Analysis of the projected parity progression ratio method using two successive censuses/surveys

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PLAGARISM DECLARATION

This research is my original work, produced with supervisory assistance from my supervisor. I have used the Harvard convention for citation and referencing. Each contribution to this dissertation from the works of other people has been acknowledged, cited and referenced. In addition, this dissertation has not been submitted for any academic or examination purpose to any other university.

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ABSTRACT

Parity progression ratios are a useful tool in analysing fertility trends. Brass (1985) described a method of using the current distribution of age-order specific fertility rates to estimate the future trends of parity progression ratios, commonly known as the projected parity progression ratio method. The major output of this approach is an indication of the future trends in fertility by parity, on the assumption that current age-order specific fertility rates continue to apply until the end of women's reproductive life. The objective of this study is to assess how well the projected parity progression ratio method works when applied to two successive censuses or Demographic Health Surveys. Four countries, namely Malawi, Zimbabwe, Cambodia and Panama, each with two recent censuses which are ten years apart, are used. Each of the census and survey used is taken through a data quality assessment process to check for inconsistencies. Using age-order specific fertility rates derived from births in the past year, parity progression ratios are projected to the next census. These results are compared with the actual parity progression ratios obtained in the second census for each country. The application of the projected parity progression ratio method to the Malawian and Panamanian datasets resulted in a relatively good fit whilst for Zimbabwe and Cambodia; the method did not produce a good fit. The results of the comparison show that the method produces a good estimate of parity progression ratios when the age pattern of fertility remains relatively constant over the intercensal period. The study also reveals that the method is dependent on the quality of the data used. A suggestion for future research is to improve the method assessed through allowing for a gradual shift in the age pattern of fertility for populations with rapidly changing fertility. This can be done by designing a model that allows for a change in the additional proportion of women expected to attain specific parity by the end of their child-bearing period.

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1. INTRODUCTION

1.1. Background to the study

Fertility transition is a vital subject in demography, which has attracted the attention of many researchers. Various methods have been designed by demographers to try to measure this phenomenon. This research focuses on testing one such method of fertility analysis, the projected parity progression ratio (PPPR). In broad terms, the method involves an analysis of parity data from women in an effort to understand the fertility transition in a given population. Parity progression ratios date back to the 1950s when they were first documented. They can be used to study fertility trends or fertility determinants, such as family planning methods.

1.2. Statement of the problem

In fertility analysis for a given population, one can look at the past trend to explain how a population got to the present day state, or analyse current fertility, or better still, try to predict the future using past and present data. One such method of understanding the current fertility trends and using it to predict the future is to use projected parity progression ratios. The projected parity progression ratio method has been used by only a few researchers, hence it is not surprising that it has not been tested to see if it can produce a good prediction of the future trends of parity progression ratios. This study applies the method to two successive censuses or surveys in a particular population to assess how well the method works.

1.3. Objectives of the study

This study tests how well the projected parity progression method works over two successive censuses using four different countries as case studies. To achieve this, the research will compare projected parity progression ratios from one census with the actual parity progression ratios obtained in the successive census. As a result, the specific objectives of this research will be to:

- compare projected parity progression ratios from one census with observed parity progression ratios in the successive census conducted ten years later; and
- determine the factors affecting the projected parity progression ratio method in relation to estimating future trends of fertility.

1.4. Justification for the study

Most studies have used common measures, such as age specific fertility and total fertility rates to analyse fertility trends. These measures, though informative on the nature of fertility behaviour in a population, provide aggregated estimates of fertility; hence do not provide enough detail on exactly how fertility is changing within parity. The analysis of fertility by parity helps us understand the different determinants that affect women at each child birth. Within this context, parity progression ratios have been one of the most frequently used demographic tool in analysing data by parity. Brass (1985) described a method of projecting parity progression ratios forward. This method uses the current age-order specific fertility rates to model a future distribution of the parity progression ratios, given a set of assumptions. To date, the method has not been tested to see how well it works; hence this study focuses on assessing how well the projected parity progression ratio method works when applied to two successive surveys from the same population.

1.5. Thesis outline

This thesis begins with a review of literature on parity progression ratios and projected parity progression ratios. It looks at the studies that have been done to date using parity progression ratios as well as the projected parity progression ratio method. Chapter Three presents the methodology of the study. The same chapter focuses on describing the how the projected parity progression method is applied using data from censuses and Demographic Health Surveys. In addition, Chapter Three also looks at the type of data that is used and the various methods applied in this study to assess and correct data errors. Chapter Four presents the results of applying the parity progression ratio method to the four different countries under review. The conclusion and limitations of the study together with suggestions for future research are presented in Chapter Five.

2. LITERATURE REVIEW

This chapter discusses the literature related to the projected parity progression ratio method. Section 2.1 describes parity progression ratios and their uses in fertility analysis while Section 2.2 focuses on projected parity progression ratio method and its uses to date.

2.1. Parity progression ratios (PPRs)

Henry (1980), citing his earlier work done in 1953, indicates that he was the first to document parity progression ratios (PPRs). In the years that followed, the concept of parity progression ratios was further refined by other authors (see for example (Aoun and Airey 1988; Brass and Juárez 1983; Rodriguez and Hobcraft 1980; Sloggett, Brass, Eldridge *et al.* 1994)). By definition, a parity progression ratio refers to the proportion of women who progress from parity *i* to *i*+1 (Feeney and Yu 1987; Preston, Guillot and Heuveline 2000). PPRs can be calculated on a cohort or period basis depending on the data available (Feeney 1991b). For cohorts, PPRs are usually calculated for women who have completed their child bearing years i.e. over 50 years (Preston, Guillot and Heuveline 2000); hence they do not give the fertility trend for the recent past since most of the births would have occurred more than a decade ago (Feeney 1991b). Cohort PPRs are often calculated from demographic data collected from censuses whereas period PPRs use probabilities of giving birth in a defined space of time (Feeney 1991b). PPRs are always less than unity when they are calculated for a specific cohort in a given period. In this study, the cohort analysis of parity progression ratios will be used to assess their trends across two censuses. The algebraic calculation of parity progression ratios is given below. The exposition and notation used is borrowed from Preston, Guillot and Heuveline (2000).

Let $W_i =$ number of women at parity *i*, $P_i = \sum_{a=i}^{I} W_i =$ number of women at parity *i* or greater and $B_i =$ number of births of parity $i = P_i$. Then, parity progression ratio from parity *i* to parity *i+1* is given by

$$PPR_{(i,i+1)} = \frac{P_{i+1}}{P_i} = \frac{B_{i+1}}{B_i}$$

Parity progression ratios have been used extensively to analyse the trends in fertility. The major reason for their use is that they provide a means to observe the trend of fertility by parity. Some parities may be prone to certain data errors that do not affect others. For instance, old women often under report the number of children ever born when they exclude those who might have died or left home. Furthermore, it is widely assumed that fertility decline usually starts with older women limiting additional births at higher parities (Van De Walle and Foster 1990). This behaviour is only visible when the fertility trends are analysed by parity. A study of the fertility transition in India using parity progression ratios showed that the decline between 1977 and 2004 was mainly caused by women limiting births for parities higher than two (Spoorenberg 2010). Within the same context, Feeney used parity progression ratios to study the nature of the fertility trends in Taiwan, China and Kenya separately (see, for example, (Feeney 1988, 1991b; Feeney and Yu 1987). For China, he used period parity progression ratios to study the effect of the country's one child policy on the fertility decline. Through the use of this method, he was able to see when the demographic effects of the Chinese one child policy started and also which parities it affected the most. For Taiwan, Feeney used period parity progression ratios again to assess the fertility decline. The major finding of his study was that fertility decline was concentrated in second and higher order births. In another study, Brass and Jolly (1993) used cohort parity progression ratios calculated from the 1989, 1993 and 1998 Kenya DHS data as part of their analysis of population dynamics of Kenya. Their study reveals that birth limitation pattern occurred simultaneously for all birth orders, as predicted by Caldwell, Orubuloye and Caldwell (1992) in their study of the nature of fertility decline in Africa. Robson and Smith (2012) used parity progression ratios to reveal that women who give birth to twins have a higher lifetime fertility compared to those who do not.

On the other hand, parity progression ratios have not been able to explain all the fertility differentials in parities. For instance, a study by McClelland (1979) revealed that parity progression ratios were not able to fully explain the impact of sex preferences on fertility in Thailand. Another shortcoming of cohort parity progression ratios is that they only present reliable fertility trends for older women, who have completed their child bearing. The parity progression ratios for younger women are affected by the different rates at which they give birth. Women who give birth to many children over a short period of time tend to contribute more numbers to the data compared to those who have longer birth intervals thus introducing bias to the data.

2.2. Projected parity progression ratios

Parity progression ratios calculated on a cohort basis can also be derived for women who have not yet completed their child bearing years. However, these estimates can be unreliable for women who are in the early years of their reproductive life. This is because the estimates are affected by censoring and selectivity effects as they will be liable to change rapidly when more women move into higher parities (Moultrie and Zaba 2012). Brass developed two ways to calculate projected parity progression ratios for women who are yet to complete their child bearing years. The first uses the numbers of children ever born and births in the last year by parity from census data (Brass 1985); the second uses censored cohorts from birth histories (Brass and Juárez 1983). This study makes use of census data from the chosen countries to assess how well the parity progression ratio method works; hence, the first approach by Brass will be used. In his exposition, Brass (1985) assumes that the current age-order specific fertility rates will apply until the end of the reproductive period and then he uses this assumption to project the future distribution of parity progression ratios.

There has not been much work done using census projected parity progression ratios since their introduction by Brass (1985). The most likely reason for this lack of attention is that the method has not been formally published and hence it is not well known in the research community. In addition, it also seems that most researchers have not looked into the usefulness of the projected parity progression ratios to enhance fertility analysis. Collumbien, Timæus and Acharya (1997) use the projected parity progression ratio method as part of an analysis of the fertility decline in Nepal. The results reveal that fertility decline in this country was happening at higher order parities as suggested by Van De Walle and Foster (1990). In another study, Muhwava (2002) used the same method on census and DHS data to study the onset of fertility transition in Zimbabwe. The use of this method in that study helped bring out the periods where fertility was declining and when birth intervals were increasing. Sloggett, Brass, Eldridge *et al.* (1994) refined the original idea of census projected parity progression ratios that was suggested by Brass (1985). Their work focused on how the projected parity progression ratio method is applied to census data. Moultrie and Zaba (2012) corrected some minor algebraic errors in the projected parity progression ratio method proposed by Sloggett, Brass, Eldridge *et al.* (1994). A detailed description of this method is presented in Chapter Three. This study will assess how well the improved projected parity progression ratio method described by Moultrie and Zaba (2012) works when applied to two successive censuses or surveys.

3. METHODOLOGY

3.1. Introduction

This chapter describes the data analysis methods used in this study. Section 3.2 presents a description of the projected parity progression ratio method assessed. Section 3.3 discusses the how the countries used in this study were selected, and Section 3.4 describes the sources of data used. Thereafter, Section 3.5 describes the data assessment methods that are used in this study. The last section also explains how data errors will be corrected.

3.2. (Projected) Parity progression ratio method

The parity progression ratio method will be applied to the census and DHS data using tabulations of average parities by age and recent fertility by parity and age. The method is based on two assumptions:

i) that women have had at most one birth in the year prior to the census; and
ii) that current age-order specific fertility rates will continue to apply in future until the respective cohort reaches the end of its child bearing years.

The method of calculating (projected) parity progression ratios is described below. The notation used in the exposition of this method follows that of Moultrie and Zaba (2012). The application of this method starts with the extraction of data for children ever born by parity, *i*, and age group. Thereafter, the number of births by parity in the 12 months prior to the census date is also extracted. In both of these tabulations, all implausible births and parities are corrected using the rule of thumb described in the section on Corrections to parity and birth data. These tabulations are then used to calculate the proportions of women who have ever attained each specific parity, *i*. To achieve this, the number of women in each five year age group who have given birth to *i* or more children is initially calculated. The algebraic calculation is described below;

If we let the number of women in each five year age group, (*x, x+5*), be represented by ${}_5N_x$, and the number of women of parity, *i*, to be ${}_5N_x(i)$, the number of women of parity *i* or greater is given by

$${}_5W_x(i) = \sum_{j=i}^{n} {}_5N_x(j),$$

for *i* upto *n*, where *n* is the highest parity. The proportion of women who have attained parity *i* or more, ${}_5M_x$, is then given by dividing the total number of women with *i* children or greater by the total number of women in that age group;

$$ {}_5M_x(i) = \frac{{}_5W_x(i)}{N}, $$

where N is the total number of women in that age group including those with zero parity but excluding those of parity unknown. From this we can now derive the proportions of women who have progressed from parity *i* to *i+1*, which are the parity progression ratios. These are obtained by dividing the proportion of women with *i+1* children by that with *i* children. Thus the parity progression ratios for parity, *i*, to *i+1* is given by;

$$ {}_5a_x(i) = \frac{{}_5M_x(i+1)}{{}_5M_x(i)} $$

These parity progression ratios are calculated for all women. However, in this calculation there are young women who have not yet completed their child bearing. To obtain their parity progression ratios when they reach the end of child bearing, we need to calculate projected parity progression ratios. The method of calculation starts with deriving age-order specific fertility rates (AOSFRs) from the tabulation of births in the last year by parity. This is done by dividing births by women in parity (*i*) for each age group (x, x+5), by the total number of women in that age group.

$$ {}_5AOSFR_x(i) = \frac{{}_5B_x(i)}{{}_5N_x} $$

Thereafter we need to calculate total order specific fertility rates (TOFRs) from the AOSFRs we have. To do this, the AOSFRs are summed up across each age group by parity and then multiplied by five.

$$ {}_5TOFR_x(i) = 5 \times \sum_{j=15,5}^{45} {}_5AOSFR_j(i) $$

This produces a table with AOSFRs and TOFRs for each parity. This implies that ${}_5TOFR_{45}(i) - {}_5TOFR_x(i)$ gives the proportion of women aged (x, x+5) who are expected to achieve parity *i* by the end of their child bearing period. The method of projecting parity progression ratios assumes that current fertility will remain constant until the end of the reproductive life span for women who are still in child-bearing ages. Hence, it presents the most probable pattern of fertility for the future if young women were to continue experiencing current AOSFRs until the end of their reproductive years.

For all births in the last year, the age distribution of cumulated order specific fertility rates refer to the midpoint of the year before the survey, thus fertility is cumulated to attained ages 19.5, 24.5, etc. This is because the ages of mothers were taken as at census date and not age at the birth of their child, hence they are assumed to have had their birthdays approximately at the midpoint of the year prior to the survey. However, the proportions of women ever attaining parity *i,* refer to the midpoint of the five year age groups. As a result, the cumulated order specific rates need to be interpolated to represent the midpoint of the five year age group. To achieve this, we first calculate the proportion of the TOFR that has been achieved by the upper limit of each respective age group. We cannot apply direct linear interpolation to these proportions because the fertility pattern is itself not linear. Therefore we need to transform the pattern of fertility into a more linear form so that we can interpolate. To do this, we use a double negative log transform commonly known as the gompit. We calculate the gompits of the proportions of order fertility calculated above, then interpolate to midpoint ages. Thereafter, we use an anti-gompit transform to return the proportions to their original scales. The algebraic expression of the above calculation is given below;

The proportion of TOFR achieved by the upper limit of each age group is given by;

$$ {}_5\theta_x(i) = \frac{{}_5TOFR_x}{{}_5TOFR_{45}}. $$

The shifted proportion to the conventional ages, ${}_5\theta_x^{\,*}$, is given by

$$ {}_5\theta_x^{\,*}(i) = \exp(-\exp(-0.4(-\ln(-\ln({}_5\theta_{x-5}(i)))+0.6.(-\ln(-\ln({}_5\theta_x(i)))). $$

The projected parity progression ratio method uses the current age distribution of fertility to estimate the trend of projected parity progression ratios at the end of a woman's reproductive years. However, in this study we focus on assessing how well the method works in projecting the trends of parity progression ratios to the next ten years, which is the time of the next census. To do this, we need to derive the proportion of future order fertility to be added in the next ten years for each cohort. This is done by subtracting the proportion of order fertility achieved by the mid-point of the one age group by that in the age group ten years older. After subtracting, we then multiply this result with the TOFR for that parity, *i,* to get the additional proportion of women reaching that parity within the next ten years from the midpoint of that age group. The algebraic expression for this calculation is given below:

$$ {}_5TOFR_{x+10}(i) - {}_5TOFR_x = {}_5TOFR_{45}(i)x\left({}_5\theta_{x+10}^{\,*}(i) - {}_5\theta_x^{\,*}(i)\right) $$

The fertility of younger women is more likely to change over a short time hence fertility projections for these are highly unreliable. As a result, this study will only do the previously mentioned calculation on slightly older women in ages 32.5, 37.5, upto 47.5 years.

The next step is to calculate the proportion of women attaining parity, *i,* in the next ten years. This is done by adding the proportion of women who have already attained parity *i* to those expected to reach the same parity in the next ten years, obtained in the previous calculation. The proportion of women who have already attained parity *i* or more, ${}_5M_x(i)$, is obtained in the calculation done earlier when we were deriving parity progression ratios for all women. Therefore, the proportion of women projected to have *i* or more children in the next ten years, ${}_5M_x^*$, is calculated as follows;

$${}_5M_x^*(i) = {}_5M_x(i) + {}_5TOFR_{45}(i)x\left({}_5\theta_{x+10}^* - {}_5\theta_x^*\right)$$

Having the proportions of women who are expected to attain each parity *i,* by the time of the next census, we can now derive the projected parity progression ratios for each parity *i* to *i+1*. This is done by dividing the proportion expected to attain parity *i+1* by that expected to achieve parity *i*. Thus the projected parity progression ratio will be given by;

$${}_5a_x^* = \frac{{}_5M_x^*(i+1)}{{}_5M_x^*(i)}$$

3.2.1. Comparison of parity progression ratios with the projected parity progression ratios

The objective of this study, as already been mentioned, is to assess how well the projected parity progression method works. After projecting the parity progression ratios by ten years to the next census, we compare this result to the actual parity progression ratios obtained in the subsequent census. The major assumption of this method is that the current distribution of AOSFRs will remain constant in the projected period. If this assumption is met, the projected and the actual parity progression ratios are expected to be identical. However, if the age pattern of the AOSFRs changes in the intercensal period, there is bound to be a deviation from the actual rates observed.

Census data are known to suffer from many errors that are incurred during data collection. The nature of the census exercise makes it prone to errors such as under coverage and under reporting. On the other hand, DHSs are smaller in size and hence more likely to be more accurate. This study will also assess how well the projected parity progression ratio method works when applied to census as well as the DHS data for the same country. This is done to eliminate as far as possible the effect of data errors on the application of the method under review.

3.3. Selection of countries

Four developing countries were selected for analysis. These are Malawi, Zimbabwe, Cambodia and Panama. Each of these countries is currently going through a different fertility transition; hence it is important to note how well the method under review will work under these scenarios. The description of the projected parity progression ratio method in section 3.2 has shown that the method depends on the current distribution of age-order specific fertility rates. As the fertility level of a country changes over time, the age pattern of this demographic aspect is in most cases altered accordingly. Within each of the countries chosen for analysis, there is a unique change in fertility. As a result, the study will assess how the method will work in under different conditions of demographic change.

