IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

Cost Escalation Management In Tertiary Institutions Using Partial Least Squares and Fuzzy Inference System

Abam, Ayeni Omini[1*] And Nsien, Edwin Frank [2]

1*. Department of Mathematics, Federal University Lafia, Nigeria.
2. Department of Statistics, University of Uyo, Uyo, Nigeria
*Corresponding author: ayeni.abam@fulafia.edu.ng

Article Info
Received: 09 September 2019 Revised: 02 February 2020
Accepted: 05 February 2020 Available online: 26 February 2020

Abstract

Escalation of costs of projects is an integral part of the construction industry that is a vital sector in any economy. The contribution of the construction industry in the Gross National Product aids development. Cost Escalation generates into projects financial loss to both contractors and owners. It stands as the major challenge facing tertiary institutions. Desiring to solve these management problems in Nigerian Institutions, this paper comparatively assesses the escalation of project costs in Tertiary Institutions in Lafia Metropolis using Partial Least Squares-Structural Equation Modelling (PLS-SEM) and Fuzzy Inference System (FIS). The results show for PLS and FIS respectively, that contractors site management related factors has 97.6% and 67% effect on cost overrun, followed by non-human resource related factors with an effect of 94.4% and 67% on cost overrun. The least was information and communication technology related factors having 75.7% and 65% effect on cost overrun. Both fluctuation in price of materials and inadequate monitoring and control has 67.4% effect on cost overrun while delay in preparation and approval of drawings has an effect of 57% on cost overrun. The findings reveal that PLS-SEM is a model that evaluates a data as a collective entity while the FIS does not.

Keywords Cost, Fuzzy, Institutions, Equation, Modelling.
MSC2010: 62J86

1 Introduction

Cost Escalation or Cost Overrun is the increase in cost of projects which involves unexpected cost incurred in excess of budgeted amount due to an under estimation of actual cost during budgeting [1]. Cost is the budgeted expenditure, which the client has agreed to commit for creating/acquiring the desired construction facility [2]. Cost escalation is a chronic and an endemic problem in all public tertiary institutions in Nigeria. Time overrun and cost escalation has been on a high rate of competition and researchers has it that there exist more cases of cost escalation than time

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

overrun [1]. This makes the problem of cost escalation or cost overrun to be of great significance. Cost overrun is one of the most important challenges facing the tertiary institutions today hence incomplete buildings littered all-round the campuses, abandonment of projects by contractors at sites, half and non-payment of salaries to staff, unavailability of lecture rooms and administrative buildings for the smooth running of the tertiary institutions [1]. Having in mind that there exist a dire need and desire to solve cost overrun management problems in Nigerian Institutions, it is therefore important to identify the factors that contribute to the cost overrun in schools in order to avoid if not reduce the problems to its barest minimal.
In another development, [3] states that cost and time overruns in Australia in traditional and new procurement systems accounts for 13-19% of cost overrun and 10 to 69% of time overrun. According to [4], cost overrun is excess in actual cost budget of a project. Cost overrun is also sometimes called "cost escalation," "cost increase," or "budget overrun". [5] defined cost overrun as the difference between the original cost estimate of project and actual construction cost on completion of works of a commercial sector construction project. In another development, [6] defined cost overrun as the change in contract amount divided by the original contract award amount. Cost is an important parameter for success of any project and suggests that cost performance results in serious sequences of projects abandonment [7]. From the backdrop, there exist a dire need and desire to solve problem of cost escalation and management in Nigerian Tertiary Institutions by identifying the factors that contribute to the cost escalation in order to avoid if not reduce the problems to its barest minimal using the Fuzzy Inference System and Partial Least Squares- Structural Equation Modelling Comparatively.

The aim of this work is to comparatively assess the cost escalation of projects in selected Public Tertiary Institutions in Lafia Metropolis using the Fuzzy Inference System (FIS) and Partial Least Squares-Structural Equation Modelling (PLS-SEM) Approaches. The objectives of the study are to:

i Assess the causes of project escalation cost in selected Public Tertiary Institutions in Lafia Metropolis using both methods.

ii Compare and contrast the escalation of projects using FIS and PLS-SEM.

iii Determine the reasons for cost escalation as well as proffer solution to them.

