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Group Membership Prediction of an Outsourced Software Project: A Discriminant Function Analysis Approach

Oluigbo I.V.[1*], Asiegbu B.C.[2], Ezeh G.N.[3], Nwokonkwo O.C.[4]

[1]Department of Information Management Technology, Federal University of Technology Owerri, Imo State, Nigeria
[2]Department of Information Management Technology, Federal University of Technology Owerri, Imo State, Nigeria
[3]Department of Information Management Technology, Federal University of Technology Owerri, Imo State, Nigeria
[4]Department of Information Management Technology, Federal University of Technology Owerri, Imo State, Nigeria

**Corresponding Author's Email: ikenna.oluigbo@futo.edu.ng, Tel: +2348052891410*

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***Abstract* -** For an organisation to achieve success as regards software outsourcing, it is important for such organisation to have a clear understanding of the requirements necessary for success. A strategic analysis approach posits that successful software development outsourcing is influenced by a number of critical success factors. In this paper, the researchers identified six (6) critical success factors of software development outsourcing for Nigeria; these critical success factors were thereafter discriminated against an outsourced software development to predict the success or non-success of the software project. A sample size of 50 respondents was used in this research, and primary data was derived from our sample respondent through a well-structured questionnaire. Furthermore, a discriminant function analysis was adopted in analysing the collected data. The results of the analysis indicated that the prediction of group membership for the outsourced software project showed more sensitivity towards successful than not successful. Hence the outsourced Citrix software was classified successful by 96.8% using the six (6) critical success factors (Cost Saving and Financial Stability, Effective Communication and Trust, Technical Expertise and Knowledge Transfer, Understanding Software Development Outsourcing Industry, Effective Software Privacy and Security, and Overcome Cultural Barrier). However of the six (6) factors, Understanding Software Development Outsourcing Industry (USDOI), and Technical Expertise and Knowledge Transfer (TEKT) contributed more to predicting the group memberships of the outsourced Citrix software by 57.5% and 34.7% respectively. The discriminant function was therefore derived of the form; $Df_{(\text{Citrix Software for ATM Reconciliation})}$ = -17.640 + .098CSFS + .026ECTR + .347TEKT + .575USDOI - .019ESPS + .124OCBA. The results of the discriminant factor analysis validates the six success factors as critical to successful software development outsourcing.

***Keywords*-** Critical Success Factor, Discriminant Analysis, Group Membership, Software Development Outsourcing, Technical Expertise

I. INTRODUCTION

Outsourcing is a house-hold name in business environment as more companies are involved in it. Outsourcing entails the delegation of tasks or jobs from internal production to an external entity such as subcontractor. Software development outsourcing is therefore the process of placing the development of system components in another organization with the aim of achieving cost reduction and a gain in the time of development ([1], [2]).

A successful software development project is one that is deemed to have been completed within the specified schedule, budget, scope and available resources. However in certain cases, the success or failure of a software project is dependent a few more variable [3]. These variables are success factors.

In [4] defined critical success factor as the term for an element that is necessary for an organisation or project to achieve its mission. To develop an effective information systems, the organisation must have a clear understanding of both its long and short term information requirements [5]. The strategic analysis or critical success factors approach argues that an organisation's information requirements are determined by a small number of critical success factors. If these goals can be attained, success of the firm or organisation is assured [6].

In this paper, six (6) critical success factors of software development outsourcing were identified [2], these success

factors were validated by discriminating them against an outsourced software project.

The aim of this paper is to predict the group membership of an outsourced software project by discriminating a number of critical success factors against it. The specific objectives include:

1. To identify the critical success factors of software development outsourcing
2. To discriminate these critical success factors against an outsourced software project; by way of validating the factors
3. To predict the success or non-success of the outsourced software project
4. To outline the steps involved in carrying out a discriminant function analysis and classification.

II. METHOD OF DATA ANALYSIS

Discriminant Function Analysis (DFA) carries out the same function as multiple linear regression by predicting an outcome from a number of predictor variables. However, multiple linear regression is restricted in that the dependent variable Y is an interval variable unlike the discriminant analysis that uses a categorical dependent variable. With multiple regression also, the fitted equation produces a numerical Y values with mean population for every weighted combinations of the independent variables (X) values [7].

