty (240) materials fit the inclusion criterion and were therefore, included.

The major exclusion criterion employed for the literature items excluded was their lack of focus on performance of building construction projects. All literature items that focused on critical success factors of industries other than construction industry were excluded, items that focused on civil and process engineering projects of the construction industry were also excluded and lastly, items that focused on Public-Private-Partnerships (PPP) projects, joint ventures and partnering arrangements on construction projects were excluded.

A total number of one hundred and sixteen (116) literature items were excluded for being focused on other industries other than the construction industry. Industries such as manufacturing, hospitality, agriculture, information technology, enterprise resource planning (ERP), etc., were the focus of such entries. Twenty-three (23) more literature items were excluded from the review because, although they were focused on the construction industry but, not on building construction projects which is the focus of this present study. Some of the items excluded focused on large infrastructure projects, construction enterprise resource planning, deep-water oil and gas projects among others. Lastly, another sixteen (16) literature items were excluded from the review not because they were not focused on building construction projects rather, they were focused on partnering or joint ventures or Public-Private-Partnership (PPP) or administration of construction organizations such as project marketing and whole life cycle assessment. Since the focus of the research is on reviewing the critical success factors of construction performance only, Public-Private-Partnership (PPP) and related literature items would be inappropriate to be included as such literatures' focus go beyond construction and include design as well as financing the projects. The Table 1 shows the list of research works that that were reviewed:

Table 3. 1: Review of Critical Success Factors by Different Authors

S/N N	Researchers	Year	Classifications
1	Chan, A. P. C., Scott, D. & Chan, A. P. L.	2004	Five groups: Project Management, Procurement, Project-Participants, Project-Related and External Factors
2	Jha, K. N. & Iyer, K. C.	2006	No classification adopted
3	Nitithamyong, P. & Skibniewski, M. J.	2006	No classification adopted
4	Chinda, T. & Mohamed, S.	2007	Focus was on Safety alone - no classification
5	Saqib, M., Farooqui, R. U., & Lodi, S. H.	2008	Seven groups: Project Management, Procurement, Client, Design Team, Contractor, Project Manager and, Business & Work Environment Factors

S/N N	Researchers	Year	Classifications
6	Koutsikouri, D., Austin, S. & Dainty, A. R. J.	2008	Four groups: Management, Design Team, Competencies & Resources and, Project Enablers Factors
7	Divakar, K. & Subramanian, K.	2009	No classification adopted
8	Shokri-Ghasabeh, M. & Kavousi-Chabok, K.	2009	No classification adopted
9	Yang, J., Shen, G. Q., Ho, M., Drew, D. S. & Chan, A. P. C.	2009	Focus was on Stakeholders management in construction projects
10	Elattar, S. M. S.	2009	Classified into: Owner, Contractor and
11	Kamar, K. A. M., Alshawi, M. & Hamed, Z.	2009	No classification adopted
12	Abu Bakar, A., Abd Razaq, A., Abdullah, S., Awang, A. & Perumal, V.	2010	No classification adopted
13	Abdullah, A. A., Abdul Rahman, H., Harun, Z., Alashwal, A. M. & Beksin, A.	2010	Classified into: Traditional and Non-traditional Factors
14	Tan, D. J. Z. & Mohamed Ghazali, F. E.	2011	Seven groups: Project Management, Procurement, Client, Design Team, Contractor, Project Manager and, Business & Work Environment Factors
15	Lee, S. K. & Yu, J. H.	2011	No classification adopted
16	Ika, L. A., Diallo, A. & Thuillier, D.	2011	No classification adopted
17	Shirouyehzad, H., Khodadadi-Karimvand, M. & Dabestani, R.	2011	Focus was on Safety alone - no classification
18	Tabish, S. Z. S., & Jha, K. N.	2011	Classified into: Schedule, Cost, Quality, Safety and No-Dispute
19	Inayat, A.	2012	Classified based on: Cost, Quality and
20	Pakseresht, A. & Asgari, G.	2012	No classification adopted
21	Khalifa, Z. A. & Jamaludin, M.	2012	The focus was on Knowledge management - no classification adopted
22	Omran, A., AbdalRahman, S. & Pakir, A. K.	2012 a	Nine groups: Contractor, Consultant, Client, External, Labour, Materials, Contractual, Procedure and Project-Related Factors
23	Omran, A., AbdulBagei, M. A., & Gebril, A. O.	2012 b	Nine groups: Project Management, Procurement, Client, Contractor, Design Team, Project Manager, Work Environment, Materials, Labour & Productivity and External Factors
24	Gudiene, N., Ramelyte, L, & Banaitis, A.	2013 a	Seven groups: Client, Contractor, Project Manager, Project Management, Project-Related and Institutional and Internal
25	Gudiene, N., Banaitis, A., Banaitiene, N. & Lopes, J.	2013 b	Seven groups: Client, Contractor, Project Manager, Project Management, Project-Related and Institutional and Internal
26	Ofori, D. F.	2013	No classification adopted
27	Memon, Z. A., Khatri, K. L. & Memon, A.	2013	The focus was on Safety performance
28	Jari, A. J. & Bhangale, P. P.	2013	Five groups: Owner, Designer, Contractor, Common and Unique
29	Sibiya M., Aigbavboa C.O., & Thwala	2014	No classification adopted
30	Mamman, E. J. and Omozokpia, E. R.	2014	No classification adopted

S/N N	Researchers	Year	Classifications
31	Zahedi-Seresht, M., Akbarijokar, M., Khosravi, S. & Afshari, H.	2014	Five groups: Organizational Sponsorship, Project Manager Competency, Customer Organization, Project Operational Environment and Organizational Experience
32	Alvani, E., Bemanian, M., & Hoseinali, M.	2014	Seven groups: Procurement & Finance, Communication Management, Legal, External & Environmental, Contractor, Design & Consultants and, Client Factors
33	Varajão, J., Dominguez,C , Ribeiro,P. & Paiva, A.	2014	No classification adopted
34	Adnan, H., Mohd Yusuwan, N., Yusof, F. & Bachik, F.	2014	Classified based on: Cost, Quality and Time
35	Alias, Z., Zawawi, E.M.A., Yusof, K. & Aris, N.M.	2014	Five groups: Project Management, Project Procedures, Human-Related, Project-Related and External Environmental
36	Sugumaran, B. & Lavanya, M. R.	2014	Seven groups: Project Management, Contractor, Project Manager, Procurement, Design Team, Client and Business & Work Environment Factors
37	Sweis, R. J., Bisharat, S. M., Bisharat, L. & Sweis, G.	2014	Labour, Material, Equipment, Contractor, Owner, Consultant, Weather and Govenrment Regulations
38	Kiani, S., Yousefi, V., Yakhchali, S. H., & Mellatdust, A.	2014	Three groups: Program, Project and Organzational Factors
39	Blaskovics, B.	2014	No classification adopted
40	Jiang, J.	2014	It focused on leadership as a success factor
41	Nghiem, D. T., Van, L. T., Viet, N. T. & Nghia,	2015	No classification adopted
42	Shibani A., & Arumugam, K.	2015	Macro-Economic, Management and, Business& Regulatory Environmental
43	Wang, N., Yao, S., Wu, C. & Jiang, D.	2015	No classification adopted
44	Amade, B., Ubani, E. C., Omajeh, E. O., & Njoku, U. A. P.	2015	No classification adopted
45	Babu, S. S. & Sudhakar	2015	No classification adopted
46	Kamau, C. G. & Mohamed, H.	2015	No classification adopted
47	Babu, N. J.	2015	Ten groups: Cost, Time, Quality, Productivity, Client Satisfaction, Regular & Community Satisfaction, People, Health & Safety, Innovation & Learning, and Environmental Factors

3.5 Reviewed Critical Success Factors in Construction Project

A thorough study of the groupings of critical success factors of construction projects, as presented in section 3.4 above, indicates that most of the researchers derived their groupings from that of Chan, *et. al,.* (2004) with either change in name as in the case of procurement related factors being named as procedures factors (Alias, *et. al.*, 2014) or splitting of a group into more groups for example, the splitting of project participants- related factors into client factors, project manager factors, design team factors, client factors, people factors (Saqib, *et.al.,*2008; Omran, *et.al.,*2012b). Materials factor group was developed in the work of Omran, *et.al.,*(2012b) with two (2) factors namely: shortage in materials and quality of materials. These two factors have effects on factor groups like project participant factors, procurement factors and project management factors as these manage and determine the availability and quality control of construction materials. Hence, the materials factors group fits into the functions of the three (3) aforementioned critical success factors groups. For the purpose of this research works, the groupings of Chan, *et. al.*, (2004) has been adopted and, they are presented and explained below:

3.5.1 Project Management Factors

These are success factors of construction projects which are key to achieving project success and are mainly made up of actions of the project management team. Omran *et. al.* (2012b) categorized feedback capabilities, project monitoring, coordination effectiveness, adequate organisation structure, planning and scheduling, training and team work and control mechanism under this group. Gudiene *et. al.* (2013b) included experience of the project management team as an important success factor under this group while Nghiem *et. al.* (2015) added management knowledge to the list. Top management support was established as a key success factor of building construction projects under the project management factors as the level of support by the management would go a long way in determining the managerial, financial, technical and organisational performance (Jha & Iyer, 2006; Shokri-Ghasabeh & Kavousi-Chabok, 2009; Abu

Bakar, *et. al.*, 2010; Ofori, 2013; Memon, Khatri & Memon, 2013; Kiani, Yousefi, Yakhchali, & Mellatdust, 2014; Sibiya, *et.al.,*2014; Varajão, *et.al.*, 2014; Liu, Wang, Skibniewski, He, & Zhang, 2014; Babu & Sudhakar, 2015) Other success factors categorized under this group are organizational culture, project integration management, project information management, value engineering, technical capability of project management, qualification of project management team, and project quality management (Nitithamyong & Skibniewsk, 2006; Koutsikouri, *et.al.*, 2008; Kamar, Alshawi & Hamid, 2009; Abdullah, Abdul Rahman, Harun, Alashwal, & Beksin, 2010; Jari & Bhangale, 2013; Gudiene *et.al.*, 2013a; Gwaya, Masu & Oyawa, 2014; Liu, *et. al.*, 2014: Sweis, Bisharat, Bisharat & Sweis,, 2014).

The importance and contribution of information technology to successful completion of construction projects have grown exponentially over the years. Type of Project Management Information System (PMIS) employed on a construction project determines the quality of information exchanged among the project participants, simplicity of information generated, relevance of provided information and, quality of service in terms of reactivity, support, reliability, system quality and usefulness (Lee & Yu, 2011).

3.5.2 Procurement Factors

These are otherwise known as project procedures factors (Alias, *et. al.*, 2014) and, they are mainly focused on project procurement and bidding methods. Success factors of construction projects categorized under this group in the literatures are: client experience, project contract mechanism, evaluating and determining the priority to the requirements of project, bidding and tendering method (Ika, *et. al.*, 2011; Martinuzzi, Kudlak, Faber & Wiman, 2011; Omran *et. al.*, 2012b; Gudiene, *et. al.*, 2013a; Adnan, Yusuwan, Yusof & Bachik, 2014; Alias, *et. al.*, 2014). Other factors contributed by other researchers are: selection of form of contract, on time financing, on time procurement, effect of contract on financing and procurement, and scope of procurement (Divakar & Subramanian, 2009; Abdullah, *et.al.*, 2010; Tan & Mohamed Ghazali, 2011; Pakseresht &

Asgari, 2012; Alias, *et. al.*, 2014; Kiani, *et. al.*, 2014; Amade, Ubani, Omajeh & Njoku, 2015).

3.5.3 Project Participants-Related Factors

This success factors group is also known as human-related factors (Alias, *et. al.*, 2014) and people-related factors (Mamman & Omozokpia, 2014). This comprises of all human inputs or participations from key players such as client, contractors, consultants, subcontractors, etc., into the successful execution of construction projects (Chan, *et. al.,* 2004). This is a group that cuts across other success factors group such as client, design team, project manager, contractors, etc. It encompasses all success factors related to or that characterize key players in construction projects. Examples of variables concerning the client are client experience, knowledge of construction project organization, project financing, client confidence in the construction team etc., which some authors (Omran, *et. al.*, 2012b; Sibiya, *et. al.*, 2014; Mamman & Omozokpia, 2014) grouped under client factors. The factors under this category can then be divided into two (2) sub-groups: (i) sub-groups related to clients and; (ii) sub-groups related to project team. Effective team spirit and cooperation among project participants is needed to achieve successful project execution (Chan, *et. al.*, 2004). The human-related factors associated with clients are: adequate time to project and client's ability to make decision, client experience, providing information to teamwork, clients' knowledge of construction project organization, client's ability to define roles, clients' consultations/contributions, clients' acceptance, information coordination among owner and project parties, clients' commitment, size of the organization (client), type of client, work suspension by client/owner and, minimize aggravation in producing a building (Jha & Iyer, 2006; Saqib, *et.al.*, 2008; Abu Bakar, *et. al.*, 2010; Omran, *et. al.*, 2012b; Sibiya, *et. al.*, 2014; Mamman & Omozokpia, 2014; Varajão *et. al.*, 2014; Shibani & Arumugam, 2015; Wang, *et. al.*, 2015; etc.) Factors associated with contractors under the human-related factors are: experience of the contractor Gudiene *et. al.* (2013a), supervision, speed of information, effective cost control system, site management, early involvement of contractors, optimal utilisation of resources, healthy financial condition by cashflow, employment of skillful forces, implementation of innovative techniques, knowledge of workers in the work, site inspection, site access limitations, competency of contractor's team, contractors' ability to manage designs, contractors' financial standing, and minimal or no surprises during the project (Saqib, *et. al.*, 2008; Divakar & Subramanian, 2009; Tan & Mohamed Ghazali, 2011; Ika, *et. al.*, 2011; Omran, *et. al.*, 2012b; Sugumaran & Lavanya, 2014; Sweis, *et. al.*, 2014; Nghiem, *et. al.*, 2015; Shibani & Arumugam, 2015; Babu, 2015).

Contractor's experience is highly rated in literatures as the more experienced a contractor is the better he is able to handle complex construction projects hence, reducing the possibility of 'surprises' on construction sites. Constructability of building construction projects is enhanced with an experienced contractor in charge as his wealth of experience helps in finding effective solution to technical problems within the shortest time possible. Development of technically feasible project designs and constructability of developed designs are enhanced by involvement of the contractor as early as the design stage of the project. The input of the contractor during the design stage contributes to construction project success by identifying technical problems early and planning as well as providing solutions ahead for the unavoidable problems identified.

Employment of technically sound and skillful workers is also important for successful execution of construction projects but, the skills and competency of workers may be undermined with unhealthy financial status of the contracting organization. Healthy cash flow and effective control system will enhance optimal utilization of resources on construction sites.

As a sub-group under the project participants-related factors group, the design team plays important roles during the pre-contract and post-contract stages of construction projects. This team is responsible for transferring the ideas and briefs of the client organisation into technically and financially feasible designs and also, to ensure that such designs are executed to the expectation of clients. Effective delivery of these and other duties by the design team depends on a number of factors which in turn, are important to successful completion of construction projects. Such success factors are: quality relationship between team, design team experience, mistake and delay in producing design documents, project design complexity, quality of team intercommunication, knowledge and experience, clear and precise drawings/documents, product/service design, and no liability or claims (Chinda & Mohamed, 2007; Divakar & Subramanian, 2009; Omran, *et. al.*, 2012b; Babu, 2015).

Project manager factors sub-group was referred to as leadership by Jiang (2014). This is so because the project manager is the leader of all other consultants or members of design team on a construction project. Responsibilities assigned to the project leader include, but not limited to, collaboration of teamwork, management of resources and communication with project participants: followers and clients. Other success factors attached with the project manager on construction projects include: project manager's efficiency, experience of project manager, sufficient salary of project manager, project manager's commitment to quality, cost, and time, project manager's competency, early involvement of project manager, accountability, project manager's authority, and technical capability of project manager (Saqib, *et.al.*, 2008; Tan & Mohamed Ghazali, 2011; Inayat, 2012; Omran, *et.al.*, 2012b; Gudiene *et.al.*, 2013a; Shibani & Arumugam, 2015; Amade, *et. al.*, 2015; Babu & Sudhakar, 2015).

The experience and competency of the project manager, who is the project leader, determines the quality of project deliverables as well as effective management of human and material resources deployed to the execution of a construction project.

3.5.4 External Factors

Saqib, *et.al.*, (2008) described this group as business and work environment related factors. Other researchers agreed that environment is a factor that has impacts on the success of construction projects. Environment is defined as all external impacts experienced on construction process which, includes social, political, physical and technical factors. Other factors are: commitment of all parties to the project, client support, supportive and understanding community, climate/weather conditions, physical work environment, nature or ecological environment, air quality, noise level, wastes around sites and administrative factors such as regulatory and building codes, problems with neighbours and unforeseen ground conditions and managing project hindrances (Jha & Iyer, 2006; Chinda & Mohamed, 2007; Ika, *et.al.*, 2011; Omran, *et.al.*, 2012b; Shibani & Alias, *et. al.,* 2014; Mamman & Omozokpia, 2014; Shibani & Arumugam, 2015;

Amade, *et.al.*, 2015; etc.). Gudiene, *et.al.,*(2013b) came up with a group that was found to be an extension or subgroup of this group, they called the group institutional factors with construction permits, construction regulations, product and service certification and, standards as success factors grouped under it.

3.5.5 Project-related Factors

The project related factors include success factors that can be described as characteristics of the project involved, such factors are project mission, vision, project value, project size, clear and realistic goals of the project, project result/outcome, and strategies employed in executing the project (Ika, *et.al.*, 2011; Inayat, 2012; Gudiene, *et. al.*, 2013a; Sibiya, *et. al.*, 2014; Wang, *et. al.*, 2015). Clear definition of realistic project goals is the most frequent success factor found in the literature under this category.

3.6 Performance Forecasting Variables

The concepts of achieving schedule, budget and quality (fitness for purpose) have been drawn out as the criteria by which project performance or project management success is defined (Baccarini, 1996 and Cooke Davis, 2002). De Wit

(1988) further added that project success is measured achievement of project functionality, contractors commercial performance and project management objectives specifically, budget, schedule and technical specification. Model building in SD begins with listing those factors that have a major influence on the output. Various approaches have been recognized to identify those influences such as observation, discussion, interviews and existing data (Forrester, 1992). Sterman (2000) recommends accessing stakeholder databases and written databases when identifying a problem.

Project management success or project performance, according to De Wit (1988), Baccarini (1996) and Cooke-Davies (2002) is the common objective between all the project members. The objective of completing project on schedule, within budget and at specified quality, also called the iron triangle, is held as the key criteria for measuring project performance. In order to evaluate the effectiveness of CSF's in forecasting project performance, a set of factors for judging project performance must be developed, thus project success criteria. The key criteria for assessing project performance have already been established as the criteria of time, cost and quality (De Wit, 1988; Baccarini, 1996 and Cooke-Davies, 2002).

But there is still a lot to learn and examine from the other performance indicators. The concept of continuous project monitoring through performance indicators is one of such. An early discussion on the concept was by Atkinson (1999) who recognized the value of continuous project assessment by separating success criteria into *delivery* and *post- delivery* stages. Given this orientation, performance indicators have a specific point in the project lifecycle where they made be applied and will give a true representation of the state of the project. Atkinson (1999) listed the iron triangle as a delivery stage performance indicator, while information system, benefits to the organization and benefit to the stakeholders and community are performance indicators used at the post-delivery stage or completion of the project. A means to improve the effectiveness of project is the identification of critical success factors CSFs. Project success has remained ambiguously defined in the mind of the construction professionals. Various attempts were made by different researchers to deter mine CSFs in construction. A number of variables influencing project success have been identified and proposed. Some variables are common to more than one list, but there is no general agreement on the variables.

Chan, Scott and Chan; (2004) identified and described five major groups of independent variables, namely project-related factors; project procedures, project management actions, human-related factors, and external environment are identified as crucial to project success. A written database is a significant source of data since it contains both mental data and interpretations for other sources of information (Forrester, 1992). Chan et al; (2004) consider that project success depends on different factors including project- related factors, project procedures, project management actions, human-related factors and external environment as depicted in Figure 3.1 showing the framework for factors affecting project success and their relationships. Chan et al; (2004) posited that key performance indicators KPIs are needed to identify causal relationships. The causal relationships, once identified, will be a useful piece of information to implement a project successfully. This feedback loop exists not only between control action and the system but also among the various components within the system therefore systemic in nature originating as a result of complicated interactions between the system variables. As a result, dynamic problems call for dynamic management, streams of decisions.

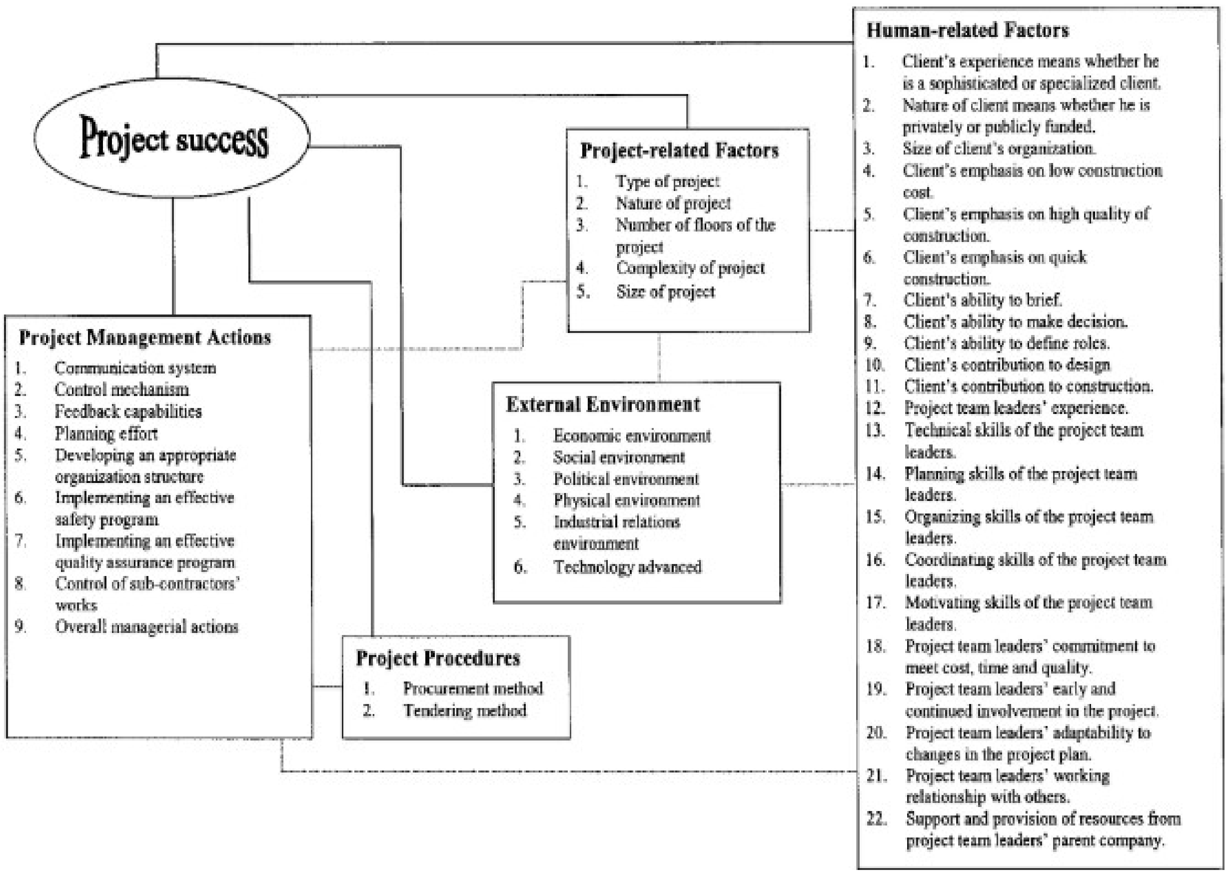


Figure 3.1: Framework for factors affecting project success

In another instance, a review of Gemuenden and Lechler (1997) revealed response rate of 43 percent from a population containing 248 successful and 190 unsuccessful projects. The authors suggested in this research, eight critical success factors with cause and effect relationship existing between these factors depicted in Figure 3.2 This framework has some similar factors with other studies, such as top management involvement, project leader, planning and controlling and project team. Nevertheless, this framework suggests the negative impact that goal changes and conflicts can have in project success. For this reason, these two factors were considered as critical factors because they are barriers that can be removed by other factors to achieve project success although at a cost higher than envisaged.

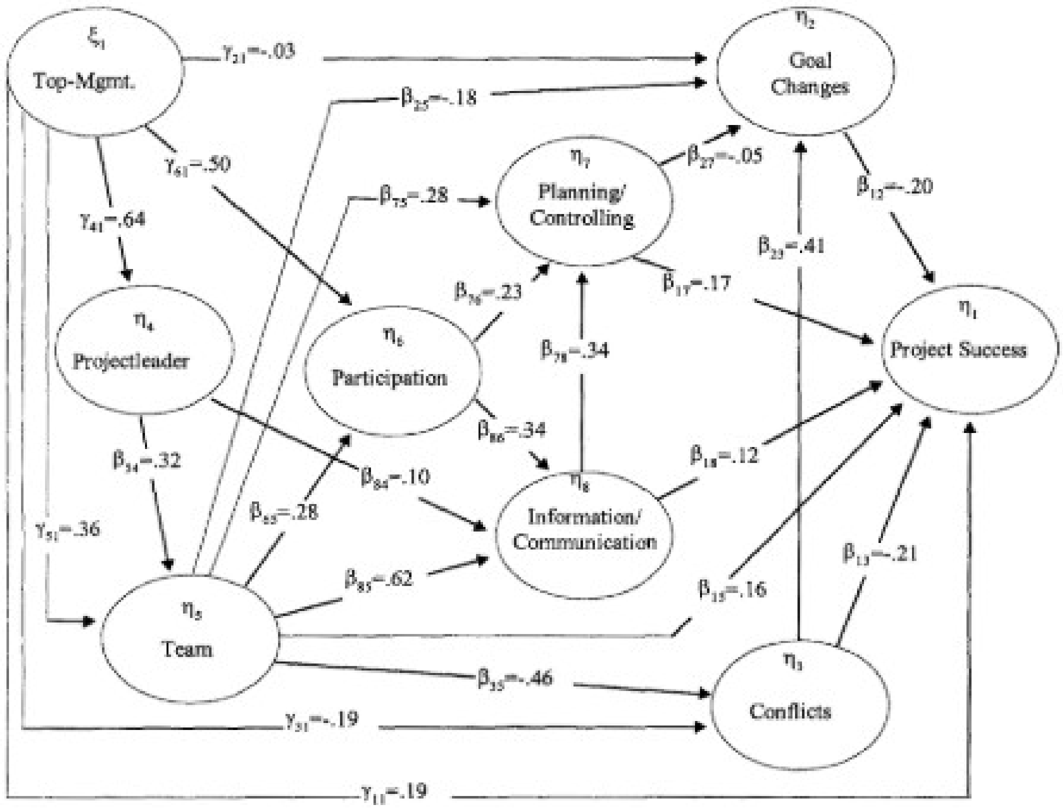


Figure 3.2: Success factors, cause and effect relationship

Source: Gemuenden and Lechler,1997)

3.7 Relationship between Project Performance Indicators

Stakeholders in the construction industry are familiar with the three most important performance measures of construction projects which are quality, budget or cost and time (Mahmoud & Scott, 2002; Idrus, *et. al.*, 2011; Chan, 2003). However, the most important measure of project performance to clients is satisfaction from both products and services (Alumbugu, *et.al.,*2015). The client, being the initiator of construction projects, should be satisfied with the process of delivering the project as well as the quality of the delivered project. Satisfaction with the product is linked and measured with the quality of the project product which, can be measured with the ability of the project to meet the ends for which it was initiated (Leong, Zakuan, Mat Saman, Md. Ariff, & Tan, 2014). Satisfaction with services is related with quality in terms of mitigation and elimination of reworks and non- compliance with specification. With reduced or eliminated rework/non-conformance with specifications, the chances of meeting the project objectives, as set out from inception, within or on time and within the budget estimates are enhanced (Odusami, Bello & Williams, 2010).

According to Muhammad, *et. al.,* (2015), implementation and non-implementation of health and safety policies on construction sites leads to increase in the overall costs of construction projects. Implementation in terms of purchase of safety and health kits, organisation of safety training and workshops for site workers, sending of safety personnel on refresher courses, etc., leads to increased construction costs while non- implementation or non-conformance on the part of site workers could lead to accidents, injuries or even deaths which also increase the overall cost of the project in terms of compensation and litigation that may arise from such incidents. However, non- conformance with health and safety policies on construction sites affect more than cost but also, quality performance of construction projects. This is depicted in the findings of Windapo, Odediran, Oyewobi and Qamata (2014) which rank construction execution efficiency and effectiveness as the most influential metric of project success and measure of stakeholders' satisfaction. Execution efficiency and effectiveness was defined as the ability to meet specifications requirement, quality and, health and safety.

Unsafe design, poor safety planning at the construction phase and high rate of accidents were identified as major obstacles to achieving quality output from construction projects (Muhammad, *et.al.*, 2015). Lack of proper health and safety management on construction sites can lead to increased number of accidents which may affect the health and productive capacity of the workers which in turn, may affect the overall project delivery (Babu, 2015).

Also, non-implementation of health and safety policies on construction sites can lead to delay in the construction project delivery as accidents or injuries to workers or any third parties, caused by non-conformance with health and safety policies, can lead to litigation, temporary closure of site and, recruiting and retraining new workers. Therefore, health and safety has a direct relationship with productivity and time performance of construction projects (Ugwu & Haupt, 2007).

Also, since there exists a direct relationship between health and safety performance and quality, cost and time (Windapo, *et. al.*, 2014), it therefore means that, client satisfaction is indirectly related to health and safety performance on construction sites. Although, a client may not be directly affected by fines and compensation that come with accidents and/or injuries on construction sites, yet he is affected by delay caused by loss of productivity that is experienced from the occurrence of such accidents (Mashood, Mujtaba, Khan, Mubin, Shafique & Zahoor, 2014). Loss in productivity, on the other hand, has negative impact on the quality, cost and time performance of construction projects (Enshassi, *et. al.,*2009).

The possibility of meeting quality standard expected from a construction project lies in a number of critical success factors related to human or project participants such as top management support, project manager's competence, interaction between project participants, owner's competence, monitoring and feedback mechanisms (Jha & Iyer, 2006). The authors identified loss in productivity; extra cost of rework and repair and; loss of reputation as side effects of failure in terms of quality performance.

Rectification of quality defects that leads to rework, require time and additional materials and labour hence, the effect of quality on time and cost performance (Babu, 2015). The achievement of cost, time, quality, health and safety and, other performance indicators on construction project will definitely reduce or eliminate occurrence of disputes between owners and other project parties and subsequently, leads to client satisfaction (Windapo, *et. al.,*2014).

3.8 The Variables of CSF for Cost, Time, Quality and, Health and Safety

Although, the measurement of construction project performance is largely based on seven(7) KPI groups (Mahmoud&Scott,2002), various researchers have demonstrated the importance of cost, time and, quality as the most important of them (Dawood, *et. al.*,2006; Alumbugu,*et.al.*, 2015). Recent research works have shown that measurement of project performance cannot be adequately justified with these three (3) indicators alone (Shirouyehzad, Khodadadi-Karimvand & Dabestani, 2011) hence, the importance of health and safety on construction projects is gaining momentum in the research world (Chinda & Mohamed, 2007; Memon, *et., al.*, 2013; Enshassi, et. al., 2009; Babu, 2015).

3.8.1 CSF for Cost Performance Indicator

Cost performance is simply a measure of the degree to which general conditions promote the completion of a construction project within the estimated budget. Idrus, *et. al.* (2011) explained the importance of cost performance as a measure of project performance by linking it to client satisfaction. An examination of these and other factors by Enshassi, *et. al.*, (2009), such as, stability of market prices of construction materials, market share of organization, profit rate of project, overhead percentage of project, project design cost, project labour cost, project overtime cost, motivation cost, cost of rework, culminated to the management factors by the contractor which shows that these factors are spread across various factor groups of construction critical success factors. Also, project management factors such as cash flow of project, regular project budget update and cost control system (Omran, *et. al.,* 2012b; Sibiya, *et. al.*, 2014); procurement factors such as liquidity of organization (Divakar & Subramanian, 2009; Sweis, *et. al.*, 2014); project-participants' factors such as cost of rework – caused by unqualified workforce and incompetent authority or supervision (Inayat, 2012); and external factors such as foreign exchange market which is caused by economic environment of construction projects affect cost performance of construction projects (Chan, Scott & Chan, 2004;Babu, 2015).A poorly performed project in terms of cost is easily identified with cost overruns and, causes attributed to its occurrence span across different groups namely: site-related; human-related; project-related and; technical issues (Shibani & Arumugam, 2015).

In this research the variables deduced from various authors for CSF for cost performance include; Clear Objectives on Project Outcomes (e.g. Time, cost, quality & Safety),Adequacy of information available on the project, Delivery time of resources (materials, equipment), The condition of the equipment (state of repair), Collaborative Supervision/inspection on the project (Consultants with Client), Construction methods adopted on the project such as use of only precast building, Use of innovations such as BIM, e-tendering impacts on project, State of Health and Safety (e.g. Accident cause delay), Management capacity and Competence of project manager, Early Involvement of Project Manager, Stability of Market Prices and Foreign Exchange, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Healthy Financial Condition and stability of contractor, Early Involvement of Contractors, Employment of Skillful Workforce, Implementation of Innovative Techniques, Contractor's Ability to Manage Designs, Site management by contractor, Client's Project Financing for regular cash flow, Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Ability of client to make timely and accurate decisions on the project, Efficiency of communication on the project, Ability to solve unanticipated problems that occur during the course of the project, Type and Nature of Client, Delay in Producing Design Documents, Clear, Correct and Precise Drawings/Documents, Physical work environment such as weather, public disturbance (area boys), Legal environment, Cultural environment, Economic environment, Nature of ecological environment, Government's institutional and administrative influence e.g. regulations, permits among others.(Mahamid & Dmaidi, 2013; Shittu, Adamu, Mohammed, Suleiman, Isa, Ibrahim & Shehu, 2013; Shibani & Arumugam, 2015; Tejale, Khadenkar & Patil, 2015).

3.8.2 CSF for Time Performance Indicator

Time performance is of great importance on construction projects especially, on commercial projects where the facility or building is to be subjected to let or rent to generate income for the client. The importance of client experience as a success factor in construction project was highlighted in the research of Kadiri and Shittu (2015) as top on the list of causes of time overrun from contractors' perspective was "lack of experience of client in construction". A successful project, in terms of time performance, is completed as specified in the contract on or ahead of predetermined schedule (Dawood, Sikka, Marasini & Dean, 2006). The variables developed for the CSF for time performance are Clear Objectives on Project Outcomes (e.g. Time, cost, quality & Safety), Adequacy of information available on the project, Delivery time of resources (materials, equipment), The condition of the equipment (state of repair), Collaborative Supervision/inspection on the project (Consultants with Client), Construction methods adopted on the project such as use of only precast building, Use of innovations such as BIM, e-tendering impacts on project, State of Health and Safety (e.g. Accident cause delay), Management capacity and Competence of project manager, Early Involvement of Project Manager, Ability to adapt to changes on the project, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Healthy Financial Condition and stability of contractor, Early Involvement of Contractors, Employment of Skilful Workforce, Implementation of Innovative Techniques, Contractor's Ability to Manage Designs, Site management by contractor, Client's Project Financing for regular cash flow, Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Ability of client to make timely and accurate decisions on the project, Efficiency of communication on the project, Ability to solve unanticipated problems that occur during the course of the project, Type and Nature of Client, Delay in Producing Design Documents, Clear, Correct and Precise Drawings/Documents, Physical work environment such as weather, public disturbance (area boys), Legal environment

Cultural environment, Nature of ecological environment, Government’s institutional and administrative influence e.g. regulations, permits(Alumbugu,*et. al.*, 2015, Lim & Mohamed, 2000; Babu, 2015; Omran, *et. al.*, 2012a; Chan, *et. al.*, 2004; Saqib, *et. al.*, 2008; Sibiya, *et.al.*, 2014; Ogunsanmi, 2013; Leong,*et. al.*, 2014).

3.8.3 CSF for Quality Performance Indicator

The measurement of quality performance of a construction project is subjective in nature. It is the entirety of features required by a product or services to satisfy a given need and its ability to fit the purpose intended for buying the product or the service (Parfitt Sanvido, 1993) as cited in Chan (2003). However, irrespective of standard of a construction project product, quality vary from clients to clients as it may be viewed as the guarantee of a product that convince the clients or the end users to invest in it (Chan, 2003). Clear Objectives on Project Outcomes (e.g. Time, cost and quality), The standard and quality of materials, The condition of the equipment (state of repair), Collaborative Supervision/inspection on the project (Consultants with Client), Construction methods adopted on the project such as use of only precast building, Experience of Project Manager, Management capacity and Competence of project manager, Information Coordination, communication and relationship among project parties, Commitment of project manager to project, Technical and Management capacity of the contractor, Healthy Financial Condition and stability of contractor, Client's Project Financing for regular cash flow, Employment of Skillful Workforce, Implementation of Innovative Techniques by contractor, Delay in Producing required Design Documents, Site management by contractor, Experience and knowledge of the client, Type and Nature of Client, Efficiency of communication on the project, Ability to solve unanticipated problems that occur during construction, Competence and experience of design team, Government's institutional and administrative influence e.g. regulations, permits, Quality of Product/Service Design, Physical work environment such as weather, public disturbance (area boys), Cultural environment. The quality requirement of a construction project is spelt out in contract documents in graphical forms (such as in architectural drawings, engineering drawings, etc.) and written forms as it is found in specifications and bills of quantities. Auma (2014) found out that qualification and experience of personnel, quality of materials and equipment used, conformance to specifications and quality (Jeptepkeny, 2015). (Enshassi, *et.al.,* 2009). (Omran *et. al.,* 2012b; Alvani, Bemanian & Huseinali, 2014). Effective decision making, quality assessment of construction works and ensuring that specified materials are used on project are the burdens of the project management team to bear (Saqib, *et. al.*, 2008; Tabish & Jha, 2011). (Shittu, *et. al.*, 2013).

3.8.4 CSF for Health and Safety Performance Indicator

The degree to which the general conditions surrounding a construction project, promote the completion without major injuries or injuries to persons directly and indirectly connected to the project is a measure of health and safety performance of the project (Chan, 2003). Aksorn and Hadikusumo (2008) found management support as the most influential factor for safety programme performance. Objectives of creating a safety program was identified by Rowlinson (2003) as critical to safety at construction sites. Although, several researchers rated safety behind cost, quality and time(Dawood, *et.al.*, 2006; Alumbugu, *et.al.*, 2015) yet, its importance cannot be overlooked. In achieving good results with health and safety performance on construction projects, factors found in literatures, as important are: management support, teamwork, appropriate safety education and training, appropriate supervision, clear and realistic goals, safety equipment acquisition and maintenance, continuing participation of employees, safety meetings, delegation of authority and responsibilities, good communication, personal attitude, personal competency, sufficient resource allocation, effective enforcement scheme, program evaluation, personal motivation and, positive group norms (Aksorn and Hadikusumo, 2008; Shirouyehzad, et. al., 2011; Memon, *et. al.*, 2012).The CSF for Health and safety developed for the study includeClear Objectives on Project Outcomes (e.g. Time, cost and quality), The condition of the equipment (state of repair),

Collaborative Supervision/inspection on the project (Consultants with Client), Construction methods adopted on the project such as use of only precast building, Management support, Management capacity and Competence of project manager, Technical Competence and Management capacity of the contractor, Experience of contractor, Employment of Skilful Workforce, Site Management on Effective enforcement scheme, Healthy Financial Condition and stability of contractor, Client's Project Financing for regular cash flow, Appropriate safety education and training, Information Coordination, communication and relationship among project parties, Safety equipment acquisition and maintenance, Government's institutional and administrative influence e.g. regulations, permits, Physical work environment such as weather, public disturbance (area boys), Program evaluation of State of Health and Safety e.g. Accident cause delay (Chan, 2003; Chan, *et. al.*, 2004; Dawood, *et. al.*, 2006; Aksorn and Hadikusumo, 2008;Enshassi, *et. al.*; 2009; Shirouyehzad, et. al., 2011; Memon, *et. al.*, 2012Mashood, *et. al,* 2014; Alumbugu, *et. al.*, 2015).

3.9 Existing Diagnostic Models for Construction project Performance

There have been researches that focused on models for construction project performance. However, such models have not analysed CSFs and KPIs with System dynamics tool. The following discussions are on review of such researches to highlight their area of focus as being different from the current research.

Sarshar, Haigh, Finnemore, Aouad, Barrett, Baldry, and Sexton (2000) introduced SPICE concepts to present the results from two case studies using the Standardized Process Improvement for Construction Enterprises (SPICE) in an attempt to develop a stepwise process improvement framework for the construction industry, utilizing experience, and in particular the Capability Maturity Model (CMM) from the software industry targeting productivity improvements. Further research was conducted by Amaratunga, Sarshar, and Baldry, (2002), and Amaratunga, Haigh, and Baldry (2005) explored and present The SPICE FM (Structured Process improvement in construction environments – facilities management) maturity framework developed as a response to organizations' lack of clear guidelines to direct their improvement efforts and to benchmark their performance against other organizations. But these researches did not capture CSFs for KPIs for project performance.

The research by Sarshar, et al., (2000) were procurement based which was conducted on design and build projects. Amaratunga, et al., (2002, 2005) focused on organisation in facility management field whereas this research is not specific on procurement which will be a subtheme for further research and focused on the execution phase of construction projects. Research had been conducted to compare FM and construction in order to identify the major benefits from performance measurement for FM organisations. Meng (2011) analysed the real effect of existing models in the FM sector and the application of models in construction within FM organisations were evaluated in the study. The study found that key performance indicators (KPI), the Balanced Scorecard (BSC), and the Business Excellence Model (BEM) are more widely accepted and more effective than others for FM. FM organisations benefit from effective performance measurement. When measuring performance, it is important for them to select the appropriate models and indicators. Major limitation of Meng's work is the small sample size.

Chan and Chan (2004) carried out a Multiple regression exercises to analyse project data and established a prediction model which suggested that the overall construction duration of projects could be modelled on the basis of a set of scope factors, construction method and housing scheme chosen. The model is to predicting duration whereas that is just one of the four KPIs considered in this research. Tsoukas (2005) and Jaafari (2007) were on a path related to this current research but Tsoukas (2005) did not utilise KPIs as defined in this research nor use SD tool for dynamic analyses of the system. Tsoukas (2005) documents a method of assessing the status of a project, at a point in its design or construction phase, or after completion. The status is assessed in terms of up to seven (7) key success factors including Cost, Time, Quality, Relationships, Safety, Environment, Stakeholder value. Any evidence of less than adequate performance in these performance areas is scrutinised to seek out the root causes of why this situation is happening. Using these identified root causes of underperformance, general suggestions can then be made as to how to return the project to good health. Jaafari (2007) presented a technique referred to as project health check in methodology and its underpinning concepts which provides a graphical picture of the health of a project at the time of assessment. The results of the project health check can then be correlated with the results obtained from traditional project progress measurement tools. As earlier described, the dynamic concepts of construction projects was not explored in these existing researches.

Du Plessis and Hoole (2006) developed a diagnostic instrument that can measure the operational 'project management culture' in organizations, PMCAT comprising five-factor scale of project process, people in project, project structure, projects systems, and project environments. The research unit of analysis was organisation which is different from this research that is analysed on project unit.

Another limitation of their study is that it is not industry specific. The same argument was established in the work of Din, Abd-Hamid, and Bryde (2011) which found that ISO9000 certification has a positive moderating effect on the causal relationship between Project Management Practices and Project Success and thus developed a Project Management Performance Assessment for Construction (PMPAC) model, which extends the PMPA to include performance enablers linked to financial management activities. PMPAC model provides a framework in construction project environments that ensures project management systems incorporate the key activities that enable better performance.

Almahmoud, Doloi, and Panuwatwanich (2012) employed the Swiss Cheese model as a guiding principle to represent the links between project health check PHC indicators and project Key Performance Indicators (KPIs) to develop the Swiss Cheese Performance Management Framework, which can potentially serve to help project managers identify the root causes of any shortcomings at the early stage in the project delivery process. Thus, it did not develop for performance investigation which is the focus of this research. In the same vein the research of Haji-Kazemi, Andersen, and Klakegg (2015) elaborated on Ansoff's management model to investigate project and project organization specifications that influence the effectiveness of responses to early warning signs in projects in order to avoid the occurrence of those problems. The research reported that there are specific barriers to the ability of Norwegian project managers or leaders' approaches to responding to identified early warning sign which can develop due to organizational factors, the lack of an outside view and due to projects' complexity.

UTS Helmsman (2016) presented a Helmsman Project Performance Diagnostic which was developed over a period of 9 years through formal research based on the empirical data rather than consulting opinion, conducted by the University of Technology Sydney (UTS). Helmsman Project Performance Diagnostic was claimed to be a groundbreaking innovative tool by the UTS Helmsman (2016) which might soon become the standard for every Mega Projects and hopefully change the face of Project Management in Australia. Depending on the unique Complexity Profile of a project, the Diagnostic reveals whether your organizational capabilities and project controls are sufficient to ensure success. The tool gives general report based on characterization questions rather than itemizing CSFs for KPIs concept analysed by SD that is adopted for this research.

3.10 Conceptual Framework

In this research performance is determined by assessing the CSFs for predicting the KPIs in evaluating performance of construction projects in order to effectively and efficiently practice decision making. It has been established from literature that there exists relationship between and quality, cost, time and health and safety for performance of construction projects. As discussed in the previous sections 3.9 to 3.11of this chapter, some CSFs appear in all or either of the KPIs of Cost, Time, Quality, and Health and Safety. This is the concept that is being advanced in this research. From the submission of different authors, the framework developed by Gudiene, *et.al.*, (2013a) seems a little bit detailed compared to that of Chan, *et.al.*, (2004) as presented in Figure 3.3 although, the classification adopted in this framework is divided into: project-related factors, project management/team members related factors, project manager factors, client related factors, contractor related factors, and external factors distributed in accordance with their relationships with other factor groups. Economic and cultural environments are perceived to affect project-related factors, social and technological environments affect project management factors, legal and physical environments affect contractor related factors and, nature ecological and political environments affect project manager related factors. Therefore, as we have this relationship in the CSF so it translates the effects in the KPIs.

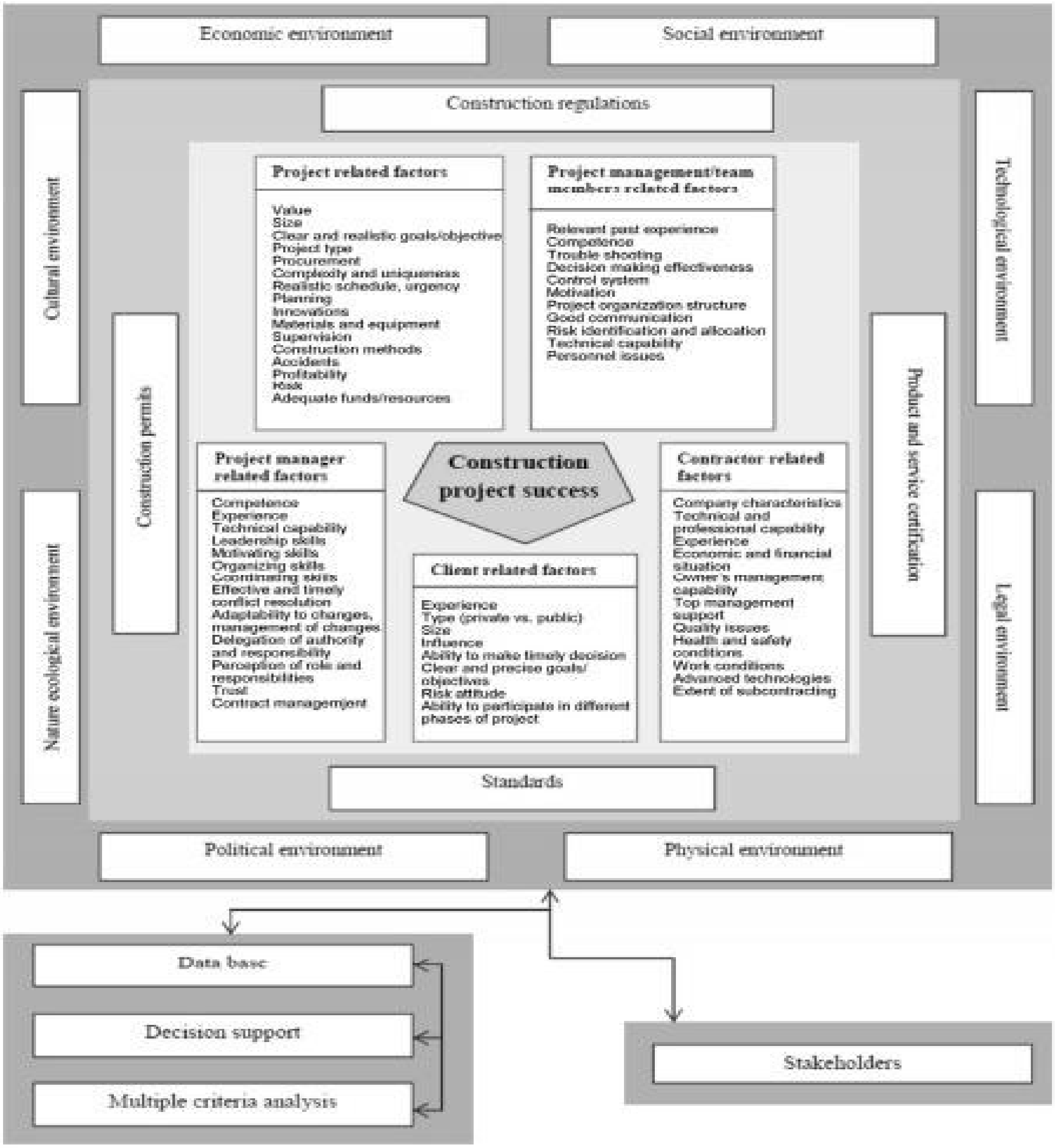


Figure 3.3: Critical success factors model for constructionprojects

Source: Gudiene, et. al.(2013a)

Also, project related and project management team factors are both influenced by construction regulations, project management and contractor related factors are affected by product and service certification, the trio of project manager, client and contractor related factors are affected by standards while construction permits had influence on both project related and project manager related factor groups. Every of these group of critical success factors interrelate to make achieving construction projects success a reality. This was also modelled in the work of Takim and Akintoye (2002) in Figure 3.4.

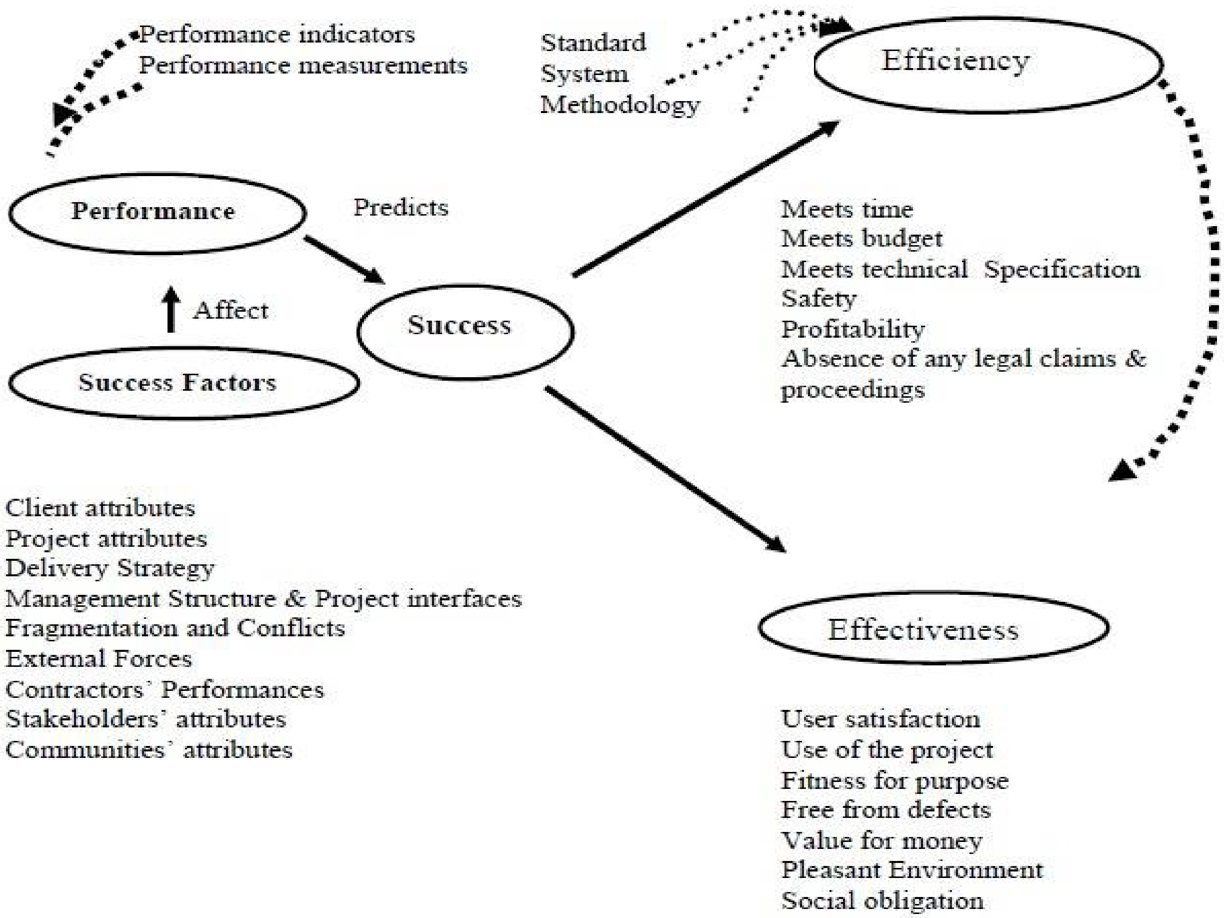


Figure 3.4: The Relationship between Success Factors, Project Performance & Project Success

Source: Takim & Akintoye (2002)

For the purpose of this research the framework of the research stem from the relationship that exists between CSF and KPI to achieving project success is as depicted in Figure 3.5.

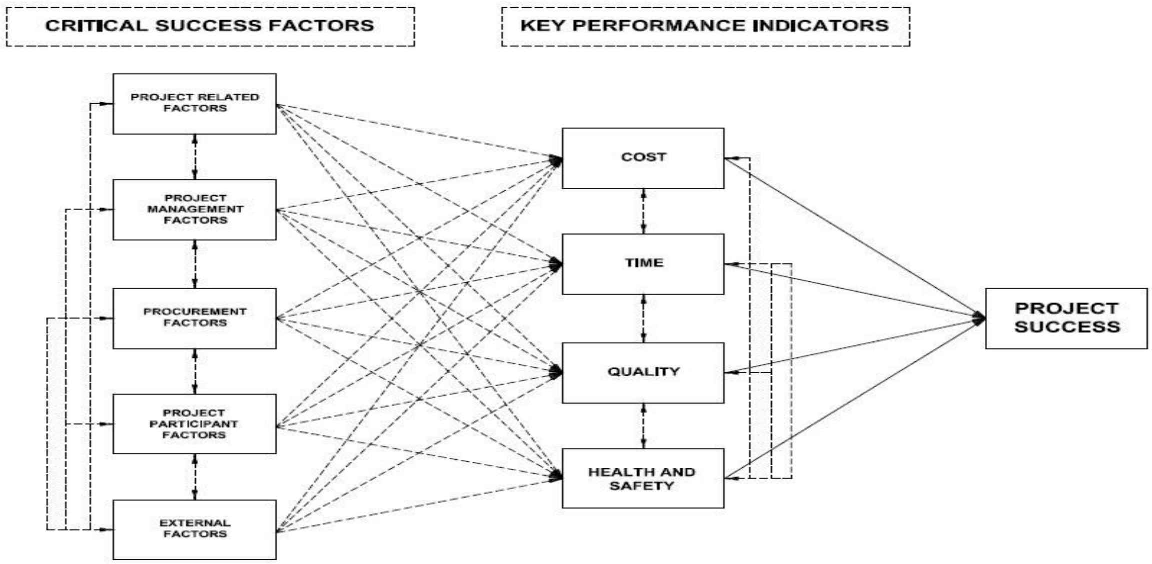


Figure 3. 5: Critical Success Factors and Key Performance Indicators - Theoretical Model.

