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An Investigation of the Factors Affecting Successful Enterprise Resource Planning (ERP) Implementation in Nigeria

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Abstract: The ERP system has been identified as a tool for delivering information technology (IT) services through software and other critical infrastructures using internet technologies. Given its nature as an industry-driven concept and system, this is universally accepted in industry as a tool to solve practical problems with a view to achieving an integrated enterprise information system. However, a developing country like Nigeria still faces a lot of hurdles in managing its construction supply chain. The aim of this study is to investigate the factors affecting the successful implementation of enterprise resource planning (ERP) systems in the Nigerian construction industry. After a literature search, expert input via the Delphi technique, the study identified four main factors and 21 sub-factors. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was used to prioritise the factors and to identify the relationship that exists between the factors. The findings revealed that the key factors affecting the implementation of ERP systems are "A lot of security concerns" (T7), "The management of ERP projects is too complex" (P5) and "The inability to align the ERP solution with the business plans of the organisation" (P2). This study recommends that the findings of this work will help both local and international practitioners alike.

Keywords: Delphi technique, DEMATEL, Enterprise resource planning, ERP implementation, Nigerian construction industry

INTRODUCTION

The advent of information systems has given rise to various dimensions and options for optimising and providing solutions to the challenges in the business environment. In order for managers and organisations to outperform and survive their competitors, the key elements of the organisation, including the business process, structures, human resources, financial and non-financial resources, etc., need to be managed as effectively as possible.

According to Bhirud and Revatkar (2016), enterprise resource planning (ERP) systems provides that organisations need to optimise their internal value chain by providing a one-time entry form of information at the point where it is created, making it easily accessible to multiple functional areas within the organisation. The use of ERP software has become increasingly common in today's businesses. It is

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deployed in a number of firms in an attempt to improve business performance (Ahmed and Ayman, 2011). ERP systems have been defined as an information system that uses a shared database to integrate and coordinate information within an organisation (Tarhini et al., 2015). Karimi (2017) also defined ERP as a comprehensive software solution that seeks to integrate information and business processes within and across functional boundaries within an organisation in order to present a corporate-wide view of the business from a single information technology (IT) architecture.

In an ever-changing global business and technology environment, firms seek to improve or maintain their competitive position. The use of information systems is to basically ease customer service, increase efficiency, decrease cycle times and lower costs. According to Matende and Ogao (2013), ERP systems have attracted a great deal of attention because they provide a variety of business benefits and therefore, for this reason, organisations are investing huge capital and time in the adoption and implementation of ERP systems, believing that they will lead to better performance by facilitating organisational operations and supporting various types of ERP systems.

However, in their study, Ahmed and Ayman (2011) argue that the benefits of ERP systems are often overstated by ERP vendors. Yang and Su (2009) noted that despite the numerous benefits of the ERP system, its application has been slow and virtually non-existent.

The construction industry is the largest economic contributor to the American economy and considered the most inefficient and most geographically dispersed. While no single construction project is the same as the other, having different phases (lifecycle) and different stakeholders with multiple responsibilities, the industry is not widely perceived to be collaborative and innovative due to the many challenges that lead to the failure of the construction project (Azhar and Abeln, 2014).

The construction industry continues to be confronted with many challenges, but it must also innovate in order to satisfy the aspirations and needs of society, as well as improve its competitiveness and overcome anticipated future challenges (Saka and Chan, 2020). Many solutions have been proposed, including the adoption and implementation of ERP and IT systems such as ERP.

Construction firms in the 21st century have continued to adopt and implement new strategies and technologies in order to achieve competitive advantage in the industry while at the same time meeting the ever-dynamic demands of clients and other stakeholders. According to Zeng, Lu and Skibniewski (2012), studies of European mid-size firms with project-based workforces found that firms adopting ERP had the lowest rate of ERP adoption. In addition, the industry currently faces a number of problems caused by the fragmentation of the industry which is occasioned by an increasing number of stakeholders, poor information management and a reliance on traditional approaches. As a result, a concerted effort has been made to refocus the industry on the value of information and communication technology (ICT) techniques as they are in developed climes. Although construction firms demonstrate poor planning and management of internal and external resources, time management, information and technology utilisation, which results in cost increases and project failure (Chung, Skibniewski and Kwak, 2009). According to Nwankpa (2015), most indigenous construction companies remain in doubt and face the challenge of adopting ERP systems. The country still remains dependent on foreign construction firms.

The aim of this study is to contribute to the literature on ERP by highlighting the reasons behind the failure to adopt ERP systems for the delivery of construction projects, with particular reference to a developing country such as Nigeria.

In an attempt to review previous studies addressing issues of potential challenges related to the implementation of ERP systems, it was found that more of these studies were concentrated in developed climes (Momoh, Roy and Shehab, 2010; Bajgoric and Moon, 2009; Chung et al., 2008; Elbertsen, Benders and Nijssen, 2006; Bozarth, 2006; Huang, Newell and Palvia, 2017; Hong and Kim, 2012; AlQashami and Mohammad, 2015). It is imperative to state that very little research on the challenges of implementing the ERP has been investigated in the construction sector and in developing countries such as Nigeria and Imo in particular. Thus, in order to fill this gap and to enkindle the spirit of the development of a sustainable construction industry management culture through the introduction of IT, the present study aims to investigate the factors affecting the successful implementation of the ERP in the construction industry sector in Imo State. The study will specifically identify the factors that hinder the successful implementation of ERP systems, determine the cause and effect of the relationship between the identified factors in order to successfully implement ERP systems in the Nigerian construction industry.

LITERATURE REVIEW

In recent years, more and more companies have implemented ERP systems and various research on the impact of ERP systems have been conducted. ERP is a software system that integrates the individual functional units of a company across the entire supply chain, linking industry and management practises in order to ensure product or service delivery at the right time at the lowest cost (Momoh, Roy and Shehab, 2010). Sandouqa (2020) contends that ERP is a system that provides how a group of software applications works together to enhance internal and external processes. It helps to support effective online decision-making by keeping the entity alive and supported and by protecting its growth.

