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RESEARCH ARTICLE

EVALUATION OF THE IMPACT OF THE FREE SECONDARY EDUCATION ON STUDENTS' PROGRESSION USING MARKOV CHAIN MODEL: A CASE STUDY OF KIAMBAA SUB-COUNTY, KIAMBU COUNTY

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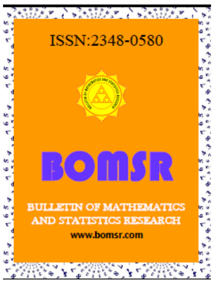

ABSTRACT

There is increasing investment being put into secondary school education all over the world. Kenyan government launched FSE policy to improve secondary education in 2008. In this study we evaluate the impact of FSE on students' progression in secondary schools in Kiambaa sub-county, Kenya, using Markov Chain Model (MCM).Two stage purposive sampling was used in selection of 7 schools from the 17 public secondary schools in Kiambaa sub- county and cohorts of students (pre-2008 and post-2008). The official students' documentary records were analyzed and MCM used to estimate the rates of retention, graduation and duration in schooling, for the 2 independent cohorts. Two sample proportions Z-tests were conducted to compare the groups' differences in retention and completion rates. To assess the groups' differences in duration in schooling, we used two-samples T-test. Z-test results unveiled significant difference in retention rates in forms 1 and 3 [p= 0.0329 and p=0.0401], but insignificant in forms 2 and 4 [p=0.1587 and p=0.0537 respectively], suggesting that there are underlying factors that influence students' retention other than ability to meet the cost of tuition. On gender disaggregation, the Z- test results unveiled significant difference in form 2 female retention in favour of the pre-2008 cohort [Z= -1.6545, p=0.0495], calling for further investigation to find the underlying cause(s) for this undesirable phenomenon. On completion rate, Z-test results showed significant difference between the two rates [p=0.0052<0.05]. All in all, we find that FSE policy has a positive impact on students' retention in secondary schools.

Keywords: Secondary Education, Markov Chain, Retention/Graduation Rates, Absorption Times

1. Introduction

Students' progression in an education system is a great concern of any government. Governments worldwide are committed in education by allocating much of their resources to education (UNESCO, 2005). Many governments develop policies and strategies to enhance a smooth transition rate in school, which are positive efforts towards the achievement of the Millennium Development Goals (MDGs) and Education for All (EFA) initiated by UNESCO in 2000. Concerning the right to education to all people, the government of Kenya showed its commitment by launching FSE policy in 2008. This was a move to enhance access and retention of Learners in secondary schools, which is one of the major concerns in education system in Kenya. Therefore, this study sought to evaluate the impact of FSE policy in Kenya on students' progression using a Markov Chain Model.

The model established will contribute significantly to the literature on application of Markov models in evaluating impact of government intervention policies on social programs of great public interest such as in education. The findings of this study will provide valuable information to secondary schools in Kiambaa sub- County for action in line with FSE. Also, schools will better plan, allocate resources and develop effective strategies and programs that will prepare and support students through their academic and social experiences at school.

1.1. Objectives of the study

To determine and compare the retention/ completion rates and expected duration in schooling of secondary school students before and after the FSE policy, in Kiambaa sub-county.

2. Literature Review

Many theories have been proposed to explain the equality of opportunities, access to education and factors that affect students' retention in an institution. Selowsky, 1979 proposed the theory of socialist economics of education that underscores the need to create an economy that redistributes income from the rich to the poor so as to create equality of wellbeing. Coleman report (1968) raised the issue of narrowing the educational gap between those who had money and others, quoting that the largest percentage of education occur when education is a must to all (Neal and Johnson, 1996). Bean (1980) proposed that students with high degree of institutional/goal commitment are more likely to complete education. Further there is a direct and causal linkage between students' background variables and dropping out (Bean, 1982).

Many empirical studies have been carried out to examine the effects of FSE policy on students' access, retention rates and quality of secondary education. Edward O.G (2015) noted that FSE policy has improved access and retention rates in Nyakach sub-county, Kisumu County but the quality of education has gone down due to increased number of students per class/per textbook/per teacher. Ngeno and Simatwa (2015) observed that FSE policy had little influence on dropout rates in

Kericho County. Mutisya (2011) observed FSE has resulted to students overcrowding in secondary schools in Katangi division, leading to limited learning/teaching facilities and equipment causing low quality of education. Ndoro and Simatwa (2016) noted that FSE policy has significantly impacted on the rates of transition from primary to secondary school in Homa Bay County- Kenya. From the literature review it emerges that the launch of FSE policy has not come without challenges towards realizing access, quality and retention of students in schools. Therefore, the present study is a continuation of the endeavor to evaluate the impact of FSE on students' progression in secondary schools in Kenya using the Markov Chain Model.

