ESTIMATION OF FERTILITY IN KENYA USING THE PROJECTED PARITY PROGRESSION RATIOS: EVIDENCE FROM 1999 AND 2009 CENSUSES

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DECLARATION

This research project is my original work and, to the best of my knowledge, contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at the University of Nairobi or any other educational institution

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This work is dedicated to my wife Peninnah Ndinda and our son Preston Mumo, who missed me dearly during my evening classes, the preparation of this work and for their unconditional love.

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ABSTRACT

The objective of this study was to analyze the fertility levels and trends in Kenya using the projected parity progression ratios. It sought to establish whether the Total Fertility Rate (TFR) computed from the projected PPRs approach is the same as the one obtained from the conventional approach. The study pursued several objectives. The first, was determine the PPRs for women who have completed child bearing and project the expected PPRs for younger women. The second was to determine whether the projected PPRs for 1999 differ from the observed PPRs 2009. The third was to compute TFR from the projected PPRs approach and establish whether it is the same as the one from the conventional method.

Data was obtained from 1999 and 2009 censuses. The sample size was 10 percent of all the households in Kenya in 1999 and 2009, which was 771,097 and 1,047,671 women respectively. For completed fertility, women aged 45 to 64 years were used; while for projected fertility, women aged 15 to 44 years were used. The main method of analysis was the projected PPRs approach. Comparisons were made between the completed PPRs and the unprojected PPRs in 1999 as well as between projected PPRs for 1999 and observed PPRs in 2009 for the same age cohort. Graphical methods were used to make the comparisons clearer. Further, TFR was computed and compared from that obtained from other methods.

The findings show a slight difference in the projected and the observed PPRs for the same age cohort in the two successive censuses. The TFR was 4.6 in 1999 and 4.4 in 2009 using the projected PPRs approach. On the other hand, the TFR obtained using the conventional approach for the two years respectively was 4.8 and 4.6 based on Kenya Demographic and Health Survey (KDHS). Clearly, the absolute difference between the two estimates was 0.2, hence the two TFRs are comparable. The main implication from the results is that if all the births in the past 12 months preceding the census date are not sampled, the TFR from the projected approach would be lower than it should. The study recommends that a variety of methods should be used in the calculation of TFR in Kenya, in order to compare whether the same fertility levels are arrived at. Future studies could investigate the progression from marriages to first birth, or first birth to marriage.

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Acronyms and Abbreviations

${}_{45}TOFR_5$	Total Order-Specific Fertility Rate
${}_{5}TOFR_x$	Cumulated Order-Specific Fertility Rates
AOSFRs	Age Order-Specific Fertility Rates
ASFRs	Age-Specific Fertility Rates
CEB	Children Ever Born
CFS	Completed Family Size
IPPR	Instantaneous Parity Progression Ratio
KDHS	Kenya Demographic and Health Survey
KPHC	Kenya Population and Housing Census
PPR	Parity Progression Ratio
TFR	Total Fertility Rate

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Fertility is one of the dynamics that influence population change. According to Moultrie and Zaba (2013), in most settings and in the long term, fertility is the most important determinant of population dynamics and growth. Over time in demographic studies, different scholars have developed methods of measuring fertility either directly or indirectly (Hinde, 1998). Direct methods of measuring fertility are mainly used when adequate data, as per methodological requirements, is available. However, many developing countries are faced with the challenge of incomplete data, hence the reason why indirect approaches are used.

In measuring fertility, demographers seek to establish trends, levels, estimates or projections. The results of such measurements are important because they do not only lead to more research but also inform the process of policy making. Hinde (2014) summarizes the limitations associated with period measures of total fertility rate (TFR). He observes that although the conventional approach (the age-specific fertility rates-ASFRs) gives the current prevailing fertility levels in a population on whose basis forecasts can be made, the approach shows that fertility levels vary substantially from one year to the next. In addition, TFR based on the conventional ASFRs (period approach) may produce misleading fertility estimates in the long run. This is because since TFR based on ASFRs is calculated on an annual basis, it could be affected by changes in the timings of births in that year. Further, the conventional TFR approach is highly affected by rapid changes in the distribution of birth among women in the reproductive age, such as changes in age at first birth. On this basis, Hinde (2014) recommends the use of cohort measures of fertility because they summarize the lifetime experiences of age cohorts of women.

Cohort TFR represents fertility levels of real cohorts of women, as opposed to the conventional period TFR approach. Hinde (2014) writes that cohort TFR is not affected by transient period effects, such as was the case in Japan in 1960s. In the years 1966, 1967 and 1968, the TFR based on the conventional approach was 2.0, 1.6 and 2.2 respectively. The fall in 1967 was occasioned by the popular belief then that girls born in that year would suffer from ill fortune. Hence Hinde proposes that the cohort TFR is consistent with the theory of population growth. Parity Progression Ratios (PPRs) are cohort measures of fertility that can help deal with the above challenges of TFR calculated from period approaches. Although PPRs as cohort measures of fertility have more data requirements (and cannot generally produce up-to-date cohort TFRs), they offer more realistic estimates of trends and levels of fertility in a population.

There are many approaches that are used to calculate the PPRs. Srinivasan (1967) proposed a method of calculating Instantaneous Parity Progression Ratios. His aim was to calculate the probability that a woman would progress to the next parity given her parity at the time of the survey or census. Feeney (1986) also proposed a method for calculating Period Parity Progression Ratios. He aimed at calculating the probability that women, having achieved a certain parity, and experienced the events of the corresponding period, progress to the next parity. Further, Brass (1985) proposed a method for projecting PPRs for women who are below the age of 45 years. The basic argument was that if the current age-order specific fertility rates prevailed in the future, the resultant parity distribution could be used to calculate the additional children that the women would add to their current parity. This study uses the projected PPRs approach as applied in the 1999 and 2009 censuses. Justifications for the use of the approach are offered.

This study was based on the thesis that parity-specific methods of estimating fertility would be more stable compared to the conventional period approaches based on mothers age. This means that such methods are not affected by fluctuations in age at first marriage (if the method was age-specific or marriage-cohort-specific) or first birth. Feeney and Yu (1987) showed that TFR values computed from the traditional age-specific fertility rates in China and those from one of the approaches of parity progression ratios were very different for the same year (2.2 and 2.7 respectively). Hence there is need to use a method that is least affected by changes in the age of the mother at first birth and related variables.

There are several advantages of using parity-based measures of fertility over the conventional ones. According to Sibanda (1999), the parity-based methods of fertility measurement control for order-specific fertility rates which are not affected by unexpected changes in the timing of births. In addition, parity-based measures can be used to study the decisions that couples make. In other words, fertility, or progression to higher parities, is a reflection of a reproductive decision hence can be used to study fertility behavior. With parity-based methods, analysts can assess at what point in the family building cycle (or what parity) do most decisions of not progressing to the next parity happen. Age-based methods are limited in this regard. The only disadvantage of the parity-based methods of fertility estimation is the data requirements (Hinde, 2014).

Compared to most countries in the Sub-Saharan Africa (SSA), Kenya has relatively more reliable data especially from censuses and fertility surveys. However, the vital registration system is incomplete (Sibanda, 1999). Like in many other countries, the methods for measuring fertility in Kenya depend on either the type of source of data or the availability of such data. The method to be used in this study has not been applied in Kenya. It would be important to investigate variations in projected and observed (actual) PPRs in the next census in a bid to assess the effectiveness of the method and the specific approach. This study was based on a method originally proposed by Brass (1985), who applied it in Seychelles, and was subsequently applied by Moultrie and Zaba (2013) in Cambodia, with some improvements. Details on other applications of the method are provided in the next chapter; section 2.3.2. While Brass' original method for projecting incomplete PPRs to the end of a woman's reproductive age did not show how TFR could be calculated, Moultrie and Zaba made this improvement.

1.2. Statement of the Problem

The conventional methods for the estimation of TFR are limited in bringing out the intra-parity experiences of age cohorts of women. Past studies show that the conventional TFR method is affected by rapid changes in births within a certain period. For instance, Feeney (1986) showed that changes in the women's attitudes towards childbearing in the 1980s led to fluctuations in the Japanese TFR. According to Pressat (2002), TFR offers the summary measure of fertility in the entire population for a specific point in time. There is thus need to analyze in details the life-long fertility experiences of age cohorts of women and compare these results with other methods.

Parity progression ratios offer a true picture of the fertility behavior experienced in a certain population (Feeney, 1986). Unlike the TFR calculated from the conventional approaches, projected PPRs obtain fertility levels and trends on the basis of the completed fertility (Jolly & Brass, 1993). However, the application of PPRs in Kenya has suffered one main limitation: they are incomplete. This is so because as women who have not completed child bearing progress to higher parities, their PPRs are bound to change (Sibanda, 1999; Agwanda, 2008). Hence in their incomplete status, PPRs for younger women do not offer a true picture of their fertility behavior since they have not yet completed child bearing process. On this basis, there is need to offer a solution to this gap in the application of the PPRs in Kenya, if their full usefulness is to be realized.

Jolly and Brass (1993) discuss the methodological issues in the estimation of fertility. He observes that the projected PPR method is less applied in Kenya. In his 2012 study, Mutakwa recommends that there is need to apply the PPR method on at least two successive censuses in a particular population to assess how well the method works. Mutakwa's recommendations appear to be in line with what Ochieng (1996) pointed out, that the method should be used on recent data sets and compare the results from other methods. Specifically, there is need to compare the projected PPRs with the observed completed PPRs in the next census; hence assess the appropriateness of the method. It is true that Kenya has experienced a substantial fertility decline (with a recent stall since the start of the millennium), hence the need to show whether other methods show the same trend as well the rate of change. This study computed the projected

PPRs for the 1999 census and compared them with the observed PPRs in 2009 for the ages of women that have completed childbearing.

The study sought to answer the following research question:

- Is the TFR computed from PPRs the same as that from the conventional approach?

1.3. Objectives of the Study

The general objective was to analyze fertility trends and levels in Kenya using the PPRs. The specific objectives of the study were:

i. To determine the PPRs for women who have completed child bearing and project the expected PPRs for younger women;
ii. To determine whether the projected PPRs for 1999 differ from the observed PPRs 2009; and
iii. To compute TFR from the projected PPRs approach and establish whether it is the same as the one from the conventional method.

1.4. Justification of the Study

The measurement of fertility in Kenya in the recent times has mainly focused on estimates based on specific periods of time (Sibanda, 1999). Literature on fertility in the country has well documented values of fertility levels in each period of time. In addition, policy makers and development planners are concerned with the aggregate measures and summary indicators of fertility. For instance, the TFR, mean Children Ever Born (CEB), Age Specific Fertility Rates (ASFRs) and other measures from 1970s to-date are well documented. However, there is less focus on the lifetime fertility experiences of cohorts of women. This study contributes to the already existing body of knowledge on fertility trends and estimates in Kenya, but from a perspective that has not been applied. In other words, the study contributes to the scrutiny and analysis of the fertility behavior of Kenyan women in different generations. It compares the extent of differences in fertility behavior among Kenyan women in different generations.

Second, the study is important because it applies a method that enables the projection of expected trends in fertility, on the basis of the past trends (Moultrie & Zaba, 2013). While the first set of explanations has been the rationale for PPRs since 1950s, it was not possible to project PPRs until Brass (1985) improved the method. If projections based on 1999 are confirmed by the observations in 2009, the projections for future censuses can be done as well. In the final analysis, the study compared its results with the already known levels and trends of fertility in Kenya.

1.5. Scope and Limitation of the Study

This study focused on Kenyan women aged 15 to 64 years at the national level. It used the 1999 census data on recent birth histories and current fertility to calculate PPRs for women who have completed their childbearing and project PPRs for younger women. Data on birth histories was checked using the el-Badry correction while data on current fertility was checked using the distribution of ASFRs. In order to check the appropriateness of the PPRs method proposed by Brass, the PPRs projected based on the 1999 census are compared for the same cohort of women in 2009 two age groups above the 1999 PPRs. The limitation of this study is that not all children born in the past 12 months preceding the censuses were captured. This was so because questions P48-P49 and P32-P33 in the 1999 and 2009 enumeration forms did not provide for the date (day) of birth. Thus, births were summed from September the previous year to August of the census year; leaving out births that occurred between August 25 and 31.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter explores the existing literature on estimation of fertility. Specifically, it investigates how the different approaches of parity progression ratios have been applied in the study of fertility trends in other parts of the world and then applying specific approaches to Kenya. The chapter begins by explaining the concept of PPRs followed by an exploration of the various approaches used to compute PPRs in section 2.2. Thereafter, specific approaches are presented in the rest of the sections. Reasons are offered regarding why the approach presented in section 2.3.2 was used. The second last section presents how PPRs have been applied in Kenya, while the last section summarizes the chapter and justifies why the cohort PPRs approach was applied in Kenya.

2.2. The Concept of Parity Progression Ratios

A parity progression ratio (PPR) is the proportion of women who progress from one parity (i) to the next (i+1) (Moultrie and Zaba, 2013). PPRs can be calculated for cohorts of women based on their dates of birth or marriage. In modern times, age cohorts are used in the calculation of PPRs. If there is no differential mortality among the older women (above 50 years of age), the PPRs are literally fixed. However, according to Brass (1985), PPRs for women who have not completed child bearing suffer from both censoring and selection effects. This is so because after such women proceed to increase their birth orders, their incomplete PPRs change. This means that comparison of the incomplete PPRs of younger with the complete PPRs for older women is misleading.

The concept of PPRs has changed over time. The initial thoughts on PPRs appear to have been put forward by Henry (1953). The pioneers of PPRs sought to calculate the proportions of marriage cohorts of women who progressed to higher birth orders and consequently analyzed the levels and trends in fertility change. A closer exploration of the changes in the concept of PPRs establishes linkages with determinants of fertility. At the infancy of demographic analysis, marriage was considered the most important determinant of fertility, hence the reason why PPRs were based on marriage cohorts. Moreover, data availability was also another factor that determined the formulations of PPRs approaches. Hinde (1998) observes that when demographers began to consider age as a more important determinant of fertility than marriage, PPRs were based on age-cohorts. In the past three decades or more, debate has taken a different turn in that many demographers consider age as a more important determinant of fertility. This led to PPRs formulations that were based on age cohorts. Furthermore, other demographers consider parity, the number of children that a woman already has, as the more significant factor in determining fertility.

More recently, there have been many developments in that PPRs can be computed from a variety of sources including birth intervals; in which cohorts of women do not matter. Admittedly, a significant change in the way PPRs are used today is in the analysis of the family building process (Agwanda, 2008) and the fertility behavior (Sibanda, 1999). When PPRs are disintegrated by age and parity of the mother, more specific fertility experiences are unraveled. Moreover, whichever approach is used, the original idea of PPRs still remains the same: analysis of fertility trends and levels.

