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Natural logarithm transformation for predicting procurement time of PPP projects in Nigeria

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Abstract: Traditional method of procurement has been in practice over a considerable period and is still the most common type of public infrastructure procurement. The major alternative to it is the Public–Private Partnerships (PPP). PPP focuses on goods or service delivery by means of partnership between two partners (private and public) to come together and share risks and rewards. However, PPP is criticized of being too costly, having a lengthy procurement period, etc. Nigeria, among other Sub-Sahara African countries, has the longest procurement time. This article, therefore, attempts to use secondary data from the World Bank to model and predict the procurement time of PPP projects in Nigeria using Natural Logarithm Transformation approach. A mathematical model that estimates the procurement time of PPP projects in Nigeria is developed using multiple regression analysis. Minitab Software version 18 was used. The model was validated and tested and was found to fall within the predetermined benchmark of ± 10% of what is obtainable in Nigeria. Using the model, procurement time of PPP projects in Nigeria was found to be 646 calendar days. A study from the World Bank on PPP procurement's benchmarking indicates that Nigeria can procure a PPP project in 660 calendar days. From the calculated amount, it is possible to procure PPP projects in Nigeria within 646 calendar days showing a difference of 2%. A total of 646 days is too long, thus indicating a need for immediate improvement for maximum benefits.

Subjects: Engineering Project Management; Supply Chain Management; Transportation Engineering; Engineering Economics

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PUBLIC INTEREST STATEMENT

The importance of infrastructures in any economy cannot be over emphasized. This is because infrastructures have been found to support foreign direct investments and economic growth. Being able to deliver infrastructure quickly means that the stakeholders would begin to derive the benefits faster while investors recoup their investments. Delays in delivering infrastructure result in higher costs, affecting value for money, discouraging investors, increased hardships on potential users and dissipation of benefits as citizens seek alternatives at long run it may lead to project abandonment. Hence, the need to develop a model to improve procurement time of PPP project in Nigeria.

Keywords: natural logarithm transformation; procurement time; public private partnerships; multiple regression model

1. Introduction

Public–private partnerships (PPP) for large scale service delivery and infrastructure development do not deliver the benefits intended to be derived from the use of the PPP procurement method. The period it takes for a PPP concession agreement to be signed and commence with the development of the projects subtracts from the benefits of such projects. Under a classic PPP arrangement, the public sector specifies the infrastructural projects which need to be procured while the private sector designs and builds a dedicated asset to deliver the service, finances its construction and subsequently operates the asset and provides the services.

The PPP model evolved from the governments' desire to develop large scale infrastructural projects for which the public sector may not have adequate resources or cannot wait until they have delivered on equally important services to other sectors of the state Dada and Oladokun (2012). Therefore, the benefits of the PPP accrue from the fact that critical service delivery infrastructure can be delivered to people quicker than the state can be able to Kettle (2008). Furthermore, and because of the shortened time to deliver a project compared to how much time it would take if the state were to develop the infrastructure on its own, the financial benefits would be realized in terms of early income and reduced cost of borrowing. Therefore, the time it takes to develop the infrastructure through the PPP method is important to full benefit realization.

However, some studies show that PPPs do not deliver on their promised benefits (Lobina, Kishimoto, & Petitjean, 2014; Ismail and Harris, 2014). One of the major issues has been the duration it takes from project inception to implementation and the eventual service availability from the infrastructure.

The problem of long periods between inception and implementation is particularly problematic in sub-Saharan African countries, which ironically need the infrastructure and better resource utilization more than developed countries. In Nigeria, for example, it takes an average of 660 days between project inception and actual development. In other countries such as Ghana, the procurement period takes no more than 100 calendar days (World Bank, 2015).

Therefore, understanding why it is possible for some projects in certain environments to be procured within a shorter period than in other scenarios is important to maximizing benefits from infrastructural projects. Most studies focus on benefits of PPP and how delivery of large infrastructural projects can be improved through the PPP. There is little information on the time it takes in the front-end of the PPP project and how this period can be shortened.

Using the principal agency theory and the institutional theory, we will demonstrate the factors which shape the period it takes to implement the PPP project. Further, we will illustrate how the period may be improved to reach the optimum level for full benefits realization. Using a mathematical model and data from Nigeria, we will show the relationship between the time to procure and the factors that are considered in the PPP projects. This study's findings will go a long way in improving procurement times of future projects.

We argue that the institutional framework dictated by the socio-political environment determines the length of the procurement period. Therefore, successful large-scale service delivery infrastructure can be explained by how well the principal and institutional logics were characterized and managed.

Therefore, in this article, we will first provide the background to the article and concept of PPP with specific reference to Africa. To ground our discourse, we will discuss the principal

and institutional theories as they relate to projects as temporal organizations. The methods section will describe how the study was conducted and how the data was collected and analyzed. The last section of the article will discuss the findings and conclude on the objectives of the study.