HIV infection is known to weaken the immune system. A weakened immune system will inevitably alter the normal functions of the body, such as the ability to conceive. A study conducted in Kenya to investigate the association between HIV infection and fertility revealed that the odds of having a recent birth for HIV infected women were significantly lower than that of uninfected women when controlled for background characteristics (Magadi and Agwanda 2010). The decline in fertility for HIV infected women could be attributable to their deteriorating health condition. Ross, Lieve, Lubega *et al.* (2004) investigate the effect of HIV-1 disease progression on fertility. Some of their findings are that as the disease progresses, the frequency of sexual intercourse is reduced and the incidence of foetal loss among pregnant women increases. These findings imply that the resultant fertility rates calculated for women who are infected are bound to be lower than that for uninfected women. Kongnyuy and Wiysonge (2008) also found a similar decline in the fertility for HIV infected women. Knowing one's HIV status also has psychological effects on the resultant fertility preferences for women. In a longitudinal study conducted in rural Malawi to investigate the linkages between HIV infection and fertility preferences, Yeatman (2007) found out that people who knew that they were HIV positive were more likely to stop child bearing compared to those who did not know their status. Furthermore, the same study revealed there were no significant differences by gender in the intention to stop child bearing after testing positive. Young (2007) also argues that the HIV epidemic in Sub-

Saharan Africa seems to lower the demand for children. Given the above arguments, the chance of a having an additional birth for a woman who has been infected by HIV is lower compared to uninfected women. This decline implies that in high HIV prevalence countries, the fertility distribution among child bearing mothers might be affected. Furthermore, HIV prevalence is usually higher among young women in the reproductive age; hence the age pattern of fertility is likely to be affected in high HIV prevalence countries. Overall, the change in fertility caused by HIV may trigger a change in the age pattern of fertility, which will in turn affect the distribution of age-order specific fertility rates. Once this distribution is altered, then the (projected) parity progression ratio method described above is likely to be affected as well. As a result, this study also considers the level of HIV prevalence in country selection. The countries selected either have consistently high or low HIV prevalence. Table 3-1 shows a matrix of different scenarios to be analysed as well as the specific category where each country falls.

Table 3-1: Scenarios for data analysis

Fertility	*HIV prevalence*	
	High	*Low*
High	Malawi	
Falling	Zimbabwe	Cambodia
Low		Panama

Source: Derived from Measure DHS website, UNAIDS estimates

3.3.1. Backgrounds of selected countries

Malawi

The fertility rate in Malawi has been high in the past decades. According to the National Statistics Office reports, since 1977 the total fertility rate has been above six children per woman. There has been a gradual decline from 7.6 children per woman reported in 1977, 7.4 in 1987 and 6.5 in 1998 up to the current six at the 2008 national census. A comparison with DHS reports confirms the high fertility pattern suggested by the census reports. They indicate that the TFR was 6.7 in 1992, 6.3 in 2000, and 6.0 in 2004 with the most recent DHS conducted in 2010 giving a rate of 5.7 children per women (Macro International Inc 2012).

HIV is still a major problem in Malawi. According to the two most recent DHSs conducted in the country in 2004 and 2010, the adult HIV prevalence declined from 11.6 to 10.8 per cent. In both of these survey estimates, the female prevalence was higher than the male prevalence. This implies that HIV infection presents a significant challenge to the fertility patterns of the country.

Zimbabwe

In Zimbabwe, fertility has been falling as well. The 2002 census report indicates a total fertility rate of 3.6 children per woman with the Demographic and Health Survey report of 1988 giving a total fertility rate of 5.4 children per woman (Central Statistics Office (CSO) [Zimbabwe] and Macro International Inc. 2007). Other DHS reports that followed showed total fertility rates of 4.3 in 1994, 4 in 1999, 3.8 in 2005-06 and 4.1 in 2010. The sudden drop in TFR in 2005-06 could be explained by the economic downturn that affected the country during this period. From 1992 to 2002 and beyond, the country was again faced with massive emigration of nationals going to neighbouring countries for economic reasons. According to the International Organisation for Migration report of 2009, the population count for 2002 is assumed to have massively undercounted the number of people in country as a result of the high emigration rate during that period. This could have contributed to the drop in the level fertility by reducing the number of women giving birth, given that a significant number were emigrating.

Given that Southern Africa is the region that is hardest hit by the HIV pandemic, Zimbabwe is still among the countries with the highest prevalence in the world. However, there has been a notable decline in prevalence in Zimbabwe, though it is still among the highest in the world. The HIV prevalence among women attending ANC clinics declined from 32 per cent to 24 per cent between 2000 and 2004 (Mahomva, Greby, Dube *et al.* 2006). The adult HIV prevalence also declined from 18 to 15 per cent between 2005/06 and 2010/11 DHS reporting periods.

Cambodia

Cambodia has been experiencing a fertility decline. The country's 2008 census report indicated that the population of children aged 0-4 had declined from 12.8 to 10.3 per cent between 1998 and 2008. This suggests that there were either fewer children being born or less women giving birth. However, this decline in proportions of young children needs to interpreted with caution since under enumeration errors are more prominent in this age group. On the other hand, Cambodia has a history of a massive genocide that happened between 1975 and 1979. There are different accounts of the exact number of people killed in this period (Kiernan 2003). However the demographic impact of the genocide is evident. The births that were missed in this 5 year period created a gap that will be evident till the whole 1975-1979 cohort exits the reproductive age group. The 2008 census report indicates that the total fertility rate for the country as at 2008 was 3.1 children per women. According to the most recent Demographic and Health Surveys held in the country, the total fertility rate fell from 3.8 to 3.1 children per woman between 2000 and 2010 . The change in fertility could be attributed to the significant increase in the use contraceptives by women in Cambodia. According to the Cambodia DHS report of 2010, the percentage of women currently using any method of contraception increased 23.8 in 2000, to 40 in 2005 and then 50.5 in 2010. The use of contraception is highest among women with 3-4 living children followed by those with 1-2 living children with 58.5 and 53.5 per cent respectively. This suggests that fertility decline in Cambodia is being driven by women with higher parities through contraceptive use. The HIV prevalence in this country has been less than one per cent from 2006 (UNAIDS 2010).

Panama

The fertility in Panama was generally constant between 1990 and 2000. The World Bank (2012) estimates that the total fertility rate for Panama decreased from 3.02 to 2.75 children per woman between 1990 and 2000. The United Nations (2011) estimates indicate a similar total fertility rate decline from 2.87 to 2.79 children per woman over the same period. The HIV prevalence in this Latin American country has been consistently low among the adult population. UNAIDS (2009) update indicates that the adult prevalence at that time was less than one per cent.

Overall, these countries present different characteristics of interest in assessing how the projected parity progression ratio method works. The method will be applied to census data from each of these countries. The data sources are described in the next section.

3.4. Sources of data

This study makes use of two most recent censuses from each of the four countries under review. The censuses to be used are Malawi, 1998 and 2008; Zimbabwe, 1992 and 2002; Cambodia, 1998 and 2008; Panama, 1990 and 2000. The census data for all these countries except for Zimbabwe were obtained from the IPUMS International website (IPUMS International 2012). In addition to these census datasets, Demographic and Health Surveys for Cambodia and Malawi will also be analysed. The study will make use of the 2000 and 2010 DHS for both Cambodia and Malawi. These two DHSs for each country respectively were selected because they have the same intersurvey period as the censuses being analysed, they were held in almost the same period as the censuses being analysed as well as being among the most recently held surveys. DHS were added so as to assess how well the method will work when applied to data sets of different surveys conducted on the same population. The age groups of women in the datasets are defined by the country's scope of eligible women for fertility analysis. For instance, in Zimbabwean censuses, women aged 12 to 49 were interviewed whilst for other countries, women upto the age of 64 years were asked questions on fertility.

3.5. Data assessment methods

3.5.1. Data errors

The majority of errors in fertility data result from children that are omitted. For lifetime fertility, older women tend to under report the number of children ever born whilst in reports on recent fertility, reference periods errors are more common (Sloggett, Brass, Eldridge *et al.* 1994). Children who die soon after birth or during infancy and those who have left home are often not included in reported number of children ever born. These errors result in average parities for older women being lower than what is normally expected. Parity progression methods depend on the accuracy of the number of children ever born by women. An underestimate of these rates will imply that the average number of children ever born will not represent the true picture in the population. In the same manner, when women are asked about the number of births they had in the last year there is a tendency to include those that were born outside the 12 month period, resulting in inflated fertility rates. However, the most common error in recent fertility data is underreporting on births by women of all ages. All these errors mentioned result in a bias in estimates, which might distort the true level of fertility in a population (Potter 1977).

3.5.2. Corrections to parity and birth data

Prior to analysis, data are assessed for consistency by checking for biologically implausible births and parities. These inconsistencies are corrected using the general rule of thumb, which stipulates that a woman can have a maximum of one child every 18 months from age 12. This rule is used in this analysis to clean the fertility data being used. Thus, women who are aged 15-19 years can have a maximum of five children (Moultrie 2012). All the births and parities that fall outside this range for each age group are re-classified as unknown. This method of correction will be applied to distributions of children ever born by age group and births in the year prior to each census by age group and parity.

Often in data collection processes, enumerators forget to record women with zero parity, leaving the space on the questionnaire blank. When the data are being processed, these women are classified as having unknown parities. el-Badry (1961) proposed a method of correcting the proportions of women with zero parity that are stated as having unknown parity. The method assumes that there are a constant proportion of women whose parity was truly not stated across all age groups. In his method, el-Badry argues that the true proportion of women with unknown parity can be obtained by looking at the relationship between the proportion of women with zero and unknown parity. He recommends that the method be only applied when there is a linear relationship between the two proportions. In the presence of such a linear relationship, the proportion of women with unknown parity after the method is applied is excluded from the denominator used to calculate average parities. This is done on the assumption that women with unknown parity have the same fertility as those with known parity. If such a linear relationship doesn't exist in the data, el-Badry proposes that the number of women with unknown parities be included in calculating average parities (el-Badry 1961). In this study, implausible parities are corrected using the rule of thumb mentioned earlier regardless of whether the el-Badry correction is necessary or not.

3.5.3. Lifetime fertility

The parity progression ratio method is heavily dependent on the quality of parity data. If data were collected accurately, the average number of children born in a cohort in the first census should be less than the average number of children born obtained the second census when the cohort is followed through. For instance, if the average number of children born to women who are 25-29 in the first census is three, then the average number of children born in the next census, say ten years later, when these women will be 35-39 is expected to be more than three. To assess the quality of lifetime fertility data, the average parities from each census are plotted on the same graph. In addition, the average parity for each cohort in the second census will be divided by the average parity of the same cohort when it was ten years younger, giving a ratio of the two proportions. If data are consistent, the ratios should be greater than unity, indicating that the average parities in the older cohort are higher than those in the younger cohort. However, this is a necessary but not sufficient condition to conclude that the data are reasonable.

Another way to analyse parity data for women who have completed their child bearing is to plot their average parities against time. This method was described by Feeney (1991a). It assumes that all births for women who have completed their child bearing years occurred exactly at age *a,* where *a* represents the mean age of mothers giving birth. The mean number of children is plotted against the time they occurred, which is given by *t-(x-a)*, where *t* is the census year and *x* is the midpoint of the age group of women being assessed. In this study, the average parities are calculated for women in five-year age groups. Thus using each five year age group as a unit of analysis, we assume the mean age at birth is 27.5 years. If the parity data are collected correctly, the mean children ever born from the first census should be consistent with those collected in the second census. For instance, if fertility was decreasing, the pattern of that decline is expected be gradual and continuous across the time plots. Furthermore, the average parities for the same time plot in the two censuses should be identical. This method will be applied in assessing the quality of parity data for women have completed their child bearing in all the four countries being used in this study.

3.5.4. Age specific fertility rate and total fertility rate

Tabulations of children born in the twelve months prior to the survey by age group of women are used to generate age specific fertility rates. The total number of births in each age group is divided by the total number of women enumerated in that age group to give the age specific fertility rate. The total fertility rate is the sum of the age specific fertility rates from all women multiplied by the number of years in each age group. The relational Gompertz method will be applied to the recent fertility data to adjust for errors of underreporting of recent births. A workbook designed by Moultrie and Zaba (2012) which applies this method will be used in this study. For each of the countries under review, age specific fertility rates from the two censuses will be compared. The comparison will involve plotting the rates on the same axis as well as standardising them to assess the shape of the fertility curves. The age specific fertility rates will be standardised by imposing a total fertility rate of one, thus eliminating the effect of a difference in the level of fertility. This allows the shape of fertility from to be compared across the two censuses to see if there has been a change in the age pattern of fertility. Other reliable data sources, such as the Demographic and Health Surveys will be used to check whether the census implied rates are plausible.

4. DATA ANALYSIS AND RESULTS

4.1. Introduction

This section presents the results obtained from applying the projected parity progression method to census data from the four countries described in Section 3.3. Prior to an in-depth analysis of the projected parity progression ratio method, each dataset is investigated to assess the quality of the data used. The results are presented by country. The method will be applied to census data for all countries and to DHS data for Malawi and Cambodia.

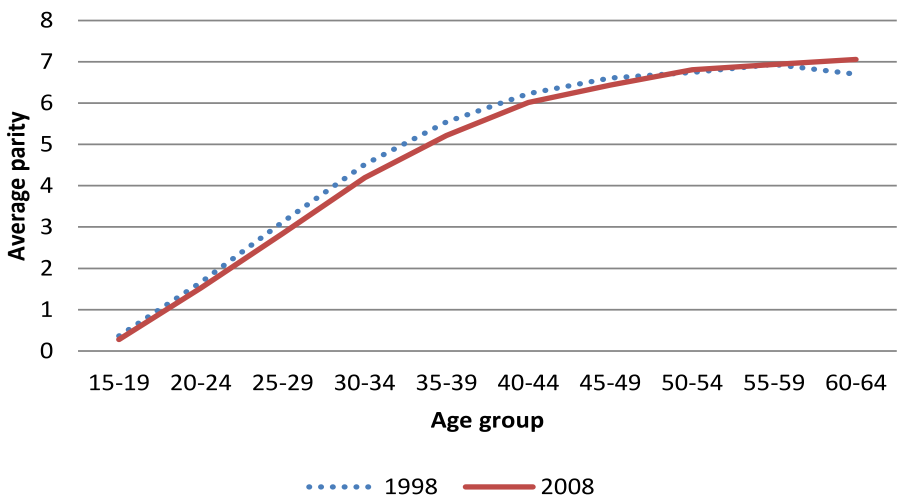
4.2. Malawi

4.2.1. Fertility data analysis

4.2.1.1. Parity data assessment

The data on children ever born by parity for two Malawian censuses were used to calculate the average parities for each age group. The total number of the women by age group for the two censuses is presented in the Appendix. Figure 1 shows the distribution of average parities for each age group in the two censuses under review. The distributions for both censuses follow an expected trend, increasing as age increases. There is a slight decline for the average parity for the last age group in the 1998 data. This decline is not plausible hence it is attributable to an error in the data. This data error might affect the results of calculations to follow. However, the bias introduced by this error is likely to be very small since the error is not too significant.

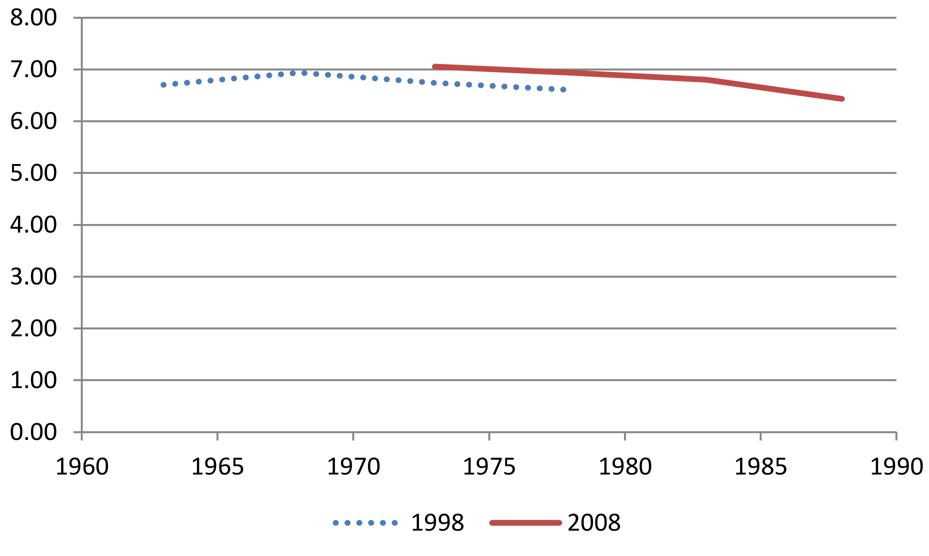
Figure 1: Average parity by age group, Malawi censuses 1998 and 2008



Source: Derived from data from IPUMS International database

Figure 2 shows the application of the time plot method described by Feeney (1991a) for assessing average parities. The distribution of average parity from the 1998 census data shows that there has been a fertility decline from 1968 through to 1978. In the same manner, the trend shown by the 2008 census data indicates that there was indeed a fertility decline from 1973 through to 1988. These two similar patterns suggest that the sudden increase shown average parities from 1963 through to 1968 may not be fertility rise but rather a data error. This data error is consistent with the observation made in the average parity for women aged 60-64 where the average parity for this cohort of women was lower than expected. Furthermore, the average parity estimates for 1973 and 1978 from the two censuses respectively should have coincided, should the data have been accurately collected. The difference of about 0.3 children per woman observed might be attributable to a consistent data error in the two census counts. The error is likely mostly likely coming from the 1998 census data. This could be attributed to a general underreporting on births by all women. The data errors obtained in the past analysis need to be taken into consideration when interpreting the results of the projected parity progression ratio.