In this study, Brass (1985) proposes an innovative way of projecting the expected PPRs for women who have not yet completed their childbearing. In the process of doing so, hypothetical cohorts are constructed. Hence, the consequent average parities are used to compute the completed family size (CFS) which the equivalent of total fertility in a real cohort. Notably, the observed and the projected proportions of women currently aged x to $x + 5$ who are expected to have had i or more births are identical after the childbearing age (x≥ 50). Thus PPRs can be expressed either as whole numbers or as proportions such that

$$a(i) = \frac{W(i+1)}{W(i)} = \frac{W(i+1)/N}{W(i)/N} = \frac{M(i+1)}{M(i)}$$

Where

$a(i)$= the parity progression ratio

W= the number of women either with parity i or i+1

N= the total number of women in the population; and

M= the proportions of women with parity i or i+1

2.3. The Evolution of PPR Approaches

This study identified three significant regimes in the evolution of approaches to the calculation of PPRs. These included the Instantaneous Parity Progression Ratios (Srinivasan, 1967), Projected Parity Progression Ratios (Brass, 1985) and the Period Parity Progression Ratios (Feeney, 1987). Perspectives of evolution of PPRs that are not captured in the three are grouped as “other approaches” towards the end of the chapter.

Henry (1953), formerly propounded the idea of PPRs. Since the time of Henry, many publications on PPRs have been done. From a review of sampled literature, what emerges is somewhat divergent views regarding the approaches and assumptions underlying the calculation of PPRs as measures of fertility trends and levels. Consequently, there are also different categorizations of the approaches to the estimation of PPRs. Moreover, one general distinction that holds for all PPRs approaches is that they are either direct or indirect. There are further subcategories of those approaches that are based on either direct or indirect methods of estimation.

After Henry’s (1953) first approach for the calculation of PPRs failed to gain wide application, he modified it in 1980. In his new formulation, he derived an expression for representing the proportion of a hypothetical cohort of women who having experienced an event, experiences another event, such as a birth and a subsequent birth. On the basis of this rationale, Feeney (1987) used the method to analyze Chinese fertility after the promulgation of the one-child policy. Using data from fertility surveys, the following variables: date of birth (first event), and subsequent events which include age at first marriage, pregnancy and contraception were analyzed.

2.3.1. Instantaneous Parity Progression Ratios

Srinivasan (1967) proposed a method for estimating PPRs based on birth intervals. He referred to it as Instantaneous Parity Progression Ratios (IPPRs). Although this study considers IPPRs as an approach of calculating PPRs, there are dominant conceptual differences. While PPRs calculate the probabilities that a women with i^{th} parity will ever proceed to the next parity, IPPRs compute the probability of a woman with i^{th} parity at the time of survey or census will ever proceed to the next parity. IPPRs can be converted to PPRs and vice versa.

The argument behind Srinivasan's method is that open birth intervals can be expressed as a function of closed birth interval and IPPR. It then follows that IPPRs can be calculated if both types of birth intervals are known. One of Srinivasan's assumptions was that at any survey time, women are either fertile or sterile. While fertile women would probably proceed to the next birth, sterile women would not. He showed that for specific parity *i*,

$$E(U_i^*) = \alpha_i^* E(U_i) + (1-\alpha_i^*) E(S_i)$$

Where

U_i = open birth interval of fertile females of parity *i*

S_i = the open birth interval of sterile females of parity i

U^*_i =the open birth interval of females of parity *i* in the population; and

α^*_i =IPPR for parity i.

Consequently,

$$E(U_i) = \frac{E(T_i^2)}{2E(T_i)}$$

$$E(S_i) = \frac{E(V_i^2)}{2E(V_i)}$$

Where

T_i =the closed birth interval between i^{th} and $(i+1)^{th}$ births; and

V_i =the interval between the birth of i^{th} child and the end of reproductive period and the i^{th} child is last child for those women.

The above imply that the method requires that the interval between the last child's date of birth and the end of the reproductive age is determined. To get this interval, survey questions are designed in such a way that the age of the last birth is known, but only for women who have completed childbearing. One difficulty in this data requirement is that most surveys only focus on women within the reproductive age. Where those who have completed child bearing are included, there are likely biases in the response to the question on the date of birth of the last child. One of the most evident things is the issue of memory, especially where such births were somewhat distant from the time of the survey. Above all, such women (who have completed child bearing), are only a small proportion compared to those in the reproductive age.

Due to the shortcomings of the Srinivasan's model, many other scholars have conducted more research to develop the method or suggest others. In order to overcome the above shortcoming, Yadava and Bhattacharya (1985) proposed a method that utilized women in the reproductive age and their open and last closed birth intervals data. Indeed, the method would be a modification of the Srinivasan's model. In Yadava and Bhattacharya's model, only women with birth intervals less than C, a pre-assigned period, are included in the calculation such that

$$P[T_i \geq C] \cong 0$$

On this basis,

$$E(U_i^*) = \frac{\alpha_i E(T_i^2) + (1-\alpha_i)C^2}{2[\alpha_i E(T_i) + (1-\alpha_i)C]}$$

Where α_i =the PPR value for parity i

From the above equation, α_i can be computed if the i^{th} order open and closed birth intervals are known and a suitable C is selected.

One of the assumptions in the above calculations is that there is a uniform distribution of the i^{th} births. However, this may not always be true in real world. This led to the more development of the earlier methods by Sheps and Menken (1972), Poole (1973), Yadava and Sharma (2004) and others. Sheps and Menken based their argument on the cohort approach and concluded that the mean of the most recent closed birth interval is greater than the usual closed birth interval. Yadava and Sharma, using the National Family Health Survey of 1998-99, also showed that for a heterogeneous population, the most recent closed birth interval is not equal to the usual closed birth interval. This is the basis for Yadava and Sharma's (2009) question: whether T_i should be the most recent closed birth interval or the usual closed birth interval. Their study used both types of closed intervals to compute and compare α_i or simply the levels of PPRs.

Their analysis was grounded on the fact that Srinivasan's and Yadava-Bhattacharya's formulae for calculating PPRs should not include E(Ti) and $E(T^2 i)$ separately but use the expression

$$\frac{E(T_i^2)}{2E(T_i)}$$

Consequently, this would imply that the PPRs estimates obtained from the most recent birth interval or the cohort-based birth interval are not affected to appreciable degrees. However, conceptually, the most recent closed birth interval measures fertility experience in the recent past while the closed birth intervals based on the cohort approach measure fertility experiences for more distant periods. Moreover, Yadava and Sharma (2009) concluded that estimates of PPRs based on the most recent closed birth intervals are more reliable than those based on the cohort approach.

2.3.2. Projected Parity Progression Ratios

Brass (1985) developed the PPRs concept to a higher level. He observed the unreliability of the PPRs calculated from the proportions of women who have attained different parities and had not completed their child bearing. It was noted that the method was initially tailored for countries that had incomplete or defective data. Brass concluded that for age cohorts of women who had completed childbearing, the PPRs were somewhat unchanging. However, there was need to devise a method for projecting the PPRs for younger women. The utility of Brass' method is that it provides insights into family limitation process and changing fertility trends. Above all, the method enables analysts to understand parity-specific fertility limitation.

The calculation of PPRs for age cohorts of women who have already completed childbearing follows Henry's (1953) original formulation. However, while Henry used marriage cohorts, Brass (1985) used age cohorts. If ratios for women in different cohorts are compared, insights into fertility trends in the past can be obtained. Moreover, Brass admits that more meaningful trends are obtained if more censuses are used. For younger women, Brass proposed a method in which fertility rates calculated from births in the past one year are applied on the current age-order distribution to envisage how future parity distributions by age would look like. It is on the basis of the future parity distributions that projected PPRs are calculated from.

The calculation of projected PPRs as proposed by Brass (1985) involves a number of steps. As earlier shown, the age-order specific fertility rates (AOSFRs) calculated from births in the past 12 months are used to projected forwards the nature of the parity distribution expected in the future (end of childbearing) if the rates were to remain constant. The AOSFRs are used to calculate the cumulated fertility rates (equivalents of total fertility) for each birth order across all age groups. The cumulated fertility rates, though synthetic cohort measures (because they are based on period rates), are used to calculate the births expected to be added to women with parity i already by the time they complete their childbearing. The additional proportion expected to reach parity i is added to the current proportion with parity i, which becomes the projected parity distribution. It is from this distribution that the projected parity progression ratios are calculated.

Brass (1985) method introduces two concepts that lacked in previous methods. The first is $M(i)$, the proportion ever-attaining parity order i. This is simply the proportion of women who have i children or more. The second is $a(i)$, the parity progression ratio. This is the proportion of women who progress from one parity to the next. The proportions of women who have at least i children and are expected to progress from one parity to the next, are given by $M^*(i)$ (projected proportions of women with at least i children) and $a^*(i)$ projected parity progression ratios respectively.

Brass (1985) applied the method in Seychelles using the 1976 census data. He observed that the projected ratios were slightly higher than the actual ratios, because there was definitely decline in fertility (the method assumes that the AOSFRs would remain unchanged till the end of the childbearing period). The method was later refined by Sloggett, Brass, Eldridge *et al.* (1994). It was also also applied in Nepal by Collumbien, Timæus and Acharya (1997) and Muhwava (2002) in Zimbabwe. Moultrie and Zaba (2012) refined Sloggett, Brass, Eldridge and Timæus' (1994) application of the method and applied it in Cambodia on the 2008 census data. Based on Moultrie and Zaba's (2012) application, Mutakwa (2012) further applied the method to study fertility trends in four countries: Zimbabwe, Panama, Malawi and Cambodia. In all these applications, there was formal publication, hence why the method has been under-applied.

Moultrie and Zaba (2013) published the new application of the method through UNFPA and the International Union for the Scientific Study of Population (IUSSP). In their application of the method, they added certain aspects that Brass had not included, such as the computation of total fertility rate (TFR) from the total order-specific fertility rates. The method has not been adequately applied in Kenya. This study applied it on the census data of 1999 and compared the results with those of 2009.

2.3.3. Period Parity Progression Ratios

Feeney and Yu (1987) are acclaimed for using the Period Parity Progression approach to measure fertility in China using data from the 1982 State Family Planning Commission. The study was based on data collected from the National One-Per-Thousand Fertility Survey that focused on the years between 1955 and 1981. The two researchers used the period parity progression measures in many aspects as they were originally proposed by Henry (1953). Feeney and Yu's approach focused on parity cohorts as opposed to age or marriage cohorts of women. Specifically, they calculated the proportions of women who proceeded from i^{th} parity to $(i+1)^{th}$ parity on a period basis.

The approach used by Feeney and Yu differs from the original approach by Henry in three aspects. First, the ratios were directly calculated from real data as opposed to Henry's ratios which were indirectly estimated. Second, their units of analysis are different. While Henry used marriage as the unit of analysis, Feeney and Yu use the individual women as their unit of analysis. Third, other than the traditional family building process of marriage then births, Feeney also calculated another ratio of the progression from a woman's first birth to marriage. It appears that the approach used by Feeney and Yu (1987) does not just focus on marital fertility but the overall fertility, including non-marital fertility such as the one described in the third difference between their approach and that of Henry.

Some of the goals of this study were similar to those of Feeney and Yu. Just as they did, the writer sought to compare the total fertility rates computed from period parity progression ratios to those computed from age-specific fertility rates. Feeney and Yu (1987) found startling differences between the TFR computed from age-specific fertility rates and the ones computed from the period parity progression ratios. Those from the age specific fertility rates showed that there was a sharp rise in TFR between 1980 and 1981, from 2.2 to 2.6. On the other hand, the period parity progression ratios method showed that in the same period, TFR actually declined from 2.70 to 2.65 children (between 1980 and 1981).

The above difference was explained by the fact that there was a policy adjustment in the age at first marriage in 1981, which led to that increase in levels calculated from the age-based method. Feeney and Yu (1987) thus concluded that in countries where fertility is low and fluctuates on the basis of the age of the mother, the period parity progression ratio approach is the best to use. This justifies why the period method is not used in this study: because Kenya's fertility is not low and is not controlled such as the Chinese one-child policy where Feeney and Yu applied the period parity progression ratio approach of PPRs.

The following represents the rationale for the calculation of period parity progression ratios in Feeney and Yu's formulation. If *A* denotes any event and B any subsequent event, for instance *A* 'first birth' and *B* 'second birth', the period ratio of progression from event *A* to *B* can be calculated if the proportions of those experiencing both events are defined and their numbers known (Feeney and Yu 1987). If q_E is the proportion of women who experience both A and B in this year, and q_x is the number of women at the beginning of this year who experienced A between exactly x and x+1 years ago, divided into the number of the same women who experience B during the same year, x=0, 1, 2…, the ratio of period progression from A to B is calculated thus;

$1-(1-q_E)(1-q_0)(1-q_1)\ldots$.

The above statistic is simply the proportion of women observed in a year, who, after experiencing the rate of progression q_E and q_x x=0, 1, …, experience *B* after *A*. Feeney and Yu (1987) appear to have borrowed the formulation from mortality measurements in which A represents birth and B death. In fact, the q_x in this case are the arithmetic complements of 'ratios of survivorship' as they are used in population projections.

In other terms, the parity progression ratios are the products of 'period ratios for progression' from one event to the other, assuming that the individuals experience the same rates in all values of x. Thus is p_M represents period ratio for progression from birth to first marriages, p_{M1} 'from first marriage to first birth' and pi 'from (*i*) to $(i+1)^{th}$ birth, *i*=1,2…, and p_0 is the product p_M and p_{M1}, the p_0 is the period parity progression ratio: the proportion of all women in an hypothetical birth cohort, who ever have a first birth (Feeney and Yu 1987). Since not all born women proceed to have the first birth and not all those who have the ith birth would have the (i+1)the birth, the period parity progression ratios (and indeed all other PPRs) all less than one and reduce successively.

Feeney and Yu (1987) showed that the total fertility rate would be computed using the formula;
$TFR=p_0+p_0p_1+p_0p_1p_2\ldots$where p_i, i=0,1,2…, are period parity progression ratios.

Feeney and Yu found out that the period parity progression ratios from parity 3 to 7 declined sharply between 1979 and 1980 due to the one-child policy. They also cite one of the disadvantages of the approach compared to those approaches based on age-specific or age-order-specific fertility rates: the approach requires more data.

Before the Chinese study, Feeney (1986) had calculated the period parity progression ratios for Japan for the years 1950 to 1982. He has used data from surveys taken in 1974, 1981 and 1984. Since the study combined survey data with data from vital registration system, there are observed inconsistencies. Hence, a method for integrating survey and vital registration data was devised. Moreover, he concluded that surveys always overstate the period ratio for progression from parity (i) to (i+1). This further justifies why the method is not used in the case of Kenya. Further, Lutz (2013) observes that period parity progression ratios are unusual fertility measures even in the field of demography. Feeney (1986) concluded that the indirect estimation of period parity progression ratios yield better results than the direct methods.

2.3.4. Other Approaches to the Calculation of PPRs

There are several approaches associated with the computation of PPRs. Mutuku (2013) compares the two fertility methods: cohort fertility and period fertility. Citing Ryder (1964) he observes that while the period fertility method describes the annual fluctuations in the age-specific fertility rate, the cohort fertility method describes the expected lifetime experience of a particular generation of women. Hence, he observes that the parity progression ratios method is a variant of the period fertility method as opposed to the cohort fertility method. The method seeks to describe the fertility experience of actual groups of women by increasing the specificity of rates. This implies that the rates are specific not only to the age of the mother but also to the parity. On this basis, it would be rightly argued that PPRs represent the probability of women in a certain generation to have an additional birth in the following year given the current parity. Mutuku (2013) further acclaims the method as a useful one since it leads to at least two ends. First, it provides a concise understanding of trends in fertility among different generations of women. Second, the method is useful because it breaks down fertility into its components (such as parity and age) and can also be used to compute the TFR.