2 Review of Related Literature

2.1 Theoretical Framework

The Rational Choice Theory is an economic principle that states that individuals always make prudent and logical decisions [8]. The theory explains further that individuals choose an outcome that provides the maximum net benefit meaning the maximum benefit minus cost or budget [9]. That is, it may lead to cost escalation or overrun as a result of materials scarcity, inflation or strike due to delay in project execution.

2.2 Conceptual Framework

The work of Angelo and Reina in 2002 as cited by [1] states that the problem of cost overrun is critical and needs studies more to alleviate this issue. Another study conducted by [10] reveals that in spite of its proven importance it is uncommon for project completion within estimated cost. In another development, [11] states that bad or inclement weather due to heavy rains and floods, scope changes, environmental protection and mitigation costs, schedule delay, strikes, technical challenges,

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

inflation and local government pressures were the major causes of cost escalation in Zambias road construction projects [1]. Similarly, [12] studied causes of cost overruns and identified the three main causes as contractor-related problems, material-related problems and again, owners' financial constraints. The research by [13] listed the following as factors that cause cost overrun on projects in Saudi Arabia; "effects of weather, number of projects going on at the same time, social and cultural impacts, project location, lack of productivity standards, level of competitors, supplier manipulation, economic stability, and inadequate production of raw materials by the country and absence of construction cost data. For [14] examined cost overrun problem in Korean social overhead capital projects and in his study of 161 completed projects the causes of cost overruns were found as changes in scope, delays during construction, unreasonable estimation and adjustment of project costs and no practical use of the earned value management system while [15] mentioned that low quality materials causes higher construction cost than expected because of the loss of materials during construction and this results from lack of standards for materials and management system and lack of ability of management to prevent cost overruns or to control construction costs causes many project to fail in achieving effective cost performance.

3 Methodology

The population of study consists of all the contractors working for the public tertiary institutions in Lafia Metropolis. These institutions include: Federal University Lafia, abbreviated as FULafia, Nasarawa State Polytechnic, Lafia and College of Agriculture, Lafia. The research design used for the study is the descriptive sample survey. A sample of 25 contractors of construction companies working for these tertiary institutions in Lafia Metropolis were sampled using a Simple Random Sampling (SRS) technique. The questionnaire, the main instrument for the study was administered to the contractors of the companies and the results were analyzed comparatively using Fuzzy Inference System (FIS) and Partial Least Squares-Structural Equation Modeling (PLS-SEM). The questionnaire was designed to reflect the causes of project cost escalation in tertiary institutions in Lafia Metropolis. The researcher constructed and used a 25-item questionnaire. This was administered on the respondents to collect the needed information. The questionnaire was constructed in two sections. Section A derived items on the respondents personal demographic and general information like sex, age, status etc. Section B was developed to rate the causes of project cost overrun in tertiary institutions in Lafia Metropolis. The questionnaire was constructed using the formation of a five-point likert scale. The response option ranged from NR to ER. The scale values allocated were 5, 4, 3, 2 and 1 respectively. Respondents were required to indicate with a tick ($\surd$) the option that they agree with. The instrument validated the content and to construct its validity, each of the instruments was scrutinized by experts in Operations Research and Construction Management. Their suggestions were adhered to strictly thus leading to the modification of relevant items.

In order to comparatively analyze the data got, the researchers used Fuzzy Inference System (Mamdani Fuzzy Inference System) via MATLAB. The Fuzzy System (FIS) was first introduced by Lotfi Zadeh in 1965 made up of two types. For the purpose of this work, the researcher used the Mamdani Fuzzy Inference System due to its advantages over Sugeno Fuzzy Inference System. Mamdani has a wide spread acceptance, it is intuitive and also well suited to human input.

