AGE MIGRATION SCHEDULES IN KENYA

BY

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DECLARATION

This project is my original work and has not been presented for a degree in any other university.

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Q56/80151/2012

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DEDICATION

This Research Project is dedicated to my parents, Jane Awuor and Albert Attitolyech, who have always been my source of inspiration, drive and discipline, thus enabling me to tackle any task coming my way with enthusiasm and determination. Without their love and support, this project would not have been accomplished.

ABSTRACT

Since their introduction, migration model schedules have become firmly established as an important part of the toolbox of methods for the analysis of migration age patterns. Empirical regularities in age pattern characterize observed migration schedules in ways that are no less important than the corresponding well-established regularities in observed fertility or mortality schedules.

The study focused on whether the patterns and consequences of internal migration and national population redistribution experienced by all nations were similar worldwide. Looking at observable regularities in age pattern exhibited by origin-destination specific rates of migration, the study sought to respond to the need of finding out whether such regularities hold all over the world taking into consideration that similar studies had mostly focused on developed nations. This study was motivated by two research questions: do age profiles of migrants in Kenya exhibit regularities as captured by the model migration schedule? Can summary measures and parameter estimates of the model migration schedules be graduated from observed Kenyan migration data for comparative analysis?

To answer these questions, transition-type data derived from census questions on migration were used to calculate out-migration probabilities for all the regions. The Model Migration Schedule was fitted in Microsoft Excel workbook in four steps. Subsequently, the study went further to illustrate the opportunities presented by the model migration schedules and how demographers could take advantage of them.

The study adopted the most commonly found schedule; the 7- parameter standard schedule, which comprises of three components: a constant, a negative exponential curve representing the pre-labor force ages, and a double exponential (unimodal) curve representing the labor force ages. The migration probability curve as observed from the Kenyan out-migration regional schedules is slightly high during infancy, and becomes extremely low during the ages of compulsory education, sharply rises after compulsory education has been completed, reaching the highest peak between the ages of 14 and 24, and gradually declines thereafter.

It seems evident, in consequence that the multiple parameter model migration schedule, attempts to describe the regularities in age profile exhibited by internal regional out-migration flows in Kenya.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

Migration in developing countries lately has drawn a great deal of academic attention, in view of the necessity to solve aggravating social problems associated with the population concentration in urban areas and also in view of the administrative needs to plan regional development. The research on the mechanism of such migration had not much progressed in the field of the population studies, partly due to the larger complexity of the mechanism than those of fertility and mortality studies and also partly due to the poor availability of basic data. However, developments of modeling the migration patterns by age group, as a mathematical function in the similar manner with fertility and mortality models, made it possible to conduct an international comparative study through the evaluation of parameters of each country.

Though the age specific migration rate varies greatly as does birth and death, there is a considerable difference in the manner in which each is generated. For instance, the birth probability by age normally draws a relatively simple exponential curve that reaches its highest in the ages of mothers between 20 and 25 years old and becomes lower on either side of that age group as the age becomes farthest apart from it; the death probability likewise draws a relatively simple curve, the normal pattern being a high level during babyhood but declining fairly steeply until the lower teens and rising gradually thereafter, except in very rare occasions such as in pre-war Japan when a small peak was observed around the age of 20. By contrast, the migration probability curve is slightly high during infancy, and becomes extremely low during the ages of compulsory education, sharply rises after compulsory education has been completed, reaching the highest peak between the ages of 15 and 25, and gradually declines thereafter. In some areas, a small peak appears again between the ages of 50 and 60; the curve is a complex one with one trough and two peaks.

The foregoing means that the probability of birth, death and migration is regulated by age which represents the lapse of time during one’s life, but needless to say, there is a decisive difference in the way each of these variables are regulated. The curves drawn by birth probability and death probability, therefore, are basically of a pattern common to all mankind that is, with a trough or a peak appearing at approximately the same ages for all mankind. The migration probability curve, however, not only greatly varies according to the differences in cultural and socio-economic conditions, but the probability of its occurrence is susceptible to change by the impact of other cultures and changes in various conditions, with the result that the number of troughs and peaks in the curve, and the ages at which they occur, differ greatly by areas.

Also, birth (entry) and death (the unilateral withdrawal) of an individual into and from the population, are experienced only once in the life of that individual. On the other hand, the two aspects of migration, namely, withdrawal (outflow) and entry (inflow) can be experienced a number of times during the life of an individual. Furthermore, while birth and death are each an independent phenomenon, withdrawal (outflow) and entry (inflow) are mutually interdependent as withdrawal from a certain area is accompanied by the entry into another area: and while birth or death may take place at only one place, the places where withdrawal (outflow) occurs and where entry (inflow) occurs in the latter case are different. Those differences influence the relative ease of statistically grasping and analyzing the two. They largely explain why birth and death statistics are better kept compared to migration statistics and also why the subject of migration in the field of demography has not been analyzed in depth and why there is only a relatively small accumulation of research results.

However, the curves drawn by the occurrence probabilities of birth, death and migration are common in the respect that they, by nature, all follow an exponential function. So, although the curves drawn by birth and death may be said to be relatively simple, they are only so in comparison to migration probability and actually their curves in themselves are fairly complex.

In spite of such complexity, the recent accumulation of research results on birth and death in mathematical demography has been remarkable, and particularly the mathematical expression called the model schedule has made it possible to summarize and systematically organize the regularity of the probability of their occurrence by age group; for example, preparation of the model life table has made it possible to advance demographic analysis in the developing countries where data are incomplete or doubtful because both birth and death are phenomena which draw relatively simple curves. In the case of migration, however, the development of a model schedule was unsuccessful due to the complexity of the curve depicting probability of occurrence by age group. It was Andrei Rogers who generated a model for migration schedule.

The current study intends to apply the migration schedule as part of the study on out-migration patterns in Kenya by sex and age and aims to analyze regional out-migration by using such a schedule. The regions considered were formerly known as Provinces at the time the 2009 Housing and Population Census was conducted. The Provinces were later divided into 47 counties for administrative purposes following the 2010 constitution and became established after the 2013 general elections.

1.2 Problem Statement

Internal migration and national population redistribution are universal phenomena experienced by all nations. But are their patterns, antecedents, and consequences similar worldwide? Are there observable regularities in age pattern exhibited by origin-destination specific rates of migration? Do such regularities hold all over the world? Why do they? How might demographers take advantage of them? At the International Institute for Applied Systems Analysis in Austria, demographers first began to address these questions in the late 1970’s by assembling an international data base on contemporary internal migration in the developed nations and successfully fitting these data with a mathematical function, since called the Rogers Castro multiexponential model migration schedule (Rogers and Castro 1981a).

Rogers and Castro (1981a) put forward three families of multiexponential model migration schedules: a standard 7-parameter model, a 9-parameter elderly post-retirement migration model, and an 11-parameter elderly retirement peak model. Several years later, Rogers and Watkins (1987) added a 13-parameter elderly retirement peak plus post-retirement model. Their analysis of over 500 age profiles of migration found throughout the more developed world made the convincing argument that migration has strong regularities in age patterns, much like fertility and mortality. The most commonly found schedule is the standard schedule, which comprises of three components: a constant, a negative exponential curve representing the pre-labor force ages, and a double exponential (unimodal) curve representing the labor force ages.

Multiexponential model migration schedules have since been used for describing, smoothing, and inferring age-specific migration patterns in a wide variety of contexts (Bates and Bracken 1982; Bates and Bracken 1987; Holmberg 1984; Kawabe 1990; Liaw and Nagnur 1985; Potrykowska 1986; Rogers 1988; Rogers and Rajbhandary 1997; Rogers and Raymer 1999). It seems evident, in consequence, that the multiple parameter model migration schedule, adequately describes the regularities in age profile exhibited by internal migration flows in the developed world today. What about migration in the less developed countries and historical migration patterns? It is clear that up to the present, model schedules, that is, the mathematical modeling of migration patterns, have not been applied to Kenyan migration data. With the increased emphasis on applied and applicable research, purely qualitative descriptions could become inadequate. It is obvious that the ability to quantify patterns, especially in the form of mathematical expressions, is of great significance.

1.3 Research Questions

This research seeks to address two questions: first, do age profiles of migrants in Kenya exhibit regularities as captured by the Model Migration Schedule and Secondly, can summary measures and parameter estimates of the Model Migration Schedule be graduated from observed Kenyan migration data for comparative analysis?

1.4 Research Objectives

The general objective of this study is to apply the Model Migration Schedule to represent age specific migration flows in Kenya. Specifically, the study seeks:

1. To describe age-specific migration flows in Kenya.
2. To derive summary measures and estimate parameters for comparative analysis using the Model Migration Schedule.

1.5 Justification of Study

Since their introduction model schedules have become firmly established as an important part of the toolbox of methods for the analysis of migration age patterns. Empirical regularities in age pattern characterize observed migration schedules in ways that are no less important than the corresponding well-established regularities in observed fertility or mortality schedules. Capturing such regularities in the form of model schedules could be used to assess the reliability of empirical migration data and indicate appropriate strategies for their correction, and they also may be used to help resolve problems caused by missing data (Raymer and Rogers 2006). Mathematical representations of age patterns of rates or probabilities (model schedules) have enabled demographers to define age-specific patterns with continuous functions described with relatively few parameters. In a nut shell, model schedules could be useful in:

1. Estimation: where migration data are missing or suspect (e.g. Rogers and Jones 2008, Rogers, Jones and Ma 2008);

2. Graduation: especially where observed migration age patterns contain a lot of noise (e.g. Congdon 1993, Raymer and Rogers 2007);

3. Comparative analyses: a small number of parameters facilitate comparisons of migration age patterns over space and time (e.g. Rogers and Castro 1981, Ishikawa 2001);

4. Data reduction: a large number of age-specific migration intensities are replaced by a small number of parameters, thus reducing memory use in computer programmes for projections (e.g. Rees 1996);

5. Projection: Historical time series of parameters are extrapolated to project the shape of migration profiles into the future (e.g. Rogers 1986)

Much of the literature on model migration schedules has argued that they provide accurate descriptions of internal migration age patterns across the developed nations and over time (Wilson, 2010).

This study hopes to show that the Rogers-Castro model migration schedule also describes migration age patterns in Kenya. With this conformity in similarity of migration age patterns worldwide, such regularities could be drawn to infer age-specific migration rates, improve the quality of collected data and facilitate comparisons of migration age patterns over space and time and to project future migration patterns

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

This section reviews the literature on studies which have been undertaken on Model Migration Schedules in order to provide a basis for the study. We shall examine the works that have been done worldwide.

2.2 Model Migration Schedules

Improved methods for measuring migration and understanding its important role in spatial population dynamics have been receiving increasing attention in recent years. The search for improved methods for measuring migration has, for example, stimulated research on the construction of multiregional life tables and demographic accounts, and the need for a better understanding of spatial population dynamics has fostered mathematical analyses of the fundamental processes of spatial population growth and redistribution (Rogers 1980).

The migration literature has until very recently adopted a curiously ambivalent position with regard to migration measurement. The paucity of work in migration measurement problems is in distinct contrast to the corresponding demographic literature in mortality and fertility – a literature that is richly endowed with detailed discussions of measurement problems. It is natural to look to the state of mortality and fertility measurement for guidance in developing measures of migration. Research on mobility has been broadly concerned with the estimation of migration flows, the identification of migration propensities by age, sex and other characteristics and with explanation migration by economic and social determinants. This approach has yielded useful results but it has also raised some new questions.

One of the most important regularities observed in human migration is its relationship to age. This may be attributed to the relationship of age to other characteristics of migrants and to other aspects of the family life-cycle and work (Courgeau 1985, p.139). As statistical schedules of the general structures of population according to the rates of age-specific fertility or mortality demonstrate, that remarkably persistent regularities are characteristic of most human populations. In demographic terminology they are known as hypothetical model schedules.

2.2.1 Regularities in the Age Patterns of Migration

Empirical schedules of age-specific rates exhibit remarkably persistent regularities in age pattern. Mortality schedules, for example, normally show a moderately high death rate immediately after birth, after which the rates drop to a minimum between ages 10 and 15, and then increase slowly until about age 50, and thereafter rise at an increasing pace until the last years of life. Fertility rates generally start to take on nonzero values at about age 15 and attain a maximum somewhere between ages 20 and 30; the curve is unimodal and declines to zero once again at some age close to 50. Similar unimodal profiles may be found in schedules of first marriage, divorce, and remarriage.

The most prominent regularity in age-specific schedules of migration is the high concentration of migration among young adults; rates of migration also are high among children, starting with a peak during the first year of life, dropping to a low point at about age 16, turning sharply upward to a peak near 20 to 22, and declining regularly thereafter, except for a possible slight hump at the onset of retirement and possibly an upward slope after that hump.

Underlying these persistent regularities in the age patterns of migration are a collection of different cause-specific age patterns (Rogers and Castro 1981b). For example, migrations due to marriage and education are concentrated between the ages of 10 and 30 years and are essentially unimodal in age profile. Migrations caused by change of employment and moving closer to the place of work have profiles that are bimodal, with local peaks during infancy and during the early years of labor-force participation. The age profiles of housing reasons for migration are similar to those of the aggregate migration schedule, exhibiting roughly the same peaks: during the early years of labor force participation, and at retirement. Finally, health is apparently an important cause of migration only for the elderly.

The different cause-specific age patterns may be interpreted within a life course framework in which individuals pass through different states of existence (Elder 1985). Starting with birth and then entry into the educational system at the elementary level, the “passage” may also include entry into military service or university, marriage, multiple entries into and withdrawals from the labor force, perhaps divorce and remarriage, retirement, death of spouse, and moves to enter sanatoria or to rejoin relatives. Life course analysis focuses on the processes of change and ultimately seeks to explain such change.

The formal demography of migration and population redistribution views interregional population transfers as a collection of independent individual movements. Yet it is widely recognized that a large fraction of total migration is accounted for by individuals whose moves are dependent on those of others, for example; children migrating with their parents, wives with their husbands, grandparents with their children. Indeed, family migration is such a well established phenomenon that Ryder (1978) has even suggested its use as a criterion for identifying family membership: a family comprises of those individuals who would migrate together. Hence, to the extent that migration is undertaken by families as a unit, the age composition of migrants tells us something about family patterns.

To better understand the influences that family and dependency relationships have on migration age compositions, Castro and Rogers (1983a and 1983b) have illustrated how by disaggregating migrants by age, sex, and dependent/independent categories, it is possible to illustrate a number of ways in which the aggregate age profile of migration is sensitive to relative changes in dependency levels and in rates of natural increase and mobility. Viewing the migration process within a framework of dependent and independent movements allows one to observe, for example, that if the independent component is mainly comprised of single persons, then the associated dependent migration may be insignificant in terms of its relative share of the total migration. On the other hand, if migration tends to consist primarily of family migration, then the share of dependent children may become a very important component of the aggregate migration age pattern. In short, just as observed population age compositions reflect particular characteristics of past fertility and mortality regimes, so do observed migration age compositions reflect key aspects of a population’s age composition. The reverse relationship also holds true. Just as observed migration age compositions reflect particular age compositions of populations, so population compositions influence key aspects of migration age compositions (Little and Rogers 2007).

