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# EXAMINING THE FACTORS INFLUENCING THE IMPLEMENTATION OF INTERNET OF THINGS IN THE NIGERIAN CONSTRUCTION SITE: A SEM APPROACH

Alao, Mohmmed Kaseem [1], Asunogie, O. F [2] and Ifabiyi Olugbemniga Stephen [3]
1. Department of Building Technology, School of Environmental Studies, Auchi Polytechnic, Auchi, Edo State
2. Department of Urban and Regional Planning, School of Environmental Studies, Auchi Polytechnic, Auchi, Edo State.
3. Department of Civil Engineering, School of Engineering Technology, Auchi Polytechnic, Auchi, Edo State
Corresponding author: kaseemalao@yahoo.com Orcid No: 0000-0002-0809-1133

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**Abstract**
The implementation of IoT in the Management of Building Production changed the trajectory of the industrial revolution; it comprises several technologies, with the Internet of Things forming the basis of this revolution. However, there is a widening gap between traditional building production management and digital, data-driven building production management. Hence, the implementation of IOT in the management of building production will increase productivity. Consequently, factors influencing IOT implementation at Nigerian construction sites need to be understood by practitioners for effective implementation. This study was conducted to identify factors influencing IoT implementation at construction sites in Nigeria. It will also serve as a benchmark for analysing the significant relationships between the construct and its items and for confirming the effect of the construct on the effective implementation of IoT in the Nigerian construction site, using the SEM-AMOS approach as the data analysis method. Hence, a model is proposed based on SEM-AMOS. The primary data from participants across the selected 6 North-Central States, totalling 220 responses, were retrieved using a convenience sampling approach, and the analysis was carried out using the Statistical Package for the Social Sciences (SPSS) Version 22.0 and AMOS Version 22.0 for modelling. This paper identified four factors that are influential in the effective implementation of the Internet of Things (IoT). They are referred to as latent constructs, namely: Technology (FAR), Security (SAR), Organisation (FEM) and Environment (ERM). The results showed a significant relationship between IOT influential factors. This paper enhances construction practitioners' knowledge of implementing IOT for effective building production management and suggests to Builders, facility managers, Architects, and engineers the need to implement IOT for effective management of building sites.
Keyword: Construction site, Building production management, Internet of things, implementation,

## 1.0 Introduction

Effective building production management is considered a critical issue in every building construction site due to a high number of reported cases of low-quality production and worker injuries (Rathnansinghe, 2021). However, existing data indicate that there are over 60,000 construction-site fatalities and several instances of poor-quality building products worldwide (Ojo, 2021). The paper

further revealed that construction sites were responsible for over 20% of the total fatalities in Europe, whereby this figure is higher in developing countries, which stood at 30-40%. In addition. It is generally agreed that the construction sector contributes greatly to the economic development of any country. Willar (2012) described that "the construction industry worldwide is one of the major contributors to the Gross Domestic Product (GDP) as well as playing an important role in determining a nation's economic growth, to this end, the Nigeria construction sector plays a significant role in meeting the desires of the country's infrastructural and economic development; thus, making it one of the foremost economic pointers that control the development of the Nigerian economy. The Internet of Things concept involves connecting various devices to a network over the Internet. This concept conceals the dream of a world in which physical equipment and digital items of daily use will interact with each other (mostly without human intervention) through a wide range of new applications and services, as well as the right structure (Ojo, 2022). New developments in the construction sector have been observed, indicating an increased role of information technology and automation across many areas of the economy (Bowen, 2021). The IoT field is a long-range technological area that offers significant opportunities for growth. The Internet of Things is a comparatively new area of knowledge that involves a high level of uncertainty, including IoT technologies and the related economic, social, legal, and technological dimensions (Oke, 2020).

The IoT is enormously important to the built environment (Dilakshan, Rathnasinghe, Seneviratne, 2021). Liu, Hong, and Jiang (2023) insisted that carpenters, welders, and painters on the worksite might not discuss the IoT in casual discussions. Nevertheless, a significant number of industry-leading builders are using IoT devices to monitor equipment, machinery, and workers, enabling better real-time decision-making. Consequently, there are 367 IoT-related projects identified worldwide, whereas industrial-related projects are 265, and IoT-related building projects are 193 (Lueth, 2019)