The conceptual framework of this research shows the relationship between critical success factors and key performance indicators in achieving project success. This is an attempt to improve on the framework of previous authors such as Chan, *et. al.*, (2004), Forcada, *et. al.,* (2008) and Gudiene, *et. al.*, (2013a) because, project success was not just considered based on critical success factors alone but also, the influence of critical success factors in achieving key performance indicators to achieve project success were proposed.Projectrelated factors such as type, nature, complexity, size of the project, etc. have impacts on performance of construction projects in terms of cost, time, quality and, health and safety. This is because these factors determine the expected features and requirements of the project outcome therefore, achieving such factors will eventually lead to client satisfaction (Windapo, *et. al.*, 2014). The complexity of projects for example, determine the time that will be needed to execute such projects and also, the more complex a project the costlier it is if the quality standard required is to be met. This is in accordance with the framework of Chan, *et. al.*, (2004) which, links project success to project-related success factors. Although, unlike the framework of this author, the framework of Chan *et. al.*, (2004) linked project-related critical success factors to project success directly yet, project success cannot be measured without key performance indicators such as cost, time, quality and, health and safety performance amongst others (Mahmoud & Scott, 2002; Enshassi, *et. al.*, 2009; Babu, 2015).

Similarly, project management factors, project participants factors, project procurement factors and external factors all predict construction project performance in terms of cost, quality, time and, health and safety. This is supported by the frameworks of Chan, *et.al.*, (2004) and Forcada, *et. al.*, (2008).The competence and experience of project management team, especially the project manager, of a construction project determines how well the project performs (Blaskovics, 2014). Leadership effectiveness, feedback capabilities, monitoring, decision making effectiveness and, coordination effectiveness amongst others have been identified by researchers, as success factors of construction projects (Jha & Iyer, 2006; Omran, AbdulBagei, & Gebril, 2012b; Sibiya, *et. al.*, 2014). These characteristics of project management success factors group determine how project resources are integrated to achieve quality and safe project within specified budget and time.The impact of external factors on other groups of critical success factors and by extension, key performance indicators is depicted cannot be brushed aside. Control of project management over external factors such as, weather and climatic condition, is minimal and, in some cases, unattainable (Omran, *et. al.*, 2012b; Mamman & Omozokpia, 2014).

Although, management of economic factors such as inflation and fluctuating foreign exchange markets, under the external factors to construction project is a measure of how capable a project management team is.The choice of procurement method adopted on a construction project determines the level of control and authority of project management on project resources. Wastage of resources and quality of materials used, which directly affects cost and quality performance depends largely, on the procurement method adopted, and management capability on construction projects (Babu, 2015).

Project participants on construction projects determine the standard required and how they are met. The choice of effective procurement method and the use of right resources in achieving projects that fit the description of clients are functions of competence of the project team, effective communication among the team and, the level of available competent, experienced and committed project team (Inayat, 2012; Omran, *et.al.,*2012b; Mamman & Omozokpia, 2014; Shibani & Arumugam, 2015). Also, the ability to meet the client goal lies in the client's experience in stating clearly, the project goals (Gudiene, Banaitis,Banaitiene & Lopes, 2013b) and commitment to the project (Koutsikouri, Austin & Dainty, 2008).

The conceptual framework for the research is presented in Figure 3.6 showing the four key performance indicators considered in this research with their individual CSFs influencing theses KPIs which is being interrelated with each other and one another and eventually determining the performance of construction project.

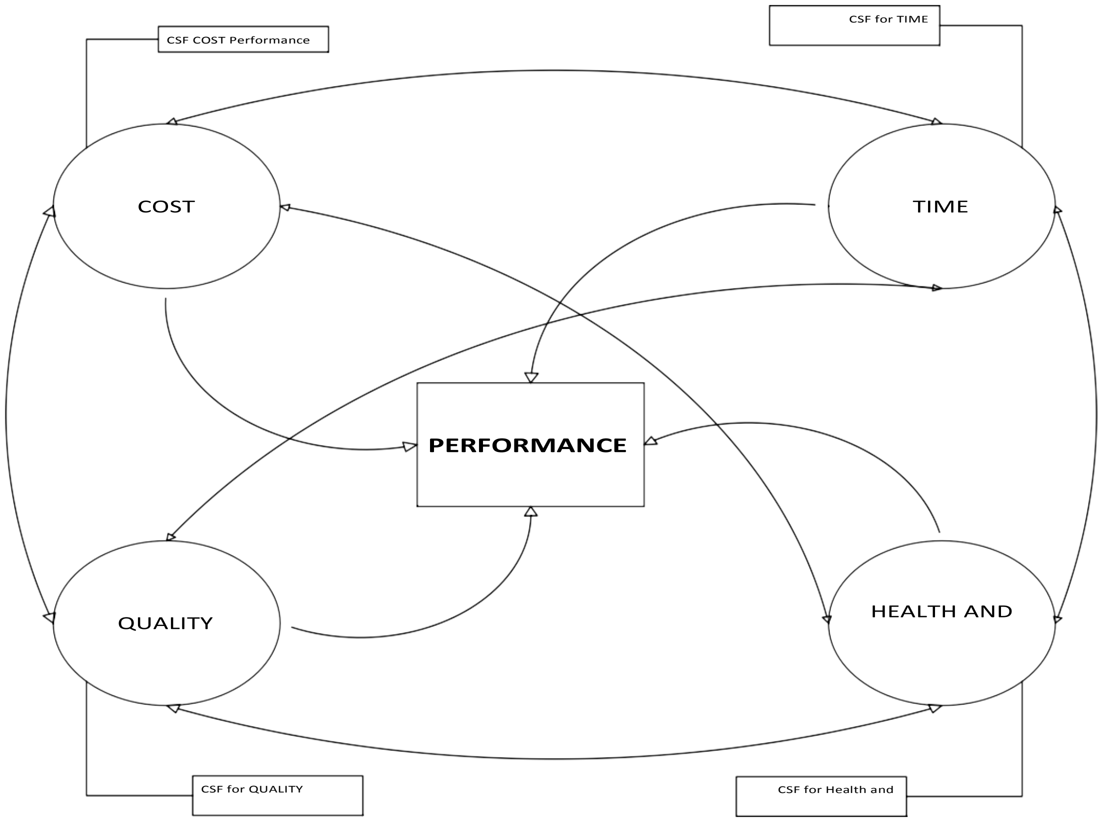


Figure 3.6: Conceptual Framework for the Research

The conceptual framework depict that a project is controlled once each factor element of the project and the relationship between the factors are understood. Rodrigues and Bowers (1996) suggested the traditional work breakdown structure of project network interrelationships between the project's components but the relationshipsare more complex than what was suggested. Therefore, there is need to treat projects as the complex dynamic systems which they are, to avoid the failure to improve project performance results (Reichelt and Lynei, 1999). Tupenaite, Kanapeckiene and Naimaviciene (2008) emphasised that construction projects have been more complicated, dynamic with interactive scenario that constantly requires Project managers to speed-up reflective decision-makings on time. Dynamic modelling of complex systems usually addresses the behaviour of the systems over time.

3.11 Construction Project as a Dynamic System

The construction industry is characterised with ever changing, evolving and complex projects (Nghiem, Van, Viet, & Nghia, 2015). The demand for complex projects, which require more attention, in shorter period of time than in the past calls for developing new measures of tracking project proceedings if success is to be achieved (Elattar, 2009). As the complexity of construction project changes so should the means of measuring performance change hence, measuring the success of construction project with the "iron- triangle" alone has become insufficient (Toor & Ogunlana, 2009). Project management and performance measure should remain vibrant so as to effectively manage different projects of diverse characteristics.

Collyer (2008) defined a dynamic project as a project that is necessarily subjected to higher than normal degree of change due to impacts from the project environment. The change in environment is not limited to physical environment alone, environmental impacts include economic, social and technological factors that cause changes in construction project.

Dealing with uncertainties of construction projects, irrespective of their complexities, can be achieved effectively by modelling the processes involved. Modelling enhance the simplification of the complex processes and makes response quicker and more effective. The dynamism of construction industry and projects that usually lead to various forms of delay in construction projects can best be responded to with system dynamics (Sterman, 1992). Due to its highly evolved guidelines for presentation, analysis and explanation of the changing aspects of complex, technical and managerial systems, system dynamics remains suitable for managing the dynamism of construction projects.

3.12 Construction Projects as a Complex System Requiring System Dynamics

The concept of complexity has to do with time assessment of events especially as it relates with level of confusion and clarity within a given space of time in a system. System dynamics, according to System Dynamics Society (SDS), "is a methodology for studying and managing *complex feedback systems*, such as one finds in *business and othersocialsystems*" (Harris & Williams, 2005). It is a tool that is used to address complex processes which involve delays, feedback and nonlinearities System dynamics is concerned with modelling of processes over time (Ossimitz & Mrotzek, 2008). System dynamics is all about simplifying reality so as to be effectively dealt with.

In construction, system dynamics are tools developed to study, predict and respond to behaviour of complex projects in a holistic perspective (De Marco & Rafele, 2009). Uncertainties that characterises construction projects lead to, if not managed properly, poor performance or project failure (Nasirzadeh, Afshar & Khanzadi, 2008). Such project failure could be in terms of delay in project delivery, cost overruns and/or poor quality. When applied to construction, system dynamics can be defined as modelling of construction processes over the period of time set out to complete the project. System dynamics is needed to properly incorporate risk management into construction process in order to enhance project performance. The complexity and nonlinearity of construction project variables or activities makes the use of traditional programme planning tools like Gantt chart and network diagrams, not effective enough to capture full effects of changes on project variables but, with system dynamics application, management of such changes become more effective (De Marco & Rafele, 2009).

Construction project is a risky endeavour and the presence of risks and uncertainties in project development usually lead to poor performance (Nasirzadeh, *et. al.*, 2008). The authors concluded that the system dynamics as a risk management tool, can be used to analyse and ascertain the full impact of various risks on every project performance indicators such as time, quality and cost thereby, making preparation of efficient response to such risks prior to their occurrence possible.

To manage complex dynamic systems, a class which construction projects belong to, models or tools adopted should be able to represent, interpret and predict reaction to their complexities – multiple interdependent components or events; dynamism; multiple feedback processes and; nonlinear relationships (Sterman, 1992). The following briefly explain the characteristics of construction projects as complex systems.

3.13 Complexity and Multiple Interdependence of Construction Projects

Projects are executed with combined efforts from different participants with the effort one participant complementing and being complemented by the efforts of others. The analysis of interdependencies of various activities that make up construction projects is beyond the capability of mental models (Sterman, 1992) hence, the use of traditional project management tools. However, the traditional project management tools analyse changes in projects in static mode neglecting their dynamism. For example, change in the scope of a construction project like extension of a pent floor by extra square meters of floor area will not only increase the cost and time estimates of the project but can also affect quality and productivity. Depending on the time the change was communicated to the team, it may necessitate reworks that extend beyond the actual change that was ordered. Rescheduling of workers may be forced, causing delay in some aspect of the work while trying to accelerate another part. This may bring about abandoning of other almost, completed tasks that may be dependent on the completion works contained in the change orders. With system dynamics, multiple interrelationships of this magnitude can be effectively captured and managed (De Marco & Rafele, 2009).

3.13.1 Construction Projects Highly Dynamic

The dynamic and complex nature of construction projects usually cause the difference between response in the short and the long run to changes or disturbances. In an attempt to meet up with completion of a construction project within a set period of time for example, a construction firm may hire more workers to improve productivity. However, productive time is unavoidably, lost in training of the newly employed workers by the existing and experienced workers. Also, the time devoted by experienced workers to train new workers reduces their productivity. Originally, employing more workers was aimed at increasing productivity but, it may end up reducing productivity rate, increasing cost (for example salary) and the project may still surfer negative time performance – an event that was being avoided by employing more workers (Sterman, 1992).

3.13.2 Construction Projects Involve Multiple Feedback Processes

The self-correcting or side-reinforcing effects of decisions made are referred to as feedbacks (Sterman, 1992). Tightly coupled systems, like construction projects, are a combination of various important feedback relationships. For example, self-correcting feedback can be increasing working hours of existing workers with additional pay instead of employing more workers in order to meet up with a set deadline. Extra hours spent helps in increasing daily productivity and consequently, reducing the overall time spent on the project. However, continuous overtime as against, employing more workers to increase productivity may lead to fatigue, monotonous and subsequently, lower productivity in the future. Such complex feedback processes can be analysed with system dynamics (Harris & Williams, 2005).

3.13.3 Construction Projects Involve Nonlinear Relationships

The relationships between causes and their effects in complex systems like construction projects are not as direct as perceived in traditional project management tools. For example, overtime may be introduced on construction sites to increase productivity which may be achieved in the short run. But, additional overtime may lead to diminishing returns in the output of workers thereby causing errors and other problems that were previously not in the picture (Sterman, 1992). The conventional project management tools could link overtime with increased productivity which is linear in nature but, will hardly link it with causes of reworks or consider diminishing or negative return as causes of reduced productivity or poor quality.

3.14 General Application of System Dynamics - Background

The system dynamics method has been used in a wide variety of applications. The systems dynamics (SD) methodology is adopted in this study for the assessment of performance of construction projects. The SD methodology is a field created at MIT by Jay Forrester in mid 1950s for modeling and analyzing the behavior of complex social systems in an industrial context (Sterman, 2000). According to Forrester (1961) it is a modeling method developed from systems thinking ideas. A system thinking is a holistic approach to problem solving based on the General Systems Theory (Von Bertalanffy, 1968) which according to Caulfield and Maj, (2001) is a philosophy of science and engineering based on the idea of combining the knowledge gained through analysis and the understanding gained through synthesis to address root causes of problems. While systems thinking is a way of thinking about problems, SD uses systems thinking principles to develop models to represent the problems (Bank, McCarthy, Thompson and Menassa, 2010). System dynamics research has made numerous contributions to a range of management subfields, including operations, organization behavior, marketing, behavioral decision making, and strategy. Gary,Kunc, John, Morecroftc and. Rockart (2008). SD was designed to help decision-makers learn about the structure and dynamics of complex systems, to design high leverage policies for sustained improvement, and to catalyze successful implementation and change. In recent years, the SD has been used by researchers and project managers to understand various social, economic and environmental systems in a holistic view (Towell 1993; Rodrigues 1996; Sycamore 1999; Mawby 2002; Love 2002; Ogunlana 2003 and Naseena 2006).

The system dynamics approach is primarily based on cause-effect relationship. This cause-effect relationship is explained with the help of stock, flow and feedback loops.

Stocks and flows are used to model the flow of work and resources through the project. Feedback loops are used to model decisions and project management policies. System Dynamics can be used to model processes with two major characteristics: (1) those involving change over time, and (2) those involving feedback (Ogunlana, 2003)

3.15 Application of System Dynamics in Built Environment

The earliest reference to SD located in the Built Environment literature discussed issues related to urban planning (White, Dajani and Wright; 1974). Subsequently, Drew (1984) created a model to illustrate interactions among four major civil systems; socio- technological; water; energy and transportation-land use. The construction project management research interest is becoming more pronounced towards the use of SD methodology, where it has been used, for effects of project personnel changes (Chapman,1998), to study performance enhancement of a construction organization (Ogunlana and Sukera, 2001), the design-build process (Pen-Mora and Li, 200) rework (Love, Holt, Shen, Irani, 2002), quality management (Lee and Pen-Mora, 2005a; Chritamara and Ogunlana, 2002), delay and disruption claims (Ibbs and Liu, 2005) , error and change management (Lee and Pen-Mora, 2005b). Sustainable construction has also been studied using SD modeling. Shen, Wu, Chan and, Hao (2005) developed a SD model to assess the sustainable performance of projects using a triple bottom line of: (1) economic; (2) social; and (3) environmental performance. An area of early and continued application of SD modeling was in urban planning, development, and land use. Forrester's models of corporate growth in urban dynamics, and world resource dynamics (Forrester, 1975) described by (Senge, 2006) as "speculative leaps" are what characterize the deep insights that help conceptualize the SD models.

In Systems Dynamics, verbal descriptions and causal loop diagrams are more qualitative; stock and flow diagrams and model equations are more quantitative ways to describe a dynamic situation. As systems Dynamics is largely based on the soft systems thinking, (learning paradigm), it is well suited to be applied on those managerial problems which are ambiguous and require better conceptualization and insight (Sushil 1993) than what the conventional methods such as PERT/CPM techniques can provide. As indicated in table 2, the SD has been successfully used in construction project related research (Nasirzadeh et al., 2008). Unlike the conventional approach (PERT/CPM), where planners use human judgement to interpret their own mental models, the SD approach according to Sterman (1992), uses computer models to overcome limitations of the mental models. Sterman established that, the SD computer models are explicit and open to all to review; capable to compute the logical consequences of the modeller's assumptions; able to interrelate many factors simultaneously and finally, can be simulated under controlled conditions for analysts to conduct experiments outside the real system.

3.15.1 System Dynamics as applied to Construction Project Management

System dynamics models have been successfully applied to Construction project management issues including the effect of rework on project performance (Cooper1994), tipping point dynamics (Taylor and Ford 2006, 2008), failures in fast track implementations (Ford and Sterman, 1998).Love *et. al.*(2002) also presented a framework using system dynamics for dealing with dynamic feedbacks in managing complex projects while Ford (1995) identified various dynamic factors affecting project development process,which provides useful reference for improving the effectiveness of project development by properly responding to those major factors.

The applications of the SD models in project management research were developed by various researchers to inform practitioners how to tackle problems of complexity, uncertainty, conflict and scale in construction and engineering fields (Nasirzadeh et al., 2008). It has also been used for studying and managing dynamically complex systems through the application of simulation models (Ford, Anderson and Darmon, 2002) to build on the reliable part of understanding systems while compensating for the unreliable part. The procedure untangled several threads that can cause confusion in ordinary debate and can be useful for managing and simulating processes with fundamental systems thinking, concepts, assumptions, and tools (Forrester 1961, 1971; Richardson 1986; Senge 1990; Darmon, 2000; and Toole, 2005).

3.15.2 System Dynamic Model as a Diagnosing Tool

The central concept of System Dynamics is to understand how the parts in a system interact with one another and how a change in one variable affects the other variable over time (Senge, 1990), which in turn affects the original variable. Systems can be modeled in a qualitative and quantitative manner. The models are constructed from three basic building blocks: positive feedback or reinforcing loops, negative feedback or balancing loops, and delays. Positive loops (reinforcing loops) are self-reinforcing while negative loops (balancing loops) tend to counteract change. Delays introduce potential instability into the system. The SD modeling process includes two main phases: Qualitative System Dynamics (or model conceptualization) and Quantitative System Dynamics. While the former is mainly to create cause-effect diagrams, the latter is devoted to quantitative computer simulation. The development of the Qualitative SD involves eliciting relative knowledge from experts and stakeholders to identify and validate the system structure and behavior. To capture this relevant knowledge, a variety of approaches has been employed such as Delphi technique, questionnaire surveys, interviews and workbooks.

3.15.3 Use of System Dynamics to Model Forecasting Construction Project Performance

Kim (2007) explained that forecasting is an essential part of decision making under uncertainty. A need for forecasting arises *only* when there is uncertainty about the future and some aspects of the future cannot be controlled (Armstrong 2002). If everything relevant to an event is certain and the future of the event is deterministically predicted or controlled based on what is known at the point of forecasting, any decisions about it can be made according to the decision maker's preference for expected outcomes. Otherwise, decisions should be made based on forecasts which account for the uncertainty about the future.

Siti and Mohd Zaimi (2006) explained that in controlling a construction project, Project Manager should understand the importance of using project baselines which serves as a benchmark. This is to ensure the project is running smoothly and early indication on deficiencies of project can be identified. Thus, necessary corrective action can be made in due time. In current practice, project baselines or planned S-Curves is used to determine variances in cost or schedule and to measure the earned value. In this context, it explains why this method is widely used in construction industry to measure the performance of projects. One of the advantages of this method is that it can identify any cost and schedule variances at the end of the project. However, there is still lacked within this method of providing corrective action plans if negative variances is identified. Therefore, the needs of forecasting performance variances at completion is necessary to Project Manager in order to decide the suitable corrective action plans and the effect on final project performance.

Forrester (2009) while illustrating a close-loop system of system dynamics used the concept of filling a glass of water as shown in the diagram below. He stated that the filling of a glass of water is not merely a matter of water flowing into the glass. There is a control of how much water. That control is the feedback loop from water level to eye to hand to faucet to water flow and back to water level. Such closed loops control all action everywhere.

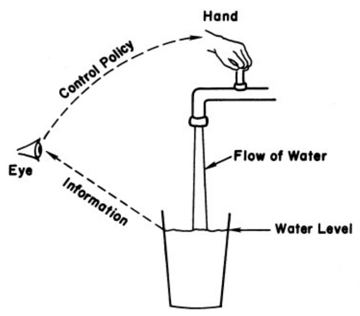


Figure 3.7*: Close-loop system* (*Forrester, 2009)*

Forrester (2009) further outlined that the translation of a mental model to a system dynamics simulation model moves through several stages namely:

- A model must be created with no logical inconsistencies. All variables must be defined. None can be defined more than once. Equations must be unambiguous.

  Mostsystemdynamicssoftwareapplicationscheckforandfindsuchlogicalerrors .
- When a model is first simulated, the results may be absurd. Simulated behavior may be impossible. Inventories may go negative; negative values often have no real-world meaning. One goes back to refine the model and make the structure more realistic and more robust.
- As a model becomes better, surprising behaviour often does not reveal model errors but instead begins to tell something about real life that was not previously realized.

The above mental model translation shaped the focus of this research in assessing the performance of construction projects through system dynamics concept.

Choopojchareon and Magzari (2012) described System dynamics with the cause-effect relationships among elements and are usually modelled using causal loop diagrams.

Loop diagrams are a simple tool that enables the analyst to have a general picture of the system components and their interaction with each other. The rules of diagram notation are clear and intuitive. A causal relationship is represented by an arrow pointing from the independent to the dependent variable. Near the head of the arrow is a polarity sign depending on whether the affected element is changing positively or negatively. Link after link, loops get created, and according to their effect on a given element, they are either reinforcing (R or +) if positive or balancing (B or -) negative. Those loops are called feedback loops. They "control" the value of the pointed element by either increasing or decreasing the quantity of interest. Figure 3.2 below shows an example of a causal loop diagram (Meadows, 2012).

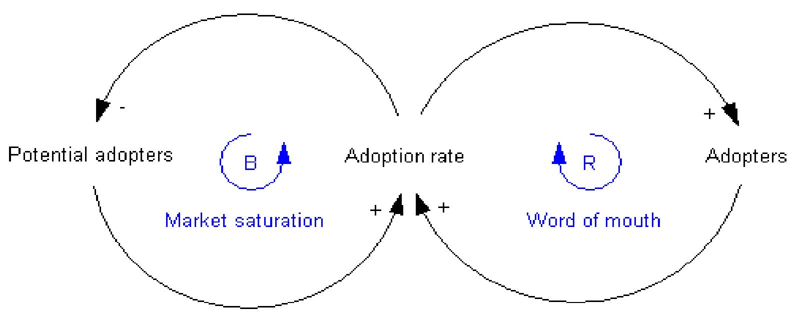


Figure 3. 8:. Causal Loop Diagram (Meadows 2012; adapted from Sterman, 2001)

In practically adopting the casual loop diagram concept to this work, forecasting the performance of construction project in relation to cost, time, quality, and helth and safety, the loop diagram can be re-represented thus;

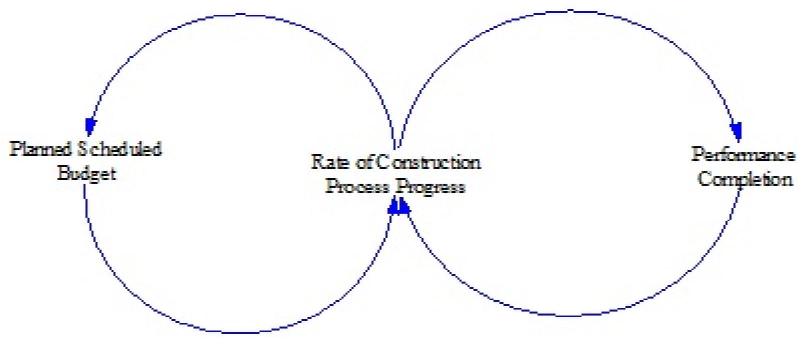


Figure 3. 9: Causal Loop Diagram for Construction Project Performance

The above figure describes the instance of a typical performance of construction project, i.e. the actual performance of a project is a dependent variable which is being influenced by some factors earlier highlighted which stands as the independent variables as they are not varied by the project performance. The positivity of these factors (the independent variables) would reduce the quantum of the variables of planned or forecasted performance thus making the casual link between them negative. This seemingly simple scenario forms a loop of multiple element related to each other, since each relation is followed by another one, the polarity of each link is multiplied by the polarity of the following one. The chain rule process continues until all the links of the loop are used. The resulting sign is the polarity of that specific loop. Only negative polarities matter according to the algebraic property of multiplying plus and minus signs. More precisely, the number of negative links in the loop is the key. An even number of negative causal links would represent a positive loop, while an odd number of negative links would prove the opposite. Furthermore, from Figure 3.3 above, there is positive link pointing from *Rate of Project Performance* to the *Actual Performance of the Project.* That actually means that the dependent element *Actual Performance* is positively changing corresponding to the independent variable R*ate of project performance.*

On the other hand, there is a negative causal link from *forecasted or planned performance for the project*. This relationship means that the dependent variable will change inversely corresponding to the independent element. Therefore, the change of the affected element over the change of the causing variable is negative. While the polarity of a causal link is rapidly determined, loop polarity requires more time and care.

3.16 Summary of the Chapter

Project managers and clients are concerned with measurement of performance which many researchers have studied over the decades. The two (2) common terms used in measuring performance of construction projects are critical success factors and key performance indicators and these were reviewed in this chapter. The dynamic nature of construction due to uncertainties and risk associated with construction business vary with every construction project thereby making key performance indicators vary from project to project. Critical success factors groups namely: human-related, project management, project procedures, project-related and external factors have direct impacts on the success of construction projects. The dynamism of construction projects requires continuous development of diagnostic or analytic model to measure the performance to keep the projects under control in terms of cost, time, quality and including health and safety identified success indicators.

The focus of this thesis is to develop a model or system that can assess performance of construction project from the KPIs. The seven (7) KPIs that are related to project performance are: client satisfaction (product), client satisfaction (service), defects (quality), predictability of cost, predictability of time, construction time and construction cost. Safety, profitability and productivity make up the list of the three indicators that measure company performance. In this research performance is determined by assessing the CSFs for predicting the KPIs in evaluating performance of construction projects in order to effectively and efficiently practice decision making. It has been established from literature that there exist relationship between and quality, cost, time and health and safety for performance of construction projects. This is the concept that is being advanced in this research and thus, the dynamics of the four key performance indicators considered in this research with their individual CSFs influencing these KPIs which is being interrelated with each other and one another and eventually determining the performance of construction project is established.

The conceptual framework depict that a project is controlled once each factor element of the project and the relationship between the factors are understood. These interrelationships between the project's components are more complex than is suggested by the traditional work breakdown structure of project and therefore there is need to treat projects as the complex dynamic systems which they are argue to avoid the failure to improve project performance. Dynamic modelling of complex systems usually addresses the behaviour of the systems over time. In Systems Dynamics, verbal descriptions and causal loop diagrams are more qualitative; stock and flow diagrams and model equations are more quantitative ways to describe a dynamic situation. As systems Dynamics is largely based on the soft systems thinking, (learning paradigm), it is well suited to be applied on those managerial problems which are ambiguous and require better conceptualization and insight and thus its application in this research.

CHAPTER FOUR

RESEARCH PARADIGMS AND METHODOLOGY

4.1 Introduction

This chapter presents the methodology adopted in conducting the research. Pathirage, Amaratunga, and Haigh (2008) argue that methodologies are best used in complementary way to develop theories, by reflecting on the issues between philosophical and methodological pluralism and that substantial development in research methodology have taken place over the last decade, especially relating to the philosophical stances of research. The research has a theoretical background as the subject of decision support system is known but requires to be studied again especially to fill the identified gap in the existing literature. The gap is assessing the failure of construction projects to perform as expected and proffer explanatory causes for diagnostic solution. In this case, the use of System Dynamics as a tool of diagnosing construction system was explored. The problem that was investigated as a research is contextual - in the Nigeria construction industry thus, investigating the subject matter as a new problem led to conclusion in establishing additional knowledge.

The philosophy behind the research objectives form the basis for the research outcome and the strategy that was used in collecting and analysing data in this study. The idea behind the model that was developed for the research aim at what constitutes projects failure in terms of completion time and budgeted cost. How to analyse the relationship of the dynamics in the success and failure events in construction process in developing a model for construction projects.

Therefore, the observation of the researcher's assessment of the dynamic relationship that exists in construction project as a complex paradigm was presented.

4.2 Aspects of Research

The systematic investigation of a subject matter, material and sources in order to establish facts and reach new conclusions for the purpose of adding to knowledge is referred to as research. According to Postlethwaite, (2005) research can mean "re-search" implying that the subject matter is already known but, for one reason or another, needs to be studied again and or alternatively, the expression can be used without a hyphen and in this case it typically means investigating a new problem or phenomenon.

Collis and Hussey (2014) summarised the general agreement from many definitions that research is

- process of inquiry and investigation
- Systematic and methodical and
- Increase knowledge

Thus, research has a methodology requiring researchers to use appropriate methods of collecting and analysing data for a purpose. This is supported by many authors in research literature including Sekaran, (1992); Sarantakos, (1993). Brynard and Hanekom (2006) enunciated the need to list objectives of undertaken a research which flow with summary of typical objectives of research in Collis and Hussey (2014) to include the following rationale:

- to review and synthesize available or current knowledge
- to examine existing situations or problems
- to proffer and provide possible solutions to these problems
- to make careful study and analyse more general issues
- to build or create new procedures or systems
- to explain or give detail clarification of a new phenomenon
- to generate and establish new or novel knowledge
- a combination of any of the above listed rationale.

The purpose of this study combined the afore-listed rationale to include examining existing situations or problems (complexity) associated with the failure in the performance of construction projects, review and synthesize existing knowledge in decision support system incorporating system dynamics, proffer and provide possible solutions to construction performance problems and create a new procedure or new knowledge for construction project performance.

The different types of research based on purpose classification according to different researchers including Neville, (2014) and Collis and Hussey (2014) classified research as being exploratory, descriptive, analytical and predictive. Other type of research classification is presented in Table 4.1.

Table 4. 1Table 4.1 Classification of different types of Research

Type of Research	Basis of Classification
Exploratory, Descriptive, Analytical and Predictive	Purpose of the research
Quantitative and Qualitative Research	Process of the research
Applied or Basic Research	Outcome of the research
Deductive and or Inductive Research	Logic of the research

Source: Collis and Hussey (2014)

Exploratory research is used when few or no previous studies exist on the subject matter thus, applicable when the problem of the research is not yet clearly defined. This kind of research aims at finding patterns, ideas and develop proposition for hypothesis. Applicable techniques for exploratory research include case studies, observations, reviews of previous studies and historical analyses.

Descriptive research extends inquiry further by examining a problem beyond exploratory. According to Gray (2014) Descriptive studies seek to 'draw a picture' of a situation, person or event or show how things are related to each other. To describe the way things are or were accurately. Descriptive research can be used to identify and classify the elements or characteristics of the subject by asking the question "what" and "how" (Collis and Hussey, 2014). Quantitative techniques are most often used to collect, analyse and summarise data. Issues concerning the decision-making process, type(s) of project diagnostic framework available for construction project managers in Nigeria and factors that impact construction performance.

In analytical research, the descriptive research is broadened and the researcher goes beyond describing the characteristics of the subject but continue to analyse and explain “why” and “how” the phenomenon being investigated is happening. Thus, analytical research focuses understanding on discovering and measuring the causal relations between phenomena. In this research the question on why and how certain (critical) factors affect construction performance in terms of time, cost and quality or why project managers make decisions in a way and not use a diagnostic tool were investigated.

If causal relationship is established, can we predict the future? Predictive research digs deeper than the analytical/explanatory research by forecasting the likelihood of similar situation occurring elsewhere. Predictive research aims at speculating intelligently on future possibilities, based on close analysis of available evidence of cause and effect, (Neville, 2014). This type of research provides answers to “why”, “when” and “where” events currently or for similar events in the future, and also helpful for “what if” situations (Collis and Hussey, 2014). A predictive research method was carried out in this particular study to establish causal variables in the performance of construction projects that could be controlled by System dynamic models to predict the schedule, budget and cost performance of an ongoing construction project. This will be applicable in the short term, when the system has continuity and momentum (Forrester, 2007).

Therefore, this research has different exposures culminating into many aspects from exploratory, descriptive, analytical and predictive as illustrated within their respective paragraphs in order to establish the purpose of the study. Part of the critical issues within the context of this research is to assess the interaction of the critical success factors in predicting performance for effective decision making by exploiting the proposed 'System Dynamics DSS' in construction projects in Nigeria. There is dearth of literatures in the use of system dynamics as a decision support system in construction industry and particularly this contributed a novel knowledge in the Nigeria context and by extension, the construction industry generally.

4.3 Research Philosophy

Appropriate methodology is important for every research. This explains the level of understanding of the researcher in conceiving the nature of the subject and also the applicability of the new body of knowledge in the chosen field of endeavour. Research philosophy branched into ontology and epistemology which lead researches to different methodology that could be applied to tackle the research (Sutrisna, 2009).

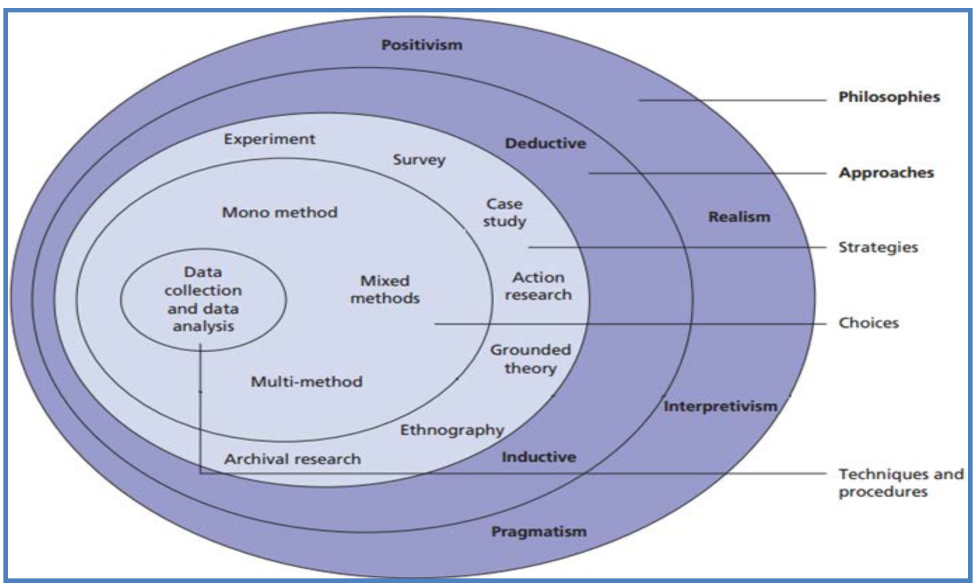


Figure 4. 1: The research 'onion'
Source: Saunders, et al. (2008)

Research design and its process could be described in an onion shape of cycle of philosophy to data collection and analysis as depicted in Figure 4.1 which is subsequently discussed further in this chapter. Construction projects have been argued and generally agreed to be complex in nature with an array of interrelated factors or variables thus, the ontological basis for the research. Research studies have also concluded that construction projects by nature (performance) are being accomplished by its social actors in terms of interaction and constant state of revision. This makes the research to be in the constructivism ontological position as being distinguished from objectivism ontological position.

Epistemology focused on analysing the nature, origin, scope and variety of knowledge and, how it relates to similar notions such as truth and beliefs thus, a branch of philosophy of knowledge that is concerned with how we come to know reality. Epistemology positions include positivism and interpretivism. Positivism focuses on using natural science methods (quantitative measures) for gathering knowledge. Positivism is a philosophical view mainly adopted in scientific research requiring hypothesis testing. Thus, interpretivism takes the opposite view; Interpretivism is an epistemological position that separate the objects of natural science from the (social) actors, the researchers/observers somehow construct their own "truth" in viewing the world it argues that cultural, historical and other issues that allow people to interact are fundamental to knowledge creation.

Another, research philosophy is Axiology which studies judgements about value. It emphasises the individual value as a guiding reason for action Saunders, Lewis and Thornhill (2009). Heron and Reason (1997) view that social practices and institutions need to enhance human association by an appropriate integration of three principles of deciding for others, with others, and for oneself. Saunders et al (2009) posited that axiology is evidently applicable to some research topics concerned with personal career development. If the research is external to the researcher, the ethical standard requirement for the dissertation according to University of Salford's value judgement could raise a question.

The origin of positive research lies in the natural sciences. This research paradigm uses precise, objective measures and is usually associated with quantitative data and this research is based on the assumption that there is a set of universal laws out there waiting.

Table 4. 2: Choice of Research Methodology

``	Choices	Choice Adopted
Research Philosophy	1. Ontology 2. Epistemology 3. Axiology 4. Methodology	All applicable
Ontology	1. Objectivism 2. Constructivism	Constructivism
Epistemology	1. Positivism 2. Interpretivism 3. Pragmatism	Pragmatism
Research Approach	1. Deduction 2. Induction 3. Abduction 4. Retroduction	Abduction
Research Strategy	1. Experiment 2. Survey 3. Case Study 4. Action Research 5. Grounded Theory 6. Ethnography 7. Archival Research	1. Survey and 2. Case Study
Type of Case Design/Studies	1. Explanatory 2. Descriptive 3. Exploratory 4. Multiple-Case 5. Intrinsic 6. Instrumental 7. Collective	Multiple-Case Designs
Unit of Analysis	1. Individual 2. Group 3. Organizations 4. Artefacts 5. Projects	Project
Research Methods/Choices	1. Mono Method 2. Multi Method 3. Mixed Method	Mixed Method
Reasons for Using Mixed Method	1. Triangulation 2. Facilitation 3. Complementarity 4. Generality 5. Aid Interpretation 6. Study Different Aspects 7. Solving a Puzzle	Triangulation
Data Collection Methods	1. Direct Observation 2. Interviews 3. Focus Group Discussion 4. Questionnaires 5. Company Documentation 6. Reports	1. FocusGroupDiscuss 2. Interviews and 3. Questionnaires
Data Analysis Techniques	Many	1. Reliability analysis 2. Factor Analysis 3. Kruska-wallis test

As displayed in Table 4.2, this research chose in between the continuum of ontological constructivism/positivism and epistemological pragmatism as its philosophical basis. This is because, pragmatism allows for alignment of variations in epistemology, ontology and axiology (Saunders et al, 2009). The abductive research approach was adopted which depicts the deductive and inductive reasoning techniques of the study. Survey and case study research strategies were employed for data generation, and multiple-case design was used in order to gain deeper understanding of expert's view of the project investigated in the construction industry. The unit of analysis in the study was projects which were studied from the initiation to completion. The study employed a mixed method of data collection for triangulation. Questionnaire distribution as well as interview schedule was the data collection tool used. The study analysed data generated through Reliability analysis test, Factor analysis and Kruska-wallis test of hypothesis.

4.4 Research Approaches

The methodological paradigms lead to the choice and use of research methods, essentially there should be a good fit between paradigms and approaches, there are three different groups of research approaches which were identified in literature. Neville (2005) identified quantitative/qualitative, applied/basic and deductive/inductive. Researchers can combine different kinds of approaches. Quantitative research uses quantitative data or qualitative data that can be analysed using statistical tools whereas qualitative research data are analysed using interpretative methods. A large study can combine elements of both as their merits are complementary in gaining better understanding of the research (Neville, Collis and Hussey, 2014).

Quantitative-qualitative research technique corresponds to the two respective ends of the positivist-constructivist paradigm continuum. The techniques or procedures that were used in gathering and analysing data to answer the research questions or test hypotheses were discussed subsequently.

Applied research is planned from the beginning to apply its findings to an existing state while in basic research the researcher strives to develop knowledge in a broad way; In general, deductive approach is a theory testing process which commences with an established theory. This approach target to develop a theory based on existing knowledge. Deductive approach is comprised of a hypothesis which is derived from the propositions of the existing theory. On the other hand, inductive research's point of departure is a specific position and it reaches to general theories from this point (Neville, 2005). In other words, researcher tends to develop generalisations based on empirical data towards the end of research as a result of observations (Goddard and Melville, 2004).

According to Cavaye (1996) both deductive and inductive research approaches can be combined together and used in the same research. This has also confirmed to be practical by Perry (2001), who has suggested that finding the midpoint between the two approaches can lead to confirming/disconfirming of the proposed theory.

The research process involves different phases, in the development of a conceptual model using the system dynamics causal loop mapping as some framework hypotheses are developed addressing the research objectives and scope by adopting a deductive approach. The process relies on the current body of knowledge and theories in developing the research model and hypotheses, thus, by definition adopting positivism paradigm view (Sutrisna, 2009).

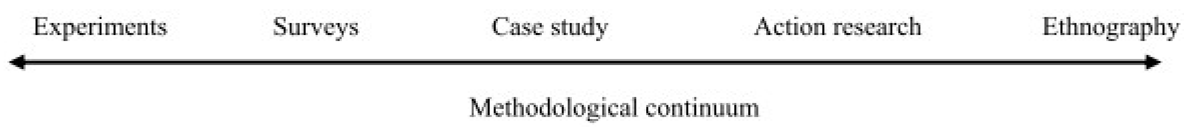
The second phase of the research was of constructivist paradigm with phenomenological epistemology deployed. This phase involved validation of the proposed conceptual model and the engineering and construction value chain through unstructured interviews in the form of case study of selected construction practitioners in organisations as a follow up to responses of a pilot questionnaire. The choice of case study strategy at this phase of the research was informed by the requirement to carry out a holistic in-depth investigation of the complex phenomenon of feedback loop in the construction process and progress of projects within the context in which it occurs. The validated conceptual framework was extended and modified through mathematical modelling using Stock and flow simulation mathematical models as applicable to system dynamics.

To accomplish the purpose of this study, the researcher used a survey method where participants completed a survey instrument of the impact of certain project factors on project performance and establishing the relationship/impact of such factor or variable on the construction project performance. The focus of the research is to get answer to the research questions, assess past/present record on performance of projects, testing the researcher's hypotheses, and establish the causal relationship and then obtaining results.

Love, Holt and Li (2002) advocate the need to adopt a robust methodological approach that takes account of both ontological and epistemological viewpoints. It is proffered that only then will we fully understand phenomena that influence organizational and project performance in construction. As Gill and Johnson (2002) proposed that research methods can be positioned by taking nomothetic (realist) and ideographic (idealist) ontologies into account (Table 4.2). Gill and Johnson (1991) define nomothetic as the research approach which utilises quantified methods for data analysis, whereas ideographic approaches deal with analysis of subjective accounts generated through inside situations and involving oneself in the everyday flow of life.

Table 4. 3: A Comparison of Nomothetic and Ideographic Methods

Nomothetic methods emphasise	Ideographic methods emphasise
Deduction	Induction
Explanation via analysis of causal relationship	Explanation of subjective meaning systems
Generation and use of quantitative data	Generation and use of qualitative data
Testing of hypothesis	Commitment to research in everyday settings
Highly structured	Minimum structure



Source: Pathirage, Amaratunga, and Haigh (2008) (as adopted from Gill and Johnson, 2002)

Pathirage et al., (2008) corroborated other researchers and posited that case study research starts with a deductive reasoning approach with a problem definition and leads to an inductive reasoning process of theory building.

4.5 The Research Methods

The choice and use of research methods is one that is secondary to that of methodological paradigms, but it is essential that there is a good fit between paradigms and methods as stated earlier. The techniques or procedures adopted to gather and analyse data to answer the research questions or test hypotheses is the research method. According to Kothari (2004) arriving at a solution for a given problem is the object of research; in particular the applied research, therefore, the available data and the unknown aspects of the problem have to be related to each other to make a solution possible. This leads research methods to be put into the three groups as follows:

- methods which are concerned with the collection of data. These methods will be used where the available data are not sufficient to arrive at the required solution;
- methods of statistical techniques which are used for grouping the data and establishing relationships between the data and the unknowns;
- methods which are used to evaluate the accuracy of the results obtained.

Research methods falling in the above stated last two groups are generally taken as the analytical tools of research (Kothari, 2004).

4.5.1 The Data Collection Technique

The data for the research were collected through interviews and survey questionnaire in a form of data generation triangulation. Conceptual model of system dynamics diagnostic model was developed from different theoretical background from which a set of hypotheses were derived using deductive research approach and embracing positivist paradigm. Data were also generated by a survey of experts' opinion in the construction industry to validate the proposed model. A pilot survey was also conducted and analysed in the process of validating the model. A survey questionnaire was used to generate the research data for general application of the research findings in contributing to knowledge using system dynamics and predicting performance in the construction projects. The research Model was eventually implemented with a case study to assess its best fit and generalisation to the construction project literature and the industry.

4.5.1.1 Questionnaire

Researchers may be tempted to begin with the design of a questionnaire, so that data can be gathered without delay but other stages must be considered first including sampling, secondary data, observation and interviews (Gray, 2014). To carry out research analysis information/data would be required from the target population. The target population for this research are construction practitioners particularly at managerial level. Postlethwaite, (2005) asserts that occasionally, data that are required to undertake a research study already exist in files, or in the data archives of research studies already undertaken. Where data already exist, the analysis of them is known as “secondary data analysis”. In contrast, primary data have to be collected.

From the specific research questions established in the first step of a research study it is possible to determine the indicators and variables required in the research, and also the general nature of questionnaire and/or test items, etc. that are required to form these. Decisions must then be taken on the medium by which data will be collected (questionnaires, tests, scales, observations, and/or interviews).

After a comprehensive literature review about decision making processes and techniques available in the construction and the level of application and take-up of decision support system by construction professionals for project forecasting and for the evaluation of project performance set of adequate and appropriate questions in a sequential order were prepared as a part of this research in order to provide the researcher with the required data to identify a solution and contribute to knowledge.

Structured and unstructured questionnaires are the two most common types of questionnaire methods. Interviews and survey questionnaire in a form of data generation triangulation were adopted as the data collection strategy for the study.

4.5.1.2 Case Study

An empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident is referred to as a case study research (Yin, 2003). The evidence to be gathered is defined as it was collected as questions were asked and were interpreted to the answers. A construction project was selected for the case study, the role of the client's project manager was administered and data were collected from the commencement of the construction on- site up until completion of the project. Interviews (unstructured and semi structured) were conducted with the project's client, site management team, consultants, subcontractors and suppliers and with a scheduled visiting time. Interviews were primarily used to determine those dynamics that influence change for identifying and establishing dynamic relationships. Direct observations and documentary evidences were sourced from the contractor, consultants, subcontractor and suppliers.

Additionally, case study process comprises three stages which are; defining and designing, preparing, collecting and analysing and analysing and concluding (Gray, 2014). This enabled the researcher to conduct a case study targeting the evaluation of the proposed SDDSS forecasting model which will identify the critical factors that impact on performance.

4.5.1.3 Triangulation

Triangulation is commonly associated with measurement practices in social and behavioural research. Triangulation in research means investigation employing more than one approach to research questions in establishing the research findings by offering enhanced confidence.

Different researchers have referenced the work of Denzin (1978) which distinguishes different types of triangulations as data triangulation, Investigator triangulation, Methodological triangulation and theory triangulation. This research will be employing methodological by using multiple methods of data collection. Data will be collected through literature review, unstructured interviews and questionnaire surveys.

The framework of the research involved theories and concepts from other disciplines including information technology/system, business strategy, and construction management. Therefore, part of this research strategy is triangulation through the use of multiple theories and use of qualitative and quantitative data generation.

4.5.2 Data Analysis Tools

The tools for the analysis of data are the readily available statistical tools and techniques in the Statistical Packages for Social Sciences (SPSS). The descriptive data were analysed using frequency and the measure of central tendency methods i.e. the mean; the median; and the mode to described clustered of obtained data about a central point. The critical Success factors for Key Performance Indicators were observed and data so collected were analysed using factor analysis statistical method to describe variability among observed, correlated variables in terms of factors that were developed from this research as CSFs for KPIs.

Furthermore, measure of dispersion took place concerning the range, variation ratio, and standard deviation of the obtained results in order to form the platform to observe similarities and or differences in the respondents' opinions. Inferential statistics were also employed to establish relationship among variables and the predictive abilities of some variables on project performance thus, Kruskal Wallis, correlations, etc., are useful tools in this. At the concluding part a computer simulation program for System Dynamics was employed in establishing the proposed Project Performance Diagnostic Model (PPDM).

4.5.3 Evaluation of the Data

Relevant data required for the research were gathered through survey and interviews for the proposed PPDM for construction industry in Nigeria and were evaluated through experts' opinion judgement from a case study project. On the other hand, with the help of case study evaluation technique, the performance of the PPDM was examined through simulation of the model using Vensim software.

4.5.4 Research Questions and Hypotheses

Problem statement served as the basis for research questions which led to hypotheses of the study. The hypotheses served to guide the direction of the research, helped identify the relevant facts and provide framework for the research focus.And should data be collected by using observations, interviews, or questionnaires? Should data be collected from just a few hand-picked projects (case study), or a probability sample of projects and participants (thus allowing inferences from the sample to the population), or a census in which all projects are included? For a case study, the sample is known as a 'sample of convenience' and only limited inferences can be made from such a sample

4.5.5 Research Design and Strategy

The research is designed to collect information through structured questionnaires with open and closed ended questions, from respondents based on a specific project as a case study.

According to Rowley, (2002) Case studies are useful tool for the preliminary, exploratory stage of a research project, as a basis for the development of the 'more structured' tools that are necessary in surveys and experiments. The system's real and existing operational environment was used for empirical investigation in case study. Identifying consistency or inconsistency in the project performance by the influence of any certain factor support the use of case studies as being appropriate to the study as multiple cases could be simultaneously examined. The findings therefore, could be generalized depending on the spread of the result between all the cases.

Review of literature on related field of the research guide the research objectives and to developing the conceptual framework for the research. Survey questionnaire and interview were employed as the instrument to get responses from managers of construction projects; the processes in undertaking the research design involved stages as presented in research design flow chart. The stages include reviewing the existing literature as described in previous chapters which provided the basis and foundation for the research. The research aim and objectives were established from the research topic and the literature leading to defining the research question. A conceptual model was derived using the theories and paradigms from the literature in order to provide a medium for answering the research question. The model derivation was detailed in chapter three. The remaining parts of the research design and strategy were presented in the subsequent chapters.

The research design flow chart is broken down to different stages of clarity as developed for this research; illustrated in Figure 4.2. The figure itself depicts how the embedded processes that were carried out throughout this study overlap with the research themes in addition to the methods/tools engaged with each stage of the process. The figure also clarifies and demonstrates the research methodology after a comprehensive literature review about the research, adopted research philosophy, approach and method deployed in the study. The different stages are as discussed in the following section.

Stage 1: The study focuses on KPIs and the likely way decision making could be supported scientifically. Therefore, the researcher carried out a comprehensive review of literature in critical success factors and KPIs and System Dynamics system in the construction industry to gather requisite knowledge, and the way professionals practice decision making. This leads to critical review of CSF, KPIs and System Dynamics and its models carried out to establish identified gap in the literature to form research question including the aim and objectives of the research.

Stage 2: Identification of critical success factors, key performance indicators, system dynamics as applicable in Nigeria construction industry, this is a follow up to stage 1 to develop a model using these influencing factors as applicable in the construction industry. Different factors impacting construction project's variables have been identified in literatures but not many as would be critically examined were checked as applicable in Nigeria, perhaps some of these factors identified in other parts of the world could be applicable or differ from the practice in Nigeria.

Stage 3: Measurement of the causal relationship between variables that determine construction performance was carried out through literature, pilot case study with Delphi technique, and eventually with questionnaires. Records from managers of construction projects especially as regards their experience on what factors impact construction progress were solicited to be measured numerically. These numerically obtained values were useful in the proposed System Dynamics Model for diagnosing construction project performance using Vensim PLE for Windows Version 6.4b (x32) software – Copyright 1988-2015 Ventana Systems, Inc. Academic Use Only.

Stage 4: This follows the preceding stage 3, having established values for the variables that could easily lead to Developing an appropriate Project Performance Diagnostic Model (PPDM) for construction project in Nigeria. Different authors have established some of these variables and applied them in particular different ways but this research sought to apply to general project performance which there is almost non-existence.

Stage 5: The model will not have built in all variables anyway, therefore analyses were carried out to determining appropriate feedback variables that impact on performance through appropriate methodology including interviews and brainstorming sessions. This led us to establishing a robust Project Performance Diagnostic Model for forecasting project performance.

Stage 6: System Dynamics mathematics is integral calculus that was developed in this case through variables established in the previous stages. Therefore, after the collection and analysis of the results from stage 3, set of mathematical equations were developed for the proposed model. This System Dynamics Model was assessed in forecasting performance of construction project with and including literature review about the equations, brainstorming session with SD experts in order to confirm the reliability of the developed equations for the proposed model.

Stage 7: Questionnaire and literature review helped in positioning the PPDM and determining appropriate variables of impacting factors of predicting construction performance. Thus, validation of the Project Performance Diagnostic Model for predicting project performance led to defining a new construction paradigm:

Stage 8: An assessment of the performance of the Project Performance Diagnostic Model to predict likely failure to improve decision making on construction project: in this stage, the reliability of the proposed Project Performance Diagnostic Model was measured and justified through set of evaluation techniques using feedbacks from experts and case study that was conducted to predict construction performance of cost, schedule, quality, and health and safety.