Markov chains are fundamental part of stochastic processes, which satisfy the Markov property, that the past and future are independent when the present is known. Markov chain has a lot of applications in education, for instance; Clement and Joshua (2017), used Markov process to explain gender gap fluctuations in performance of students graduating in mathematics at a University in North Central Nigeria. Alenka et al. (2017) demonstrated the usefulness of Markov chain in education by applying it in Slovenian higher education institution. Adeleke et al. (2014) demonstrated the usefulness of Markov process by applying it to assess the students who were admitted in mathematic department and their performances in Ekiti University. Musiga (2011) modeled students graduating with a bachelor of mathematics at University of Nairobi, Kenya using Markov chain. Mbugua (2016) used Markov model to show the progression of the boy child in Kenya public primary schools. Mose et al, (2014) showed the movement of students in various levels of secondary education in Kisii Central District using Markov chain. Mose & Getange (2016) extended the above study by Mose et al, 2014, to the entire nation using the 2015 secondary students' enrollment data from KNBS. From this brief literature review on the application of a Markov model to a school system, it is clear that the method has not been used to evaluate the impact of FSE which would require comparison of two different cohorts; pre-2008 and post-2008.

3. The Process of Model Development

A Markov Chain is a sequence $\{ X_n ; n = 0,1,2,\ldots\}$ of discrete random variables with the property that the conditional distribution of X_{n+1} given $X_1, X_2, X_3,\ldots,X_{n-1}, X_n$ depends only on the value of X_n but not further on $X_0, X_1, \ldots X_{n-1}$.

i.e. $\Pr [X_{n+1} = j / X_0 = i_0, X_1 = i_1,\ldots, X_n = i]$ for all $i_0, i_1, \ldots,i_n, i, j$ € E(state space).

$= \Pr [X_{n+1} = j / X_n = i] = [p_{ij}] = \mathbf{P}$ …………… (1)

If **E** = {1, 2… m} is a finite state space, then **P** is m x m dimensional matrix; that is,

$$\mathbf{P} = \{p_{ij}\} = \begin{bmatrix} p_{11} & p_{12} & \ldots & p_{1m} \\ p_{21} & p_{22} & \ldots & p_{2m} \\ \vdots & \vdots & \ldots & \vdots \\ p_{m1} & p_{m2} & \ldots & p_{mm} \end{bmatrix} \text{Where } p_{ij} \geq 0, \sum_{j=1}^{m} p_{ij} = 1 \text{ and } i,j \in E.$$

In this study **E**= [1, 2, 3, 4, G, D] and described as follows:

1= the student is admitted as a form one. 2= the student has progressed into form two.

3=the student has progressed into form three. 4= the student has progressed into form four. G= the student has sat for K.C.S.E (graduated). D= the student has dropped out.

Model Assumptions were

a) Admissions happened in form one only. **b)** Transitions/dropping out are assumed to occur at the conclusion of each school year. **c)** No class repetition. **d)** Any transfer from school is considered as a dropout. **e)** There are only forward transitions and no backward transitions.

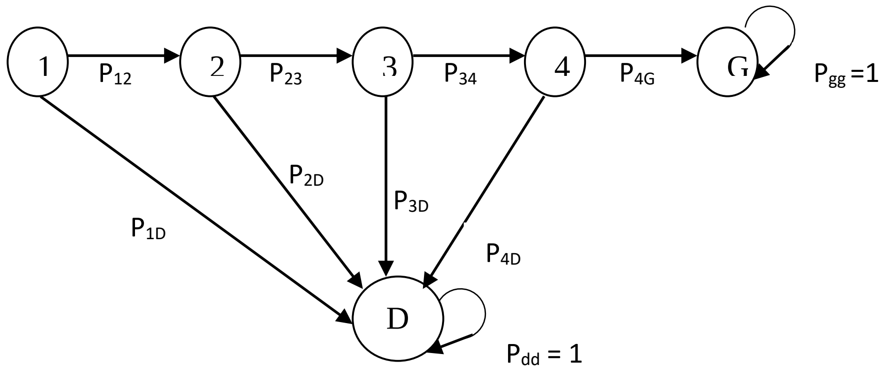

Figure 3.1. A graph representing the model with the parameters (states and transition probabilities).

From figure 3.1 the absorbing and the transient states are (G, D) and (1, 2, 3, 4) respectively. P_{ij}, i, j € E are corresponding probabilities of moving from a current state i to the next state j in a single step. Using figure 3.1 above, the matrix **P** described above is gotten and decomposed as follows:

Figure 3.2: Transition probability matrix in canonical form.

$$\mathbf{P} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ G \\ D \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & 4 & G & D \end{array} \\ \begin{pmatrix} 0 & p_{12} & 0 & 0 & 0 & p_{1D} \\ 0 & 0 & p_{23} & 0 & 0 & p_{2D} \\ 0 & 0 & 0 & p_{34} & 0 & p_{3D} \\ 0 & 0 & 0 & 0 & p_{4G} & p_{4D} \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \end{array} = \begin{array}{c} \\ TR \\ ABS \end{array} \begin{array}{c} \begin{array}{cc} TR & ABS \end{array} \\ \left[\begin{array}{c|c} \mathbf{Q} & \mathbf{R} \\ \hline \mathbf{0} & \mathbf{I} \end{array}\right] \end{array}$$

3.1. Retention Rates

These rates can be obtained directly from matrix **P** in figure 3.2 above**.** The retention rates for forms one, two, three and four are represented by p_{12}, p_{23}, p_{34} and p_{4G} respectively.

3.2: The matrix P has a Fundamental Matrix W and Absorption Time matrix T.