Therefore, the benefits of implementing IoT-based technologies across various aspects of Construction Site management cannot be overemphasised; acceptance of these technologies remains in its early stages, even in developing countries. There is a lack of research that identifies and analyses the factors affecting the implementation of IoT-based technologies to enhance activities within the construction sector. Therefore, this study aims to achieve the following objectives: identify factors that influence the effective implementation of the Internet of Things, establish significant relationships among IOT influential factors, and develop a valid structural equation model. The novelty of this research lies in the factors influencing the implementation of IoT in Nigerian construction sites, using SEM Amos as an analytical tool. The remaining parts of the research are structured as follows: Part Two reviews the literature relating to the use of IoT-based technologies in the construction sector. Part Three details the research methodology used to achieve the research objectives. Part Four presents and discusses the research findings. Finally, the concluding remarks of the study, the implications of the findings, the limitations, and the directions for future work are presented

### 1.2 Purpose of the Study

The study aims to establish factors influencing the implementation of IoT in Nigerian construction sites. It will also serve as a benchmark for analysing the significant relationship between IoT implementation and its influencing factors, and for confirming the construct's effect on effective

implementation, with particular application to Nigeria, using structural equation modelling. Based on the literature review, the following hypotheses are formulated.

H1: Technology has a significant effect on IoT implementation

H2: Security has a significant effect on IoT implementation

H3: Organisation has a significant effect on IoT implementation

H4: Environment has a significant effect on IoT implementation

## 2.0 Literature Review

The Internet of Things (IoT) is an emerging technology that has enhanced the integrity and effectiveness of all stages of construction, including the design, construction, and post-construction stages of buildings (Tabatabaee, Mohandes, Ahmed, Mahdiyar, Arashpour, Zayed, & Ismail, 2022). Intelligent design with 3D modelling brings precision and enhances productivity efficiency. This improves plan updates, which occur in real-time. The problem of lag time between the delivery of new information and updates on the job site has been resolved. This lessens the valuable resources and time that is being spent and improves the implementation of new design components speedily. IOT is a more useful and sophisticated software used beyond the design and building phases. During construction and after construction, and when the structure is in use, IOT provides benefits for construction managers, such as trends/patterns in energy usage. Most modern buildings have IoT sensors installed on walls that monitor various building systems. Collected data will be analysed regularly to identify trends and patterns in building usage. This makes building managers empowered to enhance energy efficiency, strategically handle operations, know particular trends or patterns, and effectively make use of the capabilities of a building's security, cooling and heating system, access, and water supply (Joshua, 2020)

### 2.1 Internet of Things

The International Telecommunication Union (Ryan, 2012) defined IoT as "A global infrastructure for the information society, allowing progressive services by connecting (physical and virtual) things based on existing and developing interoperable information and communication technologies, Specifically, IoT is identified as a system of 'Things' using the Internet or a private network to connect and communicate with each other (Censis, 2019). In particular, 'Things' are defined as 'smart devices' connected to a network and communicating with one another with minimal human engagement (Oke, 2020). The basic idea is that objects of day-to-day life can be equipped with detection, sensing, networking, and processing capabilities that enable them to communicate over the Internet with one another and with other devices and services to achieve a common goal (Ogunsemi, 2021). In such a context, the IoT allows people and Things to be connected anytime, anyplace, with anything and anyone, ideally using any path/network and any service (Oke,2020). The system enables acquiring, processing and responding to real-world data in real time (Viswanatha; Ramachandra; Venkata Siva Reddy; Ashwini Kumari; Srinivasa Murthy; Sathisha, 2022)

The implementation of interaction and communication with the physical environment is supported by IoT devices (sensors and actuators), with information gathered and judiciously handled to derive valuable interpretations. Examples of *sensors* include mobile phones and internet-enabled phones because they can provide input concerning their current state. An *actuator* is a device used to effect a change in the environment, such as the temperature controller of an air conditioner (Joshua,

2020). Information dispensation and storage can be affected on a remote server. The output of information processing by a device is often stored on a nearby device if the device has the capability to process it. The accessibility of limited resources is often a constraint on IoT devices due to size, processor, and computational constraints. According to Pallavi and Smruti (2017), "the main study challenge is to ensure that we get the right kind of data at the desired level of accuracy" (Nimlyat, Audu, Ola-Adisa, and Gwatau, 2017). Again, adding to the problem of data gathering and handling, there are communication issues as well because communication between IoT devices is mainly wireless, and they are generally installed at geographically discrete locations" (Pandit and Tripathi, 2019). However, well-defined standards are needed to ensure interoperability among such varied devices (Oke, Arowoiya, and Akomolafe, 2022). Calibration is impossible due to the varying requirements of applications and devices. Pallavi and Smruti(2017) concluded that "the heterogeneity of devices and applications implies the development of a middleware platform performing the task of software interface between the *things* and *applications"* (Hawash, Mokhtar, Yusof, Mukred, and Gaid,2021). In summary, an Application Programming Interface (API) is provided through the abstraction of the hardware by the middleware for communication, data management, computation, security, and privacy (Joshua, 2020)