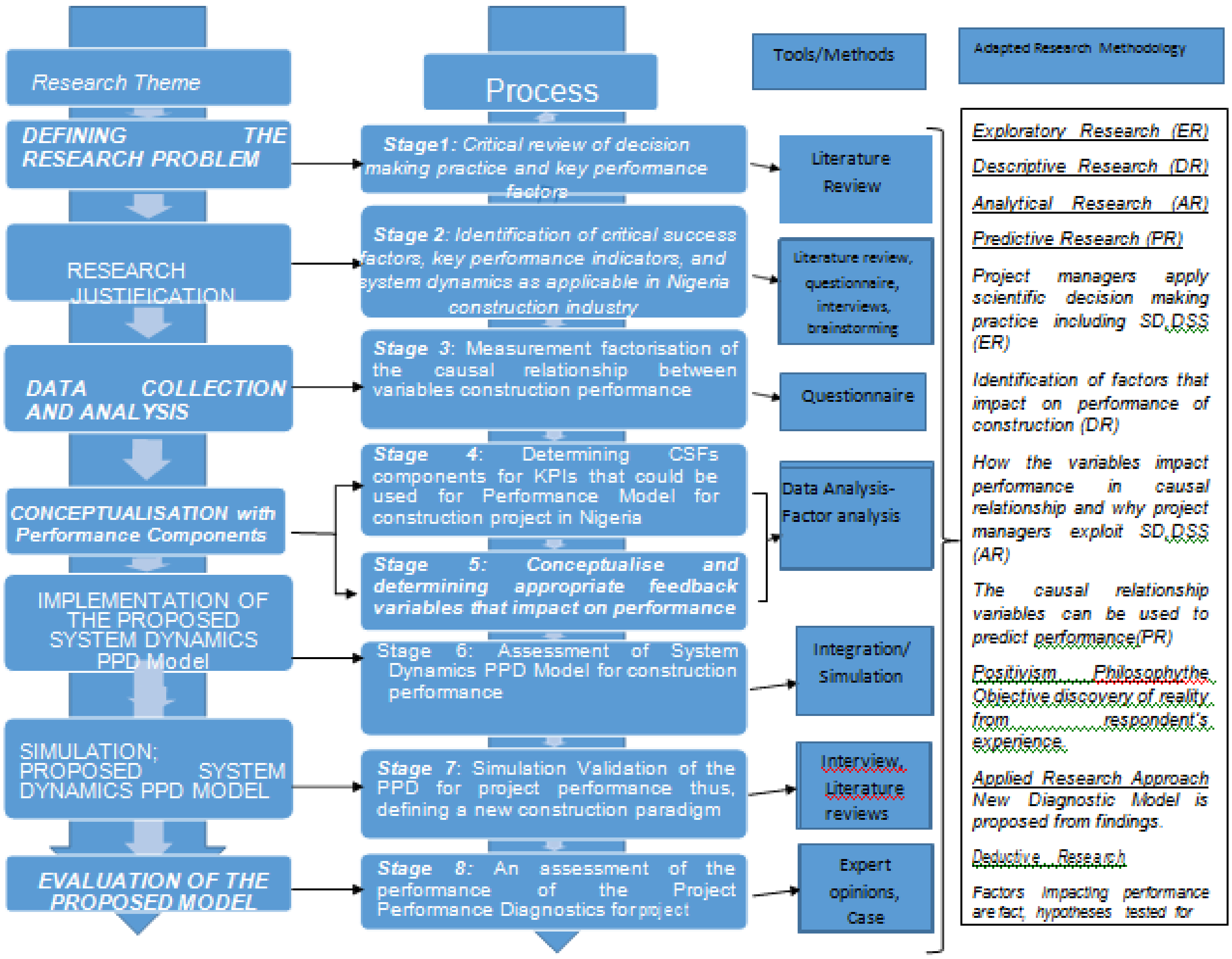


Figure 4. 2: Schematic Stage Breakdown of Research Design

4.6 Summary of the Chapter

The chapter discussed the philosophical stance of the research from the positivism or interpretivism philosophical stance to pragmatism by appropriately answering particular research question through different phases with quantitative-qualitative research technique corresponding to the two respective ends of the positivist-constructivist paradigm continuum with abductive reasoning techniques. A schematic stage breakdown of the research is presented that detailed collection of data through interviews, survey and case study. The final analysis to be used include statistics – factor analysis and the use of SD software to develop a Project Performance Diagnostic Model, PPDM is explained.

CHAPTER FIVE

ANALYSES OF CRITICAL SUCCESS FACTORS INFLUENCE ON KEY PERFORMANCE INDICATORS

5.1 Introduction

This chapter presents the research data, based on the responses collected via questionnaires, and reports the statistical analysis of the data.

The sample size for the research was influenced by the number of CSFs identified in the literature and expert opinion. Thus, the highest CSFs for a KPI (Time) was the driving factor and based on subject to item ratio. According to Costello and Osborne (2005) majority of survey studies researchers performed analyses with subject to item ratios of 10:1 or less, (63.2%) with 5:1 being the most that researchers adopt (25.8%) in determining a priori sample size. Therefore, having identified 34 factors for CSFs for Time performance a 10:1 initial priori sample size was carried out with 340 Questionnaires distributed among professionals in the industry. 207 questionnaire or 68% responses were returned; 13 responses were discovered as being unusable as the respondents failed to fill important sections of the questionnaire and so were discarded leaving 194 valid responses.

A total of One Hundred and ninety-four (194) responses were collated as properly completed, giving a 57 percent acceptable response rate with subject to item ratios of above 5:1 thus acceptable for the required analyses.

The analysis reports the background of the respondents, frequency distribution of the various project success factors, reliability test, factor analysis and the correlation between the predictor factors and the response factors, regression analysis of the success factors and a test of hypotheses. All these were carried out for reliability, validity, explicability and general integrity of the research findings.

5.2 Data Analysis and Presentation

Data collected from the questionnaire responses are analyzed and presented here in tables. The presentation is in order of appearance of the questions in the research questionnaires.

5.2.1 Highest Educational Qualification

The Table 5.1 reveals that 3% of the respondents were OND holders, 16% were HND holders, 45% were B.Sc. holders, while 31% were M.Sc. holders. The remaining 5% of the respondents had bagged Ph.D. degree.

Table 5. 1: Highest Educational Qualification

	Frequency	Percentage
OND	6	3
HND	31	16
BSC	88	45
MSC	59	31
PHD	10	5.2
TOTAL	194	100.0

It is understood from this Table that respondents who had B.Sc. and M.Sc. degrees respectively participated more in the study more than those with lower tertiary educational degrees such as OND and HND. The implication of this is that the major part of the information supplied came from the respondents who are well educated in the profession of construction. Therefore, their responses can be relied upon in explaining the study objectives. In essence, majority of the respondents are very well suited to answer the questionnaire items by reason of their knowledge and years of exposure to construction.

5.2.2 Professional Qualification

It is revealed in Table 5.2 that about 24% of the respondents were architects, 30% were quantity surveyors, about 13% were structural engineers, 6% were mechanical engineers, 5% were electrical engineers, and about 18% were builders, while people from other professions constituted 4% of the respondents.

Table 5. 2: Professional Qualification

	Frequency	Percentage
Architect	46	24
Quantity Surveyor	59	30
Structural Engineer	25	13
Mechanical Engineer	12	6
Electrical Engineer	10	5
Builder	34	4
Others	8	4
TOTAL	194	100.0

The Table shows that respondents who were Architect and Quantity surveyor constituted about 24% and 30% of the total distribution respectively. Specifically, Quantity surveyors made up 30% of the respondents; meaning that a great part of the responses to the research questions emanated from those who had practical understanding of the focus area of this study.

Table 5. 3: Professional Association

	Frequency	Percentage
NIA	46	24
NIOS	59	30
NSE	45	23
NIOB	34	18
Others	10	5
Total	194	100.0

The Table reveals that a large chunk of the respondents with 30% representation belonged to NIQS as members, followed by those that were members of NIA with about 24% participation in the study and those that disclosed their membership in NSE with 23% representation. Membership of the respondents to various professional associations as mentioned in the Table established some level of confidence in data generated for this study as the responses supplied by them were a reflection of their knowledge and exposure as far as construction profession is concerned.

5.2.3 Level of Professional Membership

According to Table 5.3, 1% of the respondents were at the level of Technicians in their membership of professional associations, 18% were at the level of Probationer in their membership, 75% were still ordinary members, while 2% of the respondents had acquired the status of fellow in the associations they belonged to.

Table 5. 4: Level of Professional Membership

	Frequency	**Percentage**
Technician	2	1
Probationer	35	18
Member	146	75
Fellow	4	2
Total	187	96

It is clear from the Table above that majority of the respondents (78%) had membership status in the professional association they belonged to, followed those that were probationers in their professional associations. Only 2% had attained the status of fellow. This implies that majority of the responses came from those that can be described as having middle membership status in their professional associations.

5.2.4 Professional Experience in Practice

Table 5.5 shows that 34% of the respondents had less than 5 years post professional qualification experience in the construction profession, while 32% had between 5 and 10 years of practical experience. About 16% had been in the profession for 11-15 years, while 11% had practical experience of 16-20 years in the profession. Seven percent have above 20 years professional experience.

Table 5. 5: Post Qualification Professional Experience in Practice

	Frequency	Percentage
Less than 5 years	66	34
Between 5-10 years	62	32
Between 11-15 years	30	16
Between 16-20 years	22	11
Above 20 years	14	7
Total	194	100.0

As shown in the Table, majority of the respondents had spent less than 5 years in the post qualification professional practice, followed by those that had spent between 5 and 10 years. Meanwhile, A sizable percent of the total distribution had been in the profession for 11-20 years with a good number of them having over 20 years experience. The point here is that data for this study were generated from a combination of those that were highly experienced in the field of construction work and those that were averagely experienced in the profession.

5.2.5 Status in the Organization

Table 5.6 presents status of the respondents in their various firms. According to the Table, 10% of the respondents were working in their firms as supervisors or foreman, 17% were working as assistant or junior professional staff, 11% as site engineers, 18% were senior staff, 29% as project managers or partners, while 2% were working as site managers. In the Table, 8% were working directors or principal partners in their firms.

Table 5. 6: Status in the Organization

	Frequency	Percentage
Supervisor/Foreman	20	10
Assistant/Junior Professional Staff	33	17
Site Engineer	22	11
Senior Staff	34	18
Project Management/Partner	57	29
Site Manager	4	2
Director/Principal Partner	16	8
Total	186	95

It is understood from the Table that respondents who were working in their firms as either project managers or partners participated more in the study than other status categories. Respondents that were senior staff in their firms had a high representation in the study followed by those that were site engineers. In essence, people that participated in this study were qualified professionals who were believed to understand the main objective of the study and thereby supplying relevant information in the course of fielding answers to the questionnaire items.

5.2.6 Age/Experience of Organization in Operation

According to Table 5.7, 14% of the respondents revealed that their organizations had less than 5 years of experience in operation, while about 27% said that their organizations had been in operation for 5-10 years. About 22% of the respondents affirmed that their firms had been operating in the construction industry for 11-

15 years, while 21% reported 16-20 years of professional experience for their organizations.

Table 5. 7: Age/Experience of Organization in Operation

	Frequency	Percentage
Less than 5 years	28	14
Between 5-10 years	52	27
Between 11-15 years	42	22
Between 16-20 vears	41	21
TOTAL	163	84

Data in the Table above shows that a large chunk of the respondents were actually qualified to participate in the study as they were working in firms that had been in operation for 5-20 years. That is, it is only 14% of the respondents who were working in firms that had less 5 years of experience in the construction industry.

5.2.7 Form of Ownership of your Organization

Table 5.8 shows that about 37% of the respondents were working in sole proprietorship companies, as against 24% that were working in partnership companies. Furthermore, 11% of the respondents were working in organizations with corporation brand, while about 27% were working in limited liability companies.

Table 5. 8: Form of Ownership of your Organization

	Frequency	Percentage
Sole Proprietorship	71	37
Partnership	47	24
Corporation	22	11
Limited Liability	52	27

It is shown in the Table above that majority of the respondents worked in sole proprietorship organizations followed by those working in limited liability companies and partnership organizations respectively. The implication is that data were generated from across forms of construction company ownership. This makes the study robust.

5.2.8 Size of Organization

The 5.9 presents data on the size of respondents' organizations. According to the Table, about 25% of the respondents operated in small firms, while about 56 worked in medium size organizations. Lastly, the Table reveals that atleast 19% of the respondents worked in large organizations.

Table 5. 9: Size of Organization

	Frequency	**Percentage**
Small	48	25
Medium	108	56
Large	38	19
TOTAL	194	100

Data presented in Table 5.9 further justified the robustness of this study as it involved participants from small, medium and large organizations. This means the study was able to access information from people working under different organizational complexity.

5.2.9 Type of Client

As revealed in Table 5.10, 30% of the respondents affirmed that their organizations get contract from the public sector; while about 70% work for the private sector.

Table 5. 10: Type of Client

	Frequency	Percentage
Public Sector	59	30
Private Sector	135	70
Total	194	100

It is understood from the Table that majority of the respondents had their experience in the profession executing contractual agreements between their firms and the private sector. However, the study did not preclude people working in organizations that execute contracts for the public sector.

5.2.10 Position of Organization on Project

According to Table 5.11, 10% of the respondents revealed that their organizations worked as clients on construction projects; while 44% indicated5 their firms worked on construction projects as contractors. About 44% said their organizations worked on projects as consultants.

Table 5. 11: Position of Organization on Project

	Frequency	Percentage
Client	20	10
Contractor	86	44
Consultant	85	44
TOTAL	191	100

Data in Table 5.11 created the understanding that majority of the respondents belonged to organizations that work on construction projects as contractors and or consultants respectively.

5.2.11Type of Project

Table 5.12 shows that 46% of the respondents belonged to organizations that work on residential projects, 29% were employees in organizations work on commercial projects. Only 5% of the respondents came from companies that have interest in industrial project, while 3% were from firms that work on civil engineering projects. Respondents that came from organizations that work on other types of projects than the ones mentioned constituted 12% of the total distribution.

Table 5. 12: Type of Project

	Frequency	Percentage
Residential	90	47
Commercial	57	29
Industrial	10	5
Civil Engineering	6	3
Others	24	12
TOTAL	187	96

It can be deduced from the Table above that majority of the respondents worked for organizations whose interest is in residential projects, followed by those that worked for companies that favour commercial projects. The import of these differences in the type projects in individual organizations is that respondents provided information to the current study as related to their professional world view.

5.2.12 Form of Contract used on Project

In Table 5.13, it is revealed that about 70% of the respondents mentioned JCT as the form of contract used on project in their organizations, while 6 indicated FIDIC as the contract form their firms use on projects. Furthermore, 2% of the respondents indicated NEC3 as the form of contract their organizations use on projects, and about 8% affirmed their companies use GC/Works contract as a contract form. Other forms of contract are used by organizations to which 8% of the respondents belong.

Table 5. 13: Form of Contract used on Project

	Frequency	Percentage
JCT	135	70
FIDIC	12	6
NEC3	4	2
GC/Works Contract	15	8
Others	16	8
TOTAL	182	94

It can be deduced that majority of the respondents work in organizationsthat make use of JCT as a contract form, followed by those that work in firms that use other forms of contract.

5.2.14 Bidding System adopted for Project

Table 5.14 reveals that organizations of about 24% of the respondents adopt open tendering, while 32% of them work in organizations that adopt negotiated tendering. Serial tendering is adopted by firms that employed less than 1% of the respondents, and selected tendering is used as a bidding system by 41% the respondents' firm.

Table 5. 14: Bidding System adopted for Project

	Frequency	Percentage
Open Tendering	46	24
Negotiated	62	32
Serial Tendering	1	1
Selected Tendering	79	41
TOTAL	188	98

It can be inferred from the Table above that majority of the respondents work in organizations that adopt selected tendering as a binding system. Second to this category are respondents that are employed in firms that adopt negotiated tendering and open tendering respectively.

5.2.15 Delivery Methods for Project

Table 5.15 presents delivery methods used by the respondents' organization for projects. According to the Table, about 35% of the respondents indicated lumpsum contract as their organizations' delivery method, 24% indicated measurement contract as their organizations' delivery method. Furthermore, 5% of the respondents affirmed their organizations use cost reimbursement contract as a delivery method, while another 5% mentioned turnkey or package deal contract as their firms' delivery method. Design and build contract was indicated by about 11% of the respondents as their firms' delivery method; while construction management was mentioned by 11% as delivery method in their organizations. More so, 3% indicated management contract as delivery method in their companies, and 4% mentioned contractor's design for specific element as a delivery method adopted by their firms.

Table 5. 15: Delivery Methods for Project

	Frequency	**Percentage**
Lump sum Contract	67	35
Measurement Contract	47	24
Cost Reimbursement Contact	10	5
Turnkey or Package Deal Contract	10	5
Design and Build Contract	21	11
Construction Management	22	11
Management Contract	6	3
Contractor's Design for Specific Element	8	4
TOTAL	191	98

This Table shows that lump sum and measurement contract respectively are the delivery methods used by organizations of the majority of the respondents.

5.3 AN EVALUATION OF CRITICAL SUCCES FACTORS FOR KEY PERFORMANCE INDICATORS

5.3.1 STATISTICAL PROCEDURES AND ANALYSES

In order to obtain an overall picture of the levels of significance of the critical success factors - CSF for the key performance indicators KPIs of construction projects from the survey, the list of CSF was assessed in line with the KPIs for Cost, Time, Quality, and Health and Safety. These CSFs were evaluated individually, and the findings are outlined in the subsequent sections. Here also a variety of statistical procedures were employed in the analyses of the data starting with basic descriptive statistics to the more complex procedures of factor analysis. The descriptive statistics encompassed frequency distributions, measures of central tendency such as means, and measures of dispersion such as the standard deviation. The scales used in the data collected were checked for reliability to ascertain the reliability of the data collected thus, Cronbach's Alpha was used to check for the internal consistency and suitability of criteria contained in the questionnaire for analysis. If the data were found reliable, then the Mean of each of the variables of critical success factors for the performance indicator is presented. The nonparametric statistical test of Kruskal-Wallis was used to test for the significance of the differences between the mean ranks of CSF for Time KPIs based on the different organisations involved in the project. Finally, Factor analysis was thereafter carried out to examine the underlying structure or the structure of interrelationships (or correlations) among the performance variables due to the need for data reduction. Principal components analysis was used for the extraction of factors. The extracted components were used to compute new variables for subsequent analysis. A set of factors or underlying variables which were developed from the analysis which, when interpreted and understood, according to Hair et al., (1998) describe the data with a more meaningful number of concepts that are closely fitted than the original individual variables.

5.3.2 Reliability Test for CSF for Time

Establishing the reliability of the data set used in this research, internal consistency of these items was evaluated using Cronbach's Alpha. This is an important recommendation for researchers in order to assess the degree to which items that make up the scale 'hang together' in ascertaining whether they measure the same construct by determining the Cronbach's alpha coefficient (Pallant, 2005; Nunnally and Bernstein,2007; Field,2013;). The Cronbach's alpha ranges from 0 to 1, the benchmark that is acceptable for consistency among researchers isanoverall value of 0.7 which represents an acceptable consistency. Nunnally and Bernstein (2007) asserted that 0.8 indicates a good internal consistency. The data for this work, the data were fed into SPSS version 24, the overall Cronbach's alpha coefficient for data set is 0.921,this confirms excellent reliability and internal consistency (Ajayi, et al., 2016). This is presented in Table 5.10.

Table 5. 16: Reliability Test Statistics

Reliability Statistics		
Cases	Valid	194
	Excluded	0
	Total	194
Statistics	Cronbach's Alpha	.921
	No of Items	34

This indicates that the data set used for the research for CSF for Time as a KPI is internally consistent and the respondents had provided responses based on clear and common understanding of the questions in the questionnaire and thus the results for the research findings are reliable. Notwithstanding the excellent result of the reliability, the Chronbach's alpha of the individual item in the data set were subsequently assessed to check for those that could still be questionable. Pallant (2005) advised researchers to consider removing item with low item-total correlation. This is discovered to indicate items with Cronbach's alpha above the established value, in this case 0.921 which Ajayi, et al., (2016) demonstrated that such item is not a good construct and should be deleted from the list of variables. Field (2013) emphasised the need to evaluate "Cronbach's alpha if item deleted" for good internal consistency and the need to delete accordingly. As shown in Table 5.11 four variables out of thirty 34 variables were discovered to have their Chronbach's alpha (Ca) value above 0.921with low item-total correlation of 0.202, 0.237, 0.224 and 0.172 respectively as will be stated (all less than 0.3), and they were therefore removed from further analysis. The deleted outliers are; Clear Objectives on Project Outcomes (Mean, 4.41; Ca, 0.922), Ability to adapt to changes on the project (Mean, 4.19; Ca, 0.922), Cultural environment (Mean, 3.90; Ca 0.923), and Use of innovations such as BIM, e-tendering impacts on project (Mean, 3.75; Ca, 0.922). They were rated 2nd, 14th, 29th and 31st respectively. After deleting these four outliers the Cronbach's alpha coefficient improved to 0.93.

Therefore, the remaining items are the CSF that 'hang together' to determine Time performance of construction projects in Nigeria.

5.3.3 Mean Score of Critical Success factors for Time Performance

From the analysis of the descriptive statistics presented in Table 5.10 the mean values of the individual factors and the rankings from the most influential factors to the lowest. The Critical Success Factors were rated using the mean score and where variables had the same mean score, standard deviation was used to determine which variable was stronger than the other. The research employed the Likert scale of 1 to 5, and interestingly the results were divided into two influential divisions thus 23 factors from the remaining 30 factors (25 less 2 outliers at 34 items)while the second division were 7 factors from the remaining 30 factors (9 less 2 outliers at 34 items) scaled between 3 and 4. All these factors tend to scale 4 which is very significant thus critical. As depicted in the Summary item statistics Table 5.13, the Mean of all the Means of these items is 4.10 which explain that they are all very significant.

Technical Competence and Management capacity of the contractor is rated first with a Mean of 4.42 and the next top four Critical Success Factor for Time performance are, Employment of Competent and Skilful Workforce, Commitment of project manager to project, Healthy Financial Condition and stability of contractor, and Client's Project Financing for regular cash flow as presented in Table 5.11. It is fascinating to note that the next six factors were in the 4.22 range, and five factors in the next 4.1 range. There are seven factors in the mean bound of 4.0 range which also correspond to the last group in the range of 3.59 to 3.99. The result is creating a pattern and one of the focus of the research is to assess the interrelationship among these CSF variables in influencing KPI.

Table 5. 17: Mean Score of Critical Success factors Time Performance

S/N	Critical Success factors	Mean	SD	Cronbach's Alpha if Item Deleted	Rating
T1	Technical Competence and Management capacity of	4.42	0.624	0.918	1
T2	Clear Objectives on Project Outcomes (e.g.	4.41	0.798	0.922	2
T3	Employment of Competent and Skilful	4.39	0.628	0.918	3
T4	Commitment of project manager to project	4.38	0.618	0.919	4
T5*	Healthy Financial Condition and stability of	4.32	0.662	0.92	5
T6	Client's Project Financing for regular cash flow	4.30	0.648	0.919	6
T7	Information Coordination, communication and	4.28	0.671	0.918	7
T8	Management capacity and Competence of	4.26	0.687	0.92	8
T9	Initial identification of all the risks	4.25	0.722	0.917	9
T10	Adequate time to project (Realistic Programme)	4.25	0.736	0.917	10
T11	Ability of client to make timely and accurate decisions on the project	4.23	0.713	0.917	11
T12	Contractor's Ability to Manage Designs	4.22	0.703	0.918	12
T13	Adequacy of information available on the	4.19	0.844	0.918	13
T14	Ability to adapt to changes on the project	4.19	0.703	0.922	14
T15	Type and Nature of Client	4.15	0.622	0.919	15
T16	Construction methods adopted on the project	4.13	0.932	0.919	16
T17	Early Involvement of Contractors	4.12	0.669	0.917	17
T18	Site management by contractor	4.11	0.693	0.917	18
T19	Timely Production of required Design	4.07	0.706	0.917	19
T20	Early Involvement of Project Manager	4.06	0.695	0.918	20
T21	Clear, Correct and Precise	4.06	0.703	0.917	21
T22	Ability to solve unanticipated problems that	4.05	0.703	0.917	22
T23	The condition of the equipment (state of repair)	4.03	0.740	0.918	23
T24	Efficiency of communication on the project	4.02	0.762	0.917	24
T25	Government's institutional and administrative	4.00	0.755	0.916	25
T26	Delivery time of resources (materials,	3.99	0.792	0.918	26
T27	Economic environment	3.96	0.655	0.92	27
T28	Collaborative Supervision/inspection on the project (Consultants with Client)	3.95	0.806	0.918	28
T29	Cultural environment	3.90	0.748	0.923	29
T30	Physical work environment such as weather, public disturbance (area boys)	3.82	0.810	0.918	30
T31	Use of innovations such as BIM, e-tendering impacts on project	3.75	0.899	0.922	31

T32	Legal environment	3.67	0.930	0.919	32
T33	State of Health and Safety (e.g. Accident cause	3.64	0.828	0.92	33
T34	Implementation of Innovative Techniques	3.59	0.924	0.919	34

Table 5.18: Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.100	3.593	4.418	.825	1.230	.044	30

Despite having a very significant Mean for the overall of all these Items that influence Time performance, the descriptive mean testing has been used to determine five key CSF for the time KPI. These are the top five most significant Critical Success factors that affect time performance as a KPI in Nigeria construction industry are related to Contractor and Client capacity to deliver the project.

5.3.4 Kruskal-Wallis test

A non-parametric test for independent samples was carried out on the data set to compare the variables across the three categories of parties involved on projects that the respondents had experienced. Kruskal-Wallis test was chosen as an alternative to the one-way between groups analysis of variance (Pallant, 2005) which is non-parametric test of null hypothesis that is used to evaluate whether different categories of respondents differ by comparing scores of a particular hypothesis (Gupta, 1999; Pallant, 2005). In this research, the difference among respondents of clients, consultants and contractors' organisation were assessed to determine the disparity between the mean ranks. p-value below 0.05 in Kruskal-Wallis test indicates that there is a significant difference between the groups of participant about the affected variable at 95% confidence level. Any p-value above 0.05 indicates that there is no significant difference among the groups. In Table 5.11, the item serial number S/N has asterisks* and thus, five CSF were having p-values (sig) less than the traditional 0.05. These are items T5, T20, T21, T22, and T25. This imply that there could be underlying facts about the distribution of the mean ranking of the affected items by the respondents as T5 relates 'Healthy Financial Condition and stability of contractor' compare to T21 'Clear, Correct and Precise Drawings/Documents' a possible disparity between contractors and consultants.

5.3.5 Exploratory Factor Analysis of CSFs for Time Performance.

In order to establish a coherent subscales of grouping of the CSF for Time performance indicator factor analysis was employed based on the aim of this research, which is to determine critical success factors for timely project delivery in Nigeria from the relationship between the variables that could be used to conceptualise the dynamic relationship of CSFs and KPIs for performance.This requires the establishment of key underlying measures from the established sets of identified factor. The 30 factors so far established can be reduced to smaller number of critical factors for ease of assessing performance of construction projects. There are three main steps required in conducting factor analysis which according to Pallant (2005) include: assessment of suitability of the data, factor extraction and factor rotation.

Table 5. 19: Summary Item Statistics

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.848
	Approx. Chi-Square	5097.146
Bartlett's Test of Sphericity	Df	435
	Sig.	.000

Assessing the data and extracting the factors was the first step explored using SPSS version 24 output of the Factor analysis shows an impressive result as all the factors have correlation coefficients that are above 0.3. Also, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling adequacy is above 0.6, and the Bartlett's test of sphericity is .000, which is significant (i.e. Sig. value should be .05 or smaller. Therefore, factor analysis is appropriate having satisfied these preliminary requirements.

In order to determine the number of components or (factors) to 'extract' (Pallant, 2011) that will suitably represent the whole factor, the 'Total Variance explained' table from the SPSS version 24 was looked into and the Initial Eigenvalues above 1 for each of the component variables that are listed. Only Seven components recorded eigenvalues above 1 (10.308, 4.557, 2.477, 1.551, 1.250, 1.103, and 1.013). These seven components explain a total of 74.197per cent of the variance. Pallant (2011) suggested that the scree plot would be useful in determining the number of components as Kaiser criterion often extract too many components.

Thus, the Scree plot is assessed for possible guide (i.e. the elbow change point) in the shape of the plot. Only components above this point are retained in the analysis. Nunnally and Bernstein(2007) recommended retaining minimum Eigenvalue of 1, Using our Scree plot it is clearly observed that there is a break between components 4 and 5 and therefore it is logical to retain four components.

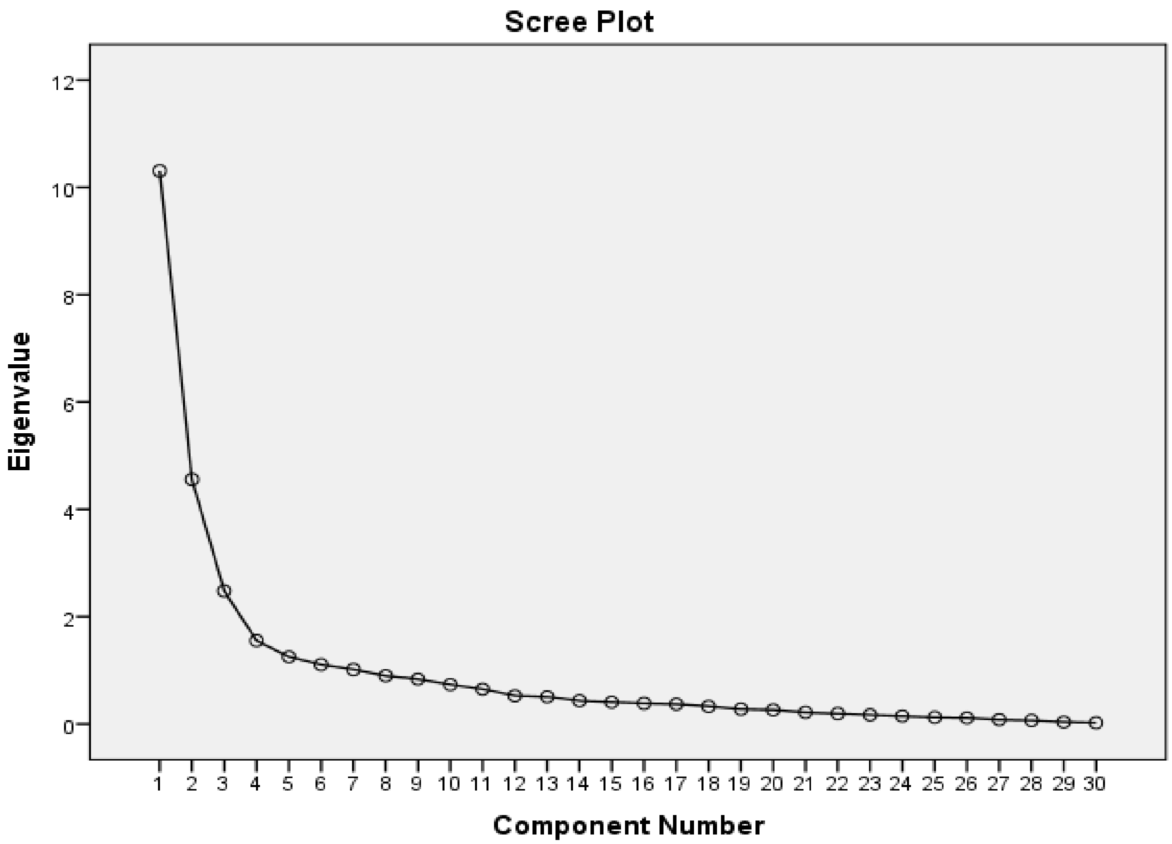


Figure 5. 1: Scree plot of the Eigenvalue for Establishing Time Components

The factor rotation and interpretation was carried out for the four components. It was observed that the distribution of the variance explained has also been adjusted after rotation. Component 1 (Comp1) now explains 34.98 percent of the variance; Comp2, 15.03 percent; Comp3, 8.80 percent; and Comp4, 5.48 percent of the variance respectively as presented in Table 5.12. The total variance explained is 64.28. These four established components were subjected to further analysis using Varimax with Kaiser Normalization rotation method. This retained the four components but with more redistribution of the components, Eigenvalue and percentage variance for each component. Out of these components, cross loadings were checked for variables that load on more than one component. The analysis was rerun for one less and one more (Pallant, 2005, 2011) and thus, 3 extracts and five extract components were tried to check the cross loadings again. It was observed that four variable factors were cross loading in two components; T11, Ability of client to make timely and accurate; T17, Early Involvement of Contractors; T34,Implementation of Innovative Techniques and T12, Contractor's Ability to Manage Designs as highlighted in Table 5.13. Tabachnick and Fidell (2000) suggested the removal of such crossloading items from the analysis thus; these three factors were subsequently dropped.

Table 5. 20: Pattern/Structure Coefficient of Extracted Components of CSF for Time Performance

	Extracted and rotated components	1	2	3	4	Eigenvalue	%variance
Comp 1	**Client's Design and Project Management Capacity**					**9.793**	**34.976**
T22	Ability to solve unanticipated problems that occur during the course of the	.954					
T21	Clear, Correct and Precise	.927					
T19	Timely Production of required Design	.905					
T24	Efficiency of communication on the	.866					
T20	Early Involvement of Project Manager	.856					
T6	Client's Project Financing for regular	.803					
T25	Government's institutional and administrative influence e.g.	.776					
T8	Management capacity and Competence of project manager	.751					
T15	Type and Nature of Client	.750					
T9	Initial identification of all risks	.717					
Comp 2	**Construction Resource Management**					**4.207**	**15.025**
T16	Construction methods adopted on the project such as use of only precast		.753				
T13	Adequacy of information available on		.715				
T11	Ability of client to make timely and accurate decisions on the project	.383	.671				
T26	Delivery time of resources (materials,		.664				
T10	Adequate time to project (Realistic		.648				
T23	The condition of the equipment		.646				
T7	Information Coordination, communication and relationship		.534				
T28	Collaborative Supervision/inspection on the project (Consultants with		.533				
T33	State of Health and Safety		.396				
T18	Site management by contractor		.326				
Comp	**Project Management of Contractor's**					**2.464**	**8.800**
T5	Healthy Financial Condition and stability of contractor			.865			
T4	Commitment of project manager to			.862			
T1	Technical Competence and Management capacity of the contractor			.843			
T17	Early Involvement of Contractors		.391	.711			
T3	Employment of Competent and Skilful			.693			
T34	Implementation of Innovative		.460	.578			
T12	Contractor's Ability to Manage Designs			.493			
Comp	**External Environment Factors**					**1.535**	**5.482**
T27	Economic environment				.445		
T30	Physical work environment such as weather, public disturbance (area				.878		
T32	Legal environment				.872		
	% of variance extracted						**64.283**

Rotation Method: Varimax with Kaiser Normalization.

Table 5. 21: Pattern/Structure Coefficient of Extracted Components of CSF for Time Performance

	Extracted and rotated components	1	2	3	4	Eigenvalue	%variance
Comp1	**Design Team Commitment to Project Management Outcomes**					**9.541**	**35.337**
T22	Ability to solve unanticipated problems that occur during the course of the project	.984					
T21	Clear, Correct and Precise	.949					
T19	Timely Production of required Design	.925					
T20	Early Involvement of Project Manager	.894					
T24	Efficiency of communication on the project	.859					
T6	Client's Project Financing for regular cash	.811					
T15	Type and Nature of Client	.790					
T25	Government's institutional and administrative influence e.g. regulations,	.779					
T8	Management capacity and Competence of project manager	.741					
T9	Initial identification of all the risks	.697					
Comp2	**Capacity of Contractor for Project Management**					**4.062**	**15.045**
T16	Healthy Financial Condition and stability of contractor		.939				
T4	Commitment of project manager to project		.925				
T1	Technical Competence and Management capacity of the contractor		.845				
T18	Site management by contractor		.697				
T17	Employment of Competent and Skilful		.663				
Comp3	**Construction Resource and Management**					**2.457**	**9.099**
T16	Construction methods adopted on the project such as, concrete pumps, use of only precast components			-.820			
T13	Adequacy of information available on the			-.769			
T26	Delivery time of resources (materials, equipment)			-.677			
T11	Ability of client to make timely and accurate decisions on the project			-.675			
T23	The condition of the equipment (state of			-.661			
T10	Adequate time to project (Realistic			-.601			
T7	Information Coordination, communication and relationship among project parties			-.542			
T28	Collaborative Supervision/inspection on the project (Consultants with Client)			-.521			
T33	State of Health and Safety (e.g. Accident			-.360			
Comp4	**External Factors**					**1.531**	**5.670**
T27	Economic environment						
T30	Physical work environment such as weather, public disturbance (area boys)				.866		
T32	Legal environment				.864		
	% of variance extracted						**65.151**

The 30 items of Critical Success Factors for Time Key Performance Indicator were subjected to principal components analysis (PCA) using SPSS version 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The KaiserMeyer-Olkin value was .848, exceeding the recommended value of .6 (Kaiser 1970, 1974) and Bartlett's Test of Sphericity (Bartlett 1954) reached statistical significance, supporting the factorability of the correlation matrix.

Principal components analysis revealed the presence of seven components with eigenvalues exceeding 1,explaining10.31%, 4.56%, 2.48%, 1.55%, 1.25%, 1.10%, and 1.01%of the variance respectively. An inspection of the scree plot revealed a clear break after the fourth component. Using scree test, following Pallant's suggestion (2005, 2011), it was decided to retain four components for further investigation. The four-component solution explained a total of **64.28**% of the variance, with Component 1 contributing 34.98%, Component contributing 15.03%,Component 3 contributing 8.80%, and Component 4 contributing 5.48%. To aid in the interpretation of these four components, oblimin rotation was performed. The Oblimin rotation for the four-component solution explained an improved total of **65.15**% of the variance, with Component 1 contributing 35.34%, Component 2 (was the Comp3 in the Varimax rotation, now with reduced variables) contributing 15.05%, Component 3 (Comp2 in the Varimax rotation,) contributing 9.10%, and Component 4 contributing 5.67%. The rotated solution revealed the presence of simple structure (Thurstone 1947), with the four components showing a number of strong loadings and all variables loading substantially on only one component. The interpretation of the four components was consistent with previous research on the PANAS Scale, with positive affect items loading strongly on Components 1,2 and 4, and negative affect items loading strongly on Component 3. There wasa weak negative correlation between Comp3 and each of the other three components factors (r =-.344, -.333 and -.209) and Comp1, 2, and 4 have weak positive correlation (r, ranges from .055 to .178). The results of this analysis support the use of the positive affect items and the negative affect items as separate scales, as suggested by the scale authors (Watson, Clark & Tellegen 1988).

Table 5. 22: Pattern and Structure Matrix for CSF with Oblimin Rotation of Four Factor Solution of Positive and Negative Affect Scale (PANAS) Items

ITEM S/N		Pattern Coefficient				Structure Coefficient				Communalities
	Item	1	2	3	4	1	2	3	4	Extraction
T22	Ability to solve unanticipated problems that occur during the course of the project	.985	.039	.077	.013	.966	.190	-.277	.064	.512
T21	Clear, Correct and Precise Drawings/Documents	.949	.009	.025	.010	.942	.170	-.306	.068	.517
T19	Timely Production of required Design Documents	.925	.031	.029	.031	.923	.188	-.305	.088	.445
T20	Early Involvement of Project Manager	.891	-.059	.087	.027	.886	.106	-.390	-.077	.600
T24	Efficiency of communication on the project	.859	-.091	-.159	-.162	.853	.072	-.205	.064	.873
T6	Client's Project Financing for regular cash flow	.810	-.059	-.070	.116	.831	.115	-.353	.181	.567
T15	Type and Nature of Client	.789	.017	.142	.127	.814	.296	-.343	.201	.248
T25	Government's institutional and administrative influence e.g. regulations, permits	.780	.151	.005	.142	.792	.206	-.398	.120	.648
T8	Management capacity and Competence of project manager	.741	.030	-.125	.044	.752	.118	-.162	.150	.740
T9	Initial identification of all the risks	.694	-.093	-.213	-.200	.737	.090	-.378	-.115	.800
T16	Healthy Financial Condition and stability of contractor	.028	.939	.185	-.050	.124	.888	-.199	.032	.769
T4	Commitment of project manager to project	-.004	.925	.108	.004	.128	.880	-.127	-.035	.808
T1	Technical Competence and Management capacity of the contractor	.106	.845	-.014	.020	.263	.870	-.336	.077	.544
T18	Site management by contractor	-.137	.697	-.132	.046	.132	.745	-.488	.158	.632
T17	Employment of Competent and Skilful Workforce	-.089	.663	-.284	.068	.035	.719	-.326	.103	.712
T16	Construction methods adopted on the project such as use of only precast building	-.163	-.066	-.820	.057	.111	.181	-.754	.215	.607
T13	Adequacy of information available on the project	-.029	-.022	-.769	.003	.231	.228	-.752	.160	.422
T26	Delivery time of resources (materials, equipment)	.004	-.020	-.677	.140	.492	.303	-.748	.014	.644
T11	Ability of client to make timely and accurate decisions on the project	.263	.040	-.675	-.146	.355	.499	-.722	.109	.826
T23	The condition of the equipment (state of repair)	.041	-.027	-.661	.162	.243	.214	-.702	.282	.939
T10	Adequate time to project (Realistic Programme)	.101	.283	-.601	-.039	.274	.209	-.700	.301	.592
T7	Information Coordination, communication and relationship among project parties	.169	.096	-.542	-.197	.253	.292	-.617	.355	.853
T28	Collaborative Supervision/inspection on the project (Consultants with Client)	.040	.099	-.521	.238	.359	.296	-.590	-.067	.888
T33	State of Health and Safety (e.g. Accident cause delay)	.032	.051	-.360	.236	.181	.190	-.438	.317	.607
T27	Economic environment	.160	.206	-.271	-.168	.279	.316	-.360	-.089	.870
T32	Legal environment	.142	.059	-.116	.866	.247	.120	-.379	.905	.223
T30	Physical work environment such as weather, public disturbance (area boys)	.138	-.002	-.151	.864	.249	.171	-.366	.903	.706
	Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization.									
	a. Rotation converged in 10 iterations.									

Oblimin rotation provides two tables of loadings. The Pattern Matrix shows the factor loadings of each of the variables. To identify and label the Components, the highest loading items on each component drives the labelling. Thus, Component 1 (Comp1) was labelled Design Team Commitment to Project Management Outcomes, Comp2 was labelled Capacity of Contractor for Project Management, Comp3 was labelled Construction Resource Management, and Comp4 was labelled External Factors. Comp1, 2 and 4 are all positive affect. The negative affect show on Comp3 – Construction Resource and Management is an indication of the general perception of practitioners in the Nigeria construction industry perceive the impact of construction resources and management strategy employed in optimising the use of these resources for time performance. Table 5.14 presents the Pattern and Structure Matrix for CSF with Oblimin Rotation of Four Factor Solution of Positive and Negative Affect Scale (PANAS). The correlation between variables and factors is depicted in the Structure Matrix table. The Communalities table is also presented to give information about how much of the variance in each item is explained. Low values (e.g. less than .3) could indicate that the item does not fit well with the other items in its component; items T15 and T32, Type and nature of client, and legal environment were typical in this regard. This suggests that further removal of these two items could improve and increase the total variance explained.

5.3.6 Labelling the Components

The four groups established in this analysis correspond with some of the success factors that had been reported in literature. Although, the research has provided a different perspective to the way the success factors should be assessed as different factors that are reported separately in literatures are linked as associates in this research indicating structure of an underlying relationship.

5.3.6.1 Design Team Commitment to Project Management Outcomes

This factor component has the highest percentage of the total variance (35.34%), and it consists of ten policy suggestions as presented in Table 5.12. The factor name, "Design Team Commitment to Project Management Outcomes", was so labelled because initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria is project management which is the core responsibility of the design team including client, project manager and the professional designers like architect and engineers. All measures that made up the group suggest measures that could only be achieved through a commitment to Project management effort on outcomes such as Ability to solve unanticipated problems that occur during the course of the project, Clear, Correct and Precise Drawings/Documents, Timely Production of required Design Documents, Early Involvement of Project Manager, Efficiency of communication on the project, Client's Project Financing for regular cash flow, Type and Nature of Client, Government's institutional and administrative influence e.g. regulations, permits; Management capacity and Competence of project manager, and Initial identification of all the risks that are likely to occur on the project. All these are key to the success of project management process.

5.3.6.2 Capacity of Contractor for Project Management

The second group factor is Capacity of Contractor for Project Management which has five measures of CSF for Time performance indicator and they contributed a total variance of 15.05%. The factor component suggests that achieving Time performance requires the Contractor to have capacity that flows in tune with project management principle thus, incorporating the project manager within its fold. The variable items under this group are, Healthy Financial Condition and stability of contractor, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Site management by contractor, and Employment of Competent and Skilful Workforce. These factors clearly show the capacity of the contractor's management but that is not all, it requires that there is an oversight on the contractor management as a well managed company could strategically desire to delay project completion if adequate oversight function is not carried out by the project manager.

5.3.6.3 Construction Resource Management

Construction Resource Management is the imposed identity for the third component. The factor component consists of nine factors, all of which suggest measures for Construction Resource Management having a total variance of 9.10%. Delivering complicated projects with thin profit margins on time and within a budget have been a unique problem for Construction companies. There are arguments and literatures advocating for resource management in the construction industry becoming more important now than ever. The CSF for Time performance under this component include Construction methods adopted on the project, Adequacy of information available on the project, Delivery time of resources (materials, equipment), Ability of client to make timely and accurate decisions on the project, The condition of the equipment (state of repair), Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Collaborative Supervision/inspection on the project (Consultants with Client), and the State of Health and Safety.

5.3.6.4 External Factors

External Environmental factors have been reported by researchers to have impact on project performance. The fourth factor category has a total variance of 5.67%, and it is labelled as "External Factors" due to its integration of only three component factors were listed in the group and this include Economic environment (could incorporate financial environment), Physical work environment such as weather, public disturbance (area boys) – which could also be termed political environment and Legal environment which comprise the legislative and government policy or regulations as they affect performance of construction projects.

5.4 Reliability Test for CSF for Cost Performance Indicator

Establishing the reliability of the data set used for CSF for Cost Performance Indicator in this research, internal consistency of these items was evaluated using Cronbach's Alpha as carried out in the last section for Time performance indicator. The Cronbach's alpha ranges from 0 to 1; the benchmark that is acceptable for consistency among researchers is an overall value of 0.7 which represents an acceptable consistency. The overall Cronbach's alpha coefficient for CSFs for Cost data set is 0.919, this confirmed excellent reliability and internal consistency (Ajayi, et al., 2016). This is presented in Table 5.23.

Table 5. 23: Reliability Test Statistics for CSFs for Cost Indicator

Reliability Statistics		
Cases	Valid	192
	Excluded	2
	Total	194
Statistics	Cronbach's Alpha	.919
	No of Items	31

This indicates that the data set used for the research for CSF for Cost as a KPI is internally consistent and the respondents had provided responses based on clear and common understanding of the questions in the questionnaire and thus the results for the research findings are reliable. Notwithstanding the excellent result of the reliability, the Chronbach's alpha of the individual item in the data set were subsequently assessed to check for those that could still be questionable. This is discovered to indicate items with Cronbach's alpha above the established value, in this case 0.919 which Ajayi, et al., (2016) demonstrated that such item is not a good construct and should be deleted from the list of variables. Field (2013) emphasised the need to evaluate "Cronbach's alpha of item deleted" for good internal consistency and the need to delete accordingly.

As shown in Table 5.24 nine variables (as highlighted in Table 5.24) out of thirty-one, 31 variables were discovered to have their Chronbach's alpha (Ca) value above 0.919 with low item-total correlation of 0.282, 0.184, 0.232, 0.114, 0.105, 0.039, 0.193, 0.188 and 0.216 respectively as will be stated (all less than 0.3), and they were therefore removed from further analysis. The deleted outliers are; C5, Timely Production of required Design Documents. (Mean, 4.59; Ca, 0.920), C6, Physical work environment such as weather (Mean, 4.55; Ca, 0.921), C7, Legal environment (Mean, 4.47; Ca 0.922); C8, Clear Objectives on Project Outcomes (e.g. Time, cost, quality & Safety) (Mean, 4.43; Ca 0.922); C12, Implementation of Innovative Techniques by Contractor(Mean, 4.33; Ca 0.921); C19, Clear, Correct and Precise Drawings and Documents (Mean, 4.26; Ca 0.923); C24, Early Involvement of Contractor (Mean, 4.14; Ca 0.923); C27, Cultural environment (Mean, 4.02; Ca 0.921) and C31, Use of innovations such as BIM, e-tendering impacts on project (Mean, 3.41; Ca 0.918). They were rated 5th, 6th, 7th, 8th, 12th, 19th, 24th, 27th, and 31st respectively. After deleting these nine outliers the Cronbach's alpha coefficient improved to 0.935.Therefore,the remaining items are the CSFs that 'hang together' to determine Cost performance of construction projects in Nigeria.

5.4.1 Mean Score of Critical Success factors for Cost Performance

From the analysis of the descriptive statistics presented in Table 5.24 the Mean values of the individual factors and their rankings from the most influential factors to the lowest are listed. The Critical Success Factors for Cost performance indicator were rated using the mean score and where variables had the same mean score, standard deviation was used to determine which variable was stronger than the other. The research employed the Likert scale of 1 to 5, and interestingly only one variable could be said to be Moderately important, all other thirty variables are Important with the top six items leaning towards being Most Important thus extremely critical for cost performance.

The results were divided into two influential divisions thus four factors from the remaining 22 factors (6 less 2 outliers at 31 items) while the second division were 18 factors from the remaining 22 factors scaled between 4.6 and 5 (25 less 7 outliers at 31 items) scaled approximately 4. All these factors tend to scale 4 which is very significant as important factors thus critical. As depicted in the Summary item statistics Table 5.25, the Mean of all the Means of these items is 4.25 which explain that they are all very significant as important factor.

Precise Project Budget Estimate is rated first with a Mean of 4.83 and the next top three Critical Success Factor for Cost performance are Client's Project Financing for regular cash flow, Government's institutional and administrative influence, and Experience of Contractor as presented in Table 5.11. It is fascinating to note that the next six factors were in the4.22range, and five factors in the next 4.1 range. There are seven factors in the mean bound of 4.0 range which also correspond to the last group in the range of 3.59 to 3.99. The result is creating a pattern and one of the focus of the research is to assess the interrelationship among these CSF variables in influencing KPI.

Table 5. 24: Mean Score of Critical Success factors Cost Performance

S/ N	Critical Success factors	Mean	SD	Cronbach's Alpha if	Rating
C1	Precise Project Budget Estimate	4.83	0.554	0.919	1
C2	Client's Project Financing for regular cash flow	4.74	0.616	0.917	2
C3	Government's institutional and administrative influence	4.71	0.627	0.912	3
C4	Experience of Contractor	4.64	0.616	0.917	4
C5	Timely Production of required Design Documents.282	4.59	0.688	0.920	5
C6	Physical work environment such as weather,.184	4.55	0.661	0.921	6
C7	Legal environment .232	4.47	0.874	0.922	7
C8	Clear Objectives on Project Outcomes (e.g. Time, cost, quality & Safety) .114	4.43	0.77	0.922	8
C9	Extent of Subcontracting	4.36	0.725	0.912	9
C1	Contractor's Ability to Manage Design	4.34	0.728	0.918	10
C1	Type and nature of Client	4.33	0.643	0.914	11
C1	Implementation of Innovative Techniques by Contractor.105	4.33	0.727	0.921	12
C1	Employment of Competent and Skilful Workforce	4.32	0.717	0.917	13
C1	Initial identification of all the risks	4.31	0.694	0.912	14
C1	Economic environment	4.30	0.738	0.912	15
C1	Technical and Management capacity of the Contractor	4.29	0.710	0.912	16
C1	Site management by contractor	4.27	0.710	0.912	17
C1	Client's Commitment and Information Coordination with Project Parties	4.27	0.774	0.917	18
C1	Clear, Correct and Precise Drawings and Documents.039	4.26	0.675	0.923	19
C2 0	Ability to solve unanticipated problems that occur during the course of the project	4.23	0.663	0.917	20
C2	Adequate time to project (Realistic Programme)	4.19	0.728	0.917	21
C2	Healthy Financial Condition and stability of the contractor	4.15	0.650	0.913	22
C2	Commitment of project manager to project	4.15	0.663	0.913	23
C2	Early Involvement of Contractor.193	4.14	0.657	0.913	24
C2	Adequacy of information available on the project	4.12	0.632	0.913	25
C2	Management capacity and Competence of project manager	4.09	0.807	0.915	26
C2	Cultural environment.188	4.02	0.701	0.921	27
C2	Construction methods adopted on the project	3.84	0.825	0.917	28
C2	Experience of Project Manager	3.66	1.071	0.919	29
C3	Collaborative Supervision/inspection on project (Client, Consultants & Contractor)	3.53	0.856	0.920	30
C3	Use of innovations such as BIM, e-tendering impacts on project.216	3.41	0.792	0.918	31

Table 5. 25: Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.251	3.531	4.833	1.302	1.369	.092	22

Despite having a very significant Mean for the overall of all these Items that influence Cost performance, the descriptive mean testing has been used to determine four key CSF for the Cost KPI. These are the top four most important Critical Success factors that affect Cost performance as a KPI in Nigeria construction industry.

5.4.2 Kruskal-Wallis test

A non-parametric test for independent samples was carried out on the data set to compare the variables across the three categories of parties involved on projects that the respondents had experienced. Kruskal-Wallis test was chosen as an alternative to the one-way between groups analysis of variance (Pallant, 2005) which is non-parametric test of null hypothesis that is used to evaluate whether different categories of respondents differ by comparing scores of a particular hypothesis (Gupta, 1999; Pallant, 2005). In this research, the difference among respondents of clients, consultants and contractors' organisation were assessed to determine the disparity between the mean rank. p-value below 0.05. The Kruskal-Wallis test indicates that there is a significant difference between the groups of participant about the affected variable at 95% confidence level. Any p-value above

0.05 indicates that there is no significant difference among the groups. None of the CSFs for Cost KPI has a p-value (sig) less than the traditional 0.05 and thus no disparity between client, consultants, and contractors organisation on these CSFs for Cost performance.

5.4.3 Exploratory Factor Analysis for Cost Performance.

In order to establish coherent subscales of grouping of the CSF for Cost performance indicator, factor analysis was employed based on the aim of this research, which is to determine critical success factors for cost effective project delivery in Nigeria from the relationship between the variables that could be used to conceptualize the dynamic relationship of CSFs and KPIs for performance. This requires the establishment of key underlying measures from the established sets of identified factor. The 22 factors so far established can be reduced to smaller number of critical factors for ease of assessing performance of construction projects. There are three main steps required in conducting factor analysis which include: assessment of suitability of the data, factor extraction and factor rotation.

Table 5. 26: The Kruskal-Wallis Test for Cost KPI

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.628
	Approx. Chi-Square	6781.743
Bartlett's Test of Sphericity	Df	231
	Sig.	.000

Assessing the data and extracting the factors was the first step explored using SPSS *version* 24. The output of the Factor analysis shows an impressive result as all the factors have correlation coefficients that are above 0.3. Also, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling adequacy is above 0.6, and the Bartlett's test of sphericity is .000, which is significant (i.e. Sig. value should be .05 or smaller. Therefore, factor analysis is appropriate having satisfied these preliminary requirements.

In order to determine the number of components or(factors) to 'extract' that will suitably represent the whole factor, the 'Total Variance explained' table from the SPSS version 24 was looked into and the Initial Eigenvalues above 1 for each of the component variables that are listed. Only Five components recorded Eigenvalues above 1 (11.268, 2.037, 1.654, 1.582, and 1.009). These five components explain a total of 79.775 per cent of the variance. The Scree plot is assessed for possible guide (i.e. the elbow change point) in the shape of the plot. Only components above this point are retained in the analysis. Nunnally and Bernstein(2007) recommended retaining minimum Eigenvalue of 1, Using our Scree plot it is clearly observed that there is an immediate break between components 1 and 2 and thus can we maintain a single component? From further analysis of the scree plot an incongruent break was observed between 3 and 4 and therefore it could be logical to consider retaining three components.