The matrix **P** described in figure 3.2 above has a matrix **W** given by:

$$\mathbf{W} = (\mathbf{I}-\mathbf{Q})^{-1} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} w_{11} & w_{12} & w_{13} & w_{14} \\ w_{21} & w_{22} & w_{23} & w_{24} \\ w_{31} & w_{32} & w_{33} & w_{34} \\ w_{41} & w_{42} & w_{43} & w_{44} \end{pmatrix} \end{array} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Where matrix **Q**, is the sub-matrix from figure 3.2.The values w_{ij}, in **W,** shows the expected time (in years) a student visits the j^{th} state having started from i^{th} state.

The entries t_i of Matrix **T** showing mean time to absorption starting from the ith state are:

$$\mathbf{T} = \mathbf{Wc} = \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix} \begin{pmatrix} t_1 \\ t_2 \\ t_3 \\ t_4 \end{pmatrix} \quad \ldots\ldots\ldots \quad (3)$$

Where **W** is equation (2) and **c =** (1, 1, 1, 1)^T.

3.3. Probabilities of being absorbed into states G or D i.e Matrix B given by

$$\mathbf{B} = \mathbf{WR} = \begin{matrix} \\ 1 \\ 2 \\ 3 \\ 4 \end{matrix} \begin{matrix} G & D \\ \left(\begin{matrix} b_{1G} & b_{1D} \\ b_{2G} & b_{2D} \\ b_{3G} & b_{3D} \\ b_{3G} & b_{4D} \end{matrix}\right) \end{matrix} \quad \ldots\ldots\ldots \quad (4)$$

Where **W** is equation 2 and **R** is sub-matrix from **P** in figure 3.2 above.

3.4. Comparison of retention rates, graduation / dropout rates and duration in schooling

In order to compare the two cohorts of students under investigation, we draw line graphs of the retention rates, graduation rates and duration in schooling. However, we assess the group differences in retention and graduation rates by performing independent two-sample proportions Z-test and to assess the group differences in average duration in schooling, we use independent two-sample means t-test.

4. Model Fitting

To apply the model, two-stage purposive sampling was used because the study is premised on the existence and operation of a school at least four years before and four after the launch of FSE in 2008. At stage one, 7 schools were purposively sampled from 17 public secondary schools in Kiambaa sub-county. At stage two, two cohorts of students were selected; a pre-2008 cohort comprising all form one admissions in the year 2004 and a post-2008 cohort comprising all form one admissions in the year 2009 in the same 7 school. The official documentary students records (admission books, class registers and KCSE print out) were used to get the form one admissions in the year 2004 [pre-2008 cohort] and 2007 [post-2008 cohort] and followed them up to the time they completed form 4 in the year 2007 and 2012 respectively.

4.1. Notations

The states space **E**= {1, 2, 3, 4, D, G} as described in section 3 above.

$\mathbf{P}_b$ and $\mathbf{P}_a$ = Probability transition matrices for the overall students enrollment before and after FSE policy respectively, in the 7 secondary schools in Kiambaa sub-county.

$\mathbf{P}_{mb}$ and $\mathbf{P}_{ma}$ = Probability transition matrices for the males before (mb) and males after (ma) FSE policy respectively, in the 7 secondary schools in Kiambaa sub-county.

$\mathbf{P}_{fb}$ and $\mathbf{P}_{fa}$ = Probability transition matrices for the females before (fb) and females after (fa) FSE policy respectively, in the 7 secondary schools in Kiambaa sub-county.

4.2. Summary of data

Table 4.1: Frequency transition data for the Pre-2008 Cohort.

CLASS	ENROLMENT			DROPOUTS		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
2004 F1	438	286	724	43	19	62
2005 F2	395	267	662	64	19	83
2006 F3	331	248	579	37	24	61
2007 F4	294	224	518	18	10	28
KCSE	276	214	490			

In table 4.1, out of the 724 (438 males and 286 females) form one admissions in 2004, only 490 (276 males and 214 females) of them sat for KCSE (graduated) in 2007. This gives estimated completion rates for the overall, males and females of 67.68%, 63.01% and 74.83% respectively before introduction of FSE.

Table 4.2: Frequency transition data for the Post-2008 Cohort.

CLASS	ENROLMENT			DROPOUTS		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
2009 F1	441	480	921	28	29	57
2010 F2	413	451	864	45	49	94
2011 F3	368	402	770	32	28	60
2012 F4	336	374	710	13	12	25
KCSE	323	362	685			

In table 4.2, out of 921 (441 males and 480 females) form one admissions in 2009, only 685 (323 males and 362 females) of them sat for KCSE (graduated) in 2012. This gives estimated completion rates for the overall, males and females of 74.38%, 73.24% and 75.42% respectively after FSE policy which was greater than 67.68%, 63.01% and 74.83% obtained before FSE.

4.3. Estimation of Probability Transition Matrices P_b, P_a, P_{mb}, P_{ma}, P_{fb} and P_{fa}

Using tables 4.1 and 4.2 we separately formed frequency transition matrices for the overall, males and females before and after FSE policy and then divided each entry of the row of the resulting matrices by its corresponding row total giving rise to P_b, P_a, P_{mb}, P_{ma}, P_{fb} **and** P_{fa}.

