Assessment of the Application of Fuzzy Logic to Project Management and Control in Some Firms in Lagos State: A Pilot Study

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Article Info	Abstract
  	Project management requires analysis of various uncertain variables and it is vital that the best techniques that are capable of providing the most accurate results are employed. Fuzzy Logic is one of those techniques; it has the capability of significantly improving the activities of project managers. This paper describes how Fuzzy Logic can be applied in the area of construction, project monitory and control which is based on observations made from the project environment of some firms in Lagos State. The data obtained from the administered questionnaire was analyzed through descriptive and factor analysis. The analysis shows that Fuzzy has significant effect on project management control. It was also observed that application of Fuzzy Logic in project management has not been considered in most firms in the country as the traditional methods such as Critical Path Analysis, PERT. are still well utilized which have numerous problems in areas such as the beta distribution and stochastic variables as well as the estimation of parameters (expected duration and variance) hence, the need for improvement.

1. Introduction

Fuzzy logic is an extension of Boolean logic by Lotfi Zadeh in 1965, based on the mathematical theory of fuzzy sets, which is a generalization of the classical set theory [1].

Fuzzy logic has since been applied to construction engineering and management and the methodologies are able to model subjective information, handle uncertainty, and address the lack of comprehensive data sets available for modeling in both construction engineering and management. Fuzzy logic has been combined with other soft computing techniques to model, simulate, and create advanced dynamic systems in the construction domain [2]. Correct scheduling is one of the vital elements for project management success. There are several ways to schedule projects, these includes the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). Due to problems in estimating durations of activities, these methods cannot accurately and completely model actual projects. For instance, PERT has numerous problems such as the beta distribution and stochastic variables as well as the estimation of parameters such as expected duration and variance. This has led researchers to seek new solutions, which includes integrating fuzzy sets with PERT and created a new approach, referred to as Fuzzy PERT [3]. Fuzzy PERT was introduced to express the durations of activities as fuzzy values. In the proposed method, fuzzy duration of activities was calculated based on three estimates, α- cut was utilized to determine the upper and lower bounds for project completion time. One of the problems with this method is that

different α value produced different bounds for project completion time, and thus there were not any effective way to show the activities of critical path in networks [4]. It was reported by [3] that [5] sought to solve this problem; they assume that the duration of each activity was a positive fuzzy number. Using α-cut, they defined an interval for each activity duration. PERT was also utilized to calculate the duration of each activity and determine the critical path. They also used the linear combination of activity durations to calculate the critical path, but different α value also leads to multiple critical activities and paths. It was assumed by [6] that the processing time of each activity could be a certain value, an interval, or a fuzzy number. Although Critical Path Method is one of the project scheduling specificities, majority of the research on the project scheduling topic of lately in developed countries has been devoted to Fuzzy PERT. The PERT technique is composed of two steps; the forward and the backward propagations [7]. The generalization of the PERT technique to fuzzy parameters is a complex task in which the forward propagation is done using fuzzy arithmetic, leading to fuzzy earliest dates and a fuzzy end-of-project event. But, backward propagation is no longer applicable because uncertainty would be taken into account twice [8]. Ref. [9] studied the criticality of tasks within fuzzy project and reported that the boundaries of some fuzzy parameters like the tasks' latest dates and floats are reached in extreme configurations.

[10] proposed to improve PERT by using Fuzzy Delphi method which is a generalization of the classical method for long range forecasting in management science known as Delphi method. It was reported to be developed in the sixties by the Rand Corporation at Santa Monica, California. The Fuzzy Delphi Method is an analytical method based on the Delphi Method that draws on the ideas of the Fuzzy Theory. The Delphi Method is a type of collective decision-making method [11].