The approaches to the estimation of PPRs can be summarized as the cohort approach and and period approach. The use of birth intervals can be based on either. The latter approach uses probabilities in computing PPRs. This study used the cohort approach to compute the ratios for completed parities for older women as well as projected parities for younger women. Elsewhere, Akers (1965) enlists three approaches to the computation of PPRs: historical, mathematical and survey approaches. From this perspective, the current study combines census survey and mathematical approaches.

Monari (2009) identifies two models of estimating PPRs. These include the life table approach and the analytical approach based on birth intervals. Henry (1953) cited in Monari (2009) developed a life-table approach that can be used for the analysis of fertility distribution. For a cohort of married women, the progression to the next parity have attaining the current parity is defined by a set of probabilities that are specific to the time since the last birth and parity. According to this approach, if $B_{i,,x,,t}$ is a representation of births of i^{th} order that occur during time (t) in (x) months after the last birth, then there are $\sum B_{i,,x,,t}$ births of order (i). This method requires data from censuses, fertility surveys as well as vital registration systems. In his 1987 study of birth intervals in England and Wales, Bhrolchain estimated the PPRs for women who proceeded up to birth order 6. The PPRs were considered as proportions of women who proceeded to parity (i+1) within a period of 10 years taking median time between the current parity and the next parity.

Whepton (1954 in Monari, 2009) had also developed a life table-based approach to the calculation of PPRs. In his approach, the progression from one parity to the next was defined by birth probabilities that were specific to age and parity. The method achieves a wide range of objectives, including distributions for completed parity as well as PPRs on a period basis. It was based on data obtained from population registers and vital registration systems. Notably, the method highly depends on birth histories data. One of the shortcomings of the method, according to Morani (2009), is that the process of calculating the age-parity-specific birth probabilities is somewhat cumbersome. Moreover, it was possible to apply the method in the United States of America to analyze fertility trends with special focus on childbearing. Other than the US and Japan, there has not been a recent national application of the method known in the popular journals of population studies and demography.

Other life table-based approaches were used by Rashad (1987) and Moreno-Navaro (1987). Rashad used the method to study fertility trends in Egypt as well the what she referred to as "collective fertility behavior". Using data from the Egyptian Fertility Survey, he showed that levels of marriage and fertility differed significantly between the years 1974 and 1979. He used the method to calculate what he referred to as Specific Parity Progression Ratio (SPPR) which, among other things, computed the probability of unmarried cohorts of women to proceed to marriage. In the case of Moreno-Navaro (1987), a life table approach based on birth intervals was used to explore patterns of childbearing in South American countries: Costa Rica, Panama, Mexico, Peru and Colombia. Data was extracted from the World Fertility Survey and used the multiplicative hazard model to arrive at its conclusions regarding Latin American fertility.

2.4. Application of PPRs in Kenya

The projected PPRs approach has not been applied in Kenya. However, there have been numerous applications of the PPRs in general in the estimation of fertility trends in Kenya. Sibanda (1999) applied PPRs in the study of fertility decline as evident in the period 1988 to 1993. Sibanda used the KDHS data and applied the parity progression ratios and conditional age-parity specific birth probabilities methods. His study contributed important insights on the specific components of fertility decline in the study period.

Ochieng (1996) used the 1993 KDHS by applying the Yadav-Bhattacharya method (a modification of Srinivasan approach) to study the fertility levels and trends in Kenya. In addition, Kimani (2005) applied the method in assessing fertility change in Kenya for the period 1998 to 2003. He found out that 87 per cent of women proceeded from parity 1 to 2, on the basis of 2003 KDHS. Further, Agwanda (2008) used the method to assess the family building patterns in Kenya at the time when fertility stalled. He found out that the proportions of women progressing to the next parity were higher for the women aged 25-34 (middle ages) especially from parity 4 to 5. Recently, Mutuku (2013) used PPRs not only to estimate trends in fertility but also to factors that contributed to thse trends. He found out that 90 percent of women in the reproductive age progressed from parity 1 to 2 while 52 percent progressed from the 4th to 5th order.

2.5. Summary

This chapter sought to explore the concept of PPRs, how PPRs approaches have evolved over time and how they have been applied in Kenya. It was shown that a parity progression ratio is the proportion of women who progress from one parity to the next. The concept of PPRs has changed over time. Although PPRs were designed to measure fertility trends and levels only, today they can be used to study fertility behavior. This study identified three significant regimes in the evolution of approaches to the calculation of PPRs. The first one was the Instantaneous Parity Progression Ratios, Projected Parity Progression Ratios and the Period Parity Progression Ratios. Other methods are based on life tables.

There have been numerous applications of the PPRs in Kenya; but the projected PPRs approach has not been applied. This study uses projected PPRs approaches for both general and specific reasons. Generally, Lutz (2013) recommended the use of a cohort based approach in the estimation of PPRs. Ryder's (1968) studies also appear to be inclined towards the preference of cohort analysis to others. Halli and Rao (1992) assert that cohort analysis enables the researcher to study exhaustively the behavior being investigated as well as the population at risk of the event of interest. The two scholars differentiate it from a longitudinal study, which are different concepts altogether. They emphasize the importance of cohort approaches by citing Frost's (1969) study on tuberculosis mortality by using cohort analysis. Although cohort effects are difficult to include in models, Halli and Rao citing Pullum (1980) admit that the gains achieved from cohort parameters outweigh those from period parameters.

More specifically, the method was used because it allows the projection of the expected parity progression ratios of younger women, who have not yet attained the menopause. Further, the projected PPRs approach makes it possible to decompose fertility into birth order components clearly superior to the components of age-specific fertility rates (Lutz, 2013). The utility of decomposing fertility into its birth order components is that the analyst is able to get information on the family size, which is the reflection of the life cycle of the family building process. Furthermore, the projected PPRs approach is not much affected by fluctuations in the timing of births within the parity cohorts, as opposed to the conventional methods of calculating TFR.

CHAPTER THREE

DATA AND METHODS

3.1. Introduction

This chapter presents the sources of data for the study and the methods of data analysis. The first part presents sources of data and methods of data analysis are discussed in part two of the chapter.

3.2. Sources of Data

This study used the 1999 and 2009 Kenya Population and Housing Censuss (KPHC). Specifically, the population file was used. The data was obtained from the Kenya National Bureau of Statistics (KNBS). Although the analysis was based on 1999 data, it was important to use the 2009 data in order to compare how far the projected PPRs for 1999 deviated from the observed un-projected PPRs for 2009 for the ages that had competed their childbearing. The second justification why the 2009 data was also used was in order to check whether the TFRs computed for the two periods depicted the same variation from the TFR computed from other methods.

It is important to note that the data used was 10 per cent sample of the entire households. Preston, Heuveline and Guillot (2001) document some of the limitations of using relatively small samples (such as 10 per cent) for data analysis. For instance, small samples generate statistics that, if used to generalize the situation for the entire population, may suffer from low validity hence rendering the entire analysis results unreliable. Moreover, as it is shown here, the input data required for analysis meets the standards proposed by Moultrie and Zaba (2013). They recommend the computation of projected PPRs should only be based on census data or otherwise large data sets that contain at least 10,000 women in each age group. It is only on the basis of such numbers of women that reliable age-order-specific fertility rates can be derived. As it can be seen in appendix 1, the age group with the least number of women was 60-64 with 21,548.

3.3. Methods of Data Analysis

The main method of data analysis for this study was the application of the projected parity progression ratios approach. In order to apply the approach, it was required that the necessary tabulations were generated from the raw data. At the preliminary stage, variables were either computed or re-coded and cross tabulations obtained. Other methods of data analysis included descriptive analysis and graphical methods (in comparing the estimates so obtained).

The mostly applied method of investigating data quality for women's parity data is the el-Badry correction. The method corrects the misrepresentation of the childless women as parity zero. In this study, when the formula was applied in the input data shown in appendices 1 and 2, the corrected values were the same as the raw values; implying that the data obtained from KNBS had been cleaned. The other explanation is that as Moultrie and Zaba caution, women with unstated parity should not be included in the denominator. As such, there was clarity in that total CEB for this study was the number of boys born alive plus the number of girls born alive: inclusion of unstated parity would have led to classification issues in defining parity zero and childless women on this basis.

Data on current fertility, that is births in the past 12 months preceding the census, was checked using the ASFRs approach suggested by Brass (1985). According to him, the distribution of ASFRs should be unimodal, slightly right-skewed and closer to zero as the age nears the end of child bearing age. In this case, the ASFR for the first age group was 0.1095 while the last age group was 0.0227 (near zero), a proof for plausibility and appropriateness of data on current fertility.

3.3.1. Description of the Method

The calculation of projected PPRs follows several steps. The idea is to use the AOSFRs calculated from births in the previous 12 months preceding the census, to project forwards the parity distribution which will be expected by the end of the childbearing period of each age cohort. As explained above, it is expected that the AOSFRs will remain constant till the end of the reproductive age. In order to project future parity distribution, cumulated fertility rates for births that occurred to women who already had achieved parity i are calculated for all age groups. To cumulate the order specific fertility rates, the AOSFRs are multiplied by 5, the class interval or the age-group. The utility of the cumulated rates is to calculate the additional births of each order expected to be added to women in each age group, by the end of the childbearing period. The additional proportion expected to attain parity *i* by the end of the reproductive span is added to the current proportion of women with at least *i* children. This summation becomes the projected proportion of women with at least *i* children, and is used to calculate the projected PPRs.

3.3.2. Data Required and Assumptions

According to Moultrie and Zaba (2013), the following data is required. For the incomplete parities, parity by age group of women aged 45 to 49 or more is required. For projected PPRs (younger women), parity by age group of women aged 45 to 49 or less, number of children born during the year preceding the survey and the number of children ever born are required. As it was shown in the literature review, the number of births in the year preceding the census are used to calculate the age-order specific fertility rates that would further be used to calculate the projected PPRs (See appendix 1, 2, 3 and 4).

There are two main assumptions underlying the projected PPRs method. According to Moultrie and Zaba (2013), women are assumed to have had at most one birth in the past year. The second assumption is that the AOSFRs so derived will remain constant in the future of the women's childbearing. The first assumption is to a large extend plausible, since a woman cannot have more than one birth in 12 months. However, it is possible for a woman to get twins, a phenomenon which is either generally rare or insignificant at the national level (Westoff & Cross, 2006). The second assumption is far from being true. In populations with rapid fertility increase, these rates (AOSFRs) cannot simply remain constant.

3.3.3. Calculation of Unprojected PPRs

Step 1: Obtain a tabulation for CEB by women's age group

In order to get the input data suggested by both Brass (1985) and Moultrie and Zaba (2013), several manipulations were done on the data. KNBS provided data with variables from which new variables were either computed or transformed. In order to create the age groups, the variable P12 (age in single years for both 1999 and 2009) was re-coded into a different variable. Each of the age groups had a class interval of 5 years, hence there were 10 categories between 15 and 64 years. For appendices 1 and 2, age-groups were created up to 60-64 while for appendices 3 and 4, they were created up to 45-49. In order to calculate the input CEB (which represents parity), it was necessary to compute another variable by summing P40 (boys born alive) and P41 (girls born alive) for 1999 and P24 and P25 for 2009. Then, a cross tabulation was done between CEB (rows) and age-group (columns).

Step 2: Obtain a tabulation of children born in the past 12 months preceding the census by mothers' age group and the already attained parity

There was only one question that could lead to the calculation of the births in the past 12 months preceding the census. This is "when was your last child born?" For 1999, it was variable P48 (month and year) while for 2009, it was variable P32 (month) and P33 (year). Hence, the births of interest were those that occurred between $24^{th}/25^{th}$ August 1998 and the same dates in 1999. In order to calculate the number of births in the last 12 months preceding the census, the "Select Cases" option under "Data" in the Statistical Package for Social Sciences (SPSS) was used. Since the two *de facto* censuses happened on $24^{th}/25^{th}$ of August, first, births that occurred in 1998 were selected and saved as a separate data set. From this data set, births that occurred after August 1998 were also selected and saved as a different data set as well. Then from the bigger data set, the population file for 1999, all the births that occurred in 1999 were selected and saved as a separate data set.

Finally, data sets with births that occurred in 1999 and after August 1998 were merged, by selecting the "add cases" option and the data set saved and a cross tabulation run. Therefore, what is contained in the cells of a cross tabulation of CEB and age-group are the number of children born to women aged x to (x+5) in the past 12 months, who had already attained parity (*i*). Consequently, the output (cross tabulation) was used as the input in Excel from which other outputs are generated as well. This process was done for both 1999 and 2009 in order to generate tabulations shown in appendices 1-4.

One assumption underlies the tabulation for births in the past 12 months preceding the census. First, any women who gave birth in the 12 months period had at most one birth (Brass, 1985). Second, it was assumed that there were no multiple deliveries. If this is so, then the next implicit conclusion is that a birth in the past 12 months to a woman of parity *i* is of birth order *i*. In other terms, if a birth occurred in the past year preceding the census, to a woman whose children ever born are 3, then it was the 3^{rd} child.

For censuses that are held in the middle of the year, tabulating the births in the past numerical year, in this case the entire 1998, would grossly overestimate these numbers. This justifies the constant use of "the past 12 months" as opposed to "the past year" which could be misinterpreted. Additionally, women whose response to the question of births in the past 12 months is "don't know" must not be included in the tabulation.

Step 3 (a): Compute the proportions of women with *i* or more births

The proportions of women ever attaining parity *i* are used in the calculation of the incomplete PPRs in the next step. To calculate these proportions, the number of women aged between x and x+5 is required and is obtained using the equation below

$$ {}_5W_x(i) = \sum_{j=i}^{\pi} {}_5N_x(j). \quad \text{................(1)} $$

Where

i= the parity order;

π= the highest parity attained in the population;

N(i)= the number of women in the population of parity *i* exactly;

N= the total number of women in the population; and

${}_5W_x(i)$ = the number of women aged between x and x+5 with parity *i* or more

The proportions of all women aged *x* to *x* + 5 who have had *i* or more births are thus calculated as

$$ {}_5M_x(i) = \frac{1}{{}_5N_x} \cdot \sum_{j=i}^{\pi} {}_5N_x(j). \quad \text{..........(2)} $$

Where

π= the highest parity attained in the population;

N(i)= the number of women in the population of parity *i* exactly;

N= the total number of women in the population; and

${}_5M_x(i)$= is the proportion of women aged *x* to *x* + 5 who have had *i* or more births.

The above proportions are computed for all the age groups of women whether the women have completed child bearing or not.

Step 3 (b): Finally, the PPRs are obtained using equation 3 below

This is done using the formula

$$ {}_5a_x(i) = \frac{{}_5M_x(i+1)}{{}_5M_x(i)} . \quad \text{……………(3)} $$

Where

${}_5M_x\,(i)$= the proportion of women aged x to x+5 who currently have *i* births;

${}_5M_x\,(i+1)$= the proportion of women aged x to x+5 who currently have *i*+1 births; and

${}_5a_x(i)$= the parity progression ratio of order *i* for women aged (x, $x + 5$)

Notably, for ages x<50, these ratios are incomplete hence the need to project the expected ratios by the end of childbearing age. Therefore, only PPRs for age groups x≥50 should be considered as presenting the true picture of fertility levels and trends. PPRs for women below 50 years are calculated using the method below.