### 2.2 IoT and Its Prospects in the Nigerian Construction Industry

As a result of developments in the IoT and the notable benefits accrued by developed countries worldwide from its use, there is no doubt that its prospects in Nigeria's construction industry, as a developing country, are bright. Nigeria faces several management problems, especially in the construction industry and other key areas of the economy, such as agriculture, education, health, transportation, and water and waste management. Despite the huge annual budgetary allocation, the government has not been able to achieve equivalent results.

The Nigerian state and federal governments are not showing interest in the new Technology that is taking over every aspect of the lives of citizens of other developed nations of the world. IoT is a complementary development of ICT and has found applications in the economy, construction, smart cities, transportation, and security. However, according to Joshua (2020), at the international level, IoT is a hot topic with great potential. It is getting support from individuals and organisations, but you cannot really say that in Nigeria, as the subject is still considered strange. Currently, media reports show that the government is willing to discover the connected world; however, it is still far from what is expected (Moodley, 2019). Indifference is one of the reasons Nigerians have not keyed into the new Technology. Nigerians are not yet persuaded about the new Technology and its applications. Companies have also not invested seriously in IoT, and the failure rate for device connectivity is high. Security concerns are another related issue, as advancements in Technology have also led hackers to upgrade their attack methods. Already, the risk of performing e-transactions in Nigeria is very high, and investors have been wary of losing their funds. Banks have also declared losses in Millions of naira as a result of e-transactions to fraudsters. However, the good news is that manufacturers of these devices have gone a long way in curtailing the activities of these hackers (Hawash et al, 2021)

### 2.3 Factors affecting the implementation of IoT

Intensive literature which was carried out to determine the Xray the factors influencing the implementation of IoT and are basically built on theories, models and frameworks which include TOE framework, TOE designed by Tornatzky and Fleischer (1990) as a rigorous techniques known as the Technology, organisation, and Environment (TOE) framework which analytically pragmatic in numerous studies in developed and developing countries and turned out to be the most significant organisational theory for measuring the implementation and reception of new technology " (Hawash et al, 2021), (Tripathi et al, 2019), and (Oke, 2020). The TOE framework has been globally accepted by many researchers in the IS field to test the effect of critical success factors on the implementation. There are other theories that have been influential in measuring the influence of the organisation to accept new Technology, which are "technology acceptance model (TAM) and diffusion of innovation (DOI)", which were not chosen for this study. The link between the implementation and the factors in the Technology, organisation, and environment settings was statistically significant; however, some factors were undesirable. Therefore, there are numerous aspects within these dimensions; for example, internal or external factors included under the technological dimension should ensure that the Technology works precisely (Oke, 2020). Furthermore, there are barriers to the implementation and use of IoT, including privacy, security, data verification, access control, user privacy, and business processes. Also, enabling the exchange of operations and services through IoT in the building industry has security benefits and makes it much easier for organisations to carry out their daily operations. This study uses dimensions to test the factors affecting IoT implementation in the building construction industry using the SEM approach. These dimensions are Technology, Organisation, Environment and Security (TOES). Each dimension includes significant factors identified in previous studies through content analysis.

Table 2.1: Factors Affecting IoT Implementation

| S/no | Factors | Authors |
|---|---|---|
| 1 | Technology factor | (Oke, 2020). (Viswanatha; Ramachandra ; Venkata Siva Reddy ; Ashwini Kumari ; Srinivasa, 2022) , (Moodley, 2019), (Ojo, Ogunsemi, & Ogunsina, 2022) |
| 2 | Organisation factor | (Viswanatha; Ramachandra ; Venkata Siva Reddy ; Ashwini Kumari ; Srinivasa, 2022), (Moodley, 2019), (Ojo, Ogunsemi, & Ogunsina, 2022). |
| 3 | Environment Factor | (Moodley, 2019) , (Ojo, Ogunsemi, & Ogunsina, 2022). |
| 4 | Security Factor | (Moodley, 2019), (Lekan, D, Ojo,2022). |

Table 2.1 lists all important factors explored through literature content analysis based on the TOE framework, with the addition of a new context (security). Accordingly, this study presents a unique model and examines the factors that influence IoT implementation at a Nigerian building construction site.