2.2.2 Case Studies of Age Patterns and Model Migration Schedules

South Africa

Migration studies in a number of countries have shown a common age-dependent characteristic of the type illustrated in Figure 2. The studies show the fundamental age pattern of migration with peaks occurring at infancy, young adulthood and retirement. Shaw (1975:18) refers to a large number of studies which corroborate the proposition that adult persons in the age group 20-29 years have the greatest propensity to migrate. It has also been demonstrated that in a number of the more industrialized countries an upturn in migration appears at about age 65.

South Africa successfully applied the mathematical model to their 1975-1980 migration data. In his findings, B. E Hofmeyr (1988) found that:

- Migration rates among young children reflect the relatively high rates of their parents, who are young adults in their late twenties. Young teens revealed a local low point around age 15. Young adults in their early twenties generally have the highest migration rates attaining a high peak at about age 22 (females) or 25 (males). After this age the migration rate as a function of age declines monotonically until it reaches the so called retirement peak at ages around 60 (females) and 65 (males).

- The age profiles of male and female migration show a distinct difference. The high peak of the female schedule is a little higher and precedes that of the male schedule by approximately 3 years which appears to be in line with the difference between the average ages at marriage of the two sexes and the fact that females usually move to their husband's place of residence. The male rates are higher from the mid-twenties to the mid-fifties and lower at most other ages. However, the absolute numbers of migrants coincide between the male ages of 33 and 57 if the female curve is displaced to a higher age by about 3 years, which might fit in with a dominant migration of couples.

- The retirement peak among females is somewhat higher and broader and starts at an earlier age than for males and is also shifted by about 3 years with respect to males. This would be consistent with both migration by couples and the fact that women usually retire 5 years earlier in South Africa.

- When comparing numbers, after the age of 55 consistently more women migrate than men, in line with their lower mortality and resulting widowhood.

Poland

In Poland, model migration schedules were primarily used to assess the temporal stability of age and sex-specific migration. The age profiles of male and female migration schedules in Poland showed a distinct and consistent difference. The high peak of the female schedule preceded that of the male schedule by an amount that appeared to approximate the difference between the average ages at marriage of the two sexes. The multinational comparative studies indicate that the level of inter-regional migration depends on the size of the areal unit selected, if the areal unit chosen is such as a county or a commune, a greater proportion of residential relocation will be included as migration than if the areal unit chosen is a major administrative division such as a state or a province.

The age profiles of migration schedules in Poland as measured by different sizes of areal units were remarkably similar and indicated that the regularity in age patterns persist across areal delineations of different size. According to the definition of migration rates, the analysis of migration patterns in Poland, reflected the level at which migration occurred out and into a given region. Out-migrations disaggregated into 12 destinations revealed that high mobility was connected with short distances. The schedules also showed additional peaks describing the high out-migration of the labor force age groups (40 to 50), which could be explained by a high out-migration of the qualified persons to the neighboring centers of the new voivodships.

The additional peaks described the elderly migration of people aged 60, 70 years and over. An analysis of the aggregated age patterns of out-migration from each of the 13 regions to the rest of Poland revealed that the lowest values of the parameter a_2, describing the level of the labor force component, are characteristic of areas of strong in-migration. Schedules for the Warsaw and Lodz regions presented additional peaks describing the outflows of the labor force age groups of 40 to 50. This fact was interpreted as the high out-migrations of the qualified persons, migration with their families to the new voivodships. The highest values of the "index of child dependency" (δ_{12} = 0.06 – 0.07) in these regions also reflected migration of the families. Regions of strong out migration were characterized by high values of the parameter a_2. The analogous index of post-labor dependence on labor force δ32 = a3/a2, and the ratio a2/a3 of the dominance of the labor force, reflect the relative migration levels of those in the working ages relative to the elderly. These characteristics explain relatively high mobility levels of the elderly in Poland. The high indices of the outflows of the oldest migrants seem to be associated with the return migrations, due to health or family reasons (Korcelli and Potrykowska 1986).

2.3 Future Research

This section has examined the relevant literature for this study. It is clear from this review that migration in a number of countries exhibit an age dependent characteristic. From the literature review it is clear that most of the studies on MMS have been done in the developed world. This implies that MMS is still a fertile area for future research especially in the developing countries. An extension can also be made to incorporate cause-specific model migration schedules.

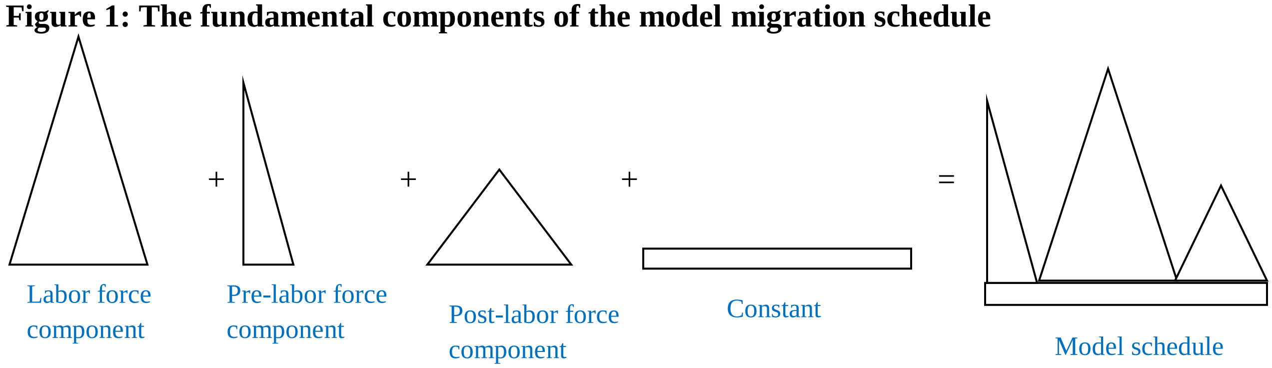
2.4 Analytical Framework

This section conceptualizes the study. The framework for this study is based on Rogers and Castro (1981) framework for the analysis of migration. According to this framework, the standard model migration schedule is the sum of five component curves (Rogers and Watkins, 1987):

Migration intensity = childhood curve + labor force curve + retirement curve + elderly curve + constant.

Figure 1 below illustrates the fundamental components of the model migration schedule.

Figure 1: The fundamental components of the model migration schedule



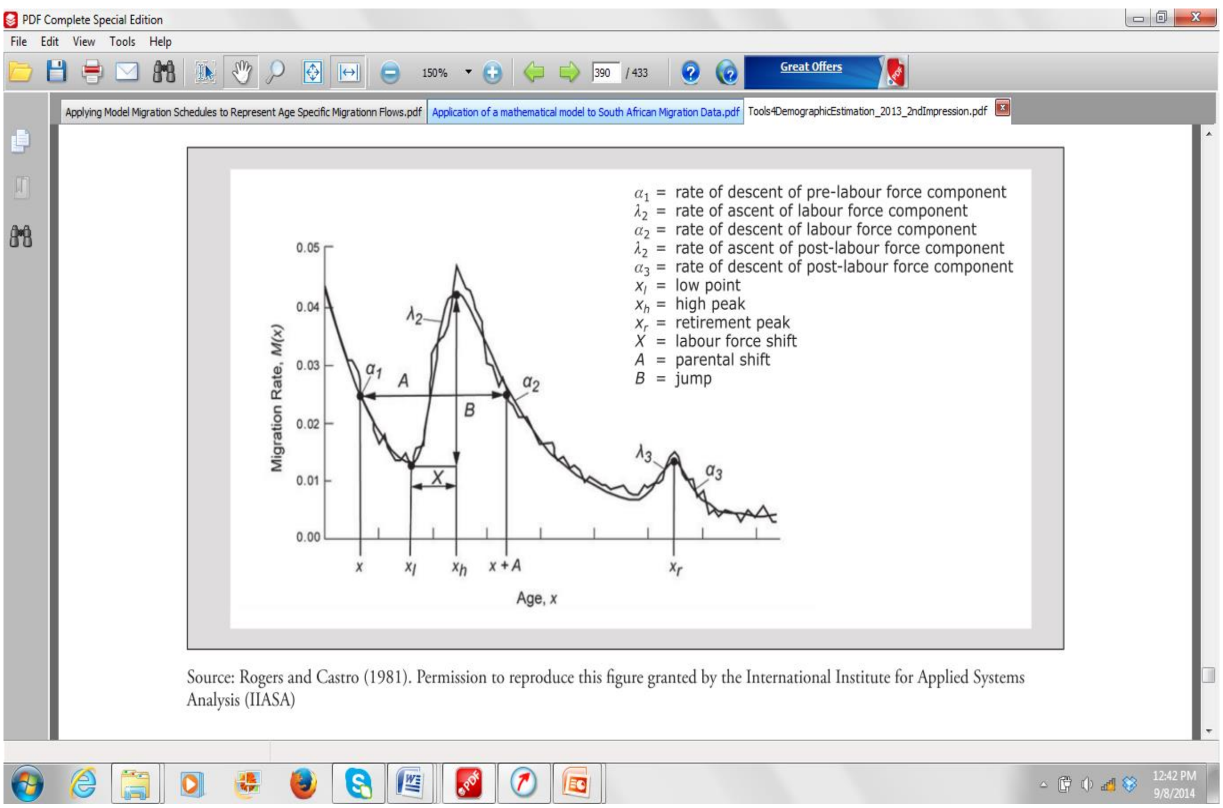
Source: Rogers 1984

Almost all age profiles will require the childhood, labor force and constant components, but only some will include retirement and elderly curves.

Expressed algebraically, the full model migration schedule contains 13 parameters and may be written as:

$$\mathbf{M(x) = a_1 \exp(-\alpha_1 x) + a_2 \exp\{-\alpha_2 (x-\mu_2) - \exp[-\lambda_2 (x-\mu_2)]\} + a_3 \exp\{-\alpha_3 (x-\mu_3) - \exp[-\lambda_3 (x-\mu_3)]\} + a_4 \exp(\lambda_4 x) + c}$$

Figure 2: The Rogers-Castro 11-parameter model migration schedule



Source: Rogers and Castro, 1981, p.53.

Where,

- The first component is a single negative exponential curve representing the migration pattern of the pre-labour force ages.

- The second component is a left-skewed unimodal curve describing the age pattern of migration of people of working age.
- The third component is an almost bell shaped curve representing the age pattern of migration post-retirement.
- The fourth component is a single positive exponential curve of the post-retirement ages, reflecting the (sometimes) observed generalized increase in migration post-retirement.
- The final component is a constant term, c, that represents 'background' migration. This is required to improve the fit of the mathematical expression to the observed schedule.

The schedules of migraproduction rates by age and sex are characterized by specific regular structure, which can be presented as an analytical function above. An analogue of the decomposition of the model into four component functions is the sum of four curves presenting the rates of labor, pre-labor and post labor forces as well as a constant. A full model schedule has 13 parameters, 4 of which - a_1, a_2, a_3 and c – define its level, and the remaining its profile.

Moreover, the parameters of the equation can be characterized according to specific categories (as basic measures); **height** - a_1, a_2, a_3, c; **locations** - μ_2, μ_3; **slopes -** α_1, α_2, λ_2, α_3, λ_3; and as indices determining the ratio allocating a fraction of the level of model migration schedule to the constant component (c/δ_{1c} = a1/c); The ratio a_2/a_1 indicates, respectively, the degree of the dominance of the labor force (index of "labor dominance") and its reciprocal the index of child dependence on labor force (δ_{12} = a1/a2). It measures the rate at which children migrate with their parents; post-labor dependence (δ_{32} = a3/a2) and the shift along the axis x ($\beta_{12} = \alpha_1/\alpha_2$), and also labor asymmetry ($\sigma 2 = \lambda_2/\alpha_2$, $\sigma 3 = \lambda_3/\alpha_3$). Additional derived measures are: the area GMR under the schedule curve in numbers per 100 according to the basic age categories %(0-14), %(15-64), %(65+); locations of extreme values (points): ñ, x_l, x_h, and distances (X, A, B). The list of definitions for the parameters and variables appears in Table 1.

Table1: The list of the parameters and variables of the model migration schedule	
a1	a_1, level of pre-labor force component
alpha1	α_1, rate of descent of pre-labor force component
a2	a_2, level of labor force component

mu2	μ_2, mean age of labor force component
alpha2	α_2, rate of descent of labor force component
lambda2	λ_2, rate of ascent of labor force component
a3	a_3, level of post-labor force component
mu3	μ_3, mean age of post-labor force component
alpha3	α_3, rate of descent of post-labor force component
lambda3	λ_3, rate of ascent of post-labor force component
c	c, constant component
mean age	ñ, mean age of migration schedule
% (0 - 14)	Percentage of GMR in 0 – 14 age interval
% (15 - 64)	Percentage of GMR in 15 – 64 age interval
% (65+)	Percentage of GMR in 65 and over age interval
delta1c	$\delta_{1c} = a_1/c$
delta12	$\delta_{12} = a_1/a_2$
delta32	$\delta_{32} = a_3/a_2$
beta12	$\beta_{12} = \alpha_1/\alpha_2$
sigma2	$\sigma_2 = \lambda_2/\alpha_2$
sigma3	$\sigma_3 = \lambda_3/\alpha_3$
x low	x_l, low point
x high	x_h, high peak
x retirement	x_r, retirement peak
X shift	X, labor force shift = $x_h - x_l$
a	A, parental shift
b	B, jump (the increase in the migration rate of individuals aged x_h over those aged x_l)

Source: Rogers and Castro, 1981, p.53.

2.5 Definition of Concepts

Migration – A migration is defined as a move across a geographically-defined (usually administrative) boundary of interest to the analyst with the effect of changing a person's place of usual residence.

In-Migration and In-Migrant – Every move is an in-migration with respect to the district (area) of destination. Every migrant is an in-migrant with respect to the district (area) of arrival. An in-migrant is thus a person who enters a migration-defining district (area) by crossing its boundary from some point outside the district (area), but within the same country.

Out-Migration and Out-Migrant – Every move is an out-migration with respect to the district (area of origin). Thus every migrant is an out-migrant with respect to the area of departure. Hence an out-migrant is a person who departs from migration-defining district (area) by crossing its boundary to a point outside it, but within the same country.

Gross Migraproduction Rate (GMR) – This index is a basis and a common measure of the intensification of mobility defined as the expected number of migrations carried out by an individual during his lifetime. Because migration is highly age selective, with a large fraction of migrants being the young, our understanding of migration patterns and dynamics is aided by computing migration rates for each single year of age. Summing these rates over all ages of life gives the gross migraproduction rate (GMR), the migration analog of fertility's gross reproduction rate. This rate reflects the level at which migration occurs out of a given region (Rogers and Castro 1981, p.2)

Crude Migration Rate – This is the simplest and most common measure of migration. It is defined as the ratio of the number of migrants, leaving a particular population located in space and time, to the average number of persons (more exactly, the number of person-years) exposed to the risk of becoming migrants.

2.6 Variables and their Measurements

2.6.1 Demographic Factors

Age – AGE gives age in years as of the person's last birthday prior to or on the day of enumeration.

MGRATE1 (Migration Status, 1 year) – MGRATE1 indicates the person's place of residence 1 year ago. The first digit records movement across major administrative divisions and countries; the second digit reports movement across minor administrative divisions.

MIGKE – Indicates the person's district and province of residence within Kenya 1 year ago.