Discriminant Analysis is used when:

1. The dependent variable Y is categorical with the predictor independent variables having interval values such as age, income, attitudes, perceptions, and years of education, although dummy variables can be used as predictors as in multiple regression.
2. There are more than two dependent variable categories for example Yes/No, Success/Failure e.t.c

DA involves the determination of a linear equation like regression that will predict which group the case belongs to. The form of the equation or function is expressed as in Equation 1:

$$D = v_1X_1 + v_2X_2 + v_3X_3 = viXi + a$$

…… Equation 1

Where D = discriminate function

v = the discriminant coefficient or weight for that variable

X = respondent's score for that variable

a = a constant

i = the number of predictor variables

This fitted equation function is similar to a multiple regression equation or function. The v's are unstandardized discriminant coefficients similar to the (betas) b's in the multiple regression coefficients. Standardized discriminant coefficients can also be used like standardized beta coefficient in multiple regression analysis.

According to [2], there are six (6) critical success factors of software development outsourcing in Nigeria. They include:

$X_1 =$ Cost Saving and Financial Stability (CSFS)

$X_2 =$ Effective Communication and Trust (ECTR)

$X_3 =$ Technical Expertise and Knowledge Transfer (TEKT)

$X_4 =$ Understanding Software Development Outsourcing Industry (USDOI)

$X_5 =$ Effective Software Privacy and Security (ESPS)

$X_6 =$ Overcome Cultural Barrier (OCBA)

X_1 to X_6 are the Independent Variables adopted for use in this study.

Two Dependent Variable Categories chosen for use in this study are Successful and Not Successful.

III. POPULATION AND SAMPLING TECHNIQUE

In carrying out this study, the researchers selected a software project outsourced by a bank to a software outsourcing vendor. The software (Citrix Software) is used for automated teller machine reconciliation. The population considered in this study includes all those involved in the development (Vendor) and users (clients - bank) of the software. A total number of fifty (50) individuals make up our population; this number was also used as our sample size.

A total of fifty copies of questionnaire were distributed to the stakeholders (both the users and the outsourcing firm) involved in the development of this Citrix Software for ATM Reconciliation (CSAR) for Ecobank, Umuahia, Abia State. Having identified six (6) success factors critical to successful software development outsourcing, the researchers tried to validate the success factors using the outsourced software project to determine if the success of the software project can be attributed to the six (6) critical success factors. The result of this analysis, using discriminant factor analysis, is presented in the following subsections.

IV. DISCRIMINANT ANALYSIS RESULTS AND DISCUSSIONS

Group Statistics Tables for CSAR

The purpose of a discriminant function analysis is to predict a group membership of a categorical dependent variable using a number of independent predictors. Using Group means and Analysis of variance (ANOVA), the first step is to determine whether there are significant differences

between the independent variables group [7]. The Group Statistics and Tests of Equality of Group Means tables in Table 1 and Table 2 provides this information. If there are no significant group differences in the independent predictor variables, it makes no sense proceeding any further with the analysis; since we wouldn't have enough variability in the variables. By inspecting the group means and standard deviations in Table 1, we can get a good idea of the variable(s) that shows more importance in the group prediction. For example, mean differences between Understanding Software Development Outsourcing Industry (USDOI), and Technical Expertise and Knowledge Transfer (TEKT) depicted in Table 1 suggest that these two variables may be good discriminators, since their separations are large.

Table 1: Group Statistics for Citrix Software

How do you rate the overall contribution of the critical success factors to the success of your software development outsourcing project?		Mean	Std. Deviation	Valid N (listwise)	
				Unweighted	Weighted
SUCCESSFUL	CSFS	16.3226	1.46940	31	31.000
	ECTR	16.5806	1.47816	31	31.000
	TEKT	16.3226	1.39969	31	31.000
	USDOI	16.3548	1.08162	31	31.000
	ESPS	16.4194	1.36074	31	31.000
	OCBA	17.0323	1.92326	31	31.000
NOT SUCCESSFUL	CSFS	13.6842	1.37649	19	19.000
	ECTR	14.1053	2.66447	19	19.000
	TEKT	13.2632	1.59311	19	19.000
	USDOI	13.6842	1.10818	19	19.000
	ESPS	13.8421	2.85313	19	19.000
	OCBA	13.4211	1.67716	19	19.000
Total	CSFS	15.3200	1.92131	50	50.000
	ECTR	15.6400	2.32783	50	50.000
	TEKT	15.1600	2.09333	50	50.000
	USDOI	15.3400	1.69766	50	50.000
	ESPS	15.4400	2.39182	50	50.000
	OCBA	15.6600	2.53635	50	50.000

Table 2 provides strong statistical evidence of significant differences between means of successful and not successful groups for all independent variables with USDOI and TEKT very high value F's.