Project management is a complex discipline with lots of variables and uncertainty in which these variables are just approximated values as a result of difficulty in getting the exact and accurate values for the variables and this is because, most of the inputs utilized in evaluating projects are subject to environmental and time-induced influences. Lagos State being the locus of projects in Nigeria entails that projects are always being executed in the region and new ones are always in progress, therefore, efficient and effective project management is an essentiality. Thus, appropriate methods should be taken into account for scheduling and estimating project implementation costs and project control. This paper aims to establish the possibilities of incorporating Fuzzy Logic Expert System into public project planning, scheduling and control in Lagos State.

2. Methodology

The data were collected through the use of questionnaire. The questionnaire was designed to elicit responses in other to develop credible answers to the research questions. This research utilized the application of mixed methods of both qualitative and quantitative approaches. The study also adopts the casual research design, which is used to study the effect of artificial neural network in project management of some firms in Lagos, Nigeria. This research focused on the area of the study which are some project management firms and professionals which the researcher was permitted to survey within Lagos state. The survey sample was composed of 33 respondents that accepted the invitation to answer the questionnaire.

3. Results and Discussion

3.1 Socio-Demographic Characteristic of Respondent

The result for each of the primary data analyzed is as presented in Figure 1.
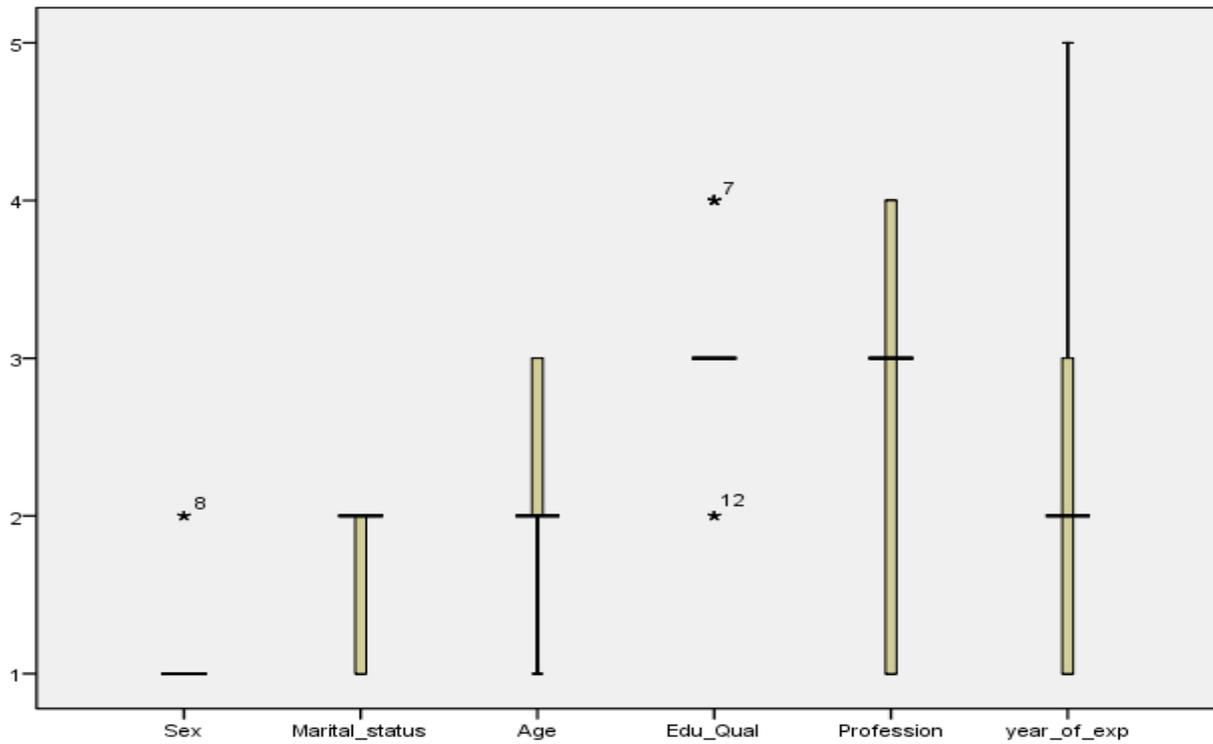
Figure 1: Socio-demographic Box plot