3.3.4. Calculation of Projected PPRs

Step 4: Derive the age-order specific fertility rates

The computation of the projected PPRs begins with the derivation of the age-order specific fertility rates (AOSFRs). These are the rates that, once applied to the past birth histories by age group and birth order, are used to calculate parity distribution in the future. These are calculated using the formula

$$ {}_5AOSFR_x(i) = \frac{{}_5B_x(i)}{{}_5N_x} \quad \text{……………..(4)} $$

Where

${}_5B_x\,(i)$= births in the past 12 months of women aged x to x+5 who had already achieved parity *i*

${}_5N_x$ = the total number of women in the age group x to x+5; and

${}_5AOSFR_x\,(i)$= the age-order specific-fertility rate for women of parity *i* aged between x and x+5

Births in the past 12 months of women aged x to x+5 who had already achieved parity *i* [${}_5B_x(i)$] are tabulated in appendices 3 and 4. It is noted that the total number of women in the age group x to x+5 should not include those with unstated parity. Two measures emanate from the AOSFRs: age-specific fertility rates (ASFRs) and total order-specific fertility rates (TOFRs); whose utility is later shown in table 4.11 and 4.12.

Step 5: Derive the total order-specific fertility rates

The AOSFRs derived in the previous step, if cumulated for order (*i*) for the entire reproductive period and multiplied by 5 (class interval), are referred to as the total order-specific fertility rates (TOFRs). Symbolically, they are calculated thus

$${}_5TOFR_x(i) = 5.\sum_{j=15.5}^{x} {}_5AOSFR_j(i) \quad \ldots\ldots\ldots\ldots\ldots(5).$$

Note that there has been a shift from the conventional age 15 to 15.5, the upper class limit. According to Moultrie and Zaba (2013), the shift is because the age of the mother was collected at the time of the census (which is almost the middle of the year: August in the case of Kenya) and not at the time of birth of the last child. The TOFRs are used to calculate the additional proportion of women who are expected to attain parity *i* between their current age and the end of the reproductive age. This is done by subtracting the cumulated order fertility rates for a specific age group from the total order-specific fertility rate (TOFR). As earlier shown, it is assumed that the current fertility will prevail in the future.

Step 6: Define the age distribution of the order-specific fertility rates and interpolate to conventional ages

The goal of this step is first to re-compute the ages to the conventional ones, as opposed to the upper class limits. While the cumulated order-specific fertility rates apply to the upper class limits such as 15.5, 19.5, and so on, the proportions ever attaining parity *i* and the PPRs only apply at the midpoints of the classes. Hence it is important that the age-order rates are interpolated in order that they may apply to the mid-points of the age groups. So as to do this, the cumulated age-order specific fertility rates are expressed in relation to the total order-specific rates followed by linear interpolation applied on the gompits of the cumulants. But first, the proportion of the total order-fertility rate attained by the upper limit of the class are computed for each parity. Hence, the proportion of the total order-specific rate achieved by the upper limit of the age group is a summation if the rates up to the upper limit of the age group divided by the total rate thus

$$ {}_5\theta_x(i) = \frac{{}_5TOFR_x(i)}{{}_5TOFR_{45}(i)} \quad \text{……………..(6)} $$

Where

${}_5TOFR_x\,(i)$= the cumulated age-order rate for women of parity *i* aged x to x+5;

${}_{45}TOFR_5\,(i)$= the total age-order rate for women of parity *i* aged x to x+45; and

${}_5\theta_x(i)$ = proportion of the total order-specific rate achieved by the upper limit of the age group.

It is found out that the actual fertility schedule is not linear but rather forms a sigmoid curve. Therefore, a double negative log referred to as a gompit is used to transform the curve into a linear function. After computing the gompits, they are interpolated to the relevant ages through an anti-gompit. Hence the above notation of the proportions of total order rates by the upper limit is denoted by an asterisk to indicate the return to conventional mid-points thus

$$ {}_5\theta_x^*(i) = \exp\left(-\exp\left(-\begin{bmatrix} 0.4.\left\{-\ln\left(-\ln\left({}_5\theta_{x-5}(i)\right)\right)\right\} \\ +0.6.\left\{-\ln\left(-\ln\left({}_5\theta_x(i)\right)\right)\right\} \end{bmatrix}\right)\right). \quad \text{………………..(7)} $$

Where

${}_5\theta_x(i)$ = proportion of the total order-specific rate achieved by the midpoint of the age-group.

In order not to introduce huge than realistic proportions of women expected to progress to higher parities, Moultrie and Zaba (2013) suggested that the proportion of order-specific fertility attained by the mid-point of an age group should be greater than 0.3. Consequently, calculations that are based on ${}_5\square^*_x$ (*i*) values less than 0.5 are considered much speculative and should thus be accepted with great caution. This is explained in details in the next chapter.

Step 7: Calculate the expected future order increment

Having shown in step 5 that the additional proportion of women who are expected to attain parity *i* between their current age and the end of the reproductive age by obtaining the difference between ${}_{45}TOFR_x\,(i)$ and ${}_5TOFR_x\,(i)$, it is now possible to calculate the order increment expected in the future. This difference is the same as the product of ${}_{45}TOFR_x\,(i)$ and the complement of ${}_5\theta^*_x\,(i)$ thus

$${}_5TOFR_{45}(i) - {}_5TOFR_x(i) = {}_5TOFR_{45}(i).\left(1 - {}_5\theta^*_x(i)\right) \quad \ldots\ldots\ldots\ldots\ldots(8)$$

Step 8: Derive projected cumulated parity progression ratios and projected parity progression ratios

In order to calculate the projected cumulated PPRs, the expected future order increments are added to the current cumulated PPRs as computed earlier. Finally, the proportion of women in each age group expected to achieve parity *i* is given by

$${}_5M^*_x(i) = {}_5M_x(i) + {}_5TOFR_{45}(i)\cdot\left(1 - {}_5\theta^*_x(i)\right) \quad \ldots\ldots\ldots\ldots..(9)$$

Where

${}_5M_x\,(i)$= the proportion of women aged x to x+5 who currently have *i* births;

${}_5TOFR_{45}\,(i)$= the difference between the total age-order rate for women of parity *i* aged x to x+45 and the cumulated age-order rate for women of parity *i* aged x to x+5 (${}_{45}TOFR_x\,(i)$- ${}_5TOFR_x\,(i)$);

${}_5\theta^*_x\,(i)$= proportion of the total order-specific rate achieved by the midpoint of the age-group; and

${}_5M^*_x\,(i)$= the proportion of women aged (x, *x* + 5) who are expected to have had *i* or more births by the end of their reproductive lives

And the projected PPRs from one parity to the next given by

$${}_5a^*_x(i) = \frac{{}_5M^*_x(i+1)}{{}_5M^*_x(i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Where

${}_5M^*_x\ (i)$= the proportion of women currently aged x to $x + 5$ who are expected to have had i or more births by the end of their reproductive lives; and

${}_5a_x\ (i)$= the projected parity progression ratios

3.3.5. Estimation of TFR

Total Fertility Rate was calculated from the projected PPRs approach adding all the cumulated order-specific fertility rates. Note that all the cumulated order rates have already been multiplied by 5, the class interval. Each cumulated order rate is a summation of all the AOSFRS for parity (i). From this approach, TFR is a summation of all the cumulated order fertility rates. This is represented thus

$${}_{45}TFR_{15}\ (i) = \sum_{i=1}^{7}(\mathrm{TOFR}) \quad \ldots\ldots\ldots\ldots(11)$$

Where

TOFR= total order fertility rate; and

${}_{45}TFR_{15}\ (i)$= the total fertility rate for women aged 15-45

The same TFR is also obtained by summing all the AOSFRs for each age group, summing them across all the age groups and then multiplying them by 5, the class interval. In this case, this formula was used

$${}_{45}TFR_5\ (i) = 5.\sum_{j=i}^{7}(\mathrm{ASFR}) \quad \ldots\ldots\ldots\ldots(12)$$

Where

ASFR= age-specific fertility are ($5*{}_5AOSFR_x(i)$); and

TFR= total fertility rate

CHAPTER FOUR

FERTILITY LEVELS AND TRENDS

4.1. Introduction

This chapter presents the results of the levels and trends of fertility in Kenya on the basis of the projected PPRs approach. It begins by presenting the incomplete or un-projected PPRs for 1999. Thereafter, the projected PPRs for 1999 are presented followed by the observed or incomplete PPRs for 2009. Later, a comparison between the projected PPRs for 1999 and the observed PPRs for 2009 is done. Last, TFRs are computed from the method and compared with the conventional TFR values.

4.2. Unprojected PPRs 1999

The unprojected PPRs are calculated so that the projected proportions additional order fertility are added to get the projected PPRs. Having established from literature that PPRs can be calculated from numbers or proportions (Brass, 1985), the first step to the calculation of the incomplete PPRs was the generation of the proportions of women with at least i children. In order to do that, the number of women in each age group was cumulated from parity i to parity π (see appendix 5), and dividing the sum by the total number of women in that age group. This explains why the proportion of women in age group 15-19 with parity 0 is 1 (see appendix 1), the total number of women aged 15-19 with parity 0-18 is 170,817). For the next proportion in the same age-group, the summation began from 23,433 (i=1). As it can be seen from appendix 5, 20.35 percent of women aged 15-19 years had at least 1 child (represented by 0.2035). It is from these proportions that unprojected PPRs are calculated. Table 4.1 below shows the actual unprojected PPRs calculated from those proportions.

Generally, the table (Table 4.1) shows that PPRs for younger women are much incomplete than the PPRs for older women. This difference is very clear if women younger than 30 years are compared with those older than 45 years.

Table 4.1: Unprojected Parity Progression Ratios

Parity (*i*)	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	0.203493	0.668701	0.852098	0.942922	0.96077	0.963658	0.964058	0.961376	0.960209	0.957444
1	0.3259	0.5830	0.8078	0.9203	0.9557	0.9656	0.9699	0.9712	0.9717	0.9668
2	0.1466	0.4794	0.7025	0.8494	0.9221	0.9459	0.9562	0.9603	0.9633	0.9613
3	0.2071	0.3883	0.6186	0.7826	0.8721	0.9186	0.9388	0.9460	0.9492	0.9501
4	0	0.3205	0.5391	0.7228	0.8189	0.8844	0.9105	0.9240	0.9325	0.9324
5		0.3070	0.4701	0.6621	0.7727	0.8463	0.8767	0.8950	0.9100	0.9072
6		0.2481	0.4369	0.5932	0.7188	0.8058	0.8422	0.8619	0.8752	0.8775
7		0.2782	0.4043	0.5391	0.6673	0.7549	0.7938	0.8184	0.8282	0.8286
8		0	0.3553	0.4891	0.5999	0.6939	0.7320	0.7586	0.7748	0.7739
9			0.3468	0.4719	0.5652	0.6475	0.6900	0.7036	0.7198	0.7155
10			0.0657	0.4176	0.5202	0.5972	0.6216	0.6313	0.6468	0.6406
11			0	0.4140	0.5094	0.5708	0.5958	0.5987	0.6032	0.6242

The PPRs in Table 4.1 above were calculated by dividing the proportion for the next parity with the proportion for the current parity in the same age group. For instance, 0.203493/1 (see appendix 5) gives 0.203493. This means that about 20 per cent of women aged 15-20 years who did not have any child proceeded to have 1 child. The results in Table 4.1 are consistent with the observation made by Brass (1985) that fewer women progress to next parity as their ages increase. As shown in Table 4.1, 67 per cent of women aged 20-24 who did not have a child before proceeded to get one child. However, those who progressed to the next parity were 58 per cent followed by 48 per cent for the next parity; until only 28 per cent progressed to parity 8. It is important to note that unprojected PPRs between ages 15-44 are incomplete while those from 45-64 are complete. This simply means that women below 45 years would still give birth to additional children, hence the idea of incomplete PPRs.

4.3. Projected PPRs 1999

Projected PPRs, which were a key goal of this analysis, were required for two purposes. First, they were compared with the unprojected PPRs. The aim was to show the proportions of future fertility that is left out if the unprojected ones are used in any analysis. Second, the projected PPRs for 1999 were required for a comparison with the completed unprojected PPRs for 2009; the difference thereof indicate change in fertility levels. The calculation of unprojected PPRs is almost straightforward. However, computing projecting PPRs involves several steps, as it was shown in the data and methods chapter. The AOSFRs computed on the basis of the births in the past 1 year are shown below.

Table 4.2: Age-order specific fertility rates

Parity (i)	$_5AOSFR_x(i)$ 15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOFR(i)
0								
1	0.0734	0.0807	0.0247	0.0060	0.0020	0.0008	0.0005	**0.9400**
2	0.0312	0.0766	0.0403	0.0125	0.0028	0.0010	0.0007	**0.8258**
3	0.0039	0.0462	0.0489	0.0210	0.0065	0.0018	0.0005	**0.6445**
4	0.0009	0.0205	0.0425	0.0271	0.0097	0.0020	0.0011	**0.5192**
5	0.0000	0.0064	0.0289	0.0295	0.0138	0.0035	0.0016	**0.4185**
6	0.0000	0.0019	0.0151	0.0286	0.0178	0.0052	0.0021	**0.3534**
7	0.0000	0.0005	0.0068	0.0218	0.0190	0.0074	0.0023	**0.2885**
8	0.0000	0.0002	0.0031	0.0135	0.0187	0.0080	0.0027	**0.2312**
9	0.0000	0.0000	0.0009	0.0061	0.0128	0.0085	0.0024	**0.1536**
10	0.0000	0.0000	0.0004	0.0032	0.0085	0.0075	0.0027	**0.1116**
11	0.0000	0.0000	0.0000	0.0012	0.0047	0.0049	0.0023	**0.0663**
12+	0.0000	0.0000	0.0000	0.0009	0.0043	0.0073	0.0037	**0.0809**

The rates were calculated by dividing the number of children born in the past year to women who had already attained parity *i* by the total number of women in that age group. For instance, from Appendix 3: Births in the Past 12 Months Preceding the 1999 Census, 12533 children were born. Diving this figure by 170,817 (Appendix 1: Women by Age-group and Parity, Kenya-1999) gives 0.0734 (see Table 4.2). This is the AOSFR for women aged 15-19 who did not have a child but proceeded to get one in the 12 months preceding the census. Note that the row for parity 0 is left blank. This is because if one has never had any birth (that is CEB=0), they cannot have had any birth in the past 12 months. In other words, there cannot be current fertility if lifetime fertility is zero. PPRs help in the study of fertility behavior by investigating trends in the fertility rates specific for each order and age.

The computed total order fertility rates are simply summations of all AOSFRs, specific to each order, across all the age groups. This sum is multiplied by 5, which is the class interval (or simply the age-group). For instance, to get 0.9400 in Table 4.2, all the rates in that row were summed up and multiplied by 5. The idea is to cumulate AOSFRs for the entire age-group, as it is assumed that all women in that age group experience that age-order fertility rate for the 5 years they are in that age group. The rationale is that if the additional fertility achieved by the end of all successive age-groups till the end of the reproductive age are added to the current fertility level (proportion), it is possible to project additional parity achieved by the end of the reproductive period.