3.1 Membership Function

Membership function is the function that deals with the degree of belongingness or degree of membership of a set, say $x \epsilon X$ in a fuzzy set A written as $\mu_a(x) : [0,1] \quad if \quad \mu(x) = 1$, it implies full

membership;
$\mu(x) : 0$, it implies non-membership and $0 < \mu(x) < 1$, implies the intermidiate membership. The membership function used by the researchers was the Trapezoidal membership function. Trapezoidal membership function according to [16] consist of Trapezoidal fuzzy number x with membership function $\mu_a(x)$ specified by four parameters $\{a, b_1, b_2, c\}$ having a lower limit a, an upper limit c, a lower support limit b_1", and an upper support limit b_2", where $a < b_1 < b_2 < c$, as shown

$$\mu_a(x) = \begin{cases} \frac{x-a}{b_1-a} & if a \leq x \leq b_1 \\ 1 & if b_1 \leq x \leq b_2 \\ \frac{x-c}{b_2-c} & if b_2 \leq x \leq c \\ 0 & otherwise \end{cases} \tag{3.1}$$

3.2 Defuzzification Method

The defuzzification method used by the researchers is the ranking of cost escalation factors by means of relative importance. The study of [16] revealed the following as the procedure adopted to calculate the rank and assess the importance index of cost overrun factors:

i The cost overrun factors prevailing in the construction industry are identified.

ii A questionnaire survey is conducted through personal interview for judging the level of importance of the above identified factors. The respondents are asked to indicate the relative importance of these factors.

iii The five-point scale ranged from 1 (not relevant) to 5 (extremely relevant) is adopted to calculate the relative importance indices (RII) for each factor.

The relative importance index (RII) is calculated by using the relation given below:

$$\mathbf{RII} = \frac{\sum W}{A * N} \tag{3.2}$$

Where: W is the weighting given to each factor by the respondent (from 1 to 5).
A is the highest weight while N is the total number of respondents.

3.3 Steps in developing the FIS model in MATLAB

According to the study of [16], the steps used to perform fuzzy logic tool box in MATLAB in order to develop the model are stated as:

1. Construct the number of input, one output system in the FIS editor.
2. Define membership functions using the function editor.
3. Perform fuzzy inference with the use of rules.
4. Choose a defuzzification method to develop the assessment model.
5. Use the rule viewer to show the roadmap of the Fuzzy Inference process.
6. Obtain the input-output maps using the view menu.

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

3.4 Partial Least Squares (PLS) Structural Equation Modeling

Partial Least Squares (PLS) Structural Equation Modeling was developed by Chin and Frye in 2001 reviewed in the work of Mitzi contained in [17]. PLS-SEM also referred to as PLS path modeling is a type of model that shows the relationship between latent variables which are connected using direct arrows called the path relationship. PLS-SEM is assessed using the coefficient of determination (R^2) of each of the latent constructs. Coefficient of determination (R^2) is used to describe the overall goodness of fit of an estimated model one or more independent variables.R^2 ranges from 0 and 1.
if $R^2 = 1$, it implies that there exist a perfect fit, that is $\hat{Y}_i = Y_i$. if $R^2 = 0$,it implies that there is no relationship between the estimator and estimate, that is $\hat{Y}_i \neq Y_i$, Similarly, if $R^2 > 0.5$, it implies that there is a good fit of the model to the given data and if $R^2 < 0.5$, it implies that there is no good fit of the model to the given data

$$R^2 = \frac{ESS}{TSS} = \frac{\sum \left(\hat{Y}_i - \bar{Y}\right)^2}{\sum \left(Y_i - \bar{Y}\right)^2} \tag{3.3}$$

$$Or\ R^2 = 1 - \frac{RSS}{TSS} \tag{3.4}$$

$$= 1 - \frac{\sum \left(Y_i - \hat{Y}\right)^2}{\sum \left(Y_i - \bar{Y}\right)^2} \tag{3.5}$$

Where Y_i =Actual value, $\bar{Y}$ = The mean of actual value and $\hat{Y}$ = The estimated value. Alternatively, R^2 can be evaluate as square of coefficient of correlation.