Sex – SEX reports the sex (gender) of the respondent

CHAPTER THREE:

DATA AND METHODOLOGY

3.1 Introduction

This chapter presents a description of the data and methods used for analysis in this study. Section 3.2 describes the design and the nature of the data that was collected while section 3.3 presents the methods utilized for data analysis.

3.2 Sources of Data

Migration data by sex and single years of age were obtained from the Kenya National Bureau of Statistics 2009 Census via the Integrated Public Use Micro data Series (IPUMS) - International data extract service at the Minnesota Population Center. IPUMS data are an invaluable resource for cross-national comparison, but are inevitably subject to sampling variability. The data are the latest available for the country. Also, the use of the Provincial data from the 2009 census was informed by multinational comparative studies which indicate that the level of inter-regional migration depends on the size of the areal unit selected, if the areal unit chosen is such as a county or a commune, a greater proportion of residential relocation will be included as migration than if the areal unit chosen is a major administrative division such as a state or a province.

These data were derived from the following census questions which sought to establish previous residence and duration of residence:

"**Where was [person] living in August 2008?**" and "**When did [person] move to the current district?**"

The data is therefore transition-type data, and count surviving migrants rather than migrations (Courgeau 1979, Rees and Willekens 1985). The migration intensity used in this study was the intensity recommended for this type of data by Rees et al. (2000), or the migration probability conditional upon survival within the country (hereafter just migration probability).

For out-migration from any particular region, the migration probability for each cohort was calculated as follows:

Out-migration probability =

$$\frac{\text{People resident in the region one year before the census who were living elsewhere in Kenya on census night}}{\text{People resident in the region one year before the census who were living anywhere in Kenya on census night}}$$

The numerator was obtained by cross tabulating in SPSS the variables Age, Sex and MIGRATE1 while the denominator was obtained by cross tabulating the variables Age, Sex and MIGKE.

3.3 Methods of Data Analysis

3.3.1 Fitting in Microsoft Excel

This section describes how the model migration schedule may be fitted in a Microsoft Excel 2007 workbook. The workbook is designed to use single year interval, single year of age period-cohort migration data (Bell and Rees, 2006) of the type typically obtained from a census or survey.

The choice of Excel, rather than a statistical package with nonlinear regression routines is preferred because it provides a method which can be used without difficulty for the purposes of graduation by individuals engaged in demographic research, but who lack access to, or knowledge of how to use, statistical software packages. Microsoft Excel is the most commonly used software for numerical work worldwide, and many professionals are highly experienced Excel users. Another reason for the preferred use of Excel is that some of the existing programmes that have been used for fitting model migration schedules, such as MODEL (Rogers and Planck 1983) or Tablecurve2D (Rogers and Raymer 1999), require a considerable degree of expertise and experience to implement.

There are four steps in the fitting procedure.

Step 1: Place input data into the Excel workbook

In the first step, single year period-cohort migration intensities for cohorts ages one to 90 at the end of the one year migration interval are entered into the workbook. As is common practice when fitting model migration schedules, the original migration intensities are scaled to sum to unity across all ages, because doing so permits the profiles of migration patterns to be compared independently of the levels of migration. These intensities are referred to here as scaled migration intensities, m(x).

Step 2: Estimate the constant

The value of the constant is estimated as the mean of between one and 15 of the lowest non-zero scaled migration intensities. In the workbook, a graph showing the scaled probabilities and the constant is provided to guide the user on how many of the lowest intensities to include.

Step 3: Estimate the childhood curve parameters

The childhood curve parameters are fitted to the scaled migration intensities minus the constant

$m_1(x) = m(x) – c$

Modeled values of $m_1(x)$, represented by the function $m_1(x) = a_1 \exp(-\alpha_1 x)$ are estimated by creating the linear model Y = C + MX where

$Y = \ln(m_1(x))$

$C = \ln(a_1)$

$M = -\alpha_1$

The Excel functions SLOPE and INTERCEPT provide the values of C and M, thus

$a_1 = \exp(C)$

$\alpha_1 = - M$

Guided by a graph showing $m_1(x)$ and the fitted childhood curve in the workbook, the user can alter the default ages over which the childhood curve is fitted (one to 14) if doing so appears to give a better fit.

Step 4: Estimate the labor force curve parameters

The labor force curve parameters are fitted to the scaled migration intensity minus the constant and the childhood curve

$m_2(x) = m(x) – c - m_1(x)$

The function $m_2(x) = a_2 \exp \{-\alpha_2 (x - \mu_2) – \exp [- \lambda_2 (x - \mu_2)] \}$ is fitted using Microsoft Excel's nonlinear regression facility, Solver. Over a user defined age range (with a default of 17 to 49), the function is fitted to minimize the sum of squared residuals. Attempts to use Solver on a variety of migration age patterns resulted in good fits being obtained almost every time. The use of Solver here raises the question of why it is not used to fit the full model schedule in one step. Solver works well when handling up to four or five parameters. However, its iterative search algorithm tends to fail to converge, or produces a nonsensical result, when a large number of parameters are introduced.

Table 2 in the appendix presents the estimated parameter values of the model migration schedule.

CHAPTER FOUR:

MODEL MIGRATION SCHEDULES BY REGION

4.1 Introduction

This section provides a description of the results of some of the preliminary analysis, which include the migration patterns based on observed values (See Appendix 1) and model migration schedules by region and their respective derived basic parameters (see Table 2: Model Migration Schedule Parameters). The observed (or a graduated) age specific migration schedule will be described in a number of ways: References will be made to the heights at particular ages; to locations of important peaks or troughs; to slopes along the schedules' age profile; to ratios between particular heights or slopes; to areas under parts of the curve; and to both horizontal and vertical distances between important heights and locations. The data and results are presented in table 2 in the appendix.

4.2 Model Migration Schedules by Region

This section presents the resulting analysis and migration profiles. They are subsequently presided by Region in what was formerly known as Provinces.

1. **NAIROBI REGION**

Figures 3a and 3b describes migration schedules for Nairobi for males (Figure 3a) and females (Figure 3b). The model migration schedule for the out-migration of both males and females in Nairobi region indicate peaks at infancy and young adult ages (labor force ages). This is an indication of the propensity of children to migrate with their parents. The two peaks are in line with the Rogers and Castro 7-parameter standard model schedule. The peaks in the first year of life and labor force migration are higher for females than for males. The age profiles of male and female migration show a distinct difference. The high peak of the female schedule is a little higher and precedes that of the male schedule. The female migration schedule had a higher age at the labor force peak than the male migration schedule. When migration was at its low point, the pre-labor force age was higher for the males than for the females. The same scenario played out when the labor force migration was at its peak. Migration rates for the male children decreased faster than their female counterparts as they approached the teenage years. Out-migration rates for males in the labor force age were higher than the females.

Figure 3a: NAIROBI OUT-MIGRATION OF MALE

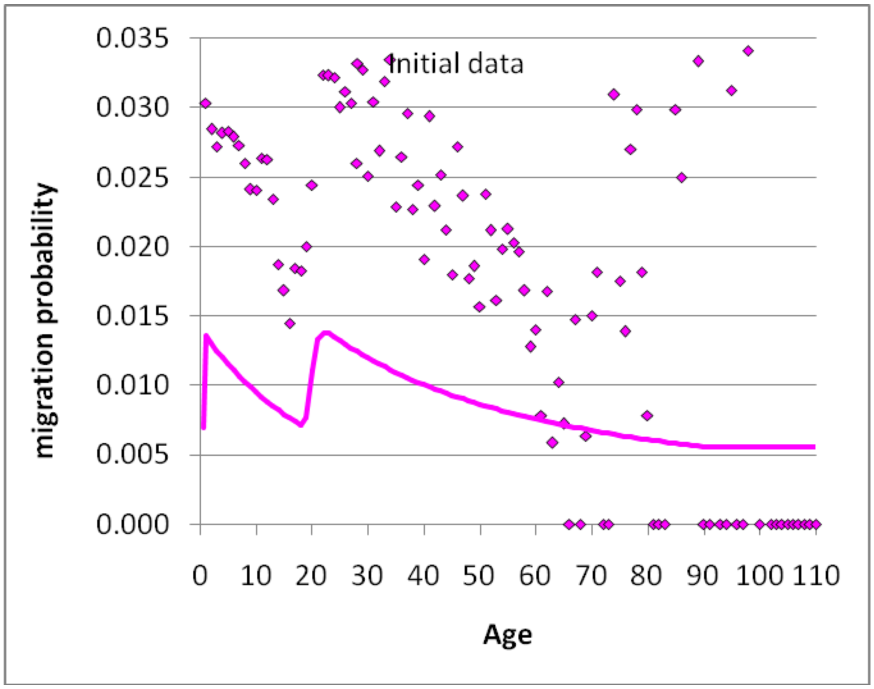
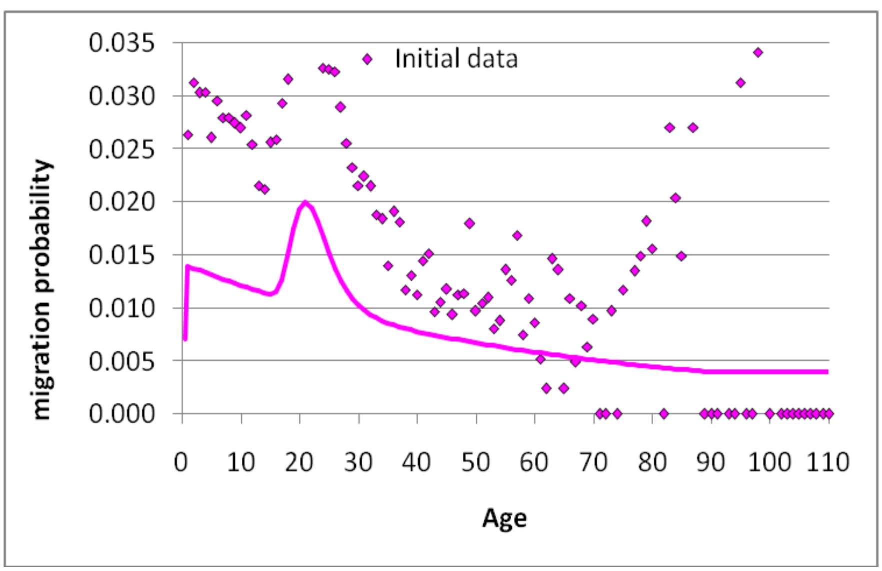


Figure 3b: NAIROBI OUT-MIGRATION OF FEMALE



2. COAST REGION

Figure 4a and 4b describes migration schedules for Coast region for males (Figure 4a) and females (Figure 4b). Compared to Nairobi region, Coast region had higher labor force age peaks and lower peaks at infancy in their out-migration schedules with near perfect fits. This implies that the tendency to migrate during the labor force ages was higher in Coast than in Nairobi while lower during infancy in Coast than in Nairobi. The height of the childhood curve was higher among females than males in Coast indicating the increased migration among females than males within this age category. The height of the labor force curve was higher among females than males in Coast region an indication of the propensity of increased female migration during the labor force ages. The ages at labor force peak were roughly the same at 19 years.

Figure 4a: COAST OUT-MIGRATION OF MALE

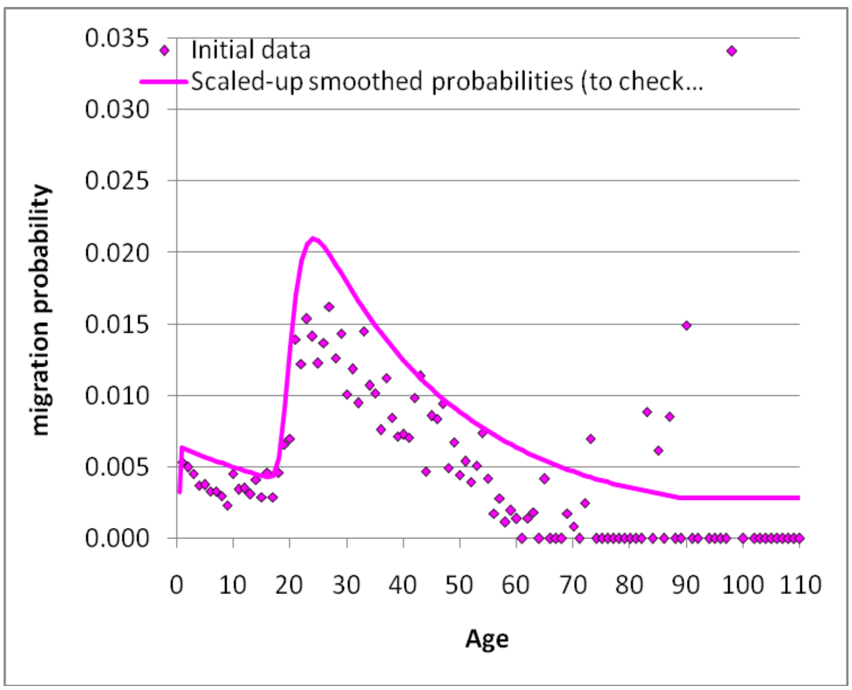
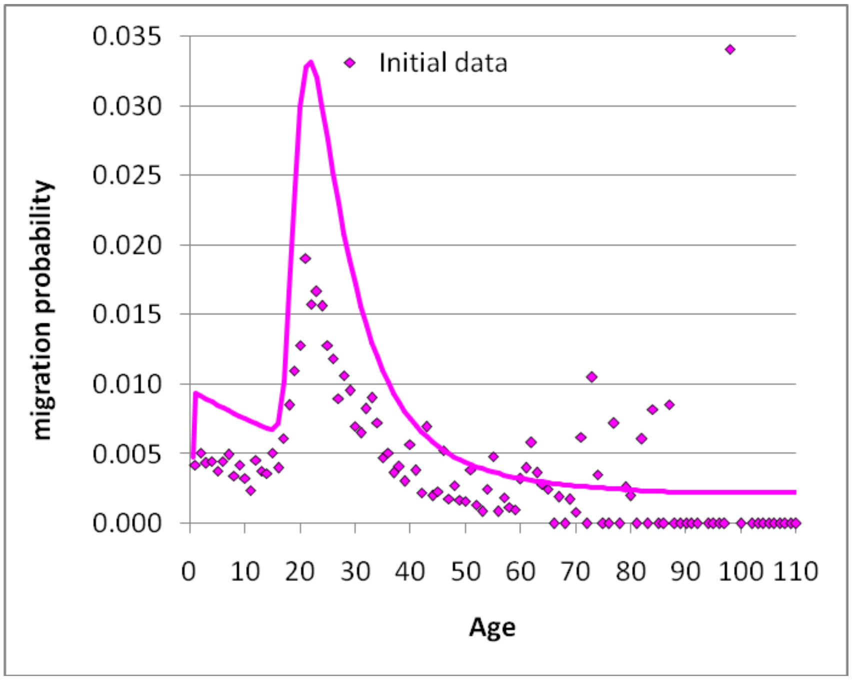


Figure 4b: COAST OUT-MIGRATION OF FEMALE



3. NYANZA REGION

Figure 5a and 5b describes migration schedules for Nyanza region for males (Figure 5a) and females (Figure 5b). Nyanza region model migration schedules exhibited relatively good fits. The height of the childhood curve was higher in the female out migration schedule an indication that more female infants migrated with their parents as opposed to their male counterparts. The rate of descent of the childhood curve was higher among males than females. This means that males migrated less as they approached teenage years. In contrast, the rate of ascent of the labor force curve among males was higher indicating that the males migrated more as they approached the labor force peak ages. The rate of descent of the labor force curve is higher among females than the males. This implies that with increasing post-labor ages, males tend to migrate less.