Box and whisker plot (Figure 1) show the variability of the set of data along a number line using the least value, the greatest value and the quartiles of the data, in which the quartile divide the data set into four equal parts. The median (second quartile, Q2) divides the data set into halves; the median of the lower half is the first quartile Q1 and the median of the upper hale is the third quartile Q3. Each whisker represents about 25% of the data likewise each side of the box to the right and left of the median represent 25% of the data. The outlier with case number eight that appears on the sex plot indicates that the respondent is the only female with age interval of (18-29) years with educational qualification of BSc. /HND while in the case of educational qualification plot, the outlier with case number seven implies that the respondents is the only one whose age is above forty years that is still single and the outlier of case number 12 implies that is the only age interval of (18-29) years that have married. In the case of age, the median age of the respondents is of the age interval between (30-39) years and those of the age above 40years falls into the third quartile: while (18-29) are of the lowest value of the analyzed data. For marital status the median is married while the second quartiles are single. The median for years of experience is (5-10) years while the upper quartile and the lower quartile are eleven years above and (0-4) years respectively. For profession the median are builders while the upper quartile and the lower quartile are project managers and civil engineers respectively.
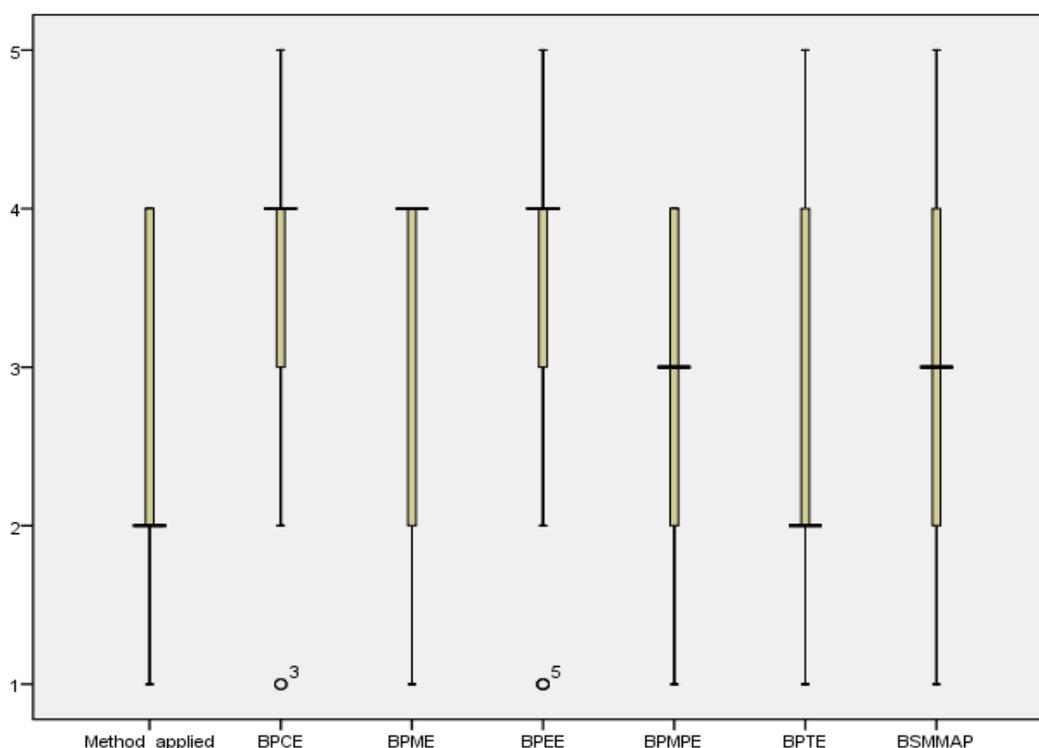
Figure 2: Most Utilized Techniques Box plot

The result for each of the Technique vs. respective questions analyzed is as presented in Figure 2.