4 Result And Discussion Using PLS-SEM

The results represented in Table 1 below shows that the major causes of cost overrun in selected public tertiary institution in Lafia metropolis as analyzed using PLS-SEM validity and reliability of each constructs. Project management and contract administration related factors has the least coefficient in Cronbach alpha and Composite reliability of 92.0% and 94.5% respectively while non-human resources related factors has higher percentages both as 97.4% and 98.1% respectively. Furthermore, non-human resources related factors is the highest in both AVE and rho_A as 92.8% and 97.5% respectively and the least in both is contractor site management related factors of 71.6% and 94.9% respectively. Researchers believe that cronbach alpha is the most commonly used reliability coefficient because it seeks to generalize a measure of a uni-dimensional and multi-dimensional item scales internal consistency (reliability).

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

Table 1: Construct Validity and Reliability of PLS-SEM of Cost Escalation

Factors	Cronbachs Alpha in %	Composite Reliability	Composite Reliability in %	Average Variance Extracted (AVE)	rho_A	rho_A in %
CSMRF	94.2	0.952	95.2	0.716	0.949	94.9
DDRF	97.3	0.979	97.9	0.904	0.976	97.6
FMRF	95.6	0.965	96.5	0.820	0.959	95.9
HRRF	94.8	0.960	96	0.829	0.957	95.7
ICTRF	93.7	0.959	95.9	0.887	0.960	96.0
NHRF	97.4	0.981	98.1	0.928	0.975	97.5
PMCARF	92.0	0.945	94.5	0.813	0.925	92.5

Table 2 below shows that contractor site management related factors (CSMRF) has 97.6% effect by $R^2$and 97.3% effect by adjusted R^2 on cost overrun followed by non-human resources related factors with 94.4% effect by R^2 and 93.8% by adjusted R^2 while the least is Information and communication related factors (ICTRF) having 75.7% and 73.0% respectively.

Table 2: Final Results and Ranking of Cost Escalation Factors.

S/N	Factors	RII	RII in %	Rank
C_8	Inadequate Monitoring and Control	0.674	67.4	1
D_5	Delay in Preparation and Approval of Drawings	0.570	57.0	6
F_4	Delay in Progress Payment by Owner.	0.644	64.4	4
H_4	High Cost of Labor	0.667	66.7	2
I_3	Lack of Communication Between Parties.	0.652	65.2	3
N_1	Fluctuation in Price of Materials	0.674	67.4	1
P_1	Poor Project Management	0.607	60.7	5

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

Table 3: Fuzzy Rules for the Cost Assessment Model and Rules Weight

S/N	Factor	Rule	Rule Weight
1	Contractors Site Management Related Factors (CSMRF)	If (Inadequate Monitoring and Control is Extremely Relevant) then (CSMRF is Extremely Relevant)	0.67
2	Design and Documentation Related Factors (DDRF)	If(Delay in Preparation and Approval of Drawings is Extremely Relevant) then (DDRF is Extremely Relevant)	0.57
3	Financial Management Related Factors (FMRF)	If (Delay in Progress Payment by Owner is Extremely Relevant) then (FMRF is Extremely Relevant)	0.64
4	Human Resource (Work force) Related Factors (HRRF)	If (High Cost of Labor is Extremely Relevant) then (HRRF is Extremely Relevant)	0.666
5	Information and Communication Related Factors (ICTRF)	If (Lack of Communication Between Parties is Extremely Relevant) then (ICTRF is Extremely Relevant)	0.65
6	Non-Human Related Factors(NHRF)	If (Fluctuation in Price of Materials is Extremely Relevant) then (NHRF is Extremely Relevant)	0.67
7	Project Management and Contract Administration Related Factors (PMCARF)	If (Poor Project Management is Extremely Relevant) then (PMCARF is Extremely Relevant)	0.607