Figure 5a: NYANZA OUT-MIGRATION OF MALE

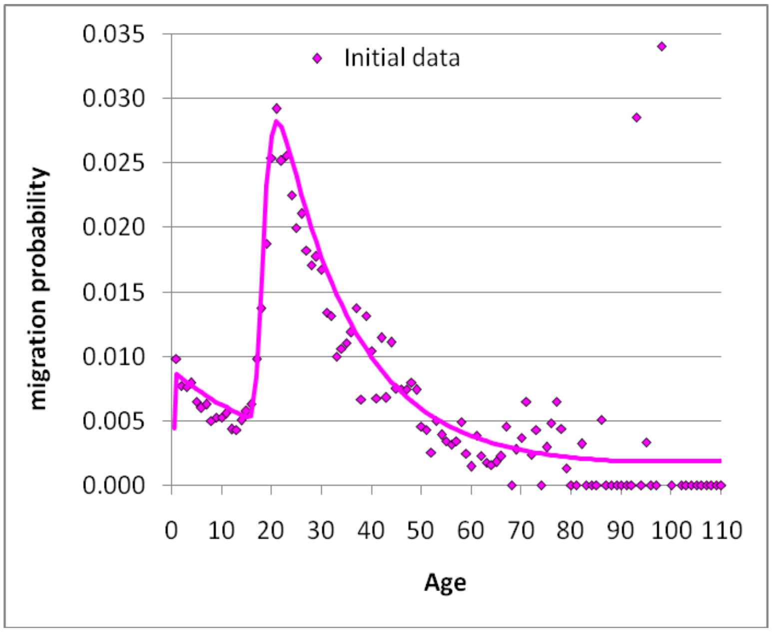
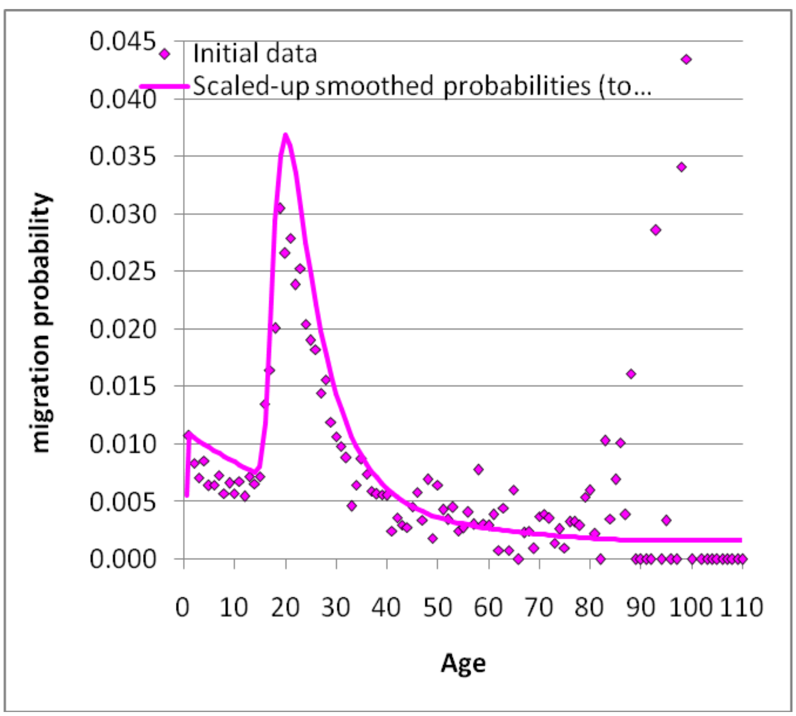


Figure 5b: NYANZA OUT-MIGRATION OF FEMALE



4. NORTH EASTERN REGION

Figure 6a and 6b describes migration schedules for North Eastern region for males (Figure 6a) and females (Figure 6b). Out-migration schedules for North Eastern region showed that the female peaks at infancy were higher compared to the male peaks at infancy. Males had higher peaks at the labor force ages compared to the females. Here also the females tended to migrate more as they approached the low point which is usually the teenage years. The reverse was true as more males tended to out migrate as they approached the labor force ages. North Eastern also appears to have a poor fit. This brings into question the quality of age data collected.

Figure 6a: NORTH EASTERN OUT-MIGRATION OF MALE

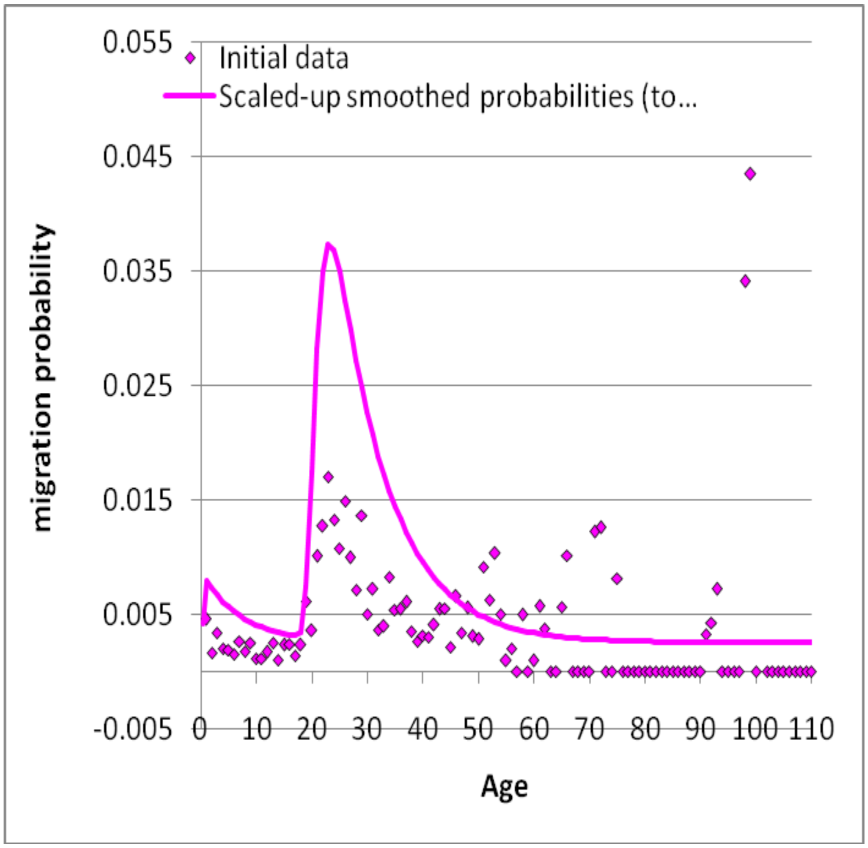
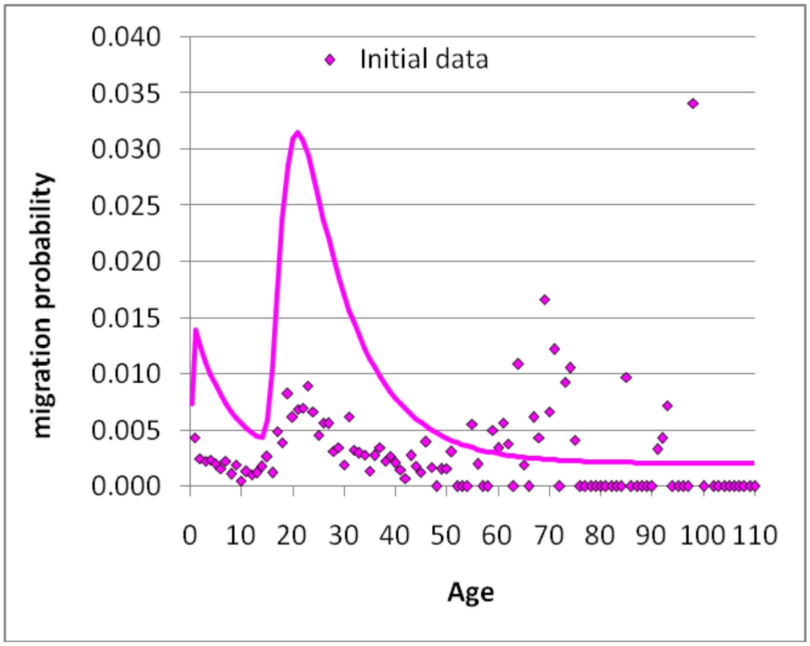


Figure 6b: NORTH EASTERN OUT-MIGRATION OF FEMALE



5. WESTERN REGION

Figure 7a and 7b describes migration schedules for Western region for males (Figure 7a) and females (Figure 7b). Western region also depicted good fits with peaks at both infancy and young adult years. Peaks at infancy were slightly higher for males than for females while the female schedule exhibited higher peaks at the labor force ages as compared to the males. The rate of descent of the childhood curve and the rate of ascent of the labor force curve were both higher in the male schedules while the rate of descent of the labor force curve was higher in the female model migration schedule.

Figure 7a: WESTERN OUT-MIGRATION OF MALE

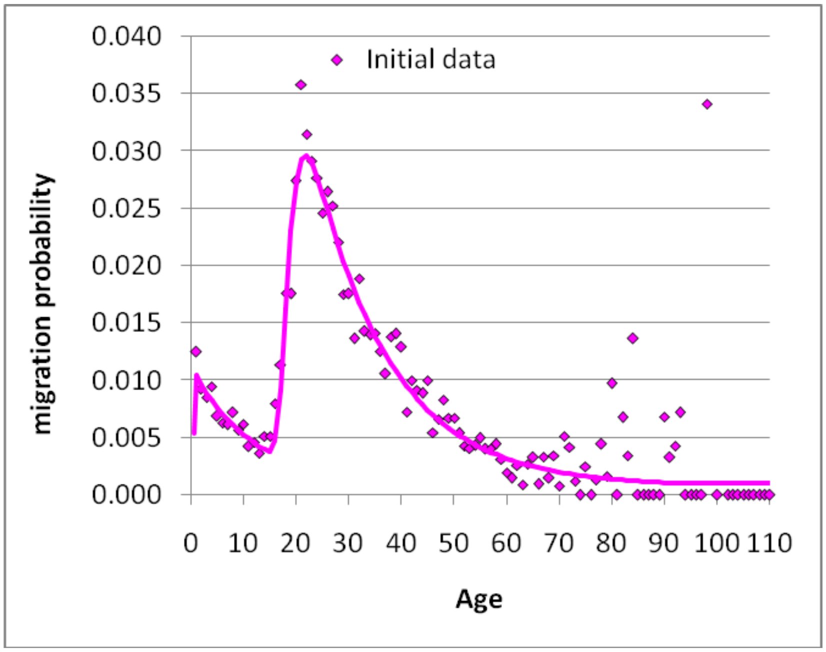
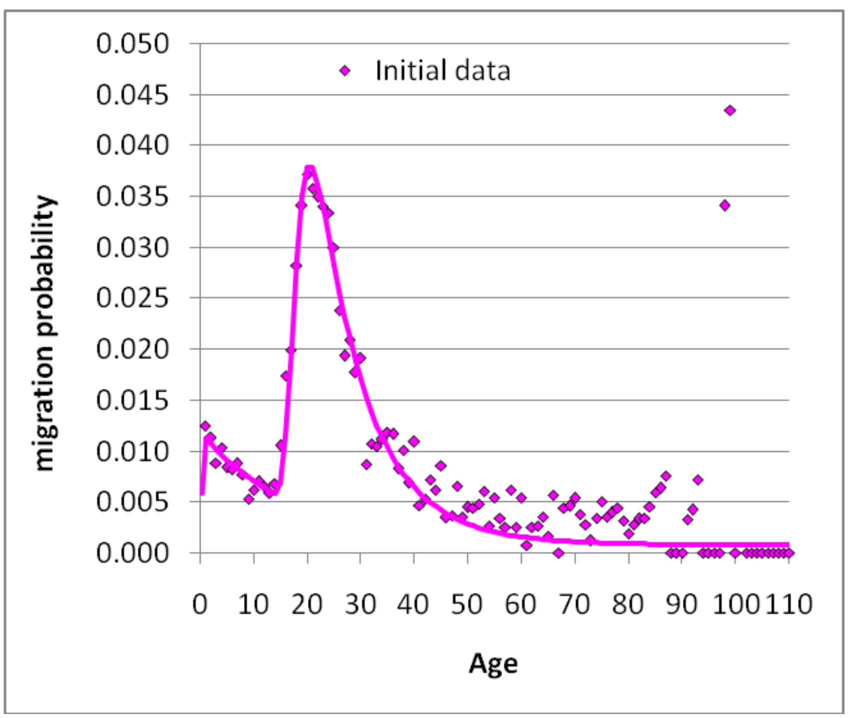


Figure 7b: WESTERN OUT-MIGRATION OF FEMALE



6. CENTRAL REGION

Figure 8a and 8b describes migration schedules for Central region for males (Figure 8a) and females (Figure 8b). The model schedules for Central region also exhibited peaks at infancy and at the labor force ages as espoused in the standard model schedule. This is a clear indication that children mirror the migration rates of their parents. The male schedule had a higher peak at infancy than the female schedule while the female schedule had a higher peak at the labor force ages. The rate of descent of the childhood curve was slightly higher among the males than the females. The rate of ascent of the labor force curve was also higher among the males. Females migrated less after attaining labor force peak ages.