	STATES	1	2	3	4	G	D
	1	0.0000	0.9144	0.0000	0.0000	0.0000	0.0856
	2	0.0000	0.0000	0.8746	0.0000	0.0000	0.1254
P_b =	3	0.0000	0.0000	0.0000	0.8946	0.0000	0.1054
	4	0.0000	0.0000	0.0000	0.0000	0.9459	0.0541
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Where

$$\mathbf{Q}_{\mathrm{b}} = \begin{pmatrix} 0.0000 & 0.9144 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.8746 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.8946 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix}, \text{ and } \quad \mathbf{R}_{\mathrm{b}} = \begin{pmatrix} 0.0000 & 0.0856 \\ 0.0000 & 0.1254 \\ 0.0000 & 0.1054 \\ 0.9456 & 0.0541 \end{pmatrix}$$

	STATES	1	2	3	4	G	D
	1	0.0000	0.9381	0.0000	0.0000	0.0000	0.0619
	2	0.0000	0.0000	0.8912	0.0000	0.0000	0.1088
P$_a$ =	3	0.0000	0.0000	0.0000	0.9221	0.0000	0.0779
	4	0.0000	0.0000	0.0000	0.0000	0.9648	0.0352
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Where

$$\mathbf{Q}_{\mathrm{a}} = \begin{pmatrix} 0.0000 & 0.9381 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.8912 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.9221 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix}, \text{ and } \mathbf{R}_{\mathrm{a}} = \begin{pmatrix} 0.0000 & 0.0619 \\ 0.0000 & 0.1088 \\ 0.0000 & 0.0779 \\ 0.9648 & 0.0352 \end{pmatrix}$$

	STATES	1	2	3	4	G	D
	1	0.0000	0.9018	0.0000	0.0000	0.0000	0.0982
	2	0.0000	0.0000	0.8380	0.0000	0.0000	0.1620
P$_{mb}$=	3	0.0000	0.0000	0.0000	0.8820	0.0000	0.1180
	4	0.0000	0.0000	0.0000	0.0000	0.9388	0.0612
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

where

$$\mathbf{Q}_{\mathrm{mb}} = \begin{pmatrix} 0.0000 & 0.9018 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.8380 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.8882 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix}, \mathbf{R}_{\mathrm{mb}} = \begin{pmatrix} 0.0000 & 0.0982 \\ 0.0000 & 0.1620 \\ 0.0000 & 0.1118 \\ 0.9388 & 0.0612 \end{pmatrix}$$

	STATES	1	2	3	4	G	D
	1	0.0000	0.9365	0.0000	0.0000	0.0000	0.0635
	2	0.0000	0.0000	0.8814	0.0000	0.0000	0.1186
P$_{ma}$=	3	0.0000	0.0000	0.0000	0.9130	0.0000	0.0870
	4	0.0000	0.0000	0.0000	0.0000	0.9613	0.0387
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Where

$$\mathbf{Q}_{\text{ma}} = \begin{pmatrix} 0.0000 & 0.9365 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.8814 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.9130 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix} \text{and } \mathbf{R}_{\text{ma}} = \begin{pmatrix} 0.0000 & 0.0635 \\ 0.0000 & 0.1186 \\ 0.0000 & 0.0870 \\ 0.9613 & 0.0387 \end{pmatrix}$$

	STATES	1	2	3	4	G	D
	1	0.0000	0.9336	0.0000	0.0000	0.0000	0.0664
	2	0.0000	0.0000	0.9288	0.0000	0.0000	0.0712
$\mathbf{P}_{fb}$=	3	0.0000	0.0000	0.0000	0.9032	0.0000	0.0968
	4	0.0000	0.0000	0.0000	0.0000	0.9554	0.0446
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Where

$$\mathbf{Q}_{\text{fb}} = \begin{pmatrix} 0.0000 & 0.9336 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.9288 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.9032 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix} \text{and } \mathbf{R}_{\text{fb}} = \begin{pmatrix} 0.0000 & 0.0664 \\ 0.0000 & 0.0712 \\ 0.0000 & 0.0968 \\ 0.9554 & 0.0446 \end{pmatrix}$$

	STATES	1	2	3	4	G	D
	1	0.0000	0.9396	0.0000	0.0000	0.0000	0.0604
	2	0.0000	0.0000	0.8914	0.0000	0.0000	0.1086
$\mathbf{P}_{fa}$=	3	0.0000	0.0000	0.0000	0.9303	0.0000	0.0697
	4	0.0000	0.0000	0.0000	0.0000	0.9679	0.0321
	G	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	D	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

Where

$$\mathbf{Q}_{\text{fa}} = \begin{pmatrix} 0.0000 & 0.9396 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.8914 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.9303 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 \end{pmatrix} \text{and } \mathbf{R}_{\text{fa}} = \begin{pmatrix} 0.0000 & 0.0604 \\ 0.0000 & 0.1086 \\ 0.0000 & 0.0697 \\ 0.9679 & 0.0321 \end{pmatrix}$$