### 3.0 Research Methodology

This study was conducted to identify factors influencing the implementation of IoT in Nigerian construction sites. It will also serve as a benchmark for analysing the significant relationships among the constructs/items and defining the effects of the constructs on the effective implementation of IoT in Nigerian

construction sites, using the SEM-AMOS approach for data analysis. The study population comprises 220 professionals in the building industry and IoT users, selected across the six (6) North-Central states of Nigeria. Two research questions were developed to guide the study. A structured questionnaire was used to collect data from participants and was duly validated by experts. The Cronbach's alpha reliability technique was used to determine the internal consistency of the questionnaire items, yielding 0.833. Data collected were analysed through Confirmatory Factor Analysis (CFA) using the Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS). The survey research design is appropriate for this study, as data were collected through a questionnaire on the factors influencing the implementation of IoT in Nigerian construction sites.

### 3.1 Justification for the Structural Equation Model

Structural Equation Modelling (SEM) is a multivariate statistical technique generally used to study relationships and to link latent constructs and observed variables in research (Qureshi, 2015). SEM's foothold rests in both factor analysis and multiple regression analysis. It is possible to estimate multiple, interrelated dependence relationships with SEM, representing unobserved constructs in the relationships and accounting for measurement error (Hair et al., 2017). A sample size of at least 200 normally distributed data is suggested when using SEM (Pallant, 2016). This study had 220 participants; therefore, SEM is applicable. The two important elements of SEM are the measurement model and the structural model. The measurement model in SEM shows the significant relationships between latent constructs and their observed indicators, while the structural model estimates the relationships between constructs. Confirmatory Factor Analysis (CFA) is a crucial method for testing the fit of the data to the hypothesised model (Qureshi, 2015). In this study, a preliminary analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23 and AMOS version 22 as a modelling tool.

### 3.2 Kaiser-Meyer-Olkin (KMO)

The application of Likert scales in any research requires that such questionnaires be subjected to the Cronbach's alpha coefficient to establish the reliability and consistency of the constructs. Using SPSS version 22, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were conducted, and the findings, as indicated in Table 3.1, revealed that the KMO value is .000, indicating that the correlation matrix is not distinctive, and the data set is appropriate and acceptable, with a value of .833. Hence, a value above 0.6, as recommended by Kaiser (1977) and cited by Pallant (2016), indicates that factor analysis is suitable

.

**Table 3.1: Results of KMO and Bartlett's Test**

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-meyer-01kin measures of Sampling Adequacy | | .833 |
| Bartlett Test of Sphericity | Approximate Chi-square | 14861.4 |
| | df | 1595 |
| | sig | .0000 |

## 4.0 Analysis of Results

**4.1** In order to provide the required answers to the research questions in this paper, the researcher made use of IBM-SPSS and AMOS software to analysed the collected data from the field. Table 4.1 explains demographic information of the participants; these include Architects, Builders, Quantity Surveyors, IoT Users, and Civil Engineers.

**Table 4.1: Demographics of the Participants**

| Parameter | Value | Frequency | Percentages% |
|---|---|---|---|
| Professionals Affiliation | NIA | 52 | 24% |
| | NIOB | 61 | 28% |
| | NSE | 37 | 16.8% |
| | NIQS | 41 | 18.6% |
| | OTHERS | 29 | 13.2% |
| Academic qualification | National Diploma | 77 | 35% |
| | Higher National Diploma | 89 | 40% |
| | Bachelor Degree | 34 | 15% |
| | Master Degree | 17 | 7.7% |
| | PhD Degree | 3 | 1.36% |
| Years of working experience | 2- 6 years | 98 | 44% |
| | 7 – 10 years | 69 | 31% |
| | 11 – 15 years | 22 | 10% |
| | 16 – 25 years | 16 | 7.3% |
| | 26 years and above | 15 | 6.8% |
| Total | | 220 | |

## 4.2 Confirmatory Factor Analysis

This section presents the measurement and Structural confirmatory factors analysis model, with the needed model fitness as shown in the Table