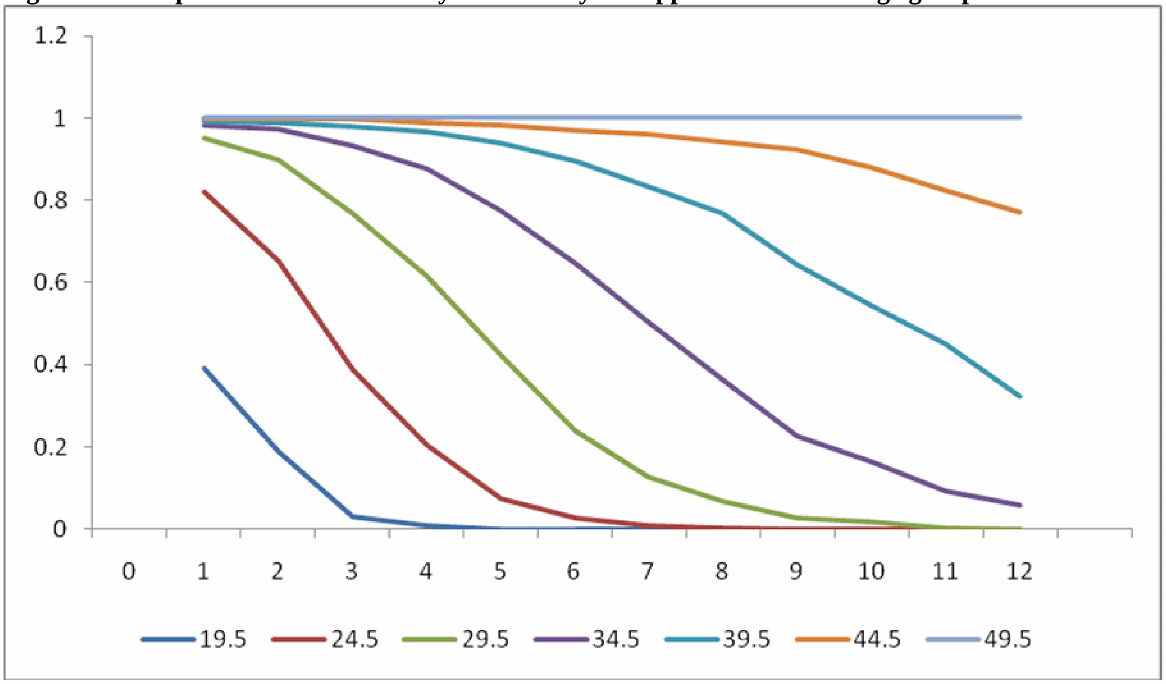
The next step was to calculate the order fertility achieved by women up to the time they reached the upper limit of the current age group. These proportions, again, are specific to birth order and age (upper class limit). From the explanation above, it inherently implies that each cumulated order fertility (AOSFR*5) is a proportion of total order fertility at the end of the row. For instance, the proportion of order-specific fertility achieved by the end of the first age group (with mid-point 19.5) is (0.0734*5)/0.9400=0.3903 shown in Table 4.3 below (for the corresponding age-group and parity. It was explained in the previous chapter that the half-year shift is necessary because the age of the mother was classified at the time of the census (mid-year) and not the time of the child's birth. Again, the first row is left blank because Table 4.3 is generated from the previous table (Table 4.2) whose first two was blank. Table 4.3 simply shows that the proportion of order fertility achieved by the upper limit of each age group increases with age, and approach unity as the childbearing age diminishes.

Table 4.3: Proportion of order fertility achieved by the upper limit of each age group

Parity (*i*)	19.5	24.5	29.5	34.5	39.5	44.5	49.5
0							
1	0.3903	0.8194	0.9508	0.9826	0.9932	0.9972	1.0000
2	0.1892	0.6529	0.8972	0.9728	0.9897	0.9960	1.0000
3	0.0305	0.3891	0.7687	0.9315	0.9822	0.9959	1.0000
4	0.0086	0.2057	0.6154	0.8765	0.9695	0.9890	1.0000
5	0.0000	0.0760	0.4213	0.7739	0.9390	0.9806	1.0000
6	0.0000	0.0264	0.2400	0.6451	0.8963	0.9700	1.0000
7	0.0000	0.0082	0.1259	0.5038	0.8331	0.9608	1.0000
8	0.0000	0.0033	0.0698	0.3627	0.7679	0.9418	1.0000
9	0.0000	0.0000	0.0285	0.2261	0.6442	0.9217	1.0000
10	0.0000	0.0000	0.0190	0.1640	0.5451	0.8794	1.0000
11	0.0000	0.0000	0.0019	0.0934	0.4513	0.8240	1.0000
12+	0.0000	0.0000	0.0000	0.0581	0.3219	0.7703	1.0000

It was realized that the proportions of women attaining each parity and the subsequent PPRs are not based on the upper class limits, but on the mid-points of the age group. From the above Table 4.3, the distribution forms sigmoid curves as shown below.

Figure 4.1: Proportion of order fertility achieved by the upper limit of each age group



Due to this fact, there was need to first transform the curves into straight lines then return the distribution to the mid-points through linear interpolation. This was done by obtaining double negative natural logarithms (gompits) then linear interpolation (factors 0.4 and 0.6) and further obtaining anti-gompits to return the distribution to the original scale. For instance, from Table 4.4 below, 0.6903= EXP(-EXP(-(0.4*(-LN(-LN(0.3903)))+0.6*(-LN(-LN(0.8194)))))).

The results are shown in Table 4.4 below. Note that from the data and methods chapter, Moultrie and Zaba (2013) suggested that the proportion of order-specific fertility attained by the mid-point of an age group must be greater than 0.3. This explains why the column with the midpoint 19.5 in Table 4.3 above was omitted, only one value for parity 1 was greater than 0.3. Moultrie and Zaba (2013) meant that in the above example, 30 per cent of all women with 1 child aged between 20-24 must have gotten a second child by the time they were aged 22.5 years.

Table 4.4: Proportion of order fertility achieved by the mid-point of each interval

Parity (*i*)	22.5	27.5	32.5	37.5	42.5	47.5
0						
1	0.6903	0.9164	0.9736	0.9901	0.9960	0.9999
2	0.4794	0.8290	0.9535	0.9848	0.9941	0.9999
3	0.2034	0.6450	0.8870	0.9694	0.9927	0.9999
4	0.0858	0.4590	0.8009	0.9463	0.9834	0.9998
5		0.2623	0.6591	0.8955	0.9693	0.9998
6		0.1256	0.4951	0.8263	0.9505	0.9998
7		0.0550	0.3440	0.7334	0.9292	0.9997
8		0.0270	0.2249	0.6361	0.8972	0.9997
9			0.1215	0.4888	0.8521	0.9996
10			0.0842	0.3910	0.7874	0.9996
11			0.0302	0.2919	0.7113	0.9995
12+				0.1944	0.6253	0.9994

After calculating the proportion of order fertility achieved by the mid-point of each interval, the next step was to calculate the additional proportion of women attaining parity *i* by the end of their reproductive period (order increment). Logically, order increment should be a fraction of the total order fertility rate. In this case, it was obtained simply by multiplying the total order fertility rate with the complement of the proportion of the cumulated age-order fertility rate (AOSFR*5) to the total order fertility rate. For instance, 0.2912 in Table 4.5 below was obtained by multiplying 0.9400 with (1-0.6903). This additional or expected future order increment is what would be added to the unprojected proportion of women with at least *i* children from which projected PPRs are computed.

Generally, Table 4.4 shows that the proportion of order fertility achieved by the midpoint of each age group, just like that achieved by the upper limit, increases with aged and approaches unity towards the end of the reproductive period.

Table 4.5: Additional proportion attaining parity (i) by the end of childbearing

Parity (*i*)	22.5	27.5	32.5	37.5	42.5	47.5
0						
1	0.2912	0.0786	0.0248	0.0093	0.0037	0.0001
2	0.4299	0.1412	0.0384	0.0126	0.0049	0.0001
3		0.2288	0.0728	0.0197	0.0047	0.0001
4		0.2809	0.1034	0.0279	0.0086	0.0001
5			0.1426	0.0437	0.0129	0.0001
6			0.1784	0.0614	0.0175	0.0001
7			0.1892	0.0769	0.0204	0.0001
8				0.0841	0.0238	0.0001
9				0.0785	0.0227	0.0001
10				0.0680	0.0237	0.0000
11					0.0191	0.0000
12+					0.0303	0.0000

For the projected proportions of women with at least *i* children, the same condition of 30 per cent also applies. Hence from appendix 5, 0.6687 (corresponding to parity 1, age-group 20-24) was added to the additional proportion of women attaining parity *i* by the end of childbearing. For this example, it means that if 30 per cent of those women in the age group 20-24 with parity 1 did not proceed to parity 2 by the time they were aged 22.5 years, they should not be included calculating the projected proportions of women with at least *i* children. To demonstrate this, there are only 2 values in Table 4.5 for 22.5 age group midpoint because from Table 4.4, although there are 4 values, only 0.6903 and 0.4794 are used in the calculation (0.2034 and 0.0858 are less than 0.3).

Generally, Table 4.5 shows that the additional proportion of women who would attain additional parity by the end of the childbearing period reduces with age. This simply means that as women get older, they get lesser children. In other words, younger women are more likely to get an additional child as opposed to the older women.

Table 4.6: Projected proportion of women with i or more children

Parity (*i*)	22.5	27.5	32.5	37.5	42.5	47.5
0	1	1	1	1	1	1
1	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641
2	0.8197	0.8296	0.9062	0.9308	0.9353	0.9352
3		0.7124	0.8099	0.8664	0.8849	0.8942
4		0.5800	0.6802	0.7663	0.8171	0.8395
5			0.5596	0.6484	0.7279	0.7644
6			0.4545	0.5286	0.6226	0.6701
7			0.3530	0.4128	0.5080	0.5644
8				0.3083	0.3919	0.4480
9				0.2130	0.2781	0.3280
10				0.1440	0.1891	0.2263
11					0.1179	0.1407
12					0.0867	0.0838

From Table 4.6, although the first row has been blank in the previous tables, logic dictates that every woman must at least have zero children (parity 0). The projected PPRs were computed from the above table. For instance, 0.9599/1 (the first two values in the 22.5 midpoint- Table 4.6)=0.9599 below. The second value in Table 4.7 below was calculated by diving 0.8197/0.9599 in Table 4.6 above (under 22.5 midpoint).

Generally, Table 4.6 shows that the projected proportion of women at least parity *i* by the end of childbearing age increases with age and decreases with birth order. Increase of these proportions with age is a demonstration of near-completion of the projected PPRs to be calculated from them. The proportions decrease with increase in birth order because naturally, many children are born to few children (those women with fewer children are more than those with many children).

Table 4.7: Projected parity progression ratios

Parity (*i*)	22.5	27.5	32.5	37.5	42.5	47.5
0	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641
1	0.8539	0.8913	0.9364	0.9595	0.9668	0.9699
2		0.8587	0.8937	0.9309	0.9460	0.9562
3		0.8142	0.8399	0.8845	0.9234	0.9389
4			0.8226	0.8461	0.8908	0.9105
5			0.8122	0.8153	0.8554	0.8767
6			0.7767	0.7808	0.8159	0.8422
7				0.7468	0.7714	0.7938
8				0.6909	0.7097	0.7320
9				0.6760	0.6799	0.6900
10					0.6235	0.6217
11					0.7352	0.5960
12						

The projected PPRs were compared with unprojected PPRs for women aged below 50 years as well as complete PPRs for women aged above 50 years in the same census (1999). Later, the projected PPRs are compared with the observed PPRs in the next census. For a clearer vision of the fertility trends represented by the above ratios, see Figure 4.2. If the projected PPRs in each age-group are cumulated by multiplying them from parity *i* to *i*+1, Table 4.8 is generated. For instance, in Table 4.8 below, age group 25-29 and corresponding parity 3, 0.7124 is calculated by multiplying 0.9307*0.8913*0.8587 in the above Table 4.7.

The projected PPRs in Table 4.7 generally show that by the time they complete their childbearing period, the currently younger women would have fewer children. In other words, fertility would be lower in the future. Table 4.8 below shows the same trend.

Table 4.8: Cumulated Projected Parity Progression Ratios

Parity (*i*)	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641	0.9614	0.9602	0.9574
2	(0.8197)	0.8296	0.9062	0.9308	0.9353	0.9351	0.9337	0.9330	0.9257
3		0.7124	0.8099	0.8664	0.8849	0.8942	0.8966	0.8988	0.8898
4		(0.5800)	0.6802	0.7663	0.8171	0.8395	0.8482	0.8531	0.8454
5			0.5596	0.6484	0.7279	0.7643	0.7838	0.7955	0.7883
6			(0.4545)	0.5286	0.6226	0.6700	0.7015	0.7239	0.7151
7			(0.3530)	0.4128	0.5080	0.5643	0.6046	0.6336	0.6275
8				0.3083	0.3919	0.4480	0.4948	0.5247	0.5200
9				(0.2130)	0.2781	0.3279	0.3753	0.4066	0.4025
10				(0.1440)	0.1891	0.2263	0.2641	0.2927	0.2880
11					0.1179	0.1406	0.1667	0.1893	0.1845
12+					0.0867	0.0838	0.0998	0.1142	0.1151
CFR			4.731	5.789	6.527	6.858	7.130	7.326	7.259

NB: PPRs in parentheses may not be reliable since the proportion of order fertility achieved by that age is less than 0.5

This table generally shows that lesser proportions of women who were aged less than 45 years of age in 1999 would progress to the next parities by the time they complete their childbearing, compared to women who were already aged 45 years and above in during the 1999 census.

Table 4.9 compares the projected PPRs (by the end of the child bearing age) with the current completed PPRs. The current projection for $i=0$ shows that 97 per cent of the women aged 35-39, by the time they complete their childbearing, will have proceeded to $i=1$. Note that the end of their reproductive period implies that they would be aged 45-49. Comparing the projected PPR 0.9701 with the completed 0.9641 (for 45-49), shows slightly higher fertility for the current (1999) cohort. Progression from the same parity $i=0$ for the 40-44 cohort displays the same behavior. Moreover, the projected PPRs for higher birth order generally show that women who are currently (1999) below age 45 will have lower fertility by the time they complete their childbearing compared to women who are have currently (1999) completed childbearing. In other words, lesser proportions of the women currently below the age of 45 will progress to higher parities by the time they reach 45 years of age.