Wu and Wang (2007) suggested that the ERP system is a collection of individual processes, each utilised for a specific purpose. According to Botta-Genoulaz and Millet (2006), an ERP system consists of a set of functional modules developed or integrated by the supplier, which can be adapted to the specific needs of any customer. The system (ERP) seeks to integrate all the departments across a company's organisation into a single computer system that can meet all their specific needs. According to Jacobs and Weston (2007), the ERP framework is a simple method for organising, defining and standardising the business processes needed to effectively plan and control an organisation, as a means of using an organisation's internal knowledge to seek external advantages.

ERP systems are designed to resolve the fragmentation of information and combine all information from the organisation (Ahmad and Cuenca, 2013). Antoniadis, Tsiakiris and Tsopogloy (2015) defines ERP as a software-driven business management system that integrates all aspects of day-to-day business and operations, which helps firms operate their businesses more efficiently and improves customer service and satisfaction, while at the same time increasing productivity and lower costs and inventories. The system supports various functional areas in the company including planning, manufacturing, sales, marketing, distribution, accounting, finance, human resource management, project management, inventory management, service and maintenance, e-business and transport.

From the definitions of various ERP literature, it can be summarised that ERP is a shared database system that integrates business processes across multiple functional areas in a company.

Across the developed and developing world, construction is an immensely competitive industry. The business revolves around the design and construction of civil engineering structures and heavy infrastructure (roads, bridges, railroads, etc.). Within the Nigerian architecture, engineering and construction industry, various issues surrounding efficiency, productivity and quality of work have been brought to attention (Saka and Chan, 2020). It has been reported a few times that one of the biggest problems with the construction industry is poor communication and poor exchange of information and data (Sekou, 2012). Interestingly, the level of technology available in today's marketplace is enormous and the industry should be aware of the benefits of using this new information system and technology as a means of facilitating productivity and improving the quality of output with a view to enhancing their business and collaborative solutions.

Success of construction firms in today's competitive business environment depends on efficient operating processes and investment in technology that enhances internal efficiency. The workings of the construction industry are very different from those of other industries. Generally, construction projects and construction firms use a variety of resources. The availability of resources defines the production capacity of the construction project manager. A construction company can access two categories of resources: (1) Internal resources owned by the company and (2) External resources which the company can obtain from the open market at a price.

The common objectives are to maximise the use of the internal resources of the construction firm and to use the market to balance the operation of the company (Abeyasinghe, Greenwood and Johansen, 2011). The construction industry is said to have wide variations in its operating system. This wide variation within the industry is a challenge in the development of the ERP system for the construction company. Other challenges include the need to communicate with other related companies – suppliers of materials and equipment, vendors, subcontractors and clients. ERP systems are being used by construction companies to improve response and customer relations, strengthen supply chain partnerships, enhance organisational flexibility, improve decision-making capabilities, reduce project completion time and lower costs (Sudhanva et al., 2014). The ERP system is designed to integrate and partially automate the entire company's business processes, such as human resources, accounts, billing and administration, site management, inventory and sales. The objective of the ERP system is to automate all processes in the construction enterprise and to maintain all information related to the enterprise. Schematically, the operations of the construction company resource planning system can be described as shown in Figure 1.

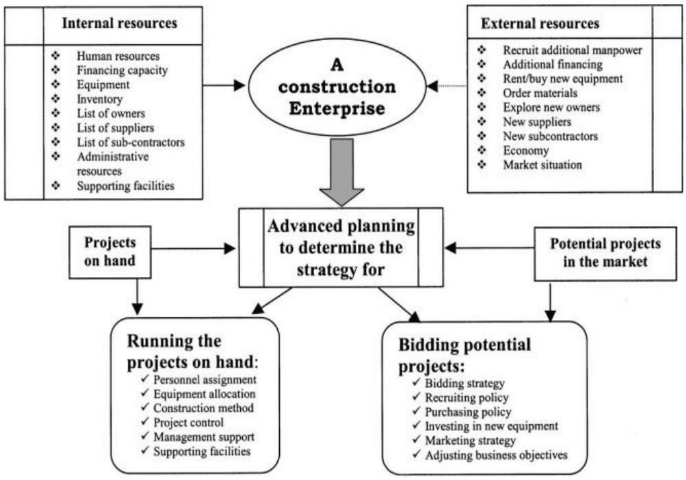

Figure 1. Construction enterprise operation
Source: Shi and Halpin (2003)

According to Rajan and Baral (2015), the benefits of implementing the ERP system can lead to significant reductions in raw material costs, inventory costs, lead time for customers, production time and total cost of production. While Al-Fawaz, Eldabi and Naseer (2010) concluded that the ERP system provides an opportunity for large corporations to break down ageing legacy systems, old work processes and counter-productive corporate cultures and to radically redefine how business operates. The business benefits of the ERP system as set out by Saputro et al. (2010) include improved stakeholder relationship management, improved interaction with subcontractors, faster information transactions, increased labour and organisational productivity and improved decision-making. While Rashid, Hossain and Patrick (2002) reiterated that some of the benefits of the ERP system include reliable access to information, delivery and cycle time redundancy, cost reduction, improved scalability, improved maintenance, global outreach, ease of adaptation and e-commerce.

Factors Affecting ERP Adoption in Construction Industry

The application of ERP systems to firms and businesses is often accompanied by significant changes in organisational structure and working patterns. Furthermore, the implementation of ERP systems in developing countries is faced with many difficulties over and above those faced by other advanced countries. However, recent studies on the acceptance of ERP systems in developing countries suffer from scarcity compared to the lack of studies on the acceptance of ERP systems in developed countries. According to Fadwa (2017), the rate of ERP systems in developing countries such as Nigeria, Ghana, Kenya, South Africa and Asia is very low compared to the developed climates that originated the ERP system and this is largely due to obvious reasons such as the differences in the relative propensity of organisations and the culture that exists between the two divides. Fadwa (2017) also highlighted the reasons for low adoption: high costs of ERP systems (software, hardware and support) are much more challenging for organisations in most developing countries than in the West, lack of national infrastructure, e.g., lack of ERP implementation skills and lack of telecommunications infrastructure. The level of integration of the ERP system is too high compared to the expectations of individuals and organisations.