Figure 2: Time plots of average parities by year, Malawi censuses 1998 and 2008



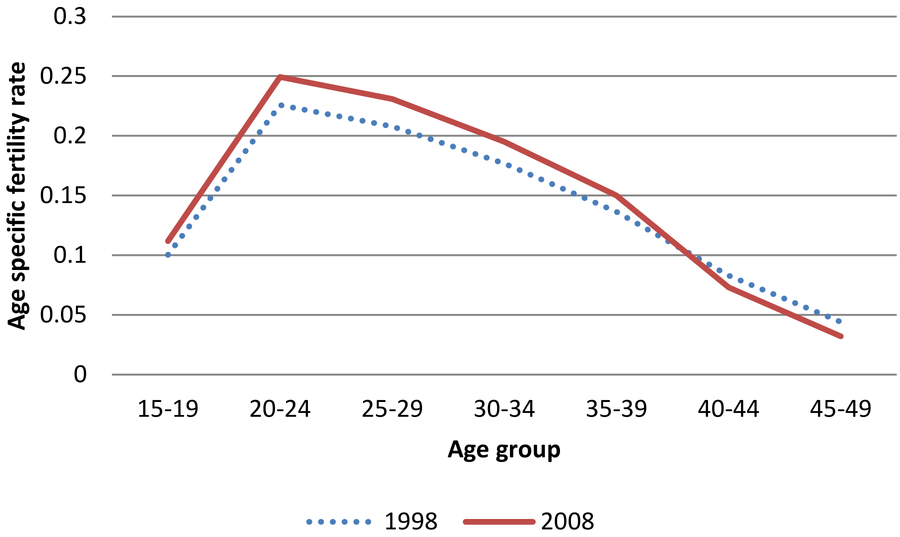
Source: Derived from data from IPUMS International database

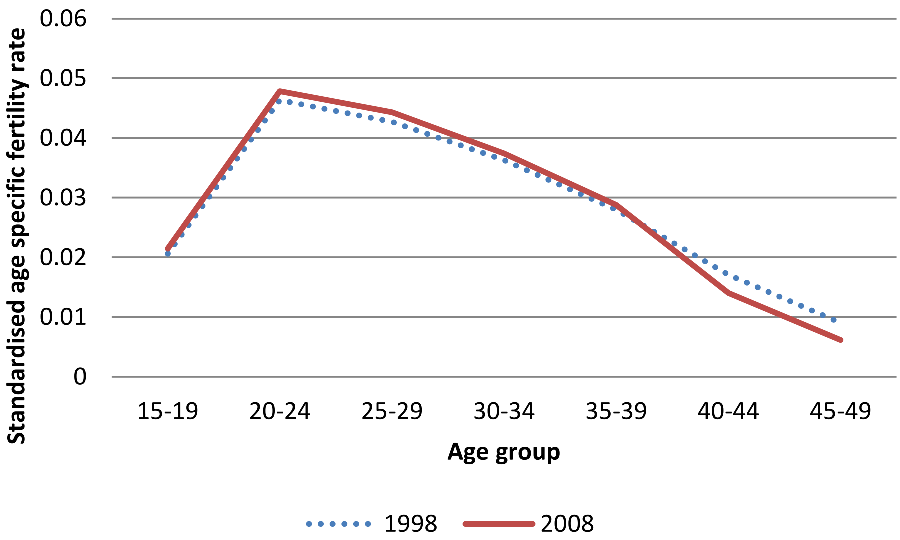
4.2.1.2. *Recent fertility data assessment*

The data on recent fertility shows that the unadjusted total fertility rate from recent births is 4.87 and 5.21 children per woman for the 1998 and 2008 censuses respectively.

These rates are consistent with the unadjusted rates in the Malawi fertility report from the 2008 census (National Statistical Office 2008). The projected parity progression ratio method uses the 1998 census to estimate a future distribution of parity progression ratios. As a result, the census 2008 data is mainly used as a consistency check.

Figure 3: Age specific fertility rates and standardised age specific rates, Malawi 1998 and 2008 censuses





Source: Derived from data from IPUMS International website

Figure 3 shows a comparison of the age specific fertility rates obtained from the Malawian censuses. The first graph in Figure 3 shows the actual age specific rates whilst the second one shows the fertility rates standardised to a TFR of one. The two patterns are almost identical at all ages except at the oldest age group where the age specific fertility rates for 40-44 and 45-49 year age groups are lower in 2008 compared to the 1998 level. The same trend is observed for the standardised rates where there is a slight deviation at the older age group. This suggests a decline in fertility at the older ages or some errors in the data.

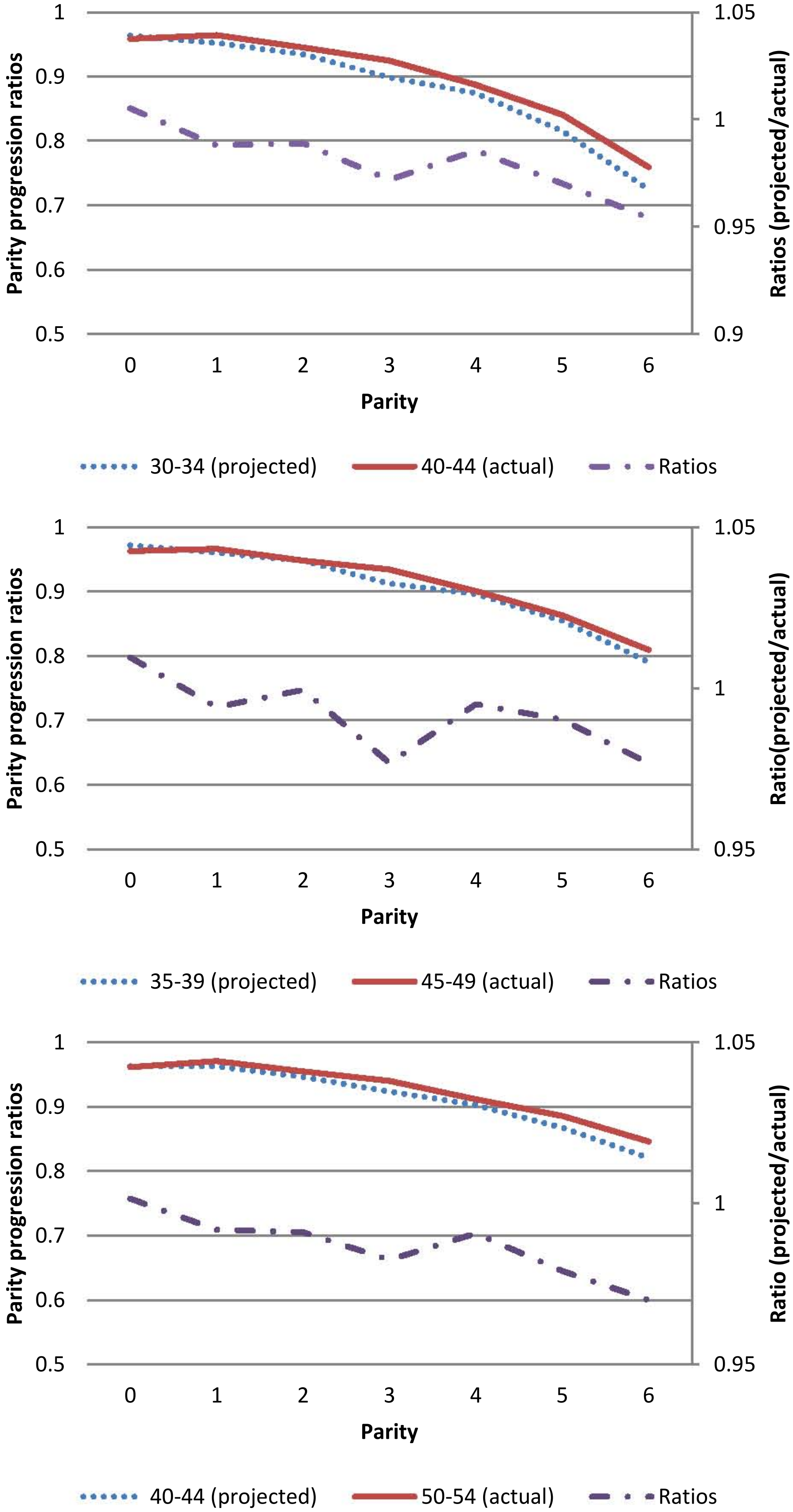
Using the relational Gompertz model, corrected TFRs of 6.09 and 6.69 children per woman were observed for the 2008 and 1998 censuses respectively. These two estimates suggest that there is a fertility decline under way in Malawi. This decline resulted in a reduction of about 0.6 children per woman in the period between 1998 and 2008.

4.2.2. Projected parity progression ratios

The major thrust of this research is to assess how well the PPRs method works when applied to one census and then compared to a successive census. To achieve this, each of the parity progression ratios for the 30-34, 35-39 and 40-44 year cohorts in the 1998 census were projected forwards by ten years using the methodology described in Chapter Three. The projected parity progression ratios obtained were then compared with the actual parity progression ratios observed in the 2008 census. Figure 4 shows the comparison. The dotted lines in the graph show projected parity progression ratios whilst the solid lines show the actual parity progression ratios obtained from the second census.

In the comparison of parity progression ratios for women who were aged 30-34 years in 1998 with the PPRs for women aged 40-44 years in the 2008, both trends show a general decline as parity increases. The projected parity progression ratios are slightly lower across all parities although the deviation is small. The ratio of the projected to the actual proportions ranges between 0.96 and 1.01, suggesting that the projection method was able to sufficiently bring out the expected trend. For the 35-39 and 45-49 year old cohort comparison, it is observed that the projected parity progression ratios lie very close to the actual parity progression ratios in the next census. A similar trend is observed for the 40-44 and 50-54 cohort comparison. The ratios for the projected to the actual proportions are all close to one for lower parities, suggesting that the two trends are almost identical. A comparison of the three different cohort projections indicates that the method gives a better estimate as the cohort becomes older. This could be attributed to the fact that there are fewer chances of fertility changing by wide margins at the older ages compared to the younger age groups. However, as the parity increases for each cohort, the ratios deviate more from one, indicating a poor fit compared with that observed in lower parities. Overall, application of the parity progression ratio method on the Malawian censuses shows a good prediction of the future distribution of parity progression ratios.

Figure 4: Projected parity progression ratios and parity progression ratios by parity, Malawi 1998 and 2008



Source: Derived from data from IPUMS International database

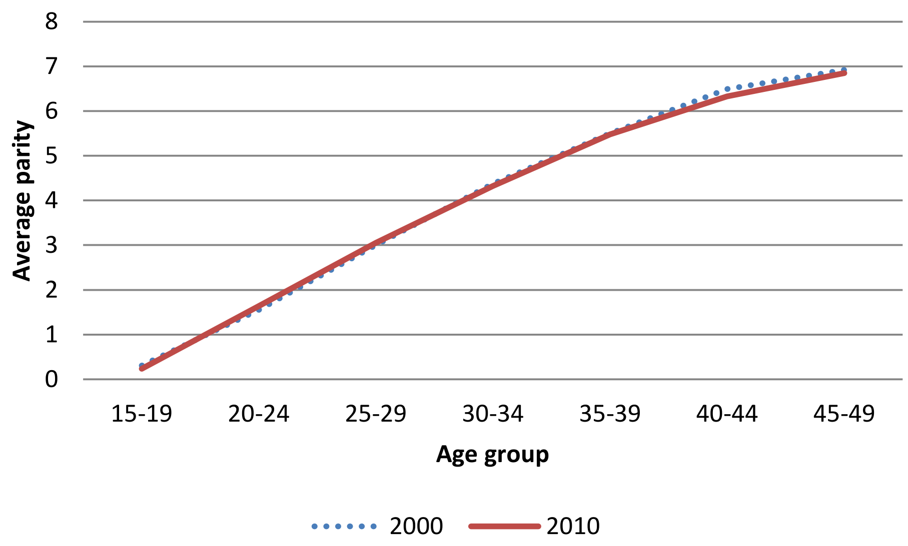
4.2.3. Projected parity progression ratios using Malawi Demographic and Health Surveys

The projected parity progression ratio method presented a fairly good fit when applied to the census data. A further analysis of the same method with Demographic and Health Survey data from Malawi is presented in this section. The 2000 and 2010 Demographic and Health Surveys are used to do a similar analysis to that in the previous section to ascertain if the same result can be reached. The section starts with an assessment of data obtained from the two Demographic and Health Surveys. Thereafter, the projected parity progression ratio method is then applied to the data.

Parity data assessment

Figure 5 shows the distribution of average parity by age groups from the 2000 and 2010 Malawian DHSs. Data from both surveys show an expected trend of fertility as age increases. The data for all the cohorts shows a plausible increase in parity across the two survey dates.

Figure 5: Average parity by age group, Malawi 2000 and 2010 DHS



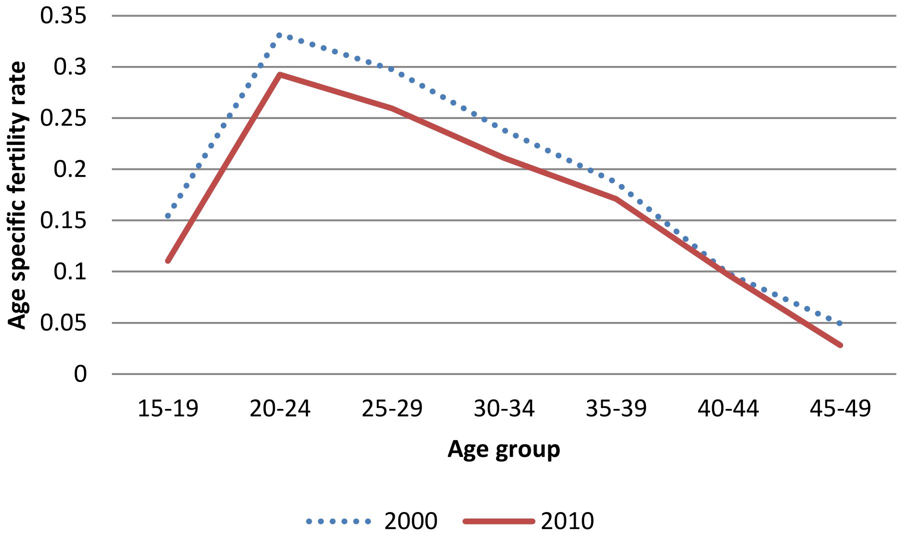
Source: Derived from data from Measure DHS

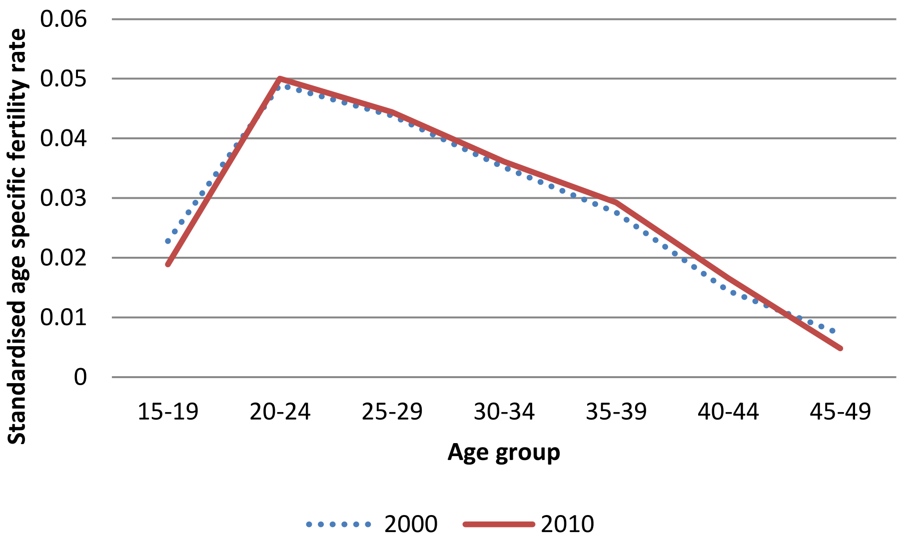
Recent fertility data assessment

Figure 6 shows the distribution of age specific fertility rates and standardised fertility rates obtained from the two DHSs. The total fertility rates obtained from these data were 6.8 and 5.8 children per woman for the years 2000 and 2010 respectively. This suggests an on-going fertility decline that is broadly consistent with the trend from the census data. The census data revealed a decline of 0.6 children per women compared to 1 child per women in the DHS. A possible reason for the difference could be attributed to the reference period of these two surveys. A continued fertility decline from 2008 when the last census was held to 2010 when the second DHS we are analysing was conducted could account for this difference. Another source for the difference could be attributed to the different scale of measurement between the DHS and the census.

To analyse the difference in the shape of the fertility curves in the DHS', the age specific fertility rates were standardised by imposing a total fertility rate of one. The resultant curve shows that there is a minor deviation at the last age group. This is the same pattern that was obtained from the census data assessment in Figure 3.

Figure 6: Age specific fertility rates by age group, Malawi 2000 and 2010 DHS



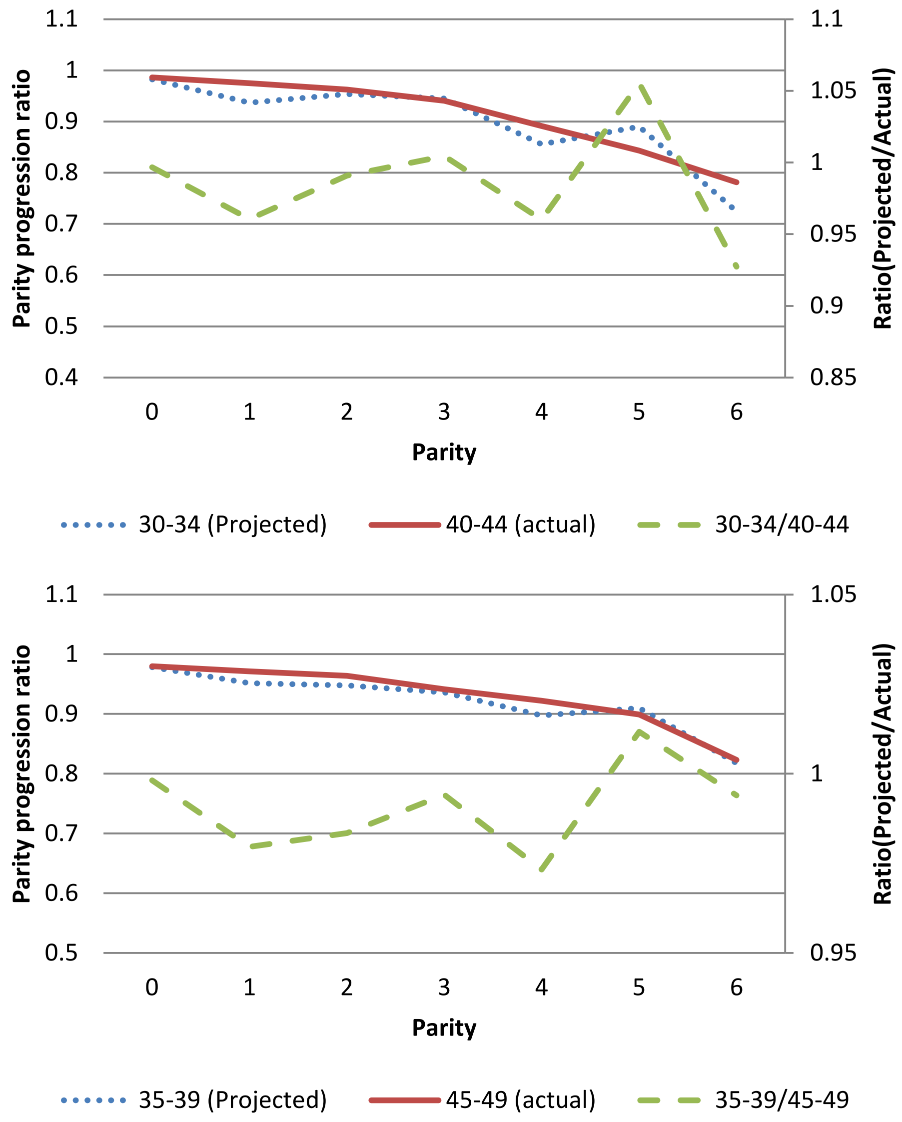


Source: Derived from data from Measure DHS

(Projected) parity progression ratios using DHS data

The parity progression ratios for younger women in the 2000 DHS were projected forwards to the 2010 DHS and then compared to the actual ratios obtained. Figure 7 show the results of applying the projected parity progression ratio method to the 2000 and 2010 Malawian DHS. The first graph shows a comparison of the 30-34 cohort projection and the actual 40-44 cohort parity progression ratios. The ratio between the projected and the actual is very close to one across all parities showing that the method works well. A comparison with the census results obtained above shows that the output from the both census and DHSs are very similar. The 35-39 cohort projection shows a better fit compared to the 30-34 cohort projection.