1.1. Literature review

1.1.1. Factors influencing PPP procurement period

The period between inception of an infrastructural project and its implementation through a PPP method is critical to ensuring that projects are successful and deliver on their intended benefits Connolly et al. (2009). However, most PPP projects in sub-Saharan Africa take longer than PPP projects implemented in other developing countries. Consequently, the delay to implement projects subtracts from the benefits that a project is supposed to provide.

The intention of the PPP procurement method is to be able to provide the much-needed large scale service delivery infrastructure to the communities that need it without waiting for the government to acquire the resources to implement the project (World Bank Group, 2012). Furthermore, the government can deliver on other developments in the country and at the same time implement a PPP project and deliver the much-needed service. This way, the time to deliver critical infrastructure is shortened.

Speedy delivery of infrastructure is now critical especially that the World Bank estimates that $93 billion annually should be spent on infrastructure if at all the infrastructural gap is to be closed in Africa. In Africa, the infrastructural networks lag behind those of other developing countries. Equally, the infrastructure services in Africa are twice as expensive when compared to other countries not on the African continent. The need for infrastructure is evident in Africa and delivery should be approached with utmost urgency.

However, several factors impact the time required to implement a PPP project. PPP projects in countries such as Nigeria have long procurement periods, due to factors such as low contract value offers, ineffective government bureaucracies, and inappropriate risk sharing between public and private sectors (Khmel and Zhao, 2016).

Risk allocation is one factor that impacts the PPP procurement period (Bing, Akintoye, Edwards, & Hardcastle, 2005). Appropriate allocation of risk is an important factor that ensures private sector partners deliver value for money and operate assets efficiently Casarin et al. (2007). Consequently, public partners take a considerable amount of time to evaluate the inherent risks in the proposed PPP agreement. Similarly, private partners undertake an extensive review of the project and what the public partner is offering. Project risk evaluation requires expertise of legal, financial and technical personnel. Therefore, the process to consult with experts to obtain value for money and minimize risk in the projects entails a longer procurement period.

The PPP procurement period is also affected by government bureaucracies. Spackman (2002) observed that bureaucracy has influence on the procurement time of PPP projects. The author argues that since it is the government that decides the method of procurement to adopt for a particular project and before the decision is made, a number of options are debated and undergo several approval gates, which adversely affects procurement time. A study conducted by (Lucas and Rambo 2016) in Kenya revealed that the policies established by the government of Kenya have led to significant delays in many projects. The authors suggested that there was a need for the Kenyan government to review the PPP Act to ensure that operations of PPP are efficient (Rambo and Lucas, 2016). According to Albertus, Ngwenyama, and Brown (2015), too much bureaucracy in Kenya has marred PPP projects such as the Lamu infrastructure project connecting Kenya, South Sudan and Ethiopia. A similar study by Babatunde, Adeniyi, and

Awodele (2017) revealed that government bureaucracy in Portugal led to cost overruns and constant delays on PPP projects.

The value of the contract for procuring the infrastructure has an equal influence on the procurement period (Chinyio & Gameson, 2009). Offering a high contract value to private partners tends to improve the procurement time on PPP projects in many countries (Chinyio & Gameson, 2009).

1.1.2. Institutional theory

PPPs often take place as a part of PPP programs under a dominant institutional environment. Therefore, in addition to the contingency theory, we look to institutional theory to understand why PPP projects take long to procure especially in Sub-Saharan Africa, because these types of projects have been described to be socio-technical undertakings embedded in institutional frameworks (Miller and Hobbs, 2005; Biesenthal, Clegg, Mahalingam, & Sankaran, 2018; Fuenfschilling and Truffer, 2014).

Institutional theory is an approach to understanding organizations and management practices as a product of social rather than economic (technical) pressures (Miller and Hobbs, 2005). Therefore, according to (Miller and Hobbs 2005; Esfahani, and Ramírez 2003), the adoption and retention of many organizational practices are often dependent on social pressures for conformity and legitimacy than technical or economic pressures.

It has also been argued and rightly so, that although there is a lot of emphasis on the technical aspect of project delivery, the institutional work should actually precede the technical management aspect in large infrastructural projects (Biesenthal et al., 2018). The need to pay more attention to the institutional aspect is that the inputs and outputs hardly ever define the projects except in functional terms (Biesenthal et al., 2005). To the contrary, projects are defined by their social construction, by those who fund, make contest and use them (Biesenthal et al., 2018).

Therefore, the institutional theory offers a valuable framework for thinking about the time it takes to procure large service delivery infrastructural projects using the PPP. We are in consonant with views held by Lundin et al. (2011) that neo-institutional theory needs to be applied to temporary organizations of which large projects are part of. The authors contend that neo-institutionalism is better prepared than ever to inform research on large projects and other forms of temporary organizations. Institutional theory can explain regimes, markets, contracts, hierarchies, regulatory frameworks and associations (Miller and Hobbs, 2005) and by inference, why it takes long to implement PPP projects.