Even though ERP systems are considered to be a critical technology that can have a positive impact on the construction industry, their rate of adoption and implementation has not yet been accelerated (Huang et al., 2004; Awolusi and Fakokunde, 2014; Otieno, 2010; Garg, 2010). Tome et al. (2014), in a study on the identification of factors that inhibit the choice and type of ERP, the study found that lack of sizeable vendors, lack of knowledge and low costs must have contributed to the barriers to the adoption of ERP. Although studies on ERP systems in developing countries are still in their infancy compared to their counterparts in the developed world. Dedan and Lyimo (2019) reported some of the major challenges of implementing the ERP in the Tanzanian public organization, the challenges were categorised as related to the ERP product, people, project schedule, agencies, technical issues and general challenges. Although Tobie, Etoundi and Zoa (2016) on a review study found that factors such as inadequate training, lack of technical and process knowledge, lack of knowledge on management and project initiatives and lack of change management were identified as contributors to failure of implementing the ERP.

Fadwa (2017) also highlights the high cost of ERP systems, the lack of national infrastructure, interoperability and lack of in-house skills as factors impeding the ERP systems in Gaza. Other factors that impede the implementation of the ERP are displayed in Table 1.

Table 1. Factors affecting successful implementation of ERP

Main Factors	Sub Factors	ID	Sources
Project management related factors	1. Management of large-scale transition process after implementation often tasking. 2. Inability of aligning ERP solution with organisation's business plans. 3. Guide on how to plan an ERP project lacking. 4. Difficulty in convincing top management to support business case. 5. Managing ERP projects too complex.	P1 P2 P3 P4 P5	Amoako-Gyampah and Salam (2004), Dedan and Lyimo (2019), Sandoe, Corbitt and Boykin (2001), Kamhawi (2008), Shah et al. (2011a), Wong et al. (2005), Ramburn, Seymour and Gopaul (2013), Tobie, Etoundi and Zoa (2016), Zeng, Lu and Skibniewski (2012), Momoh, Roy and Shehab (2010) and Ononiwu (2013)

(*Continued on next page*)

Table 1. *Continued*

Main Factors	Sub Factors	ID	Sources
ERP systems related factors	1. Complex nature of resource allocation. 2. Cost of starting-up expensive. 3. Time consuming. 4. Qualified ERP personnel lacking.	E1 E2 E3 E4	Amoako-Gyampah and Salam (2004), Dedan and Lyimo (2019), Sandoe, Corbitt and Boykin (2001), Kamhawi (2008), Lechesa, Seymour and Schuler (2012), Mushavhanamadi and Mbohwa (2013), Ramburn, Seymour and Gopaul (2013), Tobie, Etoundi and Zoa (2016), Fadwa (2017), Zeng, Lu and Skibniewski (2012), Shah et al. (2011a) and Momoh, Roy and Shehab (2010)
Technology related factors	1. Absence of IT infrastructure. 2. Software vendors lack support. 3. Complex nature of dealing with multiple parties 4. Customisation process too difficult. 5. Software functionality too complexity. 6. Difficulty in integrating new system with old ones. 7. A lot of security concerns.	T1 T2 T3 T4 T5 T6 T7	Amoako-Gyampah and Salam (2004), Dedan and Lyimo (2019), Sandoe, Corbitt and Boykin (2001), Kamhawi (2008), Francoise, Bourgault and Pellerin (2009), Rasmy, Tharwat and Ashraf (2005), Al-Mashari, Ghani and Al-Rashid (2006), Thavapragasam (2003), Faasen, Seymour and Schuler (2013), Lechesa, Seymour and Schuler (2012), Tome et al. (2014), Mushavhanamadi and Mbohwa (2013), Tobie, Etoundi and Zoa (2016), Fadwa (2017), Zeng, Lu and Skibniewski (2012), Shah et al. (2011b), Momoh, Roy and Shehab (2010) and Ononiwu (2013)
Management related factors	1. Strong resistance from users. 2. Top management support lacking. 3. Difficulty in managing change. 4. Non availability of related training programs. 5. Lack of familiarity with systems.	M1 M2 M3 M4 M5	Amoako-Gyampah and Salam (2004), Dedan and Lyimo (2019), Sandoe, Corbitt and Boykin (2001), Kamhawi (2008), Alballaa and Al-Mudimigh (2011), Leon (2008), Supramaniam and Kuppusamy (2011), Shah et al. (2011a), Finney and Corbett (2007), Bhatti (2005), Wong et al. (2005), Tome et al. (2014), Ramburn, Seymour and Gopaul (2013), Tobie, Etoundi and Zoa (2016) and Momoh, Roy and Shehab (2010)

RESEARCH METHODOLOGY

In this study, two research methods, namely the Delphi and the Decision Making Trial and Evaluation Laboratory (DEMATEL), were used. The Delphi technique is used to solve issues that rely more on a certain group of independent practitioners. The Delphi technique allows a consensus to be reached when judgements emanating from the review are sent back to the group for further analysis. The Delphi approach has been identified as one of the most widely used tools to make informed decisions some decades ago (Olawumi and Chan, 2019; Saka and Chan, 2020). The technique was found to have been applied in a variety of fields, such as location decisions, forecasting, selection of suppliers, project management, supply chain management, etc. (Olawumi and Chan, 2019; Keil, Lee and Deng, 2013). The technique helps to articulate factors affecting the adoption of ERP systems for implementation in the Nigerian construction industry. The ERP system factors have been articulated through the DEMATEL approach, while the combined efforts of Delphi and DEMATEL techniques have provided scientific support for the selection of ERP system factors for the purpose of creating a causal relationship that exists between the factors (Si et al., 2018).

The DEMATEL approach is used in this study with a view to investigate the main factors affecting the implementation of ERP systems from the perspective of the construction industry.