**Table 4.2: The three types of model fitness and level of acceptance**

| | **Name of Category** | **Name of Index** | **Level of Acceptance** |
|---|---|---|---|
| 1 | Absolute Fit | Chi-square | P-value<0.05 |
| | | RMSEA | RMSEA < 0.08 |
| | | GFI | GFI>0.090 |
| 2 | Incremental Fit | CFI | CFI> 0.90 |
| | | TLI | TLI> 0.90 |
| | | NFI | NFI>0.90 |
| 3 | Parsimonious Fit | Chisq/df | Chisq/df < 5.0 |

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### 4.3 Measurement Model Analysis

The outcomes of the measurement model were analysed using SEM-AMOS to determine construct validity, including convergent and discriminant validity (CV and DV). CV was evaluated using factor loadings, composite reliability (CR), and the average variance extracted (AVE). The test was carried out, and the results of factor loadings were statistically significant. In addition, the CR values for all factors ranged from 0.902 to 0.920, exceeding the minimum criterion of 0.7, indicating that the CR and CV of the scales were satisfactory. The analysis results for the CV are presented in Table 4.3. The results revealed that the constructs' AVE values ranged from 0.692 to 0.841, exceeding the recommended threshold of 0.5. As shown in Table 4.3, the AVE, CR, Cronbach's alpha, and factor loadings were significant, and the factors influence the Implementation of IoT in Nigerian construction sites.

Table 4.3: Results of Reliability and Validity Analysis

| Item description | No of Items | Variables | Factor loading | Cronbach Alpha Above 0.7 | Composite reliability (CR) Above 0.6 | Average Value (AVE). Above 0.5 |
|---|---|---|---|---|---|---|
| Technology (FAR) | FAR1 | ICT Infrastructure | 90 | 0.833 | 0.913 | 0.732 |
| | FAR2 | Numbers of data center | 79 | | | |
| | FAR3 | Efficiency data recording | 84 | | | |
| | FAR4 | ICT Training | 76 | | | |
| | FAR5 | Network connectivity | 76 | | | |
| | FAR6 | Knowledge of ICT | 91 | | | |
| | FAR8 | Develop IoT Standard | 61 | | | |
| Organisation (FEM) | FEM1 | Organisational scope | 76 | 0.836 | 0.951 | 0.692 |
| | FEM2 | Top Management support | 84 | | | |
| | FEM3 | I T skill | 86 | | | |
| | FEM4 | Continuous monitoring | 55 | | | |
| | FEM5 | Organisational policy | 72 | | | |
| | FEM6 | Effective power supply | 90 | | | |
| Security (SAR) | SAR1 | Security information | 88 | 0.872 | 0.964 | 0.841 |
| | SAR4 | Security cooperation | 84 | | | |
| | SAR5 | Safety hazard | 85 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | SAR6 | Data privacy | 88 | | | |
| | SAR7 | Social-economic policy | 83 | | | |
| | SAR8 | Security risk | 86 | | | |
| Environmental (ERM) | ERM1 | Government policy | 62 | 0.894 | 0.952 | 0.753 |
| | ERM2 | Awareness | 75 | | | |
| | ERM3 | Social-political motivation | 92 | | | |
| | ERM4 | Physical interaction | 80 | | | |
| | ERM5 | The right IoT Vendor | 77 | | | |
| | ERM6 | Infrastructure | 69 | | | |

**4.4 Analysis of Structural Model**

The structural model represents the relationships existing between the latent constructs. Based on the theory, the latent constructs from the measurement model were classified into second-order latent constructs, namely FAR (Technology), FEM (Organisation), SAR (Security), and ERM (Environmental), and 24 sub-latent constructs. Using AMOS, model validation is essential to transform the measurement model into a structural model for analysis. Figure 4.1 presents the results of the final structural equation model of the components of effective IoT implementation in Nigeria. The final output of the model had the following: Chi-square= 558.488, df =247, P=0000, Ratio =2.261, CFI = .946, IFI= .947, TLI= .940, RMSEA=. 060.The summary of factor loadings and the validity of the components of the effective IoT implementation construct in Nigeria.