Notwithstanding the value of institutional theory, we are encouraged as scholars of project management to consider institutional factors when investigating project management (Morris and Gerald, 2011). Managing large projects should not just be thought of in terms of technical aspects. Large infrastructure projects should also be viewed in terms of their strategic and institutional component (Morris and Gerald, 2011). At the institutional level, the issues are about the context and support for projects that should be made available to perform effectively. Consequently, focusing on the institutional level can contribute to project success and long-term performance (Flyvbjerg, 2012).

Therefore, we agree with Biesenthal et al. (2018) that understanding the institutional framing and logics of mega projects can provide the key to successful delivery of infrastructural solutions within an acceptable and beneficial period. This view is also held by Delhi et al. (2010) who contend that the institutional environment has an impact on PPP outcomes of which time is a factor.

1.1.3. Principal-agent theory

Principal-Agent Theory was developed in the 1970s, and it originated from coming up with solutions to ensure that risk problems involved in a project are shared appropriately (Roach, 2016). This theory is based on the relationship between parties whereby one party (agent) performs actions on behave

of another (principal). Roach (2016) states that contract is any decision made by the principal that determines incentives of the agent. This theory is useful in assessing issues that relate to procurement regulations in order to improve procurement. The principal-agent theory is connected to supply and purchase and hence affecting the time taken by the contract.

Helfer and Meyer (2015) claimed that projects in Nigeria take longer time compared to developed countries because there is non-compliance with procedural directives and policy guidelines on PPP projects. According to the study conducted by Helfer and Meyer (2015), risks associated with the relation of principal and agent influence procurement time. Appropriate sharing of risks between principal and agent is necessary to ensure that a project is completed within the anticipated time. Helfer and Meyer (2015) claimed that most PPP projects in Nigeria lack efficiency in governance and hence the delay in their completion. There is a need for employing Principal-Agent Theory to establish public procurement system of Nigeria to enhance improvement in procurement time.

Liu, Wang, and Wilkinson (2016) argued that application of Principal-Agent Theory can be wide since it assesses and identifies issues relating to procurement policy. It also constitutes of elements necessary in evaluating and analyzing the accountability of the public sector; if the public sector is accountable, procurement time will be improved (Helfer and Meyer, 2015). Subsequently, Liu et al. (2016) argued that the government of Nigeria is currently undertaking PPP projects, but the level of accountability on how these projects are awarded to contractors is low. This could be the reason why PPP projects take longer time in this country compared to other nations in the world.

Most PPP projects in Nigeria are characterized by delays. For instance, most projects in Nigeria take two years between their inception and actual development, unlike in other developing countries like Ghana where PPP projects normally take three months.

1.1.4. Case studies

1.1.4.1. Abidjan–Lagos Corridor highway (case study in Nigeria). This project was planned in 2013 but the actual development took place in 2016. The stakeholders of this project include the European Commission, the Economic Community of West African States (ECOWAS), and the African Development Bank (Bijaoui, 2017). The highways were planned to connect countries in West Africa and link vibrant seaports in the area such as Niger, Mali, and Burkina Faso (Faso, 2016). The project faced delays between its period of inception and actual development because of various factors. The major factors leading to delays in PPP projects in Nigeria are the availability of funds and politics.

1.1.4.2. Warri-Effurun water project (case study in Nigeria). This project was initiated in the 1993 but took three years to actual development. The project is still ongoing. From this project, it seems that most PPP projects in Nigeria take a period of not less than two years to their actual development. Funds availability is the major reason for the delays of PPP projects and hence the government of Nigeria should consider ensuring that stakeholders undertaking PPP projects have adequate finances of funding PPP projects (Akpoborie, Uriri, & Efobo, 2014; ICRC, 2016).

1.1.4.3. Accra sea water desalination plant (case study in Ghana). This project took two months between its inception and actual development. It was planned at the end of 2011 and its actual development started in early 2012. Unlike in Nigeria, PPP projects in Ghana take a shorter time. The success and completion of PPP projects on time in Ghana is as a result of effective risk management, adherence to time, and adherence to budget (Lau, Goh, Ismail, & Lai, 2014). Adhering to a budget has helped sufficient funds are available to fund the projects.

Table 1. Procurement timeline for West Middlesex Hospital PPP

	West Middlesex Hospital PPP	
S/No	**Key milestones**	**Key milestones Date**
1	OJEU announcement	Aug-1998
2	Pre-Qualification Questionnaire issued	Oct-1998
3	6 longlisted candidates issued Preliminary Invitation to Negotiate	Nov-1998
4	3 shortlisted candidates issued Final Invitation to Negotiate	Jun 1999
5	Select Preferred Bidder	Dec-1999
6	Full Business Case approval	Oct-2000
7	Financial close	Jan-2001
8	Start of construction (new build)	Aug 2001
9	Completion of construction (new build)	Mar-2003
10	First patient day	May-2003
11	Hospital completely operational	Jun-2004

1.1.5. Public private partnerships procurement process

Public–private partnerships have not been without their own problems and controversies. The general implementation process for PFI projects consists of 14 stages (Liu et al., 2016). There have been empirical studies which indicate that PPPs do not deliver their promised benefits (Lobina et al., 2014). But a major issue has always been the duration from inception to implementation and service availability as shown in Table 1 below