DEMATEL is a tool used to analyse the influence of certain factors on a set of criteria. It is used to solve complex multi criteria decision making (MCDM) problems that exist in industries. The application of DEMATEL according to Gölcük and Baykasoğlu (2016) has been used for quite some time in the resolution of decision-making problems. The application of DEMATEL was found to be useful when assigning values to factors that are influential on the basis of a certain criterion. One useful advantage of the application of DEMATEL as claimed by Seleem, Attia and El-Assal (2016) is that it defines certain actions as organised by the respondent. DEMATEL can be used to quantitatively extract the relationship that exists between multiple factors in a problem by enabling the conversion of qualitative research into a quantitative one by virtue of its nature as an MCDM method. From the literature reviewed, it is imperative to state that DEMATEL has been used several times to solve management related problems (Xia, Govindan and Zhu, 2015). DEMATEL has also been found useful in considering indirectly the direct relationship that exists between a myriad of factors. In view of the benefits associated with DEMATEL, Ranjan, Chatterjee and Chakraborty (2016) also found its usefulness to be applicable in environmental, energy and environmental protection matters. It has therefore become expedient that the DEMATEL approach, which is also an MCDM technique, is one of the appropriate tools for supporting effective management decision-making when faced with complex situations. It is in the light of the above assertion that this study has adopted the DEMATEL approach to addressing the challenge of ERP systems for the adoption and implementation of construction projects in Nigeria.

The steps to solve this problem using the DEMATEL process are outlined as follows:

Step 1. Develop a pairwise direct-relation matrix between system components through an input decision-making process: The direct influence group matrix A is generated).

In the assessment of the relationship between *n* factors *G* = {*G*1, *G*2}., *Gn*} in the system, given that *m* experts in the decision-making group B = {*H*1, *H*2}., *Hm*} is asked to show the direct influence that factor *Gi* has on factor *Gj*, using an integer scale as shown in Table 2. Thus, the different direct influence matrix *Ak* = [*akij*]*nxn* provided by the *k*th expert may be formed, where the main diagonal elements equal zero and *akij* stands for the judgement of the decision maker *Gk* on the strength to which factor *Gi* affects factor *Gj*. The group direct influence matrix A = [*aij*]*nxn* can be computed as aggregating the opinions of the *m* expert:

$$aij = \Sigma 1/1 \Sigma_{k=1}^{i} \text{ a } kij, i, j = 1, 2, \cdots, n \quad \text{Eq.1}$$

Table 2. Rating scale

Variable	**Influence Score**
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Step 2. Determine the initial influence matrix by normalising the direct-relation matrix (this involves the calculation of the normalised direct influence matrix A).

In the solution for the group direct-influence matrix A, the normalised direct-influence matrix T is given by = [*xij*]*nxn*, which can be achieved by deployment of *T* = *a*/*s* where:

$$S = \max\{\max 1 \leq i \leq n\} \Sigma_{j=1}^{i} aij, \max \Sigma_{i=1}^{i} aij \quad \text{Eq. 2}$$

Where the elements in the entire T matrix are in consonance with $0 \leq xij < 1$, $0 \leq \Sigma_{nj=1}^{i} xij \leq 1$ and at least one *i* such that $\Sigma_{nj=1}^{i} aij \leq S$.

Step 3. To determine the total relationship (influence) matrix: Set the T matrix of total influence.

By normalising the direct influence matrix A, the total influence matrix T = [*tij*]*nxn* is then calculated by adding the direct and indirect effects to the following formula, where I represents the identity matrix.

$$T = X + X^2 + X^2 + \ldots + X^h = X(I - X^{-1}) \quad \text{Eq. 3}$$

when $h \to \infty$.

Step 4. To determine the causal relationship (cause/effect) between each component and its relative weights: Establish a diagram of path analysis.

Subsequently, we determine the row and column vectors (*R* and *C*) and calculate the sum of the rows and the sum of the columns in the total influence matrix T, which are further defined by the formulas listed as follows:

$$R = \left[ri\right]_{nx1} = \left[\Sigma_{j=1}^{n} tij\right]_{nx1}$$

$$C = \left[cj\right]_{1xn} = \left[\Sigma_{j=1}^{n} tij\right]_{1xn}^{T} \quad \text{Eq. 4}$$

The *ri* represents the sum of the *i*th row in the T matrix and indicates the sum of the direct and indirect effects of the *Fi* factor on the other factors. On the other hand, *Cj* is the sum of the *j*th column in the matrix T and shows the sum of the direct and indirect effects of the *Fj* factor coming from other factors. Thus, if $i = j$ and *ij* is valid {1, 2}., *n*}, then the horizontal axis vector ($Ri + Ci$) called the prominence, depicts the force of influence that is given and received from the factor. It implies that ($R + C$) is the degree to which the central factor plays a role in the system. In the same vein, the vertical axis vector ($R – C$) is called the "Relation", showing the net effect of the factors contributing to the system. If $Rj − Cj$ shows a positive value, this implies that the factor *Fj* has a net effect on the other factors and can be grouped as a causal group. Par adventure ($Rj − Cj$) becomes negative, which means that the *Fj* factor is influenced by other factors; therefore, it should be grouped alongside the effect group. In the final analysis, the causal path diagram mapping the dataset ($R + C$, $R − C$) indicates the insights for decision making.

This study involved 26 experts, consisting of eight senior and middle-level managers from construction firms, were targeted, consisting of six project managers, five quantity surveyors, three builders, two architects and two academic experts involved in certain construction projects located in Owerri, Imo State, Nigeria. Each of the professionals had a wide range of experience ranging from eight years and over in their respective fields of activity. The questionnaire was designed and circulated among respondents (professionals) with a view to collecting the answers needed for research using the Delphi technique. The technique is one of the best procedures used to obtain the most reliable consensus from a group of experts through a series of intensive questionnaires interspersed with a controlled feedback process (Ononiwu, 2013). Professionals were selected primarily on the basis of their experience and direct involvement in the decision-making process for the adoption and implementation of IT related facilities within their organisation. These firms were chosen on the basis of the results of previous visits. Prior to data collection, the professionals were adequately briefed on the objective and usefulness of the research to each of the experts in the field of study. Professionals were asked to rate the identified factors affecting the implementation of ERP systems on the basis of the rating scale as shown in Table 2. Responses were finally collected and sorted out using the DEMATEL approach for analysis purposes.