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

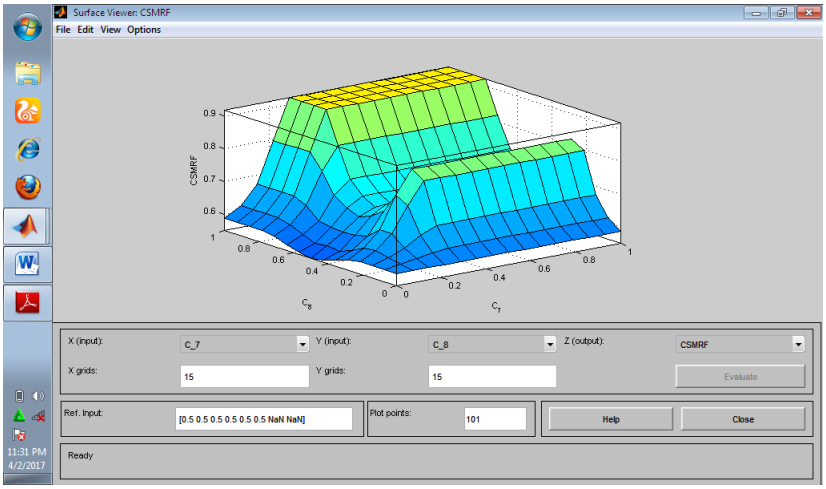

Figure 1: Surface View on Contractor Site Management Related Factors (CSMRF)

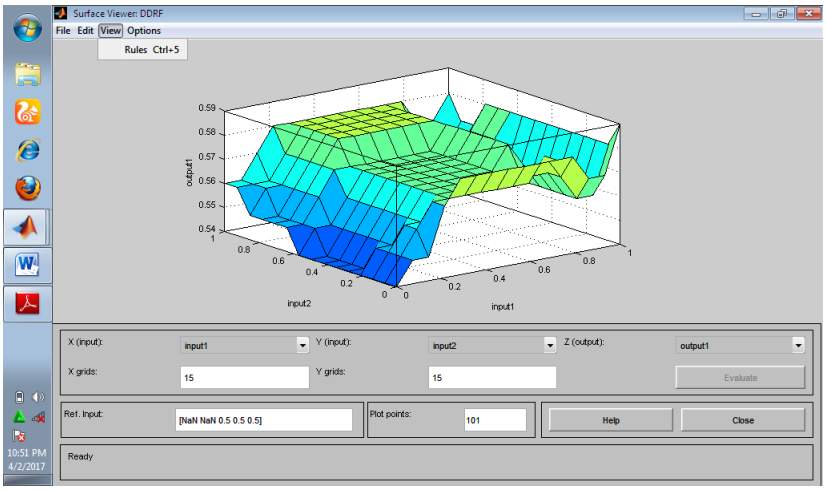

Figure 2: Surface View on Design and Documentation Related Factors (DDRF)

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

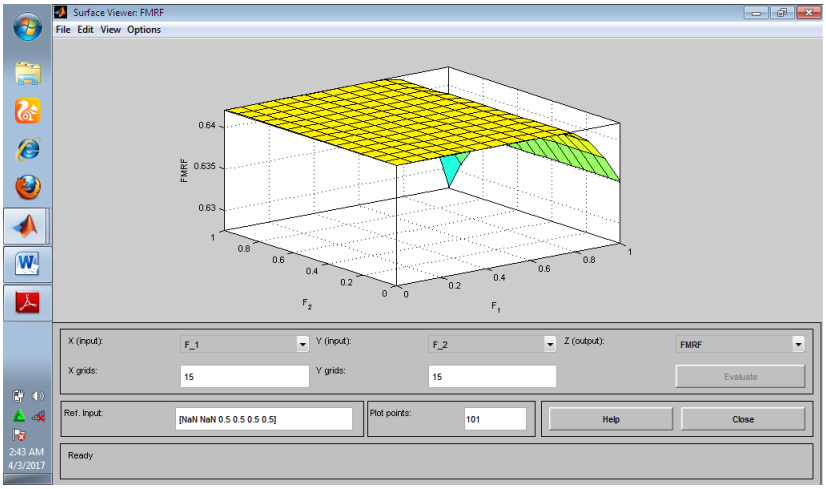

Figure 3: Surface View on Financial Management Related Factors (FMRF)

