Longitudinal Analysis of Performances of Beneficiaries of Affirmative Action Policy in Higher Education: A Case of Female Engineering Students of Makerere University in Uganda

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***Abstract*---**In order to improve the participation of women in higher education, in 1990 Government of Uganda introduced 1.5 bonus marks for every female student applying for vacancies in public universities and other tertiary institutions. The policy has remained in force up to now. However, no systematic study has been done to demonstrate how the beneficiaries of the Government affirmative policy perform while they are in the universities. Makerere University, the most dominant public university in Uganda, has been implementing the policy from 1990/1991 academic year. The aim of the study was to investigate the changes in the performances of the female engineering students of Makerere University, College of Engineering, Design, Art and Technology (CEDAT) for the entire four-year duration of their stay on the engineering programmes. From the office of the Senior Academic Registrar of CEDAT, 30 female students who were admitted into Mechanical, Civil and Electrical Engineering programmes in 2004 were identified. Of these, 11 were found to be beneficiaries of the 1.5 bonus marks. The Cumulative Grade Point Average (CGPA) of each of the participants in the study was collected. For successful students who finally graduated from the University, eight sets of results were collected. Multilevel analysis methods were used for the analysis of the longitudinal data collected. Three models were specified: the fully unconditional means model (Model A), the fully unconditional growth model (Model B) and the fully conditional model (Model C). The models were fitted to data. Deviances of the models were calculated. To answer the research question, the models B and C were compared by getting their deviance differences and were found to be – 26.5 (2 df, p < 0.995). Since $p_{cal} < 0.995$ is > p= 0.05, we failed to reject the null hypothesis at 95% level.

The paper concluded that there was no significant difference in performances between the beneficiaries and non-beneficiaries of the 1.5 bonus marks. While at the beginning the female students were admitted on lower grades, their rate of improvement with increasing stay of the programmes was 32% higher that that of the non-beneficiaries.

***Keywords*---**Gender, Uganda, Longitudinal Analysis, Hierarchical Linear Modeling

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I. Introduction

A. Background

From1990/1991 academic year, Uganda Government introduced a policy of awarding additional 1.5 bonus marks to every female student who applied to join public universities and other tertiary institutions. The policy, which is still in force, aims at increasing the participation of female students in higher education.

B. Problem Statement

No systematic study has been done to demonstrate how the beneficiaries of the Government affirmative policy perform while they are in the universities. Some sections of the community perceive that beneficiaries of the affirmative action are inferior graduates.

C. Research Location

Makerere University currently is the most dominant University in Uganda with a relatively sound research base. Engineering students are admitted into the College of Engineering, Design, Art and Technology- CEDAT).

D. Main Objective

The aim of this study was to investigate the changes over time in performances of two groups of female engineering students: beneficiaries and non-beneficiaries of the 1.5 Government bonus marks.

II. Theoretical Frameworks

In CEDAT, assessment of students is done every semester. There are two semesters in an academic year. Since engineering programmes last four academic years, it means that every successful student has a set of eight results. Performance of every student is measured in Cumulative Grade Point Average (CGPA) every semester. Investigating the changes in performances of students through time means that multilevel analysis methods should be used. Repeated measurements on the same subject through time makes the study longitudinal, a special form of multilevel analysis.

A. Model Specification

In this study, level-1 variables are taken to be $DURATION_{ij}$, duration of student i on the programme measured in semesters j. Level-2 variable is $BENEFICIARY_i$. In the study this variable was taken to be represented by dummies: BENEFICIARY = 1 for benefitting students; and BENEFICIARY = 0 for the non-beneficiaries. By putting substituting level 2 equations in level-1 equation and re-arranging, we find the composite, fully conditional individual growth model adopted from [1] and [2].

$$\begin{aligned} Y_{ij} &= [\gamma_{00} + \gamma_{01} * BENEFICIARY_i + \gamma_{10} * DURATION_{ij} \\ &+ \gamma_{11} * BENEFICIARY_i * DURATION_{ij}] + \\ &\vdots \\ &+ [\zeta_{0i} + \zeta_{1i} * DURATION_{ij} + \varepsilon_{ij}] \end{aligned} \quad (1)$$

Where, Y_{ij} denotes the CGPA score of student i during semester j; ε_{ij} are residual errors of student i during semester j; π_{0i} is the student i 's true initial average standardized score (at baseline when $DURATION_{ij}$=0). It is the intercept while π_{1i} is the rate of change of the student i 's score in a particular subject. This is the slope or gradient. It shows the rate of change in performance of a student with increasing number of semesters. γ_{00} and γ_{10} are level-2 intercepts while γ_{01} and γ_{11} are differences in level-2 average rates of change or slopes. Level-2 residuals ζ_{0i} and ζ_{1i} are also assumed to be independent and identically distributed (multivariate normality) with zero expected mean values and variances σ_0^2, σ_1^2 and covariance $\sigma_{10} = \sigma_{01}$. These residuals are deviations of individual change trajectories around the population averages, where $\begin{bmatrix} \zeta_{0i} \\ \zeta_{1i} \end{bmatrix} \sim iidMVN\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_0^2 & \sigma_{01} \\ \sigma_{10} & \sigma_1^2 \end{bmatrix}\right)$. It is further assumed that level-2 residuals ζ_{0i} and ζ_{1i} are independent of level-1 errors ε_{ij} for all *i* and *j*. Since there are two level-2 residuals, *bivariate* normality is assumed.