Cartlidge (2004) outlined and enumerating nine measures for reducing procurement time including:

(1) Reduce the stages for tendering from the current recommended 14 stages, an option currently under review by the Office of Government Commerce.
(2) Reduce time up to best and final offer
(3) Eliminate the best and final offer stage
(4) Reduce the number of bidders to two or three
(5) Develop the brief as fully as possible with improved project definition before issue to bidders
(6) Reduce the need for up-front detailed design
(7) Increasing and retaining public sector expertise
(8) Standardization of PFI contracts
(9) Do not ask bidders for full due diligence before preferred bidder stage, as this operation is often repeated on the request of the financiers before financial close, much to the frustration of the rest of the team who see matters that they thought were agreed and settled, unbundled for reconsideration.

The various stages that Cartlidge (2004) advocates to be excluded are very important for the effectiveness of PPP procurement; instead, measures should be taken to make the processes more efficient. For example, countries like Ghana and Cameroun undertake these processes and are still able to conclude procurement in less than 100 calendar days compared to Nigeria's 660 calendar days (World Bank, 2015). What needs to be done is to look at the individual processes from inception to award of contract and identify the causes of delays in the process. Because other

factors could be responsible for the lengthy duration of the PPP procurement other than the processes and number of stages involved. For example, lack of high-level political support for PPPs and weak public sector PPP capacity have been argued to be some of the factors responsible for long gestation periods (Yong, 2010, p. 110). Strong government support indicates to the private sector the readiness and commitment of political leaders to the project, thereby building their confidence to participate in the process.

1.1.6. Need for the model for estimating procurement time

The importance of PPP procurement scheme—that supports foreign direct investments and economic growth—for infrastructure delivery in any growing economy cannot be over emphasized. It is, however, important to determine the actual procurement time of PPP projects in Nigeria under normal conditions. World Bank (2015) determined the duration of PPP procurement in 10 different economies including Nigeria using survey questionnaire. The value for Nigeria was found to be 660 calendar days. However, this method was found to be crude and based on many assumptions (Bank, 2015). To this end, the need for more scientific method of calculating and arriving at a more accurate number of calendar days required to procure a PPP project in Nigeria arose, hence the use of regression model as one viable solution. Modeling using regression has been found to be reliable because it involves training of all the variables inputs in the equation (Harrell, 2015).

Therefore, the results of this study would go a long way in helping the Nigerian government understand whether any urgent measures need to be taken and what they should avoid hastening benefits realization from their pipeline of PPP projects. It is expected that the proposed PPP model will serve as a useful tool in proper planning by government officials. The finding of this study would also contribute to the growing body of knowledge and serve as a basis for further research within academia. Hopefully, the findings will foster more debate among academicians, policy-makers, designers/planners, clients/developers, etc. on the relative merits of adopting PPPs as a procurement strategy and serve as a reference material for future discussions.

2. Methodology

Research designs are programs or plans that guide the investigator in the process of collecting, analyzing and interpreting observations of data (Stephen & Christopher, 2004). Furthermore, the research design should be geared towards meeting the purpose of the research and to provide a program used by the researcher to answer the research questions Fellows and Liu, (2008).

This study adopted a mixed method approach and used case studies of PPP transportation projects implemented in Nigeria, Ghana and Rwanda. The projects were selected from the World Bank infrastructure projects database. Projects from the three countries which reached financial close between 2015 and 2018 were selected for inclusion in the study. The selected projects had to be similar in nature (transportation), financed by the same financier and undertaken in different environmental contexts.

Data for the case studies was collected through a review of project information freely available on the open World Bank databases. Furthermore, public information about the selected projects available on the Internet and print media was also consulted to frame the processes followed during procurement and the environmental situation. This approach was deemed suitable for the study because of the type of information required. The empirical data needed for the study related to the time it took for each project to reach financial close of the PPP agreement, information on key issues that arose during the procurement stage, parties to the agreement and other stakeholders, and information about the socio-political environment in each of the selected countries. The different sources of data ensured convergence and corroboration of information (Bowen, 2009).

The data on the project organization and socio-political environment was analyzed using the institutional theory lens. The characterization of the environment in each country and the PPP project organization was then related to the time it took for each PPP project to reach financial

close. This approach was used by Castano, Dewulf, and Mahalingam (2012) to explain the Complex Interplay between the Institutional Context and PPP Project Outcomes. A similar approach was adopted by Mahalingam and Levitt (2007) in their study in which they used institutional theory as a framework for analyzing conflicts on global projects. Moreover, Biesenthal et al. (2018) encouraged the use of institutional theory to understand mega project performance.

Artificial neural networks, Support Vector Machine (SVM) and Autoregressive Integrated Moving Average (ARIMA) are methodological tool for machine learning and statistical models (Jiang, Zou, Zhang, Tang, & Wang, 2016). In the SVM literature, there exists a radial basis function of SVMs, polynomials SVMs, two-layer Neural Network (NN) SVMs and so on (Zanaty, 2012). However, these methods are more suitable in managing a complex and Advanced Traffic Management System (ATMS) (Yang, Zou, Wang, & Wu, 2018; Yang et al., 2017; Zou, Hua, Zhang, & Wang, 2015). This signifies that the data must be dynamic, before applying these prediction models.