4.4. Comparison of retention rates before and after FSE policy

From matrix $\mathbf{P}_b$ the overall' retention rates before FSE were 0.9144, 0.8746, 0.8946, 0.9459 and after FSE from $\mathbf{P}_a$ were 0.9381, 0.8912, 0.9221, 0.9648 for forms one, two, three and four respectively. The retention rates for all classes improved post-2008 compared to pre-2008 situation (see Figure 4.1 below), which was quite expected since the financial constraints have been minimized by the government through paying tuition fees. However, the Z-test results for difference in retention rates before and after FSE policy was significant in forms 1 and 3 [p= 0.0329 and p=0.0401<0.05 respectively]. But, insignificant in forms 2 and 4 [p= 0.1587 and p=0.0537>0.05 respectively], suggesting that, for students in these two classes, there are underlying factors that influence retention other than inability to meet the cost of tuition. This unseemly situation requires qualitative methods like interviews and group discussions to establish the reason(s) behind it.

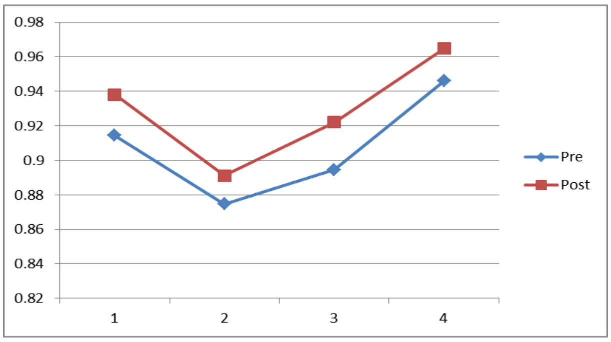

Figure 4.1: Line graph for Overall' Retention rates before (pre) and after(post) FSE policy.

From matrix $\mathbf{P}_{mb}$ the males' retention rates before FSE were 0.9018, 0.8380, 0.8820, 0.9388 and after FSE from $\mathbf{P}_{ma}$ were 0.9365, 0.8814, 0.9130, 0.9613 for forms one, two, three and four respectively. The males' retention rates for all classes improved post-2008 compared to pre-2008 situation as can be seen from the graph (Figure 4.2 below) which is due to reduced financial constraint through FSE policy. However, the Z-test results for difference in males' retention rates before and after FSE, showed significance in forms 1 and 2 [$p= 0.0294$ and $p=0.0139<0.05$ respectively] but insignificant in forms 3 and 4 [$p= 0.1357$ and $p=0.0968>0.05$ respectively] which could be due to negative peer pressure, identity crisis and deviant behavior of boys at form 3 and 4.

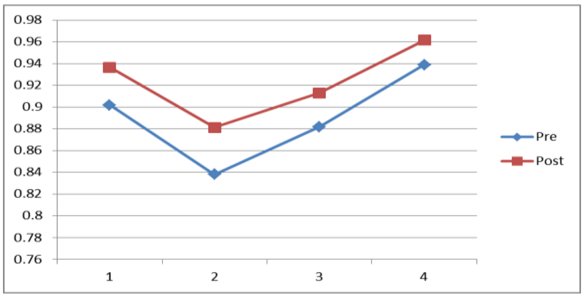

Figure 4.2: Line graph for males' retention rates before (Pre) and after (Post) FSE policy

The females' retention rates before FSE policy from matrix $\mathbf{P}_{fb}$ were 0.9336, 0.9288, 0.9032, 0.9554 and after FSE from $\mathbf{P}_{fa}$ were 0.9396, 0.8914, 0.9303, 0.9679 for forms one, two, three and four respectively. The retention rates for all classes improved in post-2008 compared to pre-2008 situation except in form 2 (see Figure 4.3 below). A possible reason is that in form two, the age factor, peer influence and the rebellious nature of teenagers at that age may have more impact on dropout than inability to pay school fees. However, the Z-test results for difference in females' retention rates before and after FSE showed significance in forms 2 [$Z_c=-1.6542$, $p= 0.0495<0.05$] implying that the retention rate of form 2 girls was higher in the period before the introduction of FSE than after FSE, calling on the government and the stakeholders to find out the underlying factors that may have more impact on female dropping out of school rather than inability to pay school fees. But no significant difference in forms 1, 3 and 4 [$p= 0.3707$, 0.1075 and $p=0.2148>0.05$ respectively].

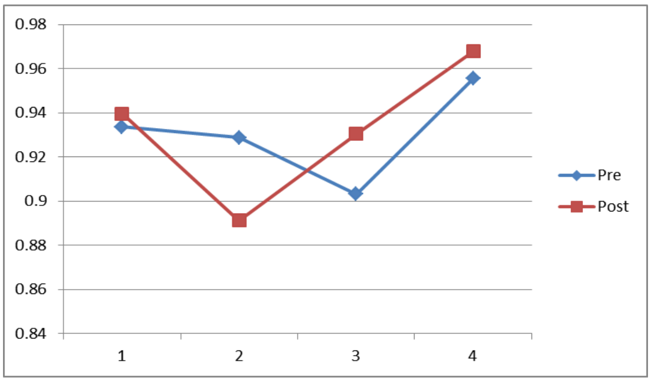

Figure 4.3: Line graph for retention rates for females before (Pre) and after (Post) FSE.