Figure 7: Projected parity progression ratios by parity, Malawi 2000 and 2010 DHS



Source: Derived from data from Measure DHS

Overall, the application of the projected parity progression ratio method data to the census and DHSs for Malawi showed no significant differences. Both data sets showed high fertility and plausible estimates for the age specific fertility rates and average parities hence the result was the same.

4.3. Zimbabwe

4.3.1. Country census background

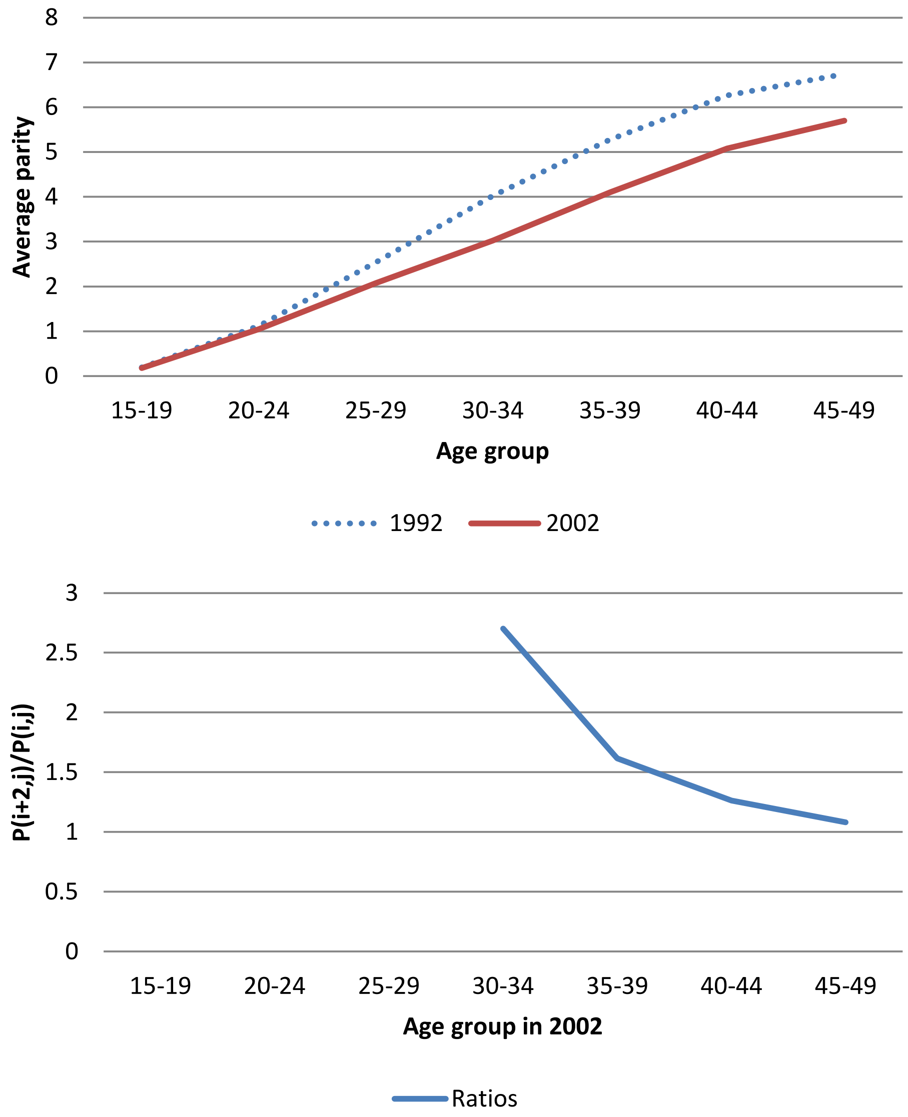
The most recent censuses in Zimbabwe were conducted in 1992 and 2002 respectively. The total population as enumerated in the 2002 census was 11 631 657, an increase from 10 412 548 in 1992 (ZIMSTAT 2010). The distribution of the women in their various age groups is given in the Appendix. Across the age groups, the population of women in the 2002 census is higher than that observed in the 1992. However, there is a slight decline in population for women aged 30-39 years in the 2002 census. This could suggest an error in the data for this age group or a result of the massive out migration that affected the country during this period. This decline in numbers will not significantly affect the calculations because the analysis uses proportions and rates.

4.3.2. Fertility data analysis

4.3.2.1. Parity data assessment

The mean number of children ever born from the two censuses was also assessed to check the quality of the data. Figure 8 shows the average parities for each census. There is a consistent increase in the average parity as age increases for both censuses. The second graph in Figure 8 shows the ratios of the same cohort followed through over two different censuses. It is observed that all the ratios were above one, implying that the average parities in the second census were greater than those in the first; hence the parities do not suffer from serious errors. However, the ratio for the average parities in the last age group is lower than expected, suggesting that there could be underreporting of children ever born by these older women in one of the two censuses.

Figure 8: Comparison of average parity for Zimbabwean censuses, 1992 and 2002



Source: Derived from data from IPUMS International database

4.3.2.2. Recent fertility data assessment

Using the two censuses from Zimbabwe, tabulations for births in the year prior to each study were extracted and age specific fertility rates were calculated.

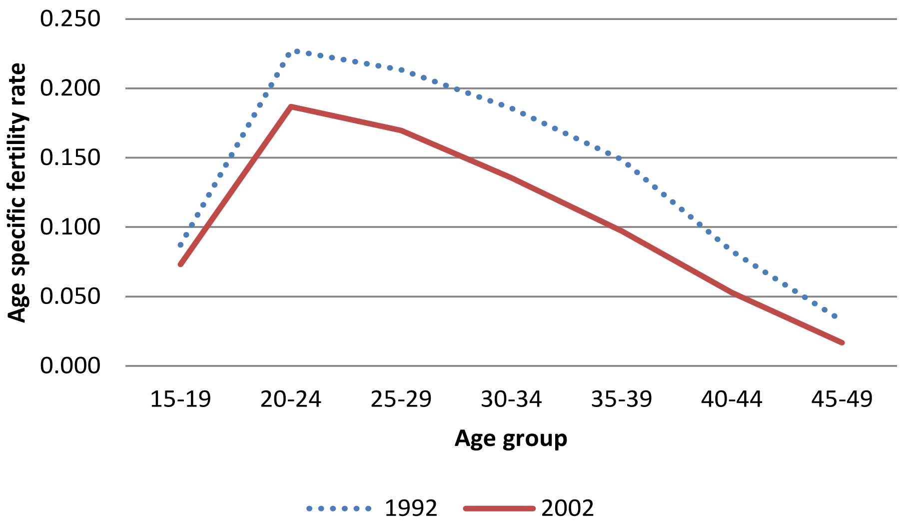
Table 4-1 shows the age specific fertility rate and standardised fertility rates for both censuses. It is observed that the total fertility rates have been declining from 1992 to 2002. Fertility decline is known to follow a slow and gradual change; hence the decline represented above is plausible.

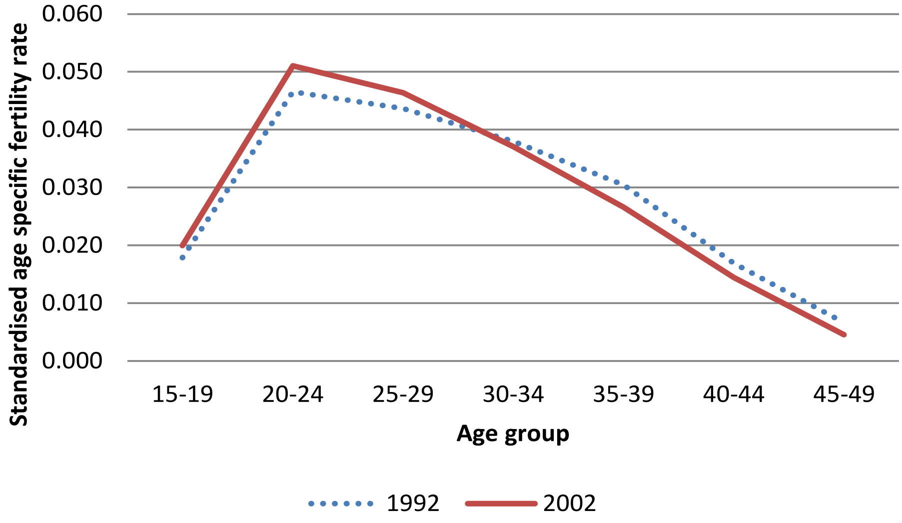
Table 4-1: Distribution of age specific fertility rates by age group, Zimbabwe 1992 and 2002 censuses

	Actual rates		*Standardised rates*	
Age group	***1992***	***2002***	***1992***	***2002***
15-19	0.087	0.073	0.018	0.020
20-24	0.227	0.187	0.047	0.051
25-29	0.213	0.170	0.044	0.046
30-34	0.186	0.135	0.038	0.037
35-39	0.149	0.097	0.030	0.027
40-44	0.083	0.053	0.017	0.014
45-49	0.032	0.017	0.007	0.005
TFR	4.9	3.7	1.0	1.0

Source: Central Statistics Office, Zimbabwe

Figure 9: Age specific fertility rates and standardised age specific rates by age group, Zimbabwe 1992 and 2002 census





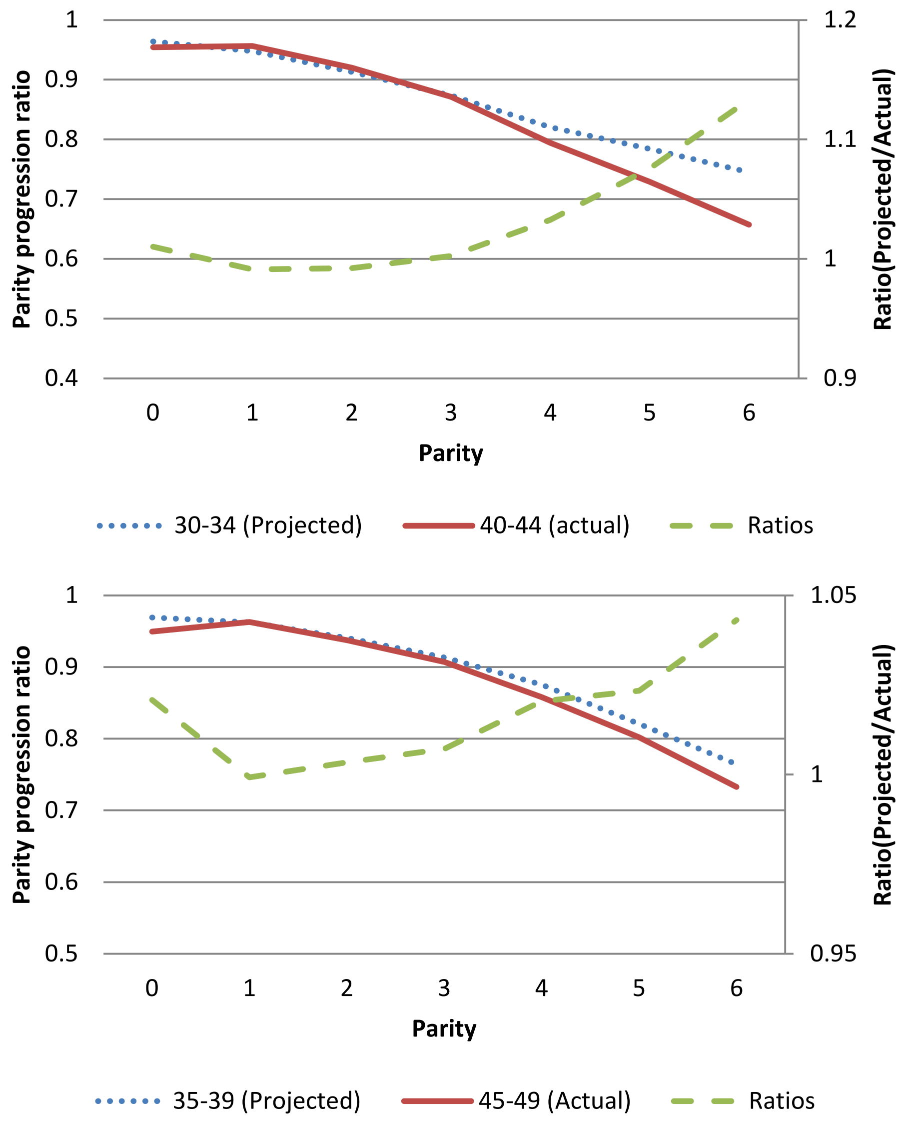
Source: Derived from data from IPUMS International database

Figure 9 shows a comparison of age specific fertility rates. The first graph shows the observed age specific fertility rates while the second one shows the standardised rates. The actual age specific fertility rates show that the level of fertility has been falling progressively from 1992 to 2002. The standardised rates show that the shape of fertility has not significantly changed in the period. However, there is a slight change that is observed at from the 30-34 year cohort going onwards. In particular, the age specific fertility rates for the 2002 census are higher than those for the 1992 census for ages younger than 34 years, but they are lower for ages higher than 35 years. This could be a result of the data error that was mentioned earlier on, out migration or an actual change in the shape of fertility at older ages. The average parities and the age specific fertility rates were then used to adjust the recent fertility observed in the raw calculations. The relational Gompertz model was applied to produce corrected total fertility rate of 4.1 children per woman for the 2002 census. The model could not be fitted for the 1992 data. This could be attributed to an error in the 1992 census data.

4.3.3. (Projected) Parity progression ratios

This section presents a comparison of projected parity progression ratios from 1992 and those observed in 2002. Figure 10 shows the three different cohorts that were compared across the censuses. Within each graph, a ratio of the projected against the actual parity progression ratios was presented. The first comparison of 30-34 and 40-44 cohorts shows that the projected distribution was very close to the actual projection for parities less than or equal to three. There after a deviation begins to be evident. The ratios of the proportions for the low parities are very close to one confirming that the method gave a good prediction. For the 35-39 and 45-49 cohort comparison, the projection method presents a good prediction of the distribution of parity progression ratios. The ratios of the projected and actual proportions range between 1 and 1.04, suggesting that the method presents a good fit. However, there is a slight decline in the parity progression ratios for 45-49 year age group in 2002. This decline indicates an error in the data. For both comparisons, the parity progression ratio method predicted slightly higher ratios at high parities compared to those that were observed. This could suggest that the women in Zimbabwe were selectively reducing higher order parities. This confirms the pattern observed in the comparison of standardised age specific fertility rates where the shape of the fertility curve in 2002 changed at older age group compared to that observed in 1992. This shift in the child bearing pattern could have caused the difference being observed between the projected and actual distributions on parity progression ratio methods.

Figure 10: Projected parity progression ratios by parity, Zimbabwe 1992 and 2002 censuses



Source: Derived from data from IPUMS International database

4.4. Cambodia

4.4.1. Introduction

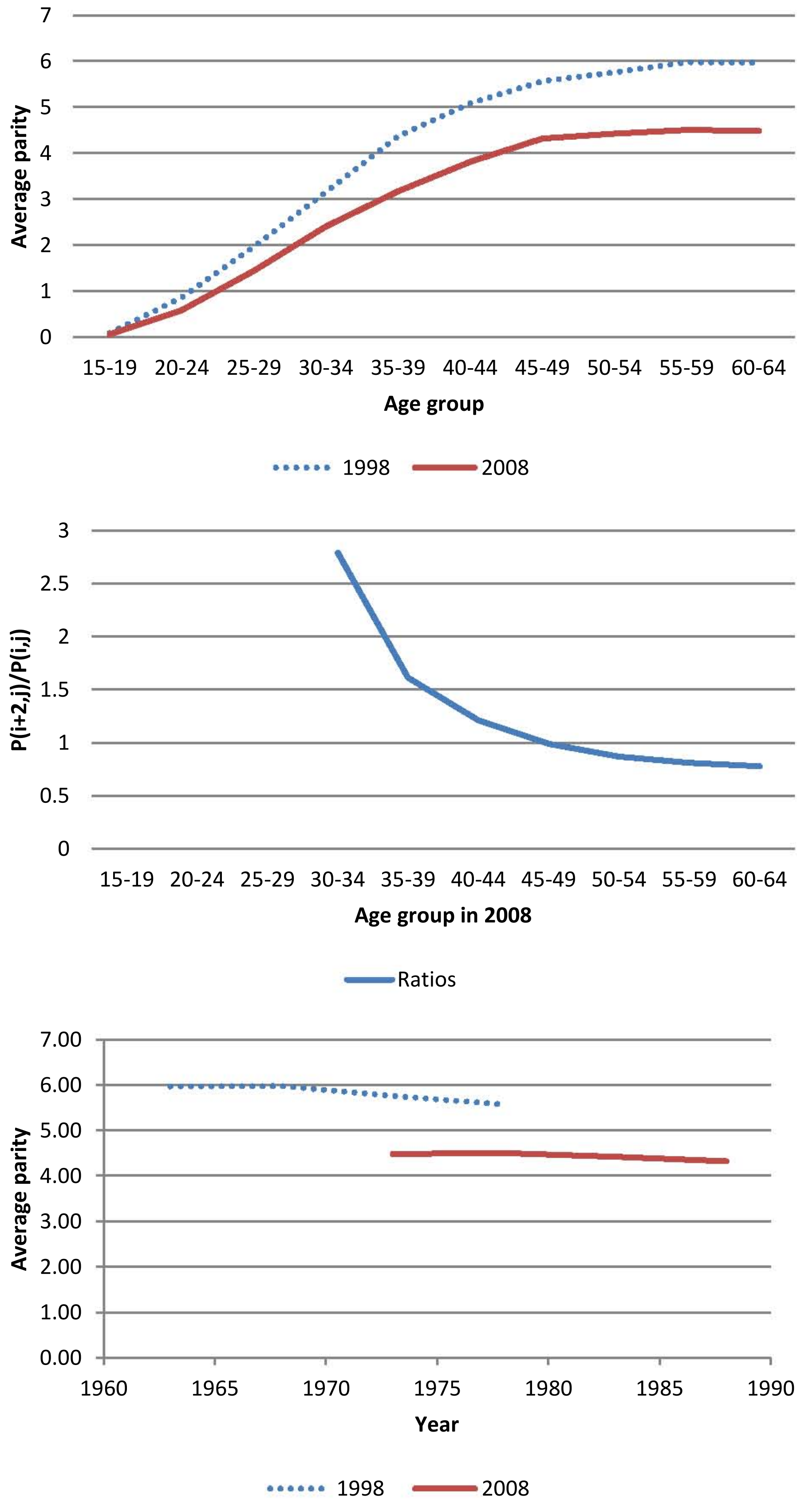
The most recent censuses in Cambodia were held in 1998 and 2008. The distributions of women in these two censuses show that there was a sudden drop in the population of 20-24 year old women in 1998 and 30-34 year old women in 2008. The most likely cause of this drop in population is the genocide that occurred in this country between 1975 and 1979. During this period, nearly three million people lost their lives (Heuveline 1998; Kiernan 2003). The high mortality of mothers during this period induced by political instability prevented a lot of births from occurring hence the sudden drop in population.