2.1. Mathematical formulation (the multiple regression equation)

In this research, multiple regression analysis was found to be suitable and is, therefore, used to estimate the numerical relationship between the variables. It is regarded as the science of estimating or predicting in functional form, the dependence of one variable upon another.

The linear function is presented hereunder:

$$y = p + qx$$

where

p = is the intercept on vertical axis (Y-axis), i.e. where the graph crosses the vertical or y-axis, x = is variable and q is the gradient of the line at which the differential coefficient of y with respect to x equals to zero.

The constants "p" and "q" of simple regression liner function $(y = p + qx)$ are determined by:

$$q = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{n\Sigma X^2 - (\Sigma x)^2}$$

$$p = y - qx$$

Minitab computer software version 18 was used in finding the values of p and q. This technique helped in developing the mathematical equations for "forecasting" the effect of one or more variable based on another variable.

However, the use of multiple linear regression in this article is in line with the fact that the variables: concession period (CP), procurement time (PT), financial close year (FCY), project value (PV) have direct and positive correlations with each other (Kaiser & Liu, 2014). This, therefore, signifies that the procurement time of PPP project is dependent on the combination of the multiple variables, namely; project value, concession period, type of project (green or brown field), and complexity of the project. Therefore, these variables are suitable for the equation. It is regarded as **multiple linear regression** because it involves two or more independent variables in predicting the value of a dependent variable.

2.1.1. Assumptions

The following are the general assumptions considered in the regression analysis:

(a) **Normality**: in the sample space, the values on the dependent variable (IV) are distributed normally for each of the possible combinations of the level of the X variables; each of the variables is distributed normally;

(b) **Independence**: the values of any particular subject are independent of the values of all other subjects within the group.

(c) **Homoscedasticity**: in the sample space, the degree of variation or variances of the dependent variable for each of the possible combinations of the levels of the X variables are the same.

(d) **Linearity**: In the sample space, the relation between the independent variable (IV) and the dependent variable (DV) is linear when all the other independent variables (IV) are held constant.

2.1.2. Coefficient of determination

The coefficient of determination which is represented by the letter R^2 is used in the analysis of this paper to determine the proportion of the total variation in one variable that is depicted by the other variable. It is a measure of casual correlation among the variables. This technique results in a proportion or percentage that makes it relatively easy to arrive at a precise interpretation of the result. It is calculated by squaring the coefficient of correction. The coefficient of determination R^2 may vary from 0.00 to or 0% to 100%. Hence, Minitab package version 18.0 was used in generating the output of R2 in every experiment.

2.1.3. The analysis of variance (ANOVA)

2.1.4. "F test"—test for significance relationship between two variables

Minitab computer package version 18.0 was also used in computing the value of F—(F-calculated) the level of significant and the number of Degree of Freedom (DF) in each of the experiments, while testing the hypothesis about the significant relationship between the variables using F—distribution. The critical values of F—can be found from statistical table (F tabulated) at 0.05 confidence level of significance. Table 2 below shows the result of the regression analysis using the 4 variables.

2.1.5. Decision rule

On the experiments conducted in this research work, the level of significance of the test carried out is set at 5% (0.05 confidence interval, consequently, the decision rule postulated is by comparing).

(1) F—calculated with F—tabulated

(2) R^2 value obtained and leading to the following conclusion:

  (a) If F calculated < F tabulated, the null hypothesis Ho is accepted.

  (b) If F calculated > F tabulated, the null hypothesis is reelected and the alternate hypothesis is accepted.

  (c) Any result less than 50% of coefficient of determination R^2 is considered to be non-significant of the conducting experiment irrespective of the result observed in (a) and (b) above. Equal to 50% of the coefficient of determination R^2 is considered significant of the conducted experiment.

Therefore, the regression results are interpreted based on the following:

(1) Nature of the relationship

(2) Statistical significance of the derived relationship.

2.2. Regression time model using natural logarithm transformation

2.3. Discussion of findings

It can be deduced from the table above, F calculated (F-Cal) 54.62 > 3.05 value of "F" tabulated when 5% level of significant is used, and the coefficient of correlation between the Project Value (PV) and Procurement Time (PT) was found to be = 0.884, showing a significant statistical relationship among the variables involved in the equation. Moreover, the coefficient of determination $\mathbf{R^2}$ was found to be 88.16%, signifying a 88.18% variation in procurement time of PPP projects in

Table 2. Regression Results

Variables	Regression Equation	R^2 (%)	Calculated "F"	Tabulated "F"	P-Value	Highest Correlation In (PT) Vs In (PV)	Deduction
In -procurement time (PT), In—concession period (CP), In- financial close year (FCY) and In- Project Value (PV)	In (PT) = −178.6 + 0.04256 In (PV) + 24.31 In (FCY) + 0.0180 In (CP) ..... **Equation (A)**	88.16	54.62	3.05	0.000	0.884	Significant

Sources: Author's compilation of result of the analysis

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Figure 1. Fitted Line Plot of In (Project value) vs. In(PPP procurement time).