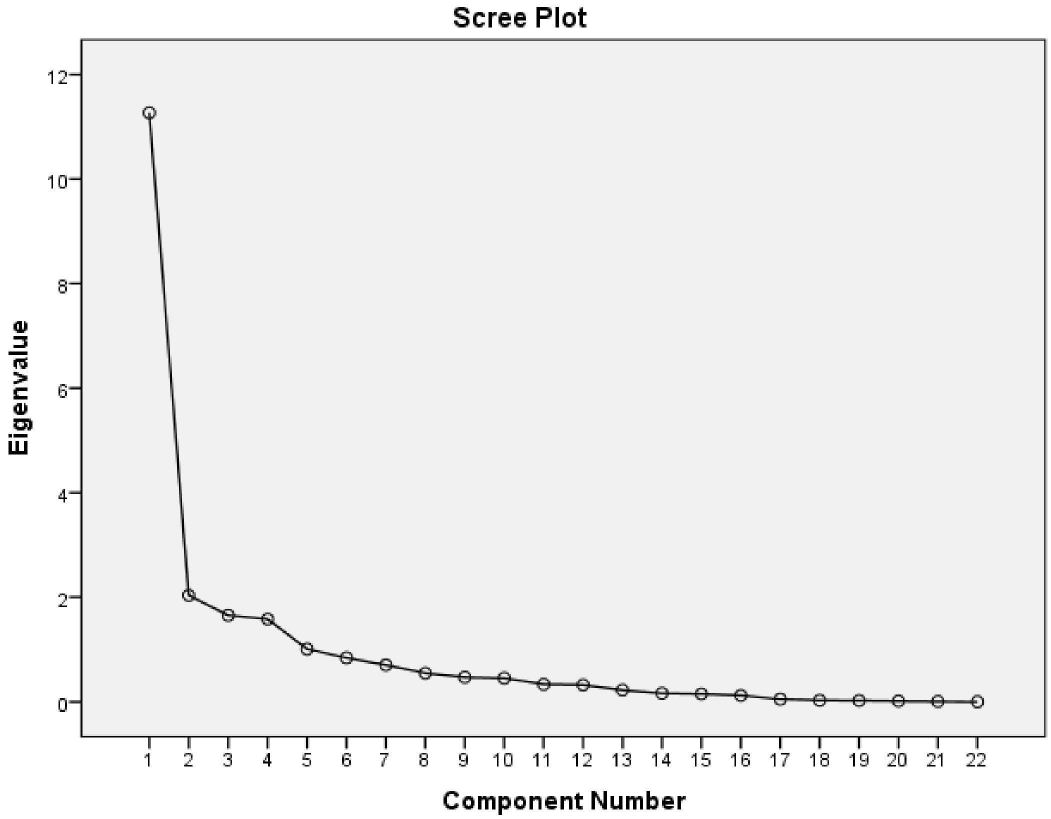


Figure 5.2: Scree plot of the Eigenvalue for Establishing Cost Components

The factor rotation and interpretation was carried out for three components. It was observed that the distribution of the variance explained has been adjusted after rotation. Component 1 (Comp1) now explains 42.773 percent of the variance; Comp2, 15.566 percent; and Comp3, 9.659 percent of the variance respectively as presented in Table 5.27. The total variance explained is 67.997. These three established components were subjected to further analysis using Varimax with Kaiser Normalization rotation method. This retained the three components but with more redistribution of the components, Eigenvalue and percentage variance for each component. Out of these components, cross loadings were checked for variables that load on more than one component. The analysis was rerun for one less and one more (Pallant, 2005, 2011) and thus, two extracts and three extract components were tried to check the cross loadings again. It was observed that five variable factors were cross loading in two or even three components; C4, Experience of Contractor, C23, Commitment of project manager to project C26, Management capacity and Competence of project manager; C29, Experience of Project Manager; and C30, Collaborative Supervision/inspection on project (Client, Consultants & Contractor) and were thus removed and dropped from further analysis.

Table 5. 27: Pattern/Structure Coefficient of Extracted Components of CSF for Cost Performance

	Extracted and rotated components	1	2	3	4	Eigenvalue	%variance
Comp	**Contractor's Management**					**8.484**	49.905
C13	Employment of Skilful	0.955					
C10	Contractor's Ability to Manage Designs	0.954					
C3	Government's institutional and administrative influence e.g.	0.952					
C9	Extent of subcontracting by	0.943					
C14	Initial identification of all the	0.932					
C16	Site management by contractor	0.914					
C17	Technical and Management capacity of the contractor	0.884					
C28	Construction Method Adopted on the Project	0.838					
C22	Healthy Financial Condition and stability of the contractor	0.837					
C25	Adequacy of Information available on the Project	0.820					
Comp 2	**Client's Commitment to Progress of Project**					**2.929**	**17.228**
C18	Client's commitment and Information Coordination with		0.843				
C20	Ability to solve unanticipated problems that occur during		0.755				
C21	Adequate time to project (Realistic Programme)		0.742				
C11	Type and Nature of Client		0.639				
C2	Client's Project Financing for regular cash flow		0.401				
Comp 3	**Economic Environment of Project Estimate**					**1.527**	**8.983**
C15	Economic environment			0.857			
C1	Precise Project Budget Estimate			0.843			
	% of variance extracted						**76.116**

Rotation Method: Varimax with Kaiser Normalization.

The factor rotation and interpretation was carried out for three components. It was observed that the distribution of the variance explained has been adjusted after rotation. Component 1 (Comp1) now explains 49.905 percent of the variance; Comp2, 17.228 percent; and Comp3, 8.983 percent of the variance respectively as presented in Table 5.27. The total variance explained is 76.116.

Table 5. 28: Pattern and Structure Matrix for CSF for Cost with Oblimin Rotation of Three Factor Solution of Positive Affect Scale Items

	Extracted and rotated components	Pattern Matrix 1	2	3	Structure Matrix 1	2	3	Eigenva
Comp 1	**Contractor's Management Capacity Management Capacity**							**9.484**
C13	Employment of Skilful workforce	0.992	-0.025	0.019	0.988	0.492	0.106	
C10	Contractor's Ability to Manage Designs	0.981	0.008	0.031	0.984	0.486	0.103	
C3	Government's institutional and administrative influence e.g.	0.980	0.003	0.029	0.981	0.463	0.092	
C9	Extent of subcontracting by	0.974	-0.010	0.045	0.973	0.471	0.118	
C14	Initial identification of all the risks	0.965	-0.017	0.026	0.959	0.459	0.098	
C16	Site management by contractor	0.938	0.020	-0.016	0.947	0.480	0.056	
C17	Technical and Management capacity of the contractor	0.905	0.026	-0.002	0.918	0.471	0.067	
C28	Construction Method Adopted on the Project	0.868	-0.008	-0.061	0.872	0.438	0.173	
C22	Healthy Financial Condition and stability of the contractor	0.857	0.013	0.108	0.859	0.416	0.004	
C25	Adequacy of Information available on the Project	0.854	-0.015	-0.084	0.840	0.401	-0.020	
Comp 2	**Client's Commitment to Progress of Project**							**2.929**
C18	Client's commitment and Information Coordination with	-0.077	0.893	0.061	0.366	0.858	0.092	
C20	Ability to solve unanticipated problems that occur during construction	-0.041	0.780	-0.059	0.440	0.800	0.159	
C21	Adequate time to project (Realistic Programme)	0.054	0.768	0.123	0.337	0.757	-0.030	
C11	Type and Nature of Client	0.045	0.652	-0.032	0.363	0.673	-0.001	
C2	Client's Project Financing for regular cash flow	0.289	0.344	-0.101	0.450	0.481	-0.065	
Comp 3	**Economic Environment of Project Estimate**							**1.527**
C15	Economic environment	0.054	-0.053	0.856	0.093	0.009	0.858	
C1	Precise Project Budget Estimate	-0.015	0.082	0.843	0.089	0.109	0.845	
	% of variance extracted							

The 31 items of Critical Success Factors for Cost Key Performance Indicator were subjected to principal components analysis (PCA) using SPSS version 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The KaiserMeyer-Olkin value was .628, exceeding the recommended value of .6

(Kaiser 1970, 1974) and Bartlett's Test of Sphericity (Bartlett 1954) reached statistical significance, supporting the factorability of the correlation matrix.

Principal components analysis revealed the presence of five components with Eigenvalues exceeding 1, explaining 51.22%, 9.26%, 7.52%, and 4.58% of the variance respectively. An inspection of the screeplot revealed an immediate break after the first component but with a clear incongruent break after the third component. Using scree test, following Pallant's suggestion (2005, 2011), it was decided to retain three components for further investigation.

The three-component solution explained a total of **76.17**% of the variance, with Component 1 contributing 49.91%, Component 2 contributing 17.23%, and Component 3 contributing 8.98%. To aid in the interpretation of these three components, oblimin rotation was performed. The Oblimin rotation for the three-component solution explained an improvedcontribution of the component with a clean output and more strongly correlated components thus, no total variance was obtained, with Component 1 loading 9.508, Component loading 4.748, and Component 3 loading 1.581. The rotated solution revealed the presence of simple structure (Thurstone, 1947), with the three components showing a number of strong loadings and all variables loading substantially on only one component. There was a weak positive correlation between Comp3 and component 1 ($r = .075$) and Comp1 and 2, have good positive correlation ($r = .055$ to $.491$).

5.4.4 Labelling the Components of CSFs for Cost KPI

Oblimin rotation provides two tables of loadings. The Pattern Matrix shows the factor loadings of each of the variables. To identify and label the Components, the highest loading items on each component drives the labelling. Thus, Component 1 (Comp1) was labelled Contractor's Management Capacity, Comp2 was labelled Client's Commitment to Progress of Project, and Comp3 was labelled Economic Environment of Project Estimate. Comp1, 2 and 3 are all positive affect. Table 5.14 presents the Pattern and Structure Matrix for CSF with Oblimin Rotation of three factors Solution of Positive Affect Scale (PANAS). The Communalities table is also presented to give information about how much of the variance in each item is explained. Low values (e.g. less than .3) could indicate that the item does not fit well with the other items in its component; items T15 and T32, Type and nature of client, and legal environment were typical in this regard. This suggests that further removal of these two items could improve and increase the total variance explained.

The four groups established in this analysis correspond with some of the success factors that had been reported in literature. Although, the research has provided a different perspective to the way the success factors should be assessed as different factors that are reported separately in literatures are linked as associates in this research indicating structure of an underlying relationship.

5.4.5 Contractor's Management Capacity

This factor component has the highest percentage of the total variance (49.91%), and it consists of ten policy suggestions as presented in Table 5.27. The factor name, “Contractor’s Management Capacity”, was so labelled because measures such as: employment of skilful workforce; ability to manage designs; government institution and administrative influence; extent of subcontracting; initial identification of risks; site management; technical and management capacity; construction method adopted; healthy financial condition and stability of the contractor and; adequacy of available information that made up the group are either core responsibilities of the contractor in order to achieve perceived success in terms of cost. Influence of government institutions on a construction project can be minimised when a managerially capable contractor is in charge of the project. All measures that made up the group suggest measures that could only be achieved by a capable management team on the part of contractor in collaboration with the project management efforts in order to forestall events that might lead to exceeding the project budget estimate.

5.4.5.1 Client’s Commitment to Progress of Project

The second group factor is Client’s Commitment to Progress of Project which has five measures of CSF for Cost performance indicator and they contributed a total variance of 17.23%. The burden of achieving cost performance cannot be totally placed on project management, design teams and contractor alone as the project client also has a lot of responsibility to achieve this aim. Reduction in error in designs leads to reduction in issuance of revised drawing which ultimately reduces the chances of reworks and cost overrun. The commitment of project client to provide all necessary information at the right time, to the design team helps in achieving this feat. Also, the type of client involved determines to a large extent, the level of information that can be given by such client. Adequate dedication of time to the project by the client will help in identifying and solving unanticipated problems beforehand thereby eliminating extra costs that might be expended on delays that might arise from such events.

All measures in this group suggest the importance of client's commitment to project success. The variable items under this group are: Client's commitment and information coordination with project parties; Ability to solve unanticipated problems that occur during construction; Adequate time to project (Realistic Programme); Type and Nature of Client and; Client's Project Financing for regular cash flow. A client who fails to finance the project in accordance with planned programme of work will end up frustrating all other efforts to make the project perform cost wise.

5.4.5.2 Economic Environment of Project Estimate

Precise project budget estimate and economic environment are the two factors listed under this group. With a total variance of 8.98%, the two variables suggest measures of achieving cost performance on construction project. Adverse economic environment such as recession and inflation could render the budget estimate prepared for a construction project incorrect or inaccurate before the project is completed thereby leading to excess cost in terms of variations, claims and fluctuations.

Also, change in economic policies of the project location could lead to additional cost in terms of extra or newly introduced statutory dues. This is usually common with projects that span through duration of different government of the state. Also, the economic situation of the project participants, which is an offshoot of the economic condition of the project country can be a big factor in the concentration and commitment invested in the project towards achieving accurate budget estimate.

5.5 Reliability Test for CSF for Quality Performance

Establishing the reliability of the data set used in this research, internal consistency of these items was evaluated using Cronbach's Alpha. This is an important recommendation for researchers in order to assess the degree to which items that make up the scale 'hang together' in ascertaining whether they measure the same construct by determining the Cronbach's alpha coefficient (Field, 2013; Pallant, 2005; Nunnally & Bernstein, 2007). The Cronbach's alpha ranges from 0 to 1, the benchmark that is acceptable for consistency among researchers is an overall value of 0.7 which represents an acceptable consistency. Nunnally and Bernstein (2007) asserted that 0.8 indicates a good internal consistency. The data for this work, the data were fed into SPSS version 24, the overall Cronbach's alpha coefficient for data set is .860, and this confirms a very good reliability and internal consistency. This is presented in Table 5.29.

Table 5. 29: Reliability Test Statistics

Reliability Statistics		
Cases	Valid	192
	Excluded	2
	Total	194
Statistics	Cronbach's Alpha	.860
	No of Items	25

This indicates that the data set used for the research for CSF for Quality as a KPI is internally consistent and the respondents had provided responses based on clear and common understanding of the questions in the questionnaire and thus the results for the research findings are reliable. Notwithstanding the excellent result of the reliability, the Chronbach's alpha of the individual item in the data set were subsequently assessed to check for those that could still be questionable. Pallant (2005) advised researchers to consider removing item with low item-total correlation.

This is discovered to indicate items with Cronbach's alpha above the established value, in this case .860 which Ajayi, et al., (2016) demonstrated that such item is not a good construct and should be deleted from the list of variables. Field (2013) emphasised the need to evaluate "Cronbach's alpha if item deleted" for good internal consistency and the need to delete accordingly. As shown in Table 5.30 two variables out of 25 variables were discovered to have Chronbach's alpha (Ca) value above 0.860 with low item-total correlation of 0.229 as will be stated (less than 0.3), and 0.183and they were therefore removed from further analysis. The deleted (highlighted) outlier are; Q24 Commitment of project manager to project (Mean, 3.81; Ca, 0.862), and Q25, Ability to solve unanticipated problems that occur during construction (Mean, 3.8021; Ca, 0.862). They were rated 24th and 25th respectively. After deleting these outliers, the Cronbach's alpha coefficient improved to 0.900. Therefore, the remaining items are the CSF that 'hang together' to determine Quality performance of construction projects in Nigeria.

5.5.1 Mean Score of Critical Success factors for Quality Performance

From the analysis of the descriptive statistics presented in Table 5.30 the mean values of the individual factors and the rankings from the most influential factors to the lowest. The Critical Success Factors were rated using the mean score and where variables had the same mean score, standard deviation was used to determine which variable was stronger than the other. The research employed the Likert scale of 1 to 5, and interestingly the results were divided into three influential divisions thus first were 9 factors from the remaining 23 factors, the second division were10 factors from the remaining 23 factors, while third division were6 factors from the remaining 23 factors, scaled between 3, 4, and 5. All these factors tend to scale 5 and or 4 which is very significant thus critical. As depicted in the Summary item statistics Table 5.31, the Mean of all the Means of these items is 4.230 which explains that they are all very significant.

Client's Project Financing for regular cash flow is rated first with a Mean of 4.71 and the next top six Critical Success Factor for Quality performance are Site management by contractor, Type and Nature of Client, Experience and knowledge of the client, Construction methods adopted on the project such as use of only precast building, Experience of Project Manager, and Collaborative Supervision/inspection on the project (Consultants with Client) as presented in Table 5.30. It is fascinating to note that the next 12 factors were in the 4.00 range, and six factors in the next 3.0 range. The result is creating a pattern and one of the focus of the research is to assess the interrelationship among these CSF variables in influencing KPI.

Table 5. 30: Mean Score of Critical Success factors Quality Performance

S/N	Critical Success factors	Mean	SD	Cronbach's Alpha if Item Deleted	Rating
Q1	Client's Project Financing for regular cash flow	4.71	0.577	0.857	1
Q2	Site management by contractor	4.67	0.657	0.853	2
Q3	Type and Nature of Client	4.66	0.644	0.853	3
Q4	Experience and knowledge of the client	4.65	0.622	0.853	4
Q5*	Construction methods adopted on the project such as use of only precast building	4.51	0.926	0.853	5
Q6	Experience of Project Manager	4.51	0.926	0.853	6
Q7	Collaborative Supervision/inspection on the project (Consultants with Client)	4.50	0.932	0.857	7
Q8	Timely Production of required Design Documents	4.48	0.965	0.854	8
Q9	The standard and quality of materials	4.47	0.873	0.858	9
Q10	The condition of the equipment (state of repair)	4.29	0.885	0.859	10
Q11	Government's institutional and administrative influence e.g. regulations, permits	4.20	0.853	0.853	11
Q12	Healthy Financial Condition and stability of contractor	4.17	0.636	0.855	12
Q13	Management capacity and Competence of project manager	4.11	0.728	0.854	13
Q14	Cultural environment	4.10	0.705	0.852	14
Q15	Technical and Management capacity of the contractor	4.09	0.982	0.855	15
Q16	Efficiency of communication on the project	4.08	0.6933	0.858	16
Q17	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)	4.07	0.709	0.852	17
Q18	Quality of Product/Service Design	4.06	0.691	0.853	18
Q19	Physical work environment such as weather, public disturbance (area boys)	4.00	0.981	0.856	19
Q20*	Competence and experience of design team	3.99	0.926	0.858	20
Q21*	Implementation of Innovative Techniques by contractor	3.98	0.917	0.855	21
Q22*	Employment of Skilful Workforce	3.94	0.878	0.854	22
Q23	Information Coordination, communication and relationship among project parties	3.90	0.783	0.858	23
Q24	Commitment of project manager to project	3.81	0.895	0.862	24
Q25*	Ability to solve unanticipated problems during construction	3.80	0.807	0.862	25

Table 5. 31: Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.234	3.802	4.708	0.906	1.238	0.082	25

Despite having a very significant Mean for the overall of all these Items that influence Quality performance, the descriptive mean testing has been used to determine seven key CSF for the quality KPI. These are the top seven most significant Critical Success factors that affect quality performance as a KPI in Nigeria construction industry are related to Contractor and Client capacity to deliver the project.

5.5.2 Kruskal-Wallis test

A non-parametric test for independent samples was carried out on the data set to compare the variables across the three categories of parties involved on projects that the respondents had experienced. Kruskal-Wallis test was chosen as an alternative to the one-way between groups analysis of variance (Pallant, 2005) which is non-parametric test of null hypothesis that is used to evaluate whether different categories of respondents differ by comparing scores of a particular hypothesis (Gupta, 1999; Pallant, 2005). In this research, the difference among respondents of clients, consultants and contractors' organisation were assessed to determine the disparity between the mean ranks. P-value below 0.05 in Kruskal-Wallis test indicates that there is a significant difference between the groups of participant about the affected variable at 95% confidence level. Any p-value above

0.05 indicates that there is no significant difference among the groups. In Table 5.30, the item serial number S/N has asterisks* and thus, six CSF were having p-values (sig) less than the traditional 0.05. These are items Q7, Q5, Q23, Q22, Q2, and Q11. This implies that there could be an underlying facts about the distribution of the mean ranking of the affected items by the respondents as Q7 relates 'Collaborative Supervision/inspection on the project (Consultants with Client)', Q5 relates to 'Construction methods adopted on the project such as use of concrete pumps, only precast building components etc, Q23 relates to 'Information Coordination, communication and relationship among project parties', Q22 relates to 'Employment of Skilful Workforce, Q2 relates to 'Site management by contractor', and Q11 relates to 'Government's institutional and administrative influence e.g. regulations, permits'.

5.5.3 Exploratory Factor Analysis for Quality Performance.

In order to establish a coherent subscales of grouping of the CSF for Quality performance indicator factor analysis was employed based on the aim of this research, which is to determine critical success factors for quality project delivery in Nigeria from the relationship between the variables that could be used to conceptualise the dynamic relationship of CSFs and KPIs for performance. This requires the establishment of key underlying measures from the established sets of identified factor. The 23 factors so far established can be reduced to smaller number of critical factors for ease of assessing performance of construction projects. The three main steps of assessment of suitability of the data, factor extraction and factor rotation required in conducting factor analysis were carried out accordingly.

Table 5. 32 The Kruskal-Wallis Test for Cost KPI

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.863
Bartlett's Test of Sphericity Approx. Chi-Square	3784.978
Df	300
Sig.	.000

Assessing the data and extracting the factors was the first step explored using SPSS version 24. The output of the Factor analysis shows an impressive result as all the factors have correlation coefficients that are above 0.3. Also, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling adequacy is above 0.6 in this case .863, and the Bartlett's test of sphericity is .000, which is significant (i.e. Sig. value should be .05 or smaller. Therefore, factor analysis is appropriate having satisfied these preliminary requirements.

In order to determine the number of components or (factors) to 'extract' (Pallant, 2011) that will suitably represent the whole factor, the 'Total Variance explained' table from the SPSS version 24 was looked into and the Initial Eigenvalues above 1 for each of the component variables that are listed. Only six components recorded eigenvalues above 1 (6.098, 4.658, 2.450, 1.977, 1.435, and 1.068). These six components explain a total of 70.743 per cent of the variance. Pallant (2011) suggested that the scree plot would be useful in determining the number of components as Kaiser Criterion often extracts too many components. Thus, the

Scree plot is assessed for possible guide (i.e. the elbow change point) in the shape of the plot. Only components above this point are retained in the analysis. Nunnally and Bernstein (2007) recommended retaining minimum Eigen value of 1. Using our Scree plot it is clearly observed that there is a break between components 3 and 4 and therefore it is logical to retain three components.

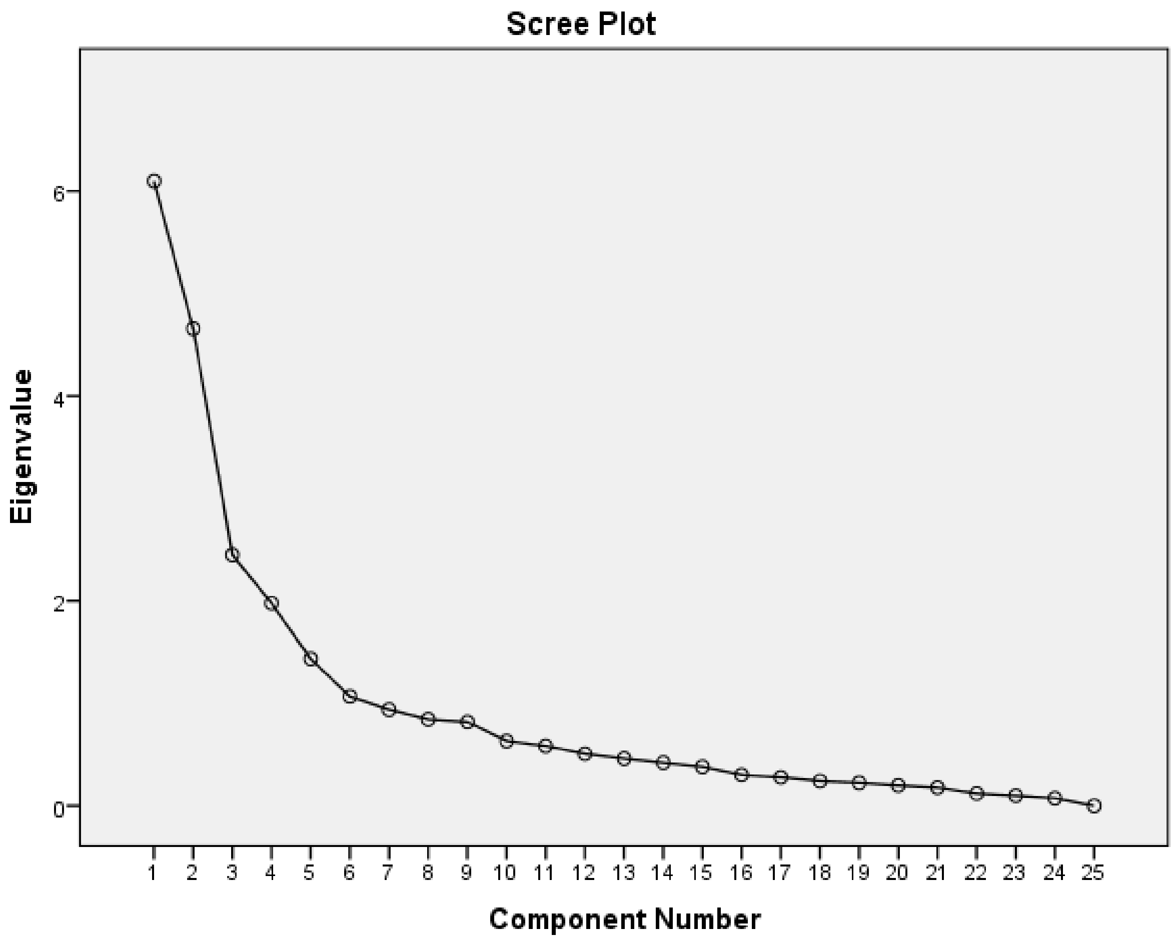


Figure 5.3: Scree plot of the Eigenvalue for Establishing Quality Components

The factor rotation and interpretation was carried out for the three components. It was observed that the distribution of the variance explained has also been adjusted after rotation. Component 1 (Comp1) now explains 26.585 percent of the variance; Comp2, 16.962 percent; and Comp3, 16.237percent of the variance respectively as presented in Table 5.33. The total variance explained is 59.784. These three established components were subjected to further analysis using Varimax with Kaiser Normalization rotation method. This retained the three components but with more redistribution of the components, Eigen value and percentage variance for each component. Out of these components, cross loadings were checked for variables that load on more than one component. The analysis was rerun for one less and one more (Pallant, 2005, 2011) and thus, two extracts and four extract components were tried to check the cross loadings again. It was observed that two variable factors were cross loading in components two and three Q19, Physical work environment such as weather, public disturbance (area boys); and Q1, Client's Project Financing for regular cash flow), and one variable factor was cross loading in components one and two (Q4, Experience and knowledge of the client) making up three variable factors cross loadings as highlighted in Table 5.31. Tabachnick and Fidell (2000) suggested the removal of such crossloading items from the analysis thus; these three factors were subsequently dropped.

Table 5. 33: Pattern/Structure Coefficient of Extracted Components of CSF for Quality Performance

	Extracted and rotated components	1	2	3	Eigenvalu	%variance
Comp	**1**				**6.115**	**26.585**
Q16	Efficiency of communication on the project	0.93				
Q11	Government's institutional and administrative influence e.g. regulations, permits	0.928				
Q20*	Competence and experience of design team	0.90				
Q3	Type and Nature of Client	0.86				
Q7	Collaborative Supervision/inspection on the project (Consultants with Client)	0.841				
Q18	Quality of Product/Service Design	0.76				
Q8	Timely Production of required Design Documents	0.75				
Q22*	Employment of Skilful Workforce	0.714				
Comp	**2**				**3.901**	**16.962**
Q10	The condition of the equipment (state of repair)		0.72			
Q17	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)		0.644			
Q19	Physical work environment such as weather, public disturbance (area boys)		0.635	0.433		
Q21*	Implementation of Innovative Techniques by contractor		0.633			
Q4	Experience and knowledge of the client	0.40	0.61			
Q15	Technical and Management capacity of the		0.58			
Q1	Client's Project Financing for regular cash flow		0.55	0.42		
Q2	Site management by contractor		0.52			
Q9	The standard and quality of materials		0.49			
Q12	Healthy Financial Condition and stability of contractor		0.406			
Q14	Cultural environment		0.36			
Comp	**3**				**3.735**	**16.237**
Q23	Information Coordination, communication and relationship among project parties			0.904		
Q6	Experience of Project Manager			0.90		
Q13	Management capacity and Competence of project manager			0.838		
Q5*	Construction methods adopted on the project such as use of only precast building			0.726		

Table 5. 34: Pattern/Structure Coefficient of Extracted Components of CSF for Quality Performance

	Extracted and rotated components	1	2	3	Eigenvalue	% variance
Comp1	**Project Design Communication Management with Workforce**				**6.115**	**26.585**
Q16	Efficiency of communication on the project	0.935				
Q11	Government's institutional and administrative influence e.g. regulations, permits	0.928				
Q20*	Competence and experience of design team	0.909				
Q3	Type and Nature of Client	0.869				
Q7	Collaborative Supervision/inspection on the project (Consultants with Client)	0.841				
Q18	Quality of Product/Service Design	0.762				
Q8	Timely Production of required Design Documents	0.756				
Q22*	Employment of Skilful Workforce	0.714				
Comp2	**Contractor Capacity for Resource Management on Quality Objective**				**3.901**	**16.962**
Q10	The condition of the equipment (state of repair)		0.723			
Q17	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)		0.644			
Q21*	Implementation of Innovative Techniques by contractor		0.633			
Q15	Technical and Management capacity of the		0.583			
Q2	Site management by contractor		0.521			
Q9	The standard and quality of materials		0.494			
Q12	Healthy Financial Condition and stability of contractor		0.406			
Q14	Cultural environment		0.362			
Comp3	**Project Manager's Competence on Information Coordination and Construction Method**				**3.735**	**16.237**
Q23	Information Coordination, communication and relationship among project parties			0.904		
Q6	Experience of Project Manager			0.900		
Q13	Management capacity and Competence of project manager			0.838		
Q5*	Construction methods adopted on the project such as use of only precast building			0.726		

The 20 items of Critical Success Factors for Quality Key Performance Indicator were subjected to principal components analysis (PCA) using SPSS version 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The KaiserMeyer-Olkin value was 0.863, exceeding the recommended value of .6 (Kaiser 1970, 1974) and Bartlett's Test of Sphericity (Bartlett 1954) reached statistical significance, supporting the factorability of the correlation matrix. Principal components analysis revealed the presence of six components with eigenvalues exceeding 1, explaining 24.393%, 18.632%, 9.798%, 7.910, 5.739, and 4.272% of the variance respectively. An inspection of the scree plot revealed a clear break after the third component. Using scree test, following Pallant's suggestion (2005, 2011), it was decided to retain three components for further investigation. The three-component solution explained a total of 59.784% of the variance, with Component 1 contributing 26.585%, Component2 contributing 16.962%, and Component 3 contributing 16.237.

5.5.4 Labelling the Components of CSFs for Quality KPI

Having established a clean output without cross loading variables in the Varimax rotation for establishing three components thus, it is unnecessary to run Oblimin rotation for the data set of Quality KPI. To identify and label the Components, the highest loading items on each component drives the labelling. Thus, Component 1 (Comp1) was labelled Project Communication Management with Design and Workforce, Comp2 was labelled Contractor Capacity for Resource Management on Quality Objective, and Comp3 was labelled Project Manager's Competence on

Information Coordination and Construction Method. Comp1, 2 and 3 are all positive affect.

5.5.4.1 Project Design Communication Management with Workforce

This factor component has the highest percentage of the total variance (26.59%), and it consists of eight policy suggestions as presented in Table 5.34. The factor name, "Project Design Communication Management with Workforce", was so labelled because measures such as Efficiency of communication on the project, Government's institutional and administrative influence e.g. regulations, permits, Competence and experience of design team, Type and Nature of Client, Collaborative Supervision/inspection on the project (Consultants with Client), Quality of Product/Service Design, Timely Production of required Design Documents, Employment of Skilful Workforce that made up the group are either core responsibilities of the project management and design team with particular focus on timely production of design drawings with an oversight function on skilful workforce for a quality product achievement. All measures that made up the group suggest measures that could only be achieved by a capable design team management with proper coordination of information and communication on the part of the design team with collaboration with the project management efforts to ensure that the workforce produce the quality design that had been achieved. Therefore, it is established that achieving quality performance requires coordination of information with collaborative efforts of all parties.

5.5.4.2 Contractor Capacity for Resource Management on Quality Objective

The second group factor is Contractor Capacity for Resource Management on Quality Objective which has eight measures of CSF for Cost performance indicator: The condition of the equipment (state of repair), Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Implementation of Innovative Techniques by contractor, Technical and Management capacity of the contractor, Site management by contractor, The standard and quality of materials, Healthy Financial Condition and stability of contractor, Cultural environment. They contributed a total variance of 16.96% and they are strongly correlated.

The burden of achieving quality performance cannot be totally placed on project management and design team; the contractor has a lot of responsibility to achieve this aim. Once the objective of the standard quality is clearly expressed as contained in the item specification and description then the contractor has to put all resources together within his management to ensure achievement of quality. A quality service in producing quality design will culminate to reduction in error in designs which leads to reduction in issuance of revised drawing which ultimately reduces the chances of reworks and poor quality output.

However, it is important to ensure the financial health of the contractor because if the contractor is not financially stable, the likelihood of compromising quality is high and this could easily be observed in the way the site is being managed. This implies that equipment are in a very good state to carrying out the works with the use of quality material. Adequate dedication of workforce to quality is key and this is exercised by the cultural environment which foster the quality culture practice experienced by the workforce. Therefore, capacity of contractor in resource management is key to achieving quality performance.

5.5.4.3 Project Manager's Competence on Information Coordination and Construction Method

The third component factor is Project Manager's Competence on Information Coordination and Construction Method which has four variable factors which include Information Coordination, communication and relationship among project parties, Experience of Project Manager, Management capacity and Competence of project manager and Construction methods adopted on the project such as use of only precast building component, concrete pumps etc.. The four variables have a total variance of 16.24%, and suggest measures of achieving quality performance on construction project. The four variables are associated together to determine quality performance through the Project Manager's competence and capacity in communication issues and particularly in the management of construction method adopted by the contractor which would have been approved by the Project Manager and the Design team.

5.6 Reliability Test for CSF for Health and Safety

Establishing the reliability of the data set used in this research, internal consistency of these items was evaluated using Cronbach's Alpha. This is an important recommendation for researchers in order to assess the degree to which items that make up the scale 'hang together' in ascertaining whether they measure the same construct by determining the Cronbach's alpha coefficient (Pallant, 2005;

NunnallyandBernstein,2007; Field,2013;). The Cronbach's alpha ranges from 0 to 1, the benchmark that is acceptable for consistency among researchers is an overall value of 0.7 which represents an acceptable consistency. Nunnally and Bernstein (2007) asserted that 0.8 indicates a good internal consistency. The data for this work were fed into SPSS version 24; the overall Cronbach's alpha coefficient for CSFs for Health and Safety data set is 0.789, this confirms a very good reliability and internal consistency. This is presented in Table 5.35.

Table 5. 35: Reliability Test Statistics for CSFs for Health and Safety Indicators

Reliability Statistics		
Cases	Valid	192
	Excluded	2
	Total	194
Statistics	Cronbach's Alpha	0.789
	No of Items	18

This indicates that the data set used for the research for CSFs for Health and Safety as a KPI is internally consistent and the respondents had provided responses based on clear and common understanding of the questions in the questionnaire and thus the results for the research findings are reliable. Notwithstanding the result of the reliability, the Chronbach's alpha of the individual item in the data set was subsequently assessed to check for those that could still be questionable. This is discovered to indicate items with Cronbach's alpha above the established value, in this case 0.789, which would be deleted from the list of variables for good internal consistency. Table 5.36 shows that one variable out of 18 variables was discovered to have its Chronbach's alpha (Ca) value above 0.789 with low item-total correlation of 0.069 as will be stated (less than 0.2), and it was therefore removed from further analysis. The deleted outlier is: Management capacity and Competence of project manager [HS4] (4.8021; Ca, 0.794). The outlier was ranked 4th. After deleting this outlier, the Cronbach's alpha coefficient improved to 0.794. Therefore, the remaining items are the CSFs that 'hang together' to determine Health and Safety performance of construction projects in Nigeria.

5.6.1 Mean Score of Critical Success factors for Health and Safety

From the analysis of the descriptive statistics presented in Table 5.10, the mean values of the individual factors and their rankings from the most influential factors to the lowest are shown. The Critical Success Factors for Health and Safety performance indicators were ranked using the mean score and where variables had the same mean score, standard deviation was used to determine which variable was stronger than the other. The research employed the Likert scale of 1 to 5, and interestingly the results, after removing the outlier, were divided into three influential divisions thus 3 factors from the remaining 17 factors (4 less 1 outlier at 18 items) while the second division were 7 factors from the initial 18 factors, and the remaining 7 factors from the 18 factors, scaled between 3, 4 and 5 respectively. Majority of these factors tend to scale 4 which is very significant thus critical. As depicted in the Summary item statistics Table 5.37, the Mean of all the Means of these items is 4.19 which explains that they are all very significant.

Healthy Financial Condition and stability of contractor is ranked first with a Mean of 4.90 and the next top three Critical Success Factor for Health and Safety are, Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, and Employment of Skilful Workforce as presented in Table 5.36. It is fascinating to note that the next seven factors were in the 4.00 range, and the following seven factors in the next 3.00 range. The result is creating a pattern and one of the focuses of the research is to assess the interrelationship among these CSFs variables in influencing KPI.

Table 5. 36: Mean Score of Critical Success factors for Health and Safety Performance

S/N	Critical Success factors	Mean	SD	Cronbach's Alpha if	RANK
HS1	Healthy Financial Condition and stability of contractor	4.90	0.38	0.784	1
HS2	Site Management on Effective enforcement scheme	4.88	0.49	0.783	2
HS3	Client's Project Financing for regular cash flow	4.85	0.51	0.783	3
HS4	Management capacity and Competence of project	4.80	0.56	0.794	4
HS5	Employment of Skilful Workforce	4.45	0.90	0.785	5
HS6	Program evaluation of State of Health and Safety (e.g. Accident cause delay)	4.34	0.82	0.778	6
HS7	Government's institutional and administrative influence e.g. regulations, permits	4.30	0.93	0.771	7
HS8	Physical work environment such as weather, public disturbance (area boys)	4.28	0.90	0.768	8
HS9	Appropriate safety education and training	4.08	0.65	0.781	9
HS10	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)	4.07	0.71	0.781	10
HS11	Experience of contractor	4.07	1.02	0.774	11
HS12	Safety equipment acquisition and maintenance	3.98	0.98	0.780	12
HS13	Construction methods adopted on the project such as use of only precast building	3.97	1.05	0.766	13
HS14	Technical Competence and Management capacity of the contractor	3.95	0.93	0.774	14
HS15	Experience of Project Manager	3.88	1.04	0.765	15
HS16	The condition of the equipment (state of repair)	3.88	0.78	0.789	16
HS17	Collaborative Supervision/inspection on the project (Consultants with Client)	3.67	0.93	0.782	17
HS18	Information Coordination, communication and relationship among project parties	3.67	0.79	0.785	18

Table 5. 37: Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/Minimum	Variance	N of Items
Items Means	4.19	3.672	4.901	1.229	1.335	0.153	17

In addition to having a very significant Mean for the overall of all these Items that influence health and safety, the descriptive mean testing has also been used to determine three key CSFs for the health and safety KPI. These top three most significant Critical Success Factors that affect health and safety as a KPI in Nigeria construction industry are related to Contractor and Client capacity to deliver the project.

5.6.2 Kruskal-Wallis test

A non-parametric test for independent samples was carried out on the data set to compare the variables across the three categories of parties involved on projects that the respondents had experienced. Kruskal-Wallis test was chosen as an alternative to the one-way between groups analysis of variance which is non-parametric test of null hypothesis that is used to evaluate whether different categories of respondents differ by comparing scores of a particular hypothesis (Gupta, 1999; Pallant, 2005). In this research, the difference among respondents of clients, consultants and contractors' organisations were assessed to determine the disparity between the Mean ranks. P-value below 0.05 in Kruskal-Wallis test indicates that there is a significant difference between the groups of participant about the affected variable at 95% confidence level. Any p-value above 0.05 indicates that there is no significant difference among the groups. In Table 5.36, one CSF was having a p-value (sig) less than the traditional 0.05. This is item HS10 (Clear Objectives on Project Outcomes [e.g. Time, cost and quality]). This implies that there could be underlying facts about the distribution of the mean ranking of the affected item by the respondents.

5.6.3 Exploratory Factor Analysis.

In order to establish a coherent subscales of grouping of the CSFs for Health and Safety indicator, factor analysis was employed based on the aim of this research, which is to determine critical success factors for a healthy and safe project delivery in Nigeria from the relationship between the variables that could be used to conceptualise the dynamic relationship of CSFs and KPIs for performance.This requires the establishment of key underlying measures from the established sets of identified factor. The 17 factors so far established can be reduced to smaller number of critical factors for ease of assessing performance of construction projects. There are three main steps required in conducting factor analysis include: assessment of suitability of the data, factor extraction and factor rotation.

Table 5. 38: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.721
Bartlett's Test of Sphericity	Approx. Chi-Square	1459.332
	Df	153
	Sig.	.000

Assessing the data and extracting the factors was the first step explored using SPSS version 24. The output of the Factor analysis shows an impressive result as all the factors have correlation coefficients that are above 0.3. Also, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling adequacy is above 0.6, and the Bartlett's test of sphericity is 1459.332, which is significant (i.e. Sig. value should be .05 or smaller. Therefore, factor analysis is appropriate having satisfied these preliminary requirements.

In order to determine the number of components or (factors) to 'extract' (Pallant, 2011) that will suitably represent the whole factor, the 'Total Variance explained' table from the SPSS version 24 was looked into and the Initial Eigenvalues above 1 for each of the component variables that are listed. Only six components recorded Eigen values above 1 (4.220, 2.875, 1.627, 1.553, 1.255, and 1.201). These six components explain a total of 70.730 per cent of the variance. The scree plot was run to determine the number of components as Kaiser criterion often extract too many components. Thus, the Scree plot is assessed for possible guide (i.e. the elbow change point) in the shape of the plot. Only components above this point are retained in the analysis. Nunnally and Bernstein (2007) recommended retaining minimum Eigenvalue of 1. Using our Scree plot it is clearly observed that there is a break between components 2 and 3 and therefore it is logical to retain two components.

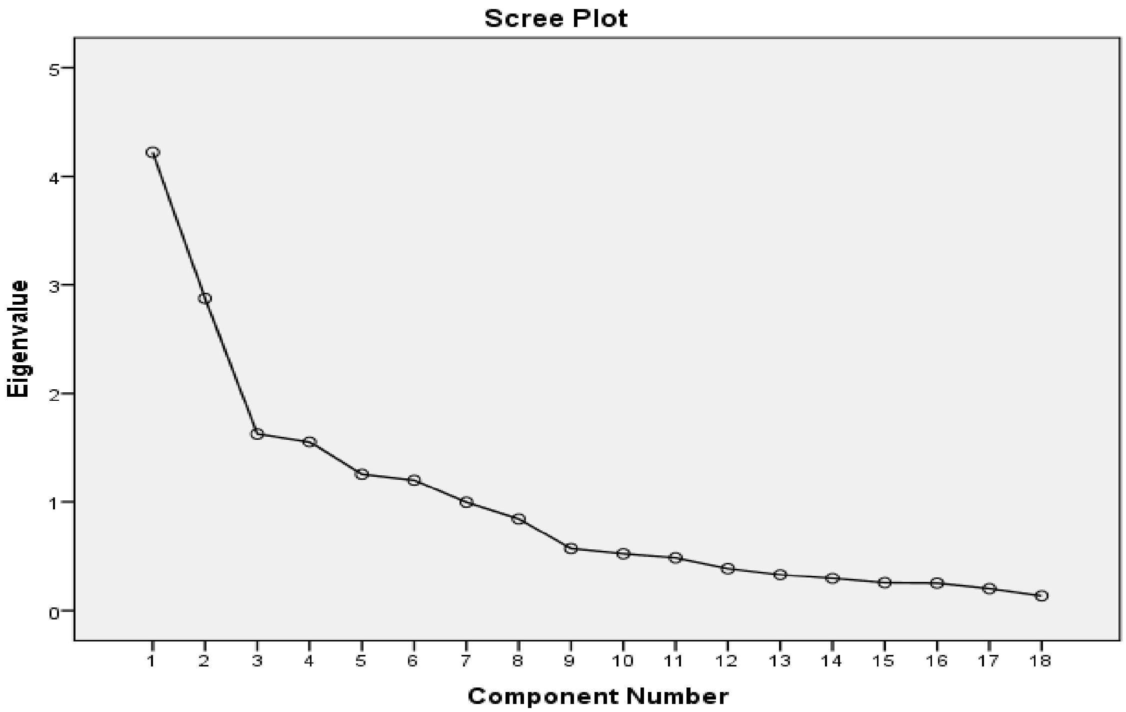


Figure 5.4: Scree plot of the Eigenvalue for Establishing Health and Safety Components

The factor rotation and interpretation was carried out for the two components. It was observed that the distribution of the variance explained has also been adjusted after rotation. Component 1 (Comp1) now explains 22.001percent of the variance; Comp2, 19.344percent. The total variance explained is 41.346. These two established components were subjected to further analysis using Varimax with Kaiser Normalization rotation method. This retained the two components but with more redistribution of the components, Eigen value and percentage variance for each component. Out of these components, cross loadings were checked for variables that load on more than one component. The analysis was rerun for one less and one more (Pallant, 2005, 2011) and thus, 1 extracts and 3 extract components were tried to check the cross loadings again. It was observed that three variable factors were cross loading in two components. These are (HS8 Physical work environment such as weather, public disturbance area boys); HS7, (Government's institutional and administrative influence e.g. regulations, permits, and HS6, Program evaluation of State of Health and Safety (e.g. Accident cause delay) as highlighted in Table 5.39. Tabachnick and Fidell (2000) suggested the removal of such cross-loading items from the analysis thus; these three factors were subsequently dropped.

Table 5. 39: Pattern/Structure Coefficient of Extracted Components of CSF for Health and Safety Performance

	Extracted and rotated components	1	2	Eigenvalue	%variance
Comp11	**Client's Design and Project**			**3.740**	**22.001**
HS2	Site Management on Effective enforcement scheme	0.841			
HS3	Client's Project Financing for regular cash flow	0.814			
HS1	Healthy Financial Condition and	0.785			
HS9	Appropriate safety education and	0.618			
HS7	Government's institutional and administrative influence e.g. regulations, permits	0.558	0.330		
HS8	Physical work environment such as weather, public disturbance (area boys)	0.553	0.367		
HS12	Safety equipment acquisition and maintenance	0.537			
HS18	Information Coordination, communication and relationship among	0.474			
Comp2	**Construction Resource Management**			**3.289**	**19.344**
HS14	Technical Competence and Management capacity of the contractor		0.720		
HS11	Experience of contractor		0.710		
HS15	Experience of Project Manager		0.686		
HS13	Construction methods adopted on the project such as use of only precast		0.637		
HS10	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)		0.561		
HS5*	Employment of Skilful Workforce		0.558		
HS17	Collaborative Supervision/inspection on the project (Consultants with Client)		0.429		
HS16	The condition of the equipment (state of repair)		0.395		
HS6	Program evaluation of State of Health and Safety (e.g. Accident cause delay)	0.346	0.365		

Table 5. 40: Pattern/Structure Coefficient of Extracted Components of CSF for Health and Safety Performance

	Extracted and rotated components	1	2	Eigenvalue	%variance
Comp11	**Effective Finance of Site Management for Health Safety Implementation**			**3.740**	**22.001**
HS2	Site Management on Effective enforcement scheme	0.841			
HS3	Client's Project Financing for regular cash flow	0.814			
HS1	Healthy Financial Condition and stability of contractor	0.785			
HS9	Appropriate safety education and training	0.618			
HS7	Government's institutional and administrative influence e.g. regulations, permits	0.558			
HS8	Physical work environment such as weather, public disturbance (area boys)	0.553			
HS12	Safety equipment acquisition and maintenance	0.537			
HS18	Information Coordination, communication and relationship among project parties	0.474			
Comp2	**Capacity of Contractor for Project Management and Safety Programme**			**3.289**	**19.344**
HS14	Technical Competence and Management capacity of the contractor		0.720		
HS11	Experience of contractor		0.710		
HS15	Experience of Project Manager		0.686		
HS13	Construction methods adopted on the project such as use of only precast building		0.637		
HS10	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)		0.561		
HS5*	Employment of Skilful Workforce		0.558		
HS17	Collaborative Supervision/inspection on the project (Consultants with Client)		0.429		
HS16	The condition of the equipment (state of repair)		0.395		
HS6	Program evaluation of State of Health and Safety (e.g. Accident cause delay)		0.365		

The 17 items of Critical Success Factors for Health and Safety Key Performance Indicator were subjected to principal components analysis (PCA) using SPSS version 24. Prior to performing PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The KaiserMeyer-Olkin value was 0.721, exceeding the recommended value of .6 (Kaiser 1970, 1974) and Bartlett's Test of Sphericity (Bartlett 1954) reached statistical significance, supporting the factorability of the correlation matrix. Principal components analysis revealed the presence of two components with eigenvalues exceeding 1, explaining **22.001**%, and **19.344**% of variance respectively.

An inspection of the scree plot revealed a clear break after the second component. Using scree test, following Pallant's suggestion (2005, 2011), it was decided to retain two components for further investigation. The two-component solution explained a total of **41.346**% of the variance, with Component 1 contributing 22.001 %, and Component 2 contributing 19.344%. To aid in the interpretation of these two components, oblimin rotation was performed. The Oblimin rotation for the two-component solution explained an improved total of **39.418**% of the variance, with Component 1 contributing 23.44%, and Component 2 contributing 15.974%. The rotated solution revealed the presence of simple sructure (Thurstone 1947), with component one alone showing two loadings under pattern and component one showing three loadings and component two showing one loading under structure. The interpretation of the two components was consistent with previous research on the PANAS Scale, with positive affect items loading strongly only on Component 1. There was weak positive correlations between the two Components (r =1.000, 0.124 and 0.124, 1.000).

5.6.4 Labelling the Components of CSFs for Health and Safety KPI

Having established 17 clean outputs without cross loading variables in the Varimax rotation for establishing three components thus, it is unnecessary to run Oblimin rotation for the data set of Health and Safety KPI. To identify and label the

Components, the highest loading items on each component drives the labelling. Thus, Component 1 (Comp1) was labelled Effective Finance of Site Management for Health Safety Implementation and Comp2 was labelled Capacity of Contractor for Project Management and Safety Programme. Both Comp1 and 2 are positive affect. The two groups established in this analysis correspond with some of the success factors that had been reported in literature. Although, the research has provided a different perspective to the way the success factors should be assessed as different factors that are reported separately in literatures are linked as associates in this research indicating structure of an underlying relationship.

5.6.4.1 Effective Finance of Site Management for Health Safety Implementation

This factor component has the highest percentage of the total variance (22.00%), and it consists of eight policy suggestions as presented in Table 5.38. The factor name was so labelled because the determining variables; Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, Healthy Financial Condition and stability of contractor, Appropriate safety education and training, Government’s institutional and administrative influence e.g. regulations, permits, Physical work environment such as weather, public disturbance (area boys), Safety equipment acquisition and maintenance are measures that made up the group suggest measures that could only be achieved through effective site management effort on health and safety implementation. All these are key to the success of project health and safety management process.

5.6.4.2 Capacity of Contractor for Project Management and Safety Programme

The second group factor is Capacity of Contractor for Project Management which has nine measures of CSF for health and safety performance indicator and they contributed a total variance of 19.34%. The factor component suggests that achieving Health and Safety performance requires the Contractor to have capacity that flows in tune with project management principle for safety performance, incorporating the experience of project manager within its fold. The variable items under this group are, Technical Competence and Management capacity of the contractor, Experience of contractor, Experience of Project Manager, Construction methods adopted on the project such as use of only precast building, Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Employment of Skilful Workforce, Collaborative Supervision/inspection on the project (Consultants with Client), The condition of the equipment (state of repair), Program evaluation of State of Health and Safety (e.g. Accident cause delay). These factors clearly show the capacity of the contractor's management but that is not all, it requires that there is an oversight on the contractor management as a well manged company could strategically desire to not to take health and safety needs of the site seriously if the project manager and even the client did not emphasise punitive measures for not carrying it out. The skilful workforce and condition of equipment go together in determining the performance of health and safety of a construction project.

5.7 SUMMARY OF FINDINGS

The financial situation of the client is the most critical success factor necessary for project performance in Nigeria. The findings of the research also showed that competence and experience of project manager, time, cost and quality objectives set out for the project, competence and experience of design team, technical capability of project manager, technical and professional capability of contractor, efficiency of communication on the project, experience of contractor, supervision on the project (client and consultants monitoring contractors work) and commitment of project manager to project are success factors critical to the performance of projects in Nigeria.

After analysing the CFSs, on Time performance, it was discovered that the Technical competence and management capacity of the contractor has the highest mean value of 4.42 while Implementation of Innovative techniques bears the lowest mean value of 3.59. From this, four components were identified which are;

design team commitment to project management outcomes and this has the highest percentage of total variance of 35.34%, capacity of contractor for project management, construction resource management and external factors.

On cost performance, our analysis revealed that precise project budget estimate has the highest mean value of 4.83 while the use of innovations such as BIM, e-tendering impacts on project has the lowest mean value of 3.41. Three cost components were identified for cost performance. These components are; contractors management capacity, clients commitment to progress of project and economic environment of project estimate.

On quality performance, the analysis shows that the client's project financing for regular cash flow has the highest mean value of 4.71 while the ability to solve unanticipated problems that occur during construction has the least mean value of 3.80. From this, three components were also identified. These components are; project communication management with design and workforce, contractor capacity for resource management on quality objective and project manager's competence on information coordination and construction methods.

On Health and Safety, the CSF with the highest mean value is the Healthy financial condition and stability of contractor with a mean value of 4.90 and the CSF with the least mean value is Information coordination and communication relationship between project parties with a mean value of 3.67. Two components were identified for the health and safety performance of construction projects in Nigeria. These components are; effective finance of site management for health safety implementation and capacity of contractor for project management and safety programmes.

5.8 DISCUSSION OF FINDINGS

On cost performance of construction projects in Nigeria the findings revealed that Contractor's management capacity with factors such as employment of skilful workforce; ability to manage designs; government institution and administrative influence; extent of subcontracting; initial identification of risks; site management; technical and management capacity; construction method adopted; healthy financial condition and stability of the contractor and; adequacy of available information; is the most important factor group. Although the research of Tan and Ghazali (2011) was on performance of construction projects generally, it was documented that contractor experience is the most important CSF in Singapore which is in agreement with this research outcome. This means that the possibility of delivering a project within a budget in Nigeria is largely dependent on the management capability of the contractor. It could be deduced that project failures in terms of cost overrun in Nigeria is largely due to deficient contractor's management skills.

Client's commitment to project success was second with five (5) factors namely: Client's commitment and information coordination with project parties; Ability to solve unanticipated problems that occur during construction; Adequate time to project (Realistic Programme); Type and Nature of Client and; Client's Project Financing for regular cash flow. This shows that the management capability of the contractor alone cannot ensure cost performance rather, it has complemented with client's commitment to the successful implementation of the project. The level of commitment of client in terms of finance and information coordination is a function of the type and nature of the client in question. Therefore, there exist a dynamic of performance issues between the Contractor management capacity and the commitment of the Client to the success of the project.