RESULTS AND DISCUSSIONS

ERP systems have traditionally been deployed by capital-intensive industries, such as construction, manufacturing, aerospace and defence, so they appear to be a dream come true and efforts should be made to make it look like an asset, not an expense. This study therefore categorised the factors and grouped them into factors related to project management, ERP systems, technology and management. The causal path analysis diagram shows that the factors are interrelated and would have an impact on the implementation of ERP systems in the Nigerian construction industry in a myriad of ways. This study focuses on the implementation of ERP systems in the Nigerian construction industry. The lack of research on the implementation of ERP systems in construction firms in Owerri, Imo State Nigeria, necessitated the need for this study.

This study analysed the interrelationships that exist between 21 factors affecting the implementation of the ERP system by the use of DEMATEL (as shown in Tables 3 to 5). The findings of the study from the causal diagram in Figure 2 are discussed. Relative vectors are divided into two parts, viz. the cause factor and the effect factor group. The cause factor group had nine factors, consisting of "A lot of security concerns" (T7), "Managing ERP projects is too complex" (P5), "Inability to align ERP solutions with business plans" (P2), "Complex nature of dealing with multiple parties" (T3), "Absence of IT infrastructure" (T1), "Software vendors have lack support" (T2) and "Difficulty in convincing top management to support business cases" (T5). Out of the nine factors, three were ranked highest in the case group, viz. T7, P5 and P2, while T7 were ranked first in the case group. This is a clear indication that construction firms in Nigeria are concerned about the safety of ERP systems/facilities and therefore provision needs to be made for adequate security through access by non-trusted parties outside construction firms who may wish to hack into the system and access information and data. In addition, 12 factors appeared in the effect factor group, consisting of "Guide on how to plan a missing ERP project" (P3), "Missing top management support " (M2), "Time consuming" (E3), "Customisation process are too difficult" (T4), "Lack of qualified ERP staff " (E4), "Start-up cost" (E2), "Complex nature of resource allocation" (E1) and "Strong user resistance" (M4).

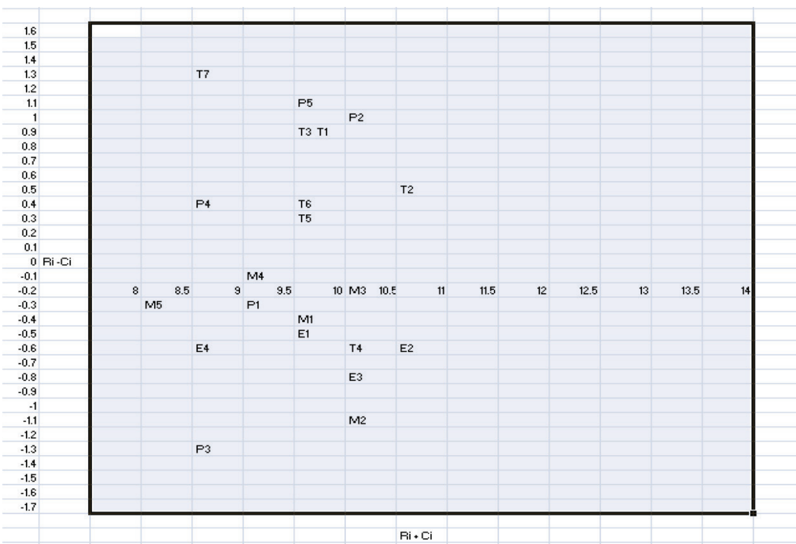

Figure 2. Causal path diagram

Table 3. Initial influence matrix A

	P1	P2	P3	P4	P5	E1	E2	E3	E4	T1	T2	T3	T4	T5	T6	T7	M1	M2	M3	M4	M5
P1	–	2	3	3	1	2	2	2	2	2	3	–	2	3	2	1	2	3	2	3	1
P2	3	–	4	4	2	3	3	3	3	2	2	2	3	1	2	2	3	4	2	3	1
P3	4	2	–	–	2	2	1	1	1	1	1	1	1	1	2	–	4	3	2	3	1
P4	2	3	2	–	1	1	1	4	3	3	1	3	2	2	2	1	2	3	2	3	1
P5	1	1	3	2	–	1	3	2	1	2	3	3	1	3	2	2	3	4	4	3	4
E1	3	3	1	1	2	–	1	2	2	3	4	–	3	1	2	–	4	3	3	1	2
E2	2	2	1	2	3	1	–	2	–	4	3	3	2	3	2	1	2	3	3	3	2
E3	1	4	2	3	1	2	2	–	1	1	2	2	3	1	2	4	1	2	4	1	2
E4	2	3	–	1	3	2	3	2	–	1	4	2	3	1	2	–	1	1	2	–	2
T1	2	2	3	1	–	3	3	2	4	–	2	4	3	2	2	3	1	4	2	2	3
T2	3	3	4	2	3	4	3	4	–	2	–	1	3	3	3	1	3	3	3	3	1
T3	1	1	–	3	4	–	4	3	3	3	4	–	1	4	1	2	3	2	3	3	3
T4	1	1	3	1	2	3	2	2	4	1	–	4	–	2	1	3	4	3	4	–	2
T5	3	2	3	3	1	4	3	3	2	3	3	1	2	–	2	1	–	4	2	3	–
T6	2	3	2	1	3	–	4	2	3	1	4	1	3	2	–	1	3	2	1	3	3
T7	4	1	4	1	2	3	2	4	1	1	–	4	4	–	3	–	3	1	1	3	3
M1	3	1	3	2	–	4	3	3	3	3	3	3	–	3	1	2	–	2	2	1	–
M2	3	2	3	3	3	2	3	–	2	1	1	2	3	4	3	2	1	–	1	–	3
M3	2	3	1	1	2	4	4	3	3	1	2	2	4	–	3	2	3	1	–	3	2
M4	1	1	1	3	1	3	2	3	1	3	4	–	3	4	2	3	–	2	2	–	2
M5	–	1	2	1	1	2	1	2	3	1	2	3	2	2	2	1	3	2	3	1	–