Table 4.4: Factor loading and validity

| Item description | No of Items | Variables | Factor loading | Composite reliability (CR) Above 0.6 | Average Value (AVE). Above 0.5 |
|---|---|---|---|---|---|
| Technology (FAR) | FAR1 | ICT Infrastructure | 73 | 0.925 | 0.832 |
| | FAR2 | Numbers of data center | 70 | | |
| | FAR3 | Efficiency data recording | 91 | | |
| | FAR4 | ICT Training | 71 | | |
| | FAR5 | Network connectivity | 78 | | |
| | FAR6 | Knowledge of ICT | 64 | | |
| | FAR8 | Develop IoT Standard | 52 | | |

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| | | | | | |
|---|---|---|---|---|---|
| Organisation (FEM) | FEM1 | Organisational scope | 79 | 0.967 | 0.792 |
| | FEM2 | Top Management support | 85 | | |
| | FEM3 | I T skill | 97 | | |
| | FEM4 | Continuous monitoring | 56 | | |
| | FEM5 | Organisational policy | 72 | | |
| | FEM6 | Effective power supply | 90 | | |
| Security (SAR) | SAR1 | Security information | 78 | 0.971 | 0.853 |
| | SAR4 | Security cooperation | 83 | | |
| | SAR6 | Data privacy | 80 | | |
| | SAR7 | Social-economic policy | 83 | | |
| | SAR8 | Security risk | 85 | | |
| Environmental (ERM) | ERM1 | Government policy | 82 | 0.972 | 0.854 |
| | ERM2 | Awareness | 72 | | |
| | ERM3 | Social-political motivation | 92 | | |
| | ERM4 | Physical interaction | 79 | | |
| | ERM5 | The right IoT Vendor | 75 | | |
| | ERM6 | Infrastructure | 66 | | |

Table 4.5: Summary of the fitness indices results for measurement and structural equation model

| Category's Name | Parsimonious Fit | Absolute Fit | Incremental Fit | Incremental Fit | Absolute Fit | Remark |
|---|---|---|---|---|---|---|
| Fitness indexes | Chisq/df | CFI | IF | TLI | RMSEA | |
| Acceptance level | Chisq/<3.0 | CFI >0.90 | NFI > 0.90 | NFI > 0.90 | RMSEA <0.08 | Fitness level required |
| Measurement model | 562.073 | 0.952 | 0.915 | 0.945 | 0.58 | Fitness level achieved |
| Structural model | 558.488 | 0.946 | 0.908 | 0.940 | 0.60 | Level required is achieved |
| **MODEL IS ACCEPTED** | | | | | | |

### 4.5 Discussion of Results

The final result in Figure 4.1 shows the collaboration effect of all the constructs in the path diagram. This study used standardised regression weights along with squared multiple correlations (R2), given their advantage for interpreting interactions among the constructs in the model. As noted by Awang (2014), R2 represents the percentage of variation in the dependent variable (s). Hereafter, the model's explanation improves as the R2 value increases. Generally, R2 values are described as follows: 0.75 as strong, 0.5 as moderate, and 0.25 as weak (Henseler, Ringle, & Sinkovics, 2009; Wong, 2013). In Table 4.5, all Fitness Indexes met the mandatory level, thereby indicating the validity of the constructs in the model. The model in Table 4.6 shows that all p-values are highly significant, with $p < 0.005$. Figure 1 result reveals that the correlation between the constructs is below the threshold of 0.85, indicating that redundancy does not exist among the components. All factor loadings are positive and high, indicating that all items are important for measuring the respective constructs. The research hypotheses were formulated, and the structural model was used to test them. The structural model results, along with path coefficient values, are presented for each relationship between independent and dependent constructs, using the standardised regression weights in SEM-Amos. The structural model was analysed by testing the hypothesised relationships among the constructs across all factors. The proposed relationships in this study have been measured using standardised path coefficients at the $p < 0.05$ level, which will be considered satisfactory. Therefore, all the relationships were found to be significant. The results from SEM-Amos revealed the effects of all constructs in the path diagram, as presented in Table 4.6. Hypothesis testing was conducted, and the hypotheses were analysed based on the relationships among factors. Therefore, the relationships among the factors and the correlations, as estimated from standardised structure coefficients, are presented. Furthermore, the hypothesised relationship between influential IoT factors and IoT implementation was tested at the 0.05 significance level ($p < 0.05$). The results revealed that the hypotheses were supported and significant, as presented in Table 4.6. From these outcomes, all hypotheses are accepted. Therefore, the factors in this study significantly affect the implementation of IoT on Nigerian construction sites. Therefore, the relationship between all factors and the implementation of IoT is significant and positive. The results indicated that C.R values used to test the relationships between factors and IoT implementation are significant, and the P-values for all factors are significant and less than 0.05. The hypotheses are thus statistically supported. Table 4.6 shows that the four research hypotheses H1, H2, H3, and H4 are significant and have positive effects on IoT Implementation factors. Therefore, the hypotheses are all supported