4.4.2. Fertility data evaluation

4.4.2.1. Parity data assessment

The first graph in Figure 11 shows average parities by age group for both censuses. The average parities for each census increase monotonically as age increases. At older ages, the average parities tend to level off. This suggests underreporting of children ever born by older women or mortality selection effects in data collection. The second graph shows ratios of average parities in the second census being compared to the average parities in the first. If data were collected accurately, the ratios should all be greater than unity. There is a general decline as age increases for all the ratios. Of note are the ratios for women aged 45-49 and older, which are all below one. This indicates that the average parities in the older age groups for women in the second census were less than those observed in the first, when they were 10 years younger. This pattern shows that there were errors in parity data collected in 2008. In Chapter Three, it was observed that the projected parity progression ratio method depends on the age pattern of fertility. The error observed in the average parities for the 2008 data is likely to affect the results if the underreporting of children ever born was big enough to effect a change in the age pattern of fertility.

Figure 11: Comparison of average parities for Cambodian censuses, 1998 and 2008



Source: Derived from data from IPUMS International database

The last graph in Figure 11 shows the application of the time plot method suggested by Feeney (1991a) to the Cambodian censuses. The average parities in the first census indicate that the average parity for women who have completed their child bearing was fairly constant between 1960 and 1970 with women having a mean of 6 children. The average parities begin to fall from the early 70's continuing through to 1978. However, the average parities obtained in the second census for the years 1973 and 1978 are not consistent with the observed decline. In addition, the second census shows results which are approximately 1.5 children less than that observed in the previous census. This pattern is consistent with the observation made in the ratios, which suggests that there was a significant under reporting of children ever born by older women. Feeney (1991a) suggests that such differences are either caused by under reporting of children ever born or because of mortality selection effects. In this case, it is mostly likely that there was severe under reporting of children ever born, poor data collection or something else that went wrong with the question on children ever born in the 2008 census. Overall, there is a clear indication of a fertility decline from 1973 through to 1988. Due to inconsistencies mentioned above, the parity data from the 2008 census should be interpreted with caution.

4.4.2.2. Recent fertility data assessment

Table 4-2 shows the age specific fertility rates and the standardised age specific fertility rates derived from fertility data in Cambodian censuses.

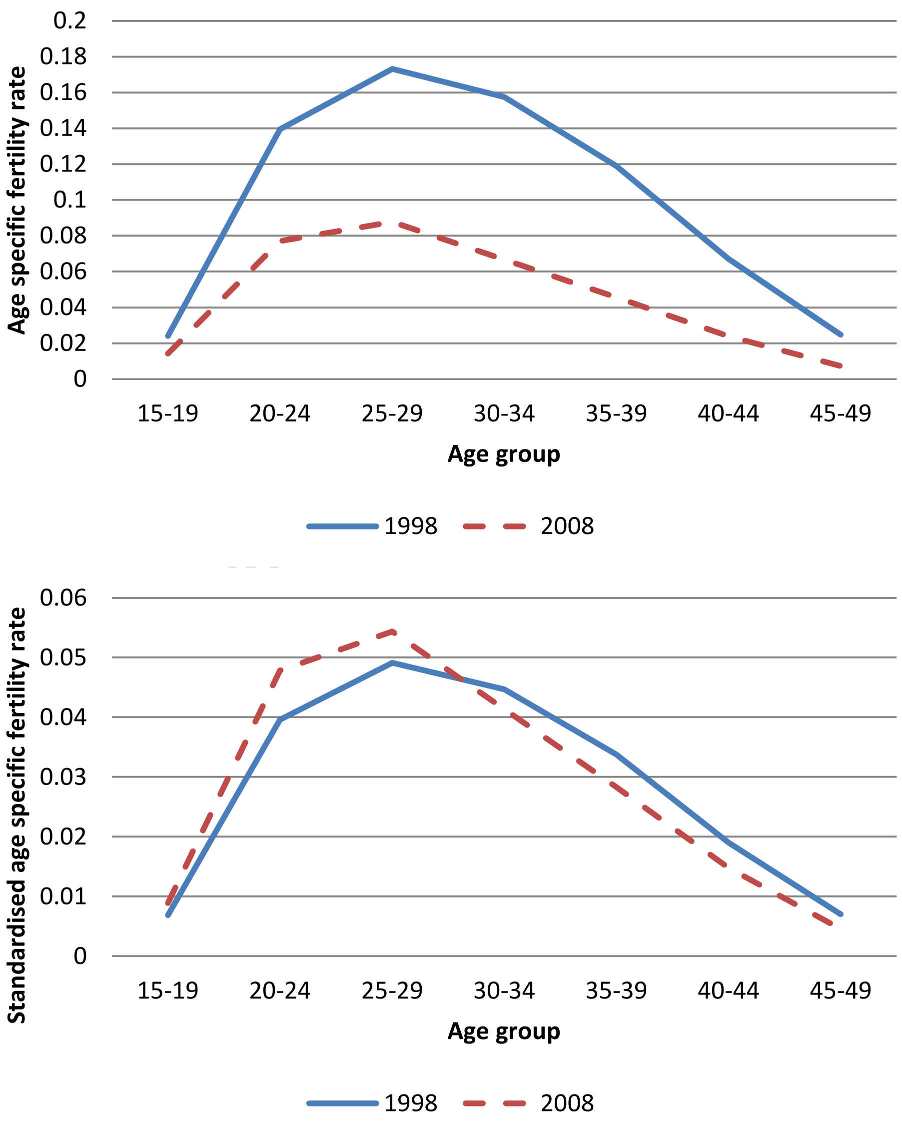
Table 4-2: Age specific fertility rates by age group for Cambodia

Age group	Year			
	1998 census	*2008 census*	*DHS 2000*	*DHS 2010*
15-19	0.024	0.014	0.044	0.046
20-24	0.139	0.077	0.178	0.173
25-29	0.173	0.088	0.192	0.167
30-34	0.157	0.067	0.16	0.121
35-39	0.119	0.046	0.111	0.071
40-44	0.067	0.024	0.057	0.028
45-49	0.025	0.007	0.013	0.004
TFR	3.5	1.6	3.8	3.1

Source: Measure DHS and IPUMS International database

The unadjusted total fertility rate for 2008 was 1.6 children per woman, a decline of more than half of from 3.5 children per woman observed in 1998. This suggests evidence of data errors that were observed in the parity data. In order to adjust for this anomaly, the Relational Gompertz model was applied to the 2008 census data. An adjusted total fertility rate of 3.4 children per woman was obtained. This adjusted figure is more plausible compared to the actual one obtained from the census data. The observed rates are compared to the DHSs that were held close to these census years. The 2010 DHS shows a TFR of 3.1 children per women, which is closer to 3.4 children per women observed in the 2008 census. The difference of 0.3 children per women between these two estimates suggests that there could be a significant data error in the 2008 census data. The 2010 Cambodia DHS report suggests that the fertility decline observed is hugely attributed to the significant increase in contraception by women in with 3 or more children surviving.

Figure 12: Age specific fertility rates and standardised age specific rates by age group, Cambodia 1998 and 2008 census



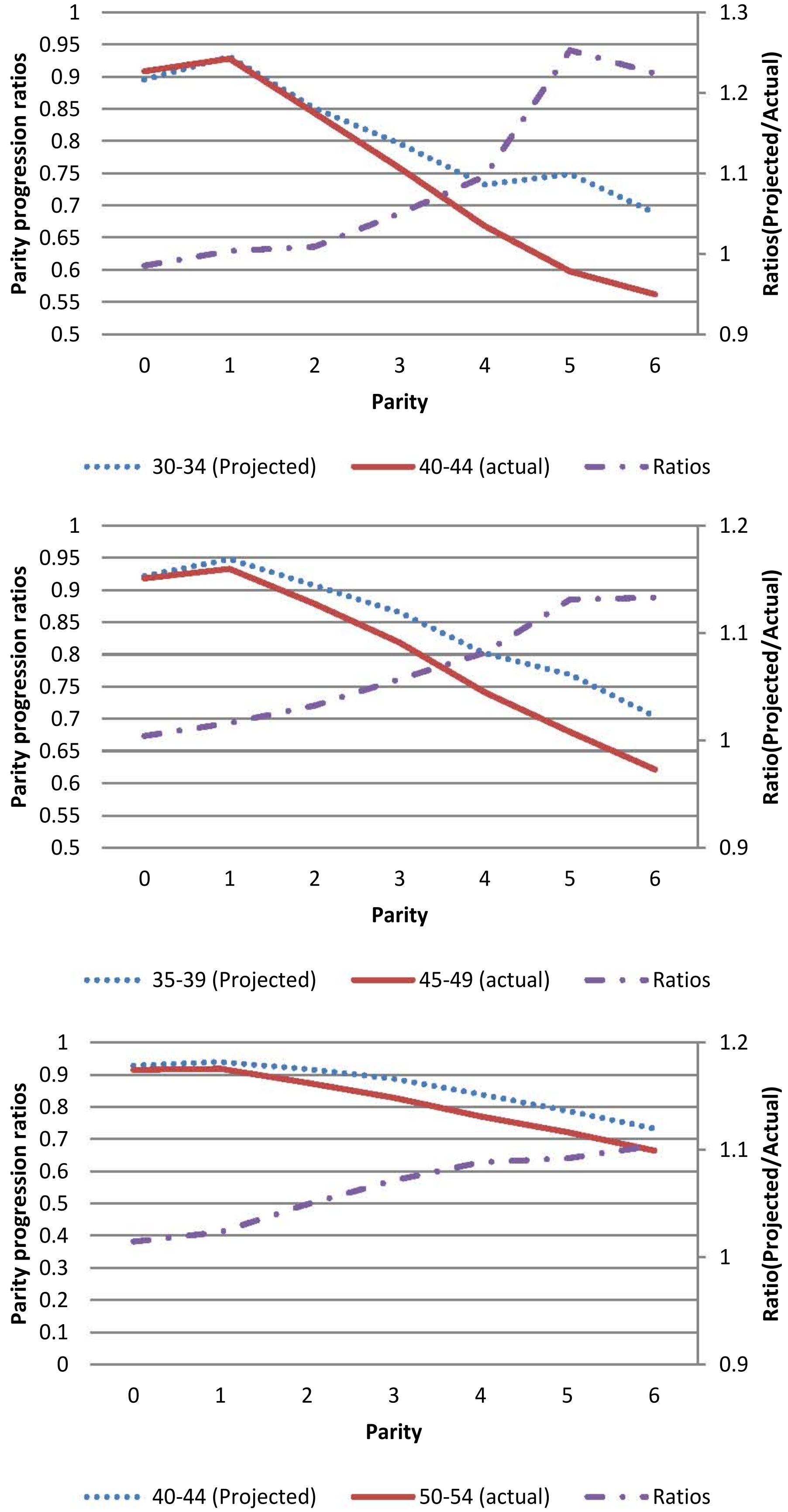
Source: Derived from data from IPUMS International database

Figure 12 shows the comparison of age specific fertility rates for the two censuses. The first graph shows the actual age specific fertility rates whilst the second one shows the standardised rates. In line with the data error and the rapid increase in the use of contraception indicated above for the 2008 census, the age specific rates are a very low level compared to the other two estimates. For the standardised rates there is a clear shift in the age pattern of fertility from 1998 to 2008 census.

4.4.3. Parity progression ratios

The parity progression ratios for younger women in 1998 were projected forwards by ten years and then compared to the observed parity progression ratios in 2008. Figure 13 shows a comparison of projected parity progression ratios from the 1998 census data and those observed in the follow up census. The first graph represents the comparison of 30-34 year cohort projection, followed by the 35-39 and 40-44 year cohorts respectively. At higher parities, all projections show an increasing deviation from the actual parity progression ratios. However, the deviation decreases as the age groups get older. If projected values were exactly the same as the observed, then ratios of the projected against the actual proportions would be equal to one across all parities. However, these ratios progressively increase at higher parities for all the age groups being compared. For the last comparison of 40-44 and 50-54 cohorts, the ratios between the actual and the projected parity progression ratios show that this is the best fit of the three presented. Given that the 40-44 year old cohort has a shorter projection component, this result follows an expected trend because there is little room for a significant fertility change for women who are close to the end of their reproductive health. Furthermore, the section of parity data assessment revealed that the number of children ever born by older women in 2008 showed evidence of data collection errors. The deviation observed in the first two comparisons could be attributed to these errors. Overall, the parity progression method did not produce a good fit at higher parities across the three cohorts that were compared. The differences are mainly attributed to implausible parities for older women observed; hence the results should be interpreted with caution. In addition, the increase in contraceptive use by women in Cambodia between 2000 and 2010 could also have contributed to the discrepancies observed in the application of the method at higher parities

Figure 13: (Projected) parity progression ratios by parity for 1998 and 2008 Cambodian censuses



Source: Derived from data from IPUMS International database

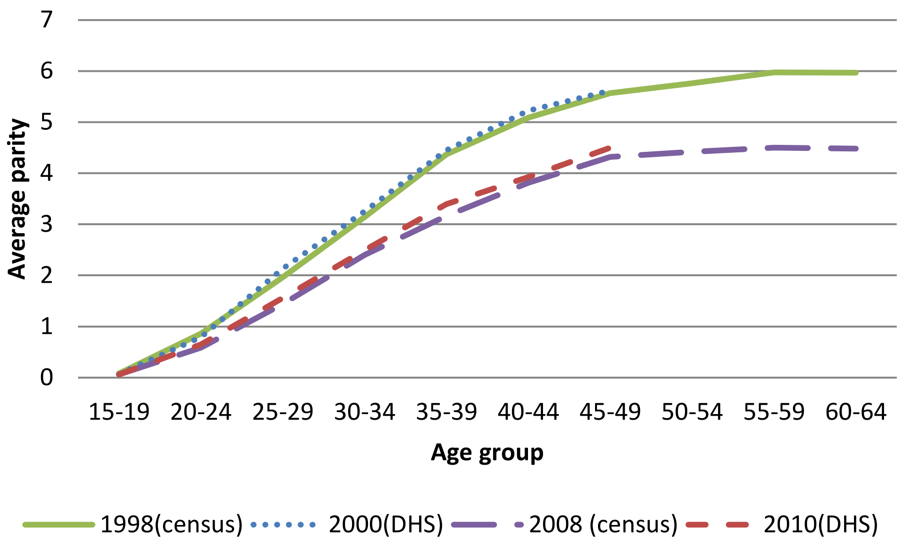
4.4.4. (Projected) parity progression ratios using Cambodia Demographic Health Surveys

The analysis in the previous section showed that there were many errors with the census data in Cambodia. In particular, parity data for older women was severely inconsistent whilst the recent fertility estimates from the census were significantly lower than the estimates obtained from the DHS reports. This section applies the same analysis done on the Cambodia census data with DHS data from 2000 and 2010 to assess if the method will work, given a more reliable data set such as the Demographic and Health Survey.

4.4.4.1. Data description and assessment

Figure 14 shows that distribution of average parities for the 2000 and 2010 DHSs; and 1998 and 2008 censuses. Looking at DHS average parities, it is observed that data sets show a sigmoid shape as age increases. Of note, is that the average parities from the 2010 DHS are consistently lower across all age groups compared to the 2000. This could suggest that fertility decline is under way. However, a closer look at the cohorts shows that the 2010 DHS average parities for the older women are much lower than expected. For instance, the average parity for women who are 35-39 in 2000 is 4.45 children per women whereas that for the same cohort ten years later is 4.5 children per women. This suggests an increase of 0.05 children per women over a ten year period. This is implausible. Older women are more likely to have underreported the number of children ever born. This finding is consistent with what was observed in the average parities from the 2008 census data set where there was again a significant under reporting of children ever born by older women. A comparison of the census and DHS average parities shows that the 1998 and 2000 average parity data are consistent across all ages. However, the 2008 census average parities are consistently lower at all age groups compared to the 2010 DHS average parities.

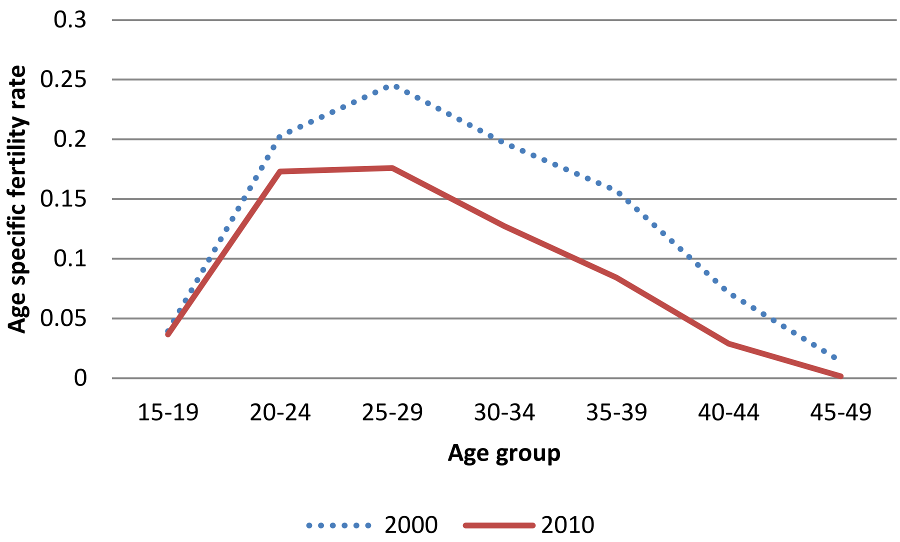
Figure 14: Average parity by age group, Cambodia 2000 and 2010 DHS; 1998 and 2008 censuses

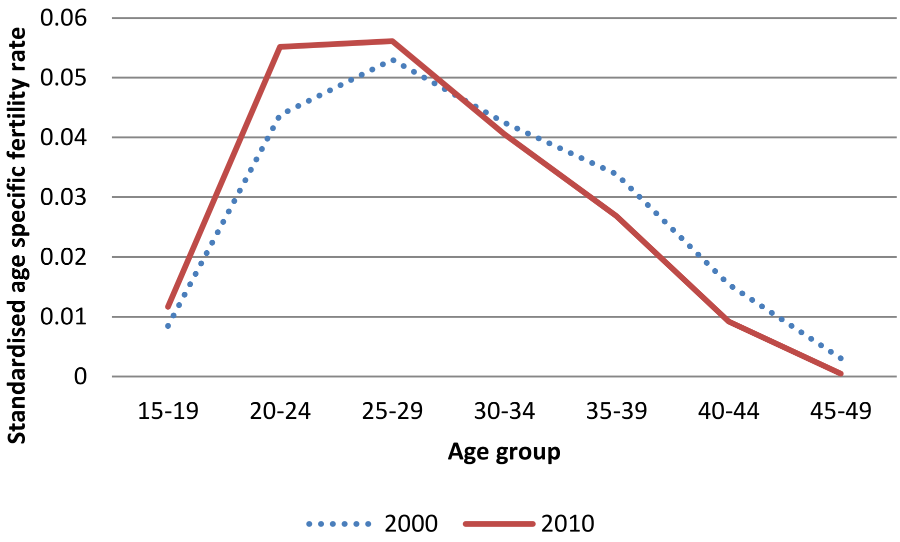


Source: Derived from data from Measure DHS and IPUMS International website

Figure 15 shows a comparison of age specific fertility rates calculated for the 2000 and 2010 Cambodian DHSs. The first graph shows us that both DHSs showed an expected shape of fertility. However, the level of the ASFRs for 2000 DHS is higher than that observed for 2010 DHS. If the effect of the level is eliminated by imposing a TFR of one on both datasets, it is observed that the shape of the fertility curve has shifted in the ten year period. In particular, the shape of the fertility curve has shrunk, rising at the lower ages and narrowing at older ages. This same pattern was observed in the analysis of recent fertility data from the censuses. A similar trend suggests that this fertility change is true for the Cambodian population.