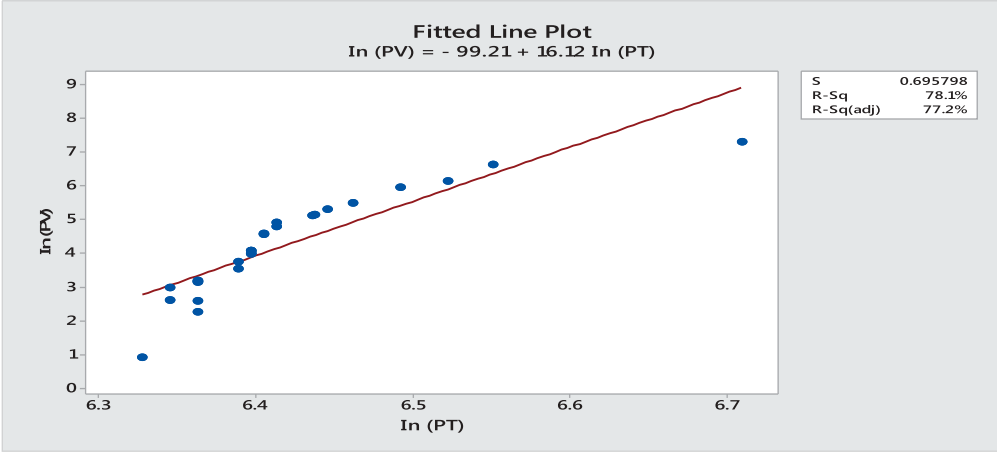
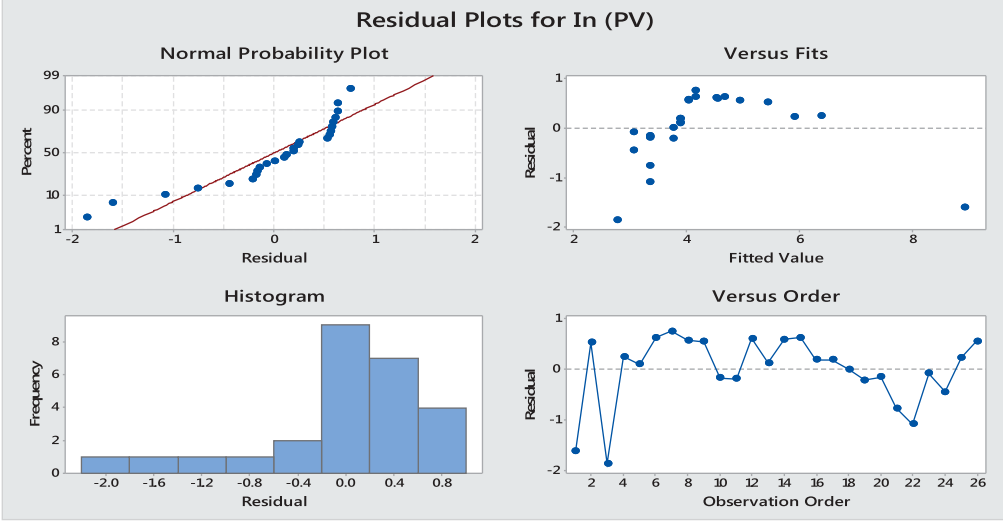


Figure 2. Residual Plots for In (PV).



Nigeria as a result of change in the variables that formed the equation combined together; that is In [concession period (CP)], In[Financial close year (FCY)], In[Project Value (PV)] related to PPP projects in Nigeria. It further confirms that there is a significant statistical relationship between the variables used in the prediction.

Similarly, a regression equation to predict the procurement time is obtained as follows:

$$\mathbf{In}\ (\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\ \mathbf{In}\ (\mathbf{PV}) + \mathbf{24.31}\ \mathbf{In}\ (\mathbf{FCY}) + \mathbf{0.0180}\ \mathbf{In}\ (\mathbf{CP}) \quad \text{(A)}$$

where In (PT) = $\log_e$ (Procurement time in days), In (PV) = $\log_e$ (Project value in million USD), In (FCY) = $\log_e$ (Financial close year) and In (CP) = $\log_e$ (Concession period in years).

The equation above shows the tendency of procurement time increases as a result of increase in the combination of the variables that form the equation.

The fitted line plot in Figure 1 below shows the dotted lines are concentrated and arranged along a straight line showing the variation in natural logarithm of the project value as a result of change or variation in natural logarithm of the procurement time of PPP projects in Nigeria. Also Figure 2 shows the dotted points are concentrating along a staightline on the residual plot of In (PV) signifying that the linear model is appropriate for the data.