4.5. The Results of Fundamental Matrices $\mathbf{W_b}$,$\mathbf{W_a}$, $\mathbf{W_{mb}}$, $\mathbf{W_{ma}}$, $\mathbf{W_{fb}}$ and $\mathbf{W_{fa}}$

Using equation (2), the above matrices are obtained and were as below:

$$\mathbf{W_b} = \begin{pmatrix} 1.0000 & 0.9144 & 0.7997 & 0.7155 \\ 0.0000 & 1.0000 & 0.8746 & 0.7825 \\ 0.0000 & 0.0000 & 1.0000 & 0.8946 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$ and

$$\mathbf{W_a} = \begin{pmatrix} 1.0000 & 0.9381 & 0.8360 & 0.7709 \\ 0.0000 & 1.0000 & 0.8912 & 0.8218 \\ 0.0000 & 0.0000 & 1.0000 & 0.9221 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$ Where $\mathbf{W_b} = (\mathbf{I} - \mathbf{Q_b})^{-1}$ and $\mathbf{W_a} = (\mathbf{I} - \mathbf{Q_a})^{-1}$

$$\mathbf{W_{mb}} = \begin{pmatrix} 1.0000 & 0.9018 & 0.7557 & 0.6712 \\ 0.0000 & 1.0000 & 0.8380 & 0.7443 \\ 0.0000 & 0.0000 & 1.0000 & 0.8882 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$ and

$$\mathbf{W_{ma}} = \begin{pmatrix} 1.0000 & 0.9365 & 0.8345 & 0.7619 \\ 0.0000 & 1.0000 & 0.8910 & 0.8136 \\ 0.0000 & 0.0000 & 1.0000 & 0.9130 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$, Where $\mathbf{W_{mb}} = (\mathbf{I} - \mathbf{Q_{mb}})^{-1}$ and $\mathbf{W_{ma}} = (\mathbf{I} - \mathbf{Q_{ma}})^{-1}$

$$\mathbf{W_{fb}} = \begin{pmatrix} 1.0000 & 0.9336 & 0.8671 & 0.7832 \\ 0.0000 & 1.0000 & 0.9288 & 0.8390 \\ 0.0000 & 0.0000 & 1.0000 & 0.9032 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$ and

$$\mathbf{W_{fa}} = \begin{pmatrix} 1.0000 & 0.9396 & 0.8375 & 0.7792 \\ 0.0000 & 1.0000 & 0.8913 & 0.8293 \\ 0.0000 & 0.0000 & 1.0000 & 0.9304 \\ 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix}$$, Where $\mathbf{W_{fb}} = (\mathbf{I} - \mathbf{Q_{fb}})^{-1}$ and $\mathbf{W_{fa}} = (\mathbf{I} - \mathbf{Q_{fa}})^{-1}$

4.6. The Absorption times T_a, T_b, T_{mb}, T_{ma}, T_{fb} and T_{fa}

Using equation (3), the above absorption times were obtained and the results were:

$$\mathbf{T}_a = \begin{pmatrix} 3.5451 \\ 2.7130 \\ 1.9221 \\ 1.0000 \end{pmatrix}, \mathbf{T}_b = \begin{pmatrix} 3.4295 \\ 2.6571 \\ 1.8946 \\ 1.0000 \end{pmatrix}, \mathbf{T}_{mb} = \begin{pmatrix} 3.3288 \\ 2.5823 \\ 1.8882 \\ 1.0000 \end{pmatrix}, \mathbf{T}_{ma} = \begin{pmatrix} 3.5329 \\ 2.7046 \\ 1.9130 \\ 1.0000 \end{pmatrix}, \mathbf{T}_{fb} = \begin{pmatrix} 3.5839 \\ 2.7678 \\ 1.9032 \\ 1.0000 \end{pmatrix} \mathrm{T}_{fa} = \begin{pmatrix} 3.5562 \\ 2.7206 \\ 1.9304 \\ 1.0000 \end{pmatrix}$$, where $\mathbf{T_a}=\mathbf{W_a}$*c, $\mathbf{T_b}=\mathbf{W_b}$*c, $\mathbf{T_{mb}}=\mathbf{W_{mb}}$*c, $\mathbf{T_{ma}}=\mathbf{W_{ma}}$*c, $\mathbf{T_{fb}}=\mathbf{W_{fb}}$*c, $\mathbf{T_{fa}}=\mathbf{W_{fa}}$*c.

4.7. Comparison of Absorption Times before and after FSE policy

The overall absorption times T_a (POST) was slightly higher than T_b (PRE), see figure 4.4 below. However, the two sample t-test for difference in the average duration in schooling before (T_b) and after (T_a) FSE policy was found to be insignificant [p=0.4747 >0.05].

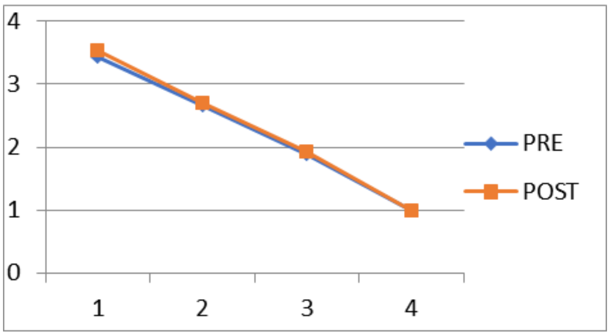

Figure 4.4: Line graphs of absorption times before (PRE) and after (POST) FSE policy.