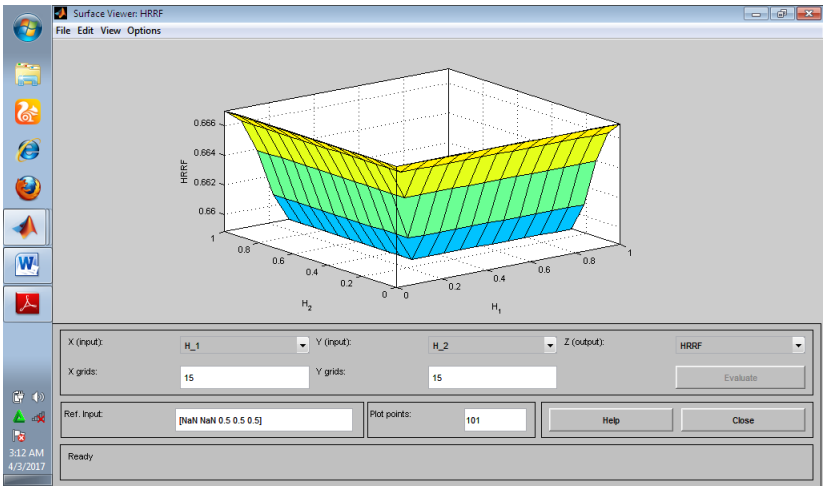

Figure 4: Surface View on Human Resource Related Factors (HRRF)

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

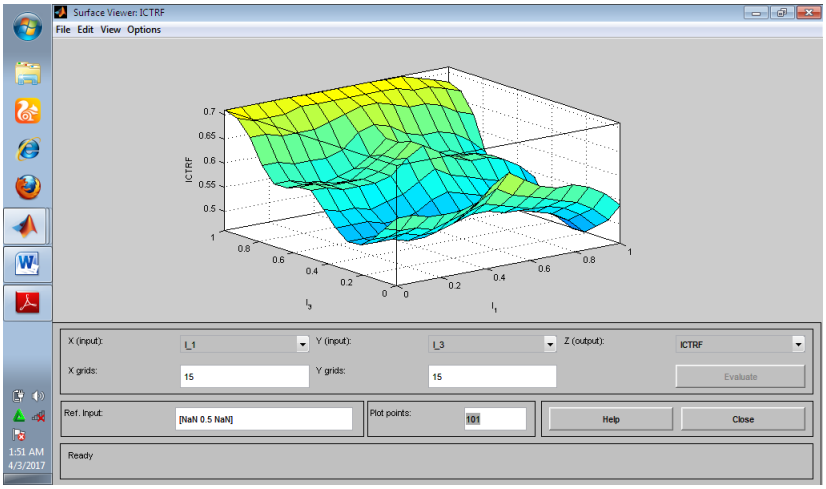

Figure 5: Surface View on Information and Communication Technology Related Factors (ICTRF)

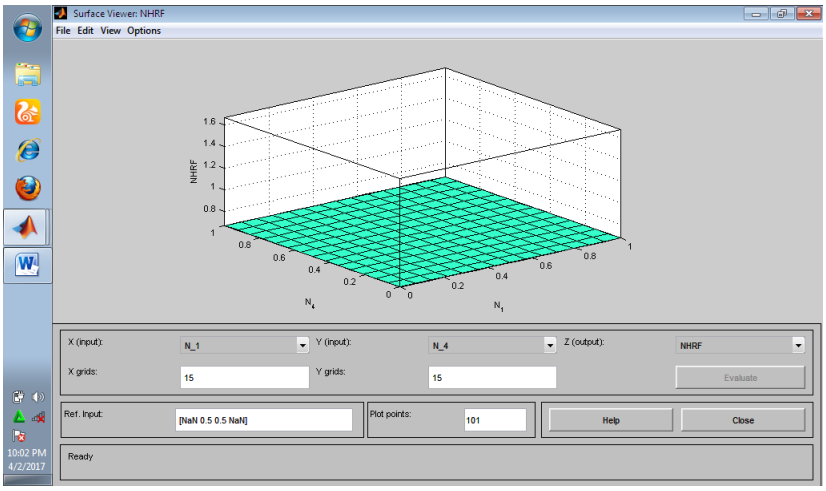

Figure 6: Surface View on Non-Human Resources Related Factors (NHRF)