Table 2: Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
CSFS	.547	39.806	1	48	.000
ECTR	.728	17.921	1	48	.000
TEKT	.486	50.667	1	48	.000
USDOI	.405	70.502	1	48	.000
ESPS	.721	18.586	1	48	.000
OCBA	.513	45.630	1	48	.000

The Pooled Within-Group Matrices of Table 3 also supports use of these Independent Variables as intercorrelations between them are low.

Table 3: Pooled Within-Groups Matrices

		CSFS	ECTR	TEKT	USDOI	ESPS	OCBA
Correlation	CSFS	1.000	.259	.240	.287	.105	.445
	ECTR	.259	1.000	.293	.154	.581	.258
	TEKT	.240	.293	1.000	.026	.417	.281
	USDOI	.287	.154	.026	1.000	.199	.241
	ESPS	.105	.581	.417	.199	1.000	.149
	OCBA	.445	.258	.281	.241	.149	1.000

Box's Test of Equality of Covariance Matrices for CSAR

An assumption in ANOVA is that the variances were equivalent for each group of independent variables, but in discriminant analysis the assumption is that there is an equivalence in the variance-co-variance matrices [8].

Box's M tests the null hypothesis that the covariance matrices do not differ between groups formed by the categorical dependent variable (tests the assumption of homogeneity of covariance matrices.). Basically, the Box's M test is a kind of test of homogeneity. The researcher wants this test not to be significant so that the null hypothesis that the groups do not differ can be retained.

For this assumption to hold, the log determinants for the dependent should be equal or very similar. When tested by Box's M, we are looking for a non-significant M (using a significance level of 0.05) to show similarity and lack of significant differences. In this case the log determinants appear similar and Box's M is 36.026 with F = 1.461 which is not significant at p >0.05 (Tables 4 and 5). We therefore accept the null hypothesis that states that possibility of reaching either of the dependent variable categories (successful and not successful) do not differ across the independent predictor variables used in the analysis. What it means is that we have no problem of homogeneity.

Table 4: Log Determinants

How do you rate the overall contribution of the critical success factors to the success of your software development outsourcing project?	Rank	Log Determinant
SUCCESSFUL	6	5.684
NOT SUCCESSFUL	6	5.694
Pooled within-groups	6	4.563

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Table 5: Test Results

Box's M		36.026
F	Approx.	1.461
	df1	21
	df2	5358.006
	Sig.	.080

Tests null hypothesis of equal population covariance matrices.

Summary of Canonical Discriminant Functions for CSAR

Table of eigenvalues

This provides information on each of the discriminate functions (equations) produced. The maximum number of discriminant equation functions produced is the number of Dependent Categories minus 1 (in this case, we have 2 categorical dependent variable; 2-1 = 1). We are only using two groups here, namely 'successful' and 'not successful', so only one function is displayed.

The larger the eigenvalue (as shown in table 6), the more of the variance in the dependent variable is explained by that function (independent variables). The canonical correlation is the multiple correlation between the predictors (the 6 critical success factors) and the discriminant function. With only one function it provides an index of overall model fit which is interpreted as being the proportion of variance explained (R2). The square of canonical correlation coefficient is the percentage of variance explained in the dependent variable.

In this research as shown in Table 6, a canonical correlation of .852 suggests the model explains 73% of the variation in the dependent categories, i.e. whether an outsourced software project is successful or not successful. Also, the eigenvalue shows a high variability of 2.704, which is very high.

Table 6: Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	2.704[a]	100.0	100.0	.852

a. First 1 canonical discriminant functions were used in the analysis.

Wilks' lambda

Wilks' lambda indicates the significance of the discriminant function. Table 7 shows a high significant function ($p < 0.05$) and provides the proportion of total variability not explained (it is the converse of the square of the canonical correlation). So we have 27% unexplained variability by the six (6) critical success factors.