There are eight parameters to be determined from the composite model above: γ_{00}, γ_{10}, γ_{01} and γ_{11} are called *fixed effects* while random error variances σ_e^2, σ_0^2 and σ_1^2 and covariance $\sigma_{10} = \sigma_{01}$ are called *random effects* parameters.

B. Model Fitting

The above composite model (1) can be fitted to data collected resulting in the following individual growth models:

a. Fully Unconditional Means Model (Model A) -a model with no predictors at either level.
b. Unconditional Growth Model (Model B) -a model with level-1 predictor variable DURATION added.
c. Fully Conditional Growth Model (Model C**)-** a model with variables at both levels; DURATION and BENEFICIARY.

C. Hypotheses to be Tested

Models A, B and C are nested models. For example, Model B is nested in Model C. Deviance statistics is used for comparing nested models. For normally distributed errors, deviance is the Sum of Squares of residual errors.

$$Deviance = total\ \text{var}iance.(n-1), \quad (2)$$

Where, n is the average sample size per group of students.

To answer the research question in this study, Model B can be obtained from Model C by invoking two constraints hence 2 degrees of freedom. The null hypotheses are

$H_0 : \gamma_{01} = 0;\ \gamma_{11} = 0$ where γ_{01} and γ_{11} are differences in Level-2 average intercepts and rates of change or slopes respectively.

The difference between the deviances of Models B and C has a chi-squared distribution with 2 df.

D. Research Ethics

To avoid disclosing the identities of the students, unique numbers were assigned to the participants in the study.

III. Methodology

A. Research Approach/ Philosophy

This was a retrogressive quantitative social science research.

B. Population

From the office of the Senior Academic Registrar of CEDAT, female students who were admitted into Mechanical, Civil and Electrical engineering programmes in 2004 were identified. That year, 49 female students were admitted; 6 were in Mechanical, 18 in Civil and 25 in Electrical Departments. Of the 49 that were admitted, only 32 reported for the training; 5 in Mechanical, 13 in Civil and 14 in Electrical Engineering Departments. Furthermore, two students were eliminated from the study since they were admitted through the Diploma (in Civil Department) and Mature (from Electrical Department) entry schemes. Consequently, the population in the study consisted of the performance of 30 female students.

C. Sampling Method

Multistage sampling was done to identify the participants. Using the cut-off points that Makerere University used for admitting students into the three degree programmes in 2004/5 academic year, 11 female students were found to have benefited from the Government policy of awarding 1.5 extra points to female applicants for entry into public universities.

Of the 11 beneficiaries, 6 were sponsored by the Government (4 in Electrical Department and one in Civil Department). The remaining beneficiaries were privately sponsored.

D. Variables

Response Variables- these are the CGPA of every student at the end of a semester.

Independent Variables: In longitudinal studies, there are two levels of independent variables.

Level 1 Predictor is the DURATION of a student on the degree programme.

Level 2 Predictor is whether the student is a BENEFICIARY of the affirmative action or not.

E. Data Collection Method

The semester CGPA of each of the participants in the study was collected from the Academic Registrar's office, CEDAT. The data collected are depicted in table 1.

F. Data Analysis Method

Multilevel statistical data analysis method was used for specifying Individual growth models before fitting the models to the data collected.

III. Results

Table II shows the results of calculating the eight model parameters: four fixed effects and four variance components of the composite model (1) after fitting it to data collected.

TABLE II
RESULTS OF CALCULATING FIXED EFFECTS AND VARIANCE COMPONENTS OF THE PERFORMANCES OF FEMALE ENGINEERING STUDENTS OF CEDAT

Fixed Effects		**Parameter**	**Model A**	**Model B**	**Model C**
Initial status, π_{0i}	Intercept	γ_{00}	3.868	3.706	3.572
	Differences in intercepts between the two groups of female students	γ_{01}			-0.211
Rate of change,	Intercept	γ_{10}		0.032	0.0379
	Differences in rates of change between the two groups of female students	γ_{11}			0.009
Variance Components					
Level-1	Within-person	σ_{ε}^2	0.026	0.051	0.051
Level-2	In initial status	σ_0^2	0.254	0.368	0.597
	In rate of change	σ_1^2		0.002	0.038
	Covariance	$\sigma_{10} = \sigma_{01}$		-0.016	-0.029
Goodness of fit statistics		Deviance	28	42.1	68.6