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

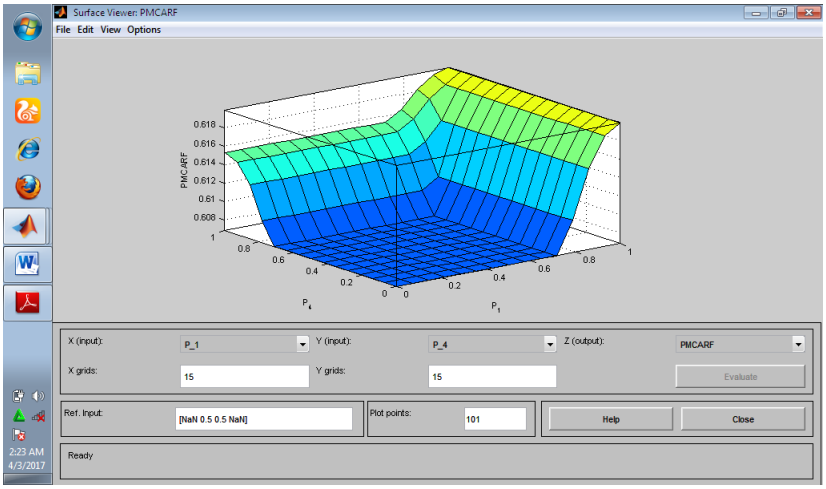

Figure 7: Surface View on Project Management and Contract Administration Related Factors (PMCARF)

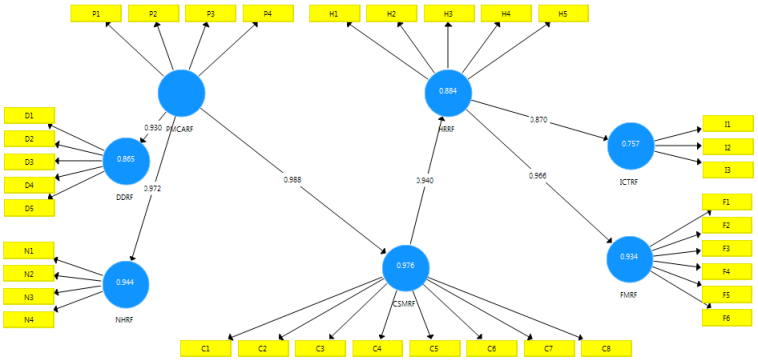

Figure 8: Pictorial Representation of PLS-SEM using Smart PLS 3

4.1 Analysis And Discussion of Result Using FIS

The results using Fuzzy inference system reveals that Inadequate Monitoring and Control and Fluctuation in Price of Materials have equal relative importance index (RII) of 0.674 (67.4%). The Delay in Preparation and Approval of Drawings has 0.570 (57%) effect on cost overrun. The results show that the major causes of cost overrun in selected public tertiary institution in Lafia metropolis in percentages are as follows: Inadequate Monitoring and Control (67.4%); Delay in Preparation and Approval of Drawings (57.0%); Delay in Progress Payment by owner (64.4%); High Cost of Labor (66.7%); Lack of Communication between Parties (65.2%); Fluctuation in Price of Materials (67.4%); Poor Project Management (60.7%)

IJMAO

International Journal of Mathematical Analysis and Optimization: Theory and Applications
Vol. 2019, No. 2, pp. 631 - 643

5 Summary And Conclusion

The researchers discovered that using Fuzzy inference system, both fluctuation in price of materials and inadequate monitoring and control has 67.4% effect on cost overrun while the delay in preparation and approval of drawings has an effect of 57% on cost escalation. FIS as a model, reveals that there exist seven factors that causes cost escalation. The fluctuation in price of materials and inadequate monitoring and control has 67.4% effect on cost overrun while the delay in preparation and approval of drawings has an effect of 57% on cost overrun. Similarly, using Partial Least Squares-Structural Equation Model (PLS-SEM), it reveals that it is a model that evaluates data as a collective entity. From PLS-SEM, the results shows that contractor's site management related factors has 97.6% effect on cost overrun, followed by non-human resource related factors with an effect of 94.4% on cost overrun. The least was information and communication technology related factors (ICTRF) having 75.7% effect on cost overrun. Conclusively, the PLS-SEM performed better than the FIS model.