Economic environment of project estimate was the third factor group with just two measures that determine the cost performance of construction project. Nigeria, being a developing country, is subject to economic fluctuation. The impact of unstable economic environment on cost performance of construction project is felt much in a developing country than in developed countries. Also, unstable economy could affect the accuracy of construction documents produced especially the budget estimate. This is in agreement with the findings of Pakseresht and Asgari (2012) that investigated CSFs in Tehran (Iraq) and reported technical and economic assessment of the project required resources as the most important CSF. This research content that economic environment affects the estimate or budget of the project and this unfold an interesting focus. Today corruption has permeated every facet of life in Nigeria with alarming revelations. A good economic environment would support standard and proper professional practice while a poor and bad economic environment could necessarily exacerbate corruption and sharp practice and this is multifaceted in its occurrence with professionals throwing ethics into the bin.

On time performance, design team's commitment to project management outcomes was revealed to be the most important factor group. This group is made up of success factors like: Ability to solve unanticipated problems that occur during the course of the project, Clear, Correct and Precise Drawings/Documents, Timely Production of required Design Documents, Early Involvement of Project Manager, Efficiency of communication on the project, Client's Project Financing for regular cash flow, Type and Nature of Client, Government's institutional and administrative influence e.g. regulations, permits; Management capacity and Competence of project manager, and Initial identification of all the risks that are likely to occur on the project. This is in contrast with the findings of previous research. Saquib, Farooqui and Lodi (2008) showed that the most important critical success factor in Pakistan was the decision making effectiveness of the project management team. Tan and Ghazali (2011) documented contractor experience as the most important CSF in Singapore. Pakseresht and Asgari (2012) investigated CSFs in Tehran (Iraq) and reported technical and economic assessment of the project required resources as the most important CSF. However, it should be pointed out that these research works were focused on performance generally with no special attention given to the key performance indicators independently.

Capacity of contractor for project management follows closely which implies that the project management skills of contractor play important roles in achieving time performance in Nigeria. With factors such as: Healthy Financial Condition and stability of contractor, Commitment of project manager to project, Technical

Competence and Management capacity of the contractor, Site management by contractor, and Employment of Competent and Skilful Workforce, these findings contradicts the findings of Saquib, Farooqui and Lodi (2008) which showed that the most important critical success factor in Pakistan was the decision making effectiveness of the project management team while it supports the submission of Tan and Ghazali (2011) which documented contractor experience as the most important CSF in Singapore.

With factors such as: Construction methods adopted on the project, Adequacy of information available on the project, Delivery time of resources (materials, equipment), Ability of client to make timely and accurate decisions on the project, The condition of the equipment (state of repair), Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Collaborative Supervision/inspection on the project (Consultants with Client), and the State of Health and Safety; Construction resource management group was revealed to be the third most important factor group for time performance. This is in agreement with the findings of Pakseresht and Asgari (2012) which reported technical and economic assessment of the project required resources as important for achieving project performance.

The least important, according to the findings of this research that affect time performance is external factor.

On quality performance, Client's Project Financing for regular cash flow is rated first and the next top six Critical Success Factor for Quality performance are Site management by contractor, Type and Nature of Client, Experience and knowledge of the client, Construction methods adopted on the project such as use of only precast building, Experience of Project Manager, and Collaborative Supervision/inspection on the project (Consultants with Client). Chua et al. (1999) as cited in K.N. Jha & K.A. Iyer (2006) have developed a hierarchical model for construction project success for different project objectives. For quality objectives they find that it is influenced by four main project aspects, namely, project characteristics, contractual arrangements, project participants, and interactive processes.Their findings clearly show that the four (4) project aspects that influenced the project quality performance are in line with the findings of this research work.

Auma (2014) found out that qualification and experience of personnel, quality of materials and equipment used, conformance to specifications and quality assurance and follow up have influence of quality performance of construction projects. Clear and effective definitions of project specifications usually improve the chances of achieving quality project result. This means that there exists a direct and positive relationship between procurement procedures employed on construction project and quality performance (Jeptepkeny, 2015).

On health and safety performance, Healthy Financial Condition and stability of contractor is ranked first and the next top three Critical Success Factor for Health and Safety are, Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, and Employment of Skilful Workforce. Aksorn and Hadikusumo (2008) found management support as the most influential factor for safety programme performance. Whereas, (Aksorn and Hadikusumo, 2008; Shirouyehzad, et. al., 2011; Memon, *et. al.*, 2012) reported that to achieve good results with health and safety performance on construction projects, factors found in literatures, as important are: management support, teamwork, appropriate safety education and training, appropriate supervision, clear and realistic goals, safety equipment acquisition and maintenance, continuing participation of employees, safety meetings, delegation of authority and responsibilities, good communication, personal attitude, personal competency, sufficient resource allocation, effective enforcement scheme, program evaluation, personal motivation and, positive group norms.

The contractors' healthy financial condition and stability greatly improves the project performance regarding health and safety and the clients' financial commitment to the project are critical success factors CSFs for health and safety programme performance. Information coordination and communication relationships between project parties indicated that it is the least factor that can affect the health and safety programme performance. This is in agreement with Aksorn and Hadikusumo (2008) that management support has the most influential factor for safety programme performance.

CHAPTER SIX

PROJECT PERFORMANCE DIAGNOSTICS: A SYSTEM DYNAMICS MODEL

6.1 Overview of the Chapter

This chapter presents the focused aim of this research which is to conceptualise a System dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables. Dynamic framework of relationship between project variables of CSFs and KPIs for actually exist in project performance. Having established typical project variables that determine the performance of construction projects based on a review of literature, focused group of expert opinions, interviews, questionnaire, and analysis of the responses from the questionnaire thus, the project variables of CSFs to determining the KPIs is an important step toward developing the thesis model as the chapter establishes the foundations for understanding the dynamics of management practice as it affects the performance of construction project performance in terms of time, cost, quality, and health and safety. Therefore, each of the KPIs was identified with their various variables that were being influenced by the CSFs for their individual performance. At the end of the chapter the summary of all the four KPIs were modelled for the system dynamic Project Performance Diagnostics Model as they determine the performance of construction projects.

6.2 Data Collection Strategy for Building the Models

In Systems Dynamics, verbal descriptions and causal loop diagrams are more qualitative; stock and flow diagrams and model equations are more quantitative ways to describe a dynamic situation. In previous discussion under the approach to conducting the research, the appropriate mode of approach that was selected is a mix research to fulfil the objectives of the research. The use of qualitative and quantative techniques drives the system dynamics model which requires testing constantly to ascertain if the data indeed depicts the mirror image of the reality of the system under study (Luna-Ryes and Andersen (2003); Kapmeier, 2006). Effective decision making and learning in a world of growing dynamic complexity requires us to become systems thinkers-to expand the boundaries of our mental models and develop tools to understand how the structure of complex systems creates their behaviour (Sterman, 2000). According to Kapmeier (2006) applying real-world data has long tradition in System Dynamics and thus, qualitative empirical social research might provide model builders with appropriate missing data. Forrester identified qualitative data as a main source of information in the modelling process of the system dynamics (Forrester, 1975).

The conventional etiquette and rigour of the SD modelling process requires qualitative data collection and analysis and therefore data selected for the model developed in this research were qualitative which add richness and details. Mental models of experts in the field and the understanding of practitioners about meaning and connections as corroborated by Luna-Ryes and Andersen (2003) to revealing the complexity of real world system through detailed stories and descriptions. This is a common path in sytem dynamics modelling and the general agreement that emphasise the importance of qualitative data during the development of a system dynamics model (Luna-Ryes and Andersen, 2003). In order to increase the validity of the research data, it was decided to combine a number of data collection techniques. Sterman (2000) suggests that to develop good model of the problem situation, "we should supplement the links suggested by the interview with other data sources such as our own experience and observations, archival data, and so on". He added that "we may add additional causal links not mentioned in the interviews or other data sources". While some of these will represent basic physical relationships and be obvious to all, others require justification or explanation. He concluded that "we should draw on all the knowledge we have from our experience with the system to complete the diagram".

This research builds the SD models following the approach of Luna-Ryes and Andersen (2003) on qualitative data collection techniques that support system dynamics model building including

- Interviews: Strength = Collection of qualitative data from construction professionals
- Oralhistory:Verifiedtranscriptsofinterviewswhichbecomepartofthepublicrecord; not employed
- Focus groups: Similar to group model building particularly those that are involved in the particular case study of this research
- Delphi groups: Extension of focus groups. □Q&A Cycles, ranking of critical issues, try to reach consensus, mostly experts.
- Observation: Collect social structure, culture, process and human interaction information; not employed
- Participant observation: Interacting with the participant; not employed.
- Experimental approaches: e.g. tasks for participants not employed.

The aforementioned is the key guide to the model content which was strengthened by the following techniques of data collection

6.2.1 Literature review

Previous researches had shown variables that interrelate in the construction project system that are used for assessing the dynamics of construction works. Such literatures were relied upon and they were reviewed to gain proper insights into issues related to construction project performance and its dynamics variables. Importantly, the direct observance of any author does not guarantee the reaction or its exact prediction for the modelling in this thesis but those variables will guide in assessing the interdependencies of the variables. The literature as a data collection tool also assists in defining the variables from the research problem, eliciting information and observation requirements mixed-mode research methodology. The model thrives with mental model thus, apart from the literature further information were required, which led the research to seek further research techniques for collecting data.

6.2.2Case study projects

This research is an opportunity to observe and analyse a typical construction project in Nigeria using System Dynamics as a tool to assess performance which is a phenomenon of research concept that is almost not explored in Nigeria. The case study method provides the qualitative analysis where in careful and complete observation of the situation is done with in depth study to generate values for the quantitative stock and flow.. Thus, the case study is essentially an intensive investigation of the particular unit under consideration by eliciting information about the variables that are relevant to determining performance. The focus of the case study method in this section is to locate variables and their relationship as they account for the performance of the project by inputting the experts' assessment of CSFs in the KPIs and see the way it performs.

6.2.3 Focus Group Interview

In furtherance to the above case study technique, the experts involved in the project were interviewed based on their cumulative experience in the industry the variables that are useful and applicable to the models that is being developed. It should be noted that all these techniques are interwoven in the building of the model since the importance of mental model from the construction practitioner is key to relevant data available from their experience. The focus group consist of 3 Architects, 3 Quantity Surveyors, 5 Engineers, and the Builders consist of the contractor's team numbering 5 professionals including the Managing Director of the company. All the information in mental models, including the expectations, effects, feelings on outcomes and understandings, stories, and the dynamics experienced in the system and how decisions were made. Interview was essential to collect these mental data which cannot be accessed directly. The interactive session of the interviews allowed the researcher to probe fully the meaning of questions and to add supporting contextual evidences. Having established literature references, and analysed responses understanding the interrelationship of the variables were easier to argue and understand and the unstructured format of these interviews provided an opportunity to make further observations qualitatively that influence the subsequent deployment of the research. According to Sterman (2000) much of the data a modeller uses to develop a dynamic hypothesis comes from interviews and conversations with people in organizations and in fact semi-structured interviews (where the modeller has a set of predefined questions to ask but is free to depart from the script to pursue avenues of particular interest) have proven to be particularly effective. There are many techniques available to gather data from members of organizations, including surveys, interviews, participant observation, archival data, and so on. Interviews are an effective method to gather data useful in formulating a model, either conceptual or formal.

6.2.4 Questionnaire

Questionnaire data collection was used to survey information on the experience of practitioner of the construction industry in Nigeria in the management of performance of projects and the underlying factors that actually determine the behaviour of the project as it performs. Sterman (2000) asserted that Surveys generally do not yield data rich enough to be useful in developing system dynamics models whereas semistructured interviews have proven to be particularly effective.

Sufficiently large sample size of responses was elicited to enable statistical analysis of data groups and for generalisation to be made possible with the outcome of the research. Variety of question forms were constructed to ensure that data of the type and in the format required for analysis was elicited from respondents considering the fact that a minimum sample size for this type of data collection was that which allows normal distribution assumptions to be used rather than using a *t* distribution in thirty cases (Hinkle et al.,1988). A skewed distribution would not be as reliable as a normal distribution which forms a more reliable sample (Levin 1987, p394).

The questionnaires were distributed to practitioners and professionals that were selected from the qualified professional groups consisting of Quantity Surveyors, Architects, Builders, Engineers (Structural, and Mechanical and Electrical). The result of the questionnaires and the background information collected for this research will be discussed in detail in Chapter Six generally and as it affects the model.

6.3 Modelling Process

Software that was used for the modelling is Vensim which provides a graphical modeling interface with stock and flow and causal loop diagrams, on top of a text-based system of equations in a declarative programming language. It includes a patented method for interactive tracing of behaviour through causal links in model structure, as well as a language extension for automating quality control experiments on models called Reality Check. (Vensim Causal Tracing, and Peterson and Eberlein; 1994). Barlas (1996) emphasised that Reality Check consists of statements of the form: “if input A is imposed on the system, then behavior B should result.” Then, the software performs simulations and tests the conformance of the model to the anticipated behaviour. This makes validity easier once the model is completed.

Problem articulation is the most important step in modelling. The most concerned issue is clearly stated. In this research the problem we are trying to solve is to show the relationship between observed variables that determine performance. Thus, in this chapter the endogenious variables are clearly defined “endogenous” means “arising from within.” An endogenous theory generates the dynamics of a system through the interaction of the variables and agents represented in the model (Sterman, 2000). To deduce the exogenous variables that comprised the critical success factors, the descriptive and inferential statistics are used for the analysis. These are described in Chapter Five of this dissertation. The initial characterization of the problem was carried out through discussion with the construction experts, supplemented by archival research, literature, focus group data collection, interviews, and direct observation or participation. Two of the most useful processes are establishing reference modes and explicitly setting the time horizon.

6.3.1 Reference Modes and Time Horizon

The model is characterized with performance effect from four different parameters and many different variables interacting dynamically, that is, as a pattern of behaviour, unfolding over time, which shows how the problem arose and how it might evolve in the future. Literally a set of graphs were developed as a reference mode from the mental model developed into the dynamics of stock and flow in a loop diagram. Reference modes (so-called because you refer back to them throughout the modelling process) helps to break out of the short term event-oriented worldview. Thus, the time horizon is identified and defined for those variables and concepts that are important for understanding the problem and designing policies to solve it. The time horizon should extend far enough back in history to show how the problem emerged and describe its symptoms. It should extend far enough into the future to capture the delayed and indirect effects of potential policies. Most people dramatically underestimate the length of time delays and select time horizons that are far too short. A principal deficiency in our mental models is our tendency to think of cause and effect as local and immediate instead of understanding them as involving feedbacks with long delays. Dynamic complex systems, cause and effect are distant in time and space. Most of the unintended effects of decisions leading to policy resistance are far removed from the point of decision or the problem symptom. A long time horizon is a critical antidote to the event-oriented worldview so crippling to our ability to identify patterns of behaviour and the feedback structures generating them.

6.3.2 Time Horizon Causal loop diagrams and Stock and flow maps

Model boundary charts and subsystem diagrams show the boundary and architecture of the model but would not show how the variables are related. Causal loop diagrams (CLDs) are flexible and useful tools for diagramming the feedback structure of systems in any domain. Causal loop diagrams emphasize the feedback structure of a system. Stock and flow diagrams, Figure 6.1 emphasize their underlying physical structure. Stocks and flows track accumulations of material, money, and information as they move through a system. Flows are the rates of increase or decrease in stocks, such as production. A flow is the rate of accumulation of the stock. Stocks characterize the state of the system and generate the information upon which decisions are based. The decisions then alter the rates of flow, altering the stocks and closing the feedback loops in the system.

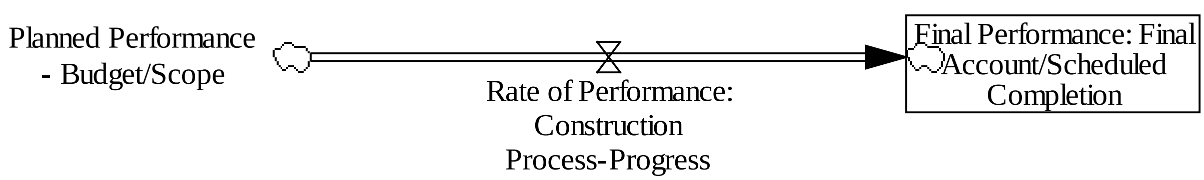


Figure 6.1: Feedback flow Map for Construction Project Performance

6.4 Model Structure and Assumptions

Sterman (2000) in his defence of explicitly stating the assumption underlying a model, stated that Often, models are used not as tools of inquiry but as weapons in a war of advocacy. The importance of clear assumptions about variables is emphasised because the model users should be able to examine the boundary of the models and provide required information. The model as depicted in Figure 6.2 makes several simplifying assumptions: a) the final performance at completion depends on the rate of construction process progress or rate of performance; b) scheduled or planned performance flows to process progress or rate of performance; c) final performance at completion increases by the rate of performance; and d) the planned scheduled performance scope is decreased by rate of construction progress performance. The process progress or rate of performance rate is a function of the planned scheduled performance scope and final performance at completion.

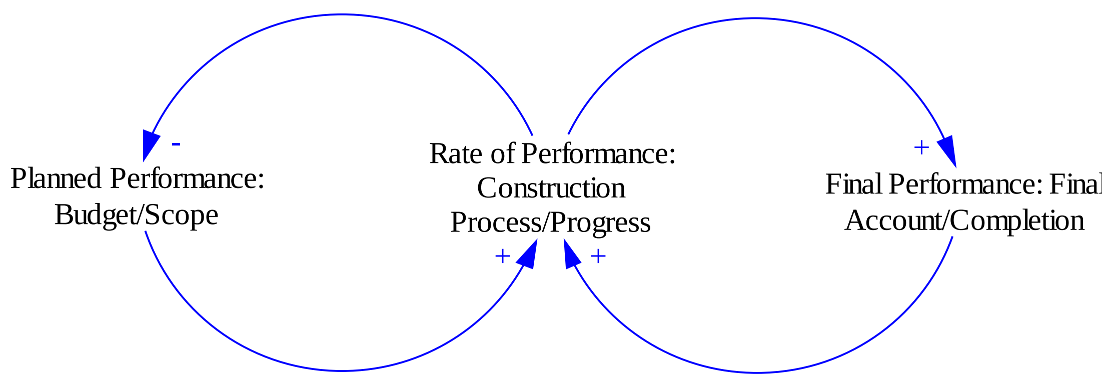


Figure 6. 2: Causal Loop Diagram for Construction Project Performance

Barlas, (1996) asserted that models could be “causal-descriptive” and purely “correlational” (purely data-driven, “black-box”). In purely correlational models, since there is no claim of causality in structure, what matters is the aggregate output behaviour of the model; the model is assessed to be valid if its output matches the “real” output within some specified range of accuracy, without any questioning of the validity of the individual relationships that exist in the model. Models that are built primarily for forecasting purposes (such as time-series or regression models) belong to this category. On the other hand, causal-descriptive (whitebox) models are statements as to how real systems actually operate in some aspects.

The first important assumption is the model's scope and focus, as reflected in the model boundary. This will focus the research on the inner working mechanism of the performance of indicators within a project. Stable environment is another important boundary assumption, process and organization throughout the project life, e.g. the use of an exogenous constant to describe the average duration required to complete the task of projects. These values and functions do not change during the simulation. This is followed by a third assumption which is the level of aggregation assumption within the model boundary, as it focuses the research and model purpose. This assumption concerns the fundamental units which flow through projects. These units are described as "task" in the model, which is defined as unit of work. The developed hypothetical model was continuously revised so that it could best explain the causal relationship between project performance and various project characteristics.

6.5 Model Testing and Validation

Accuracy of models to reflect actual environment in a reasonable pattern is the focus of modelers. An essential part of modeling process in system dynamics is Model validation and according to (Sterman, 2000); Modelers and clients often suffer from confirmation bias, selectively presenting data favorable to their preconceptions, and then stickin' to their story despite the evidence. Model testing should instead be designed to uncover errors so you and your clients can understand the model's limitations, improve it, and ultimately use the best available model to assist in important decisions. Among the techniques used for testing models validity in SD are structure verification test, dimensional consistency test, parameter assessment test, and extreme condition test. These are discussed subsequently

6.5.1 Structure Verification Test of Models

Model building is about representation of real life relationship and interactions of the various components in the model. The consistency of relevant descriptive knowledge in the system and appropriate level of aggregation were ascertained to conform to the basic physical laws. The relationships among the variables were confirmed through the Factor Analysis and Variables that are not consistent with loadings to their latent factors were excluded from the SD Models. The Vensim software inbuilt mechanism for validating the model for structural verification test was used for model check and it was confirmed that all the elements with causal influence on one another were adequately considered. Each of the Model diagram were confirmed ok as presented in the screen shots diagram for the appropriate Figures for each of the KPIs and the Project Performance Diagnostics Model (PPDM)

6.5.2 Dimensional Consistency Test

Parameters in SD model (SDM) should have real world meaning. In assessing the performance of construction projects percentage (%) is used as a unit having real life meaning with a general understanding by practitioners in the construction industry. Vensim could perform the task of checking for dimensional consistency test by clicking on this function from a drop down menu in the model icon of the software. This will confirm that the unit of measure of variables on both sides of the particular equation is equal. The models presented in this research were checked and confirmed to be dimensionally consistent and ok.

6.5.3 Parameter assessment test

This assessment test is required to check the parameter values of the syatem that they are consistent with relevant descriptive and numerical knowledge. It also requires confirming if the parameters have real world counterparts. (Sterman, 2000) highlighted a number of techniques that could be used for this tests including the use of judgmental methods based on interviews, expert opinion, focus groups, archival materials and direct experience among others. The models developed in this research were based on wellgrounded factors identified from literature, confirmed by expert opinion/interviews from generally acceptable factors among construction industry real life practitioners in the Nigerian built environment and rigorously analysed with statistical tools.

6.5.4 Extreme Condition Test

This test presumes that the model is consistent in performing at unusual or extreme cases whether the equation make sense even when its inputs take on extreme values or whether it responds plausibly when subjected to extreme policies, shocks, and parameters. This is a test of simulation at extremely high or extremely low level. The models validated in this research performed reasonably well under the two extremes.

6.6 KPIs Model in Stock and Flow Diagram

The modelling for the four key performance indicators considered in this research are hereby presented. A central idea in dynamics is the Stocks and flows, and along with feedback, are the two central concepts of dynamic systems theory (Sterman, 2000). Stock and flow diagram represents the causal relationship between elements in system dynamics models with algebraic representation for simulation run on a computer and thus, enhance mathematical simulation and quantitative analysis of the relationships between elements in the model.

Diagnosing the performance of construction projects as a SD model requires a stock and flow diagram having established the CSF components of KPIs using Factor Analysis. The Stock and flow was developed in order to simulate the dynamic relationship between the various CSF components of the KPIs to assess the performance of construction projects using VENSIM software tool. The stock and flow diagram is presented in Figure 6.3.

Chapter Five presented the results of all variables that were identified for the KPIs (Cost, Time, Quality and Health and Safety) in the SD model and thus present the description of all variables included in the Stock and flow diagram model. The factors that are not relevant in this research were removed during the reduction process of factor analysis. The diagram provides valid model of CSFs component relationship for determining the KPI performance by simulating impact of one variable on different parts of the model as well as on the overall model and therefore, the, impacts of adopting a particular critical success factor on overall performance of construction projects were simulated.

In what follow is the Model Stock and Flow diagram for individual KPI and thus provide the required answer to objective 4 by evaluating the dynamic framework/model of CSFs for individual KPI for its suitability for construction project performance diagnostic for effective project delivery in Nigeria. This would eventually lead the research to finally present the SD performance model for the overall project performance and thus the Project Performance Diagnostic Model. The required testing and validations were carried out to confirm the validity of the model.

6.6.1 Cost Performance Forecasting Variables

Major causes attributed to cost failure or cost overrun on construction projects are cost of materials, incorrect planning, and wrong method of estimation, contract management and inflation of prices of materials (Mukuka, Aigbavboa & Thwala, 2014). This research developed three components for Cost Performance which include "Contractor's Management Capacity", with critical success factors such as: employment of skilful workforce; ability to manage designs; government institution and administrative influence; extent of subcontracting; initial identification of risks; site management; technical and management capacity; construction method adopted; healthy financial condition and stability of the contractor and; adequacy of available information that made up the group are either core responsibilities of the contractor in order to achieve perceived success in terms of cost.

The second group factor is "Client's Commitment to Progress of Project" which has five measures of CSF for Cost performance indicator, the variable items under this group are: Client's commitment and information coordination with project parties; Ability to solve unanticipated problems that occur during construction; Adequate time to project (Realistic Programme); Type and Nature of Client and; Client's Project Financing for regular cash flow. A client who fails to finance the project in accordance with planned programme of work will end up frustrating all other efforts to make the project perform cost wise.

The third component of Cost Performance CSF is "Economic Environment of Project Estimate" and explains the fact that Precise project budget estimate and economic environment are the two factors or variables that suggest measures of achieving cost performance on construction project. Adverse economic environment such as recession and inflation could render the budget estimate prepared for a construction project incorrect or inaccurate before the project is completed thereby leading to excess cost in terms of variations, claims and fluctuations. These were modelled for cost performance as described in Figure 6.2. The Model is tested and validated ok.

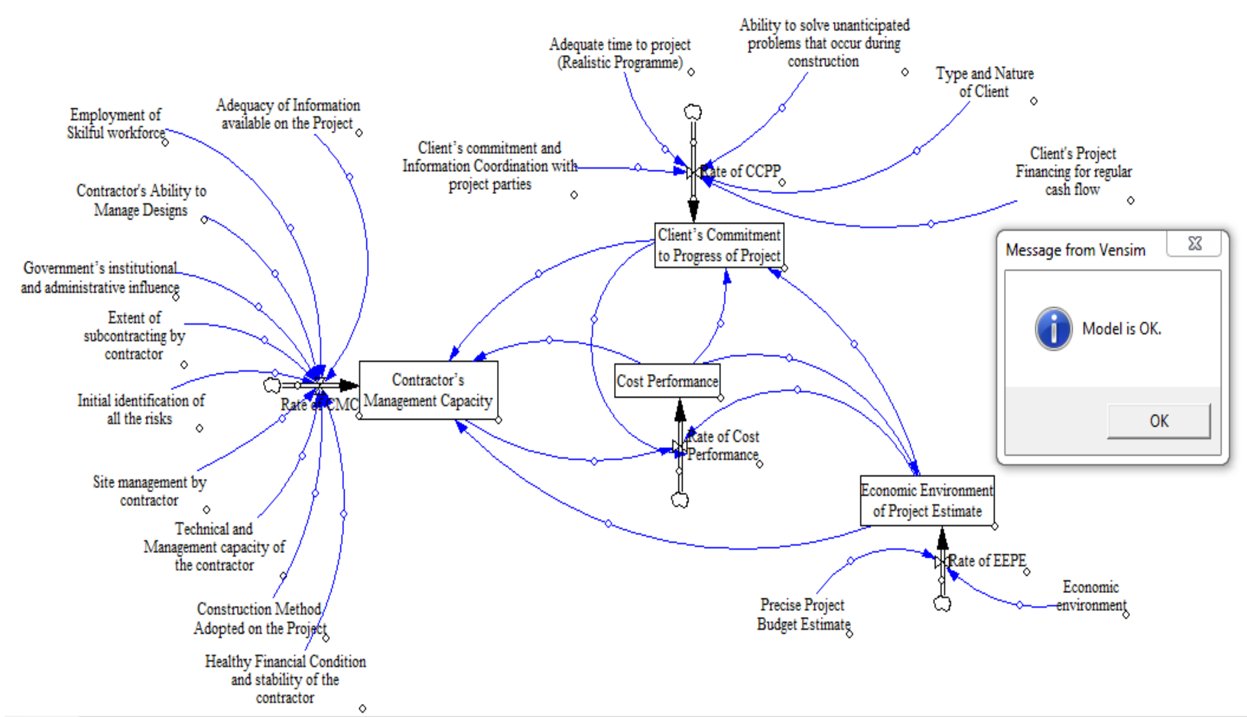


Figure 6. 3a: System Dynamic Model of Cost Performance of Construction Projects

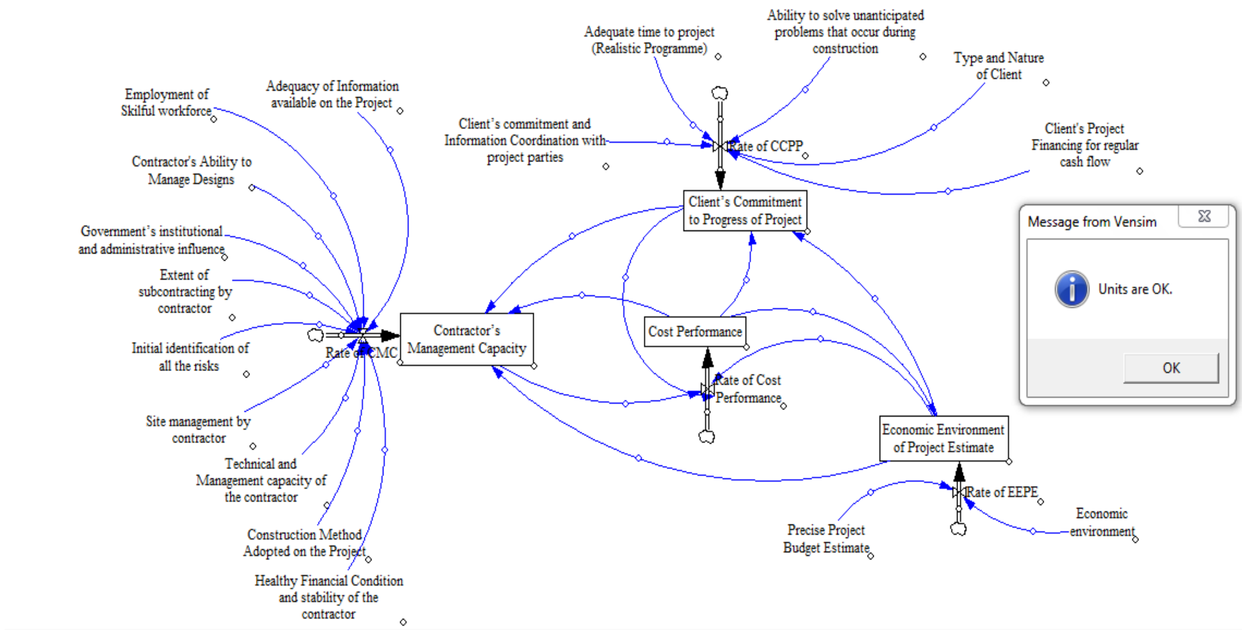


Figure 6.3b: System Dynamic Model of Cost Performance Dimensional Consistency Check

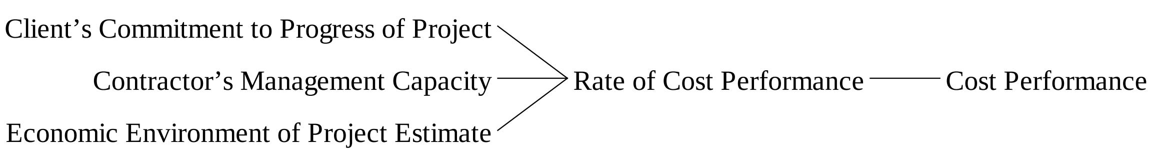


Figure 6.3c: Tree Diagram from the SD Model of Cost Performance

Figure 6.3c is the Tree Diagram showing the variables causing the Cost performance of Construction projects through the auxiliary variables that drives the Budget rate or rate of cost performance from the causal loop diagram of the stock and flow in Figure 6.3a and b. The equation from the model shows that;

Cost Performance= INTEG (Rate of Cost Performance^0.5,0)

Units: "%"*"%" [0,100]

6.6.2 Time Performance Forecasting Variables

The causes of schedule overrun, which is the most obvious effect of poor time performance, are identified as: design error, poor site condition, delay in payment, financial incapability of client, financial incapability of contractor and non-availability of subcontractor and suppliers, financial or cahflow difficulties, frequent change orders, shortage of resources, escalation of materials prices, increase in the scope of works and late deliverey of construction materials among others (Mukuka, et. al., 2014). In this research four component factors were established for time performance and the first factor is "Design Team Commitment to Project Management Outcomes", was so labelled because initiating, planning, executing, controlling, and closing the work of a team to achieve specific goals and meet specific success criteria is project management which is the core responsibility of the design team including client, project manager and the professional designers like architect and engineers.

All measures that made up the group suggest measures that could only be achieved through a commitment to Project management effort on outcomes such as Ability to solve unanticipated problems that occur during the course of the project, Clear, Correct and Precise Drawings/Documents, Timely Production of required Design Documents, Early Involvement of Project Manager, Efficiency of communication on the project, Client's Project Financing for regular cash flow, Type and Nature of Client, Government's institutional and administrative influence e.g. regulations, permits; Management capacity and Competence of project manager, and Initial identification of all the risks that are likely to occur on the project. All these are key to the success of project management process. The second component factor is “Capacity of Contractor for Project Management” which has five measures of CSF for Time performance indicator.

The factor component suggests that achieving Time performance requires the Contractor to have capacity that flows in tune with project management principle thus, incorporating the project manager within its fold. The variable items under this group are, Healthy Financial Condition and stability of contractor, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Site management by contractor, and Employment of Competent and Skilful Workforce. These factors clearly show the capacity of the contractor’s management but that is not all, it requires that there is an oversight on the contractor management as a well managed company could strategically desire to delay project completion if adequate oversight function is not carried out by the project manager. “Construction Resource Management” is the imposed identity for the third component.

The factor component consists of nine factors, all of which suggest measures for Construction Resource Management. The CSF for Time performance under this component include Construction methods adopted on the project, Adequacy of information available on the project, Delivery time of resources (materials, equipment), Ability of client to make timely and accurate decisions on the project, The condition of the equipment (state of repair), Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Collaborative Supervision/inspection on the project (Consultants with Client), and the State of Health and Safety. External Environmental factors have been reported by researchers to have impact on project performance and this is the fourth factor category so labelled as "External Factors" due to its integration of only three CSF factors listed in the group which include Economic environment (could incorporate financial environment), Physical work environment such as weather, public disturbance (area boys) – which could also be termed political environment and Legal environment which comprise the legislative and government policy or regulations as they affect performance of construction projects. All these four component factors were interrelated in the analysis conducted and thus dynamically affect Time performance as modelled inFigure 6.3a and 6.3b checked, tested and modelled validated okay.

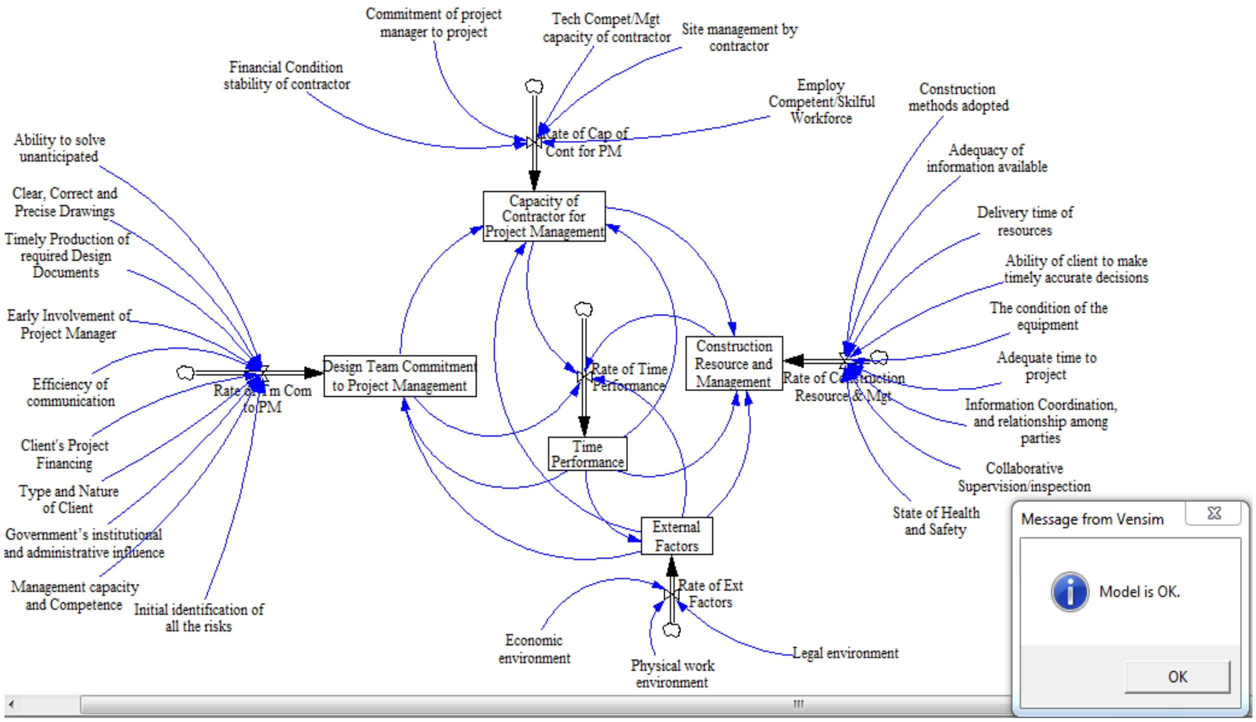


Figure 6.4a: System Dynamic Model of Time Performance of Construction Projects

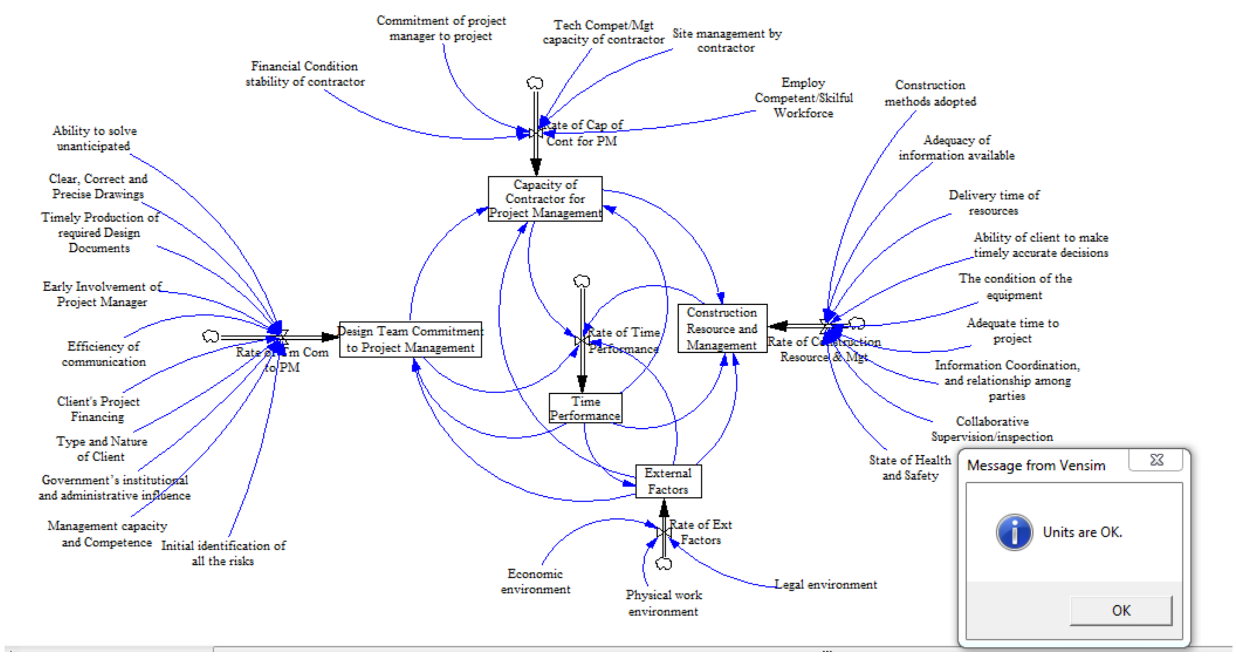


Figure 6.4b : System Dynamic Model of Time Performance Dimensional Consistency Check

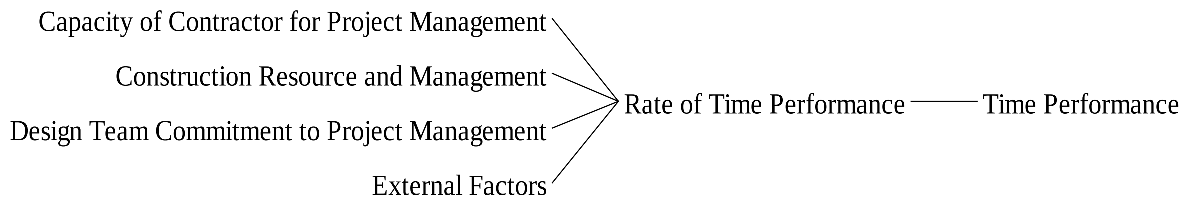


Figure 6.4c: Tree Diagram from the SD Model of Time Performance

Figure 6.4c is the Tree Diagram showing the variables causing the Time performance of Construction projects through the auxiliary variables that drives the Schedule rate or rate of time performance from the causal loop diagram of the stock and flow in Figure 6.3. The equation from the model shows that;

Time Performance= INTEG (Rate of Time Performance^0.5,0)

Units: "%"*"%" [0,100]

6.6.3 Quality Performance Forecasting Variables

In order to achieve planned quality on construction projects adequate attention must be paid to certain quality performance variables. These variables, according to Shittu, et. al., (2013) could impact negatively on the quality of workmanship deployed which in turn, cause defects in construction projects especially building projects.Causes attributed to poor workmanship quality are eight in number with limited cost topping the list. This is corroborated with the findings of Mahamid (2016) which attributed low designs fees as one of the numerous causes of rework in construction projects. Unsuitable construction equipment was another factor pointed as responsible for poor workmanship on construction projects (Shittu, et. al., 2013).

The research found three component factors for quality performance and the first is "Project Design Communication Management with Workforce", which include Efficiency of communication on the project, Government's institutional and administrative influence e.g. regulations, permits, Competence and experience of design team, Type and Nature of Client, Collaborative Supervision/inspection on the project (Consultants with Client), Quality of Product/Service Design, Timely

Production of required Design Documents, Employment of Skilful Workforce that made up the group are either core responsibilities of the project management and design team with particular focus on timely production of design drawings with an oversight function on skilful workforce for a quality product achievement.

All measures that made up the group suggest measures that could only be achieved by a capable design team management with proper coordination of information and communication on the part of the design team with collaboration with the project management efforts to ensure that the workforce produce the quality design that had been achieved. Therefore, it is established that achieving quality performance requires coordination of information with collaborative efforts of all parties. The second group factor is “Contractor Capacity for Resource Management on Quality Objective” which has eight measures of CSF for Quality performance indicator: The condition of the equipment (state of repair), Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Implementation of Innovative Techniques by contractor, Technical and Management capacity of the contractor, Site management by contractor, The standard and quality of materials, Healthy Financial Condition and stability of contractor, Cultural environment.

Once the objective of the standard quality is clearly expressed as contained in the item specification and description then the contractor has to put all resources together within his management to ensure achievement of quality. “Project Manager’s Competence on Information Coordination and Construction Method” which has four variable factors is the third component factor which include Information Coordination, communication and relationship among project parties, Experience of Project Manager, Management capacity and Competence of project manager and Construction methods adopted on the project such as use of only precast building component, concrete pumps etc.. The effects of these variables on quality performance of construction projects are depicted in Figure 6.5: The model is tested and validated okay.

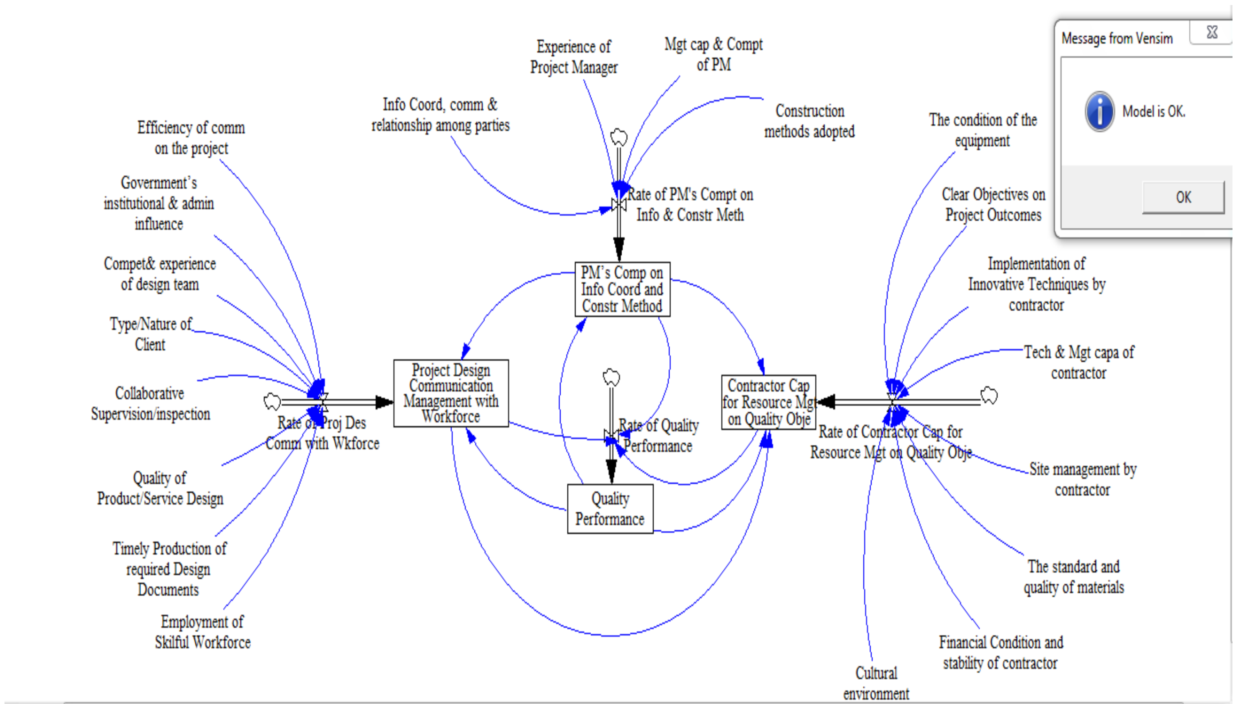


Figure 6.5a: System Dynamic Model of Quality Performance of Construction Projects

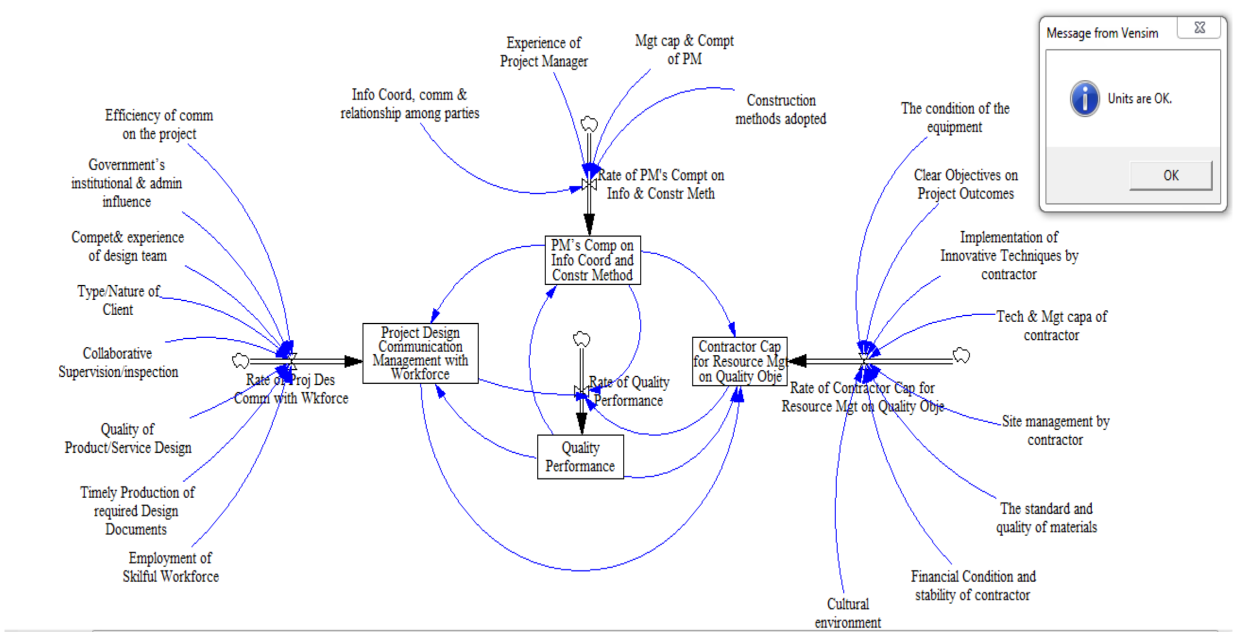


Figure 6.5b: System Dynamic Model of Quality Performance Dimensional Consistency Check

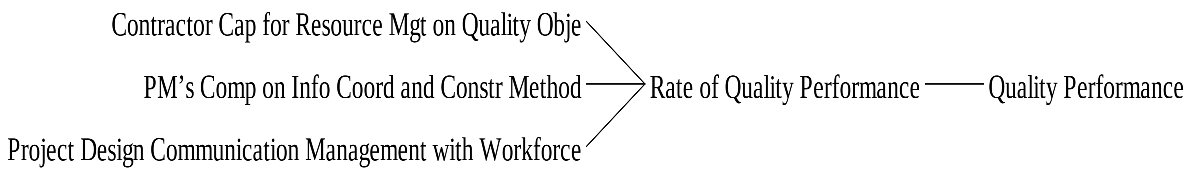


Figure 6.5c: Tree Diagram from the SD Model of Quality Performance

Figure 6.5c is the Tree Diagram showing the variables causing the Quality performance of Construction projects through the auxiliary variables that drives the Quality rate or rate of quality performance from the causal loop diagram of the stock and flow in Figure 6.5a and b. The equation from the model shows that;

Quality Performance= INTEG (Rate of Quality Performance^0.5,0)

Units: "%"*"%" [0,100]

6.6.4 Health and Safety Performance Forecasting Variables

Frequency of occurrence of ill health, injuries and accidents on construction sites is an indication of safety performance of such projects (Memon, *et. al.*, 2012). The extent of damage to property experienced on construction project is also an indication of how safe the project is (Muhammad*, et. al.*, 2015). Causes ascribed to these health and safety failure events are non-availability of safety equipment, defective equipment and noncompliance with health and safety policy of construction organizations. Two component factors were established for health and safety performance.

The first factor is the “Effective Finance of Site Management for Health Safety Implementation” it consists of eight policy suggestions including; Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, Healthy Financial Condition and stability of contractor, Appropriate safety education and training, Government’s institutional and administrative influence e.g. regulations, permits, Physical work environment such as weather, public disturbance (area boys), Safety equipment acquisition and maintenance are measures that made up the group suggest measures that could only be achieved through effective site management effort on health and safety implementation. All these are key to the success of project health and safety management process.

The second group factor is “Capacity of Contractor for Project Management and Safety Programme” which has nine measures of CSF for health and safety performance indicator. The variable items under this group are, Technical Competence and Management capacity of the contractor, Experience of contractor, Experience of Project Manager, Construction methods adopted on the project such as use of only precast building, Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Employment of Skilful Workforce, Collaborative Supervision/inspection on the project (Consultants with Client), The condition of the equipment (state of repair), Program evaluation of State of Health and Safety (e.g. Accident cause delay).

These factors clearly show the capacity of the contractor’s management but that is not all, it requires that there is an oversight on the contractor management as a well managed company could strategically desire to not to take health and safety needs of the site seriously if the project manager and even the client did not emphasise punitive measures for not carrying it out. The dynamic model of Health and Safety Performance is displayed in Figures 6.6a and b.

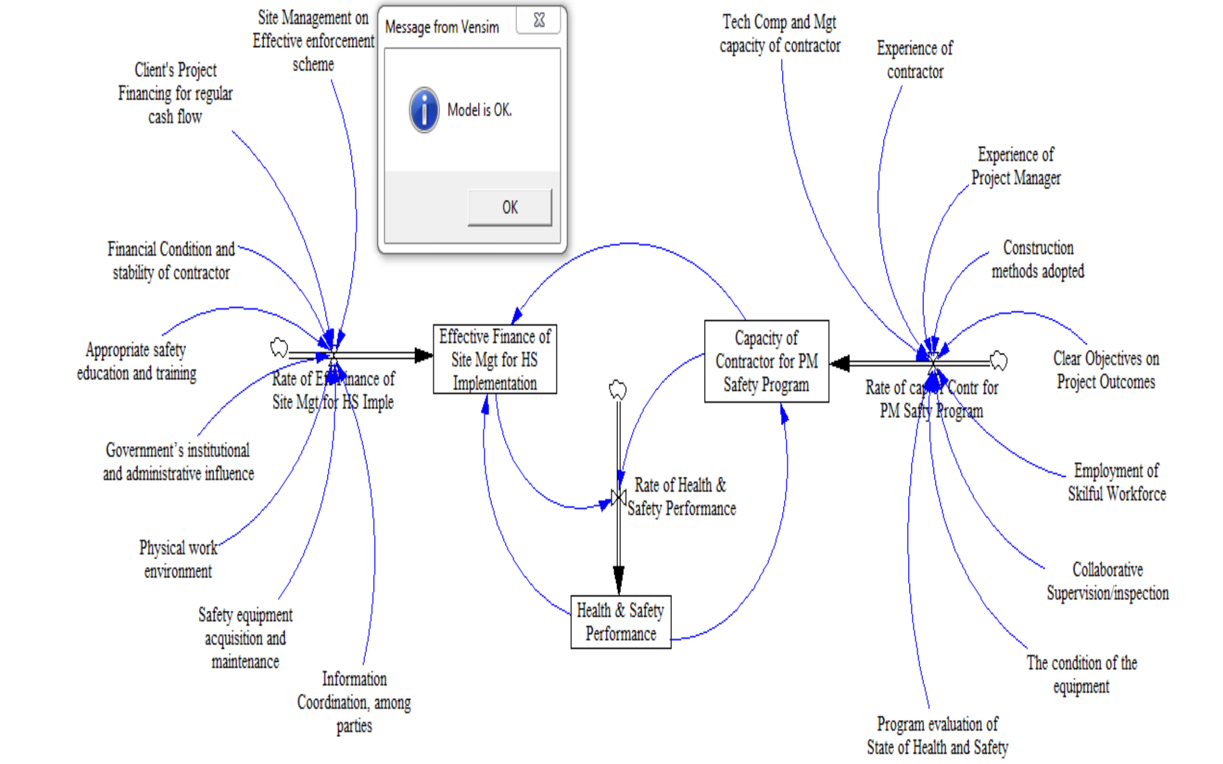


Figure 6.6a: System Dynamic Model of Health and Safety Performance of Construction Projects

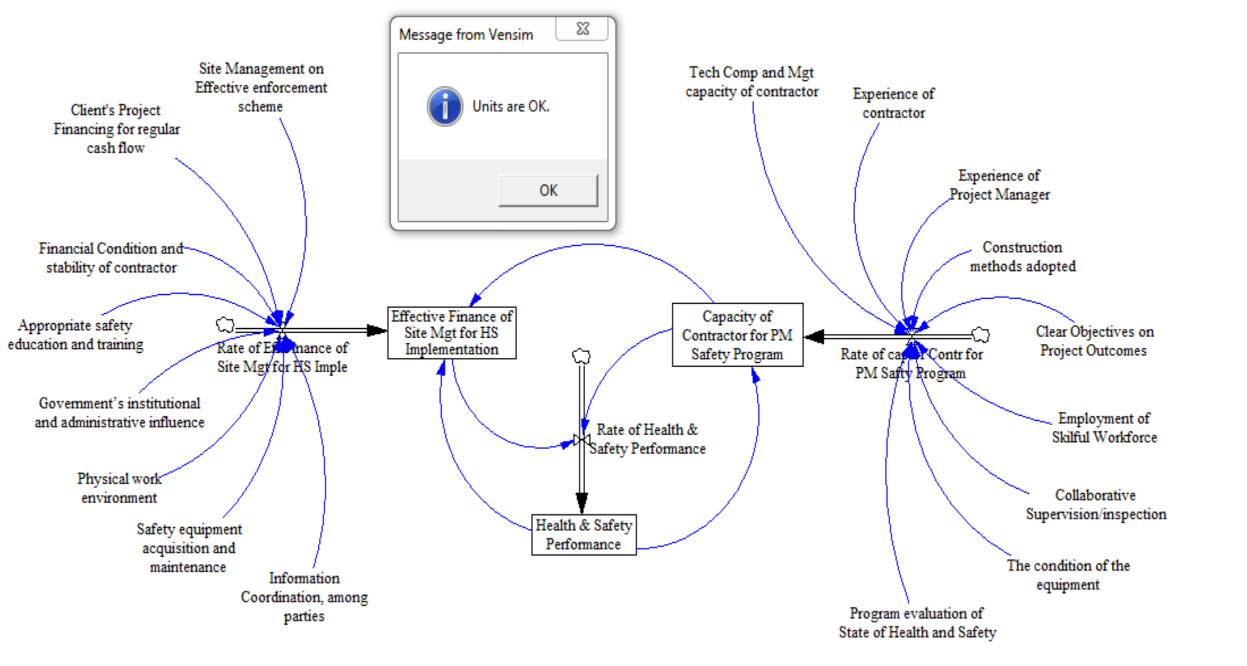


Figure 6.6b: System Dynamic Model of Health and Safety Performance Dimensional Consistency Check.