Table 4. Normalised direct influence for criteria T

	P1	P2	P3	P4	P5	E1	E2	E3	E4	T1	T2	T3	T4	T5	T6	T7	M1	M2	M3	M4	M5
P1	–	0.04	0.06	0.06	0.02	0.04	0.04	0.04	0.04	0.04	0.06	–	0.04	0.06	0.04	0.02	0.04	0.06	0.04	0.06	0.02
P2	0.06	–	0.08	0.08	0.04	0.06	0.06	0.06	0.06	0.04	0.04	0.04	0.06	0.02	0.04	0.04	0.06	0.08	0.04	0.06	0.02
P3	0.08	0.04	–	–	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	–	0.08	0.06	0.04	0.06	0.02
P4	0.04	0.05	0.04	–	0.02	0.02	0.02	0.08	0.06	0.06	0.02	0.06	0.04	0.04	0.04	0.02	0.04	0.06	0.04	0.06	0.02
P5	0.02	0.02	0.06	0.04	–	0.02	0.06	0.04	0.02	0.04	0.06	0.06	0.02	0.06	0.04	0.04	0.06	0.08	0.08	0.06	0.08
E1	0.06	0.06	0.02	0.02	0.04	–	0.02	0.04	0.04	0.06	0.08	–	0.06	0.02	0.04	–	0.08	0.06	0.06	0.02	0.04
E2	0.04	0.04	0.02	0.04	0.06	0.02	–	0.04	–	0.08	0.06	0.06	0.04	0.06	0.04	0.02	0.04	0.06	0.06	0.06	0.04
E3	0.02	0.08	0.04	0.06	0.02	0.04	0.04	–	0.02	0.02	0.04	0.04	0.06	0.02	0.04	0.08	0.02	0.04	0.08	0.02	0.04
E4	0.04	0.06	–	0.02	0.06	0.04	0.06	0.04	–	0.02	0.08	0.04	0.06	0.02	0.04	–	0.02	0.02	0.04	–	0.04
T1	0.04	0.04	0.06	0.02	–	0.06	0.06	0.04	0.08	–	0.04	0.08	0.06	0.04	0.04	0.06	0.02	0.08	0.04	0.04	0.06
T2	0.06	0.06	0.08	0.04	0.06	0.08	0.06	0.08	–	0.04	–	0.02	0.06	0.06	0.06	0.02	0.06	0.06	0.06	0.06	0.02
T3	0.02	0.02	0	0.06	0.08	–	0.08	0.06	0.06	0.06	0.08	–	0.02	0.08	0.02	0.04	0.06	0.04	0.06	0.06	0.06
T4	0.02	0.02	0.06	0.02	0.04	0.06	0.04	0.04	0.08	0.02	–	0.08	–	0.04	0.02	0.06	0.08	0.06	0.08	–	0.04
T5	0.06	0.04	0.06	0.06	0.02	0.08	0.06	0.06	0.04	0.06	0.06	0.02	0.04	–	0.04	0.02	–	0.08	0.04	0.06	–
T6	0.04	0.06	0.04	0.02	0.06	–	0.08	0.04	0.06	0.02	0.08	0.02	0.06	0.04	–	0.02	0.06	0.04	0.02	0.06	0.06
T7	0.07	0.02	0.08	0.02	0.04	0.06	0.04	0.08	0.02	0.02	–	0.08	0.08	–	0.06	–	0.06	0.02	0.02	0.06	0.06
M1	0.06	0.02	0.06	0.04	–	0.08	0.06	0.06	0.06	0.06	0.06	0.06	–	0.06	0.02	0.04	–	0.04	0.04	0.02	–
M2	0.06	0.04	0.06	0.06	0.06	0.04	0.06	–	0.04	0.02	0.02	0.04	0.06	0.08	0.06	0.04	0.02	–	0.02	–	0.06
M3	0.04	0.06	0.02	0.02	0.04	0.08	0.08	0.06	0.06	0.02	0.04	0.04	0.08	–	0.06	0.04	0.06	0.02	–	0.06	0.04
M4	0.02	0.02	0.02	0.06	0.02	0.06	0.04	0.06	0.02	0.06	0.08	–	0.06	0.08	0.04	0.06	–	0.04	0.04	–	0.04
M5	–	0.02	0.04	0.02	0.02	0.04	0.02	0.04	0.06	0.02	0.04	0.06	0.04	0.04	0.04	0.02	0.06	0.04	0.06	0.02	–