Figure 15: Age specific fertility rates and standardised age specific rates, by age group, Cambodia 2000 and 2010 DHS





Source: Derived from data from Measure DHS

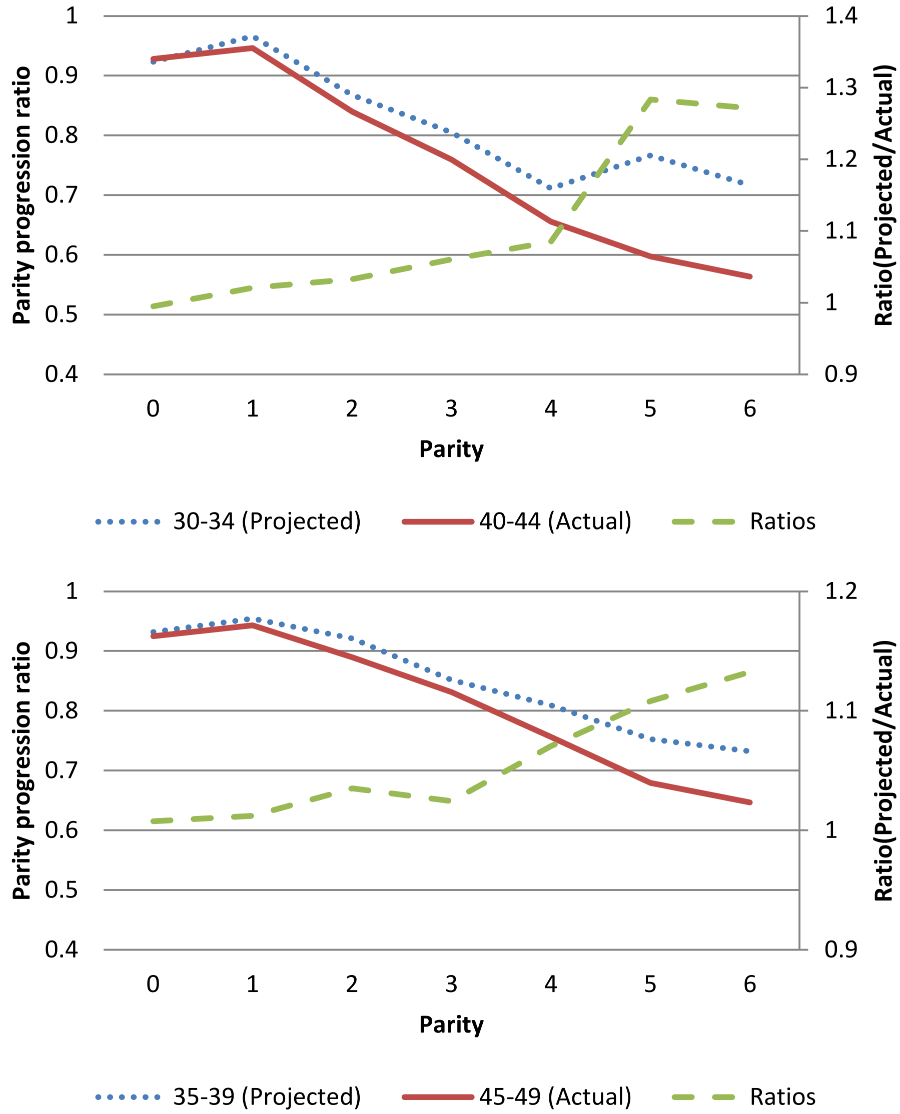
4.4.4.2. Projected parity progression ratios using DHS data

The data assessment for 2000 and 2010 DHSs has shown some similarities in the fertility transition that seems to have occurred between 1998 and 2010. Despite the DHS being a more reliable data source of data, the shift in the age pattern of fertility observed in the 1998 and 2008 censuses was also observed in the 2000 and 2010 DHS datasets. However, the under reporting of recent births and children ever born observed in the 2008 census was not as severe in the 2010 DHS. Hence the need to apply the parity progression ratio method to the 2000 and 2010 Cambodia DHSs see if it will yield a better result. As was done with the census data, the fertility distribution of data from

2000 was used to project the future parity progression ratios. The resultant projected parity progression ratios were then compared to the actual parity progression ratios obtained in the 2010 DHS. A ratio of the two estimates is also presented in the same graphs.

Figure 16 shows the comparison of projected and actual parity progression ratios as obtained from the DHS data. The first graph shows the comparison of the 30-34 year old cohort projected forwards by ten years with the actual PPRs obtained in the 2010 DHS. It is observed that the projected estimates are higher than the actual across all age groups. The ratios of the two estimates indicate that the deviation between the observed and projected parity progression estimates increase as parity increases. It is interesting to note that the same pattern was observed when the same method was applied to the census data. The second graph shows a slightly better fit for projected parity progression ratios compared to the first.

Figure 16: Projected parity progression ratios by parity, Cambodia 2000 and 2010 DHSs



Source: Derived from data from Measure DHS

The analysis of the projected parity progression ratio method using DHS data has yielded the same results as those obtained in the census comparison. The expectation was that DHS data would produce a better fit since it is deemed to more accurate. Given that the each of the DHS was conducted two years after each of the censuses; it suggests that the change in the age pattern of fertility obtained in the two estimates could be true. A possible contributing factor to this significant fertility change could be the significant increase in the proportion of women using contraception in this country between 2000 and 2010 as reported by the country's 2010 DHS report. Furthermore, under reporting errors were also observed from both censuses and surveys though they were less in the DHSs. This suggests that there could be a consistent trend in data collection errors in surveys conducted in Cambodia.

Pertaining to the projected parity progression ratio method, similar results in both the DHS and census data sets suggests that it is not dependent on the level of fertility obtained in country. Both data sources suggested that there had been a change in the age pattern of fertility between the 1998 and 2010, thus suggesting that the method is likely to depend on this phenomenon.

4.5. Panama

4.5.1. Country census background

The most recent censuses in Panama were conducted in 1990 and 2000 respectively. The total number of the women by age group for the two censuses is presented in the Appendix. This section shows the projected parity progression ratio method applied to these two Panama censuses. Section 4.5.2 describes the fertility data evaluation followed by section 4.5.3, which shows the application of the method under assessment.

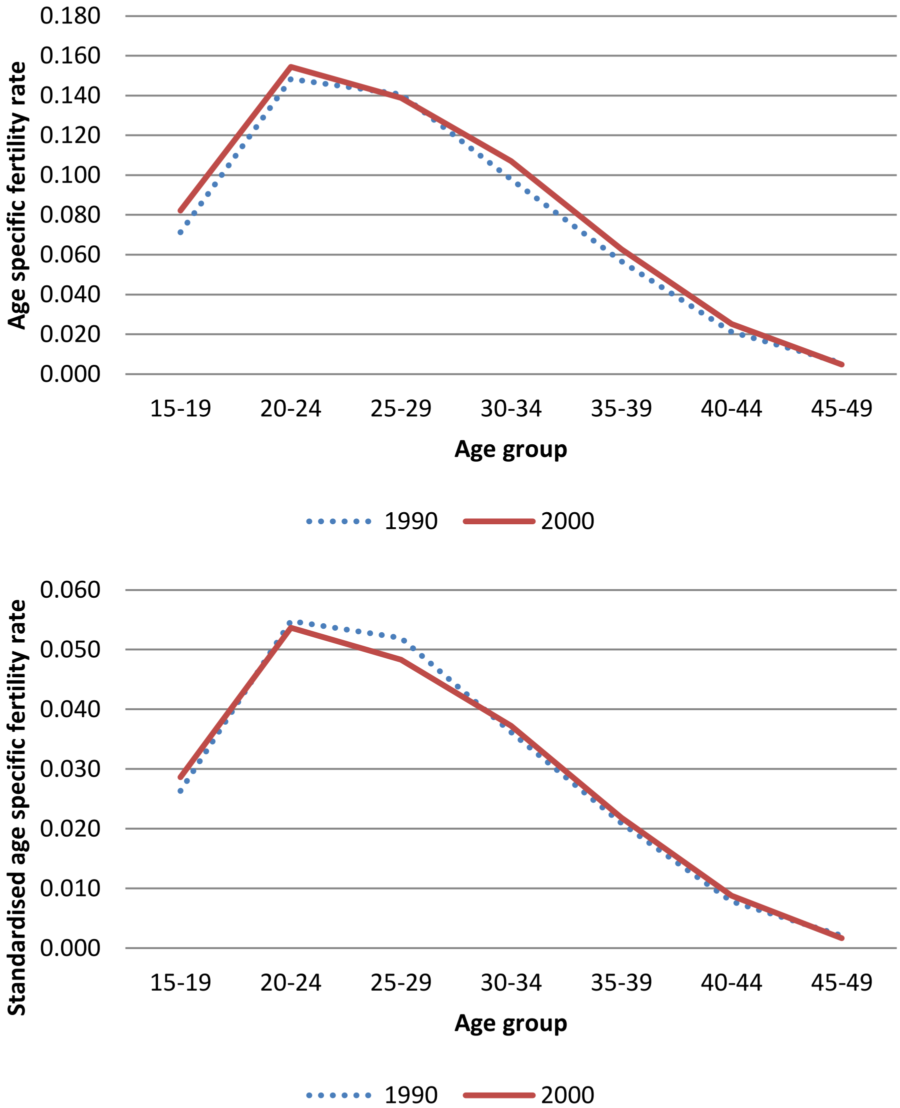
4.5.2. Fertility data evaluation

Table 4-3 shows the distribution of age specific fertility rates from the two Panama censuses. The unadjusted total fertility rates indicate that fertility in this country has not changed much in the period between the two censuses.

Table 4-3: Age specific fertility rates by age group, Panama 1990 and 2000 census

	Observed rates		*Standardised rates*	
Age group	***1990***	***2000***	***1990***	***2000***
15-19	0.071	0.082	0.026	0.029
20-24	0.148	0.154	0.055	0.054
25-29	0.141	0.139	0.052	0.048
30-34	0.098	0.107	0.036	0.037
35-39	0.057	0.063	0.021	0.022
40-44	0.021	0.025	0.008	0.009
45-49	0.006	0.005	0.002	0.002
TFR	2.71	2.88	1.00	1.00

Figure 17: Age specific fertility rates by age group, Panama 1990 and 2000 censuses



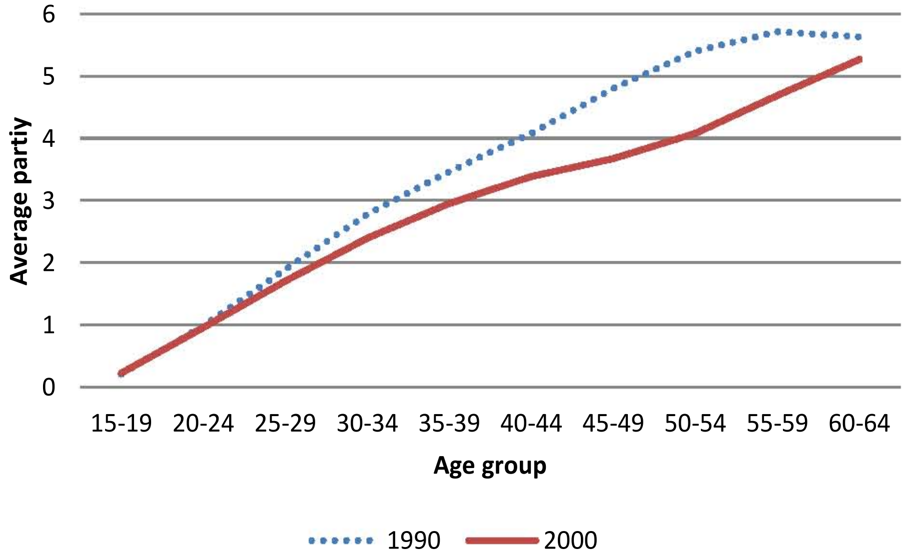
Source: Derived from data from IPUMS International database

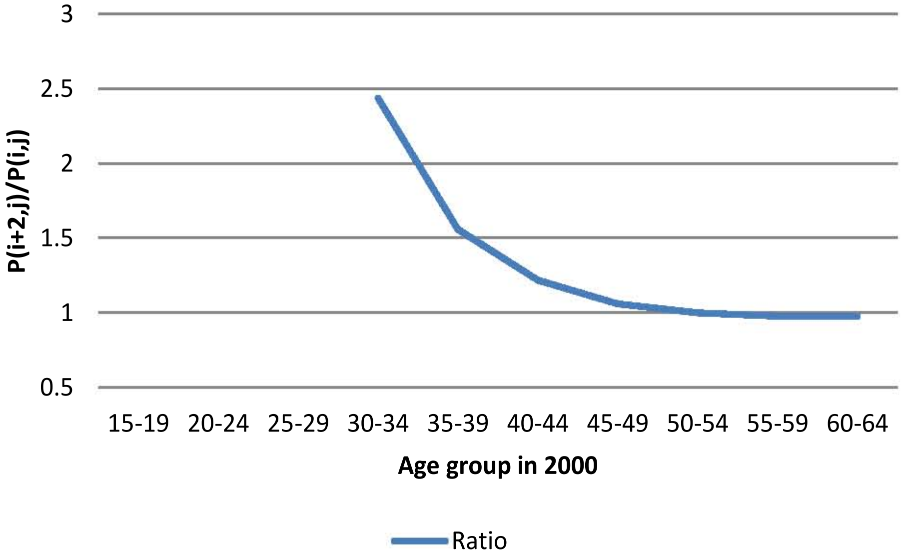
Figure 17 shows that the shape of the fertility curve for both censuses has been fairly constant between 1990 and 2000. The only major difference between the two trends is observed on the 25-29 year cohort in 1990, which is higher than that observed in 2000. The standardised rates show that there has not been any significant change in the shape of the fertility curve over the intercensal period. The relational Gompertz model was applied to the data from these two different censuses to get a revised and adjusted total fertility rate. The adjusted total fertility rates were 3.36 and 3.13 for 1990 and 2000 censuses respectively. These rates suggest that there has been a slight fertility decline in the ten year period under review.

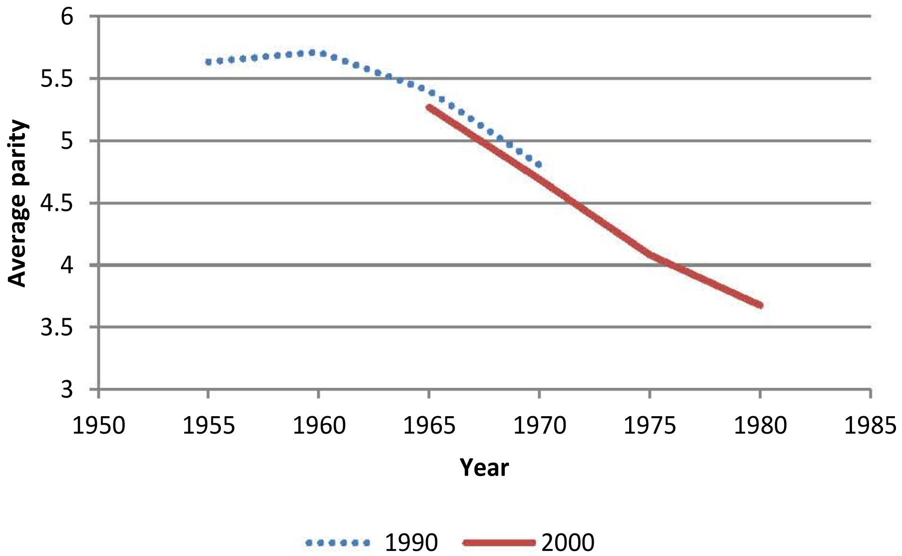
4.5.2.1. Parity data assessment

Figure 18 shows different assessments of average parities for the two censuses from Panama. The ratios from the 30-34 year cohort up to the 50-54 year cohort are all above one, meaning that the parities are plausible. However, the ratios for women older than 55 are below one, indicating that the average parities in the second census were less than those in the first census. This could be a result of mortality selection effects or underreporting of children ever born by older women. The average parities for women who have completed their child bearing show that there was a general decline in the number of children ever born from 1960 to 1980. These time plots give an indication that average parity data in the two censuses is relatively consistent.

Figure 18: Average parities by age group and year, Panama 1990 and 2000 censuses





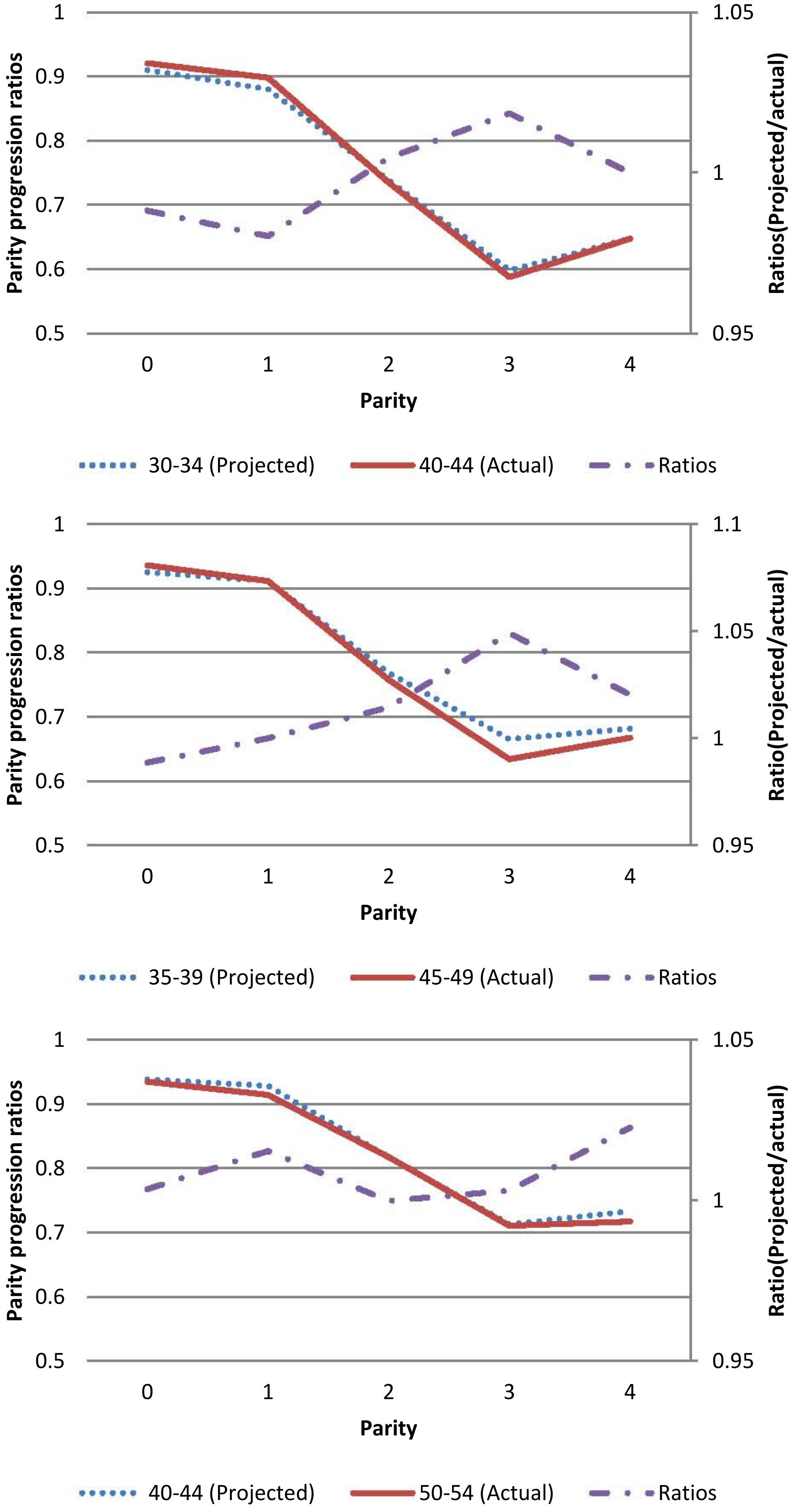


Source: Derived from data from IPUMS International database

4.5.3. Parity Progression ratios

This section compares the projected parity progression ratios in the 1990 census with those obtained in the 2000 census. Three cohorts are compared to each other to assess how the PPRs method works. Figure 19 shows the comparison of PPRs for the three age groups under review. The projected parity progression ratios for Panama have been limited to parity four because the total fertility rate for Panama has been below four children per woman ever since the 80's. The results show that for the 30-34 and 40-44 year cohort comparison, the method of projection matches to a great extent the observed PPRs in the next census. For the 35-39 and 45-49 year cohort comparison, there is an almost perfect fit for parities zero to two, with parity three and four showing a small deviation. This suggests that the projection method gives a better result as the cohort age gets closer to the end of the reproductive age group. The same trend is observed for the last cohort comparison. The projected PPRs show a good fit for all the data points.