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Table 4.6: Significant effect of influential factors on IoT implementation in the Nigerian construction Site

| Construct | Path | Dependent Variable | Std.Estimate | S. E | C.R | P-Value | Result |
|---|---|---|---|---|---|---|---|
| FAR | _<------ | IoT Implementation (FSM) | .148 | .049 | 20.875 | **** | Significant |
| FEM | <------ | IoT Implementation (FSM) | .122 | .065 | 13.603 | **** | Significant |
| SAR | <------- | IoT Implementation (FSM) | .180 | .064 | 16.160 | **** | Significant |
| ERM | <------- | IoT Implementation (FSM) | .150 | .064 | 14.850 | **** | Significant |

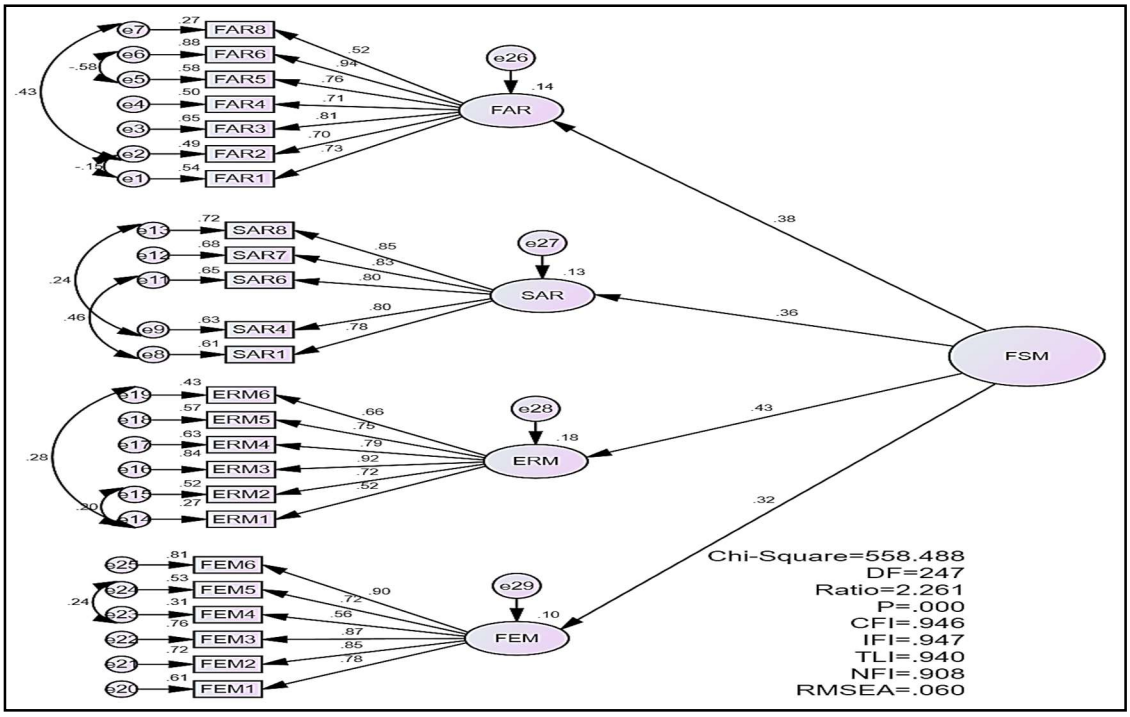



Figure 4.1: Structural Model

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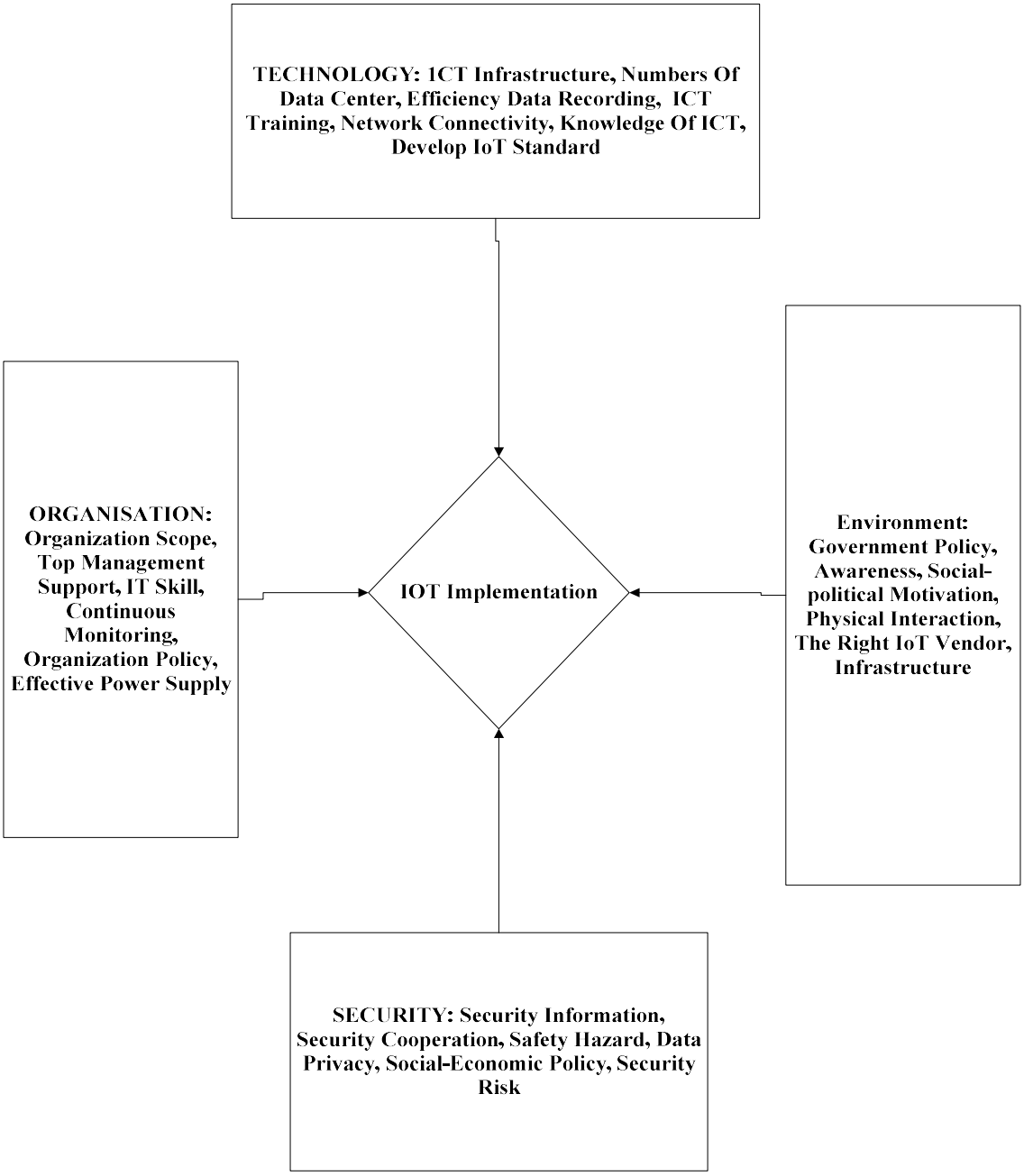



**Figure2: Proposed Model IoT model for Building construction professionals**

## 5.0 Conclusion

This study examines the effect of four main factors, such as Technology (FAR), Organisation (FEM), Security (SAR), and Environment (ERM), which were explored from an intensive literature review on the implementation of the IoT in the Nigerian construction site. This study seeks to provide empirical insight into the feasibility of integrating the explored factors and their items into a framework/model for the effective implementation of IoT technology in the management of building construction sites. Data were collected from highly

educated professionals in the Nigerian building industry and IoT users and analysed using the SEM-AMOS approach, which is considered by many researchers to be ideal for testing significant relationships of multiple variables and is capable of determining the effect of dependent variables on independent variables, especially in the case of multiple data. The results of this study provide new insights into the significant factors that impact the adoption of IoT in Nigerian construction sites. The proposed framework in this study can be used as a guideline for the implementation of IoT Technology in the construction site.

Furthermore, the findings of this study will provide suggestions for Builders, Facility managers, Quantity Surveyors, Architects, and other Building stakeholders to support the effective implementation of IoT on construction sites. The study focused on data from professionals in the building industry and IoT users; therefore, the conclusions may differ in other areas of application.

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