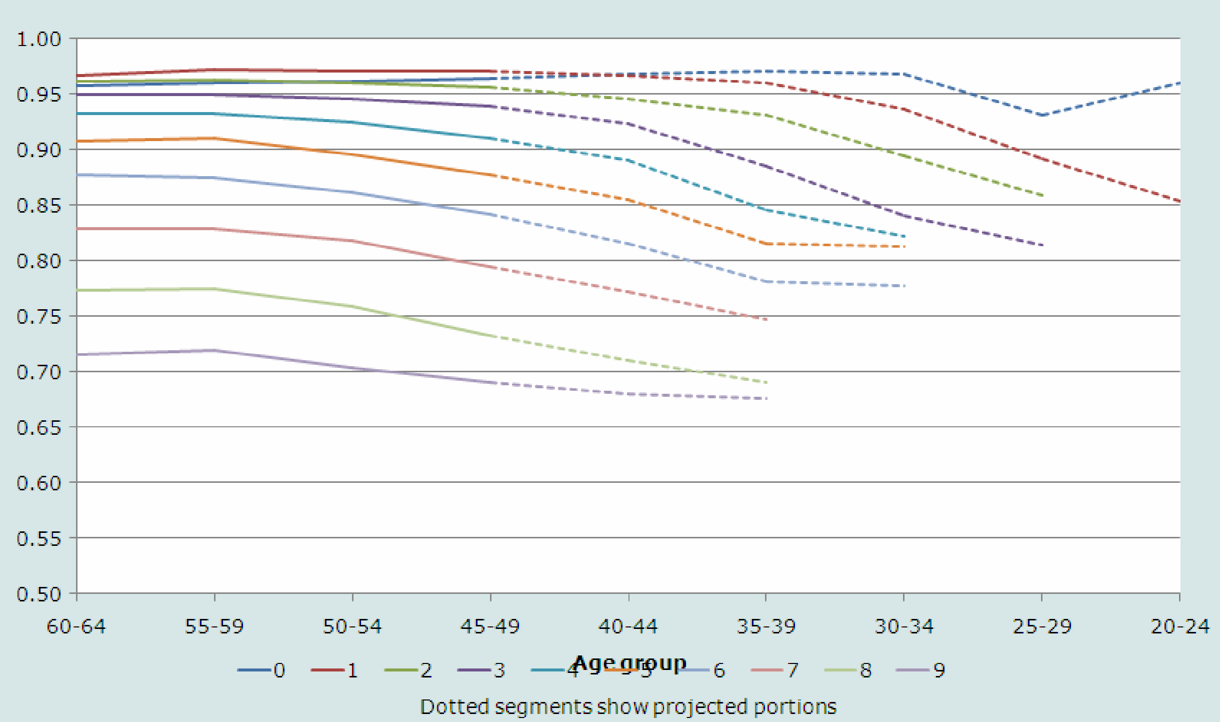
Table 4.9: Comparison of Projected and Completed Parity progression ratios

Parity (*i*)	Projected Parity progression ratios Projected					Completed			
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641	0.9614	0.9602	0.9574
1	(0.8539)	0.8913	0.9364	0.9595	0.9668	0.9699	0.9712	0.9717	0.9668
2		0.8587	0.8937	0.9309	0.9460	0.9562	0.9603	0.9633	0.9613
3		(0.8142)	0.8399	0.8845	0.9234	0.9388	0.9460	0.9492	0.9501
4			0.8226	0.8461	0.8908	0.9105	0.9240	0.9325	0.9324
5			(0.8122)	0.8153	0.8554	0.8767	0.8950	0.9100	0.9072
6			(0.7767)	0.7808	0.8159	0.8422	0.8619	0.8752	0.8775
7				0.7468	0.7714	0.7938	0.8184	0.8282	0.8286
8				(0.6909)	0.7097	0.7320	0.7586	0.7748	0.7739
9				(0.6760)	0.6799	0.6900	0.7036	0.7198	0.7155
10					0.6235	0.6216	0.6313	0.6468	0.6406
11					0.7352	0.5958	0.5987	0.6032	0.6242

NB: PPRs in parentheses may not be reliable since the proportion of order fertility achieved by that age is less than 0.5

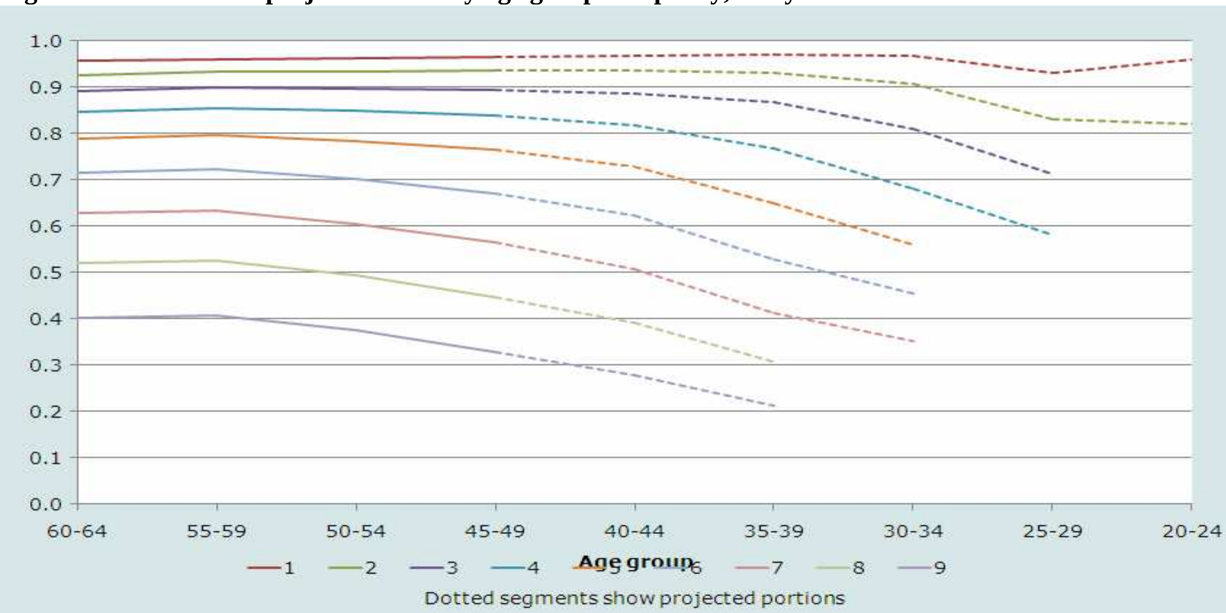
By applying the same condition that at least 30 per cent of women must have progressed to the next parity by the time they attain the midpoint age, it is implicitly expected that 60 per cent (30*2) should have done the same by the time they achieve the upper limit age of the age-group.

Figure 4.2: Projected PPRs by age group and parity, Kenya 1999



The above graph simply shows that fewer women who are currently below 45 years of age will be progressing to higher parities (will be getting additional children) by the time they complete their reproductive age. The same is depicted in the figure below.

Figure 4.3: Cumulated projecetd PPRs by age group and parity, Kenya 1999



4.4. Unprojected PPRs 2009

The aim of Table 4.10 below was to compare those levels projected in 1999 with the ones observed in 2009. The values are computed from appendix 2 in which proportions of women with at least parity *i*+1 are divided with those with parity *i* (see appendix 8). For instance, in Table 4.10, 0.1489 (group 15-19 and parity 0) is obtained by dividing 0.1490/1 in appendix 8 (corresponding age group and parity). Figure 4.4 shows this comparison.

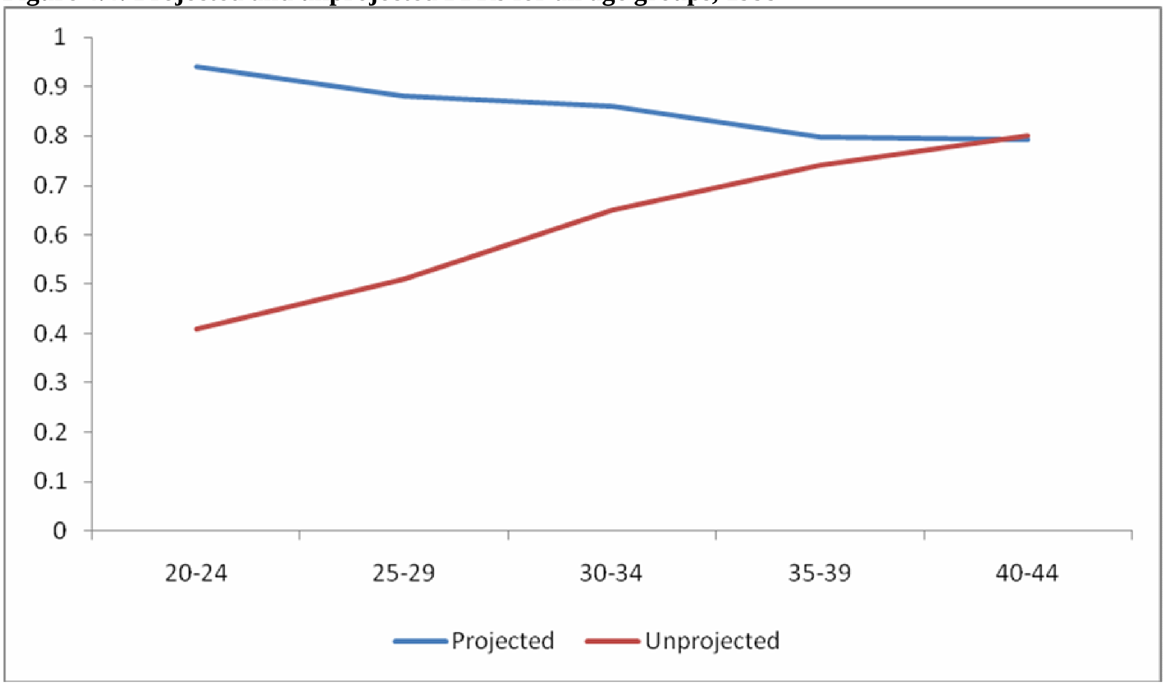
Table 4.10: Observed/unprojected Parity Progression Ratios, 2009

Parity (*i*)	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	0.148992	0.614857	0.843204	0.926741	0.955981	0.963907	0.969312	0.966713	0.965557	0.961874
1	0.2980	0.5796	0.7764	0.8940	0.9392	0.9552	0.9636	0.9646	0.9644	0.9619
2	0.2774	0.4696	0.6562	0.7867	0.8686	0.9070	0.9333	0.9499	0.9557	0.9603
3	0.3879	0.4331	0.5902	0.7290	0.8034	0.8540	0.8931	0.9214	0.9408	0.9470
4	0	0.4039	0.5053	0.6713	0.7630	0.8118	0.8438	0.8870	0.9125	0.9245
5		0.4815	0.4808	0.6263	0.7276	0.7857	0.8102	0.8536	0.8785	0.8970
6		0	0.4485	0.5505	0.6674	0.7456	0.7748	0.8124	0.8391	0.8588
7			0.4800	0.5418	0.6301	0.7092	0.7386	0.7664	0.7877	0.8169
8			0	0.4681	0.5282	0.6278	0.6674	0.7037	0.7310	0.7563
9				0.5234	0.5417	0.6114	0.6482	0.6696	0.6810	0.6944
10				0.5210	0.5012	0.5585	0.5843	0.5990	0.6105	0.6201
11				0.5843	0.5261	0.5550	0.5852	0.5961	0.5959	0.5954

4.5. Projected PPRs Versus Unprojected PPRs 1999

The figure below shows that the projected PPRs are higher than the unprojected PPRs for the same census. The gap in the two curves represents the extent of incompleteness of the ratios across the age groups. It can be seen that PPRs for younger women are more incomplete compared to older women (all under 45 years).

Figure 4.4: Projected and unprojected PPRs for all age groups, 1999



4.6. Projected PPRs 1999 versus Observed PPRs 2009: A Comparison

It was found out that there was not much difference between the projected PPRs for 1999 and the observed PPRs for the next census (Figure 4.5). This was concluded after the 1999 age cohort aged 35-39 was compared with itself in 2009 when they were aged 45-49. For instance, the 1999 projected PPR of 0.9701 for the cohort aged 35-39 in 1999 (see appendix 7a) did not deviate much from observed complete PPR value of 0.9693 for the same cohort now aged 45-49 in 2009. Figure 4.5 also shows similar comparison curves as obtained by Mutakwa (2012) for Malawi and Zimbabwe, as shown appendix 6 (2). Figure 4.6 also compares corresponding age cohorts. The age cohort 40-44 (2009) was selected since they are almost about to complete their childbearing period, hence would give close to complete PPRs. Again, not much difference in fertility levels was found. However, it is expected that there would be wider gaps between the projected and the observed fertility levels for much younger cohorts who have not yet completed childbearing.

Figure 4.5: Comparison Between the projected and observed cohort PPRs in successive censuses (a)

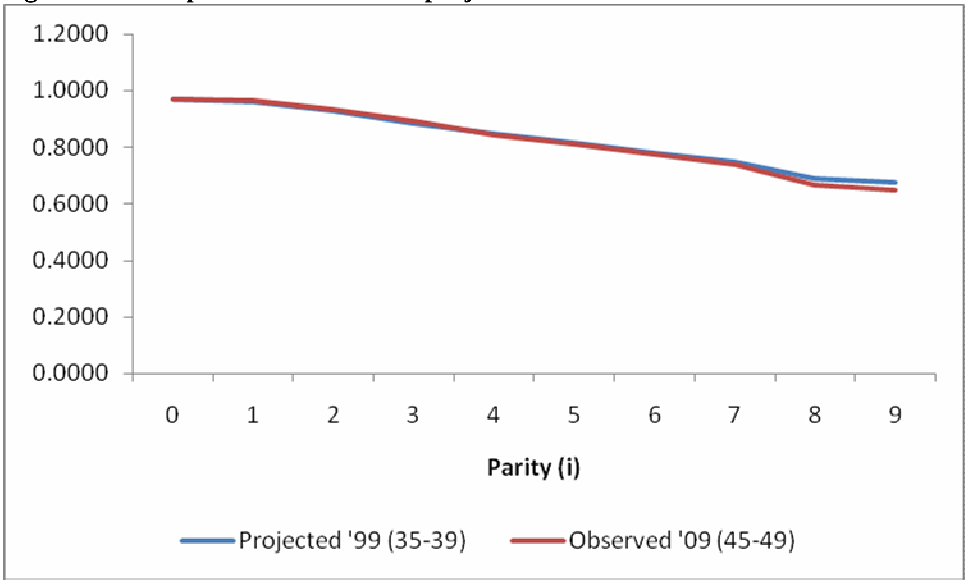
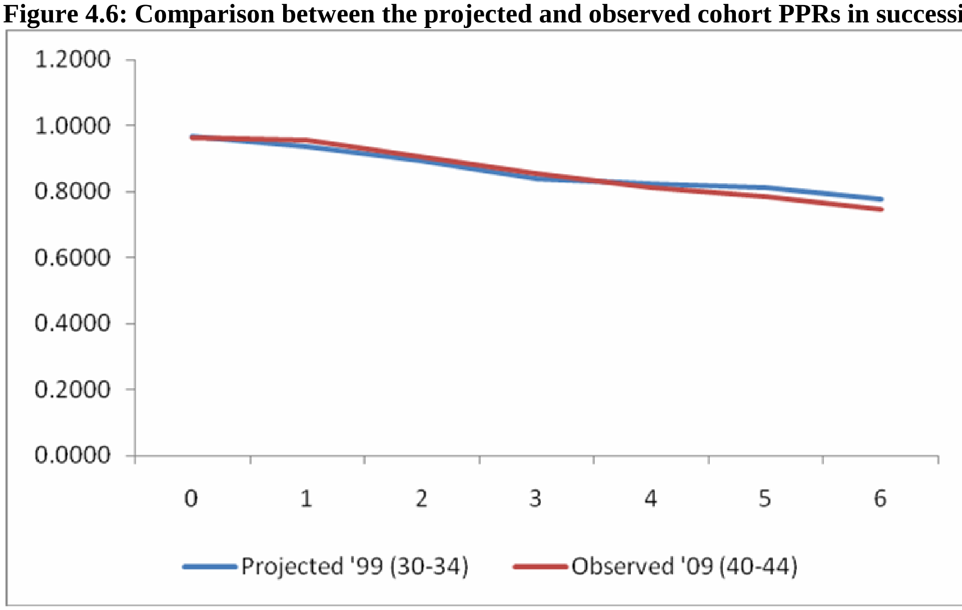


Figure 4.6: Comparison between the projected and observed cohort PPRs in successive censuses (b)



4.7. Estimation of the TFR

As Table 4.11 shows, the TFR from projected PPRs method for 1999 was 4.6. On the other hand, KNBS (1999) estimated the TFR for the same year as 4.8 (on the basis of the KDHS) or 5.4 (on the basis of the census). In the same way, while the TFR level published by KNBS for 2009 was 4.6 (KDHS), the projected PPRs method led to TFR of 4.4. For both censuses, the absolute difference between the conventional and the projected PPRs approach is 0.2. Hence the two TFRs are comparable suggesting the appropriateness of the new method in the case of Kenya.