Figure 19: Projected parity progression ratio and parity progression ratios by parity, Panama 1990 and 2000 censuses



Source: Derived from data from IPUMS International database

4.6. Discussion

This section presents a summary and discussion of the results that were obtained in Chapter Four. Section 4.6.1 discusses the quality of the data used in this study, and section 4.6.2 explains the results obtained in applying this data to the projected parity progression ratio method.

4.6.1. Data quality

Prior to the application of any demographic estimation method, it is vital to assess the quality of the data being used. Incomplete and inconsistent data, if left unchecked and uncorrected, results in estimates that might give rise to unreliable conclusions. For this reason, the data used in this study went through quality assessment prior to application of the projected parity progression ratio method. Both census and DHS data from all four countries used in this study were assessed for errors, such as underreporting of children ever born by older women and implausible births by young women. The data from Malawi showed that it had been edited as there were no implausible births. This is rare in a census as there are bound to be errors of misreporting and incorrect recording of the number of births or children ever born. The data for Malawi also showed consistent average parities. As a result, the calculations obtained thereof were reliable. A similar trend was obtained for Panama. The Panama data showed relatively consistent data except for some minor underreporting of children ever born by older women. Application of the time plots method that was described by Feeney (1991a) showed that there was a consistent decline in fertility over the past years for women in both Malawi and Panama. On recent fertility data, Malawi and Panama had a consistent shape of age specific fertility rates across the two censuses assessed. This was shown by the graphs for standardised age specific fertility rates for both countries. In addition to census data, the Malawi DHSs for 2000 and 2010 showed almost similar estimates of age specific fertility rates and total fertility rates compared to that of the censuses. It is interesting to note that even the shape of the fertility curve for both the census and the DHS for Malawi were the same. This is a sign that the data were plausible given that the two data estimates were collected on separate occasions. The error of underreporting of children ever born at older ages observed in Panama censuses has limited effect on the overall application of the projected progression ratio since the magnitude of errors was small.

On the other hand, census data from Cambodia showed significant evidence of errors. In particular, there were inconsistent average parities between the two censuses. There seemed to be significant underreporting of children ever born by older women in the second census. This was shown by cohorts of older women having fewer children in the second census compared to what they had in the previous census. The recent fertility data for this country also showed a low total fertility rate for the second census. However, after adjusting the fertility rates in the second census by the Relational Gompertz model, a more reasonable total fertility rate was obtained. Due to the inconsistencies in the data from the Cambodian censuses, 2000 and 2010 Demographic Health Surveys were introduced into the analysis. The assumption was that the fertility estimates obtained from the DHS are more reliable compared to that obtained from the census. The total fertility rates obtained from DHSs were plausible as compared to those obtained from the census. The Zimbabwean data also had some inconsistencies at the older age groups, where average parities were lower than expected. Analysis of the recent fertility data for Cambodia and Zimbabwe showed that the age pattern of fertility had shifted in the intercensal period. In particular, the shape of the fertility curve for Zimbabwe had shifted at older age groups, resulting in lower rates at for women in the second census who were nearing the end of their reproductive life. For Cambodia, the age pattern of fertility had increased in the mid-twenties and narrowed at the older ages between the two censuses assessed. Both country results suggest that there was a significant reduction of fertility as women approached the end of their reproductive years. The change in age pattern of fertility observed for Cambodia and Zimbabwe violates the assumption used in the projected parity progression ratio method which holds the distribution of the age-order specific fertility rates constant until the end of the reproductive lifespan. The errors observed in the Cambodian and Zimbabwean data, coupled with the change in fertility pattern observed, reduced the efficiency of the projected parity progression ratio method in forecasting the future trend of parity progression ratios.

4.6.2. Application of the projected parity progression ratio method

The projected parity progression ratio method uses current age-order specific rates to calculate the expected future distribution of the parity progression ratios. Thus, the current distribution of age-order specific fertility rates is projected forwards on the assumption that it will remain constant until the end of a woman's child-bearing years. This implies that the projected parity progression ratio method depends on the stability and robustness of the distribution of the age pattern of fertility in the initial data set used. The application of the projected parity progression ratio method to the Malawi 1998 and 2008 census data resulted in a relatively good fit. This can be attributed to the constant shape of fertility that was shown by the fertility curves standardised to a total fertility rate of 1. This implies that the age pattern of fertility was constant between the two censuses. Given that the fertility estimates obtained in the census and DHS for Malawi were consistent, it is not surprising that the application of the projected parity progression ratio method on the 2000 and 2010 DHSs data resulted in similar results. Both data sources showed an improved fit as the age increased. This can be attributed to the fact that there are lower chances of a woman's fertility changing by a big margin as she approaches the end of her child-bearing years. Given that the method assumes a constant age order fertility rate, the deviation of the actual distribution from the projected gets narrower, hence, giving a better fit. Panama censuses resulted in a relatively good fit for all the comparisons done. This is because the age pattern of fertility prevalent in the first census was relatively similar to that observed in the follow-up census.

In cases where the shape of the fertility curve changes, the projected parity progression ratio method did not present a good forecast of the expected distribution of these ratios. For instance, the analysis of Zimbabwean censuses showed that the shape of the fertility curve obtained from age specific fertility rates narrowed at older ages. This could be a true fertility change or an error in the second census. Though the data for this country were relatively consistent, the change in the shape of the fertility curve resulted in projected parity progression ratios overestimating the actual trend observed at higher parities. This scenario suggests that it is not sufficient to just have correct and consistent data for the parity progression ratio method to work, rather the shape of the fertility curve also needs to be fairly constant. The Cambodia censuses presented a different view on the analysis of projected parity progression ratios. The average parity as well as the recent fertility data for the second census in this country were both lower than expected. In addition, the shape of the fertility curve for the two censuses were different, suggesting that it had changed or the data was not collected accurately. The application of the projected parity progression ratio method in this scenario did not produce a good fit. This can be attributed to the data errors and/or the change in the age pattern fertility. To eliminate the effect of the errors observed in the census data, the Cambodian DHSs for 2000 and 2010 were also used to assess the how the method works. It is interesting to note that the DHS results presented the same the results obtained in the census estimates, which suggests that the rapid fertility decline suggested by the data is actually plausible. In addition, this rapid change in fertility might have also altered the shape of the age pattern of fertility. The Cambodia DHS report for 2010 indicates that there was an increase in contraceptive use from about 23 to 51 per cent between 2000 and 2010. The contraceptive usage was highest among women with 3 or more living children. This suggests that contraceptive usage also significantly contributed to the change in the fertility curve observed. The change in fertility observed in the census and DHS surveys were consistent. As a result of the changed age pattern of fertility and the fertility decline, the projected parity progression ratio method overestimated the actual ratios obtained in the follow-up census. Furthermore, since the DHS gave the same results as the census, even though the census data had some inconsistencies, it suggests that the change in the shape of fertility is more important to the application of the projected parity progression ratio method compared to the accuracy in the level of fertility.

The literature review in this thesis suggests that the high prevalence of HIV in a country could have an impact of the age pattern of fertility by affecting women biologically or psychologically. The effect of HIV on the women's reproductive behaviour could have contributed to the slight decline in fertility especially in women who would have tested positive. However, the general trend in sub-Saharan Africa is that most women still do not know their HIV status. Although Malawi has a relatively high HIV prevalence, the method did not seem to be affected by this fact. A possible reason for this could that there the Antiretroviral Treatment in the country is making reducing the effect of HIV. In June 2004, Malawi implemented a rapid ART program that saw about two thirds of the patients eligible for ART receiving treatment(Lowrance, Makombe, Harries *et al.* 2008). This approach is assumed to have the lowered the effect of HIV on the reducing the fertility of women. However, part of the change in the shape of the age pattern of fertility in Zimbabwe between 1992 and 2002 could be attributed to the impact of HIV. As suggested by Yeatman (2007), the psychological pressure of knowing that a child born from an infected person could be infected as well does, to some extent limit the number of children women would want to have. Although this effect might be small, it is likely to be a contributor to the decrease in fertility and subsequent change in age pattern of fertility observed in Zimbabwe In addition, this country was facing significant economic and political challenges, which could have caused a disruption in the normal birth intervals that women would have. The high volume of out migration experienced in the country around between 1992 and 2002 could have reduced the number of women giving birth in the country, result to some extent lowering the fertility level. However, the emigration impact on fertility needs further researcher to substantiate it. For Cambodia and Panama there is no evidence that HIV could have affected the application of the method.

The application of the projected parity progression ratio method for all the countries assessed showed an improved fit from the youngest to the oldest cohorts being compared. This could be attributed to the fact that there are high chances of many young women having more children to achieve their desired parity and this probability reduces as women get older. Hence, the deviation of the projected result from the actual parity progression ratios observed reduces as the age increases mainly because the method assumes a constant distribution of age-order specific fertility rates. The results also showed that the projected parity progression ratio method showed a reasonable fit for parities lower or equal to the overall total fertility rate for that country. For parities above the overall total fertility rate, the method showed increased deviation from the actual parity progression ratios obtained. Thus the method can be applied sufficiently within the plausible parity range for each population, for parities higher than the total fertility rate; the method does not produce plausible results.

Overall, the application of the projected parity progression ratio method has demonstrated that if the age pattern of fertility in a country remains constant, coupled with consistent fertility data, then the projected ratios will present a plausible estimate of the future distribution of fertility.

5. CONCLUSION

The objectives of this study were to assess how well the parity progression ratio method works and also to investigate the factors that affect the parity progression ratio method. Four developing countries, namely Malawi, Zimbabwe, Cambodia and Panama, were used in the study. These were selected on the basis that they have two most recent censuses and that each of them presents a different pattern of fertility. In addition, two Demographic and Health Surveys, a pair each from Malawi and Cambodia, were also used in the study. Using these datasets, parity progression ratios from the first census were projected by ten years, to the second census, and the result was compared to the actual parity progression ratios obtained in the follow-up census. The results generally show that the method works well when the fertility of a country was generally constant over the intercensal period. A change in fertility, particularly a shift in the age pattern of fertility, results in the method failing to produce a good fit of the parity progression ratios expected in the future. The study also reveals that the method is dependent on the quality of the data being used. The following section summarises the quality of the data.

5.1. Data quality

The study used the number of children ever born and the number of births per woman in the year prior to each survey. The quality of data from Malawian and Zimbabwean censuses were generally good. There were few errors which were corrected either by the el-Badry correction method or by the rule of thumb, which estimated that each woman will have at most one birth in every 18 months from the age of 12. The Cambodian censuses had several inconsistencies. For instance, the average parities in the second census were less than those in the first census for older cohorts of women. The data also suggested a rapid fertility decline. Application of the Relational Gompertz model to the second census resulted in a more plausible age specific fertility rate and total fertility rate. The Panama datasets were generally of good quality. The DHS datasets used for Cambodia and Malawi did not require any adjustment.

The projected parity progression method uses children ever born data and births in the last year tabulated by parity. If there is underreporting of births in the last year by a specific cohort of women, the age pattern of fertility will be affected. The change in age pattern of fertility observed in Cambodia could be attributed to the under reporting suggested by the data or selectivity effects in data collection. On the other hand, the method uses the proportion of fertility achieved by each age group and hence the level of fertility in a country does not affect the method. Overall, the method works very well where the data has plausible births in the last year.

5.2. Projected parity progression ratio method

The results show that the projected parity progression ratio method, when applied to one census and compared to the following census, produces a relatively good fit when the shape of the fertility between the two surveys remains fairly constant in the inter-survey period. On the contrary, application of the method in a country which has experienced a significant change in the shape of the fertility curve, such as is observed in Cambodia and somewhat in Zimbabwe, results in a poor fit of the method. This is mainly because the assumption made in the projected parity progression ratio method, that the current age-order specific fertility rates will continue to apply until the end of the reproductive years will have been violated. In addition, the quality of the data, although not very significant, also affects the extent to which the method will fit the data. Application of the method to the DHS data shows the same results as those obtained from the census. This suggests that data errors in the censuses did not affect the functioning of the method, suggesting that the method, in the absence of a census, can be applied to a population using a nationally representative survey, such as the Demographic and Health Survey. High HIV prevalence can affect the shape of the fertility curve when it is combined with other socioeconomic characteristics. However, for countries assessed in this study, the effect of HIV on the method needs to be interpreted with caution. It is noteworthy that in two countries where some form of demographic disruption has occurred, that is, in Zimbabwe where high levels of emigration due to economic hardships coupled with high HIV prevalence; and in Cambodia, where a massive genocide occurred, the method appears to be less robust when comparing projected results with subsequent actual observations. Given the nature of those disruptions and their effects on women's childbearing patterns, perhaps this is understandable. However, in the case of Cambodia, the disruption occurred approximately three decades before the data were collected, so the data does not straddle the period of disruption directly, but this may point to the longer-term consequences of such disruptions on demographic behaviour, where the process of readjustment is neither instantaneous nor rapid.

In conclusion, the projected parity progression ratio method is useful in predicting the future in the case where the current fertility rates do not change.

However, when one wants to predict an exact fertility trend by parity for a certain period in the future, there is need to adjust the method, particularly the assumptions, to allow for any changes in fertility distribution that might occur along the time line. In general, the method presents a starting point in assessing the future trend in fertility.

5.3. Limitations of the study

The major assumption used in the method assessed is that the current distribution of age-order specific fertility rates will remain constant until the end of the reproductive age group of women. This assumption is not practical for countries that are still experiencing rapid fertility transition. The countries used in this study are all part of the developing world; hence determinants, such as education and employment of women and contraception still have a significant effect on how fertility changes. As observed in Cambodia fertility trends, the DHS reports suggest that in cases where there is a rapid increase in the number of women using contraception, the fertility rate inevitably falls. This implies that the fertility patterns of such countries are bound to be affected.

Another limitation is that the method being assessed has not been formally published. As a result, literature which relates to the use of this method is still very thin; hence there are very few works that can be compared with the results of this study.

5.4. Areas for further research

Based on the results obtained in this study, a suggestion for future assessment of the projected parity progression ratio method would be to allow for a change in the age pattern of fertility as opposed to the current assumption in the method, which assumes the distribution of the age-order specific fertility rates will remain constant until the end of the reproductive years. This can be done by factoring in a model which adjusts the proportion of addition women expected to attain certain parity, before the end of their reproductive life. The degree of adjustment may be modelled from the trends in fertility over the past few years. This adjustment will then be applied in countries that have rapidly changing fertility; for example that depicted by the Cambodian data. Within this context, the literature suggests that the rapid change in fertility in Cambodia was partly attributed to a rise in contraceptive use, therefore uptake of contraceptive methods by women should also be considered in the adjusting this model. In addition, in countries where there has been a demographic disruption, such as genocide, a war or high emigration, there needs to be an adjustment factor to cater for this in the revised model. This would allow the method not only to measure the implication of current age-order specific fertility rates on the future trends but also to predict the most probable distribution, given the prevailing fertility determinants in a country.