Figure 6.6c: Tree Diagram from the SD Model of Quality Performance

Figure 6.6c is the Tree Diagram showing the variables causing the Health and safety performance of Construction projects through the auxiliary variables that drives the health and safety rate or rate of health and safety performance from the causal loop diagram of the stock and flow in Figure 6.6a and b. The equation from the model shows that;

"Health & Safety Performance"= INTEG ("Rate of Health & Safety Performance"^0.5,0)

Units: "%"*"%" [0,100]

The SD models developed for the KPIs of Time, Cost, Quality and Health and Safety have shown the dynamic workings of the endogenous variables interactions and thus, CSFs operate in a dynamic relationship and from these underlying dynamic relationships a causal relationship is established beyond the correlation established previously through factor analysis technique. This has suggested that modelling CSFs for KPIs in assessing causal relationship, through the process of stock and flow feedback system has been confirmed and thus would be suitable for construction project performance diagnostic that will be useful for assessing effective construction project delivery in Nigeria. This outcome leads the research to the main aim of the dissertation and the last and final objective 5 which is to conceptualise the development of a system dynamics Project Performance

Diagnostic Model (PPDM) from the KPI models for diagnosing project performance based on the project variables.

6.7 The Project Performance Diagnostic Model of the four KPIs

This research has established three components for Cost performance indicator identified as Contractor's Management Capacity, Client's Commitment to Progress of Project, and Economic Environment of Project Estimate; four components were established for Time performance indicator identified as Design Team Commitment to Project Management Outcomes, Capacity of Contractor for Project Management, Construction Resource Management, and External Factors. Quality performance indicator were found to have three component factorswhich include Project Design Communication Management with Workforce, Contractor Capacity for Resource Management on Quality Objective and Project Manager's Competence on Information Coordination and Construction Method. Health and Safety performance indicator has two groups of CSFs Effective Finance of Site Management for Health Safety Implementation and Capacity of Contractor for Project Management and Safety Programme.

These different component factors with their individual CSF variables of KPIs were used for the development ofdynamic Project Performance Diagnostic Model in delivering the main purpose of the research. Figure 6.7 is the model tested ok.

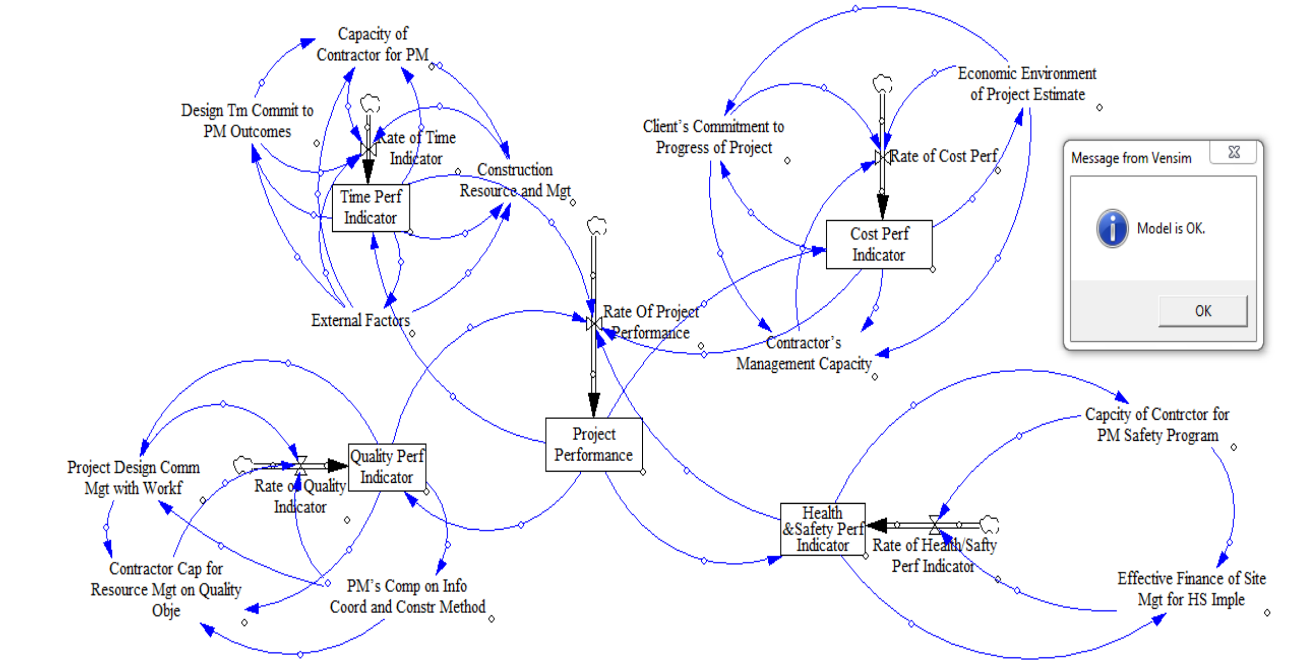


Figure 6.7: System Dynamic Model of the four KPIs of Time, Cost, Quality, and Health and Safety using their Component Factors for Construction Projects Performance.

The presentation in Figure 6.7 is the simple model developed from the component factors of CSFs of individual KPIs previously established in this chapter. A comprehensive detailed model follows in Figure 6.8a and Figure 6.8b which depicts the interaction of all the CSFs that were determined as contributing to performance indicators for the overall construction project performance – The Project Performance Diagnostics Model (PPDM). This model is tested and validated okay. Subsequently, simulation runs were carried out to test for assumptions made for the workings of the model. The structure of the model and the dimension consistency check were confirmed okay and thus the validity of the conceptualisation of a System Dynamic Project Performance Diagnostic Model.

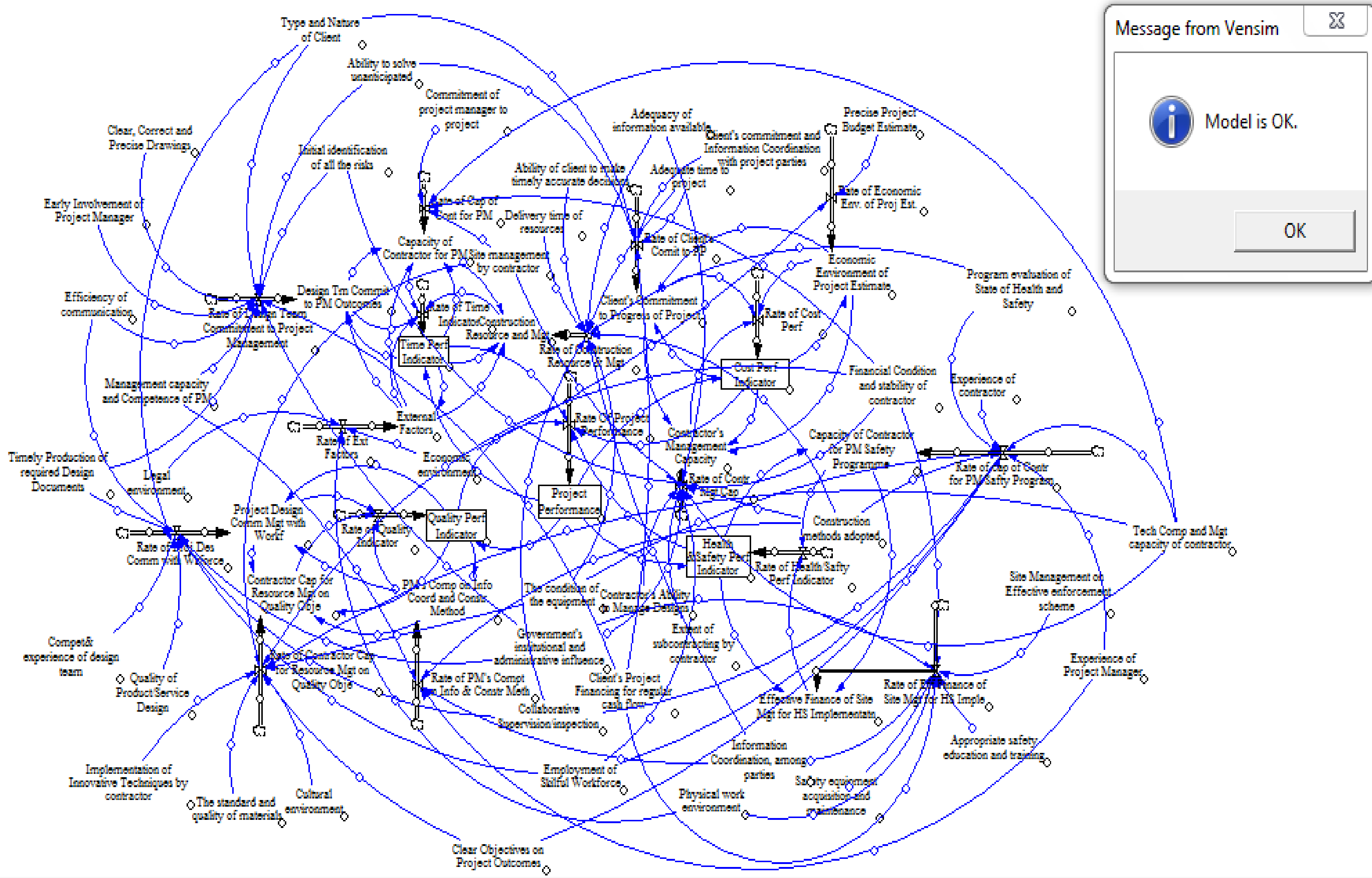


Figure 6.8: Project Performance Diagnostic Model (PPDM) for Construction Project Performance

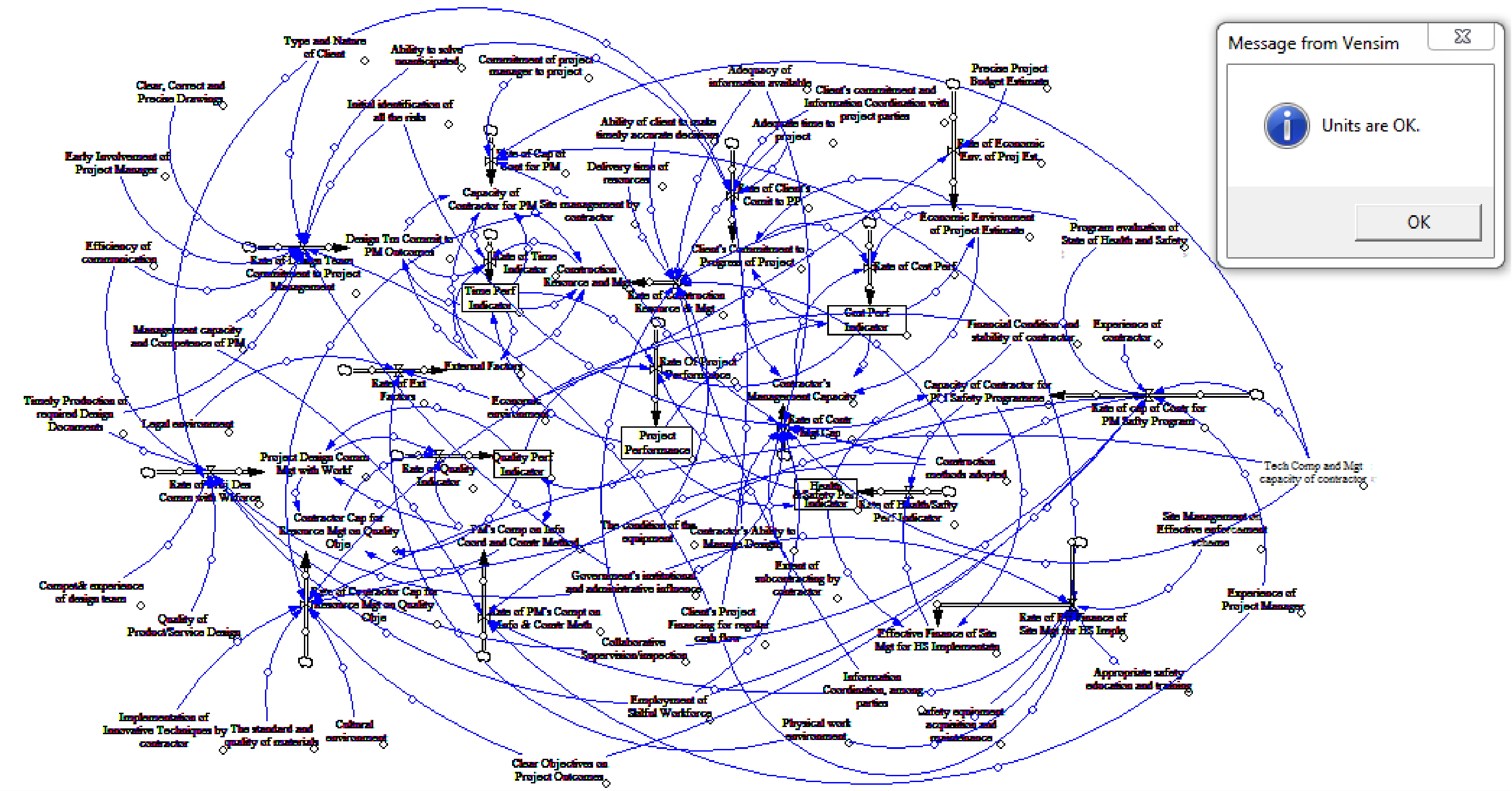


Figure 6.9a: Project Performance Diagnostic Model (PPDM) for Construction Project Performance Dimensional Consistency Check.

Figure 6.9b: Tree Diagram from the (PPDM) Model of Construction Project Performance

Figure 6.9b is the Tree Diagram showing the variables causing Construction Projects Performance through the auxiliary variables that drives the Project Performance or Rate of Project Performance from the causal loop diagram of the stock and flow in Figure 6.8. The equation from the model shows that;

Project Performance= INTEG (Rate Of Project Performance^0.5,0)

Units: "%"*"Week" [0,100]

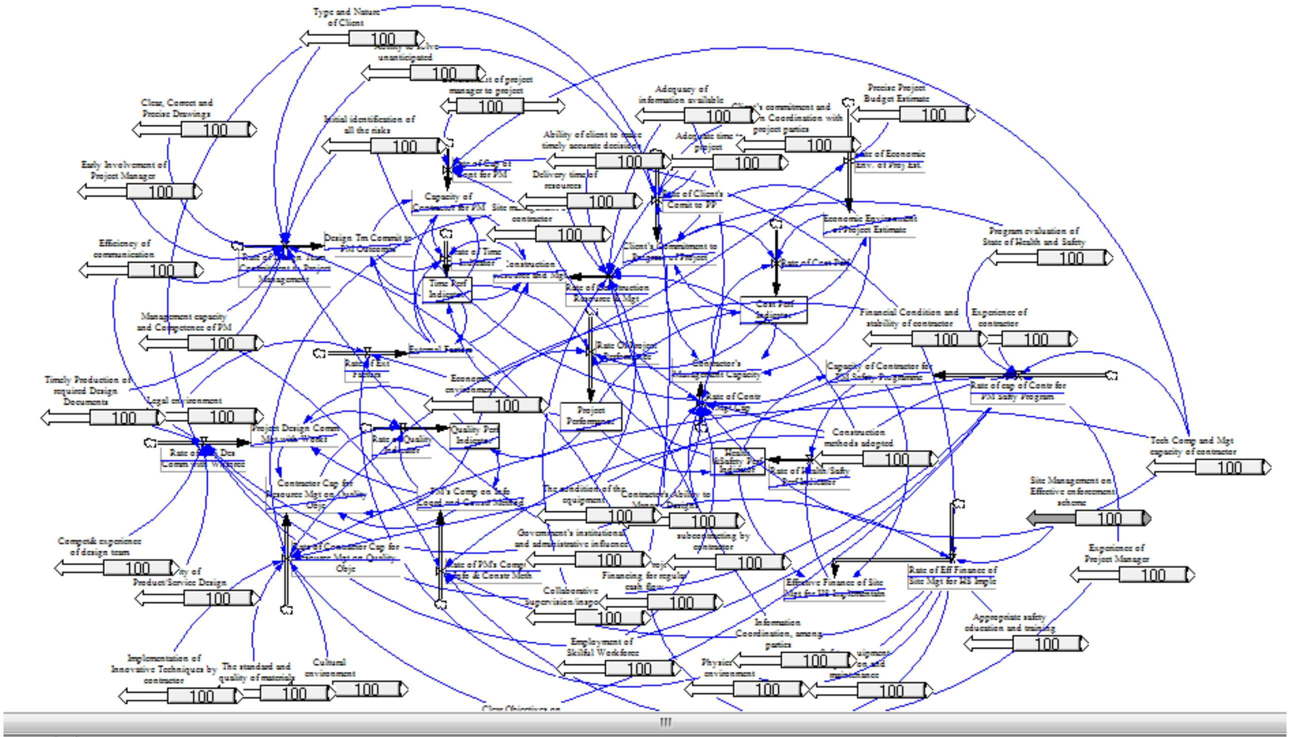


Figure 6. 10: Simulation Run of the Project Performance Diagnostic Model (PPDM) at 100% Extreme test for Construction Project Performance

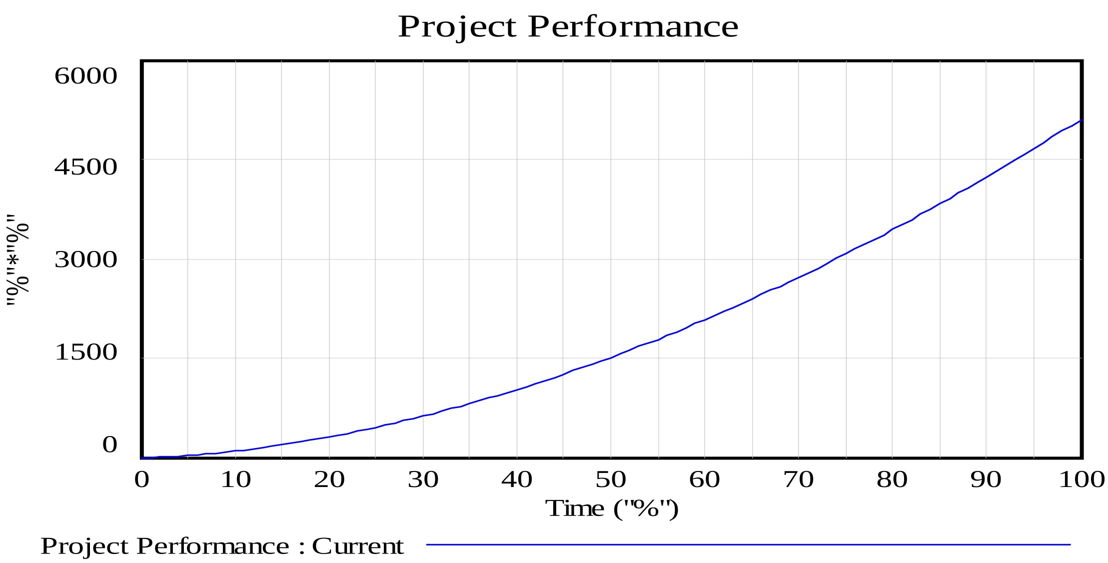


Figure 6. 11: Graph of the Simulation Run of the (PPDM) at 100% Extreme Test

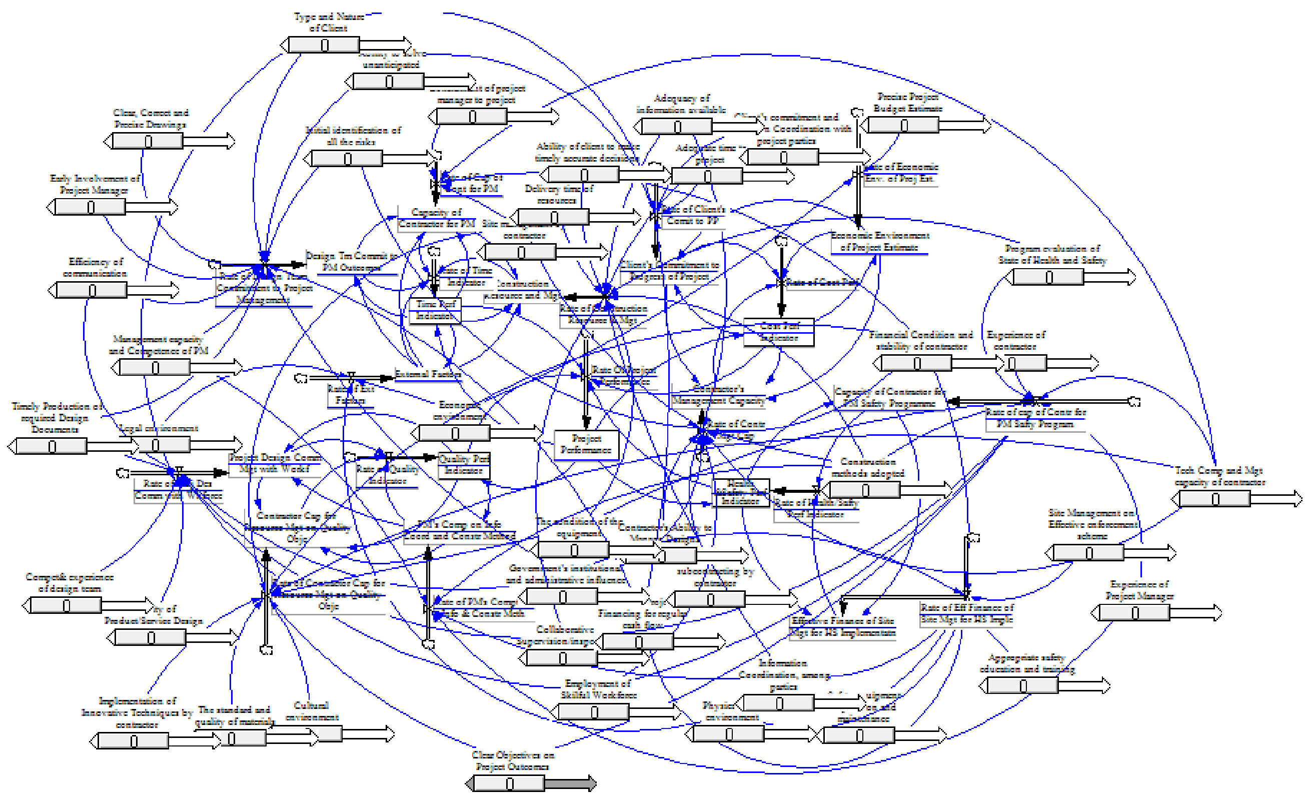


Figure 6.12: Simulation Run of the Project Performance Diagnostic Model (PPDM) at 0% Extreme test for Construction Project Performance

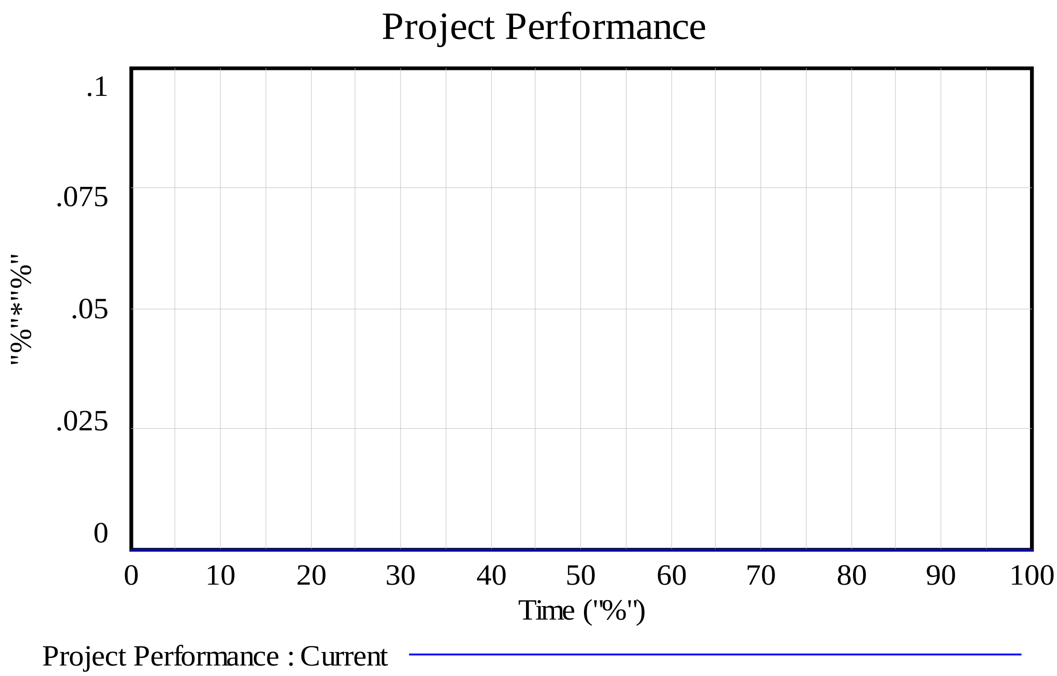


Figure 6.13 Graph of the Simulation Run of the (PPDM) at 0% Extreme Test

6.8 Loading the Vensim model for Equation

The modelled equation was later loaded with the values of the factor analysis loadings for each of the retained variables of critical Success Factors for each of the Key Performance Indicators in establishing the formula for the calculation of each KPI and the overall performance of any construction project as typically analysed for the Nigeria Construction Industry. After loading the model and ascertaining the structure of the model is confirmed ok and the units are confirmed ok then the model was subsequently put to simulation test by running the model to see how it performs in diagnosing the performance of construction projects and the output of the simulation runs is presented below.

6.9 Dynamic Impact of the Four Key Performance Indicators on Construction Project Performance

The models extreme test case scenario simulations run were successfully performed to validate the model's response to different impacts within the construction project system and reporting the outcome of the dynamics. In furtherance of the test of different impact as it affects the dynamics of construction project, each of the KPIs were separately stepped down and its impacts was assessed on the other KPIs and the overall Project Performance. The Vensim analyses tools were subsequently engaged for each of the KPIs. The adoption/implementation levels were reduced to 0% for each of the KPIs at a time, while keeping others at 100%. The impacts of the overall construction project performance was evaluated by the impacts of keeping all the CSFs for the particular KPI at 0% while leaving all other CSFs of the other three KPIs at 100%.

The results of the scenario of the simulation runs were presented in Figure 6.14 to Figure 6.23. The results suggest that Cost Performance Indicator has the highest impacts on overall construction project performance and in fact every other performance indicators.

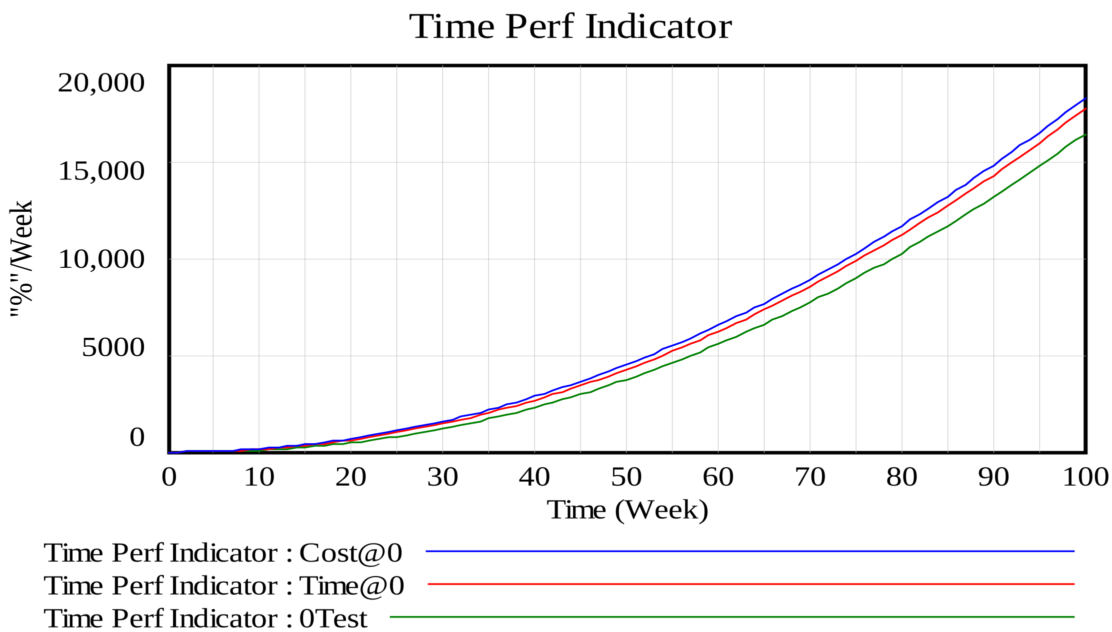


Figure 6.14: Graph of the Dynamic Impact of Cost@0%& Time@0% on Time Performance.

At Cost @ 0, Time Performance is better than Time@0 thus. Time performance is worse off when Time performance performed abnormally. Compare the red and blue lines in the graph of Figure 6.14.The 0Test is the Base line when all KPIs are at 0% after loading the model with the coefficient loadings of the factor analyses.

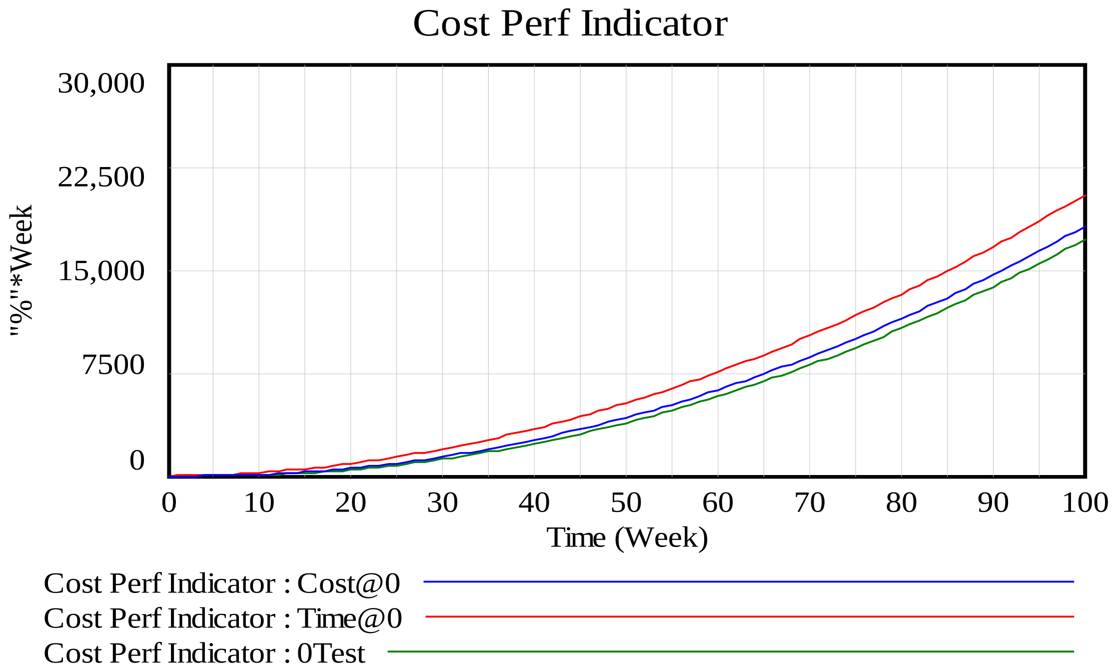


Figure 6.15: Graph of the Dynamic Impact of Cost@0% & Time@0% on Cost Performance.

Cost Performance worse off when Cost indicator performs abnormally and in fact far lower than when Time performance is abnormal. This performance indicate a serious concern as it is clear that abnormal cost performance could tend to exacerbate the actual symptoms of every an overall poor performance.

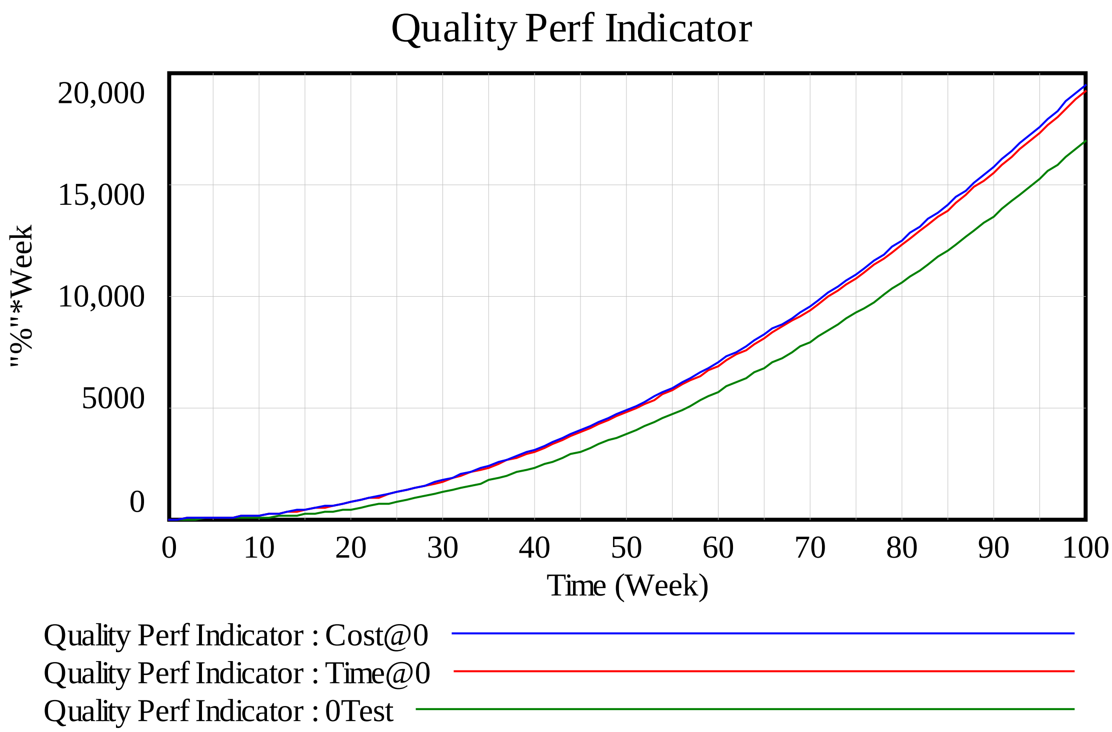


Figure 6. 16: Graph of the Dynamic Impact of Cost@0% & Time@0% on Quality Performance.

Quality performs relatively closely on poor performances of both Time and Cost Indicators. A closer look at the graph shows that quality performs relatively worse on poor Time performance than poor cost performance. The Quality performance is better than the Base line poor performance when all KPIs are at their lowest as clearly illustrated in the graph in Figure 6.16.

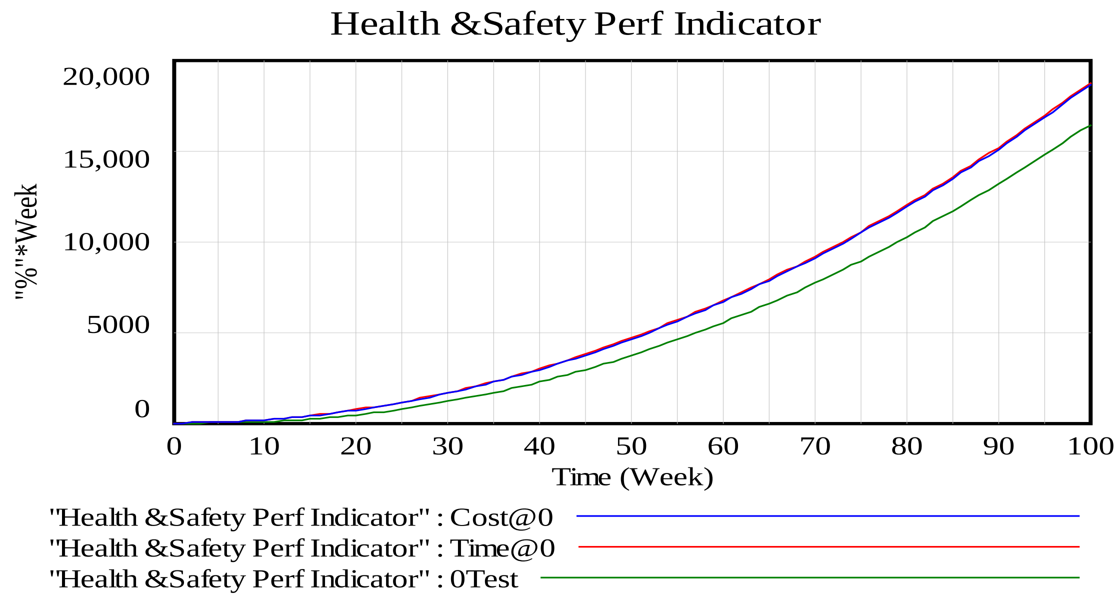


Figure 6.17: Graph of the Dynamic Impact of Cost@0% & Time@0% on Health/Safety Performance.

Health and Safety performed similarly when the Time and Cost performances turn abnormal i.e. equal response as depicted in Figure 6.17.

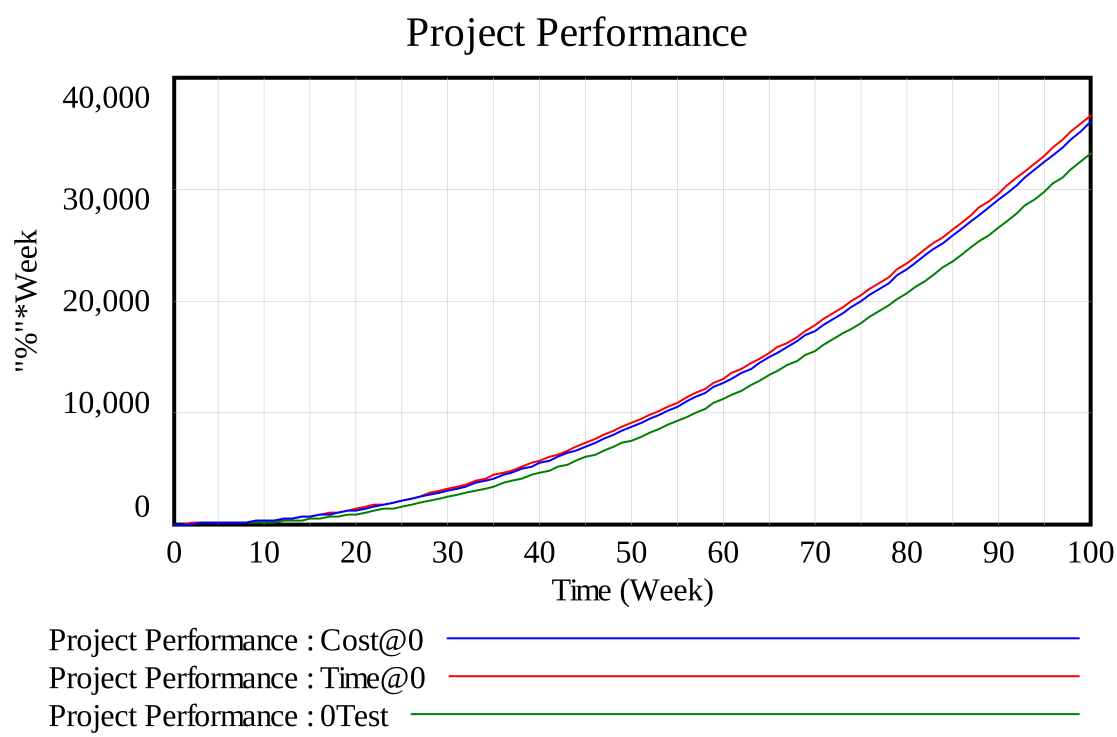


Figure 6. 18: Graph of the Dynamic Impact of Cost@0% & Time@0% on Project Performance.

The Project Performance performs relatively similarly by the effect of Time and Cost poor performances however, Cost poor performance has a relatively more impact on Project performance than the effect of Time Performance in Nigeria. This is clearly illustrated in the Figure 6.18.

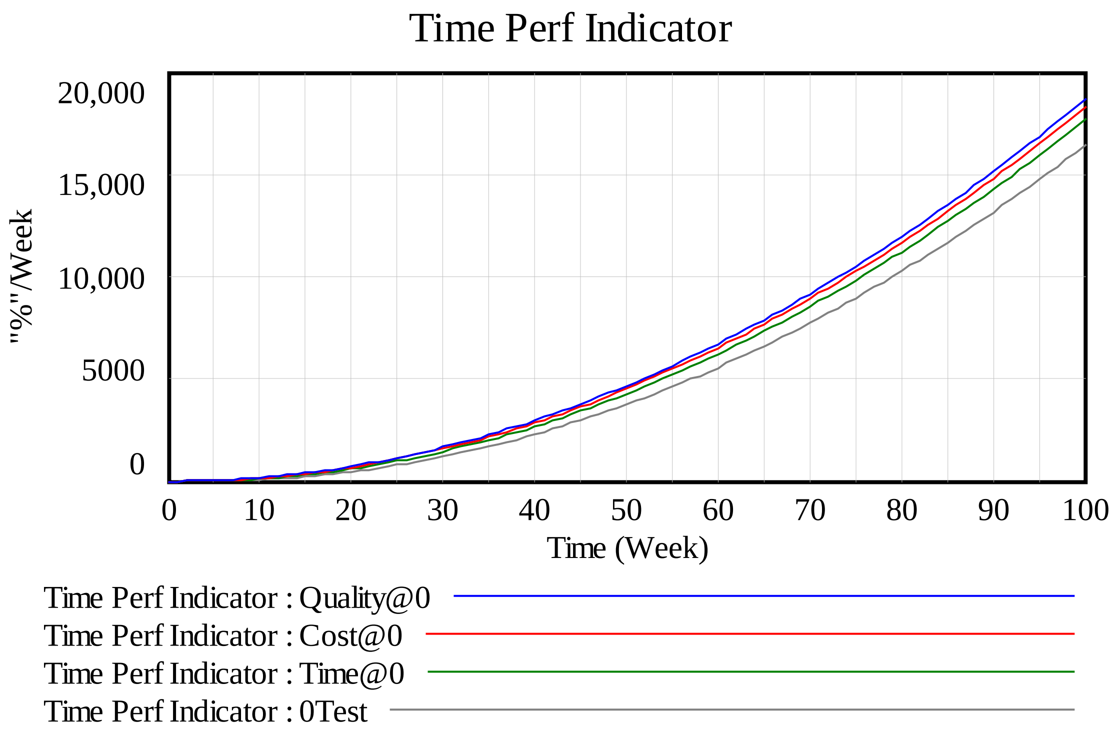


Figure 6. 19: Graph of the Dynamic Impact of Quality@0% on Time Performance.

Abnormal quality performance does not have much adverse effect on Time Performance. Therefore, poor quality output does not necessarily results to poor time performance as indicated in the graph of Figure 6.19.

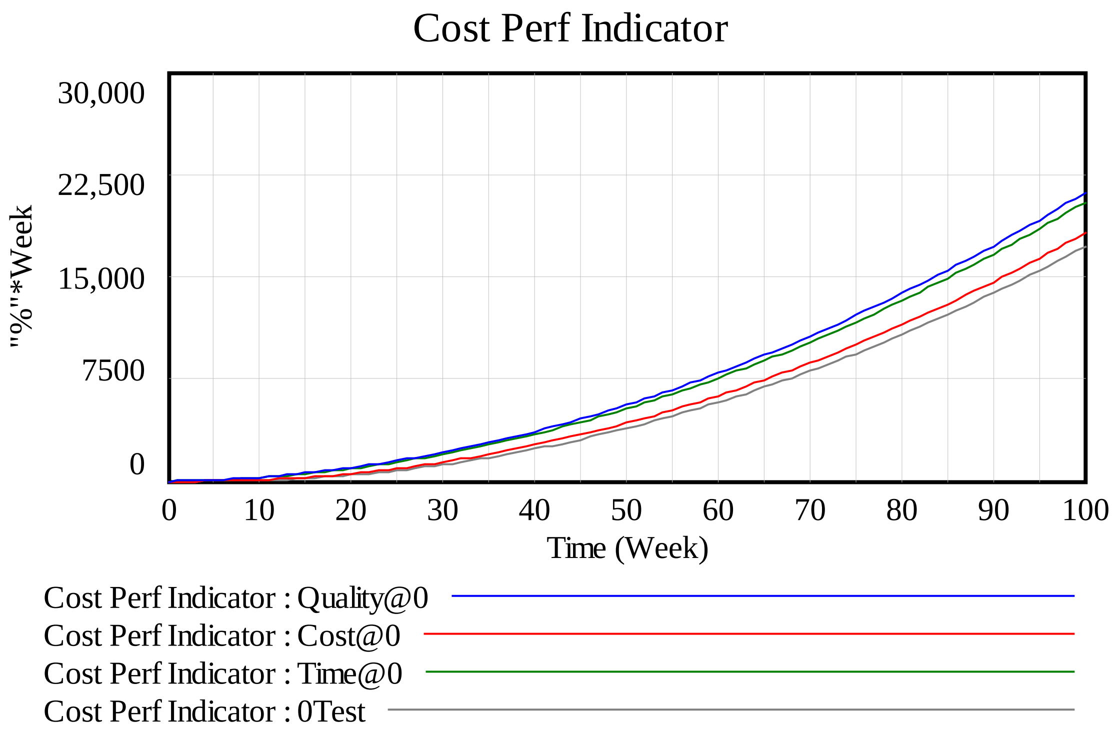


Figure 6.20: Graph of the Dynamic Impact of Quality@0% on Cost Performance.

Cost performance is still better when quality performance performs poorly than Time performance becomes abnormal as in Figure 6.20. This implies that Quality does not have much adverse effect on time and cost performance indicator.

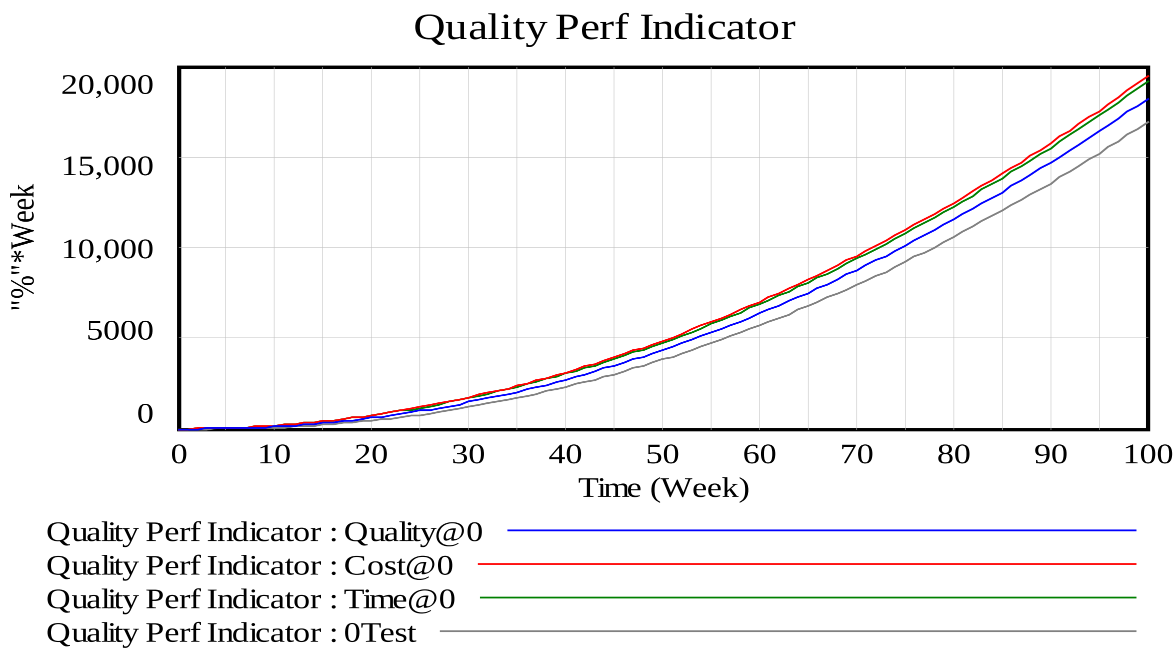


Figure 6. 21: Graph of the Dynamic Impact of Quality@0% on Quality Performance.

Abnormal quality performance creates worst performance indicator for quality performance than any other indicator as illustrated in Figure 6.21

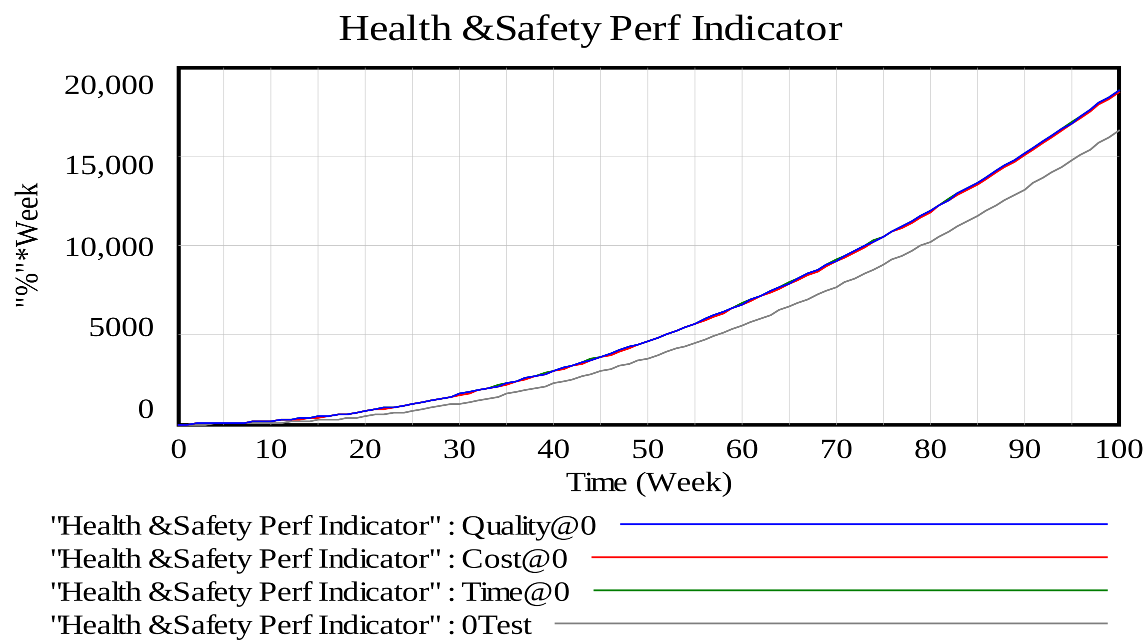


Figure 6.22: Graph of the Dynamic Impact of Quality@0% on Health/Safety Performance.

Health and Safety performance remains relatively the same impact irrespective of the poor performance of all the other three performance indicators.

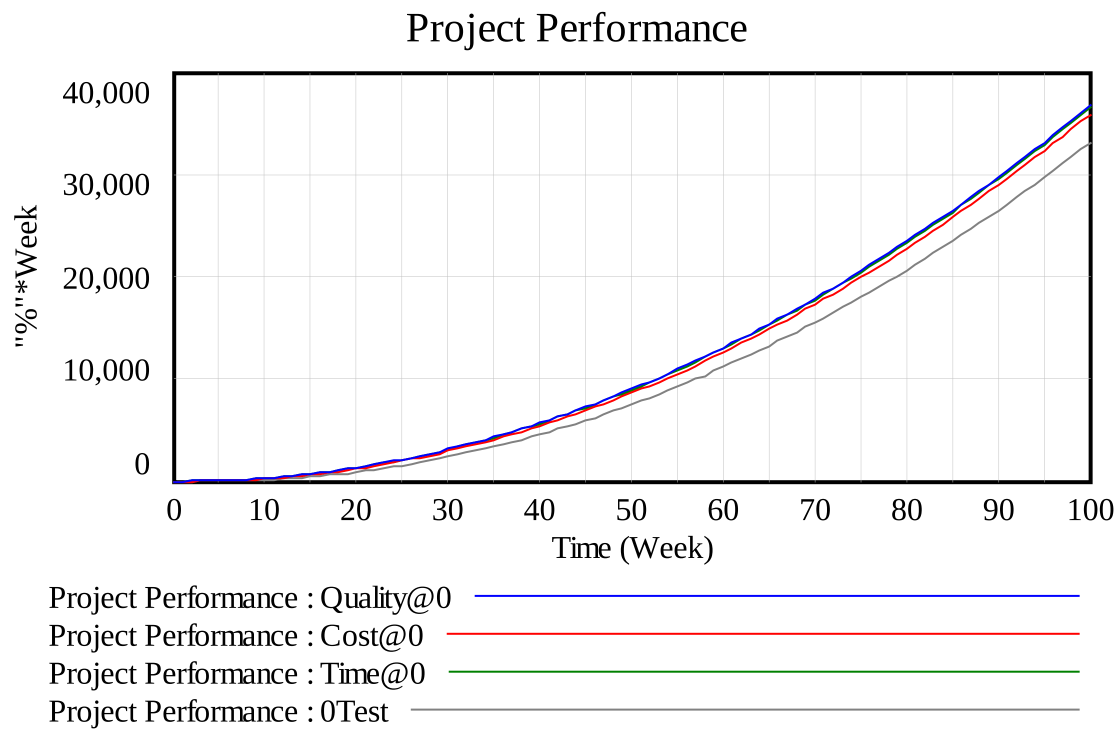


Figure 6.23: Graph of the Dynamic Impact of Quality@0% on Project Performance.

Project Performance is not adversely affected by Quality performance poor affects as compare to the others as the graph indicates a close performance outcome of Time and Quality with abnormal Cost Performance having the worst impact on Project Performance as indicated in Figure. Although, a critical look into the analysis table clearly indicates that Quality Performance effect on Project Performance is less than the impact other two performance indicators of time and cost as depicted in Figure 6.23.