Variables on the vertical axis of Figure 2 are represented as follows: 1=Fuzzy Logic, 2= Critical Path Analysis (CPM), 3 = Not Sure, 4= Project Evaluation and Review Technique (PERT), 5= Genetic Algorithm. Variable 1,2,4,5 are the possible Techniques that have been utilized on specific project. On the horizontal axis are:

Method applied = Method applied in actual project, BPCE= which method/technique is the best in project cost evaluation, BPME= which technique is the best in project material evaluation, BPEE= which technique is the best in project equipment evaluation, BPMPE= which technique is the best in project man-power evaluation, BPTE= which technique is the best in project time evaluation, BSMMAP= which technique is the best in creating system models that mirror the actual project.

According to the graph in Figure 2 the most utilized method/Technique in actual project is CPM which has the maximum quartile while Fuzzy Logic is the least applied often with the minimum whisker. PERT is the technique mostly utilized in project cost evaluation, project equipment evaluation, project material evaluation, and in creating system models that mirror the actual project while CPM technique is mostly utilized in project time evaluation. In the case of technique most utilized in project man-power evaluation the maximum quartile indicates that majority of the respondents are not sure of the most suitable technique to be utilized for the evaluation while the second quartile indicates that PERT has higher usage compare to Fuzzy Logic that has the minimum whisker. What this implies is that majority of the respondents are still utilizing the traditional techniques in evaluating project while very few have applied the new technique such as Fuzzy Logic and Genetic Algorithm and those that have actually applied these new techniques do so by outsourcing the tools needed which are not readily available.

Table 1: Communalities

	Initial	Extraction
Techniques is Helpful in Evaluating Project	1.000	0.689
Fuzzy Logic is Effective and Efficient Technique in analyzing vague/uncertain result	1.000	0.880
Fuzzy Logic can Predict Future of Value of Project Deliverables	1.000	0.562
Fuzzy Logic can be used in Evaluating and Determining the Cost of a Project	1.000	0.603
Fuzzy Logic can be used in Determining the Duration of a Project	1.000	0.812
Fuzzy Logic can be used in Project Selection to determine most worthwhile project	1.000	0.832
Fuzzy Logic can be used to create System Models	1.000	0.740
Fuzzy Logic can be used in Collaboration with other method	1.000	0.608
Fuzzy Logic describes Systems in Terms of combination Numeric and Linguistic	1.000	0.878
Fuzzy Logic has ability to describe system in both numeric and symbolic terms	1.000	0.751
Fuzzy methods have a Shorter Development Time than conventional method	1.000	0.802

Extraction Method: Principal Component Analysis

Table 1, shows the random values for extraction which are the proportion of the variable variance that can be explained by the factors. The values tend to have direct impact on factor loading of 0.5 and Cronbach alpha value of 0.801which is adequate as shown in Table 2. The data reveal that Fuzzy Logic has significant effect on project management control.

Table 2: Reliability Statistics

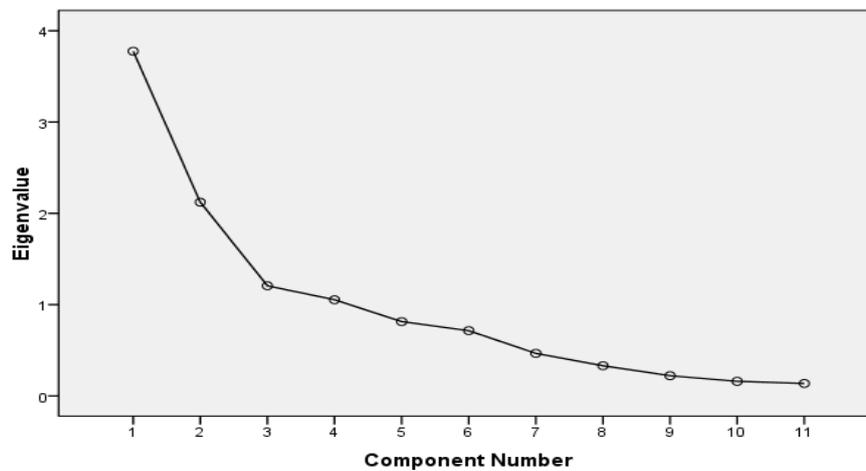| Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.801	0.799	11