This also fits into Retherford's et al (2013) conclusion that the PPRs TFR should be less than that derived from conventional PPRs. In their study of fertility levels in Philippines using PPRs, they established that the absolute difference was 0.39. The PPRs TFR was 3.18 while the conventional TFR 3.57. The fact that this method used census data and obtained TFR of 4.6 for 1999 implies that the 1998 KDHS TFR of 4.8 may have been the appropriate one, as compared to the census-based TFR of 5.4. This is because according to Retherford et al (2013), the PPRs should be lower than the conventional TFR level.

Table 4.11: Estimation of TFR from TOFRs and ASFRs, 1999

	$_5$AOSFRx(*i*)								
Parity (*i*)	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**TOFR(*i*)**	
0									
1	0.0734	0.0807	0.0247	0.0060	0.0020	0.0008	0.0005	**0.9400**	
2	0.0312	0.0766	0.0403	0.0125	0.0028	0.0010	0.0007	**0.8258**	
3	0.0039	0.0462	0.0489	0.0210	0.0065	0.0018	0.0005	**0.6445**	
4	0.0009	0.0205	0.0425	0.0271	0.0097	0.0020	0.0011	**0.5192**	
5	0.0000	0.0064	0.0289	0.0295	0.0138	0.0035	0.0016	**0.4185**	
6	0.0000	0.0019	0.0151	0.0286	0.0178	0.0052	0.0021	**0.3534**	
7	0.0000	0.0005	0.0068	0.0218	0.0190	0.0074	0.0023	**0.2885**	
8	0.0000	0.0002	0.0031	0.0135	0.0187	0.0080	0.0027	**0.2312**	
9	0.0000	0.0000	0.0009	0.0061	0.0128	0.0085	0.0024	**0.1536**	
10	0.0000	0.0000	0.0004	0.0032	0.0085	0.0075	0.0027	**0.1116**	
11	0.0000	0.0000	0.0000	0.0012	0.0047	0.0049	0.0023	**0.0663**	
12+	0.0000	0.0000	0.0000	0.0009	0.0043	0.0073	0.0037	**0.0809**	
ASFR	**0.1095**	**0.2328**	**0.2117**	**0.1715**	**0.1206**	**0.0579**	**0.0227**	**4.6335**	**(TFR)**

Table 4.12: Estimation of TFR from TOFRs and ASFRs, 2009

	$_5$AOSFRx(*i*))								
Parity (*i*)	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**TOFR(*i*)**	
0									
1	0.0425	0.0761	0.0309	0.0080	0.0019	0.0008	0.0002	**0.8021**	
2	0.0127	0.0659	0.0486	0.0204	0.0059	0.0012	0.0003	**0.7755**	
3	0.0028	0.0357	0.0472	0.0291	0.0123	0.0029	0.0008	**0.6534**	
4	0.0014	0.0166	0.0392	0.0317	0.0159	0.0047	0.0012	**0.5541**	
5	0.0000	0.0059	0.0234	0.0297	0.0186	0.0062	0.0016	**0.4272**	
6	0.0000	0.0046	0.0122	0.0256	0.0200	0.0077	0.0025	**0.3625**	
7	0.0000	0.0000	0.0049	0.0154	0.0185	0.0086	0.0029	**0.2517**	
8	0.0000	0.0000	0.0041	0.0097	0.0160	0.0098	0.0036	**0.2153**	
9	0.0000	0.0000	0.0000	0.0043	0.0089	0.0080	0.0030	**0.1210**	
10	0.0000	0.0000	0.0000	0.0020	0.0054	0.0061	0.0025	**0.0801**	
11	0.0000	0.0000	0.0000	0.0009	0.0028	0.0039	0.0019	**0.0470**	
12+	0.0000	0.0000	0.0000	0.0012	0.0027	0.0051	0.0034	**0.0613**	
ASFR	**0.0594**	**0.2047**	**0.2106**	**0.1778**	**0.1288**	**0.0650**	**0.0239**	**4.3512**	**(TFR)**

Table 4.13: Comparison of the projected PPRs TFR and the conventional TFR

Projected PPRs TFR		Conventional TFR	Absolute Difference
1999	4.6	4.8	0.2
2009	4.4	4.6	0.2

4.8. Comparison with Past Works

Assuming that different methods should arrive at the same PPRs, Table 4.14 below shows how this study builds up on past work. The values for 1999 census in column 3 are obtained by calculating the averages for PPRs for each parity across age groups 15 to 49 from the unprojected PPRs table, while column 4 is derived from the projected PPRs table. Note that Kimani used the method used by Feeney (1989). Mutuku (2013) also used the period PPRs approach. The author here uses both the projected and unprojected PPRs approaches. The differences are explained by the different assumptions for each method and whether the PPRs are based on completed fertility or not.

Table 4.14: Comparison of PPRs from/with past studies

i	**1993 KDHS (Mutuku)**	**1999 Census (Author-unprojected)**	**1999 Census (Author-projected)**	**2003 KDHS (Mutuku)**	**2003 KDHS (Kimani)**	**2009 Census (Author-unprojected)**
1	0.786	0.788	0.923	0.739	0.877	0.7723
2	0.703	0.715	0.726	0.601	0.864	0.6998
3	0.624	0.675	0.692	0.480	0.789	0.6701
4	0.520	0.599	0.512	0.417	0.770	0.6665

The aim of the above comparison was to check whether the fertility trend line followed what is known in the literature. On this basis, it would be expected that there would be a decline in the proportions of women who progressed to the next parities between 1993 and 1999. This should have been followed by a trend line whose slope is close to zero, since the TFRs in 1998, 2003 and 2009 were 4.7, 4.9 and 4.6 respectively. However, this expected trend is not seen in Table 4.14. The disparity in the results (expected curve) could be as a result of the fact that the scholars used different methods or incomplete PPRs. Hence there is need to ensure that all calculations for PPRs are based on completed fertility, or otherwise projected. All other methods, including the life table approach, should device ways in which expected future order increment is used in the current analyses.

4.9. Discussion of Results

The TFR values obtained using the projected PPRs method and the conventional approach are a subject of discussion. Clearly, the two approaches do not yield same results. Although the values are not very far apart from each other (from simplistic comparison), this study offers two possibilities. First, as Preston et al (2001) note, a relatively small sample size may lead to invalid results. In this case, the use of the 10 per cent sample of all the households used in this study may have contributed to this variation.

In addition, there was an underestimation of the births in the past 12 months. Since the census questionnaire did not include the day of birth, it was considered a more acceptable underestimation to exclude births between 24^{th}-31^{st} August than to include all the births from August 1^{st} – 23^{rd}. This study considers the exclusion of children born in the last 7 days of August as one of the possible causes of the discrepancy in the two TFRs.

Generally, the results obtained from this study are comparable with those published in the 1999 analytical report on fertility and nuptiality. There is no much difference between the results obtained in table 4.1 and appendix 9. In other words, the unprojected PPRs for 1999 from this study approach are generally the same as the incomplete PPRs from the analytical report on fertility and nuptiality for the same year (if all are presented in 4 decimal places). For instance, for this study approach, the PPRs for age-groups 15-19 and 40-44 representing progression from parity 0 to 1 were 0.2035 and 0.9637 respectively. The corresponding PPRs in the analytical report were 0.204 and 0.963.

Further, the AOSFRs from the study approach were comparable with those published in the analytical report for the same year. This was done by comparing table 4.2 and appendix 10. From the comparison, it emerged that the AOSFR from the study approach for age group 15-19 and birth order 1 was 0.0734. On the other hand, the corresponding rate in the analytical report was 0.077. It was shown that the summation of all the total order fertility rates should give rise to the total fertility rate. From the analytical report, this total implied that the TFR from AOSFRs should have been 5.0, though the study approach value was 4.6. This discrepancy was explained by the fact that the analytical report included age-group 10-14 as shown in appendix 10.

Lastly, as it was expected, the unprojected PPRs in table 4.1 were exactly the same as the projected PPRs in table 4.7 for the age-group 45-49. This simply meant that proportions of women who were aged 45 to 49 years in 1999 progressing from one parity to the next would be the same by the time they complete their childbearing period.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter presents a summary of the study, conclusion and recommendations. These are based on the study findings.

5.2. Summary

The main aim of this study was to analyze trends and levels of fertility in Kenya using the PPRs. Specifically, the projected PPRs method devised by Brass (1985) was applied. The research question for the study was whether the TFR computed from the projected PPRs approach is the same as the one from the conventional method. In this process, various objectives were achieved. First, PPRs for women who have completed child bearing were calculated and for younger women projected forwards. Second, it was determined that the projected PPRs for 1999 did not differ much from the observed PPRs 2009. Finally, TFR from the projected PPRs approach was calculated and compared to that from the conventional method.

Extensive review of literature showed that generally, PPRs are a more appropriate method of studying fertility since they do not only break it down to its components but also investigate the life-long fertility experience of a cohort of women of the same age. Above all, PPRs are the most effective method of studying fertility behavior in a quantitative perspective. Although they are used to study the family building process such as from first marriage to first birth and from one birth to the next, this study began its analysis from parity 1 to the maximum parity achievable. Among all other PPRs approaches such as period PPRs and instantaneous PPRs, the projected PPRs approach was preferred due to its possible policy contributions in the case of Kenya.

Data was obtained from 1999 and 2009 censuses. The samples size was 10 percent of all the households in Kenya in 1999 and 2009. The main method of analysis was the projected PPRs approach as proposed by Brass (1985) and improved by Moultrie and Zaba (2013). Comparisons were made between the completed PPRs and the unprojected PPRs in 1999 as well as between projected PPRs for 1999 and observed PPRs in 2009 for the same age cohort. Graphical methods were used to make the comparisons clearer. Further, TFR was computed and compared from that obtained from other methods. Finally, this study compared its results with those obtained from other methods.

5.3. Conclusions

The whole question of projected PPRs begins from the fact that the traditional PPRs are known to be incomplete: the proportions of women who have not yet competed childbearing, proceeding from one parity to the next, are expected to change in due time. To offer answers to the research question, this study undertook to accomplish the following: calculation of incomplete PPRs, calculation of projected PPRs, comparison between the projected and the observed PPRs for 1999 and 2009 censuses respectively, calculation of the resultant TFR and the comparison of the latter with the TFR computed from the conventional ASFRs method.

It was found out that the TFRs from the projected PPRs approach were 4.6 and 4.4 for 1999 and 2009, the official TFRs for the same years, based on KDHS, were 4.8 and 4.6 respectively. It was shown that indeed, the results obtained from the projected PPRs approach, both actual PPRs and TFR, are comparable (close) to those obtained using other methods. The findings were also similar to what Mutakwa found out in Zimbabwe by applying the same approach.

The results of this study show that proportions of women progressing to higher parities decline with age of the woman. It is also in line with literature which shows that the TFR computed from PPRs is lower than the TFR computed from the conventional approach.

In the final analysis, the study met all the objectives. First, the PPRs for women who had completed child bearing were determined and PPRs for the younger women were projected. Second, the projected PPRs for 1999 were compared with the observed PPRs in 2009 for the same age cohorts. Last, TFR was computed from the projected PPRs approach and compared with that obtained from the conventional approach.

5.4. Recommendations

5.4.1. Recommendations for Policy

I. More than one method should used in the calculation of TFR in Kenya. This enables policy makers to compare the results obtained from all the methods for a more informed understanding of the fertility levels in the country.

II. There is need to project fertility trends and levels in the future in Kenya especially for planning purposes. The projected PPRs approach would be useful in this regard.

III. From the data and methods chapter, it was evident that in selecting the births in the past 12 months, those that occurred between August 24 and September were not captured. This may have led to the variation seen in the TFRs; indeed, it is expected that the TFR from the projected PPRs method to be lower due to the exclusion of these births. The KNBS should consider including the day of the birth of the last child in the enumeration form or questionnaire.

5.4.2. Recommendations for Further Research

i. Although the projected PPRs approach can establish trends using one census, it would be more useful to use several data points for a more informed trend analysis. Future studies could apply the method on all the census data sets in Kenya and a more critical analysis of the deviation of the projected PPRs from the observed ones carried out.

ii. This study mainly compared the TFRs from the projected PPRs method and the conventional ASFRs-based method. It is suggested that future research may focus on the results obtained using the different approaches of calculation of PPRs.

iii. In addition, the focus of this study was on the progression from parity (*i*) to parity (*i*+1). However, it was shown that family building begins at marriage (in most cases). It is suggested that the projected PPRs method or any other PPRs approach is used to study progression from marriage to first birth in Kenya. Moreover, the data inputs for such a study should be defined in advance.

iv. It would be important to study the situation of premarital births in Kenya, hence progression from first birth to marriage and the trends over time. This would answer the question whether the proportions of progression from fist birth to marriage have increased with time or otherwise. Potential difficulty in such a study would be the definition of marriage in Kenya.

v. Since the projected PPRs approach has not been used in Kenya sufficiently, there is need to apply the method in many censuses in order that its effectiveness may be more appropriately assessed. This study mainly used 1999 data set. It is recommended that at least two successive data sets are always applied in applying the method. This enables the analyst to compare estimates so obtained with the true observed values.

vi. Due to the weakness of this study that led to the exclusion of births in the last 7 days of August, it is recommended that weights are applied to the month of birth of the last child. This would enable the analyst to estimate roughly how many births may have occurred in that period, in cases where the date (day) of birth is not included as a question.