2.3.1. Example 1

Given the following data, and under the normal conditions, the natural logarithm of the procurement time and hence the actual value of the procurement time of PPP project is calculated thus:

- Project type = An active brownfield port project A in Nigeria
- Project value = USD34.27 million
- financial close the year = 2005.
- The concession period for the project was pegged at 25 years.

Using the established natural logarithm of procurement time equation, the value is estimated as follows:

$$(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,\mathbf{In}\,(\mathbf{PV}) + \mathbf{24.31}\,\mathbf{In}\,(\mathbf{FCY}) + \mathbf{0.0180}\,\mathbf{In}\,(\mathbf{CP}) \quad (A)$$

By substituting the values in the equation, the natural logarithm of Procurement Time (PT) can be predicted as follows:

$$\begin{aligned}
&\mathbf{log_e}(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,\mathbf{In}(\mathbf{34.27}) + \mathbf{24.31In}(\mathbf{2005}) + \mathbf{0.0180In}(\mathbf{25})\\
&\mathbf{log_e}(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,(\mathbf{3.5342}) + \mathbf{24.31}\,(\mathbf{7.6034}) + \mathbf{0.0180}\,(\mathbf{3.2189})\\
&\mathbf{log_e} = -\mathbf{178.6} + \mathbf{0.15} + \mathbf{184.84} + \mathbf{0.06} = \mathbf{6.4470}\\
&(\mathbf{PT}) = \mathbf{e}^{\mathbf{6.4470}} = \mathbf{630.8070}\\
&\underline{\underline{(\mathbf{PT}) \approx \mathbf{630.81\ days}}}
\end{aligned} \quad (1, A)$$

2.3.2. Example 2

Given the following data, and under the normal conditions, the natural logarithm of the procurement time and hence the actual value of the procurement time of PPP project is calculated thus:

- Project type = An active Greenfield ICT project B in Nigeria
- Project value = USD121 million
- financial close the year = 2003.
- The concession period for the project was 25 years.

Using the established natural logarithm of procurement time equation, the value is estimated as follows:

$$\mathbf{log_e}\,(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,\mathbf{In}\,(\mathbf{PV}) + \mathbf{24.31}\,\mathbf{In}\,(\mathbf{FCY}) + \mathbf{0.0180}\,\mathbf{In}\,(\mathbf{CP}) \quad (A)$$

By substituting the given values in the equation, the natural logarithm of Procurement Time (PT) can be predicted as follows:

$$\begin{aligned}
&\mathbf{log_e}(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,\mathbf{In}(\mathbf{121}) + \mathbf{24.31In}(\mathbf{2003}) + \mathbf{0.0180In}(\mathbf{25})\\
&\mathbf{log_e}(\mathbf{PT}) = -\mathbf{178.6} + \mathbf{0.04256}\,(\mathbf{4.7958}) + \mathbf{24.31}\,(\mathbf{7.6024}) + \mathbf{0.0180}\,(\mathbf{3.2189})\\
&\mathbf{log_e} = -\mathbf{178.6} + \mathbf{0.20} + \mathbf{184.81} + \mathbf{0.06} = \mathbf{6.4764}\\
&\mathbf{log_e}(\mathbf{PT}) = \mathbf{6.4764}\,\mathbf{log_e}(\mathbf{e})\\
&(\mathbf{PT}) = \mathbf{e}^{\mathbf{6.4764}} = \mathbf{649.6280}\\
&\underline{\underline{(\mathbf{PT}) \approx \mathbf{649.63\ days}}}
\end{aligned} \quad (2, A)$$

2.3.3. Example 3

Given the following data, and under the normal conditions, the natural logarithm of the procurement time and hence the actual value of the procurement time of PPP project is calculated thus:

- Project type = An active Greenfield Port Project C in Nigeria
- Project value = USD60 million

- financial close the year = 2006.
- The concession period for the project was 25 years.

Using the established natural logarithm of procurement time equation, the value is estimated as follows:

$$\mathbf{log_e\,(PT)\;=\;-178.6+0.04256\,In\;(PV)\;+\;24.31\;In\;(FCY)\;+0.0180\;In\;(CP)} \tag{A}$$

By substituting the given values in the equation, the natural logarithm of Procurement Time (PT) can be predicted as follows:

$$\begin{aligned}
&\mathbf{log_e(PT)=-178.6+0.04256\,In(60)+24.31In(2006)+0.0180In(25)}\\
&\mathbf{log_e(PT)=-178.6+0.04256\,(4.0943)+24.31\,(7.6039)+0.0180\,(3.2189)}\\
&\mathbf{log_e=-178.6+0.17+184.85+0.06=6.4830}\\
&\mathbf{log_e(PT)=6.4830\,log_e(e)}\\
&\mathbf{(PT)=e^{6.4830}=653.9298}\\
&\underline{\mathbf{(PT)\;\approx\;653.93\;days}}
\end{aligned} \tag{3, A}$$

2.3.4 Example 4

Given the following data, and under the normal conditions, the natural logarithm of the procurement time and hence the actual value of the procurement time of PPP project is calculated thus:

- Project type = An active Greenfield Port project D in Nigeria
- Project value = USD40 million
- financial close the year = 2007.
- The concession period for the project was 25 years.