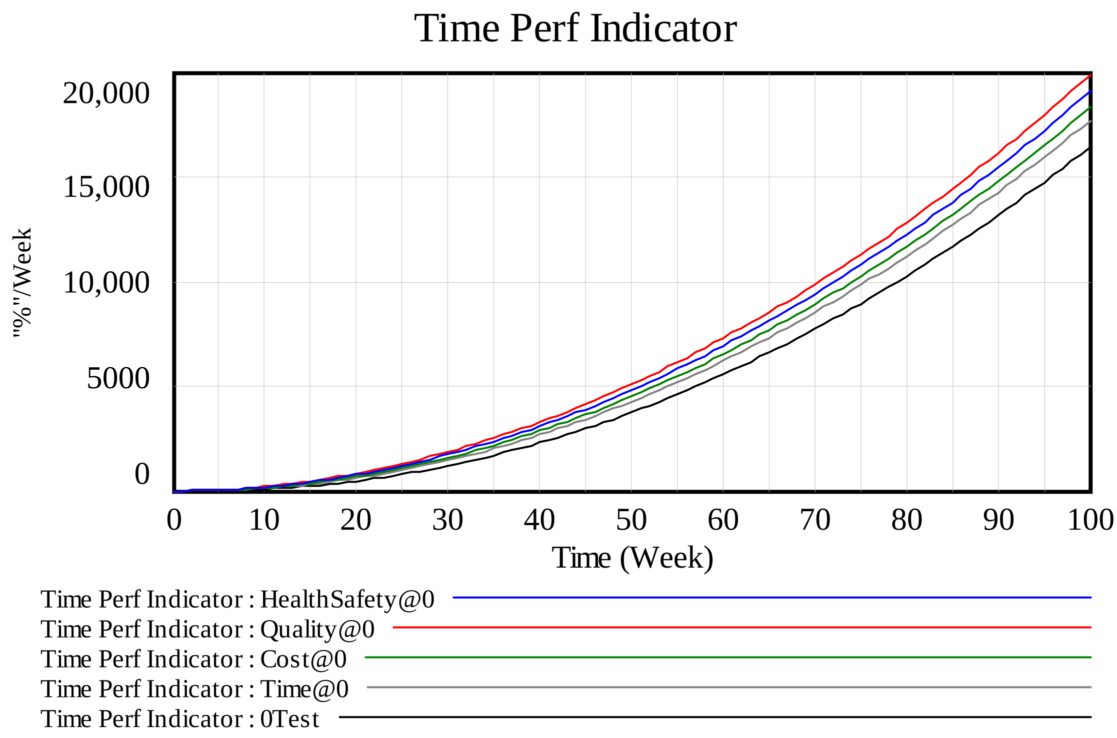


Figure 6. 24: Graph of the Dynamic Impact of Health/Safety@0% on Time Performance.

Time performance drops with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of poor Quality performance as in Figure 6.24. This indicate a very interesting result that health and safety failure can affect the Time performance of the project e.g. any serious incident could adversely drag completion time on tasks and the entire project.

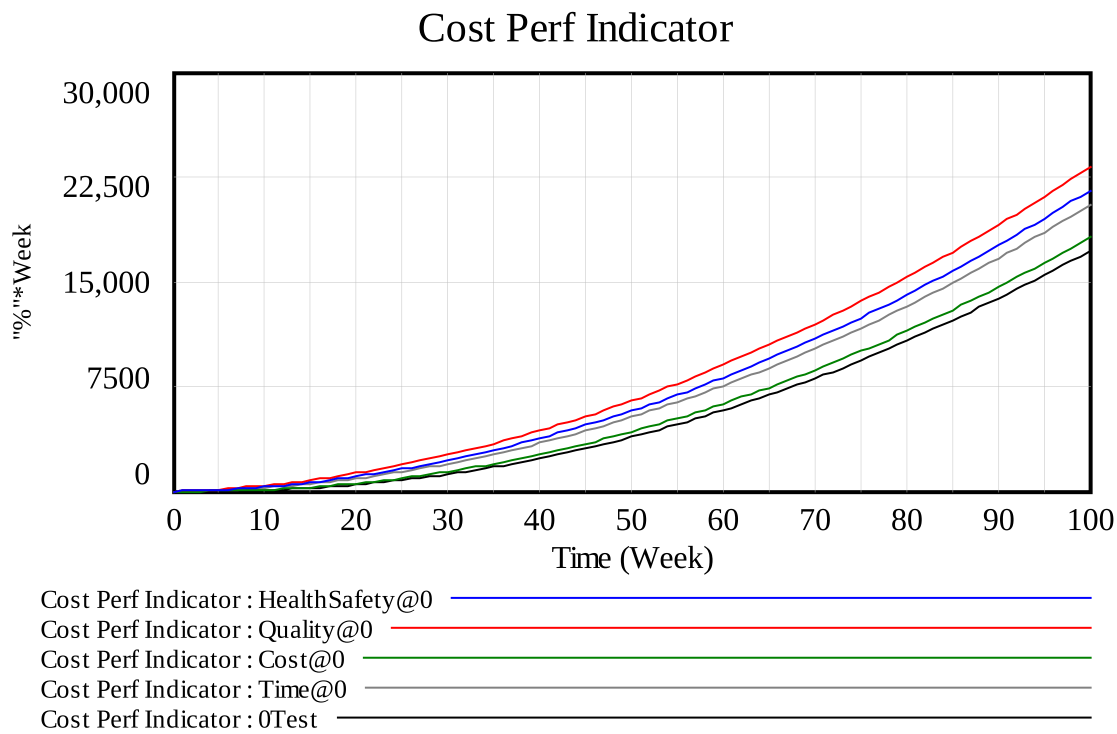


Figure 6.25: Graph of the Dynamic Impact of Health/Safety@0% on Cost Performance

Cost Performance drops with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of poor Quality performance as did Time performance, Figure 6.25.

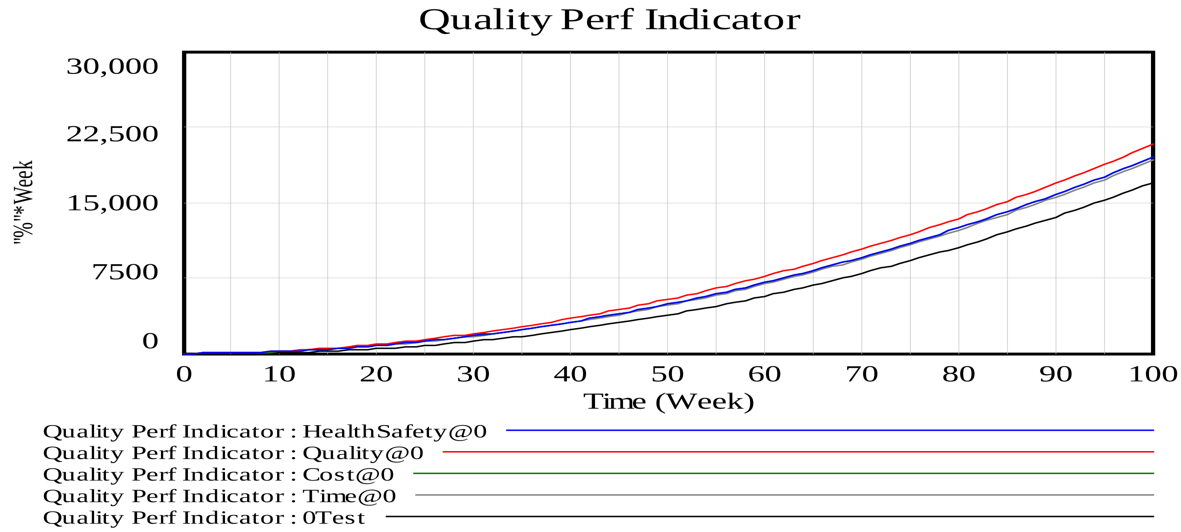


Figure 6. 26: Graph of the Dynamic Impact of Health/Safety@0% on Quality Performance

Quality Performance experienced a poorer performance as the health and safety performance indicator drops compare to the effect of Quality performance indicator drops thus, while time impact more on Quality performance, cost, and health and safety also impact poorly on quality than drop in quality performance indicators itself as illustrated in the graph in Figure 6.26. In fact this typically explains the correlation of the critical success factors that are having underlying structure of relationship that makes impact in a particular KPI prompt the impact of other KPI(s).

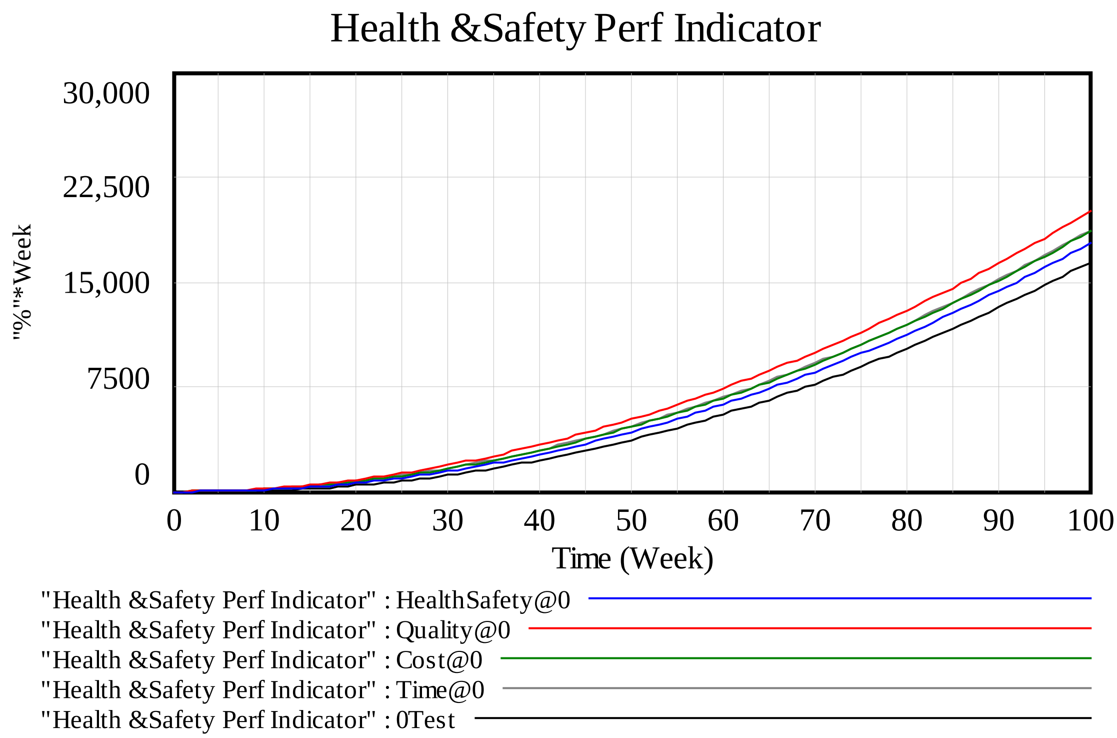


Figure 6.27: Graph of the Dynamic Impact of Health/Safety@0% on Health/Safety Performance

Health and Safety worst performance indicator as every critical factor drops to zero with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of any of the other three performance indicator as clearly illustrated in the graph of Figure 6.27.

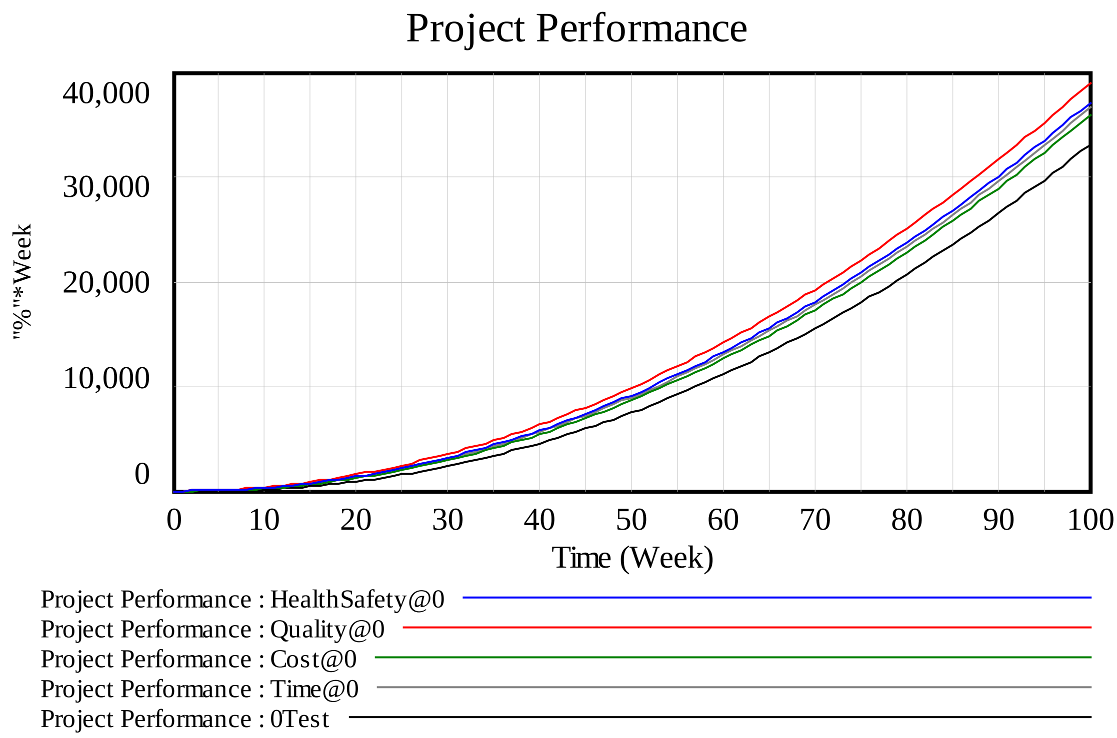


Figure 6. 28: Graph of the Dynamic Impact of Health/Safety@0% on Project Performance

Project Performance is lower by the impact of health and safety compare to the Quality performance indicator and it is clear that poor Cost Performance abnormality impacts the worst impact on project performance than any of the other three performance indicators as could be seen in the graph analysis in Figure 6.28.

6.10 Evaluating the Dynamic of the KPIs Impacts with 100% Performance

In comparison, the dynamic influence of the preceding tests can be fully appreciated by putting all the graphs together and then compare the positions. The observation can lead to proper evaluation of the performance dynamics.

Therefore, the dynamic impacts of adopting individual KPIs at 0% were simulated by keeping other KPI at 100%. In what follows both the extreme 100% and extreme 0% baseline with the simulations of the KPIs tests are presented. The impacts of the KPIs from the CSFs, as it indicated dynamic impacts of adopting each KPIs from the Component factors of the group of CSFs as they influence the performance is properly established. The key issue of interest here is that whatever abnormal performance of any of the KPIs would not allow the ultimate performance to be achieved. This is illustrated in Figures 6.29 to Figure 6.33 as presented in the following sections.

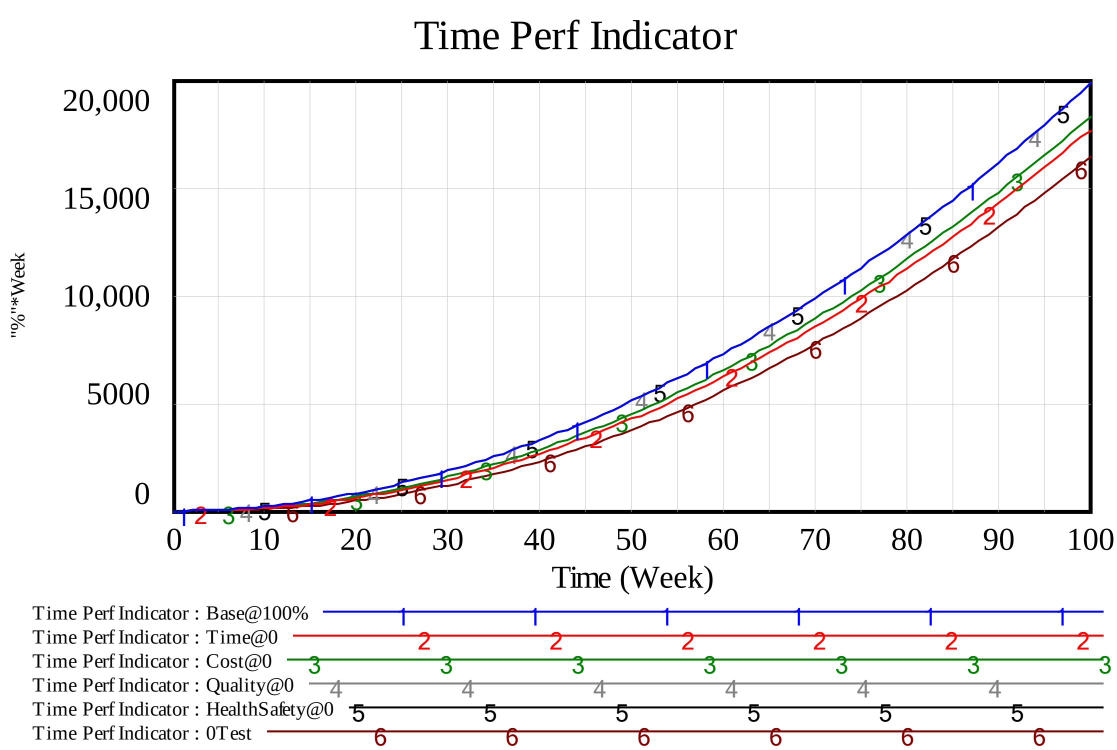


Figure 6. 29: Graphs of the Dynamic Impacts within the two extremes for Time Performance

Figure 6.29 shows how the worst time performance impacts Time performance indicator at its worst.

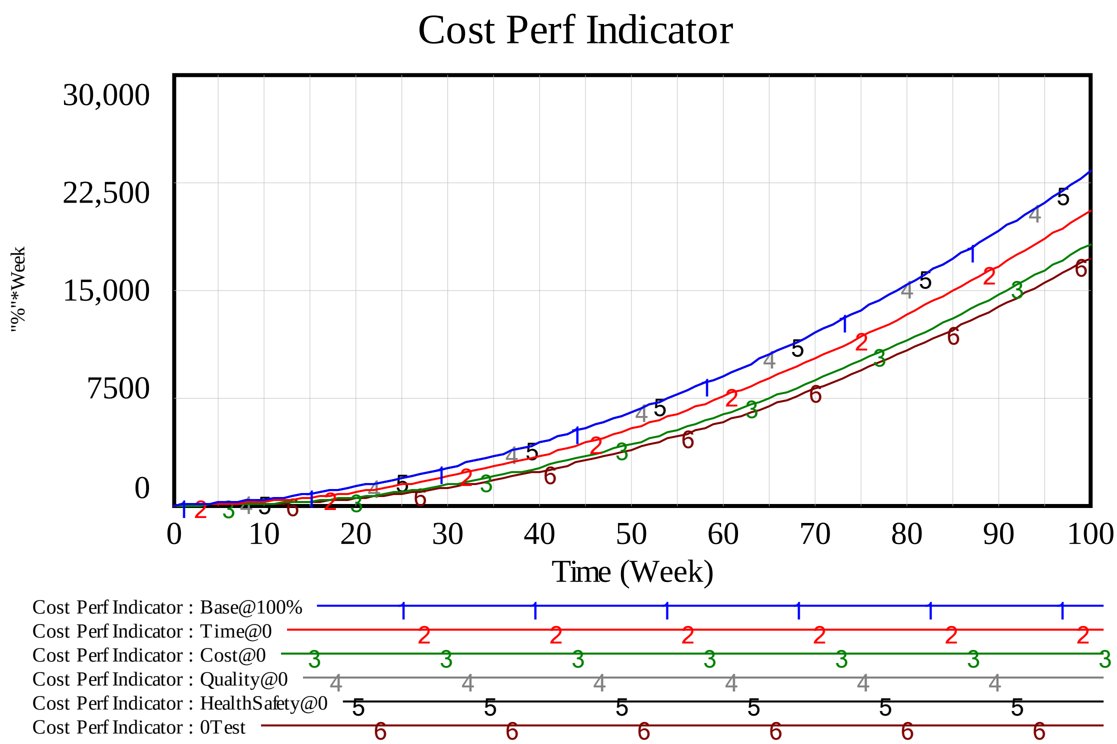


Figure 6. 30: Graphs of the Dynamic Impacts within the two extremes for Cost Performance

Figure 6.30 shows how the worst cost performance impacts cost close to the baseline.

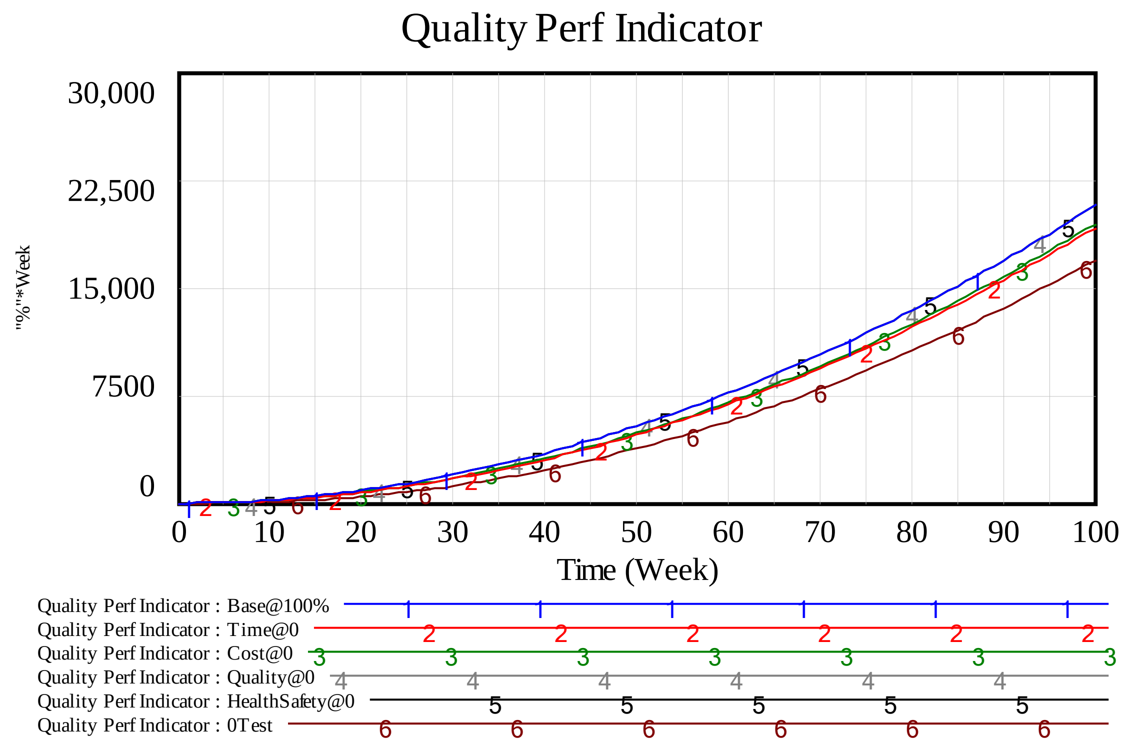


Figure 6. 31: Graphs of the Dynamic Impacts within the two extremes for Quality Performance

Figure 6.31 shows how the worst quality performance impacts quality just like other KPIs and their impacts did not drop much from the 100% reference line.

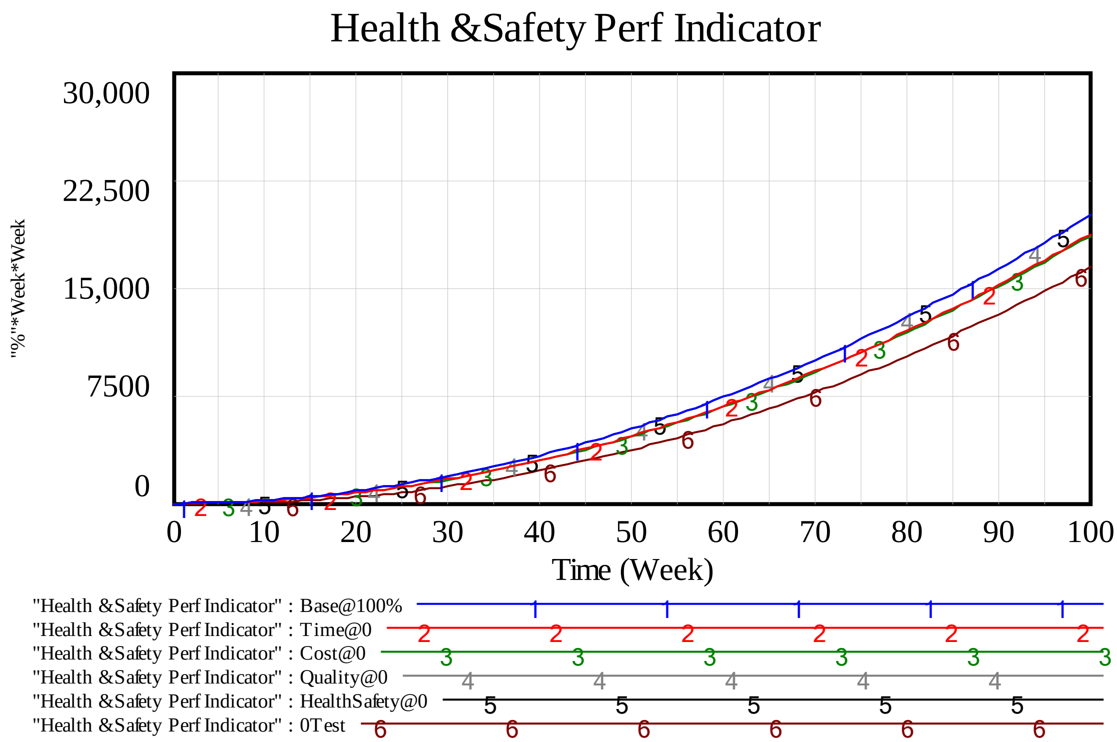


Figure 6. 32: Graphs of the Dynamic Impacts within the two extremes for Time Performance

Figure 6.32 shows how the worst health/safety performance impacts health/safety similar to quality impacts, just like other KPIs. And performance would not drop much from the 100% baseline reference.

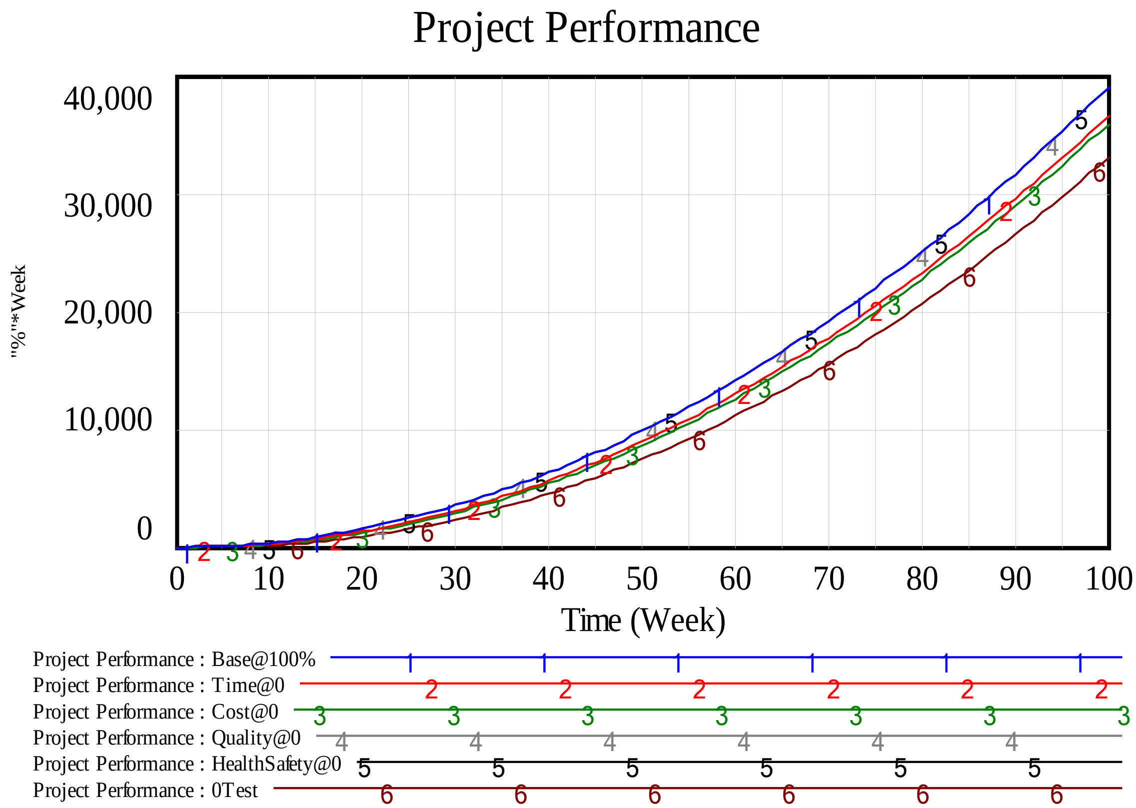


Figure 6.33: Graphs of the Dynamic Impacts within the two extremes for Time Performance

The overall performance at extreme of 100% - all things being equal established the gap influence of extreme poor performance of any of the Key Performance Indicators of construction projects to hover at the middle – in-between the two extremes of 0% and 100%. Therefore, each of the KPIs has its impact on the construction project performance and none could be waved aside even though their individual impact differs. From the graph in Figure 6.33, it is clear that the worse impact of Cost would impact more on project performance and followed by the impact of time.

6.11 Case Study: Data Collection and Analysis for Model Validation

A typical project was used for the assessment and validation of the application of the model to see how it will run and perform the purpose for which it was developed. This case study is required to generate practitioners assessed values for the measured variables as developed from the factor analysis carried out and used in the formulation of the equation for the model.

These values were used in the Stock and flow model diagram for this study. This case study was selected among the project in which the researcher has established relationship with professionals involved who are ready to give a firsthand information on the scoring of the variables from a check list questionnaire containing the critical success factors, CSFs for the four key performance indicators, KPIs of Time, Cost, Quality, and Health and safety which were the scope of the research. The checklist is as contained in the Appendix. The selected project was a new built residential house of flat apartments. The detailed information and description of the case study project is presented in Table 6.1.

Table 6.1*: Information and Description of the case study project*

PROJECT DESCRIPTION		
Features	**Detailed Value**	**Remark: At Completion**
Project Type	New Built Residential House	
Client	Private - Corporate	
Usage	Flats/Apartments	
Initial Cost	₦1,597,032,300.00	Changed Slightly
Final Cost	₦1,613,225,700.00	₦16,193,400.00 (1% cost overrun) Insignificant
Start date	April, 2014	Delayed 6 weeks
End Date	December, 2015	July, 2016
Project Duration	85 Weeks	114 Weeks (29 weeks Approved Extension of time – additional work) – Satisfactory delivery
Building Type	Reinforced Concrete Framed Structure	
Building Height	26.95m	26.95m
Gross Floor Area	$2845m^2$X2 (i.e. 5690)	$6164m^2$
Building Area	$1298m^2$	$1298m^2$
Net Area Available	$2814m^2$	$2814m^2$
Area of Site	$4105m^2$	$4105m^2$
Percentage Area Covered	32%	32%
Landscaping Covered	33%	33%
Parking Covered	22%	22%
Others	13%	13%

Data were collected through formal meetings with professionals involved on the case study project. The group consists of the Architects, Quantity Surveyors, Engineers, and the Builders consist of the contractor's team including the Managing Director of the company including the project manager and the site manager. They were all experienced in the construction industry and they were stakeholders on the project which they were fully involved from inception to the completion of the project. Only the variables that were established in the factor analysis were included in the questionnaire checklist.

The participating project team members were required to assess the adoption of the CSF in the particular KPI as implemented on the project. The scale given was in percentages from 0% for non implementation to 100% as a fully implemented success factor on the project. The average of their overall ratings was used as the value for a particular CSF in the KPIs within the Model equation for the eventual simulation runs.

6.12 Mathematical Equation for Model Simulation

Mathematical equations were developed for the assessment of the relative adoption of the CSFs for the individual KPIs for the performance diagnosis of the project performance before using the rated value of the CSF. The following were the ste[ps taken for the Simulation model equation.

1. **Percentage Adoption for the CSFs**

The ratings for the CSFs were established within a range of 0% to 100% as this could easily be understood in the adoption or implementation of a particular CSF for the KPI.

2. **Computation of the Rate of adoption of CSFs for the Component Factor**

The ratings for the CSFs were subsequently loaded for the established underlying relationship forming the component group factor of CSFs and their interaction is established with the formular e.g. Rate of Design Team Commitment to Project Management:

Rate of Design Team Commitment to Project Management = (Ability to solve unanticipated X 0.984+"Clear, Correct and Precise Drawings" X 0.949 + Client's Project Financing for regular cash flow X 0.811+Early Involvement of Project Manager X 0.894+Efficiency of communication X 0.89 + Government's institutional and administrative influence X 0.779 + Initial identification of all the risks X 0.69 + Management capacity and Competence of PM X 0.741+Timely Production of required Design Documents X 0.925 +Type and Nature of Client X 0.79)/10

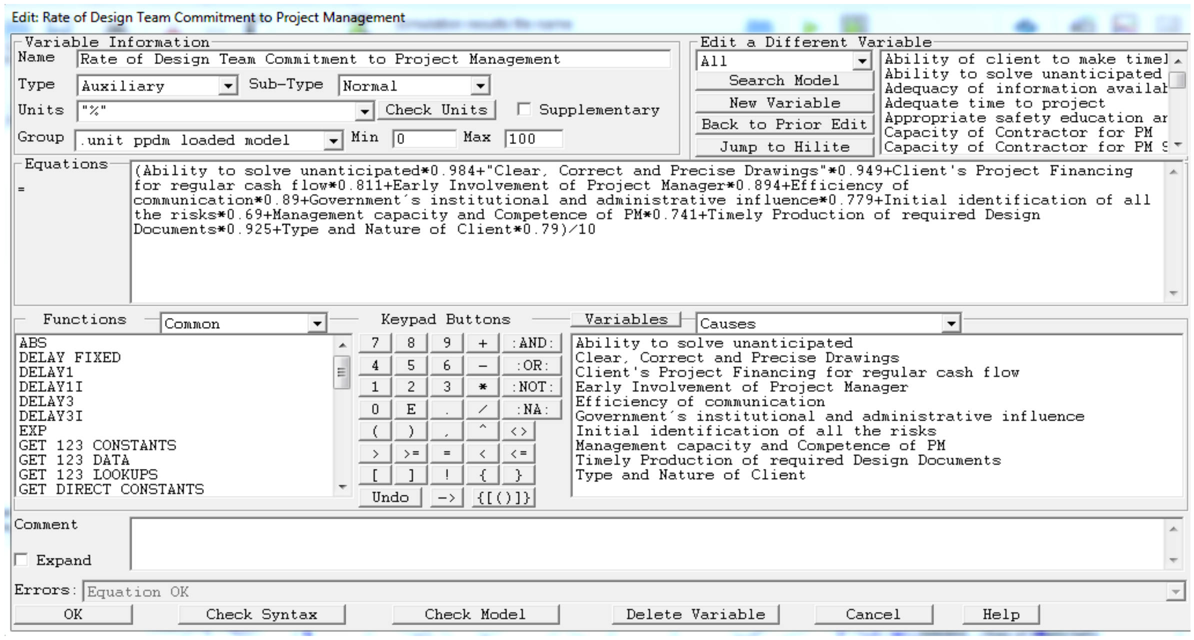


Figure 6.34: Equation input Window in Vensim showing the Platform for Auxiliary (Rate)

The coefficients are the loading values as established as weightings from the factor analysis.

3. Computation of the Rate of adoption of CSFs for the Component Factor

The resultant rate is computed to give a level of CSF group component performance with a subsequent model equation according to the dynamic relationship established within the model to form the following:

Design Tm Commit to PM Outcomes= INTEG ((External Factors^0.5+Time Perf Indicator^0.5+Rate of Design Team Commitment to Project Management)*0.353,0)

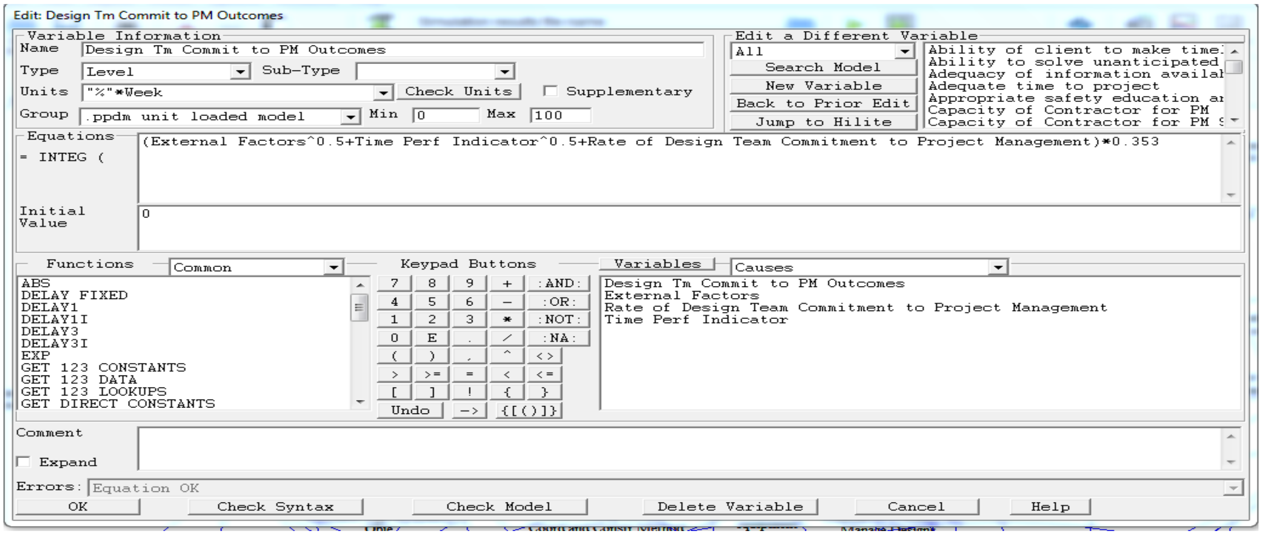


Figure 6. 35: Equation input Window in Vensim showing the INTEG (Integral) Platform for Level

4. Computation of the Rate of CSFs for KPI

The resultant CSF component factor would interrelate to generate the rate of the KPI for example the above equation illustration is for the Design Team Commitment to Project Management Outcomes as previously established which now become one of the variables (one of the four component factors established for Time Performance) in the equation for the rate of time performance indicator as follows:

Rate of Time Indicator = (Capacity of Contractor for PM+Construction Resource and Mgt+Design Tm Commit to PM Outcomes+External Factors)/4

5. **Computation of the KPI**

The resultant rate of the KPI will now determine the KPI e.g for Time performance, the modeled equation gave the following:

> Time Perf Indicator= INTEG (Rate of Time Indicator^0.5+Project Performance^0.5+Time Perf Indicator^0.5,0)

Thus, the time performance is established. The exponential value 0.5 is to maintain the units for the modeled equation as applicable in integral calculation.

6. **Computation of the Rate of Project Performance from the KPIs**

Having established the KPI effect from the preceding equations, each of the KPIs having been established from their CSFs would eventually metamorphosed into the modeled equation for the Project Performance as diagnosed from the following equation:

> Rate Of Project Performance = Cost Perf Indicator^0.5+"Health &Safety Perf Indicator"^0.5+Quality Perf Indicator^0.5+Time Perf Indicator^0.5

7. **Computation of the Project Performance**

The equation of the rate of project performance would lead to the establishment of the resultant actual project performance generally within the confine of the interactions within the model boundary and thus;

> Project Performance= INTEG (Rate Of Project Performance+Project Performance^0.5,0)

6.13 Case Study: Evaluating the Dynamic Performance of Project

The case study data were collated and analysed by establishing the mean average percentage for each of the CSFs that were assessed by the professionals who were involved on the project from inception to completion. The percentages were applied in the slider of the Vensim Model for all the variables and the Model was subsequently run with the Synthesim. The graphs generated for different levels of outcome requirement were presented as follows in Figures 6.36 to Figure 6.40.

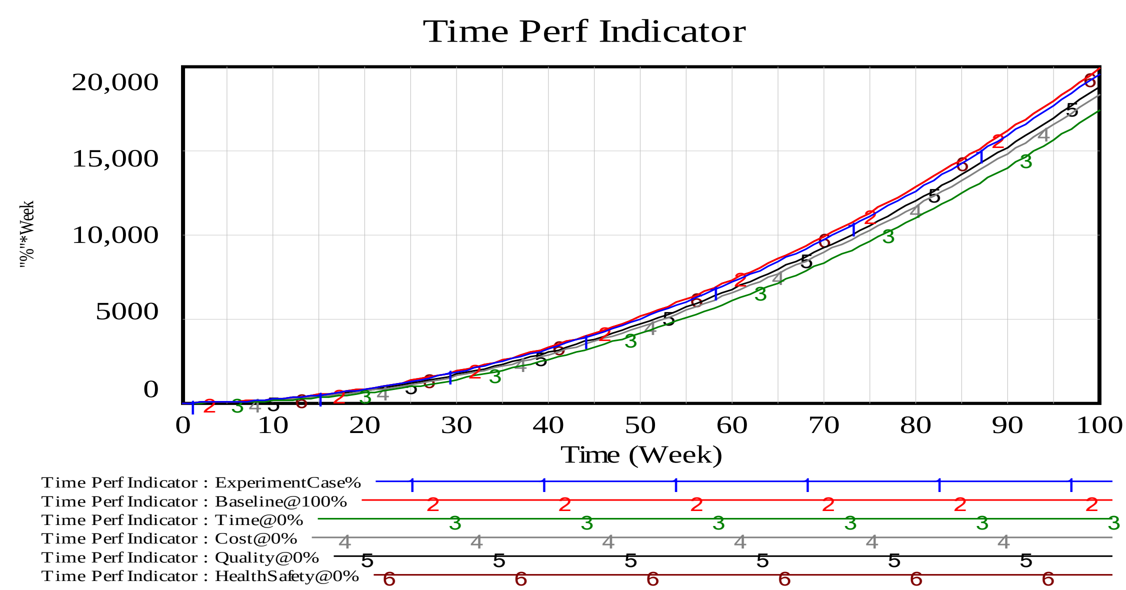


Figure 6.36: Graphs of the Dynamic Impacts of Case Study Experiment (Experiment Case%) for Time Performance

Figure 6.36 indicates that Time performance was below the expected performance, Baseline@100% by a marginal gap difference – blue line1 compares red line 2.

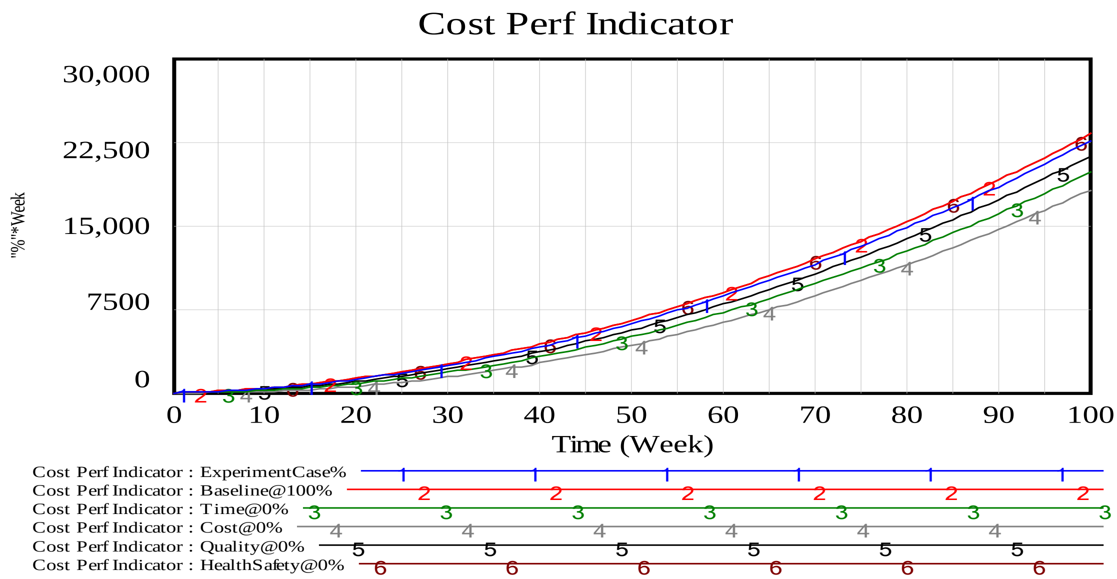


Figure 6. 37: Graphs of the Dynamic Impacts of Case Study Experiment (ExperimentCase%) for Cost Performance

The result in Figure 6.37 also indicates that Cost performed below the expected performance, Baseline@100% by a marginal gap difference.

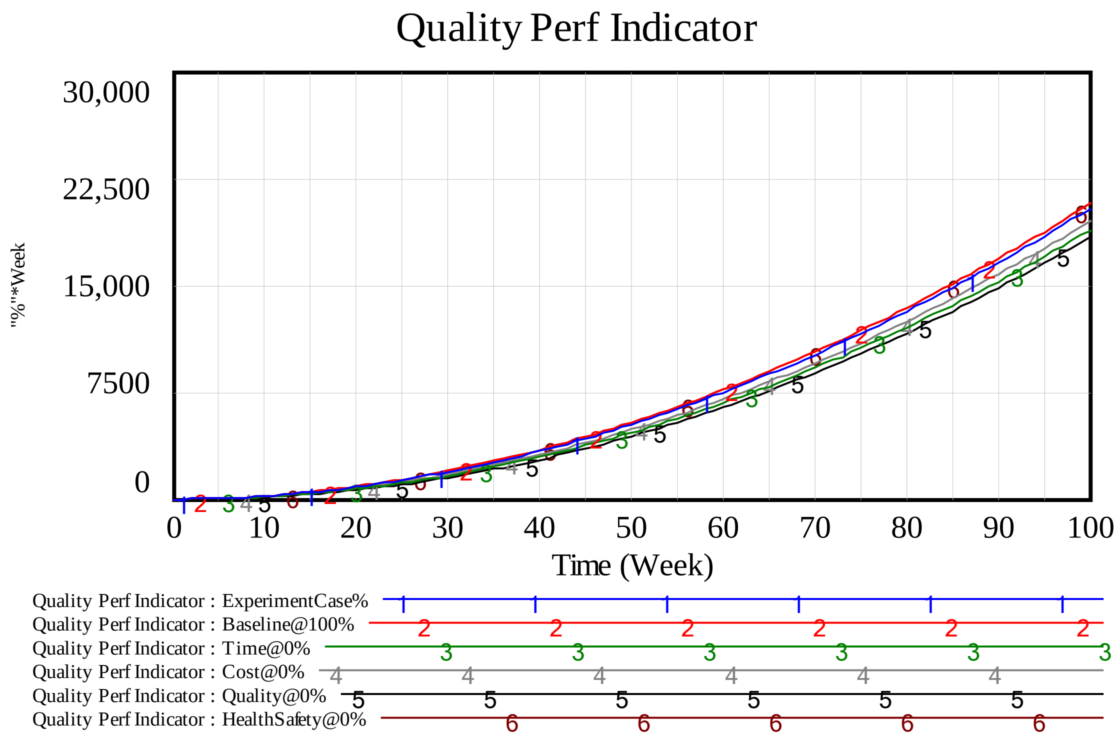


Figure 6. 38: Graphs of the Dynamic Impacts of Case Study Experiment (ExperimentCase%) for Quality Performance

Figure 6.38 indicates that Quality performance was almost at par with the expected performance, Baseline@100%. In fact this is an interesting result as the project was actually assessed by all the respondents as successful and satisfactory in Quality.

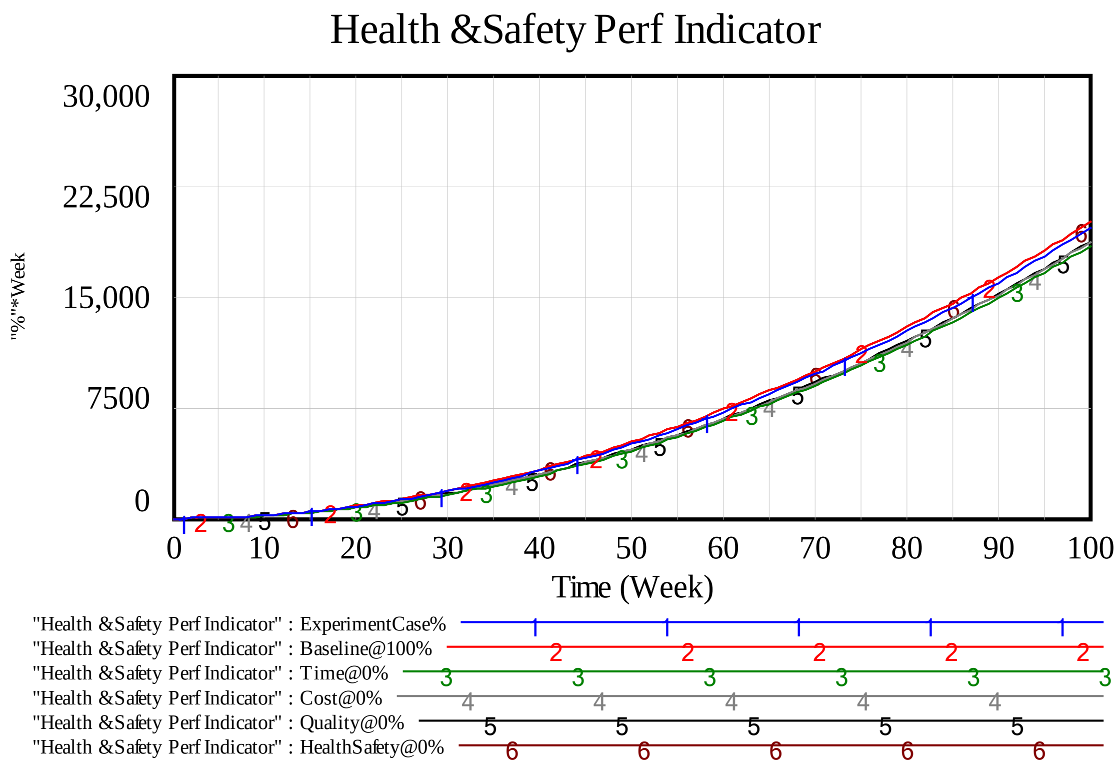


Figure 6.39: Graphs of the Dynamic Impacts of Case Study Experiment (ExperimentCase%) for Health and Safety Performance

Figure 6.39 indicates that Health and Safety performance was almost dropped slightly from the expected performance, Baseline@100% but still very much align. There was no major incidence on the project. The client was assertive in praising the contractor that despite non high-tech safety arrangement the usual health and safety rrangement adopted by the contractor is commendable having confirmed no incidence of concern throughout the over two years work on site.

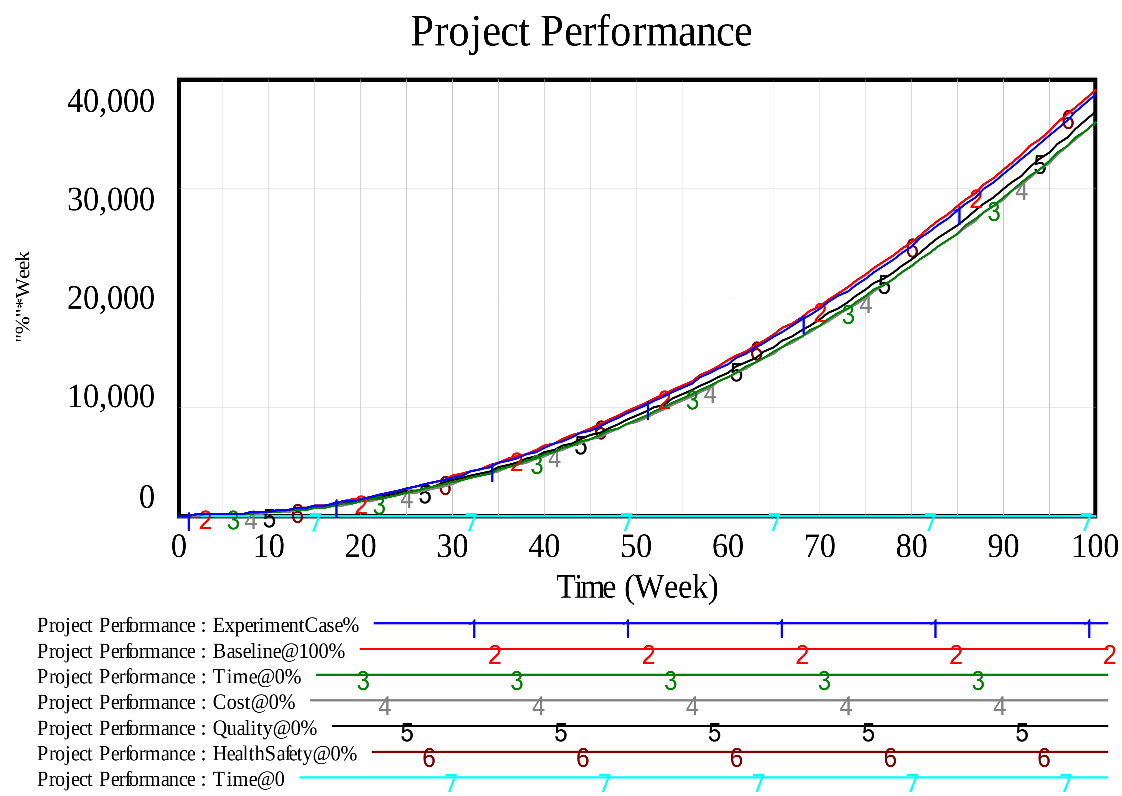


Figure 6.40: Graphs of the Dynamic Impacts of Case Study Experiment (ExperimentCase%) for overall Project Performance

Figure 6.40 revealed the overall performance of the project compared to the baseline established in this study for the Nigeria construction environment. It is clear that the project did fall slightly below the baseline expectation generally despite the commendation and satisfactory performance of the project as confirmed by the stakeholders, the imbalance in all the performances that could not add up to 100% actually indicate a marginal fall in the overall performance of the project. The clients were highly experienced in construction delivery process and they were practically involved in the delivery process from inception to completion. By this clients' experience all the teams were confirmed to be knowledgeable, experienced and committed to the delivery of the process and that account for the very good performance of the project. The slight drop in performance was actually understandable by the parties and stakeholders since finance was not a challenge – additional requirements led to certain imbalance which were properly managed by the design team led by a capable Project Manager. In fact the provisional sums and contingencies on the project match the required change order with a slight increase on the budget. The contractor's management team were hands on with the required technical and managerial skills which produce the required results. The speed with which some aspects of work were carried out paid off for the time loss experienced due to he state of repairs of equipment particularly the crane. The project manager actually emphasised the importance of the experience and skill of the Contractor's site management team. The noticeable performance question on the project was the time extension which they emphasised as understandable.

6.14 Further Deductions from the Model Analysis

The Vensim model is clear and easy for observation. A proper observation of the model indicates that some variable affect three KPIs or the four KPIs. Four CSFs were found to impact all the four KPIs of cost, time, quality and, health and safety. These are healthy financial condition and stability of contractor; government institution/administrative influence, regulations; technical competence and management capacity of the contractor; employment of skilful workforce; these were followed with six other variables that impact on atleast three of the KPIs and these are type and nature of client, site management by contractor; client's project financing; information coordination, communication and relationship among project parties; construction methods adopted on the project; collaborative supervision/inspection on the project; and the condition of the equipment. These made CSFs that are critical to the influence and performance outcome of the conceptualised model.

6.15 Summary of the Chapter

There exist relationships between cost and time performance of construction projects as they both share a number of causes and effects. Examples of causes common to both time and cost performance are: resources availability (shortage of materials), errors in design, change orders and, financial difficulties (Haseeb et. al., 2011; Mahamid & Dmaidi, 2013). Hence, measures of achieving positive cost performance would be applicable to enhance time performance on construction projects.