The average duration in schooling for males after FSE (T_{ma}) is slightly higher than before FSE (T_{mb}) see figure 4.5 below. However, the t-test results on difference in males average duration in schooling before and after FSE policy, were insignificant [p=0.4544 >0.05].

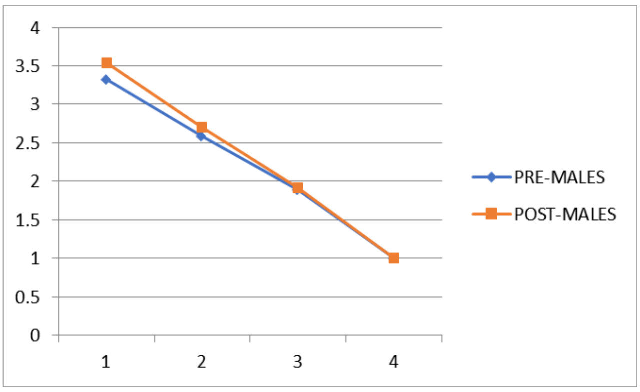

Figure 4.5: Line graph for Absorption time for males before (PRE-MALES) and after(POST-MALES) FSE policy.

From matrices T_{fb} and T_{fa}, the average duration in schooling for females after and before FSE policy are almost the same, (see Figure 4.6 below). However, the t-test results on difference in female average duration in schooling before and after FSE policy was insignificant. [p=0.4941 >0.05].

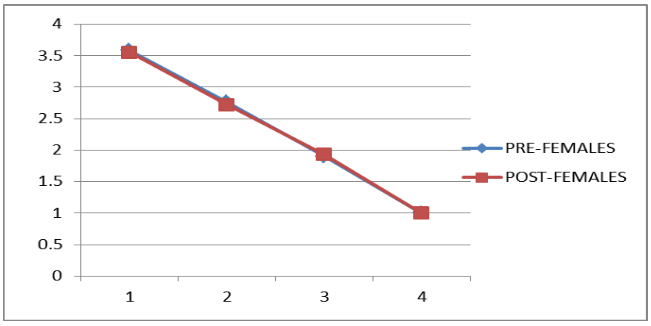

Figure 4.6: Line graph for Absorption time for females before (PRE-FEMALES) and after (POST-FEMALES) FSE policy.

4.8. Absorption Probabilities B_b, B_a, B_{mb}, B_{ma}, B_{fb} and B_{fa}

Using equation (4), the above probabilities are obtained and the results were as below.

$$\mathbf{B}_\mathrm{b} = \begin{pmatrix} 0.6765 & 0.3235 \\ 0.7399 & 0.2601 \\ 0.8460 & 0.1540 \\ 0.9456 & 0.0544 \end{pmatrix}, \mathbf{B}_\mathrm{a} = \begin{pmatrix} 0.7438 & 0.2562 \\ 0.7928 & 0.2072 \\ 0.8896 & 0.1104 \\ 0.9648 & 0.0352 \end{pmatrix}, \mathbf{B}_\mathrm{mb} = \begin{pmatrix} 0.6301 & 0.3699 \\ 0.6987 & 0.3013 \\ 0.8338 & 0.1662 \\ 0.9388 & 0.0612 \end{pmatrix}$$

$$\mathbf{B}_\mathrm{ma} = \begin{pmatrix} 0.7324 & 0.2676 \\ 0.7821 & 0.2179 \\ 0.8777 & 0.1223 \\ 0.9613 & 0.0387 \end{pmatrix}, \mathbf{B}_\mathrm{fb} = \begin{pmatrix} 0.7483 & 0.2517 \\ 0.8015 & 0.1985 \\ 0.8629 & 0.1371 \\ 0.9554 & 0.0446 \end{pmatrix} \text{ and } \mathbf{B}_\mathrm{fa} = \begin{pmatrix} 0.7542 & 0.2458 \\ 0.8027 & 0.1973 \\ 0.9005 & 0.0995 \\ 0.9679 & 0.0321 \end{pmatrix} \text{ where}$$

$B_b=W_b*R_b$, $B_a= W_a*R_a$, $B_{mb}=W_{mb}*R_{mb}$, $B_{ma}= W_{ma}*R_{ma}$, $B_{fb}=W_{fb}*R_{fb}$ and $B_{fa}= W_{fa}*R_{fa}$,

4.9. Comparison of graduation probabilities before and after FSE policy

The overall graduation probabilities before FSE **(**from matrix **B**$_b$) were 0.6765, 0.7399, 0.8460, 0.9456 and after FSE **(**from matrix **B**$_a$) were 0.7438, 0.7928, 0.8896, 0.9648 in forms one, two, three and four respectively. The probability of graduating after FSE was higher than before FSE as seen in figure 4.7 below, which is quite expected due to increased retention rates discussed above. However, the Z-test results on difference in completion rates of a form 1 student completing the secondary school after and before FSE, was found to be significant [p=0.0052 < 0.05].

