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# Modelling Admission Exercise in the Joseph Sarwuan Tarka University Makurdi using Discriminant Analysis

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**Abstract**
*Candidates intending to gain admission into the university go through vigorous processes which include, passing Senior Secondary School Certificate Examination, passing Unified Tertiary Matriculation Examination (UTME) and passing the University of Choices screening test which is post-UTME. Despite all these processes, many candidates who met the requirements do not gain admission into the university while some of the candidates admitted may not be on merit. The study was carried out on secondary data of UTME scores of candidates who apply for admission in the College of Science for 2011/2012 session at Joseph Sarwuan Tarka University, with the aim of using discriminant function to discriminate between those "admitted" and those "not admitted" in the college. The data collected were analysed using average scores, Hotelling's $T^2$ distribution and discriminant function. The results shows that the average scores of those candidates admitted is higher compared to the average score of those not admitted. The hotelling's $T^2$ distribution used showed that the population mean vectors of the two groups are significantly different since $T^2 = 62.691 > T^2_{0.05,2,718} = 6.034$. This shows that 63.5% of the candidates were correctly classified and 36.5% of the candidates were misclassified. We recommend that discriminant analysis should be used in admission exercise for university candidates and that merit should not be sacrificed on the altar of catchment areas and educationally less-developed states, if that must be in consideration in the admission requirements, those with merit in those states should be prioritized*
**Keywords:** JAMB scores, Post JAMB, Hotelling's $T^2$ Statistic, Discriminant analysis, classification rule

## Introduction

Admission process in the university is paramount in the educational sector in Nigeria. Candidates intending to gain admission into the university undergo several processes before given admission. This include writing the Unified Tertiary Matriculation Examination (UTME) which was introduced by Joint Admission and Matriculation Board (JAMB) in 1978 to be an avenue through which candidates wishing to get into the university can pass through. The examination comprises of four subjects depending on the course of study of the candidate [1]. The university conduct Post Unified Tertiary Matriculation Examinations (Post-UTME) screening for candidates that have achieved a certain level of performance in the UTME. The screening has taken various forms depending on the approach of the university. This is part of the Federal Government reform in 2005. This is a problem entirely in the development of higher education as it appears that we now have multiple hurdles before intending candidates could secure admission into the university system. The hurdles require firstly, passing SSCE, secondly passing UME and thirdly passing the University of Choices screening test which is post-UTME [3]

However, despite all these processes, many candidates who meet the requirements do not gain admission into the university while some of the candidates admitted may not be on merit. This paper will show how discriminant function can be used to classify the candidates into the appropriate group which they belong, and identify the candidates that were misclassified. The first group are candidates who were admitted and the second group were the candidates who were not admitted. Therefore, the objective of this paper is to develop a model, a discriminant function that will classify the candidates.

[9] applied the discriminant analysis on the Unified Tertiary Matriculation Examination (UTME) scores for candidates admitted into the department of industrial chemistry Anambra State University for 2009/2010 session. The results of the analysis showed that the average scores of those candidates accepted using the UTME subjects is higher compared to the average score of those not accepted, and that there are candidates that were wrongly classified.
[6] of the Department of mathematics and statistics, Ambrose Ali University Nigeria, compares the academic performances of students who majorly use pidgin English and those who majorly use conventional English using Fisher's linear discriminant. Their result successful separated the two groups of students' interims of their academic performance.
[4], applied the method of discriminant analysis to predict the academic performance of students considering the previous education, regular active class attendance, lectures and motivation for the studies, and the construct a discriminant function that discriminates gender on students' performance.
[5] used the discriminant analysis to predict the class of degree obtained in the University system. The conditions for predictive discriminant analysis were obtained and the analysis yielded a linear discriminant function which successfully classified or predicted 87.5 percent of the graduating students' class of degree. The function had a hit ratio of 88.2 percent when generalized as a valid tool to classify fresh students of unknown group membership. It also discovers that success in classifying

or predicting fresh students in unknown group into classes of degree was essentially similar to that of the historical sample.
[8] used the method of multivariate analysis in analysing the scores of candidates admitted into the university of Nigeria medical school in the 1975/1976 academic session and constructed a discriminant function that successfully discriminate between those "admitted" and those not "admitted"
[10] applied the method of discriminant analysis in analysing the scores of candidates admitted into school of physical sciences in 2000/2001 session and constructed a discriminant function that successfully discriminates between those admitted and those not admitted.

## Materials and Methods

The study was carried out on the Unified Tertiary Matriculation Examination (UTME) and Post UTME scores of candidates admitted in the College of Science for 2011/2012 session in Joseph Sarwuan Tarka University Makurdi. The methods adopted for this research paper was average scores, Hotellings' $T^2$ distribution discriminant function and classification rule.