TABLE 1
PERFORMANCES OF A COHORT OF 2004/5 FEMALE ENGINEERING STUDENTS OF CEDAT

ID/ Semester	1	2	3	4	5	6	7	8	Beneficiary
2	3.32	3.62	3.69	3.77	3.68	3.67		3.81	No
4	3.87	4.09	3.94	4.08	4.1	4.2		4.36	No
5	3.71	4.27	4.34	4.36	4.4	4.5		4.58	No
7	3.8	3.45	3.25	3.29	3.36	3.44	3.52	3.59	No
8	3.8	3.66	3.49	3.54	3.68	3.8	3.91	3.96	No
9	3.73	4.08	3.73	3.74	3.8	3.93	3.97	4.03	No
12	3.88	3.84	3.66	3.65	3.74	3.85	3.83	3.86	No
14	3.58	3.41	3.43	3.47	3.56	3.66	3.72	3.78	No
15	3.7	3.95	3.83	3.92	3.99	4.09	4.16	4.24	No
16	4.58	4.42	4.16	4.21	4.31	4.34	4.39	4.44	No
17	3.93	3.75	3.6	3.32	3.43	3.54	3.66	3.76	No
19	2.68	2.83	2.74	2.62	2.77	2.9	3.07	3.21	No
19	4.68	4.58	4.47	4.35	4.28	4.28	4.33	4.4	No
23	3.53	3.13	3.36	3.47	3.52	3.6	3.55	3.54	No
27	3.84	4	4.16	4.16	4.14	4.22	4.3	4.37	No
28	4.37	4.12	4.22	4.33	4.41	4.47	4.54	4.58	No
30	4.68	4.74	4.67	4.62	4.57	4.6	4.65	4.68	No
31	4.37	4.09	4.15	4.1	4.12	4.22	4.27	4.35	No
32	4.08	3.5	3.49	3.45	3.59	3.7	3.77	3.89	No
1	2.18	2.65	2.74	2.73	2.86	2.87		3.02	Yes
3	2.82	3.22	3.4	3.48	3.63	3.71		3.8	Yes
6		2.66		2.71		3.04		3.1	Yes
10	3.33	3.2	3.21	3.32	3.43	3.58	3.64	3.74	Yes
11	3.73	3.87	3.43	3.27	3.3	3.49	3.59	3.69	Yes
20	3.84	4.05	4.15	4.23	4.22	4.2	4.25	4.24	Yes
21	4.16	3.66	3.52	3.6	3.7	3.78	3.88	3.98	Yes
22	3.84	4.16	4	3.87	3.84	3.82	3.91	3.98	Yes
25	4.58	4.54	4.4	4.34	4.39	4.43	4.48	4.53	Yes
26	4.47	4.11	4.17	4.21	4.32	4.31	4.37	4.41	Yes
29	4.58	4.53	4.49	4.44	4.44	4.48	4.5	4.54	Yes

Hypothesis testing using Deviance Statistics

Using equation (2) and putting n = 11, the deviances of the model were found to be 28 (Model A), 42.1 (Model B) and 68.6 (Model C)

The differences in deviances of Models B and C was determined: (42.1 – 68.6) = -26.5 (2 degrees of freedom). From the standard Chi-squared table, and p-value = 0.05, the critical chi-squared value is 5.991. Since the deviance difference of -26.5 is much less than the critical value of 5.991, we 'fail to reject' the null hypotheses (at 2df, $p < 0.995$). There was no significant difference in the performances of the two groups of students.

IV. Discussion

The data collected for analysis in this study were repeated measurements of CGPA every semester of a cohort of female engineering students of Makerere University. In some cases, there were missing data. The measurement occasions were also unequal. These three reasons let to the justification for using multilevel methods for the analysis of the correlated, dependent data [2] and [3]. Raudenbush, a pioneer in the development of the concept of hierarchical linear modeling, recommends three assumptions to be made when using this method. Assumptions must be made about the error distribution, measurement metrics and variance-covariance structure. In this study normal distribution of the errors was assumed. The performances of the students were subjected to the same measurement metrics used for calculating the CGPA. The unstructured variance-covariance structure was assumed.

The estimated initial value of CGPA of the non-benefiting students was 3.783. For the benefiting students, it was only 3.572 giving a difference of 0.211. This means that the non-benefiting female students had their initial CGPAs lowering at the rate of 0.211 per semester.

In case of the slopes (rates of change in CGPA), the benefiting female students were improving at a rate which was 32% higher than that of the non-benefiting students. The estimated rate of change for the non-beneficiaries was only 0.0287 while for the beneficiaries, it was 0.0379. The implication is that the benefiting female students were improving at 0.009 per semester.

Since the beneficiaries on the programmes started on a lower initial CGPA and their rates of improvement was higher than that of the non-beneficiaries, at the end of their four year training, no significant difference in performances could be detected.

V. Conclusion

At 95% level, the study found that there was no significant difference between the two groups of female students. While at the beginning the female students were admitted on lower grades, their rate of improvement with increasing stay of the programmes was 32% higher that that of the non-beneficiaries.

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