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APPENDIX

Appendix 1: Distribution of the total numbers and proportions of women by country

Distribution of women by age group for 1998 and 2008 censuses, Malawi

Age group	*1998 census*	*2008 census*
15-19	558810	688780
20-24	544450	701860
25-29	395200	584410
30-34	297100	416840
35-39	247350	303390
40-44	179150	225600
45-49	167520	177630
50-54	116290	145490
55-59	85220	135350
60-64	81710	97910
Total	2672800	3477260

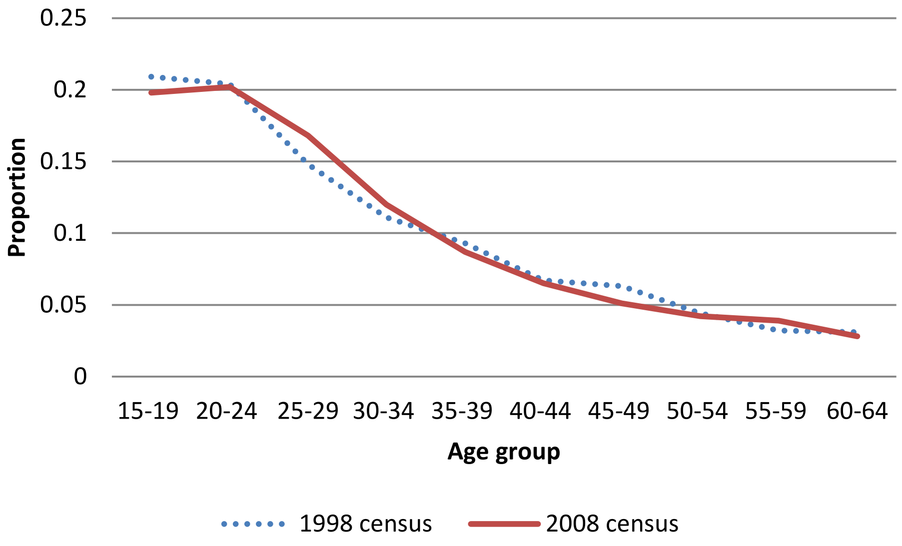
Source: IPUMS international website

Proportions of women by age group for 1998 and 2008 censuses, Malawi

Age group	*1998 census*	*2008 census*
15-19	0.209	0.198
20-24	0.204	0.202
25-29	0.148	0.168
30-34	0.111	0.120
35-39	0.093	0.087
40-44	0.067	0.065
45-49	0.063	0.051
50-54	0.044	0.042
55-59	0.032	0.039
60-64	0.031	0.028

Source: IPUMS international database

Proportion by age group, Malawi 1998 and 2008 censuses



Source: IPUMS International website

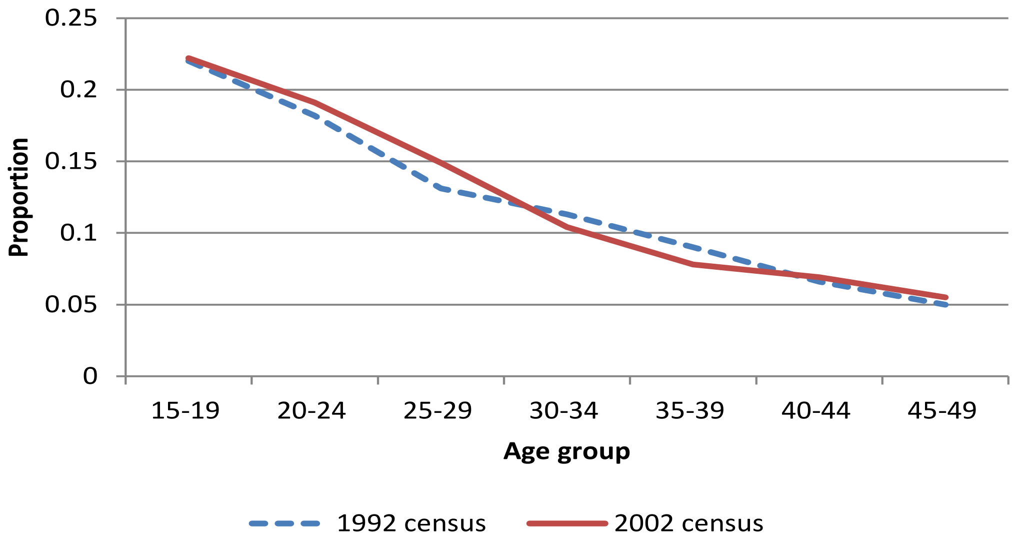
Distribution of women by age group for 1992 and 2002 censuses, Zimbabwe

Age group	*1992 census*	*2002 census*
15-19	632510	766890
20-24	523061	658873
25-29	376495	513793
30-34	326299	360291
35-39	259555	268797
40-44	189509	239727
45-49	143441	191168
Total	2877394	3455861

Proportions of women by age group for 1992 and 2002 censuses, Zimbabwe

Age group	*1992 census*	*2002 census*
15-19	0.220	0.222
20-24	0.182	0.191
25-29	0.131	0.149
30-34	0.113	0.104
35-39	0.090	0.078
40-44	0.066	0.069
45-49	0.050	0.055

Proportion by age group, Zimbabwe 1992 and 2002 census



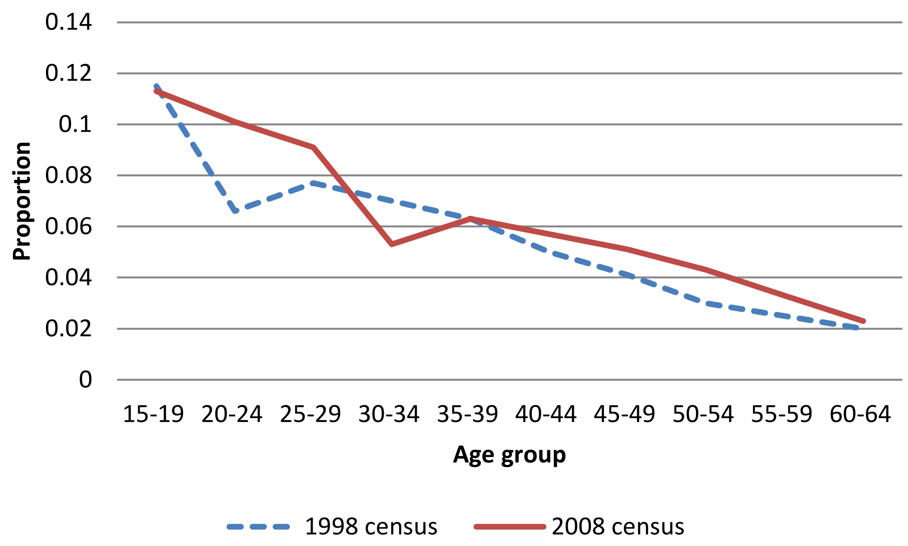
Distribution of women by age group for censuses 1998 and 2008, Cambodia

Age group	*1998 census*	*2008 census*
15-19 years	677760	780320
20-24 years	391240	697160
25-29 years	458140	626430
30-34 years	413370	361650
35-39 years	371950	435880
40-44 years	297080	393760
45-49 years	239900	352520
50-54 years	177890	294280
55-59 years	147210	230200
60-64 years	118520	160590
Total	5916070	6880090

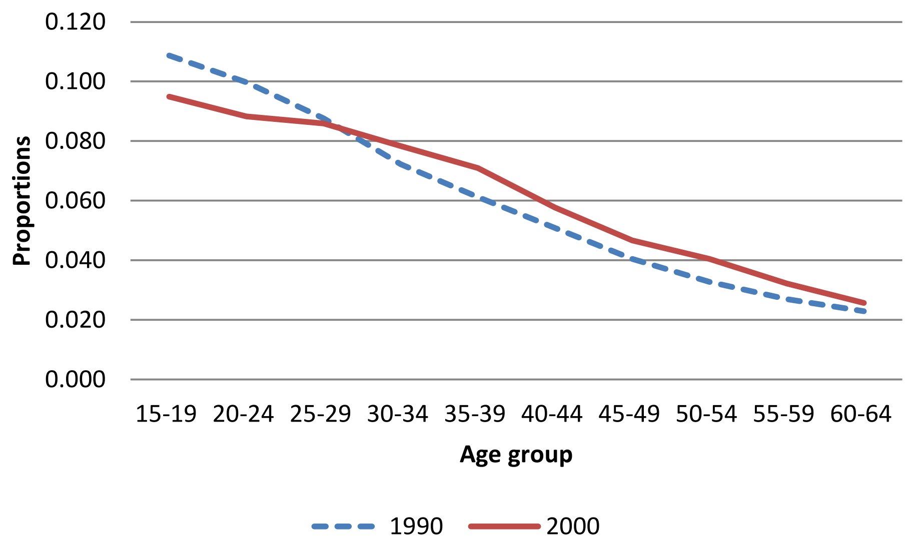
Proportions of women by age group for 1998 and 2008 censuses, Cambodia

Age group	*1998 census*	*2008 census*
15-19	0.115	0.113
20-24	0.066	0.101
25-29	0.077	0.091
30-34	0.070	0.053
35-39	0.063	0.063
40-44	0.050	0.057
45-49	0.041	0.051
50-54	0.030	0.043
55-59	0.025	0.033
60-64	0.020	0.023

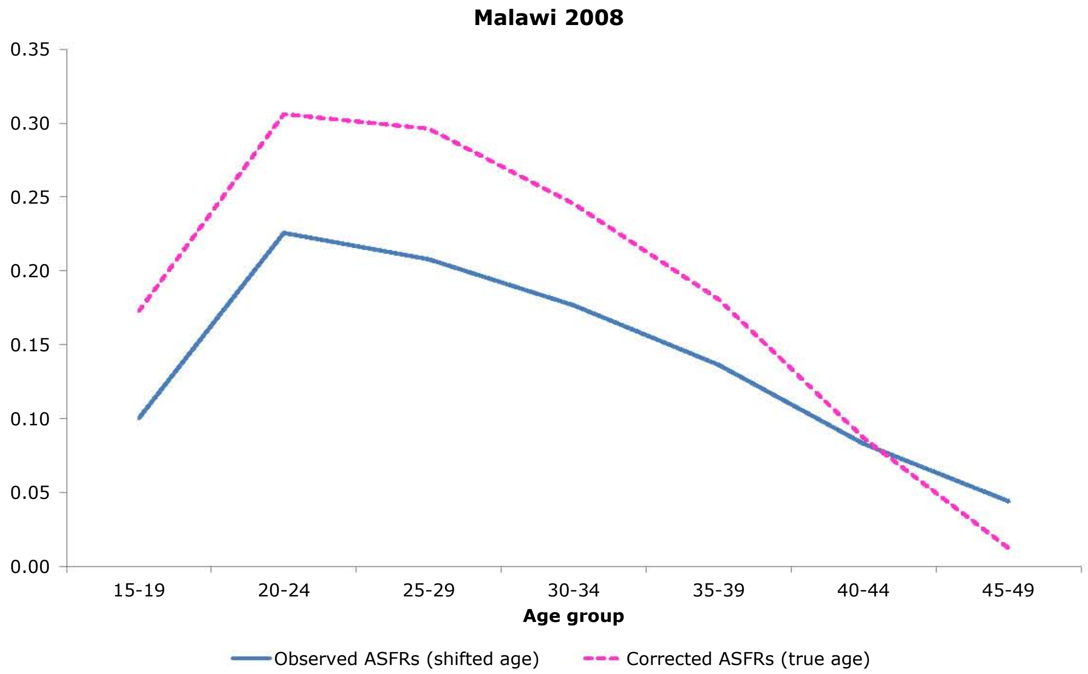
Proportion by age group, Cambodia 1998 and 2008 censuses

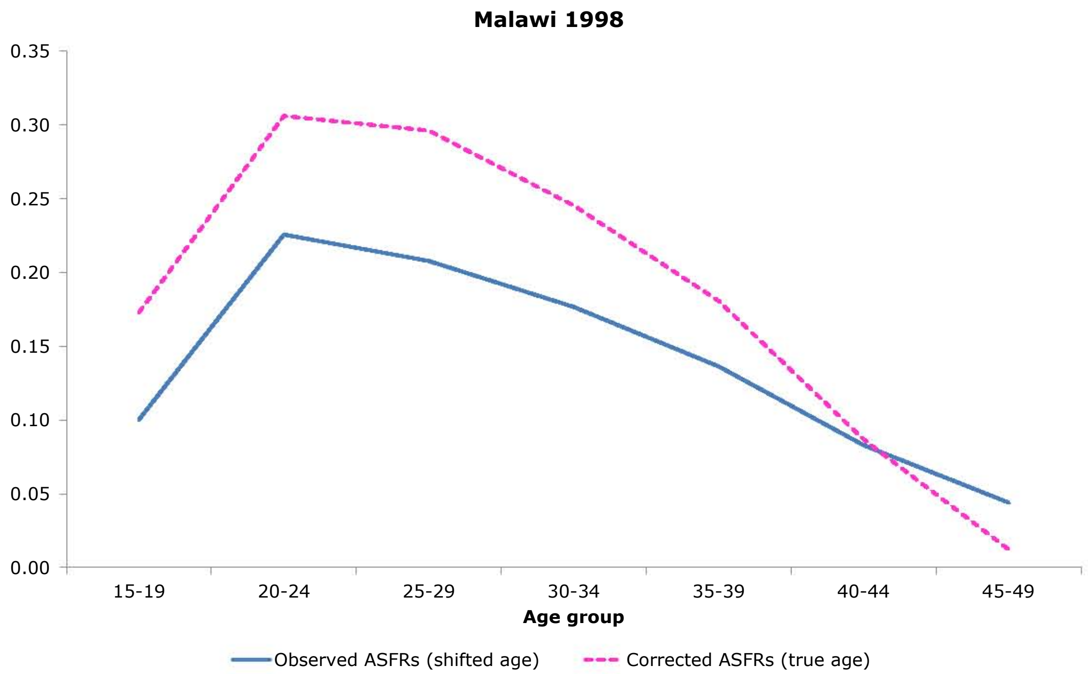


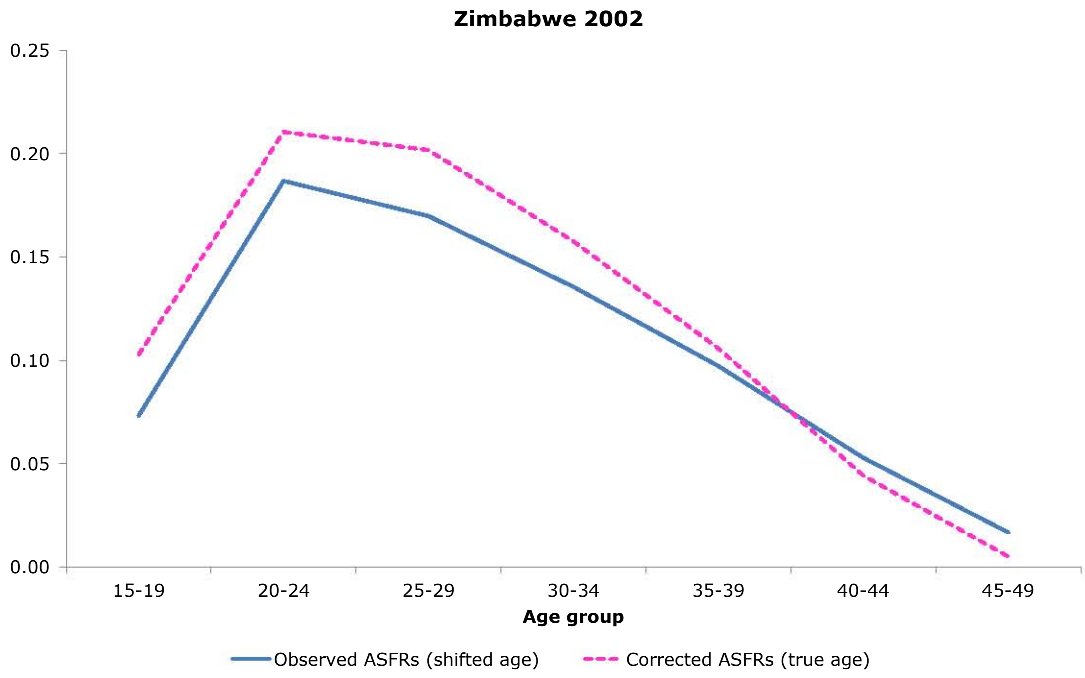
Proportion of women by age group, Panama 1990 and 2000 census

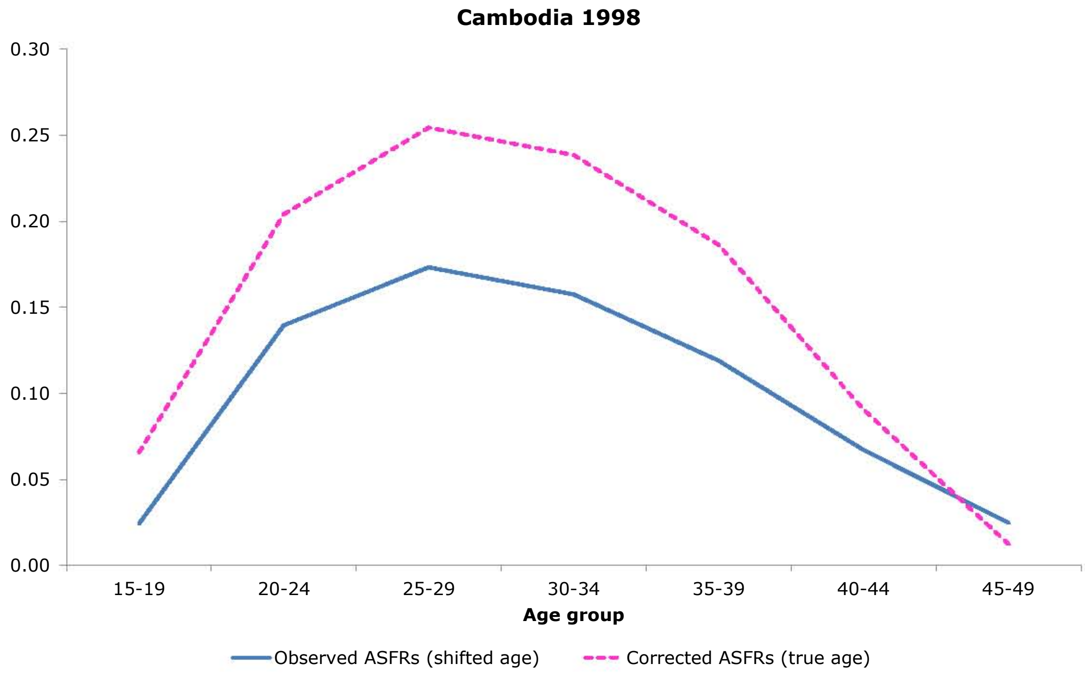


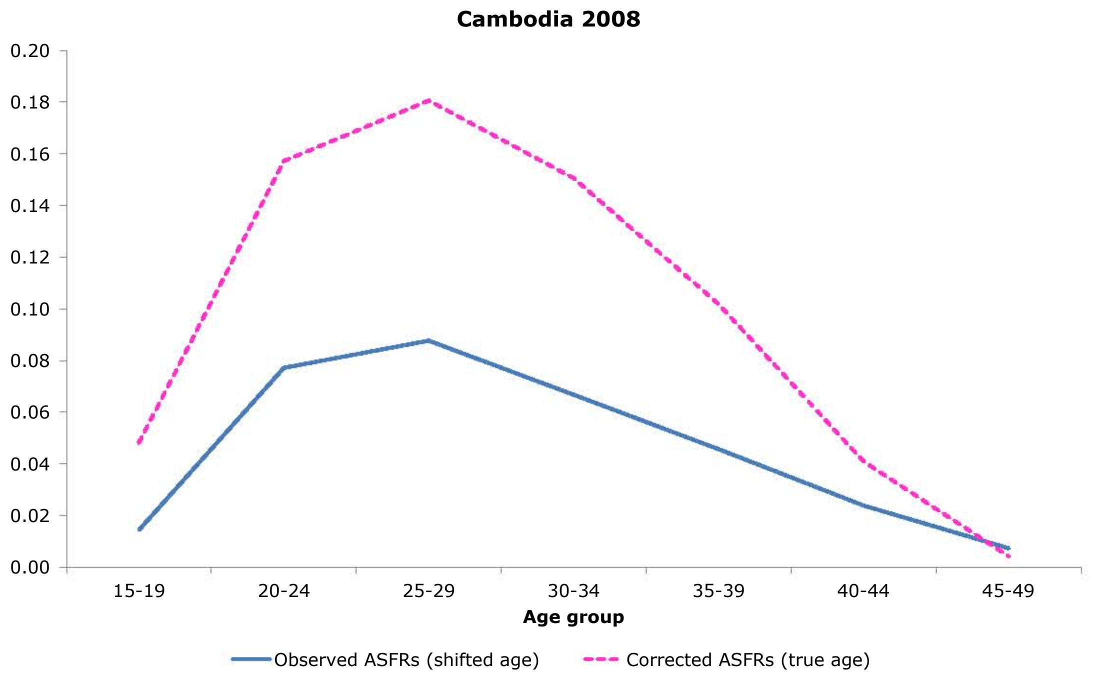
Appendix 2: Relational Gompertz Model Fits






Zimbabwe 2002
0.25
0.20
0.15
0.10
0.05
0.00
15-19
20-24
25-29
30-34
35-39
40-44
45-49
Age group
Observed ASFRs (shifted age)
Corrected ASFRs (true age)


Cambodia 1998
0.30
0.25
0.20
0.15
0.10
0.05
0.00
15-19
20-24
25-29
30-34
35-39
40-44
45-49
Age group
Observed ASFRs (shifted age)
Corrected ASFRs (true age)


Cambodia 2008
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
15-19
20-24
25-29
30-34
35-39
40-44
45-49
Age group
Observed ASFRs (shifted age)
Corrected ASFRs (true age)