Table 7: Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.270	58.921	6	.000

The standardized canonical discriminant function coefficients table

More like in the standardized coefficients of multiple regression, Table 8 provides an index of the importance of each critical success factor. The sign (positive or negative) indicates the direction of the relationship. Understanding Software Development Outsourcing Industry is the strongest predictor while Technical Expertise and Knowledge Transfer is next in importance as a predictor. These two variables with large coefficients stand out as those that strongly predict (discriminate more) allocation to the successful or not successful group. The other four factors were less successful (showed less importance) as predictors.

Table 8: Standardized Canonical Discriminant Function Coefficients

	Function
	1
CSFS	.141
ECTR	.052
TEKT	.512
USDOI	.628
ESPS	-.039
OCBA	.227

The canonical discriminant function coefficient table

These unstandardized coefficients (b) are used to create the discriminant function (equation). It operates just like a multiple regression equation as shown in Table 9 and Equation 1;

Table 9: Canonical Discriminant Function Coefficients

	Function
	1
CSFS	.098
ECTR	.026
TEKT	.347
USDOI	.575
ESPS	-.019
OCBA	.124
(Constant)	-17.640

Unstandardized coefficients

$$\mathbf{Df_{(Citrix\ Software\ for\ ATM\ Reconciliation)} = -17.640 + .098CSFS + .026ECTR + .347TEKT + .575USDOI - .019ESPS + .124OCBA \quad \ldots\ldots\ldots\ldots \quad (Equation\ 1)}$$

The discriminant function coefficients of Table 9 indicate the contribution of each variable to the discriminate function controlling for all other variables in the equation. The table assesses each independent variable's (Critical success factors) unique contribution to the discriminate function and therefore provide information on the relative importance of each variable. The result of Table 9 shows that Understanding Software Development Outsourcing Industry (USDOI), and Technical Expertise and Knowledge Transfer (TEKT) contributes more to predicting the group memberships of the outsourced Citrix software by 57.5% and 34.7% respectively.

Group centroids table

A further way of interpreting discriminant analysis results is to describe each group in terms of its profile, using the group means of the predictor variables. These group means are called centroids. These are displayed in the Group Centroids table of Table 10. The results of Table 10 indicates that the mean of successful is 1.261 while that of unsuccessful is -2.058. Cases with scores near to a centroid are predicted as belonging to that group.

Table 10: Functions at Group Centroids

How do you rate the overall contribution of the critical success factors to the success of your software development outsourcing project?	Function 1
SUCCESSFUL	1.261
NOT SUCCESSFUL	-2.058

Unstandardized canonical discriminant functions evaluated at group means

Classification Statistics for CSAR

Prior Probabilities are used in classification as shown in Table 11. It is necessary to determine the prior probabilities

of membership in the groups formed by the dependent since we have different group sizes. 31 cases were for successful group while 19 were for unsuccessful group, representing prior probabilities of 62% and 38% respectively.

Table 11: Prior Probabilities for Groups

How do you rate the overall contribution of the critical success factors to the success of your software development outsourcing project?	Prior	Cases Used in Analysis	
		Unweighted	Weighted
SUCCESSFUL	.620	31	31.000
NOT SUCCESSFUL	.380	19	19.000
Total	1.000	50	50.000

Classification Result Table

The classification table is a table in which the rows are the observed categories of the dependent and the columns are the predicted categories.

The cross validated set of data is a better presentation of the power of the discriminant function than that provided by the original classifications. The cross validation successively classifies all cases but one to develop a discriminant function and then categorizes the case that was left out. This process is repeated with each case left out in turn. This cross validation produces a more reliable function. The argument behind it is that one should not use the case you are trying to predict as part of the categorization process.

The classification results of Table 12 reveal that 96% of the outsourced software project were correctly classified correctly into 'successful' or 'not successful' groups. This overall predictive accuracy of the discriminant function is called the 'hit ratio'. Original "Successful" group were classified with better accuracy (96.8%) than "Not Successful" (73.7%).

The cross-validated classification, a more reliable classification, shows a much larger disparity between the two groups. A much high accuracy of 87.1% was classified successful, while 68.4% classification was unsuccessful.