Table 5. Total relation matrix for criteria T

	P1	P2	P3	P4	P5	E1	E2	E3	E4	T1	T2	T3	T4	T5	T6	T7	M1	M2	M3	M4	M5
P1	0.19	0.21	0.25	0.22	0.18	0.24	0.25	0.24	0.21	0.20	0.26	0.17	0.24	0.24	0.21	0.16	0.23	0.28	0.24	0.23	0.18
P2	0.29	0.22	0.31	0.28	0.24	0.30	0.32	0.31	0.28	0.24	0.29	0.25	0.31	0.24	0.25	0.21	0.30	0.35	0.29	0.27	0.22
P3	0.22	0.18	0.15	0.14	0.16	0.20	0.20	0.18	0.17	0.15	0.19	0.15	0.19	0.17	0.18	0.11	0.23	0.23	0.20	0.20	0.15
P4	0.22	0.24	0.23	0.17	0.18	0.22	0.24	0.28	0.24	0.22	0.23	0.23	0.25	0.22	0.21	0.17	0.23	0.28	0.25	0.23	0.18
P5	0.23	0.22	0.28	0.23	0.19	0.25	0.31	0.27	0.23	0.23	0.29	0.26	0.26	0.27	0.24	0.20	0.28	0.33	0.31	0.26	0.30
E1	0.24	0.24	0.22	0.18	0.20	0.20	0.24	0.24	0.22	0.22	0.28	0.18	0.26	0.20	0.21	0.14	0.27	0.28	0.26	0.19	0.20
E2	0.24	0.23	0.23	0.22	0.23	0.24	0.24	0.26	0.20	0.26	0.28	0.24	0.26	0.26	0.23	0.17	0.25	0.30	0.28	0.25	0.21
E3	0.21	0.25	0.23	0.22	0.18	0.24	0.25	0.21	0.20	0.19	0.24	0.21	0.26	0.20	0.21	0.21	0.22	0.26	0.28	0.20	0.20
E4	0.20	0.21	0.17	0.16	0.20	0.21	0.24	0.22	0.16	0.17	0.25	0.19	0.23	0.18	0.19	0.12	0.19	0.22	0.22	0.16	0.18
T1	0.25	0.24	0.27	0.21	0.19	0.29	0.30	0.27	0.28	0.19	0.27	0.27	0.29	0.24	0.24	0.21	0.24	0.32	0.27	0.24	0.24
T2	0.29	0.28	0.32	0.24	0.26	0.32	0.32	0.33	0.22	0.25	0.26	0.23	0.31	0.28	0.28	0.19	0.30	0.34	0.31	0.28	0.22
T3	0.23	0.23	0.23	0.25	0.26	0.24	0.33	0.31	0.26	0.26	0.32	0.21	0.26	0.29	0.23	0.20	0.28	0.30	0.30	0.27	0.25
T4	0.21	0.20	0.25	0.19	0.20	0.26	0.26	0.25	0.26	0.19	0.21	0.25	0.21	0.22	0.20	0.20	0.28	0.28	0.28	0.18	0.20
T5	0.26	0.23	0.27	0.24	0.20	0.29	0.29	0.28	0.23	0.24	0.28	0.20	0.26	0.20	0.23	0.17	0.21	0.32	0.26	0.25	0.18
T6	0.23	0.24	0.24	0.20	0.23	0.22	0.30	0.26	0.24	0.20	0.29	0.20	0.27	0.23	0.19	0.17	0.26	0.27	0.24	0.24	0.23
T7	0.27	0.21	0.27	0.19	0.21	0.26	0.26	0.29	0.21	0.20	0.22	0.26	0.29	0.20	0.24	0.15	0.27	0.25	0.24	0.24	0.23
M1	0.25	0.20	0.25	0.20	0.17	0.28	0.27	0.27	0.23	0.23	0.27	0.23	0.21	0.24	0.20	0.18	0.20	0.26	0.25	0.20	0.16
M2	0.24	0.22	0.25	0.22	0.22	0.23	0.27	0.21	0.22	0.19	0.23	0.21	0.26	0.26	0.23	0.17	0.22	0.23	0.23	0.18	0.22
M3	0.24	0.25	0.23	0.20	0.22	0.29	0.31	0.28	0.25	0.21	0.27	0.23	0.30	0.20	0.25	0.19	0.28	0.26	0.23	0.25	0.22
M4	0.21	0.20	0.21	0.22	0.18	0.26	0.25	0.26	0.20	0.22	0.27	0.18	0.27	0.26	0.21	0.20	0.20	0.26	0.24	0.18	0.20
M5	0.16	0.17	0.20	0.16	0.16	0.21	0.20	0.21	0.21	0.16	0.21	0.20	0.21	0.19	0.19	0.14	0.22	0.22	0.23	0.17	0.14

On the effect group, the following two factors ranked highest based on expert's evaluation: (1) Insufficient guide on how to plan an ERP project and (2) Insufficient top management support. The causal diagram in Figure 2 clearly shows that of the three main factors, T7, P5 and P2, were the main impediments for the lack of implementation of ERP systems in the Nigerian construction industry. The findings from this study reveal that there are significant security concerns associated with adopting ERP systems in the construction industry. Additionally, managing ERP projects are complex and these complexities are representative of many of the challenges encountered when implementing ERP systems for project implementation. The inability of an ERP system to match business plans makes ERP implementation a challenge. It is clear that construction industry practitioners must align their priorities with their organisation's plans and focus more on streamlining their business plan with ERP proposals in order to achieve the much-needed gains associated with ERP deployment.

We define *Ri* and *Ci* as the degree of impact, while the values of *Ri* + *Ci* indicate the relative importance of each factor to each other. In short, while the sum of influences on criteria for each factor are shown in Table 6, those factors with higher *Ri* + *Ci* values are given preference based on the prominence vector *Ri* + *Ci* values shown in Table 7, T7, P5 and P2 are the top three of the 21 factors considered.

Table 6. The sum of influences on criteria

Factors	*Ri*	*Ci*	*Ri* + *Ci*	*Ri* – *Ci*
P1	4.591657	4.864363	9.45602	–0.27271
P2	5.752901	4.691571	10.44447	1.06133
P3	3.719446	5.039123	8.758569	–1.31968
P4	4.72582	4.328919	9.054739	0.396901
P5	5.380461	4.232887	9.613348	1.147574
E1	4.6765	5.219159	9.895659	–0.54266
E2	5.062866	5.628864	10.69173	–0.566
E3	4.658906	5.41073	10.06964	–0.75182
E4	4.07509	4.701749	8.776839	–0.62666
T1	5.318755	4.418845	9.7376	0.89991
T2	5.844732	5.391347	11.23608	0.453385
T3	5.47999	4.559398	10.03939	0.920592
T4	4.768817	5.39711	10.16593	–0.62829
T5	5.065644	4.782735	9.848379	0.282909
T6	4.969172	4.611978	9.58115	0.357194
T7	4.948678	3.648643	8.597321	1.300035
M1	4.744672	5.174582	9.919254	–0.42991
M2	4.700163	5.826267	10.52643	–1.1261
M3	5.172329	5.419746	10.59208	–0.24742
M4	4.667678	4.676316	9.343994	–0.00864
M5	3.938995	4.238941	8.177936	–0.29995

Table 7. The prominence vectors on criteria

Rank	Factors	*Ri + Ci*
1	T2	11.23608
2	E2	10.69173
3	M3	10.59208
4	M2	10.52643
5	P2	10.44447
6	T4	10.16593
7	E3	10.06964
8	T3	10.03939
9	M1	9.919254
10	E1	9.895659
11	T5	9.848379
12	T1	9.737600
13	P5	9.613348
14	T6	9.581150
15	P1	9.456020
16	M4	9.343994
17	P4	9.054739
18	E4	8.776839
19	P3	8.758569
20	T7	8.597321
21	M5	8.177936

In so far as the cause criteria have an impact on the entire system, special attention needs to be paid as the *Ri* – *Ci* values are positive, which means that the degree of impact and influence of *Ri* is greater than that of (*Ri*)(*Ci*). With regard to the causal pathway diagram in Figure 2, this study presents some implications for practitioners as follows:

1. M5, P1, M1, E1, E4, T4, E3, M2 and P3 are factors with weak driving power and weak dependence. They are cut off from the original system and have few attachments. E2 is a factor with a weak driving power, but a strong dependency power. The factor depends on other factors and may be addressed by addressing other related factors. This factor is an unfavourable factor.