6 Recommendation

The results of the study revealed that cost escalation can be reduced to the barest minimum if the owners of the project take into consideration Contractors site management related factors (CSMRF) as well as Non-human resource related factors (NNRRF). This recommendation is made since both the inadequate monitoring and control the price of materials to be used in the project are contained in the contractors site management related factors and the non-human resource related factors that play vital role in the bidding state of each project.

References

[1] Abam, A. O., Ogbonna, E. N., Nsien, E. & Nzeako, G. Project Cost Overrun Management in Universities Using Partial Least Squares-Structural Equation Modelling. *American Journal of Applied Mathematics*, 5(4), 108- 113, (2017).

[2] Chitkara, K. K., Construction Project Management-Planning, Scheduling and Controlling, (2^{nd} ed.), Tata McGraw Hills. (Chapter 2), (2011).

[3] Love, P. E. D., Raymond, Y. C. T. & David, J. E. Time-Cost relations in Australia Building Construction Projects; *ASCE Journal of Construction Engineering and Management*, 2(131), 187-194, (2005).

[4] Zhu, K. & Lin, L. A stage by stage factor control frame work for cost estimation of construction projects, *Owners Driving Innovation In taal Conference.*, (2004). http://flybjerg.Plan.aau.dk/JAPAASPUBLISHED.pdf.

[5] Choudhury, I., & Phatak, O. Correlates of time overrun in commercial construction, ASC Proceeding of 4th Annual Conference, Brigham Young University- Provo-Utah, April 8-10. *Arabian international Journal of Project Management*, 17(2), 101-106, (2004).

[6] Al-Najjar, J. M. *Factors Influencing Time and Cost Overruns on Construction Projects in the Gaza Strip*: Masters Thesis: The Islamic University of Gaza, (2002),

[7] Shreenaath.A, Arunmozhi. S. & Sivagamasundari. R. Prediction of Construction Cost Overrun in Tamil Nadu- A Statistical Fuzzy Approach, *International Journal of Engineering and Technical Research, 3(3),* 267-275, (2015).

[8] Investopedia (2016). Rational Choice Theory, https://www.investopedia.com/terms/r/rational-choice-theory.asp Assessed 10 November 2016.

[9] Chin W. Partial Least Squares for Researchers: An Overview and Presentation of Recent Advances Using the PLS Approach. Retrieved from http://disc-nt.cba.uh.edu/chin/indx.html. (2000).

[10] Azhar, N., Farooqui, R. U. & Ahmed, S. M. Cost Overrun Factors in Construction Industry in Pakistan. *Proceeding of First International Conference on Construction in Developing Countries* (ICCIDE-1), Karachi, Pakistan, (2008, August).

[11] Kaliba, C., Muya, M. & Mumba, K. Cost Escalation and Schedule Delay in Road Construction Projects in Zambia, *International Journal of Project Management, 5(27)*, 522-531, (2009).

[12] Koushki, P. A., Al-Rashid, K., & Kartam, N. Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics*, 23(3), 285-294, (2005).

[13] Bubshait, A. A. & Al-Juwait, Y. A. Factors Contributing to Construction Costs in Saudi Arabia. *Cost Engineering*, 44(5), 30, (2002).

[14] Le - Hoai, L., Lee, Y.D., & Jun, Y. L. Delay and Cost Overruns in Vietnam Large Construction Projects: A Comparison with Other Selected Countries. *KSCE Journal of Civil Engineering,* 367-377, (2008).

[15] Sriprasert, E.. Assessment of Cost Control System: A Case Study of Thai Construction Organizations. *Asian Institute of Technology, Bangkok*, (2000).

[16] Sharma, S. & Goyal, P. K. Cost Overrun Assessment Model in Fuzzy Environment. *American Journal of Engineering Research (AJER),* 3(7): 44-53, (2014).

[17] Mitzi (Maritza), P. T. Structural Equation Modeling Approach to Factors that Contribute to the impact MYMATHLAB has on Commitment and Integration of Technology, 65-71, (2008).