***Discriminant Function Analysis***

Discriminant Function Analysis (DFA) is a statistical technique used for classifying observations [7]. It has been used extensively in the past to derive optimal combinations of variables to differentiate groups because of its computational simplicity. However, DFA assumes that the predictors (i.e., tests included in the model) are each normally distributed and the set of predictors has a multivariate normal distribution along with homogeneous variance-covariance matrices [2].

***Hotelling's $T^2$-Test for Multivariate Two -Sample***

Hotellings $T^2$ is the multivariate generalisation of student's t. Hotellings $T^2$ is useful in most problems in multivariate analysis where one would use the t statistic in univariate analysis.
The Hotellings $T^2$ distribution for multivariate two samples is presented as follows:

$$T^2 = \frac{n_1 n_2}{n_1+n_2}\left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}} \mathbf{S}_{\mathbf{p1}}^{-1}\left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right) \qquad (1)$$

Were

$\boldsymbol{S_{p1}^{-1}} = \frac{1}{\boldsymbol{n_1+n_2-2}}[(\boldsymbol{n_1}-\mathbf{1})\boldsymbol{S_1} + (\boldsymbol{n_2}-\mathbf{1})\boldsymbol{S_2}]$ is the pooled variance,

$\boldsymbol{S_1} = \frac{1}{n_1-1}\sum_i^{n_1}(\boldsymbol{y_{1i}} - \bar{\boldsymbol{y}}_1)(\boldsymbol{y_{1i}} - \bar{\boldsymbol{y}}_1)^T$ is the variance for group 1

$\boldsymbol{S_2} = \frac{1}{n_2-1}\sum_i^{n_2}(\boldsymbol{y_{2i}} - \bar{\boldsymbol{y}}_2)(\boldsymbol{y_{2i}} - \bar{\boldsymbol{y}}_2)^T$ is the variance for group 2

***Test of Hypothesis***

Null hypothesis: the mean vectors of the two groups (Admitted and not admitted) are equal, $H_0$: $\boldsymbol{\mu_1} = \boldsymbol{\mu_2}$.
Alternative hypothesis: the mean vectors of the two groups (Admitted and not admitted) are not equal, $H_1$: $\boldsymbol{\mu_1} \neq \boldsymbol{\mu_2}$.

***Decision Rule***

The null hypothesis is rejected at level of significance $\propto = 0.05$, if $T^2 > F_{p,\ v-P+1,}$ otherwise fail to reject.

***Classification Rule***

To express the classification rule in terms of y, we first write $\frac{1}{2}(\bar{z}_1 + \bar{z}_2)$ in the form

$$\frac{1}{2}(\bar{z}_1 + \bar{z}_2) = \frac{1}{2}\left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}} \mathbf{S}_{\mathbf{p1}}^{-1}\left(\bar{\mathbf{y}}_1 + \bar{\mathbf{y}}_2\right) \qquad (2)$$

Where $\bar{z}_1$ is the mean for group 1 and $\bar{z}_2$is the mean for group 2
Then the classification rule becomes: Assign y to group 1 if

$$\mathbf{a}^{\mathrm{T}}\mathbf{y} = \left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}}\mathbf{S}_{\mathbf{p1}}^{-1}\mathbf{y} > \frac{1}{2}\left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}} \mathbf{S}_{\mathbf{p1}}^{-1}\left(\bar{\mathbf{y}}_1 + \bar{\mathbf{y}}_2\right) \qquad (3)$$

and assign y to group 2 if

$$\mathbf{a}^{\mathrm{T}}\mathbf{y} = \left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}}\mathbf{S}_{\mathbf{p1}}^{-1}\mathbf{y} < \frac{1}{2}\left(\bar{\mathbf{y}}_1 - \bar{\mathbf{y}}_2\right)^{\mathrm{T}} \mathbf{S}_{\mathbf{p1}}^{-1}\left(\bar{\mathbf{y}}_1 + \bar{\mathbf{y}}_2\right) \qquad (4)$$