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APPENDICES

Appendix 1: Women by Age-group and Parity, Kenya-1999

		Age 5yr grps										Total
		15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	
Parity	0	136057	49736	17751	4796	2850	1889	1509	1323	943	917	217771
	1	23433	41866	19651	6317	3094	1725	1217	949	644	685	99581
	2	9666	30464	24576	10979	5195	2617	1718	1270	812	772	88069
	3	1317	17162	22134	13466	7865	3723	2296	1658	1082	957	71660
	4	344	7404	16550	13436	9716	4859	3156	2207	1365	1231	60268
	5	0	2420	10258	11838	9983	5714	3957	2818	1697	1576	50261
	6	0	806	5124	9435	9544	6108	4439	3319	2141	1888	42804
	7	0	192	2368	6342	8118	6211	4885	3761	2579	2317	36773
	8	0	74	1036	3789	6515	5857	5040	4092	2800	2533	31736
	9	0	0	373	1916	4248	4680	4268	3810	2700	2467	24462
	10	0	0	185	997	2649	3462	3594	3335	2450	2230	18902
	11	0	0	13	419	1409	2203	2387	2292	1780	1494	11997
	12	0	0	0	226	741	1425	1642	1575	1267	1200	8076
	13	0	0	0	41	358	782	940	898	707	617	4343
	14	0	0	0	29	217	352	478	473	392	333	2274
	15	0	0	0	0	86	176	260	239	169	159	1089
	16	0	0	0	0	40	85	98	116	92	97	528
	17	0	0	0	0	12	47	38	44	29	34	204
	18	0	0	0	0	9	63	62	74	50	41	299
Total		170817	150124	120019	84026	72649	51978	41984	34253	23699	21548	771097

Source: Kenya National Bureau of Statistics, KNBS

Appendix 2: Women by Age-group and Parity, Kenya-2009

		Age 5yr Grps										Total
		15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	
Parity	0	174084	77331	26022	9199	4423	2641	1960	1588	1224	1145	299617
	1	21396	51894	31287	12333	5837	3160	2252	1633	1220	1101	132113
	2	6563	37954	37351	22186	11854	6264	3977	2230	1466	1102	130947
	3	1542	19051	29218	22185	15404	8924	5950	3320	1873	1414	108881
	4	977	8676	20818	19612	14924	9821	7766	4400	2604	1908	91506
	5	0	3048	11041	14967	13084	9080	7966	5057	3300	2407	69950
	6	0	2831	5639	11277	11624	8468	7655	5529	3837	2959	59819
	7	0	0	2384	6328	8629	7216	6885	5595	4248	3295	44580
	8	0	0	2201	3980	6936	6550	6472	5438	4241	3583	39401
	9	0	0	0	1669	3558	4293	4568	4268	3676	3398	25430
	10	0	0	0	878	2098	2982	3499	3468	3057	2933	18915
	11	0	0	0	397	999	1679	2040	2092	1936	1937	11080
	12	0	0	0	558	1109	1046	1372	1439	1291	1336	8151
	13	0	0	0	0	0	486	716	794	721	691	3408
	14	0	0	0	0	0	261	345	406	373	389	1774
	15	0	0	0	0	0	132	204	216	217	189	958
	16	0	0	0	0	0	169	241	100	116	103	729
	17	0	0	0	0	0	0	0	48	53	52	153
	18	0	0	0	0	0	0	0	85	84	90	259
Total		204562	200785	165961	125569	100479	73172	63868	47706	35537	30032	1047671

Source: Kenya National Bureau of Statistics, KNBS

Appendix 3: Births in the Past 12 Months Preceding the 1999 Census

		Age 5yr grps							Total
		15-19	20-24	25-29	30-34	35-39	40-44	45-49	
CEB	1	12533	12112	2966	502	145	39	22	28319
	2	5338	11497	4841	1050	202	54	28	23010
	3	672	6939	5873	1763	475	92	22	15836
	4	153	3072	5106	2278	702	105	48	11464
	5	0	955	3468	2480	1004	181	68	8156
	6	0	280	1812	2406	1290	271	89	6148
	7	0	71	815	1832	1380	383	95	4576
	8	0	23	369	1138	1361	418	113	3422
	9	0	0	105	510	933	443	101	2092
	10	0	0	51	272	618	388	113	1442
	11	0	0	3	102	345	257	98	805
	12	0	0	0	60	161	172	77	470
	13	0	0	0	11	77	111	44	243
	14	0	0	0	8	43	46	17	114
	15	0	0	0	0	14	22	12	48
	16	0	0	0	0	11	12	5	28
	17	0	0	0	0	3	8	0	11
	18	0	0	0	0	1	6	1	8
Total		18696	34949	25409	14412	8765	3008	953	106192

Source: Kenya National Bureau of Statistics, KNBS

Appendix 4: Births in the Past 12 Months Preceding the 2009 Census

		Age 5yr Grps							Total
		15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Parity	1	8691	15277	5131	1001	194	60	13	30367
	2	2592	13231	8072	2566	592	91	21	27165
	3	578	7164	7834	3648	1231	212	49	20716
	4	289	3328	6513	3982	1598	347	79	16136
	5	0	1180	3888	3734	1865	454	104	11225
	6	0	919	2022	3210	2008	563	160	8882
	7	0	0	815	1928	1861	632	186	5422
	8	0	0	675	1215	1607	714	228	4439
	9	0	0	0	538	895	584	193	2210
	10	0	0	0	253	543	446	160	1402
	11	0	0	0	107	280	284	120	791
	12	0	0	0	147	268	181	100	696
	13	0	0	0	0	0	85	50	135
	14	0	0	0	0	0	59	27	86
	15	0	0	0	0	0	19	17	36
	16	0	0	0	0	0	26	21	47
	17	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0
Total		12150	41099	34950	22329	12942	4757	1528	129755

Source: Kenya National Bureau of Statistics, KNBS

Appendix 5: Proportions of women who have already attained parity i (unprojected)

Parity (*i*)	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	1	1	1	1	1	1	1	1	1	1
1	0.2035	0.6687	0.8521	0.9429	0.9608	0.9637	0.9641	0.9614	0.9602	0.9574
2	0.0663	0.3898	0.6884	0.8677	0.9182	0.9305	0.9351	0.9337	0.9330	0.9257
3	0.0097	0.1869	0.4836	0.7371	0.8467	0.8801	0.8942	0.8966	0.8988	0.8898
4	0.0020	0.0726	0.2992	0.5768	0.7384	0.8085	0.8395	0.8482	0.8531	0.8454
5	0	0.0233	0.1613	0.4169	0.6047	0.7150	0.7643	0.7838	0.7955	0.7883
6	0	0.0071	0.0758	0.2760	0.4673	0.6051	0.6700	0.7015	0.7239	0.7151
7	0	0.0018	0.0331	0.1637	0.3359	0.4876	0.5643	0.6046	0.6336	0.6275
8	0	0.0005	0.0134	0.0883	0.2241	0.3681	0.4480	0.4948	0.5247	0.5200
9	0	0	0.0048	0.0432	0.1345	0.2554	0.3279	0.3753	0.4066	0.4025
10	0	0	0.0016	0.0204	0.0760	0.1654	0.2263	0.2641	0.2927	0.2880
11	0	0	0.0001	0.0085	0.0395	0.0988	0.1406	0.1667	0.1893	0.1845
12+	0	0	0	0.0035	0.0201	0.0564	0.0838	0.0998	0.1142	0.1151

Source: Computed by the Author

Appendix 6: Values for Projected Graphs

a. Projected PPRs

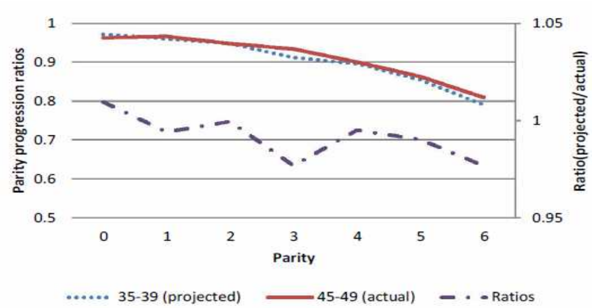
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641	0.9614	0.9602	0.9574
1	0.8539	0.8913	0.9364	0.9595	0.9668	0.9699	0.9712	0.9717	0.9668
2	#N/A	0.8587	0.8937	0.9309	0.9460	0.9562	0.9603	0.9633	0.9613
3	#N/A	0.8142	0.8399	0.8845	0.9234	0.9388	0.9460	0.9492	0.9501
4	#N/A	#N/A	0.8226	0.8461	0.8908	0.9105	0.9240	0.9325	0.9324
5	#N/A	#N/A	0.8122	0.8153	0.8554	0.8767	0.8950	0.9100	0.9072
6	#N/A	#N/A	0.7767	0.7808	0.8159	0.8422	0.8619	0.8752	0.8775
7	#N/A	#N/A	#N/A	0.7468	0.7714	0.7938	0.8184	0.8282	0.8286
8	#N/A	#N/A	#N/A	0.6909	0.7097	0.7320	0.7586	0.7748	0.7739
9	#N/A	#N/A	#N/A	0.6760	0.6799	0.6900	0.7036	0.7198	0.7155

b. Cumulated projected PPRs

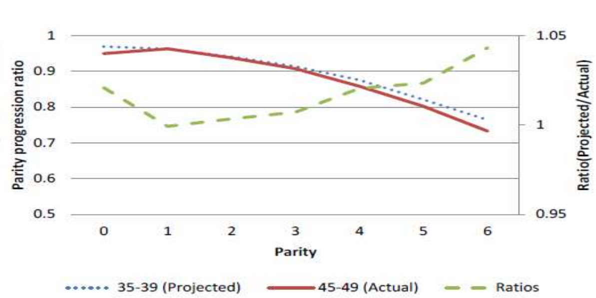
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	1	1	1	1	1	1	1	1	1
1	0.9599	0.9307	0.9677	0.9701	0.9674	0.9641	0.9614	0.9602	0.9574
2	0.8197	0.8296	0.9062	0.9308	0.9353	0.9351	0.9337	0.9330	0.9257
3	#N/A	0.7124	0.8099	0.8664	0.8849	0.8942	0.8966	0.8988	0.8898
4	#N/A	0.5800	0.6802	0.7663	0.8171	0.8395	0.8482	0.8531	0.8454
5	#N/A	#N/A	0.5596	0.6484	0.7279	0.7643	0.7838	0.7955	0.7883
6	#N/A	#N/A	0.4545	0.5286	0.6226	0.6700	0.7015	0.7239	0.7151
7	#N/A	#N/A	0.3530	0.4128	0.5080	0.5643	0.6046	0.6336	0.6275
8	#N/A	#N/A	#N/A	0.3083	0.3919	0.4480	0.4948	0.5247	0.5200
9	#N/A	#N/A	#N/A	0.2130	0.2781	0.3279	0.3753	0.4066	0.4025

Appendix 6 (2): Comparison of projected and observed PPRs for the same age cohort in successive censuses, Malawi and Zambia

Malawi



Zimbabwe



Projected PPRs in Malawi were lower than the observed PPRs because of generally high fertility
Projected PPRs in Zimbabwe were higher than the observed PPRs because of falling fertility (<u>same as Kenya</u>)

Appendix 7: Values for Comparison Graphs

a. Comparing cohort *i*=5 & *i*=7

	Projected '99 (35-39)	Observed '09 (45-49)
0	0.9701	0.9693
1	0.9595	0.9636
2	0.9309	0.9333
3	0.8845	0.8931
4	0.8461	0.8438
5	0.8153	0.8102
6	0.7808	0.7748
7	0.7468	0.7386
8	0.6909	0.6674
9	0.6760	0.6482

b. Comparing cohort *i*=4 & *i*=6

	Projected '99 (30-34)	Observed '09 (40-44)
0	0.9677	0.9639
1	0.9364	0.9552
2	0.8937	0.9070
3	0.8399	0.8540
4	0.8226	0.8118
5	0.8122	0.7857
6	0.7767	0.7456

c. Comparing projected and unprojected PPRs, 1999

	Projected	Unprojected
20-24	0.9409774	0.4091553
25-29	0.8823762	0.5090137
30-34	0.8607498	0.6504162
35-39	0.7990865	0.7402636
40-44	0.793085	0.7995346

Appendix 8: Unprojected proportions of women with at least *i* children, 2009

Parity (*i*)	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	1	1	1	1	1	1	1	1	1	1
1	0.1490	0.6149	0.8432	0.9267	0.9560	0.9639	0.9693	0.9667	0.9656	0.9619
2	0.0444	0.3564	0.6547	0.8285	0.8979	0.9207	0.9341	0.9325	0.9312	0.9252
3	0.0123	0.1674	0.4296	0.6518	0.7799	0.8351	0.8718	0.8857	0.8900	0.8885
4	0.0048	0.0725	0.2536	0.4752	0.6266	0.7132	0.7786	0.8161	0.8373	0.8414
5	0	0.0293	0.1281	0.3190	0.4781	0.5789	0.6570	0.7239	0.7640	0.7779
6	0	0.0141	0.0616	0.1998	0.3479	0.4548	0.5323	0.6179	0.6711	0.6978
7	0	0	0.0276	0.1100	0.2322	0.3391	0.4124	0.5020	0.5632	0.5992
8	0	0	0.0133	0.0596	0.1463	0.2405	0.3046	0.3847	0.4436	0.4895
9	0	0	0	0.0279	0.0773	0.1510	0.2033	0.2707	0.3243	0.3702
10	0	0	0	0.0146	0.0419	0.0923	0.1318	0.1813	0.2208	0.2571
11	0	0	0	0.0076	0.0210	0.0516	0.0770	0.1086	0.1348	0.1594
12+	0	0	0	0.0044	0.0110	0.0286	0.0451	0.0647	0.0803	0.0949

Source: Computed by the Author

Appendix 9: Incomplete PPRs for 1999 from the analytical report on fertility and nuptiality

1999 PPRs	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0 to 1	0.204	0.668	0.852	0.943	0.960	0.963	0.965
1 to 2	0.328	0.585	0.808	0.921	0.957	0.966	0.970
2 to 3	0.150	0.478	0.699	0.850	0.921	0.946	0.956
3 to 4	0.199	0.394	0.619	0.784	0.872	0.919	0.938
4 to 5		0.331	0.538	0.719	0.819	0.882	0.911
5 to 6		0.293	0.478	0.661	0.772	0.845	0.879
6 to 7		0.257	0.432	0.594	0.721	0.803	0.839
7 to 8		0.267	0.403	0.541	0.666	0.755	0.793
8 to 9			0.340	0.492	0.605	0.697	0.737
9 to 10			0.360	0.462	0.564	0.652	0.686

Source: KNBS 1999: KPHC Analytical Report on Fertility and Nuptiality Vol. IV, p. 20

Appendix 10: Age-Order Specific Fertility Rates for 1999 from the analytical report on fertility and nuptiality

Age group	Total	Birth order 1	2	3	4	5	6	7	8	9	10+
10-14	0.029	0.028	0.001								
15-19	0.116	0.077	0.033	0.004	0.001						
20-24	0.249	0.087	0.081	0.050	0.021	0.007	0.002	0.001	0.000		
25-29	0.226	0.027	0.044	0.051	0.046	0.030	0.016	0.007	0.003	0.001	0.001
30-34	0.182	0.007	0.013	0.022	0.029	0.032	0.030	0.022	0.014	0.007	0.006
35-39	0.129	0.002	0.004	0.007	0.011	0.015	0.019	0.021	0.019	0.014	0.018
40-44	0.061	0.001	0.001	0.002	0.003	0.004	0.005	0.007	0.009	0.009	0.020
45-49	0.022	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.008
Total (X5)	5.070	1.148	0.892	0.681	0.560	0.450	0.375	0.300	0.240	0.170	0.265

Source: KNBS 1999: KPHC Analytical Report on Fertility and Nuptiality Vol. IV, p. 24