This chapter presents the focused aim of this research by conceptualising a system dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables. The model conceptualisation was achieved through the research design process and the resultant factors as determined from the factor analysis were used to develop the DynamicProject Performance Diagnostics Model. The developed model was tested and validated as appropriate. The underlying structure of interaction among the variables was established. The PPDM model based on the Nigeria built environment influencing equation shows that Cost CSFs have greater influence on performance followed by Time CSFs. The influence of Quality and

Health/Safety are very closely related whereas the influence of Health and Safety could be critical particularly to Time performance indicator.

After different simulation runs and evaluation of performance scenarios ten CSFs were established as being very significantly influential in predicting at least three of the KPIs. These include healthy financial condition and stability of contractor; government institution/administrative influence, regulations; technical competence and management capacity of the contractor; employment of skilful workforce; type and nature of client, site management by contractor; client's project financing; information coordination, communication and relationship among project parties, construction methods adopted on the project, collaborative supervision/inspection on the project; ; and the condition of the equipment.These CSFs were discovered to have more impacts on the KPIs and eventually impact the performance of construction project performance.

CHAPTER SEVEN

Conclusions and Recommendations

7.1 Introduction

The chapter discusses the conclusions based on research objectives and findings of the research as reviewed for the study carried out. This thesis started with the aim to develop a System Dynamic Project Diagnostic Framework, primarily for improved decision making in the context of diagnosing/predicting construction project performance in the Nigeria construction industry. In order to satisfy this aim, following objectives were outlined.

1. To investigate critical success factors (CSF) and underlying measures for key performance indicators (KPI) in terms of cost, time, quality and health/safety for construction project performance.
2. To establish component factors of CSFs with their underlying relationship for each KPIs (Cost, Time, Quality, and Health/Safety) for effective project performance.
3. To evaluate the dynamic interrelationship between project variables of CSFs for individual KPI for its suitability as model for construction project performance diagnostic for effective project delivery in Nigeria.
4. To develop and validate a System dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables.

The first objective was achieved through the review of the literature and through Delphi technique with experts. Therefore, the researcher carried out a comprehensive review of literature in critical success factors and KPIs (also considering System Dynamics) in the construction industry to gather requisite knowledge, and what professionals consider in assessing performance. This leads to critical review of CSF and KPIs with a focused clarification in differentiating the two concepts which was carried out to establish identified gap in the literature. Identification of critical success factors and key performance indicators as applicable in Nigeria construction industry were carried out and different factors impacting construction project's variables were identified in literatures but not many were found in literatures applicable for Nigeria, perhaps some of these factors identified in other parts of the world could be applicable or differ from the practice in Nigeria. The literature as a data collection tool also assists in defining the variables from the research problem, eliciting information and observation requirements in mixed-mode research methodology. The model thrives with mental model thus, apart from the literature further information were required, which led the research to seek further research techniques for collecting data. Experts involved in construction projects were interviewed based on their cumulative experience in the industry. The focus group consisting of Architects, Engineers, Quantity Surveyors, and the Builders including University lecturers were requested in form of a Delphi technique, and eventually with questionnaires to assess the CSFs and KPIs from literatures and tick as the variables that are useful and applicable to assessment of construction performance in Nigeria and thus the variables were identified and this provided a basis for contextualisation, further rigorousstatistical analysis was carried out to ascertain the CSFs for KPIs in the Nigeria construction industry and thus Factor Analysis was employed as a tool to determine the CSFs for KPIs in the Nigeria construction industry. After the factor analysis was conducted on the data, from all the factors identified in the literature as critical success factors 27, 17, 20, and 17 CSFs were determined for time, cost, quality, and health and safety KPIs respectively. These were statistically determined by factor analysis reduction of the items and therefore made the subsequent division of the KPIs into manageable components achievable.

The second objective of the research was achieved after the factor analysis was conducted for each of the key performance indicators of time, cost, quality, and health and safety, thereby establishing the component factors of CSFs with their underlying relationship for each KPIs. After reducing the identified items for these key performance indicators in construction project into barest minimum, redistribution of the items into different components were done. The Initial Eigenvalues above 1 and the Scree plot were used in determining the number of components of CSFs for each of the KPIs.

The third objective of evaluating the dynamic framework/model of CSFs for individual KPI for its suitability for construction project performance diagnostic for effective project delivery in Nigeria was achieved through dynamics of Stocks and flows, and along with feedback central concepts of dynamic systems theory. Stock and flow diagram represents the causal relationship between elements in system dynamics models with algebraic representation for simulation run on a computer and thus, enhance mathematical simulation and quantitative analysis of the relationships between elements in the model. The established CSFs components were used as determinants for variables in the system dynamic model conceptualisation for the assessment of performance of construction project. The Stock and flow was developed in order to simulate the dynamic relationship between the various CSF components of the KPIs to assess the performance of construction projects using VENSIM software tool. The components CSFs for each KPIs were validated and certified okay and suitable for subsequent use in the conceptualisation or development of the PPDM.

The fourth objective was to develop and validate a System dynamics Project Performance Diagnostic Model from the KPI models for diagnosing project performance based on the project variables. This was accomplished through System Dynamics of Stock and flow diagram which was developed in order to simulate the dynamic relationship between the various CSF components of the KPIs to assess the performance of construction projects using VENSIM software tool. Diagnosing the performance of construction projects as a SD model requires a stock and flow diagram having established the CSF components of KPIs using Factor Analysis. The research focused aim was achieved through the SD PPDM that was developed, tested and validated as presented in chapter 6. The underlying structure of interaction among the variables was established. The result of the case study research confirmed the validation of the practical application of the developed PPD model.

7.2 Conclusions

Conclusions of this research are in line with the findings to the aim and objectives of that this research was set out to achieve which were satisfactorily achieved. The conclusions from this work are as follows:

The research confirmed the clarification of differentiating critical success factors - CSF and key performance indicators - KPIs as different terms requiring proper application in the construction industry terminology.

1. Different CSFs are applicable as variable factors for KPIs and therefore, CSFs for four KPIs of time, cost, quality, and health and safety were independently established as applicable in Nigeria construction industry.
2. Additional factors impacting construction project's variables in other parts of the world which were not found in literatures applicable for Nigeria were identified and found applicable in practice in Nigeria. The research identified 31 CSFs for Cost performance, 34 factors for time; 25 for quality; and 18 CSFs for health and safety of which were 27, 17, 20, and 17 CSFs were eventually determined for time, cost, quality, and health and safety KPIs respectively
3. This research provided a different perspective to the way the success factors should be assessed as different factors that are reported separately in literatures which are linked as associates in this research indicate structure of an underlying relationship.
    a. Time performance as a KPI has four components of CSFs namely; Design Team Commitment to Project Management Outcomes; Capacity of Contractor for Project Management; Construction Resource and Management; and External Factors.
    b. The Cost performance was established into three components of Contractor's Management Capacity; Client's Commitment to Progress of Project; and Economic Environment of Project Estimate.

c. The Quality performance have three components namely, Project Design Communication Management with Workforce; Contractor Capacity for Resource Management on Quality Objective; and Project Manager’s Competence on Information Coordination and Construction Method.

d. Similarly, the determined CSFs for Health and Safety were organized into two components. The first component is Effective Finance Management for Health and Safety Implementation while the second component is Capacity of Contractor, for Project Management and Safety Programme. These components were appropriately established and grouped as CSF factors for KPIS for construction project performance.

4. The CSFs for Time performance indicator have the following groupings;

   a. Design Team Commitment to Project Management Outcomes is the first CSF component for Time Performance and it includes the following variables of underlying relationship: Ability to solve unanticipated problems that occur during the course of the project; Clear, Correct and Precise Drawings/Documents; Timely Production of required Design Documents; Early Involvement of Project Manager; Efficiency of communication on the project; Client's Project Financing for regular cash flow; Type and Nature of Client; Government’s institutional and administrative influence e.g.

regulations, permits; Management capacity and Competence of project manager; and Initial identification of all the risks that are likely to occur on the project. Project management effort and process are key to the success of project time performance.

b. Capacity of Contractor for Project Management requires the Contractor to have capacity that flows in tune with project management principle for time performance and thus, the variables with underlying relationship for this element include, Healthy Financial Condition and stability of contractor, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Site management by contractor, and Employment of Competent and Skilful Workforce. These factors clearly show the capacity of the contractor's management but that is not all, it requires that there is an oversight on the contractor management as a well managed company could strategically desire to delay project completion if adequate oversight function is not carried out by the project manager.

c. Construction Resource Management is the third CSF group for Time Performance and consists of nine critical factors, all of which suggest measures for Construction Resource Management The CSF for Time performance under this component include Construction methods adopted on the project, Adequacy of information available on the project, Delivery time of resources (materials, equipment), Ability of client to make timely and accurate decisions on the project, The condition of the equipment (state of repair), Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Collaborative Supervision/inspection on the project (Consultants with Client), and the State of Health and Safety.

   d. The fourth CSF group for time performance is the External Factors which integrates three underlying factors of relationship including Economic environment (could incorporate financial environment); Physical work environment such as weather, public disturbance – which could also be termed political environment; and Legal environment which comprise the legislative and government policy or regulations as they affect performance of construction projects.

5. The CSFs for Cost Performance are divided into Contractor's Management Capacity, Client's Commitment to Progress of Project and Economic Environment of Project Estimate and discussed as follows;
   a. The critical success factors having underlying relationship that determines the Contractor's Management Capacity on cost performance are employment of skilful workforce; ability to manage designs; government institution and administrative influence;

extent of subcontracting; initial identification of risks; site management; technical and management capacity of contractor; construction method adopted; healthy financial condition and stability of the contractor and; adequacy of available information. These factors suggest that management capacity of contractor would definitely affect the performance of project budget estimate.

b. Client's Commitment to Progress of Project is another cost performance CSF with the following variables having relationship to determining performance: Client's commitment and information coordination with project parties; Ability to solve unanticipated problems that occur during construction; Adequate time to project (Realistic Programme); Type and Nature of Client and; Client's Project Financing for regular cash flow. A client who fails to finance the project in accordance with planned programme of work will end up frustrating all other efforts to make the project perform on budgeted cost.

c. Economic Environment of Project Estimate has two critical factors; Precise project budget estimate and Economic environment. The underlying relationship of these factors suggests measures of achieving cost performance on construction project. Adverse economic environment such as recession and inflation could render the budget estimate prepared for a construction project incorrect or inaccurate before the project is completed thereby leading to excess cost in terms of variations, claims and fluctuations. Also, the economic situation of the project participants, which is an offshoot of the economic condition of the project country can be a big factor in the concentration and commitment invested in the project towards achieving accurate budget estimate.

6. On Quality Performance,
    a. the first group of CSF is Project Design Communication Management with Workforce comprising core responsibilities of the project management and design team with particular focus on timely production of design drawings with an oversight function on skilful workforce for a quality product achievement which include factors such as Efficiency of communication on the project, Government's institutional and administrative influence e.g. regulations, permits, Competence and experience of design team, Type and Nature of Client, Collaborative Supervision/inspection on the project (Consultants with Client), Quality of Product/Service Design, Timely Production of required Design Documents, Employment of Skilful Workforce which. Therefore, it is established that achieving quality performance requires coordination of information with collaborative efforts of all parties.

b. The second CSF for quality performance is Contractor Capacity for Resource Management on Quality Objective which has eight variable factors of CSF including The condition of the equipment (state of repair), Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Implementation of Innovative Techniques by contractor, Technical and Management capacity of the contractor, Site management by contractor, The standard and quality of materials, Healthy Financial Condition and stability of contractor and, Cultural environment. The burden of achieving quality performance cannot be totally placed on project management and design team; the contractor has a lot of responsibility to achieving this aim. Once the objective of the standard quality is clearly expressed as contained in the item specification and description then the contractor has to put all resources together within its management to ensure achievement of quality. A quality service in producing quality design will culminate to reduction in error in designs which leads to reduction in issuance of revised drawing which ultimately reduces the chances of reworks and poor quality output. The financial health of the contractor's impacts on quality is high and this could easily be observed in the way the site is being managed. This implies that equipments are in a very good state to carrying out the works with the use of quality material.

Adequate dedication of workforce to quality is key requirement and this is exercised by the cultural environment which fosters the quality culture practice experienced by the workforce. Therefore, capacity of contractor in resource management is key factor to achieving quality performance.

c. The third component factor is Project Manager's Competence on Information Coordination and Construction Method which has four variable factors which include Information Coordination, communication and relationship among project parties; Experience of Project Manager; Management capacity and Competence of project manager; and Construction methods adopted on the project such as use of only precast building component, concrete pumps. The four variables are associated together to determine quality performance through the Project Manager's competence and capacity in communication issues and particularly in the management of construction method adopted by the contractor which would have been approved by the Project Manager and the Design team.

7. Health and Safety were organized into two components.

   a. The first component is Effective Finance Management for Health and Safety Implementation which consists of eight determining variable factors to include; Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, Healthy Financial Condition and stability of contractor, Appropriate safety education and training, Government's institutional and administrative influence e.g. regulations, permits, Physical work environment such as weather, public disturbance (area boys), Safety equipment acquisition and maintenance.

b. Capacity of Contractor for Project Management and Safety Programme is the second CSF element for Health and Safety Performance requires the Contractor to have capacity that corroborate the project management principle for safety performance, incorporating the experience of project manager. The variable items under this group are, Technical Competence and Management capacity of the contractor, Experience of contractor, Experience of Project Manager, Construction methods adopted on the project such as use of only precast building, Clear Objectives on Project Outcomes (e.g. Time, cost and quality), Employment of Skilful Workforce, Collaborative Supervision/inspection on the project (Consultants with Client), The condition of the equipment (state of repair), Program evaluation of State of Health and Safety (e.g. Accident cause delay). The skilful workforce and condition of equipment go together in determining the performance of health and safety of a construction project. Therefore, the capacity of the contractor's management with dedicated oversight function by project manager (by extension client's interest) would results in better health and safety performance.

8. Client's commitment to project success complements the management capability of the contractor as the level of commitment of client in terms of finance and information coordination is a function of the type and nature of the client in question. Therefore, there exist a dynamic of performance issues between the Contractor management capacity and the commitment of the Client to the success of the project.

9. This research contends that economic environment affects the estimate or budget of the project and this unfold an interesting focus. Today corruption has permeated every facet of life in Nigeria with alarming revelations. A good economic environment would support standard and proper professional practice while a poor and bad economic environment could necessarily exacerbate corruption and sharp practice and this is multifaceted in its occurrence and impacts with professionals throwing ethics into the bin.

Design team's commitment to project management outcomes is the most important component for time performance. This group is made up of success factors like: Ability to solve unanticipated problems that occur during the course of the project, Clear, Correct and Precise Drawings/Documents, Timely

Production of required Design Documents, Early Involvement of Project Manager, Efficiency of communication on the project, Client's Project Financing for regular cash flow, Type and Nature of Client, Government's institutional and administrative influence e.g. regulations, permits; Management capacity and Competence of project manager, and Initial identification of all the risks that are likely to occur on the project. The Capacity of contractor for project management is the next component which closely followed the first component which implies that the project management skills of contractor play important roles in achieving time performance in Nigeria. Its factors include: Healthy Financial Condition and stability of contractor, Commitment of project manager to project, Technical Competence and Management capacity of the contractor, Site management by contractor, and Employment of Competent and Skilful Workforce, With factors such as: Construction methods adopted on the project, Adequacy of information available on the project, Delivery time of resources (materials, equipment), Ability of client to make timely and accurate decisions on the project, The condition of the equipment (state of repair), Adequate time to project (Realistic Programme), Information Coordination, communication and relationship among project parties, Collaborative Supervision/inspection on the project (Consultants with Client), and the State of Health and Safety; Construction resource management was revealed to be the third most important factor group for time performance.

On quality performance, Client's Project Financing for regular cash flow is critical to achieving quality performance followed by Site management by contractor, Type and Nature of Client, Experience and knowledge of the client, Construction methods adopted on the project such as use of only precast building, Experience of Project Manager, and Collaborative Supervision/inspection on the project (Consultants with Client).

On health and safety performance, Healthy Financial Condition and stability of contractor is the most critical followed by Site Management on Effective enforcement scheme, Client's Project Financing for regular cash flow, and Employment of Skilful Workforce.The contractors' healthy financial condition and stability greatly improves the project performance regarding health and safety and the clients' financial commitment to the project are critical success factors CSFs for health and safety programme performance.

There is underlying structure of relationship among the groups of CSFs of KPIs for the assessment and predicting the performance of construction projects. The research developed a model for assessing performance of construction projects – Project Performance Diagnostic Model - PPDM was developed to assess performance in a feedback loop of Stock and Flow diagram using the CSFs as variables.

The result indicator of the Project Performance Diagnostic Model, PPDM developed in this research clearly established that;

Cost Performance is worse off when Cost indicator performs abnormally and in fact far lower than when Time performance is abnormal. This performance indicate a serious concern as it is clear that abnormal cost performance would exacerbate the actual symptoms of every other KPI leading to overall poor performance. Cost Performance drops with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of poor Quality performance as did Time performance.

Time performance is worse off when Time performance performed abnormally compared to when cost performs abnormally. Compare the red and blue lines in the graph of Figure 6.14. The 0Test is the Base line when all KPIs are at 0% after loading the model with the coefficient loadings of the factor analyses. Time performance drops with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of poor Quality performance as in Figure 6.24. This indicate a very interesting result that health and safety failure can affect the Time performance of the project e.g. any serious incident could adversely drag completion time on tasks and the entire project.

Quality performs relatively closely on poor performances of both Time and Cost Indicators. However, quality performs relatively worse on poor Time performance than poor cost performance. Quality does not have much adverse effect on time and cost performance indicator whereas time and cost have significant effect on quality performance. Quality Performance experience a poorer performance as the health and safety performance indicators drop compare to the effect of Quality performance indicator drops thus, while time impact more on Quality performance, cost, and health and safety also impact poorly on quality than drop in quality performance indicators itself. In fact this typically explains the correlation of the critical success factors that are having underlying structure of relationship that makes impact in a particular KPI prompt the impact of other KPI(s).

Health and Safety performed almost the same way when the Time and Cost performances turn abnormal. Health and Safety exhibits worst performance indicator as every critical factor drops to zero with abnormal or corresponding drop in health and safety performance indicator in fact worse than the effect of any of the other three performances.

The Project Performance performs relatively similarly by the effect of Time and Cost poor performances however, Cost poor performance has a relatively more impact on Project performance than the effect of Time Performance in Nigeria. Project Performance is lower by the impact of health and safety compare to the Quality performance indicator and it is clear that poor Cost Performance abnormality exhibits the worst impact on project performance than any of the other three performance indicators.

10. Ten CSFs that are correlated in determining at least three KPIs of project performance are healthy financial condition and stability of contractor; government institution/administrative influence, regulations; technical competence and management capacity of the contractor; employment of skilful workforce; type and nature of client, site management by contractor; client's project financing; information coordination, communication and relationship among project parties, construction methods adopted on the project, collaborative supervision/inspection on the project; ; and the condition of the equipment. The Simulation runs and evaluation of performance scenarios of the model established the ten CSFs as being very significantly influential in predicting at least three of the KPIs. These CSFs were discovered to have more impacts on the KPIs and eventually impact the performance of construction project performance.

11. Healthy financial condition and stability of contractor; government institution/administrative influence and regulations; technical competence and management capacity of the contractor and; employment of skilful workforce are four CSFs that impact all the four KPIs of cost, time, quality and, health and safety. The other six variables impact on at least three of the KPIs. These are type and nature of client, site management by contractor; client's project financing; information coordination, communication and relationship among project parties;

construction methods adopted on the project; collaborative supervision/inspection on the project; and the condition of the equipment. These made the CSFs that are critical to the influence and performance outcome of the conceptualised model.

12. The role of finance, precise and accurate project estimate; contractor's management capacity; and client's commitment to performance of the project are driving force for achieving construction project performance.

13. The PPDM model based on the Nigeria built environment influencing equation shows that Cost CSFs have greater influence on performance followed by Time CSFs. The influence of Quality and Health/Safety are very closely related whereas the influence of Health and Safety could be critical particularly to Time performance indicator.

14. The factors affecting project performance are many with different impacts on the performance indicators of the project and therefore, it is important to assess the critical success factors independently as they affect individual KPIs as the assessment of performance of projects is not one dimensional but multi dimensional culminating into reporting project performance on the KPIs first before the overall report of the general project performance.

15. A construction project will perform once the design team is committed to project management through proper design communication management

with a competent contractor having a sound technical/management capacity within proper financial management regime.

7.3 Contributions of This Research

The research has carved out a niche for itself in literatures on CSFs and KPIs in the assessment of performance in the construction industry particularly in Nigeria. The major contributions of this research particularly for Nigeria construction industry are listed here, some of which are applicable to the construction industry in general.

The research confirmed and propagates the clarification of differentiating critical success factors - CSF and key performance indicators - KPIs as different terms requiring proper application in the construction industry terminology. Therefore, the research clearly established critical success factors as a subset of key performance indicators.

1. Different CSFs are applicable as variable factors for KPIs and therefore, there are group of CSFs for four KPIs of time, cost, quality, and health and safety which were independently established as applicable in Nigeria construction industry.
2. Additional factors impacting construction project's variables in other parts of the world which were not found in literatures applicable for Nigeria were identified and found applicable in practice in Nigeria. The research identified 31 CSFs for Cost performance, 34 factors for time; 25 for quality; and 18 CSFs for health and safety of which 27, 17, 20, and

17 CSFs were eventually determined for time, cost, quality, and health and safety KPIs respectively.

3. This research provided a different perspective to the way the success factors should be assessed as different factors that are reported separately in literatures (avoiding confusing CSFs as KPIs) which are linked as associates in this research indicate structure of an underlying relationship and established as follows;
    a. Time performance as a KPI has four components of CSFs namely; Design Team Commitment to Project Management Outcomes; Capacity of Contractor for Project Management; Construction Resource and Management; and External Factors.
    b. There are three components for Cost performance that were established in this research which are; Contractor's Management Capacity; Client's Commitment to Progress of Project; and Economic Environment of Project Estimate.
    c. The Quality performance have three components namely, Project Design Communication Management with Workforce; Contractor Capacity for Resource Management on Quality Objective; and Project Manager's Competence on Information Coordination and Construction Method.
    d. Health and Safety were organized into two components. The first component is Effective Finance Management for Health and Safety

Implementation while the second component is Capacity of Contractor, for Project Management and Safety Programme.

4. This research has established ten CSFs that are correlated with underlying structure of relationship in determining the KPIs of project performance which are healthy financial condition and stability of contractor; government institution/administrative influence, regulations; technical competence and management capacity of the contractor; employment of skilful workforce; type and nature of client, site management by contractor; client's project financing; information coordination, communication and relationship among project parties, construction methods adopted on the project, collaborative supervision/inspection on the project; ; and the condition of the equipment. The Simulation runs and evaluation of performance scenarios of the model established the ten CSFs as being very significantly influential in predicting at least three of the KPIs. These CSFs were discovered to have more impacts on the KPIs and eventually impact the performance of construction project performance.
5. Cost performance is most critical indicator that could exacerbate the symptoms of every other KPI thus, single most significant impact on the overall performance. Therefore, the role of finance, precise and accurate project estimate; contractor's management capacity; and client's

commitment to performance of the project are driving force for achieving construction project performance.

6. There is underlying structure of relationship among CSFs of KPIs for the assessment and predicting the performance of construction projects. The research developed a model for assessing performance of construction projects – Project Performance Diagnostic Model - PPDM was conceptualised and developed to assess performance in a feedback loop of Stock and Flow diagram using the CSFs as variables. This was exclusively developed from the conceptual model of the research with extensive review of literature and this model is unique in the industry to assisting project manager in effective decision making. It seems novel in the Nigeria construction industry and thus, other research efforts could spring towards the direction of this research in assessing project performance.
7. PPDM model based on the Nigeria built environment influencing equation shows that Cost CSFs have greater influence on performance followed by Time CSFs. The influence of Quality and Health/Safety are very closely related although the influence of Health and Safety could be critical particularly to Time performance indicator.

The PPDM has been added to the construction industry literature and as a tool that attempts to simplify the analysing process and reduces the time needed in thought process, understanding project dynamics and preparing precise reports by professionals in the industry.

8. The research also directs the consciousness of other researchers, practitioners and academics in the Nigeria built environment to adopting the System dynamics methodology for assessing construction project performance and therefore, propagates the inclusion of System Dynamics in the curricula of schools in Built Environment studies in Nigeria. The importance of System Dynamics is emphasised and efforts should be geared towards incorporating teaching SD not only in tertiary institutions and Universities offering Built Environment Courses but earlier from secondary schools.

7.4 Limitations of This Research

There are some limitations that are associated with this study.

1. The study is limited to Nigeria construction industry and may not be generalised universally till similar studies are conducted for other countries and regions of the world.
2. The adopted methodology has its limitations as pragmatism fails to give a coherent rationale for mixed methods due to its lack of a clear definition to what works, although pragmatism overcomes the problem inherent in multiple paradigm approach – at least in principle – based on fundamentally different assumptions.

3. The choice of data collection also posed its limitation to the research despite the use of focus group (a limited population), survey questionnaire (with challenge on representativeness) and interview (limited by participants experience), the researcher had hoped for a documented record of project performance which were not readily available based on the specific factors being assessed. Company documentation of archival data could have increased the scope and depth of analyses.
4. Scope of discussions is believed to be limited being a PhD research and particularly the discussion under the SD framework revealed more information than discussed as the researcher has limited years of experience in SD compared to experts in the field – the researcher is currently a trainee with System Dynamics Society and will be presenting a paper on this research in the 35thInternational Conference of the System Dynamics Society at the Cambridge, Massachusetts Conference in July 2017 for the annual educational and collaborative conference.

7.5 Future Directions of Research

This research is not a destination but a process in the area of project performance for construction projects and the use of SD in the Nigeria built environment and thus expect that many researches will spring up from this research. Can we possibly model the performance of managers in the construction industry like we see the model analysis of football games in assessing the performance of teams? This is not impossible and of course the future to explore in construction project performance diagnosis.

The research has attempted to collate all factors that are critical to affecting successful performance of construction project but the researcher believes that this would not be exhaustive. This study is limited to Nigeria; future researches can look at other countries to establish some kind of a universal framework for project performance. The need to carry out similar research elsewhere and in fact focus on a global exploration of the factors that affect construction performance and see how to develop a comprehensive model for the construction world at large.

This research has not differentiated any sector of the construction industry and no comparison had been done for private and public sectors, future research should dwell in this area.

Training requirements for the use of the PPDM is another area that would require research particularly for training future researchers and practitioners in this field of study. Therefore, more research is expected in System Dynamics as applicable to built environment in Nigeria.

The research is able to conceptualise a tool for practically assessing construction project performance. Further research would be carried out to subsequently improve upon the model to make it a versatile and robust tool for assessing the performance of construction projects. The need for future exploration in this area of research is clear as the SD model is wide in scope due to mental model built into the equation and thus, improved understanding of construction system would create need for improving mental models and thus, improving the PPD model. As earlier mentioned, the mental model input of the SD model triggers the need to reassess the developed model and introduce a more comprehensive system equation that capture more in depth interactions of the CSFs in the construction process to determining KPIs and the overall project performance. The conceptualized model is a call to greater assertive model development for the industry with use of SD software. From the experience gained in simulation run of the model, the researcher believes there is no one fixed way of calibrating or modelling the equations for the model, the difference in certain factors of locality, behavioural, technology could influence the modelling process and thus another dimension to this research.

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APPENDICES

Appendix 1: Sample of the Main Questionnaire for the Research

University of Salford MANCHESTER

Dear Sir/Madam,

PROJECT PERFORMANCE DIAGNOSTICS: A FRAMEWORK FOR EVALUATING CONSTRUCTION PROJECT PERFORMANCE

You have been selected to take part in this study as your organisation has a track record of responding favourably to research from your many decades of practising. This is a survey being conducted as part of PhD study at the University of Salford. By drawing on your experiences in participating in the evaluation of construction project performance, I plan to develop a framework that can be used to assess the performance of construction project by the practitioners involved indecision making for project performance. It is hoped that this study will provide information on critical success factors that affect construction performance that will help organisations to evaluate the performance of construction projects through its feedback mechanism thus enhancing the quality of decisions beingmade to influence the performance of the construction projects.

The evaluation of performance of construction projects provides a feedback that could be used to assess the performance of future construction projects. The System Dynamics based framework developed as part of this research will help organisations assess the performance of their construction projects and make better decisions for better performance of construction projects in Nigeria.

The researcher; Mr. Bello is to embark on this research project for the following purposes:

1. To identify critical success factors (CSFs) for key performance indicators (KPIs) in terms of cost, time, quality and health/safety for construction project performance.
2. Todetermine CSFs fortimely, safe, qualityandcosteffectiveprojectdeliveryinNigeria.
3. To establish component factors of CSFs with their underlying relationship for each KPIs (Cost, Time, Quality, and Health/Safety) for effective project performance.
4. To evaluate the dynamic framework of CSF/KPI for its suitability for construction project performance diagnostic for effective project delivery in Nigeria.
5. To develop Project Performance Diagnostic Framework/Model for diagnosing project performance based on the project variables.

Participation in this questionnaire is voluntary and you may choose to withdraw at any time. Your individual answers will be treated in confidence and the responses from all the completed questionnaires will be aggregatedforuseintheresearchreport.Ifyouwouldliketoreceiveasummaryoftheresearch findings, please provide your contact details at the end of the questionnaire and this will be shared after the data has been aggregated and analysed. Should you wish to withdraw at any stage, your responses will be destroyed immediately.

The researcher assures that all data will be password protected and will be kept in a secure place. This data will be destroyed within 3 years of receipt of responses. Please complete the questionnaire and return it via email by15thNovember2016toW.Bello@edu.salford.ac.ukorifyourequireapostaladdressforsendingahardcopy please contact Mr Bello on +2348028308826. If you require any further information or clarification, please do nothesitatetocontacttheresearcherthroughthestatedemailaddressandphonenumber.

I appreciate your kind co-operation in this matter, and look forward to receiving your input. Please sign below to acknowledge your willingness and freewill to participate implying that you are satisfied with the measures taken by the researcher.

With very best regards,

W. A. Bello.

PART A: PARTICULARS OF RESPONDENTS AND ORGANISATION

Please mark the appropriate answer

1. Kindly indicate your highest educational qualification:

OND [ ] HND [ ] BSc. [ ] MSc. [ ] PhD [ ]

2. Your discipline:

Architect [ ] Quantity Surveyor [ ] Structural Engineer [ ]Mechanical Engineer [ ] Electrical Engineer [ ] Builder [ ] Others pleasespecify…………

3. To which professional body do you belong:

NIA [ ] NIQS [ ] NSE [ ] NIOB[ ]
others please specify…………

4. Please indicate your level of professional membership:

Technician[ ] Probationer[ ] Member[ ] Fellow [ ]

5. How long have you been in professional practice:

Less than 5 years [ ] 6 – 10 years [ ] 11 –15years [ ] 16 – 20 years [] 21 years and above [ ]

6. Kindly indicate your status in the organization:

Supervisor/Foreman [ ] Assistant /Junior Professional Staff [ ] Site Engineer [ ] Senior staff [ ] Project Manager/Partner [ ] Site manager [ ] Director []

Organisational Information

7. How long has your organisation been in operation:

Less than 5 years [ ] 6 – 10 years [ ] 11 – 15 years [ ] 16 – 20years [ ] 21 years and above[]

8. Please indicate the form of ownership of your organization:

Sole proprietorship [ ] Partnership [ ] Corporation [] Limited liability [ ]

9. Please indicate the size of your organization:

Small [ ] Medium [] Large [ ]

This is a case study; please provide your answers according to a recently completed project you managed.

10. Type of Client of the project:
Public (government projects) [ ]   Private []

11. The position of your organization on the project was as the:
Client []   Contractor [ ]   Consultant []

12. Type of project: Building: Residential [ ] Commercial [ ]
Civil: industrial (plants, factories…)[ ] Infrastructure: roads, bridges.
[ ] others please specify…

13. What form of contract was used on the project:
JCT[ ]FIDIC [ ]   NEC3[ ]GC/works contract[ ] others please specify..

14. Contract Procurement or Delivery Method: Lump sum [ ] Measurement [ ] Cost Reimbursable [ ] Turnkey/Package Deal Contract [ ] Design and Build [ ] Construction Management [ ] Contractor's Design Specific Elements (portion) [ ]

15. Costs (In Naira)
    a. Estimated cost of project……………………………
    b. Cost of project at completion……………………………………………….
    c. What was the planned contract duration…………………………………………….
    d. What was the actual contract duration…………………………………………………………………

PART B: CRITICAL SUCCESS FACTORS FOR TIME PERFORMANCE

Please rate the following factors based on their impact on Time Performance of Construction Project

1 = Not important, 2 = Less important, 3 = moderately important, 4 = Important, 5 = Most important.

	How important are the following factors in enhancing Time performance of construction projects	Degree of importance				
		1	2	3	4	5
1.	Clear Objectives on Project Outcomes (e.g. Time, cost, quality& Safety)					
2.	Adequacy of information available on the project					
3.	Delivery time of resources (materials, equipment)					
4.	The condition of the equipment (state of repair)					
5.	Collaborative Supervision/inspection on the project (Consultants with					
6.	Construction methods adopted on the project such as use of only precast					
7.	Use of innovations such as BIM, e-tendering impacts on project					
8.	Initial identification of all the risks					
9.	State of Health and Safety (e.g. Accident cause delay)					
10	Management capacity and Competence of project manager					
11	Early Involvement of Project Manager					
12	Ability to adapt to changes on the project					
13	Commitment of project manager to project					
14	Technical Competence and Management capacity of the contractor					
15	Healthy Financial Condition and stability of contractor					
16	Early Involvement of Contractors					
17	Employment of Competent and Skilful Workforce					
18	Implementation of Innovative Techniques					
19	Contractor's Ability to Manage Designs					
20	Site management by contractor					
21	Client's Project Financing for regular cash flow					
22	Adequate time to project (Realistic Programme)					
23	Information Coordination, communication and relationship among					
24	Ability of client to make timely and accurate decisions on the project					
25	Efficiency of communication on the project					
26	Ability to solve unanticipated problems that occur during the course of					
27	Type and Nature of Client					
28	Timely Production of required Design Documents					
29	Clear, Correct and Precise Drawings/Documents					
30	Physical work environment such as weather, public disturbance (area					
31	Legal environment					
32	Cultural environment					
33	Economic environment					
34	Government's institutional and administrative influence e.g. regulations,					

PART C: CRITICAL SUCCESS FACTORS FOR COST PERFORMANCE

Please rate the following factors based on their impact on Cost Performance of Construction Project

	How important are the following factors in enhancing Cost performance of construction projects	Degree of importance				
		1	2	3	4	5
1.	Clear Objectives on Project Outcomes(e.g. Time, cost, quality& Safety)					
2.	Adequacy of information available on the project					
3.	Collaborative Supervision/inspection on project (Client, Consultants &					
4.	Construction methods adopted on the project					
5.	Use of innovations such as BIM, e-tendering impacts on project					
6.	Experience of Project Manager					
7.	Management capacity and Competence of project management team					
8.	Commitment of project manager to project					
9.	Technical and Management capacity of the contractor					
10.	Initial identification of all the risks					
11.	Experience of contractor					
12.	Competitive and Transparent procurement process (Best practice no					
13.	Optimal Utilisation of Resources					
14.	Healthy Financial Condition and stability of the contractor					
15.	Employment of Competent and Skilful Workforce					
16.	Implementation of Innovative Techniques by contractor					
17.	Contractor's Ability to Manage Designs					
18.	Extent of subcontracting by contractor					
19.	Site management by contractor					
20.	Type and Nature of Client					
21.	Client's Project Financing for regular cash flow					
22.	Adequate time to project (Realistic Programme)					
23.	Client’s commitment and Information Coordination with project parties					
24.	Ability to solve unanticipated problems that occur during construction					
25.	Timely Production of required Design Documents					
26.	Clear, Correct and Precise Drawings/Documents					
27.	Government’s institutional and administrative influence e.g. regulations,					
28.	Physical work environment such as weather, public disturbance (area					
29.	Legal environment					
30.	Cultural environment					
31.	Economic environment					

PART D: CRITICAL SUCCESS FACTORS FOR QUALITY PERFORMANCE

Please rate the following factors based on their impact on Quality Performance of Construction Project

1 = Not important, 2 = Less important, 3 = Moderately important, 4 = Important, 5 = Most important.

	How important are the following factors in enhancing Quality performance of construction projects	**Degree of importance**				
		1	**2**	**3**	**4**	**5**
1	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)					
2	The standard and quality of materials					
3	The condition of the equipment (state of repair)					
4	Collaborative Supervision/inspection on the project (Consultants with					
5	Construction methods adopted on the project such as use of only precast					
6	Experience of Project Manager					
7	Management capacity and Competence of project management team					
8	Information Coordination, communication and relationship among					
9	Commitment of project manager to project					
10	Technical and Management capacity of the contractor					
11	Healthy Financial Condition and stability of contractor					
12	Client's Project Financing for regular cash flow					
13	Employment of Competent and Skilful Workforce					
14	Implementation of Innovative Techniques by contractor					
15	Timely Production of required Design Documents					
16	Site management by contractor					
17	Experience and knowledge of the client					
18	Type and Nature of Client					
19	Efficiency of communication on the project					
20	Ability to solve unanticipated problems that occur during construction					
21	Competence and experience of design team					
22	Government's institutional and administrative influence e.g. regulations,					
23	Quality of Product/Service Design					
24	Physical work environment such as weather, public disturbance (area					
25	Cultural environment					
26	Legal environment					
27	Economic environment					

PART E: CRITICAL SUCCESS FACTORS FOR HEALTH AND SAFETY PERFORMANCE

Please rate the following factors based on their impact on Health and Safety Performance of Construction Project1 = Not important, 2 = Less important, 3 = Moderately important, 4 = Important, 5 = Most important.

	How important are the following factors in enhancing Health and Safety performance of construction projects	**Importance of factor**				
		1	**2**	**3**	**4**	**5**
1.	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)					
2.	The condition of the equipment (state of repair)					
3.	Collaborative Supervision/inspection on the project (Consultants with					
4.	Construction methods adopted on the project such as use of only precast					
5.	Experience of Project Manager					
6.	Management capacity and Competence of project management team					
7.	Technical Competence and Management capacity of the contractor					
8.	Experience of contractor					
9.	Employment of Skilful Workforce					
10.	Site Management on Effective enforcement scheme					
11.	Healthy Financial Condition and stability of contractor					
12.	Client's Project Financing for regular cash flow					
13.	Appropriate safety education and training					
14.	Information Coordination, communication and relationship among					
15.	Safety equipment acquisition and maintenance					
16.	Government's institutional and administrative influence e.g. regulations,					
17.	Physical work environment such as weather, public disturbance (area					
18.	Program evaluation of State of Health and Safety (e.g. Accident cause					

Kindly assess (tick) the performance of the project according to the following performance indicators.

Assign grades according to the following scale:

1 - POOR 2 - FAIR 3 - GOOD 4 –VERYGOOD 5 - EXCELLENT

	PERFORMANCE INDICATORS	**1**	**2**	**3**	**4**	**5**
1	**Time**					
2	**Cost**					
3	**Quality**					
4	**Health and Safety**					

PART F: GENERAL QUESTIONS

Please grade the degree to which your response on this project is applicable to every other project you have been involved with in the construction industry in Nigeria.

Not Applicable	Slightly Applicable	Moderately Applicable	Very Applicable	Extremely Applicab
◯	◯	◯	◯	◯

ADDITIONAL INFORMATION

If you have further comments or suggestions about design, procurement and construction strategies for waste minimization, please write it in the box below.

Thank you. We have reached the end of the survey. We are grateful for your time and cooperation; it is well appreciated.

University of Salford MANCHESTER

Appendix 2: Sample of the Questionnaire for CSF Checklist used for System Dynamic Modelling (SDM), for equation loading in Vensim for the validation of the PPDM.

This questionnaire is designed to collect information about the extent to which critical Success Factors for Key Performance Indicators were adopted or implemented on the chosen construction case study project. The research is significantly focusing the management performance of construction projects thus; require the experience opinion of professionals and practitioners in the construction field. The choice of respondent is based on your knowledge and position of your involvement in the case project from inception till the completion and final handover/commissioning of the project. Kindly assess the level of adoption/implementation of the identified critical success factors for their key performance indicators using a scale from 0% - not implemented - to 100% - fully implemented. The questionnaire will take about 15 minutes to complete.Your invaluable input is greatly appreciated.

PART A: PARTICULARS OF RESPONDENTS AND ORGANISATION

Please mark the appropriate answer within the parenthesis √ i.e. [√]

1. Kindly indicate your role on the project:

Client [ ]

Project Manager [ ]

Architect [ ]

Quantity Surveyor [ ]

Structural Engineer [ ]

Mechanical Engineer [ ]

Electrical Engineer [ ]

Contractor [ ]

PART B: CRITICAL SUCCESS FACTORS FOR TIME PERFORMANCE

Kindly rate the percentage level at which the following critical success factors were adopted/implemented for Time performance indicator in the case study project from 0% - 100% as applicable.

No.	**CSFs for the Four Extracted Components of Time Performance Indicator**	**Level of Adoption/ Implementation**
Comp1	**Design Team Commitment to Project Management Outcomes**	
T22	Ability to solve unanticipated problems that occur during the course of the project	
T21	Clear, Correct and Precise Drawings/Documents	
T19	Timely Production of required Design Documents	
T20	Early Involvement of Project Manager	
T24	Efficiency of communication on the project	
T6	Client's Project Financing for regular cash flow	
T15	Type and Nature of Client	
T25	Government's institutional and administrative influence	
T8	Management capacity and Competence of project manager	
T9	Initial identification of all the risks	
Comp2	**Capacity of Contractor for Project Management**	
T16	Healthy Financial Condition and stability of contractor	
T4	Commitment of project manager to project	
T1	Technical Competence and Management capacity of the contractor	
T18	Site management by contractor	
T17	Employment of Competent and Skilful Workforce	
Comp3	**Construction Resource and Management**	
T16	Construction methods adopted on the project such as, concrete	
T13	Adequacy of information available on the project	
T26	Delivery time of resources (materials, equipment)	
T11	Ability of client to make timely and accurate decisions on the project	
T23	The condition of the equipment (state of repair)	
T10	Adequate time to project (Realistic Programme)	
T7	Information Coordination, communication and relationship among project parties	
T28	Collaborative Supervision/inspection on the project (Consultants	
T33	State of Health and Safety (e.g. Accident cause delay)	
Comp4	**External Factors**	
T27	Economic environment	
T30	Physical work environment such as weather, public disturbance	
T32	Legal environment	

PART C: CRITICAL SUCCESS FACTORS FOR COST PERFORMANCE

Kindly rate the percentage level at which the following critical success factors were adopted/implemented Cost performance indicator in the case study project from 0% - 100% as applicable.

No	CSFs for the Four Extracted Components of Time Performance Indicator	Level of Adoption/
Comp1	**Contractor's Management Capacity Capacity**	
C13	Employment of Skilful workforce	
C10	Contractor's Ability to Manage Designs	
C3	Government's institutional and administrative influence e.g	
C9	Extent of subcontracting by contractor	
C14	Initial identification of all the risks	
C16	Site management by contractor	
C17	Technical and Management capacity of the contractor	
C28	Construction Method Adopted on the Project	
C22	Healthy Financial Condition and stability of the contractor	
C25	Adequacy of Information available on the Project	
Comp2	**Client's Commitment to Progress of Project**	
C18	Client's commitment and Information Coordination with	
C20	Ability to solve unanticipated problems that occur during	
C21	Adequate time to project (Realistic Programme)	
C11	Type and Nature of Client	
C2	Client's Project Financing for regular cash flow	
Comp3	Economic Environment of Project Estimate	
C15	Economic environment	
C1	Precise Project Budget Estimate	

PART D: CRITICAL SUCCESS FACTORS FOR TIME PERFORMANCE

Kindly rate the percentage level at which the following critical success factors were adopted/implemented for Quality performance indicator in the case study project from 0% - 100% as applicable.

No	CSFs for the Four Extracted Components of Time Performance Indicator	Level of Adoption/ Implementation
Comp1	**Project Design Communication Management with Workforce**	
Q16	Efficiency of communication on the project	
Q11	Government's institutional and administrative influence e.g.permits	
Q20*	Competence and experience of design team	
Q3	Type and Nature of Client	
Q7	Collaborative Supervision/inspection on the project (Consultants with Client)	
Q18	Quality of Product/Service Design	
Q8	Timely Production of required Design Documents	
Q22*	Employment of Skilful Workforce	
Comp2	**Contractor Capacity for Resource Management on Quality Objective**	
Q10	The condition of the equipment (state of repair)	
Q17	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)	
Q21*	Implementation of Innovative Techniques by contractor	
Q15	Technical and Management capacity of the contractor	
Q2	Site management by contractor	
Q9	The standard and quality of materials	
Q12	Healthy Financial Condition and stability of contractor	
Q14	Cultural environment	
Comp3	**Project Manager's Competence on Information Coordination and Construction Method**	
Q23	Information Coordination, communication and relationship among project parties	
Q6	Experience of Project Manager	
Q13	Management capacity and Competence of project manager	
Q5*	Construction methods adopted on the project such as use of only precast building	

PART D: CRITICAL SUCCESS FACTORS FOR TIME PERFORMANCE

Kindly rate the percentage level at which the following critical success factors were adopted/implemented for Health and Safety performance indicator in the case study project from 0% - 100% as applicable.

No	CSFs for the Four Extracted Components of Time Performance Indicator	Level of Adoption/
Comp1	**Effective Finance of Site Management for Health Safety Implementation**	
HS2	Site Management on Effective enforcement scheme	
HS3	Client's Project Financing for regular cash flow	
HS1	Healthy Financial Condition and stability of contractor	
HS9	Appropriate safety education and training	
HS7	Government's institutional and administrative influence e.g.	
HS8	Physical work environment such as weather, public disturbance (area	
HS12	Safety equipment acquisition and maintenance	
HS18	Information Coordination, communication and relationship among project parties	
Comp2	**Capacity of Contractor for Project Management and Safety**	
HS14	Technical Competence and Management capacity of the contractor	
HS11	Experience of contractor	
HS15	Experience of Project Manager	
HS13	Construction methods adopted on the project such as use of only	
HS10	Clear Objectives on Project Outcomes (e.g. Time, cost and quality)	
HS5*	Employment of Skilful Workforce	
HS17	Collaborative Supervision/inspection on the project (Consultants with	
HS16	The condition of the equipment (state of repair)	
HS6	Program evaluation of State of Health and Safety (e.g. Accident cause	

PART E: OVERALL PERFORMANCE OF KPIS ON THE CASE STUDY PROJECT

Kindly assess (tick) the performance of the project according to the following performance indicators.

Assign grades according to the following scale:

1 - POOR   2 - FAIR   3 - GOOD   4 –VERYGOOD   5 - EXCELLENT

	PERFORMANCE INDICATORS	**1**	**2**	**3**	**4**	**5**
1	**Time**					
2	**Cost**					
3	**Quality**					
4	**Health and Safety**					

PART F: ADDITIONAL INFORMATION

If you have further comments or suggestions about design, procurement and construction strategies for waste minimization, please write it in the box below.

Thank you. We have reached the end of the survey. We are grateful for your time and cooperation; it is well appreciated.

Appendix 3: Sample Simulation Results Table from Vensim

	"Project Performance" Runs:					
Time (Week)	Base@100%	HealthSafety @0	Quality@0	Cost@0	Time@0	0Test
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	3.87492	3.87492	3.87492	0	2.13503	0
3	17.63324	17.63324	17.63324	4.90523	11.07806	0.66249
4	40.57316	40.57316	40.57316	15.6849	27.42395	2.79855
5	72.41702	72.41702	72.41702	33.86775	51.3292	9.3606
6	112.97321	112.97321	112.97321	59.43097	82.83431	21.10637
7	162.10164	162.10164	162.10164	92.46625	121.9496	38.80664
8	219.69449	219.69449	219.69449	133.0066	168.6747	62.82381
9	285.66559	285.66559	285.66559	181.0688	223.0048	93.38075
10	359.94409	359.94409	359.94409	236.6611	284.9335	130.6269
11	442.47046	442.47046	442.47046	299.7874	354.4539	174.6689
12	533.19379	533.19379	533.19379	370.4487	431.559	225.5862
13	632.06989	632.06989	632.06989	448.6447	516.2418	283.44

14	739.05994	739.05994	739.05994	534.374	608.4959	348.2791
15	854.12958	854.12958	854.12958	627.6343	708.3151	420.143
16	977.24805	977.24805	977.24805	728.4233	815.6935	499.0645
17	1108.3877	1108.3877	1108.3877	836.7385	930.6257	585.0711
18	1247.52344	1247.52344	1247.52344	952.5772	1053.107	678.1862
19	1394.63232	1394.63232	1394.63232	1075.936	1183.131	778.4299
20	1549.69336	1549.69336	1549.69336	1206.814	1320.695	885.8198
21	1712.68726	1712.68726	1712.68726	1345.206	1465.794	1000.371
22	1883.59619	1883.59619	1883.59619	1491.111	1618.424	1122.098
23	2062.40381	2062.40381	2062.40381	1644.526	1778.581	1251.012
24	2249.09448	2249.09448	2249.09448	1805.449	1946.262	1387.125
25	2443.65381	2443.65381	2443.65381	1973.876	2121.463	1530.446
26	2646.06836	2646.06836	2646.06836	2149.807	2304.18	1680.983
27	2856.32568	2856.32568	2856.32568	2333.238	2494.412	1838.746
28	3074.41382	3074.41382	3074.41382	2524.167	2692.155	2003.741
29	3300.32153	3300.32153	3300.32153	2722.593	2897.406	2175.976
30	3534.03833	3534.03833	3534.03833	2928.512	3110.163	2355.455
31	3775.5542	3775.5542	3775.5542	3141.924	3330.423	2542.186
32	4024.85962	4024.85962	4024.85962	3362.827	3558.184	2736.174
33	4281.94531	4281.94531	4281.94531	3591.218	3793.443	2937.423

34	4546.80322	4546.80322	4546.80322	3827.095	4036.199	3145.938
35	4819.4248	4819.4248	4819.4248	4070.458	4286.449	3361.724
36	5099.80273	5099.80273	5099.80273	4321.304	4544.191	3584.784
37	5387.9292	5387.9292	5387.9292	4579.632	4809.423	3815.122
38	5683.79736	5683.79736	5683.79736	4845.441	5082.145	4052.742
39	5987.40039	5987.40039	5987.40039	5118.729	5362.353	4297.646
40	6298.73145	6298.73145	6298.73145	5399.494	5650.045	4549.84
41	6617.78467	6617.78467	6617.78467	5687.735	5945.222	4809.324
42	6944.55371	6944.55371	6944.55371	5983.451	6247.88	5076.103
43	7279.0332	7279.0332	7279.0332	6286.64	6558.019	5350.178
44	7621.21729	7621.21729	7621.21729	6597.302	6875.636	5631.552
45	7971.10059	7971.10059	7971.10059	6915.435	7200.73	5920.228
46	8328.67773	8328.67773	8328.67773	7241.037	7533.301	6216.207
47	8693.94434	8693.94434	8693.94434	7574.108	7873.347	6519.493
48	9066.89551	9066.89551	9066.89551	7914.647	8220.866	6830.086
49	9447.52637	9447.52637	9447.52637	8262.653	8575.857	7147.99
50	9835.83301	9835.83301	9835.83301	8618.124	8938.32	7473.206
51	10231.8106	10231.81055	10231.8106	8981.06	9308.253	7805.736
52	10635.4551	10635.45508	10635.4551	9351.459	9685.654	8145.581
53	11046.7627	11046.7627	11046.7627	9729.32	10070.52	8492.743

54	11465.7285	11465.72852	11465.7285	10114.64	10462.86	8847.225
55	11892.3496	11892.34961	11892.3496	10507.43	10862.66	9209.026
56	12326.6221	12326.62207	12326.6221	10907.67	11269.93	9578.149
57	12768.543	12768.54297	12768.543	11315.38	11684.66	9954.596
58	13218.1084	13218.1084	13218.1084	11730.54	12106.85	10338.37
59	13675.3145	13675.31445	13675.3145	12153.15	12536.5	10729.46
60	14140.1582	14140.1582	14140.1582	12583.23	12973.62	11127.89
61	14612.6367	14612.63672	14612.6367	13020.76	13418.19	11533.64
62	15092.7471	15092.74707	15092.7471	13465.74	13870.23	11946.72
63	15580.4854	15580.48535	15580.4854	13918.18	14329.72	12367.13
64	16075.8496	16075.84961	16075.8496	14378.08	14796.67	12794.88
65	16578.8359	16578.83594	16578.8359	14845.42	15271.08	13229.95
66	17089.4434	17089.44336	17089.4434	15320.22	15752.94	13672.36
67	17607.668	17607.66797	17607.668	15802.47	16242.26	14122.1
68	18133.5059	18133.50586	18133.5059	16292.17	16739.03	14579.18
69	18666.957	18666.95703	18666.957	16789.32	17243.26	15043.6
70	19208.0176	19208.01758	19208.0176	17293.93	17754.94	15515.36
71	19756.6836	19756.68359	19756.6836	17805.98	18274.07	15994.45
72	20312.9551	20312.95508	20312.9551	18325.47	18800.65	16480.88
73	20876.8281	20876.82813	20876.8281	18852.42	19334.69	16974.65

74	21448.3008	21448.30078	21448.3008	19386.81	19876.18	17475.76
75	22027.3711	22027.37109	22027.3711	19928.65	20425.11	17984.21
76	22614.0371	22614.03711	22614.0371	20477.94	20981.5	18500.01
77	23208.2969	23208.29688	23208.2969	21034.67	21545.33	19023.15
78	23810.1484	23810.14844	23810.1484	21598.85	22116.61	19553.63
79	24419.5898	24419.58984	24419.5898	22170.47	22695.34	20091.46
80	25036.6172	25036.61719	25036.6172	22749.54	23281.52	20636.63
81	25661.2305	25661.23047	25661.2305	23336.04	23875.14	21189.15
82	26293.4277	26293.42773	26293.4277	23930	24476.21	21749.02
83	26933.207	26933.20703	26933.207	24531.39	25084.73	22316.23
84	27580.5645	27580.56445	27580.5645	25140.23	25700.69	22890.79
85	28235.5	28235.5	28235.5	25756.51	26324.1	23472.69
86	28898.0117	28898.01172	28898.0117	26380.23	26954.95	24061.95
87	29568.0977	29568.09766	29568.0977	27011.39	27593.24	24658.55
88	30245.7578	30245.75781	30245.7578	27649.99	28238.97	25262.51
89	30930.9883	30930.98828	30930.9883	28296.03	28892.15	25873.81
90	31623.7871	31623.78711	31623.7871	28949.51	29552.77	26492.47
91	32324.1543	32324.1543	32324.1543	29610.43	30220.84	27118.48
92	33032.0898	33032.08984	33032.0898	30278.79	30896.34	27751.84
93	33747.5898	33747.58984	33747.5898	30954.59	31579.29	28392.55

94	34470.6523	34470.65234	34470.6523	31637.82	32269.67	29040.61
95	35201.2773	35201.27734	35201.2773	32328.5	32967.5	29696.03
96	35939.4609	35939.46094	35939.4609	33026.61	33672.76	30358.8
97	36685.2031	36685.20313	36685.2031	33732.15	34385.46	31028.93
98	37438.5039	37438.50391	37438.5039	34445.14	35105.61	31706.41
99	38199.3594	38199.35938	38199.3594	35165.55	35833.19	32391.24
100	38967.7695	38967.76953	38967.7695	35893.41	36568.21	33083.43