Figure 8a: CENTRAL OUT-MIGRATION OF MALE

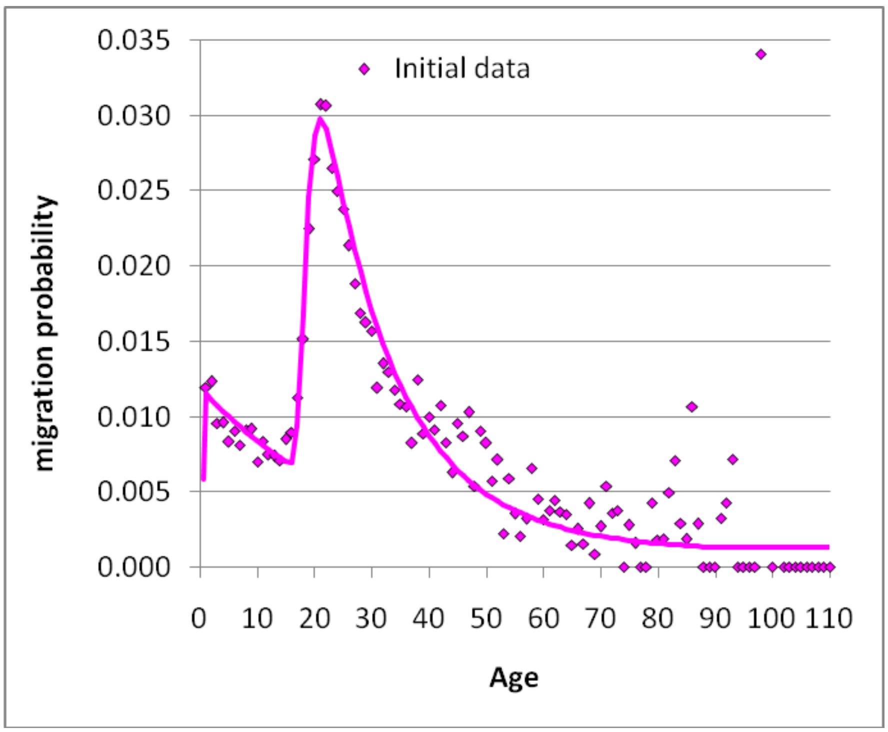
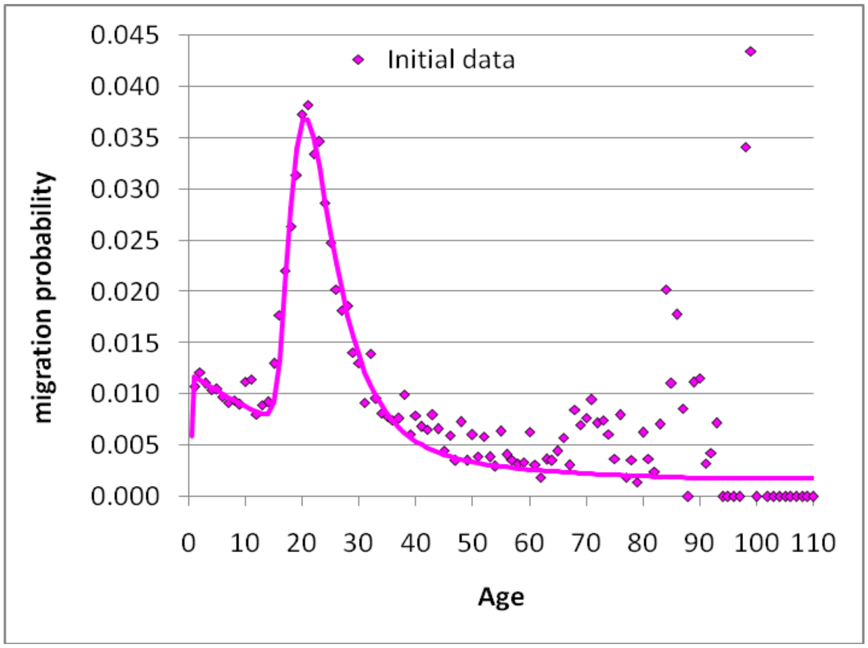


Figure 8b: CENTRAL OUT-MIGRATION OF FEMALE



7. EASTERN REGION

Figure 9a and 9b describes migration schedules for Eastern region for males (Figure 9a) and females (Figure 9b). Eastern region exhibited a relatively better fit of the model with peaks at infancy and at the young adult ages. The male schedule produced a higher peak at infancy while the female schedule produced a higher peak at the labor force ages. The rate of descent of the childhood curve and rate of ascent of the labor force curve are both high for the male schedule while the rate of descent of the labor force curve depict a higher value for the female schedule.

Figure 9a: EASTERN OUT-MIGRATION OF MALE

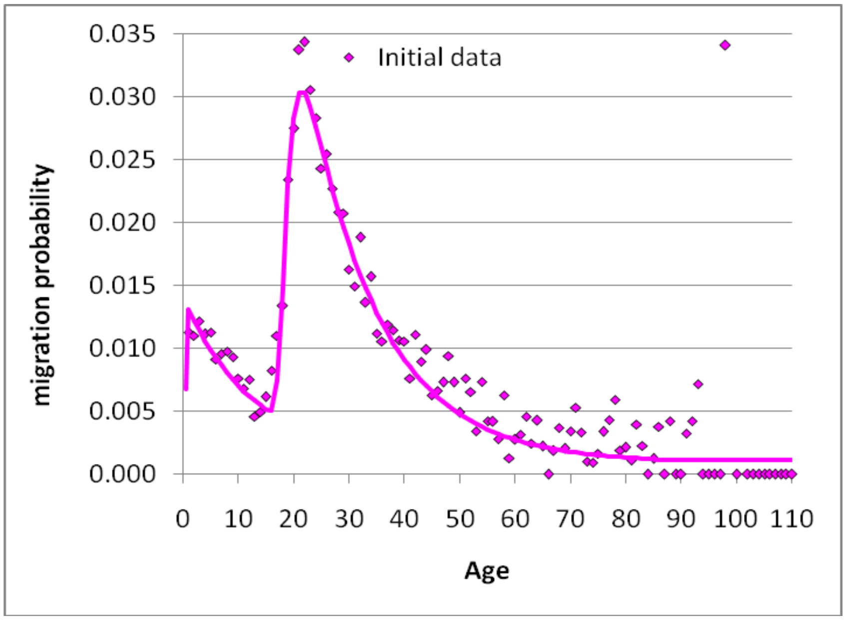
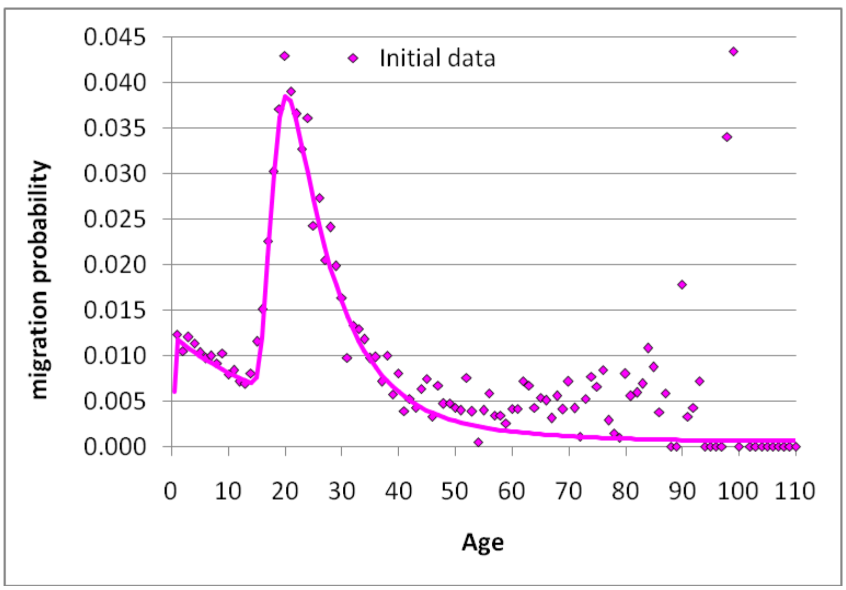


Figure 9b: EASTERN OUT-MIGRATION OF FEMALE



8. RIFT VALLEY REGION

Figure 10a and 10b describes migration schedules for Rift Valley for males (Figure 10a) and females (Figure 10b). Out migration schedules for Rift Valley region also resemble the standard model schedule with peaks at infancy and at the labor force ages. The height of the childhood curve is higher among the males than the females while the height of the labor force curve is higher among the females than the males. The ages at the labor force peak are slightly higher for the males than the females. The rate of descent of the childhood curve and the rate of ascent of the labor force curve are higher in the male schedule while the rate of descent of the labor force curve in the female schedule is higher than that of the male schedule.

Figure 10a: RIFT VALLEY OUT-MIGRATION OF MALE

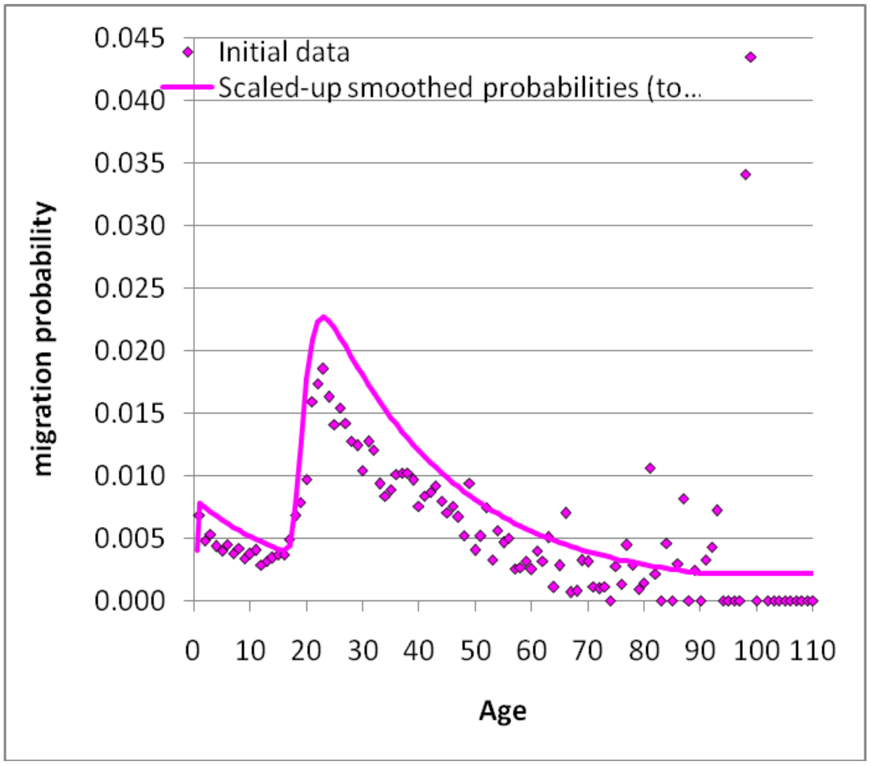
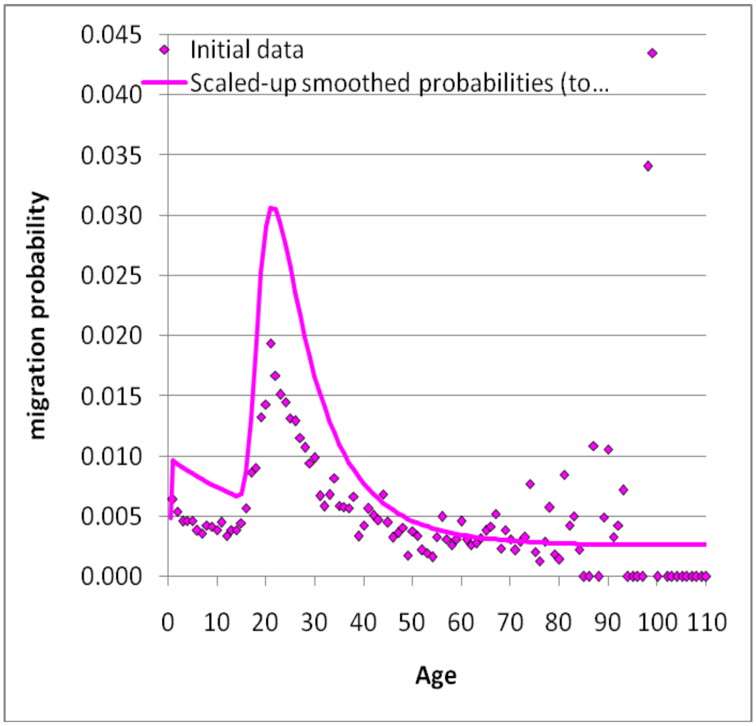


Figure 10b: RIFT VALLEY OUT-MIGRATION OF FEMALE



4.3 Discussion on Age-Specific Out-Migration Flows in Kenya

With respect to Kenyan regional out-migration patterns, the above findings seem to support the general pattern as illustrated in Figure 2 of the Rogers-Castro Model Migration Schedule with parameters labeled according to Rogers and Castro (1981).

The age profiles of migration schedules in Kenya as measured by different sizes of regions were remarkably similar and indicated that the regularity in age patterns persist across areal delineations of different size. According to the definition of migration rates, the analysis of migration patterns in Kenya reflected the level at which migration occurred out a given region. The schedules also showed additional peaks describing the high out-migration of the labor force age groups, which could be explained by a high out-migration of the qualified persons to the neighboring regions.

An analysis of the aggregated age patterns of out-migration from each of the 8 regions to the rest of Kenya revealed that the lowest values of the parameter a_{2}, describing the level of the labor force component, are characteristic of areas of high rates of in-migration. The highest values of the “index of child dependency” (δ_{12}) in these regions also reflected migration of the families. Regions of high rates of out migration were characterized by high values of the parameter a_2. These regions include Western, Eastern, Central and Nyanza.

Migration rates among young children reflected the relatively high rates of their parents, who are young adults in their late twenties. This affirms the widely recognized fact that a large fraction of total migration is accounted for by individuals whose moves are dependent on those of others, for example, children migrating with their parents, wives with their husbands, grandparents with their children. Young teens reveal a local low point around age 16 for males and 14 for females. Young adults in their early twenties generally have the highest migration rates, attaining a high peak at about 22 for males and 21 for females. After this age the migration rate as a function of age declines monotonically.

The male rates are higher from the mid-twenties to the mid-forties. Migrations due to marriage and education are concentrated between the ages of 10 and 30 years and are essentially unimodal in age profile. Migrations caused by change of employment and moving closer to the place of work have profiles that are bimodal, with local peaks during infancy and during the early years of labor-force participation. In all the regions, males exhibit higher low points and higher peaks than their female counterparts. The labor force shift, X, which gives an indication of the speed at which the work force settles down is lower in Nairobi region and highest in Coast region.

Rogers and Castro (1981) highlighted a detailed analysis of the parameters defining the various classes of over 500 schedules among national average age profiles. An examination of the labor force component defined by the four parameters a_2, μ_2, α_2, and λ_2 revealed that the national average values for these parameters generally lie within the following ranges:

$0.05 < a_2 < 0.10$

$17 < \mu_2 < 22$

$0.10 < \alpha_2 < 0.20$

$0.25 < \lambda_2 < 0.60$

When we compare these to the Kenyan schedules, we realize that in all instances apart from the parameter μ_2 which indicate that both male and female values lie within the given range; the male parameter values do not lie within the range given while the average female values do lie within the given range for the other parameters. Also, according to Rogers and Castro, the female values for a_2, α_2, and λ_2 were larger than those for males and the reverse was the case for μ_2. In this study, the same applies for a_2, α_2, and μ_2.

The two parameters defining the pre-labor force component, a_1 and α_1 generally lie within the ranges of 0.01 to 0.03 and 0.08 to 0.12, respectively. The exception with the Kenyan Schedule is α_2 which exhibits low average values for both male and female. The ratio of the two basic vertical parameters, a_1 and a_2, is a measure of the relative importance of the migration of children in a model migration schedule.

According to Rogers and Castro, the index of child dependency, $\boldsymbol{\delta_{12}=}$ a_1/a_2, tends to exhibit a mean value of about one-third with 80% of the values falling between one-fifth and four-fifths. The average values for the Kenyan Schedule fall within this range. Apart from Nairobi Province, female schedules in the rest of the provinces exhibit a tendency of being labor dominant, while Nairobi Province Schedule's of above two fifth's characterizes it as child dependent. Average values of the index of parental-shift regularity fall within the examined range of between one-third and four-thirds.

The above findings affirm that one of the most important regularities observed in human migration is its relationship to age. This may be attributed to the relationship of age to other characteristics of migrants and to other aspects of family life cycle and work. This explanation is beefed up with the expression of infants moving with their parents, low migration rates towards teenage years because these are compulsory school going ages, after school around ages 18 one has to migrate to join college, enter into marriage, look for a job including multiple entries into and withdrawals from the labor force and migrate as a result of divorce or remarriage.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the research findings, makes conclusions and recommendations. Recommendations are made for policy makers and future researchers. These are based on the research findings.