2. T7, P5, P2, T3, T1, P4, T6, T5, M4 and M3 are factors with strong driving power but with weak dependence power (highest prominence and relation). They are considered to be the most important factors affecting the implementation of ERP systems.

3. T2 is a factor that has both strong driving power and dependence power. The factor affects other factors as well as provides feedback on itself.

Under the causal group factors, T7 (1.300) ranked first with the highest value (as shown in Table 8), followed by P5 and P2, respectively. Similarly, "A lot of security concerns" (T7), "Too complex management of ERP projects" (P5) and "Inability to align ERP solutions with business plans" (P2) are considered to be very important for the implementation of ERP systems. This supports the findings that there are still a lot of security concerns regarding the implementation of ERP systems in South Africa (Faasen, Seymour and Schuler, 2013; Lechesa, Seymour and Schuler, 2012; Tobie, Etoundi and Zoa, 2016), the management of too complex ERP projects in Bahrain and South Africa (Kamhawi, 2008; Ramburn, Seymour and Gopaul, 2013) and the inability to align ERP with Tanzania's business plans (Dedan and Lyimo, 2019). This study therefore reiterates the need to provide much-needed assurance to ERP system specialists that the security of ERP software is guaranteed and therefore practitioners should not be afraid to adopt ERP systems. There is also a need for practitioners to be optimistic and confident enough to withstand the expected complexity of ERP projects. And finally, there is also a need to re-align the implementation of ERP systems with the business plan of the organisation in order to reap the immense benefits associated with the adoption of the ERP system in the successful delivery of construction projects.

Table 8. The relative vector criteria

Rank	Factors	*Ri* + *Ci*	Factors	*Ri* – *Ci*	Cause/Effect
1	T2	11.23608	T7	1.300035	Cause
2	E2	10.69173	P5	1.147574	Cause
3	M3	10.59208	P2	1.061330	Cause
4	M2	10.52643	T3	0.920592	Cause
5	P2	10.44447	T1	0.899910	Cause
6	T4	10.16593	T2	0.453385	Cause
7	E3	10.06964	P4	0.396901	Cause
8	T3	10.03939	T6	0.357194	Cause
9	M1	9.919254	T5	0.282909	Cause
10	E1	9.895659	P3	–1.31968	Effect
11	T5	9.848379	M2	–1.12610	Effect
12	T1	9.737600	E3	–0.75182	Effect
13	P5	9.613348	T4	–0.62829	Effect
14	T6	9.581150	E4	–0.62666	Effect
15	P1	9.456020	E2	–0.56600	Effect
16	M4	9.343994	E1	–0.54266	Effect
17	P4	9.054739	M1	–0.42991	Effect
18	E4	8.776839	M5	–0.29995	Effect
19	P3	8.758569	P1	–0.27271	Effect
20	T7	8.597321	M3	–0.24742	Effect
21	M5	8.177936	M4	–0.00864	Effect

CONCLUSIONS AND RECOMMENDATIONS

In this study, we investigated the factors affecting the implementation of ERP systems in the Nigerian construction industry. The work was carried out with the help of Delphi and DEMATEL-based approaches. The Delphi technique was used to analyse the main factors affecting the implementation of ERP systems after a thorough literature search. DEMATEL technique was later used to evaluate the causal relationship between the ERP challenge factors. The study identified 21 factors impeding the adoption and implementation of ERP systems in the Nigerian construction industry through a thorough literature search and a Delphi analysis. Based on the results of the DEMATEL analysis, the following factors are given: T7, P5, P2, T3, T1, T2, P4, T6 and T5, while the following factors, namely P3, M2, E3, T4, E4, E2, E1, M1, M5, P1, M3 and M4, came under the effects group factors. After collecting insights from expert submissions through the Delphi approach, the DEMATEL method was later used to map qualitative data to quantitative values by identifying the cause-and-effect relationships between the evaluation criteria. The results of this study have shown that the professionals of the Nigerian construction industry are sceptical about the state of security concerns regarding the adoption and implementation of ERP systems in the industry (T7), followed by their inability to manage ERP projects due to their complexity (P5), while the other issue is the inability of the professionals to align ERP with or to align ERP solutions. This study recommends that professionals in the Nigerian construction industry need to work closely with key IT specialists and suppliers when implementing ERP solutions for their projects. This will help to address security issues when trying to implement ERP solutions. With regard to the complexity of ERP projects, we recommend that adequate measures be put in place to deal with complex ERP projects. A work breakdown structure (WBS) of the entire process should be implemented with a view to simplifying the process for ease of implementation. Finally, practitioners must, as a matter of fact, weigh the objective and business plan of their organisation, be it at the strategic or operational level, before considering the implementation of ERP solutions. This is very important because poor decision-making may undermine the business plans of the organisations in the future. Some of the significant implications of this study are that the DEMATEL technique gives some advantages over some of the existing methods used in existing ERP studies in both developed and developing countries through the combined efforts of Delphi and DEMATEL to create a causal relationship between the factors affecting the successful implementation of the ERP in construction projects. Second, the study contributes to the few studies on obstacles to the successful implementation of the ERP in construction projects, particularly from the point of view of developing countries. Finally, the study presents the dynamics of the challenges of successful implementation of the ERP and outlines the factors for easy identification by practitioners and other stakeholders in the built environment industry.

The findings of this study are expected to help both local and international industry practitioners to adopt ERP systems in the delivery of their projects. In addition, an increase in awareness of the challenges that affect the implementation of the ERP systems would allow practitioners to find ways to overcome the envisaged challenges. This study has certain limitations in the sense that some of the disadvantages of the Delphi technique include, because of its time-consuming nature, the reactions of the expert may not be objective in terms of their feedback.

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