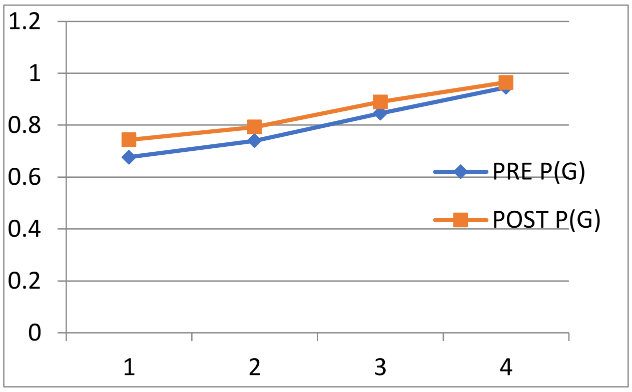

Figure 4.7: Line graphs for overall graduation probability before (PRE) and after(POST) FSE policy.

The probability of males graduating before FSE **(**from matrix **B**$_{mb}$) were 0.6301, 0.6987, 0.8338 0.9388 and after FSE **(**from matrix **B**$_{ma}$) were 0.7324, 0.7821, 0.8777, 0.9613 in forms one, two, three and four respectively. The probability of a male student reaching graduation stage after FSE policy is higher than before FSE policy in all the classes [Figure 4.8 below]. However, the Z-test results for difference in male completion rate before and after FSE policy was significant [p=0.0014<0.05]. That is, the probability of a male student who joins form one post- 2008 graduating from the system is higher than one who joined form one pre- 2008.

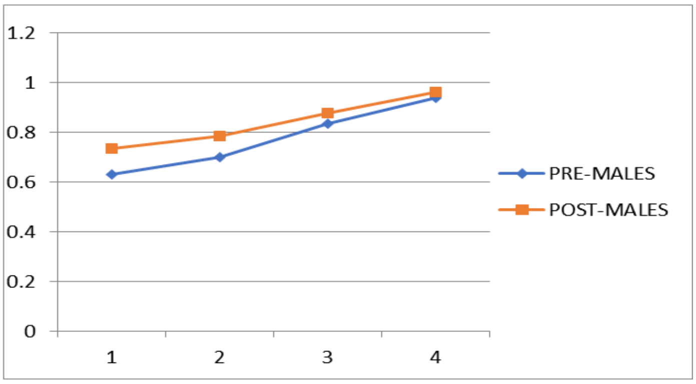

Figure 4.8: Line graphs for males' graduation probabilities before and after FSE policy.

The probabilities of females graduating before FSE (from matrix B_{fb}) were 0.7483, 0.8015, 0.8629, 0.9554 and after FSE **(**from matrix $\mathbf{B}_{fa}$) were 0.7542, 0.8027, 0.9005, 0.9679 in forms one, two, three and four respectively. The probability of a female student reaching graduation stage after FSE policy is slightly higher than before FSE policy in some classes [Figure 4.9 below]. However, the Z-test results for difference in female completion rate before and after FSE policy, were insignificant [$p=0.4522 > 0.05$]. In other words, the probability of a female student who joins form one post- 2008 graduating from the system is not different from the one who joined at least four years before introduction of FSE. Some plausible explanations are that usually girls marry earlier than boys, early pregnancies and therefore dropout of school before completing their education. In addition, rich household parents might have transferred their daughters to private schools since the Kenyan government did not impose any restriction on attending private secondary schools.

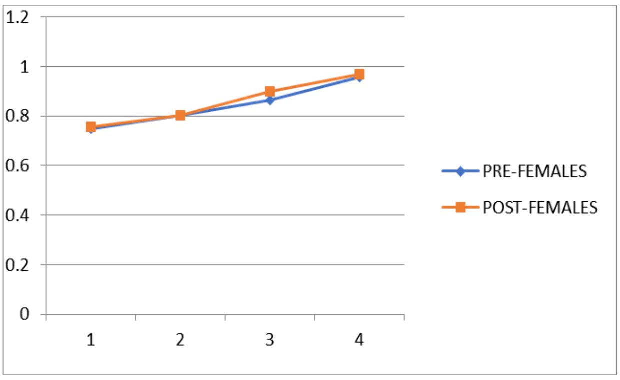

Figure 4.9: Line graphs for female graduation probabilities before(PRE) and after(POST) FSE

5. CONCLUSION

FSE policy has increased students' enrollment in secondary schools but has not succeeded in improving gender balance as evidenced by the low boys' enrollment as compared to girls and therefore there is need to expand opportunities for access to boys by establishing more day and boarding schools for boys in Kiambaa sub-county

FSE policy has impacted positively in form 1 and 3 for the overall students' retention rates, in form 1 and 2 for the male students' retention rates and negatively in form 2 females' retention rates. Sensitization and studies to be done in Kiambaa sub-county to increase the female students' retention and completion rates.

The average duration in schooling of secondary students in Kiambaa sub-county has remained relatively the same, calling on the government and stakeholders to find out why this is so.

The program has impacted positively towards the completion rates of the overall and the male students but no impact in female completion rates. All in all, further research should be done on student background variables and institution factors that may influence the students' progression in secondary schools.

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