5.2 Summary of the Study

This study sought to address two questions; first, do age profiles of migrants in Kenya exhibit regularities as captured by the Model Migration Schedule? Second, can summary measures and parameter estimates of the Model Migration Schedule become graduated from observed Kenyan migration data? The literature review revealed that migration in a number of countries exhibit an age dependent characteristic and that most of the studies on Model Migration Schedules had been done in the developed world.

To answer the first research question, migration probabilities were calculated from a cross-tabulation of Age, Sex and MIGKE variables and Age, Sex and MIGRATE1 variables. The probabilities were then input into a Microsoft Excel workbook to fit the model migration schedules. The data were fitted on the 7-parameter version of the model. From, the fitted Model Migration Schedules, parameter estimates were graduated. This showed that the most prominent regularity in age-specific schedules of regional out-migration is the high concentration of migration among young adults; rates of migration also are high among children, starting with a peak during the first year of life, dropping to a low point at about age 16 (males) and 14 (females), turning sharply upward to a peak near 22 (males) to 21 (females), and declining regularly thereafter.

The outputs made the convincing argument that migration in Kenya has strong regularities in age patterns, much like fertility and mortality. From the foregoing, it seems evident, in consequence that the model migration schedule which is the standard schedule, attempts to describe the regularities in age profile exhibited by out-migration flows in the Kenya.

5.3 Conclusions

The two peaks and lack of the third and fourth peaks indicate that the dominant force of out-migration in Kenya is schooling and labor force followed by associational moves. There seems to be no evidence of retirement or ill-health induced migration. The analysis of the regional out-migration age patterns reported in this study demonstrates the utility of examining the regularities in age profile exhibited by empirical schedules of interregional migration.

5.4 Recommendations

Further avenues for research on model migration schedule include:

5.4.1 Recommendations for policy makers

The availability of data on in – migration can help us analyze trends in parameters and indices for model age migration schedules over time to see whether they are characterized by regularity and stability or otherwise. Also, extensions of the standard model migration schedule by Wilson (2010) to better represent those migration age patterns characterized by significant and highly age-focused student migration can be replicated to determine in what ways student migration age profiles vary across the country. Historical time series of parameters derived from model schedules can also be extrapolated to project the shape of migration profiles into the future.

Rogers and Castro (1979, 1985) have concentrated their studies on age-specific migration patterns that are disaggregated by family status and by causes of migration. "For example, if divorce is a reason for migration, and if the level of migration and the number of divorces per capita both increase with economic development, should one expect a particular shift in the age profile of aggregate migration?' (Rogers and Castro 1985, pp. 188-189).

If the age pattern of migration is influenced by its cause-specific structure, it should be possible to interpret the differences in specific age patterns of migration. For example, migration motivated by health reasons is a phenomenon characteristic of old persons, whereas education-related migration is characteristic of young people In order to understand better why people move, it is important to disaggregate cause-specific migration data by age and sex. The different cause specific age patterns may be interpreted within a life-cycle framework, by referring to both individual and family life cycles.

This suggests an alternative way of accounting for the migration age profile. Courgeau (1985) developed the analysis of the relationship of age to other personal characteristics and other aspects of the family life-cycle and work. That author explored both the influence of life events on spatial mobility and the behavior of individual birth cohorts in different social, economic and political contents. To study the interaction of a number of interdependent relational systems: familial, economic, political, and educational, Courgeau considered their expression in time and space through events. One of eight important questions of this study of interaction between migration and family and career life-cycle was the problem: "How can all the above effects explain the age profiles of migration?" (Courgeau 1985, p. 140). This is an extremely relevant statement which should be followed in future research.

5.4.2 Recommendation for future research

It would also be worthwhile to know how the relatively simple fitting procedure implemented in the Microsoft Excel workbook compares with those available through other statistical packages, such as Data Master 2003, Tablecurve2D and R. Several additional extensions have also been proposed focusing on population heterogeneity. They deal with variations in the level, as well as overall mobility by age pattern that produce the so called specific migration schedules. These schedules contribute in various proportions to aggregate migration curves and their changes over time and space.

REFERENCES

Bates J and I Bracken. 1982. "Estimation of migration profiles in England and Wales", *Environment and Planning A* **14**(7):889–900

Bates J and I Bracken. 1987. "Migration age profiles for local authority areas in England, 1971–1981", *Environment and Planning A* **19**(4):521–535

Bell, M. and Rees, P. (2006). Comparing migration in Britain and Australia: harmonisation through use of age-time plans. Environment and Planning A 38(5): 959-988.

Congdon, P. (1993). Statistical graduation in local demographic analysis and projections. Journal of the Royal Statistical Society Series A 156(2): 237-270. doi:10.2307/2982731.

Courgeau, D. (1979). Migrants and migrations. Population: Selected Papers 3: 1-35.

Courgeau, D. 1985, Interaction between spatial mobility, family and career life-cycle: A French survey, European Sociological Review 1, 2, 139-162

Dorrington RE and TA Moultrie. 2009. "Making use of the consistency of patterns to estimate age-specific rates of interprovincial migration in South Africa," Paper presented at Annual Meeting of the Population Association of America. Detroit, MI, 29 April–2 May 2009.

George MV. 1994. *Population projections for Canada, provinces and territories, 1993–2016*. Ottawa: Statistics Canada, Demography Division, Population Projections Section.

Hofmeyr BE. 1988. "Application of a mathematical model to South African migration data, 1975–1980", *Southern African Journal of Demography* **2**(1):24–28.

Holmberg I, ed. 1984. Model migration schedules: The case of Sweden. Stockholm: Scandinavian Demographic Society.

Ishikawa, Y. (2001). Migration turnarounds and schedule changes in Japan, Sweden and Canada. Review of Urban and Regional Development Studies 13(1): 20-33.

Kawabe H. 1990. *Migration rates by age group and migration patterns: Application of Rogers' migration schedule model to Japan, The Republic of Korea, and Thailand. Tokyo*: Institute of Developing Economies.

Liaw K-L and DN Nagnur. 1985. "Characterization of metropolitan and nonmetropolitan outmigration schedules of the Canadian population system, 1971–1976", *Canadian Studies in Population* **12**(1):81–102.

Little JS and A Rogers. 2007. "What can the age composition of a population tell us about the age composition of its outmigrants?", *Population, Space and Place* **13**(1):23–19.

McNeil DR, TJ Trussell and JC Turner. 1977. "Spline interpolation of demographic data", *Demography* **14**(2):245–252.

Minnesota Population Centre. Integrated Public Use Microdata Series, International: Version 6.3 [Machine-readable database]. Minneapolis: University of Minnesota, 2014.

Morrison PA, TM Bryan and DA Swanson. 2004. "Internal migration and short-distance mobility," in Siegel, JS and DA Swanson (eds). *The Methods and Materials of Demography*. San Diego: Elsevier pp. 493–521.

Peristera, P. and Kostaki, A. (2007). Modeling fertility in modern populations. Demographic Research 16(6): 141-194. doi:10.4054/DemRes.2007.16.6.

Potrykowska A. 1986. Modelling inter-regional migrations in Poland, 1977-81. Papers of the Regional Science Association, 60:29-40.

Potrykowska A. 1988. "Age patterns and model migration schedules in Poland", *Geographia Polonica* **54**:63–80.

Raymer, J. and Rogers, A. (2007). The American Community Survey's interstate migration data: strategies for smoothing irregular age patterns. Southampton: Southampton Statistical Sciences Research Institute: 16pp. (Southampton Statistical Sciences Research Institute Methodology Working Paper M07/13).

Raymer J and A Rogers. 2008. “Applying model migration schedules to represent age-specific migration flows,” in Raymer, J and F Willekens (eds). *International Migration in Europe: Data, Models and Estimates*. Chichester: Wiley, pp. 175–192.

Rees, P. (1996). Projecting the national and regional populations of the European Union using migration information. In: Rees, P., Convey, A., and Kupiszewski, M. (eds.). Population Migration in the European Union. Chichester: John Wiley: 331-364.

Rees PH. 1977. “The measurement of migration, from census data and other sources”, *Environment and Planning A* **9**(3):247–272.

Rees, P., Bell, M., Duke-Williams, O., and Blake, M. (2000). Problems and solutions in the measurement of migration intensities: Britain and Australia compared. Population Studies 54(2): 207-222

Rees, P. and Willekens, F. (1985). Data and accounts. In: Rogers, A. and Willekens, F. J. (eds.). Migration and Settlement: A Multiregional Comparative Study. Dordrecht: D Reidel: 19-58.

Rogers, A. (1986). Parameterized multistate population dynamics and projections. Journal of the American Statistical Association 81(393): 48-61.

Rogers, A. (1988). Age patterns of elderly migration: An international comparison. Demography, 25(3):355-370.

Rogers, A. and Jones, B. (2008). Inferring directional migration propensities from the propensities of infants in the United States. Mathematical Population Studies 15(3):182-211.

Rogers, A., Jones, B., and Ma, W. (2008). Repairing the migration data reported by the American Community Survey. Boulder: University of Colorado at Boulder, Institute of Behavioral Science. (Working Paper, Population Program).

Rogers A and LJ Castro, 1979. Migration Age Patterns: Cause-specific profiles, IIASA, WP-79-65, Laxenburg, Austria.

Rogers A and LJ Castro. 1981. *Model Migration Schedules*. Laxenburg, Austria: International Institute for Applied Systems Analysis.http://webarchive.iiasa.ac.at/Admin/PUB/Documents/RR-81-030.pdf

Rogers A and LJ Castro. 1981a. Model migration schedules. RR-81-30, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Rogers A and LJ Castro. 1986. "Migration," in Rogers, A and F Willekens (eds). *Migration and Settlement: A Multiregional Comparative Study*. Dordrecht: D. Reidel, pp. 157–208.

Rogers A, LJ Castro and M Lea. 2005. "Model migration schedules: Tree alternative linear parameter estimation methods", *Mathematical Population Studies* **12**(1):17–38.

Rogers A and JS Little. 1994. "Parameterizing age patterns of demographic rates with the multiexponential model schedule", *Mathematical Population Studies* **4**(3):175–195.

United Nations. 1983. Manual X: Indirect techniques for demographic estimation. New York: Department of International Economic and Social Affairs.

Rogers A, JS Little and J Raymer. 2010. *The Indirect Estimation of Migration: Methods for Dealing with Irregular, Inadequate, and Missing Data*. Dordrecht: Springer.

Rogers A and J Raymer. 1999. "Estimating the regional migration patterns of the foreign-born population in the United States: 1950–1990", *Mathematical Population Studies* **7**(3):181–216.

Rogers A and J Raymer. 1999. Fitting observed demographic rates with the multiexponential model schedule: An assessment of two estimation programs. Review of Urban and Regional Development Studies, 11(1):1-10.

Rogers A and J Watkins. 1987. "General versus elderly interstate migration and population redistribution in the United States", *Research on Aging* **9**(4):483–529.

Rogers, A. and Planck, F. (1983). MODEL: A general program for estimating parameterized model schedules of fertility, mortality, migration and marital and labor force status transitions. Laxenburg: International Institute for Applied Systems Analysis. (Working Paper WP-83-102)

Rogers A and S Rajbhandary. 1997. Period and cohort age patterns of US migration, 1948-1993: Are American males migrating less? Population Research and Policy Review, 16:513-530.

APPENDIX 1: <u>MIGRATION PATTERNS BASED ON OBSERVED VALUES BY REGION</u>

1. NAIROBI REGION

Figure 1.1(a): Out-Migration of Male

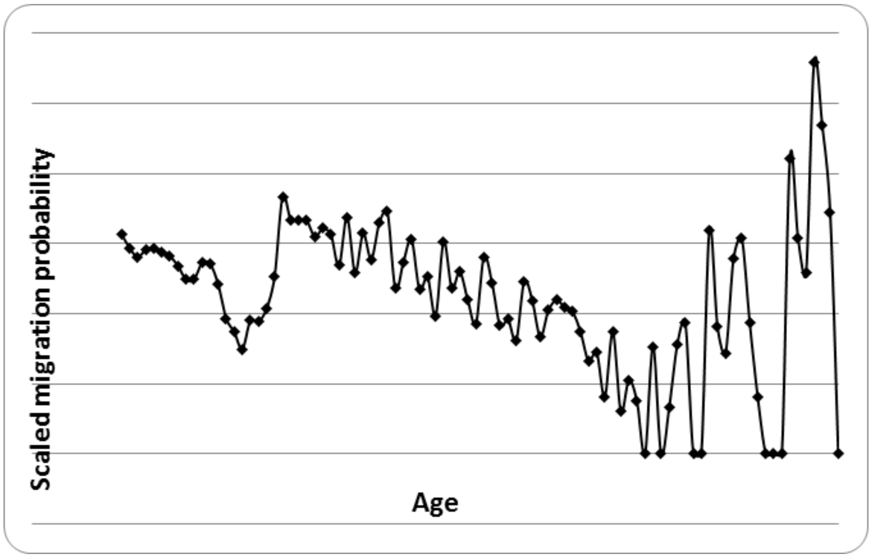
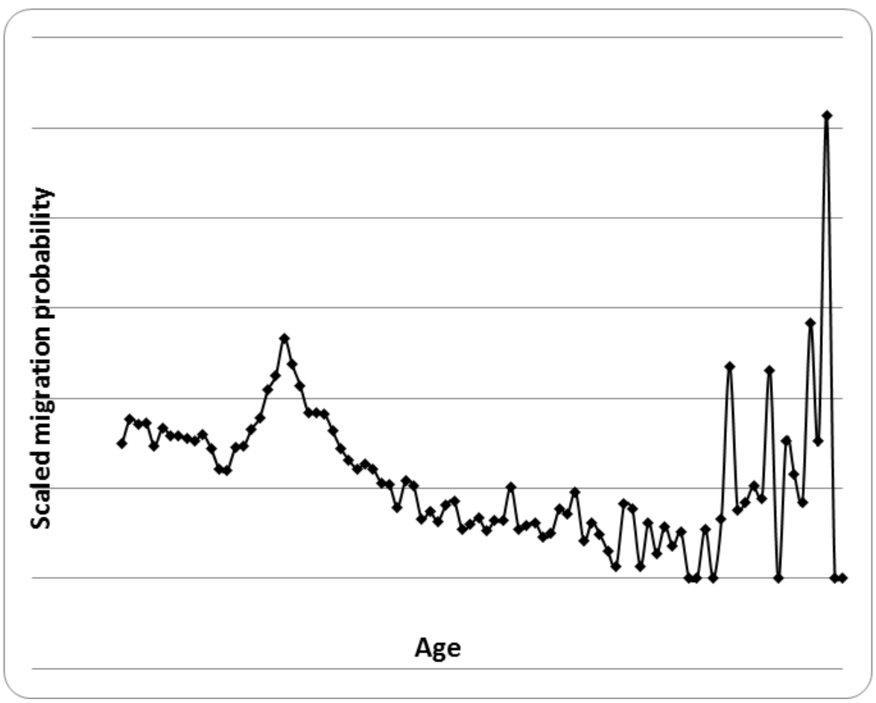