Figure 3: Scree Plot

The scree plot (Figure 3) shows four factors are above the Eigenvalue of 1 while other variables below this eigenvalue were subsumed into the four factors as shown in Table 3. From Table 3 it can

be observed that data below the factor loading of 0.5 were suppressed and the result achieved shows that component 1 and 2 have more loading factor which means they have more significant effect on the set of analyzed data hence, referred to as the principal factors. The rotation converged in 6 iterations. The rotation of the factors was carried out using varimax such that the variance of the loading is maximized.

Table 3: Rotated Component Matrix

	Component			
	1	2	3	4
Techniques is Helpful in Evaluating Project		0.827		
Fuzzy Logic is Effective and Efficient Technique in analyzing vague/uncertain result			0.923	
Fuzzy Logic can Predict Future Value of Project Deliverables	0.555			
Fuzzy Logic can be used in Evaluating and Determining the Cost of a Project	0.604			
Fuzzy Logic can be used in Determining the Duration of a Project	0.862			
Fuzzy Logic can be used in Project Selection to determine most worthwhile project				0.839
Fuzzy Logic can be used to create System Models		0.562		0.568
Fuzzy Logic can be used in Collaboration with other method		0.721		
Fuzzy Logic describes Systems in Terms of combination Numeric and Linguistic		0.591	0.524	
Fuzzy Logic has ability to describe system in both numeric and symbolic terms			0.595	
Fuzzy methods have a Shorter Development Time than conventional method	0.872			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Using the rotated factor loading (Table 4), the extracted factors reveal the influence of Fuzzy Logic Technique to project management control in some firms in Lagos State, Nigeria

Table 4: Result Summary with Clusters

Creative Label	Factor Code	Variables	Factor Loading
Project Prediction	Factor 1	Fuzzy Logic can Predict Future Value of Project Deliverables.	0.555
		Fuzzy Logic can be used in Evaluating and Determining the Cost of a Project.	0.604
		Fuzzy Logic can be used in Determining the Duration of a Project.	
		Fuzzy methods have a Shorter Development Time than conventional method.	0.862
			0.872
Suitable Technique/Method	Factor 2	Techniques are Helpful in Evaluating Project.	0.827
		Fuzzy Logic can be used to create System Models.	0.562
		Fuzzy Logic can be used in Collaboration with other method.	0.721
		Fuzzy Logic describes Systems in Terms of combination Numeric and Linguistic.	0.591
Analysis	Factor 3	Fuzzy Logic is Effective and Efficient Technique in analyzing vague/uncertain result.	0.923
		Fuzzy Logic describes Systems in Terms of combination Numeric and Linguistic.	0.524
		Fuzzy Logic has ability to describe system in both numeric and symbolic terms.	0.595
Project Selection/System Model	Factor 4	Fuzzy Logic can be used in Project Selection to determine most worthwhile project.	0.839
		Fuzzy Logic can be used to create System Models.	0.568

Factor 1, in the first cluster in Table 4, labeled as Project Prediction, reveals that Fuzzy Logic can be utilized in project duration evaluation to predict future project schedule, project cost and estimate project time. It can be developed in a shorter time compare to the conventional/traditional methods.

Factor 2 in the second cluster labeled as Suitable Technique/Method shows that, Fuzzy Logic is also a suitable technique in project evaluation which can be utilized to create system models that can be employed in future project evaluation and to describe the system both in Numeric and Linguistic term. It can also be utilized along with other convectional techniques in project evaluation.