Table 12: Classification Results[a,c]

		How do you rate the overall contribution of the critical success factors to the success of your software development outsourcing project?	Predicted Group Membership		
			SUCCESSFUL	NOT SUCCESSFUL	Total
Original	Count	SUCCESSFUL	30	1	31
		NOT SUCCESSFUL	5	14	19
	%	SUCCESSFUL	96.8	3.2	100.0
		NOT SUCCESSFUL	26.3	73.7	100.0
Cross-validated[b]	Count	SUCCESSFUL	27	4	31
		NOT SUCCESSFUL	6	13	19
	%	SUCCESSFUL	87.1	12.9	100.0
		NOT SUCCESSFUL	31.6	68.4	100.0

a. 96.0% of original grouped cases correctly classified.
b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
c. 88.0% of cross-validated grouped cases correctly classified.

Table 12 when expressed mathematically, the table gives information about actual group membership versus predicted group membership.

--Overall % correctly classified = 96%
--Sensitivity = 30 / 33 = 96.8% 27 / 31 = 87.1% Cross Validated
--Specificity = 18 / 19 = 73.7% 13 / 19 = 68.4% Cross Validated

V. CONCLUSION

This result shows that the prediction of group membership for the outsourced software project showed more sensitivity towards successful than not successful (when the critical success factors were rated). What this means is that the outsourced Citrix software was successful by 96.8% when the six (6) critical success factors (Cost Saving and Financial Stability, Effective Communication and Trust, Technical Expertise and Knowledge Transfer, Understanding Software Development Outsourcing Industry, Effective Software Privacy and Security, and

Overcome Cultural Barrier) were considered. Security was also importantly considered in [9].

Having discriminated the six (6) critical success factors with the outsourced software development projects (Citrix Software for ATM Reconciliation), the researchers concludes that the discriminant factor analysis validates the six success factors as critical to successful software development outsourcing.

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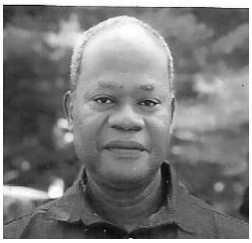
AUTHOR'S PROFILE

Oluigbo Ikenna Victor has a B.Tech and MSc in Information Technology from Federal University of Technology Owerri, Nigeria (FUTO). He is a seasoned IT Researcher and a lecturer in the department of Information Management Technology, FUTO. He is a member of International Association of Computer Science and Information Technology, International Association of Engineers, Institute of Research Engineers and Doctors. In addition, he is a reviewer member of International Journal for Innovative Research in Science and Technology, and International Journal of Trends in Research and Development. He has published over fifteen research papers in recognised international journals. His research interests includes Network Administration and Security, Data Science and Analytics, Green Technologies and Energy Efficient Networks, Impact of ICT and Internet Technologies, Research Methodologies, Quantitative and Qualitative Analysis.



Professor Asiegbu Baldwin C. is a professor of Economics and Information Management Technology in the department of Information Management Technology, FUTO. He had his BSc, MSc and Phd in Economic Cybernetics from Kharkov State University, Ukraine. He is a member of Nigerian Economic Society, Information Technology Financial Management Association, and an affiliate member of the Computer Professionals of Nigeria. His Research Interests includes Applied (Managerial) Economics and Business Management, as well as Information Management Technology. He has published over 35 research papers and Technical Reports in international journals and conferences.

Ezeh Gloria N. is a Lecturer in the department of Information Management Technology, FUTO. She has B.Eng in Electrical Electronics Engineering, MSc in Information Technology, and currently a Phd Researcher Student in Information Technology. She has attended several seminar, conferences and workshop. She has a passion for books on personal development. G.N. Ezeh is a member of Computer Professional Council of Nigeria (CPN), Nigeria Society of Engineer (NSE) and Nigeria Women in Information Technology (NIWIT). Her research interests includes Security, IT, Computer and Network Administration.

Engr. Dr. Nwokonkwo Obi Chukwuemeka is an accomplished academic**.** He began his teaching career as an assistant lecturer in March 5 2003 and has progressed to the rank of Lecturer 1. He has a B.Eng in Electrical/Electronic Engineering, and an MSc and Phd in Project Management Technology. He is a corporate member of Nigerian Society of Engineers, Member of Computer Professionals of Nigeria, and a COREN registered Engineer. His research interest include but not limited to digital systems, computer and systems engineering. He has published over 15 research papers in revered International journals, and have attended quite a number of conferences and other learned activities.