***Probability of misclassification***

A simple estimate of the error rate can be obtained by trying out the classification procedure on the same data set that has been used to compute the classification functions. This method is commonly referred to as resubstitution. Each observation vector $\mathbf{y}_{ij}$ is submitted to the classification functions and assigned to a group. We then count the number of correct classifications and the number of misclassifications.
The results can be conveniently displayed in a classification table or confusion matrix, as in table 1 for two groups. The proportion of misclassification resulting from resubstitution is called the apparent error rate.
Among the $n_1$ observations in group 1 ($G_1$), $n_{11}$ are correctly classified into $G_1$ and $n_{12}$ are misclassified into group 2 ($G_2$), where $n_1 = n_{11} + n_{12}$. Similarly, of the $n_2$ observations in $G_2$, $n_{21}$ are misclassified into $G_1$, and $n_{22}$ are correctly classified into $G_2$, where $n_2 = n_{21} + n_{22}$.
Thus,

$$\text{Apparent error rate (probability of misclassification)} = \frac{n_{12}+n_{21}}{n_1+n_2} = \frac{n_{12}+n_{21}}{(n_{11}+n_{12})+(n_{21}+n_{22})} \qquad (5)$$

$$\text{Apparent correct classification rate (probability of correct classification)} = \frac{n_{11}+n_{22}}{n_1+n_2} \qquad (6)$$

**Table 1: Classification table for Two Groups**

| Actual Group | Number of Observation | Predicted Group 1 | Predicted Group 2 |
|---|---|---|---|
| 1 | $n_1$ | $n_{11}$ | $n_{12}$ |
| 2 | $n_2$ | $n_{21}$ | $n_{22}$ |

## Results and Discussion

The procedure described above was used to tackle the problem of admitting students into the college of Sciences in the University of Agriculture Makurdi. JAMB Scores and Post JAMB Scores of candidates for 2011/2012 academic session obtained from the college of sciences office was used in this research. The discriminant analysis function was used practically to classify these candidates into two groups which is "admitted"

and "not admitted". In this analysis, the variable $\mathbf{y_1}$ stands for candidate's mean Jamb score, $\mathbf{y_2}$ stands for candidates' Post Jamb score. Group 1($G_1$) refers to those who were "admitted" while Group 2($G_2$) refers to those who were "not admitted". Minitab statistical software was used to achieve the analysis in this research and result is presented as follows.

**Table 2: Summary of classification**

| | True Table | |
|---|---|---|
| **Put into Group** | Admitted | Not Admitted |
| Admitted | 167 | 124 |
| Not admitted | 139 | 290 |
| Total N | 306 | 414 |
| N correct | 167 | 290 |
| Proportion | 0.546 | 0.700 |

N = 720 N Correct = 457 Proportion Correct = 0.635

**Table 3: Squared distance between groups**

| **Put into Group** | Admitted | Not Admitted |
|---|---|---|
| Admitted | 0.000000 | 0.356354 |
| Not admitted | 0.356354 | 0.000000 |

**Table 4: Mean of the two groups for the JAMB and Post JAMB scores**

| | Means for Pooled Group | | |
|---|---|---|---|
| Variable | Mean | Admitted | Not admitted |
| Jamb | 51.461 | 53.157 | 50.208 |
| Post Jamb | 48.228 | 50.490 | 46.556 |

**Table 5: Mean difference of candidates admitted (Group 1) and not admitted (group2)**

| **Mean difference for group 1 and group 2 ($\bar{y}_1 - \bar{y}_2$)** | |
|---|---|
| Jamb | 2.949 |
| Post Jamb | 3.934 |

**Table 6: Standard Deviation of the two groups for the Jamb and Post Jamb Scores**

| **Standard Deviation** | | | |
|---|---|---|---|
| | | Group | |
| Variable | Pooled St Dev | Admitted | Not Admitted |
| Jamb | 5.413 | 6.314 | 4.635 |
| Post Jamb | 9.326 | 10.166 | 8.654 |

**Table 7: Covariance matrix for Group 1 ($S_1$)**

| | Jamb | Post Jamb |
|---|---|---|
| Jamb | 39.870 | 29.002 |
| Post Jamb | 29.002 | 103.339 |

**Table 8: Covariance matrix for Group 2 ($S_2$)**

| | Jamb | Post Jamb |
|---|---|---|
| Jamb | 21.487 | 9.829 |
| Post Jamb | 9.829 | 74.892 |

**Table 9: Pooled covariance matrix**

| | Jamb | Post Jamb |
|---|---|---|
| Jamb | 29.30 | 17.97 |
| Post Jamb | 17.97 | 86.98 |

**Table 10: Inverse Pooled Covariance Matrix ($S_{p1}^{-1}$)**

| | Jamb | Post Jamb |
|---|---|---|
| Jamb | 0.0391 | -0.0081 |
| Post Jamb | -0.0081 | 0.0132 |