Figure 1.1(b) Out-Migration of Female



2. COAST REGION

Figure 2.1(a): Out-Migration of Male

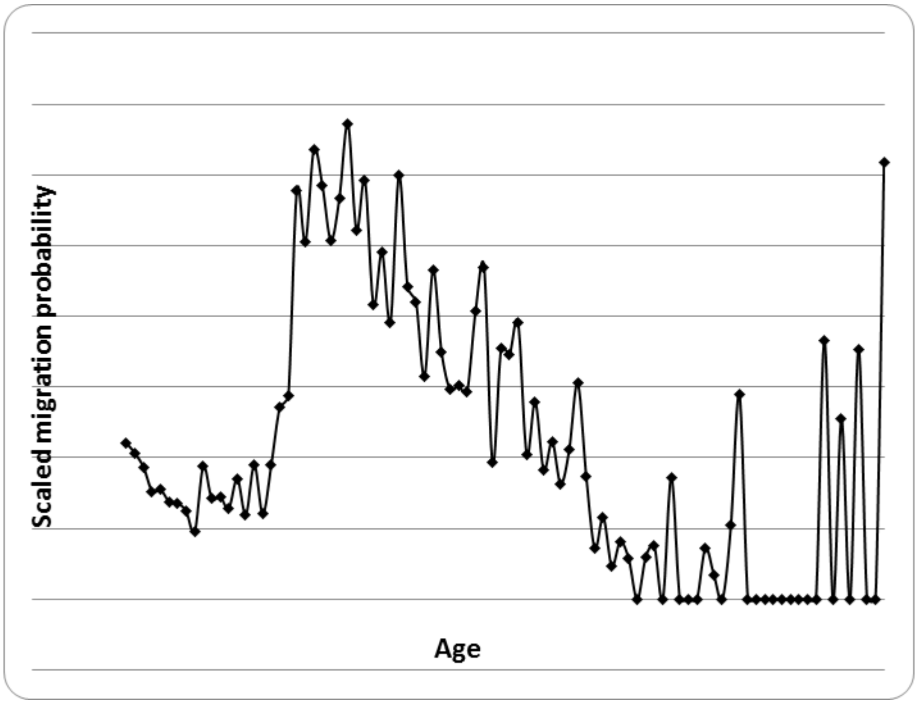
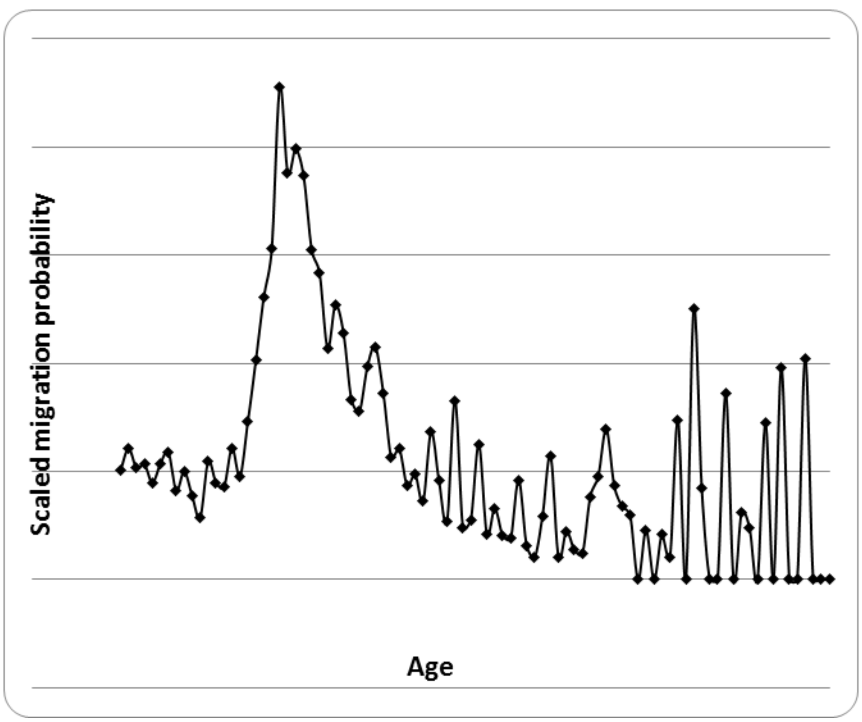


Figure 2.1(b): Out-Migration of Female



3. NYANZA REGION

Figure 3.1(a): Out-Migration of Male

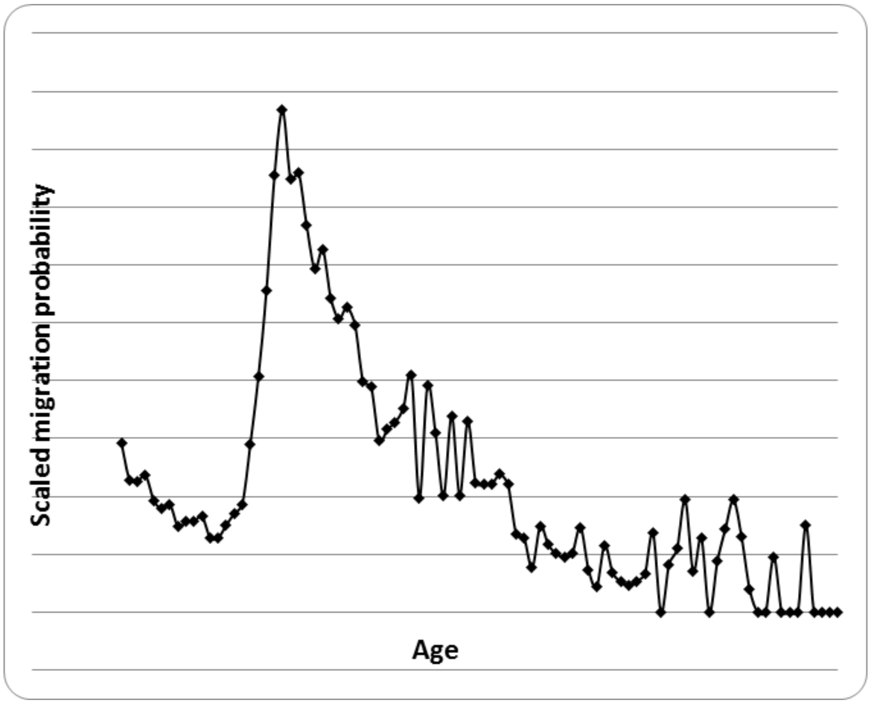
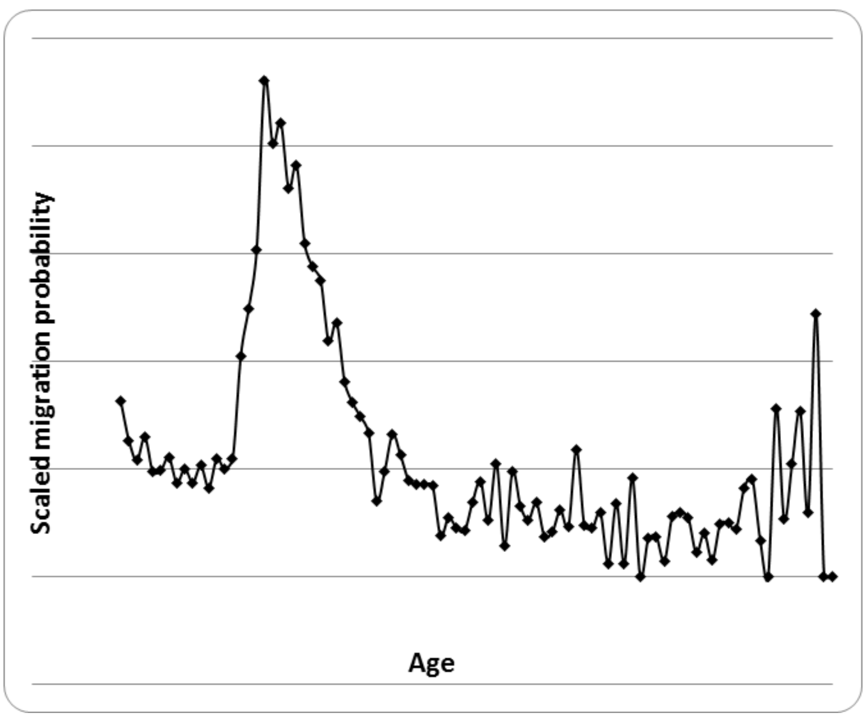


Figure 3.1(b): Out-Migration of Female



4. NORTH EASTERN REGION

Figure 4.1(a): Out-Migration of Male

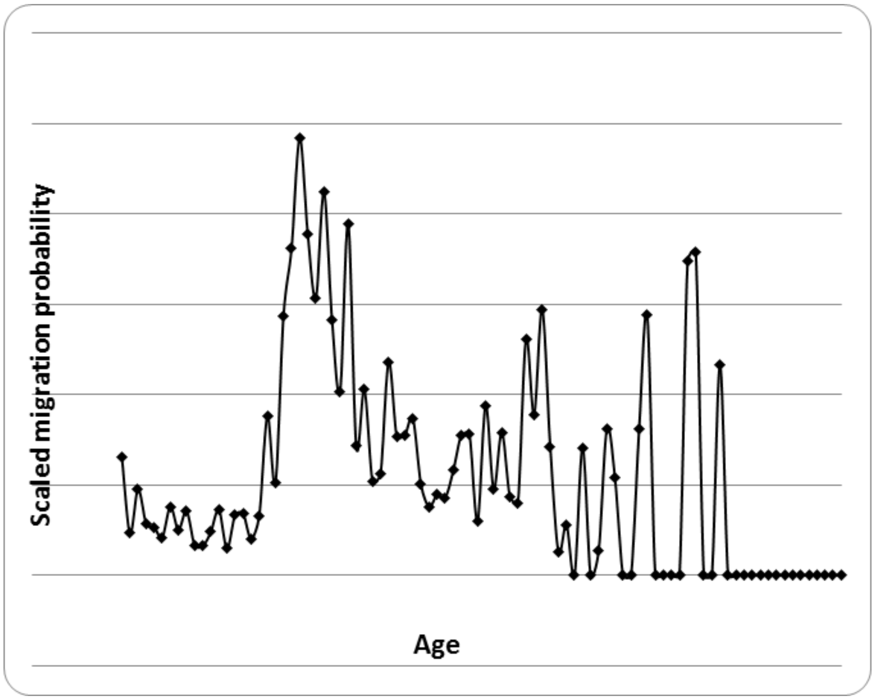
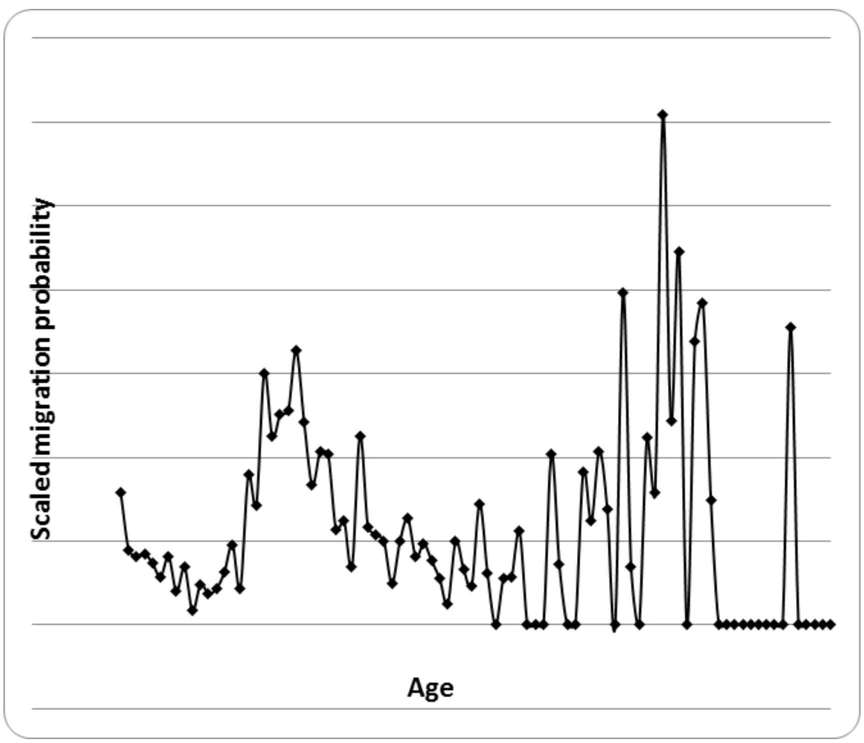


Figure 4.1(b): Out-Migration of Female



5. WESTERN REGION

Figure 5.1(a): Out-Migration of Male

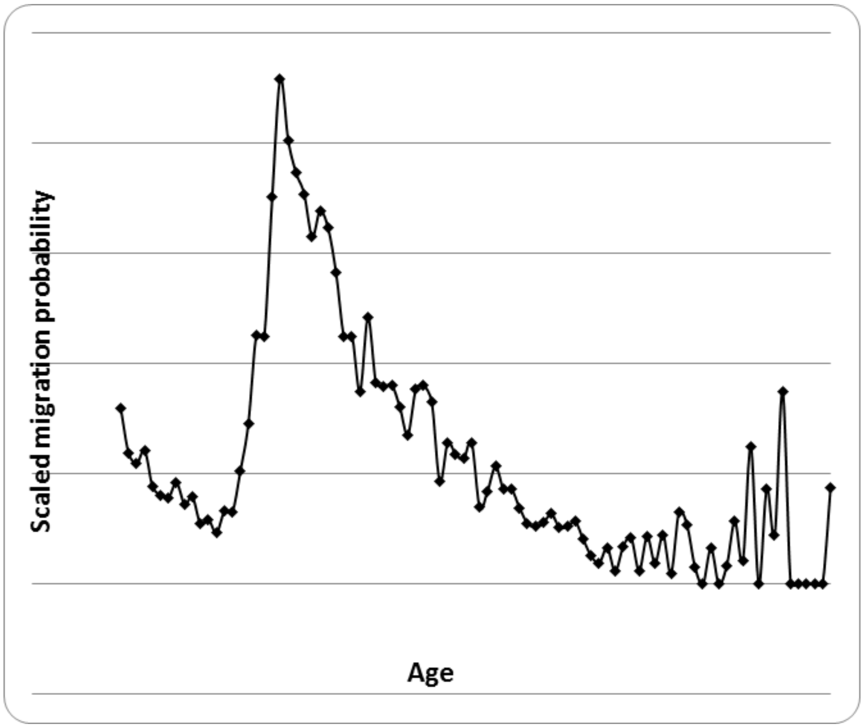
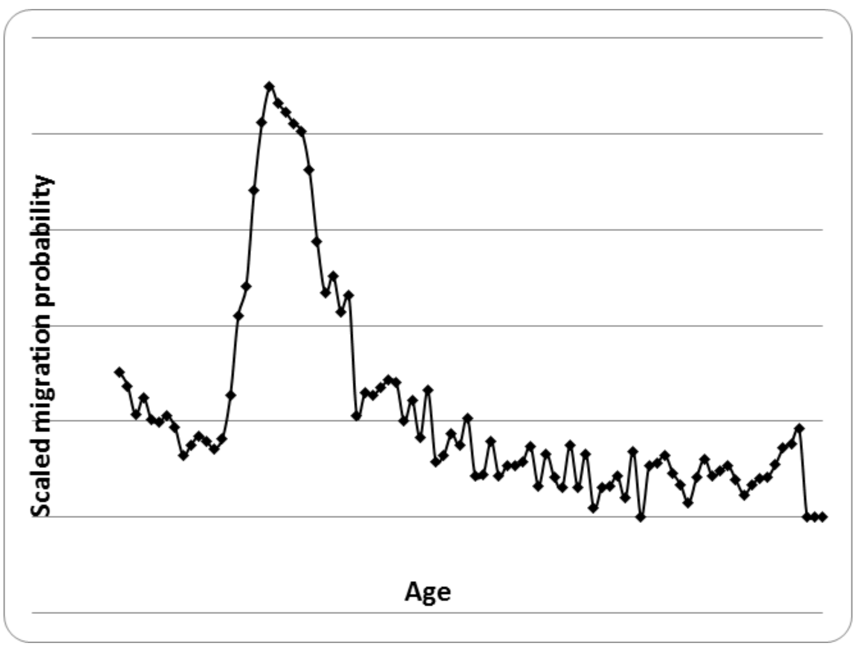