Using the established natural logarithm of procurement time equation, the value is estimated as follows:

$$\mathbf{log_e\,(PT)\;=\;-178.6+0.04256\,In\;(PV)\;+\;24.31\;In\;(FCY)\;+0.0180\;In\;(CP)} \tag{A}$$

By substituting the given values in the equation, the natural logarithm of Procurement Time (PT) can be predicted as follows:

$$\begin{aligned}
&\mathbf{log_e(PT)=-178.6+0.04256\,In(40)+24.31In(2007)+0.0180In(25)}\\
&\mathbf{log_e(PT)=-178.6+0.04256\,(3.6889)+24.31\,(7.6044)+0.0180\,(3.2189)}\\
&\mathbf{log_e=-178.6+0.16+184.86+0.06=6.4778}\\
&\mathbf{log_e(PT)=6.4778\,log_e(e)}\\
&\mathbf{(PT)=e^{6.4778}=650.5382}\\
&\underline{\mathbf{(PT)\;\approx\;650.5382\;days}}
\end{aligned} \tag{4, A}$$

2.4. Summary of findings

The table below shows the finding of the regression analysis obtained:

From the above calculations, the result/finding from the multiple regression equations 1A to 4A is presented and summarised in Table 3 below. The calculated values are presented in column 4 of Table 3 **"Estimated Procurement Time (PT) (in days)"**. The last column shows the percentage deviation from the actual procurement time. This is quite realistic as all calculated values fall within the range of plus or minus 7%. The average calculated procurement time has been found to be **646** calendar days which is the key finding after the analysis.

Table 3. Result of the Regression Analysis

S/N	Project	Actual Procurement Time (PT)	Estimated Procurement Time (PT) (in days)	Percentage Deviation from the Actual
1	Brownfield port Project (A)	671	631	−5.99
2	Greenfield ICT Project B	660	650	−1.57
3	Greenfield Port Project C	616	654	6.16
4	Greenfield Port Project D	633	651	2.77
	Average Procurement time of the four projects	**645**	**646**	0.19

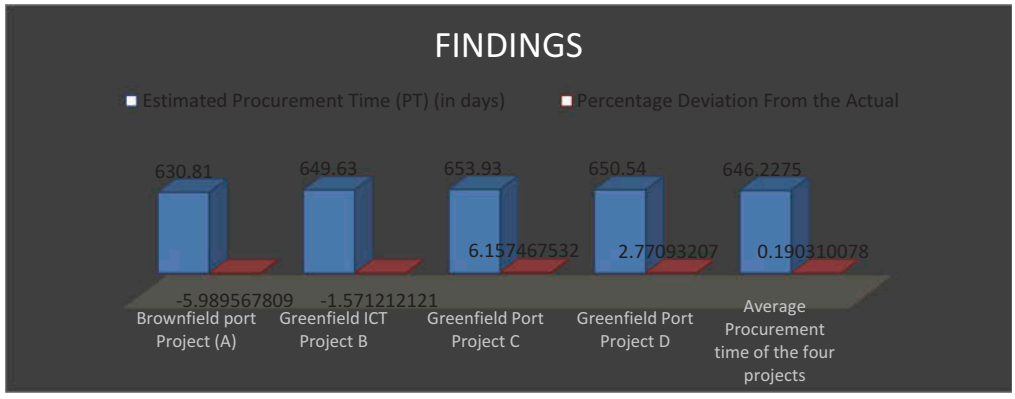


Figure 3. Bar chart showing the summary of findings.

3. Conclusion

Countries such as Nigeria and some other developing countries that rely heavily on crude oil as a major source of revenue are at a crossroad of what to do in the face of falling crude oil prices. As the traditional source of investment shrinks further in 2017, it reinforces the fact that PPPs will become indispensable as a major source of closing the infrastructure gap in Nigeria. However, the procurement cycle in Nigeria is so huge that the realization of projects under PPP is becoming impossible.

A mathematical model was developed for estimating the procurement time of Public–Private Partnerships PPP projects in Nigeria under normal conditions. After testing and validating the model using three different projects, the model was able to achieve the predetermined benchmark or allowance of plus or minus 10% of the established procurement time under normal conditions. By taking the average procurement time of the three projects, the value of the procurement time of PPP project in Nigeria was found to be approximately 635 days. This value is less than the value of procurement time established by the World Bank by 4% only. This signifies that, under normal conditions, it is possible to procure a PPP project in Nigeria within 635 days, showing an improvement of 4%. However, this value is still high compared to the 65 calendar days of procurement in Ghana and 75 calendar days in Cameroon.

Accordingly, Nigeria would only benefit from its adoption of PPPs if it improves on its procurement time, reducing it from the current 660 calendar days to the 65 calendar days achieved in Ghana or the 75 calendar days achieved by her neighbor Cameroon. Unless Nigeria strives to do

this, its investments in infrastructure through PPPs would continue to deliver only a fraction of the potential benefits.

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