**Table 11: Coefficient of discriminant function (a′)**

| | |
|---|---|
| Jamb | 0.0675 |
| Post Jamb | 0.0280 |

The discriminant Function $z = \mathbf{a^T y}$ is
$z = 0.0675\text{JAMB} + 0.0280\text{Post JAMB}$
$\bar{z}_1 = \mathbf{a^T \bar{y}_1} = 0.0675\bar{y}_1 + 0.0280\bar{y}_2$
$\bar{z}_1 = \mathbf{a^T \bar{y}_1} = 0.0675(53.157) + 0.0280(50.49)$
$\bar{z}_1 = 5.0018$

$\bar{z}_2 = \mathbf{a^T \bar{y}_2} = 0.0675(50.208) + 0.0280(46.556)$
$\bar{z}_2 = 4.6926$

Discriminant function cut off point is
$\frac{1}{2}(\bar{z}_1 + \bar{z}_2) = \frac{1}{2}(5.0018 + 4.6926)$
$= 4.8472$

The Hotellings $T^2$ distribution test statistic is
$T^2 = \frac{n_1 n_2}{n_1 + n_2}(\mathbf{\bar{y}_1} - \mathbf{\bar{y}_2})^{\mathrm{T}} \mathbf{S_{p1}^{-1}}(\mathbf{\bar{y}_1} - \mathbf{\bar{y}_2})$
$T^2$
$= \frac{(306)(414)}{306 + 414}(2.949, 3.934)\begin{pmatrix} 0.0391 & -0.0081 \\ -0.0081 & 0.0132 \end{pmatrix}\begin{pmatrix} 2.949 \\ 3.934 \end{pmatrix}$
$= 62.691$

$T^2_{0.05,2,718} = 6.034$

***Discussion***

The discriminant function found for admitted and not admitted candidates successfully classified those candidates admitted from those not admitted. It agrees with the result of the study by [8] that analysed the scores of candidates admitted into the University of Nigeria medical schools in the 1975/1976 academic session in which a discriminant function constructed successfully discriminate between those 'admitted' and those not 'admitted.' It also agrees with the result of [10] that analysed the scores of candidates admitted into school of physical science in 2000/2001 session using discriminant function that successfully discriminated between those admitted and those not admitted. Hotellings $T^2$ distribution used rejects the null hypothesis that the population mean vectors of the two groups are equal and conclude that the population mean vectors are different since $T^2 = 62.691 > T^2_{0.05,2,718} = 6.034$. Average scores of those 'admitted" is higher compared to average scores of those not admitted.

***Classification Rule***

The discriminant function cut off point is $4.8472$. Assign an individual to group 1 if the discriminant function $z = 0.0675\text{JAMB} + 0.0280\text{Post JAMB}$ is greater than $4.8472$, and to group 2 if the discriminant function $z = 0.0675\text{JAMB} + 0.0280\text{Post JAMB}$ is less than $4.8472$. For example, if candidate 1 scores averagely 47 in JAMB and 46 in Post JAMB and candidate 3 score averagely 53 in JAMB and 56 in Post JAMB, then their discriminant functions are 4.4605 and 5.1455 respectively. Assign candidate 1 to group 2 since the discriminant function is less than the cut-off point, and assign candidate 3 to group 1 since discriminant function is greater than cut off point.

Table 2 the summary classification table shows that 457 candidates were correctly classified with 167 candidates correctly admitted and 290 correctly not admitted. 263 candidates were misclassified (124 were not admitted but should have been admitted and 139 were admitted but should not have been admitted). This also shows that 63.5% of the candidates were correctly classified and 36.5% of the candidates were misclassified. The probability of correctly classifying those admitted is 0.546 and the probability of correctly classifying those not admitted is 0.70. The square distance (the Mahalanobis distance) between the two groups is 0.356, this shows that there is 35.5% distance between the variables.

## Conclusion

The overall percentage of correct classification is 63.5% for this research which is a measure of classification ability. This shows that discriminant analysis can be used to classify or predict the admission status of candidates. The use of discriminant analysis in this manner that is conducting discriminant analysis for classification purpose enables us to identify the candidates who were misclassified. We conclude that with 63.5% correct classification signify that there was a good consideration of candidates on merit for admission and the other 36.5% misclassification may be as a result of other factors such as consideration of the quota system that is, the 35% catchment areas and 20% educationally less-developed states incorporated by the Federal Government to give equal chance to all the citizen of the country to be educated.

**Recommendation**

Base on the findings in this research, the following recommendations are hereby presented;

i. Discriminant analysis should be use in depicting the admission status of intending university candidates.
ii. Merit should not be sacrifices at the altar of catchment areas and educationally less-developed states, if that must inconsideration in the admission requirements, those with merit in those states should be considered first.
iii. More research should be carried out on the admission exercise considering other factors such as the catchment areas and educationally less-developed states to have a perfect classification of the candidates.

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