Figure 5.1(b): Out-Migration of Female



6. CENTRAL REGION

Figure 6.1(a): Out-Migration of Male

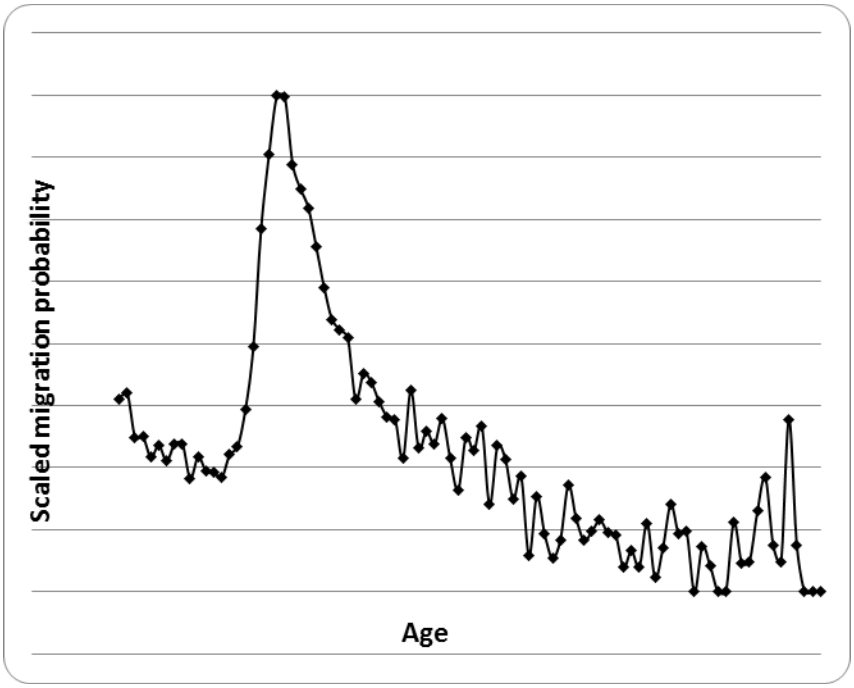
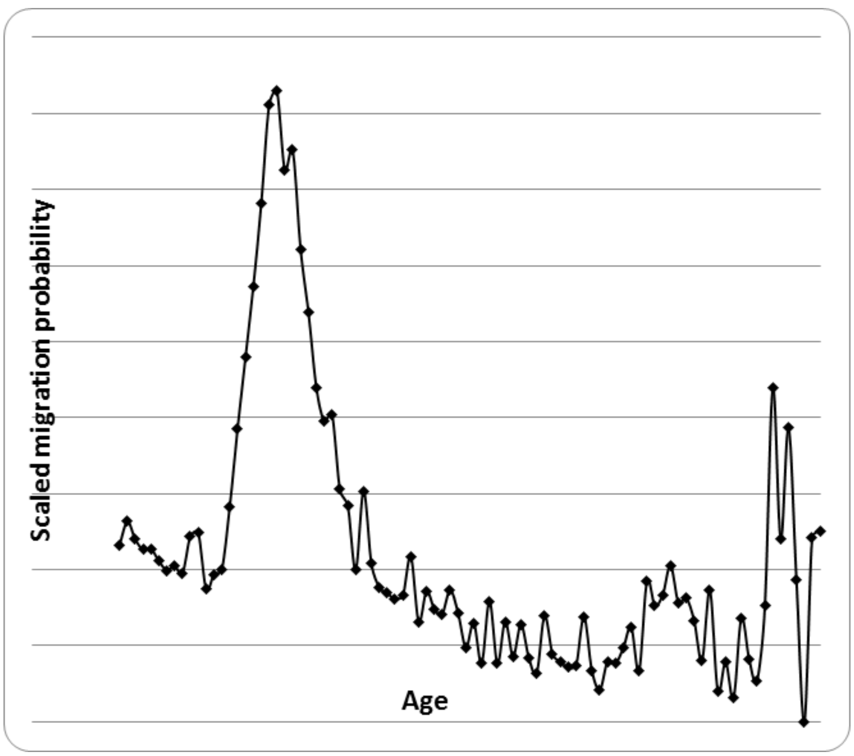


Figure 6.1(b): Out-Migration of Female



7. EASTERN REGION

Figure 7.1(a): Out-Migration of Male

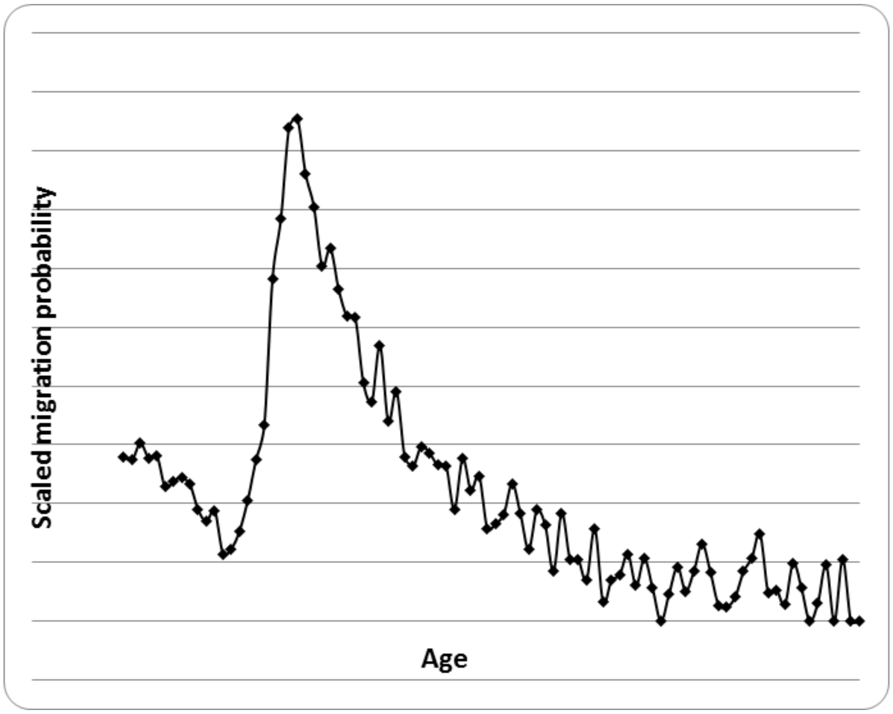
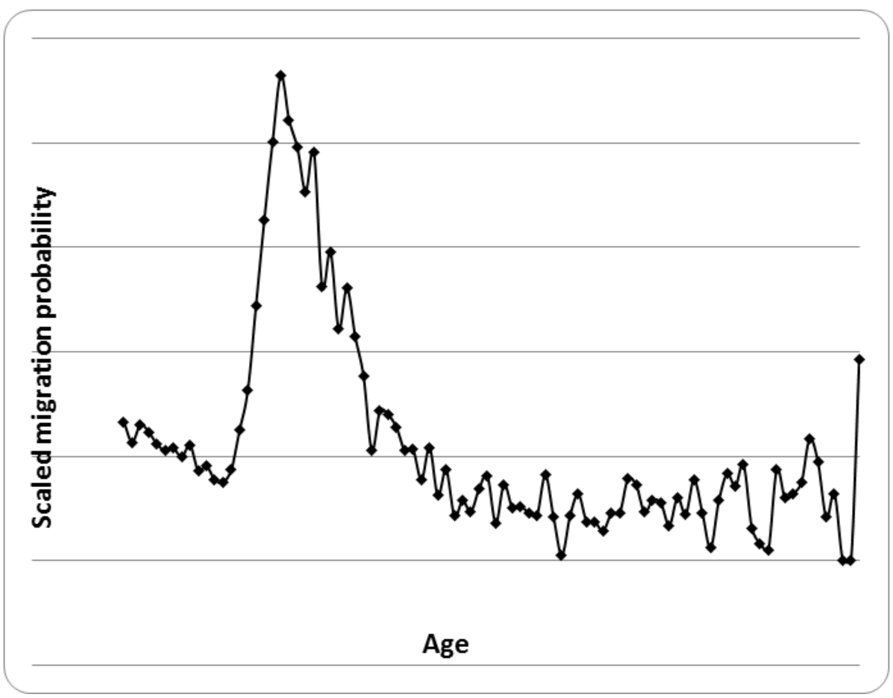


Figure 7.1(b): Out-Migration of Female



8. RIFT VALLEY REGION

Figure 8.1(a): Out-Migration of Male

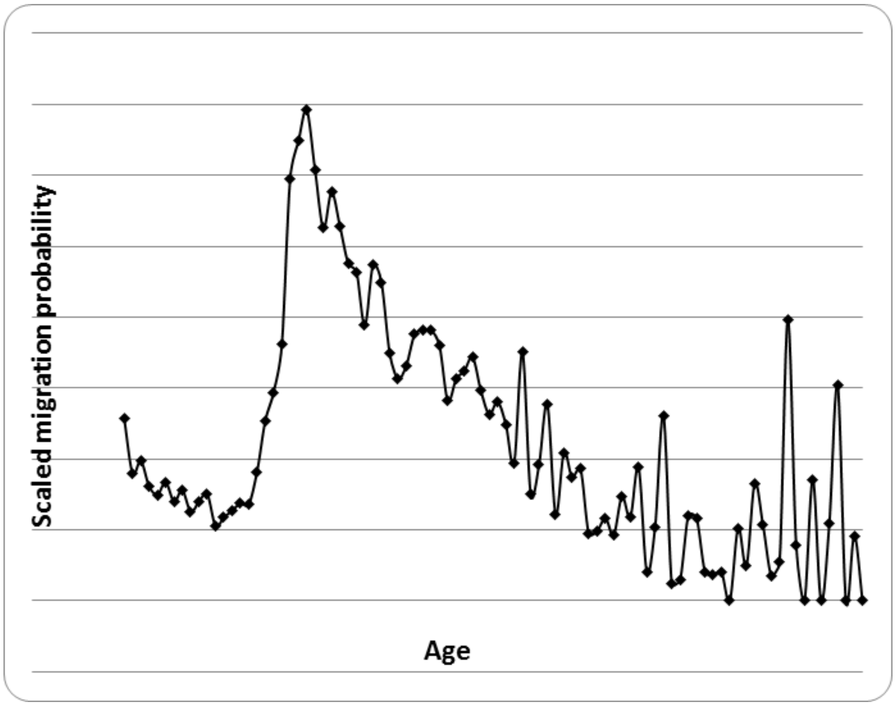


Figure 8.1(b): Out-Migration of Female

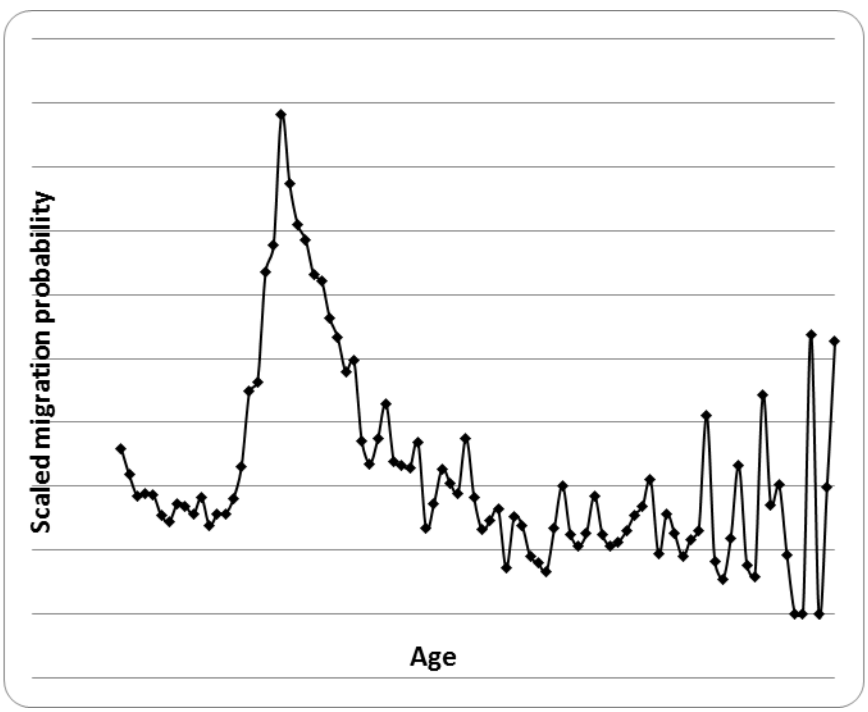


Table 2: Model Migration Schedules' Parameters

SEX	DIR	a_1	α_1	a_2	α_2	λ_2	c	μ_2	X - low	X - peak	X - Shift
NAIROBI											
M	**OUT**	0.014592	0.050594	0.010065	0.014011	1.381879	0.003022	19.631739	18	22	4
F	**OUT**	0.015966	0.016900	0.032030	0.330671	0.346243	0.001356	20.993530	15	21	6
COAST											
M	**OUT**	0.007538	0.034422	0.031779	0.040116	0.582358	0.001740	19.725915	16	24	8
F	**OUT**	0.009310	0.030684	0.058371	0.126773	0.512304	0.002009	19.026194	15	23	8
NYANZA											
M	**OUT**	0.010086	0.045224	0.043427	0.068116	0.769651	0.002020	18.077913	15	21	6
F	**OUT**	0.011838	0.031263	0.064106	0.143939	0.579362	0.001163	17.719124	14	20	6
NEP											
M	**OUT**	0.006526	0.138095	0.057072	0.104975	0.656696	0.002646	20.485088	17	23	6
F	**OUT**	0.011361	0.133736	0.040374	0.094779	0.479289	0.001712	17.570406	14	21	7
WESTERN											
M	**OUT**	0.013638	0.084422	0.050587	0.067058	0.593688	0.000983	18.139788	15	22	7
F	**OUT**	0.013197	0.056737	0.069314	0.114798	0.524403	0.000897	17.687309	14	21	7
CENTRAL											
M	**OUT**	0.013791	0.039610	0.042386	0.083178	0.774841	0.001145	18.224517	16	21	5
F	**OUT**	0.011423	0.036637	0.072365	0.177492	0.415023	0.001549	18.549353	14	21	7
EASTERN											
M	**OUT**	0.016788	0.075549	0.048983	0.074951	0.701338	0.001192	18.394308	16	21	5
F	**OUT**	0.013285	0.042075	0.066003	0.127370	0.556483	0.0005	17.692251	14	20	6
RIFT VALLEY											
M	**OUT**	0.009541	0.054645	0.032844	0.042695	0.657400	0.001214	18.996726	16	23	7
	OUT	0.008160	0.041496	0.048941	0.114585	0.476375	0.002673	18.501515	15	21	6