Factor 3 shows that the application of Fuzzy Logic to project management is an effective and efficient technique to analyze vague project data both in numeric and linguistic term which can also describe the results in both terms.

Likewise, from the fourth cluster, factor 4 shows that Fuzzy Logic can be employed in creating system models in project selection.

The loading factors of each variable in all the clusters considered are all positive and statically significant since the respective loading factor values are not less than 0.5(factor loading). This implies that utilization of Fuzzy Logic has significant and positive influence when applied on projects.

4. Conclusion

The study examined the application of Fuzzy Logic to project management and control in some firms in Lagos State. It has been established based on the results of this research that, Fuzzy Logic technique in a suitable concept in project control and management can be used collaboratively with other techniques and its benefits are: Effective and efficient in vague data analysis; adequate project cost evaluation and scheduling; adaptability with other convectional techniques such as PERT and CPM; description of system in both numeric and symbolic terms allowing more versatility in terms of comparison with other methods; possession shorter development interval than the conventional techniques; possible utilization in creating a system model which makes it effective to predict. In this study, it was observed that project managers in Lagos State utilize the convectional techniques (CPM and PERT) and are yet to key into the new techniques as a result of non-availability of enabling resources and technical know-how for its usage. The current project management techniques utilized in Lagos State are fair, but there is room for improvement and one way of improving these techniques in order to achieve more accurate estimations that will be closer to reality is through the adoption of Fuzzy Logic. Hence, project management firms are encouraged to equip their facilities with equipment's and software's that will enable the utilization of Fuzzy Logic in managing of projects likewise, organize training for their staffs on application of Fuzzy Logic in management of projects.

References

[1] Franck D., 2011, "Fuzzy logic: between human reasoning and artificial intelligence" Accessed 30 October 2019, available from: https://www.researchgate.net/publication/235333084

[2] Aminah R., F. and Chrysostomos S., 2018 "Fuzzy Logic Applications in Construction Engineering and Management". Accessed 30 October 2019, available from: http://nafips.cs.utep.edu/specialsessions/FuzzyLogicInConstruction.pdf

[3] Farhad H., Omid T. B., Henk K., and Stojan R., 2018, "Using fuzzy logic to improve the project time and cost estimation based on Project Evaluation and Review Technique (PERT)", *Journal of Project Management 3 (2018) 183–196.*

[4] Chanas, S., and Kamburowski, J., 1981, "The use of fuzzy variables in PERT". *Fuzzy sets and systems, 5(1), 11-19.*

[5] Mon, D. L., Cheng, C. H., and Lu, H. C., 1995, Application of fuzzy distributions on project management. *Fuzzy sets and systems, 73(2), 227-234*

[6] Chanas, S., and Zieliński, P. (2001). Critical path analysis in the network with fuzzy activity times. *Fuzzy sets and systems, 122(2), 195-204.*

[7]   Malek, E. H., and Alain H., 2011, "Fuzzy tactical project planning: Application to helicopter maintenance". *In the 16th IEEE International Conference on Emerging Technologies and Factory Automation ETFA'2011, Toulouse, France. pp 24-25,44, 48-49,51,56).*

[8]   Chanas, S., Dubois, D., Zielinski, P., 2002, "Necessary criticality in the network with imprecise activity times". *IEEE Transactions on Systems, Man and Cybernetics 32, pp393–407.*

[9]   Dubois, D., Fargier, V., Avagonon, H. V., 2003, "On latest starting times and floats in task networks with ill-know durations". *European Journal of operational research 145, 10 t 3, pp266-280.*

[10] Thaeir Ahmed Saadoon Al Samman, and Ramadan M. Ramo Al Brahemi, 2014, "Fuzzy Pert For Project Management". *International Journal of Advances in Engineering &   Technology, Vol. 7, Issue 4, pp. 1150-1160.*

[11] Linstone, H. A., and Turoff, M., ed, 2002, "The Delphi Method: Techniques and   Applications", ISBN 0-201 - 04294-0