Analysis of fertility estimates in Zimbabwe: A comparison of the census and DHS data

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ABSTRACT

Analysis of census data is important to uncover new insights as well as highlight where improvements in future data collection are required. The study provides an assessment of the fertility estimates derived from census data in comparison to those derived from the Zimbabwe Demographic and Health Surveys. Robust methods are used to estimate fertility levels and to identify the trends in fertility in Zimbabwe. Fertility decline in Zimbabwe is observed to have started in the early 1980s. The greatest level of decline occurred between the 1980s and the mid-1990s. In more recent years fertility in Zimbabwe has stalled at roughly four children per woman. Using projected parity progression ratios fertility decline has been observed to be in part a result of parity limitation, as fewer women progress to higher parities. A comparison of the census and Zimbabwe Demographic and Health Survey fertility measures show that for the same cohort of women, the measures of fertility are strongly congruent. While there are problems with census data, it has been shown that using robust estimation the census fertility estimates are comparable to those from the Demographic and Health Surveys.

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1 INTRODUCTION

Among the three processes that determine population growth, fertility, mortality and migration, fertility has the greatest bearing on the growth of a population (Moultrie, Dorrington, Hill et al. 2013). High quality fertility estimates are necessary in order to inform policy decisions as well as to evaluate family planning programmes. Although the vital registration system in Zimbabwe is deficient, there is a wealth of information from the censuses and surveys conducted in the country. Fertility estimates are derived from the census which has been conducted decennially since 1982 and from the Zimbabwe Demographic and Health survey, which has been conducted approximately every five years since 1988.

Schoumaker (2010), in reconstructing fertility trends using Demographic and Health Survey data in sub-Saharan Africa, uses Zimbabwe as an exemplar for his reconstruction approach as he notes that the data from the Zimbabwe Demographic Health Survey are little affected by data problems. In aggregate, by analysing birth histories, Schoumaker shows that there is consistency in the total fertility rates at a national level for four of the Demographic and Health Surveys that had been conducted in Zimbabwe and that there is a clear trend of fertility decline in Zimbabwe. This dissertation seeks first to expand on Schoumaker's work for Zimbabwe. The research seeks to determine whether the apparent consistency is also present at sub-national levels and among population sub-groups. Determining whether the results are consistent by other differential factors gives more confidence in the data and in Schoumaker's results. To further investigate consistency in the Demographic Health Surveys, parity progression ratios and projected parity progression ratios will be compared across surveys to see whether they all show the same picture.

Schoumaker shows that the Zimbabwe Demographic Health Surveys are consistent; meaning that from one survey to another the total fertility rates are in harmony and tell the same story. The second part of the research will look at the results of various censuses which have been held in Zimbabwe to investigate how well the fertility rates, parity progression ratios and projected parity progression ratios from the censuses compare with those from the Demographic and Health Surveys. Since it can be shown that the Demographic and Health Survey are consistent, it will give some indication as to the quality of the data on fertility collected in the census. The end goal will be also to have a more detailed time trend of fertility in Zimbabwe.

The specific objectives of the study are:

1. To determine whether the apparent consistency in fertility decline in Zimbabwe is also present at sub-national levels and among population sub groups
2. To assess the consistency of census data with regard to fertility information

Assessing fertility estimates at different levels and from different sources helps to evaluate the quality of the data collected and determine whether errors are due to inconsistences in the data or errors in the methods used. Further, estimates published from these sources are used to inform policy decisions and development planning programmes, thus if errors are there they should be highlighted and corrected in future studies. Reliable estimates are also required when assessing and evaluating programmes which are related to fertility and fertility outcomes.

The study is made up of five chapters. Chapter Two presents a review of literature related to fertility levels and trends in Zimbabwe. Chapter Three provides an evaluation of the data and an outline of the methods used to analyse the datasets. The results from applying the methods discussed in Chapter Three are presented in Chapter Four and at the end of the chapter a discussion is presented on the implications of the results. The conclusion of the study is presented in Chapter Five.

2 LITERATURE REVIEW

This chapter presents the general history of fertility in Zimbabwe. It also looks in depth at the problems commonly encountered in Demographic Health Surveys and censuses.

2.1 Overview of fertility in Zimbabwe

As documented by Muhwava and Timæus (1996), Guilkey and Jayne (1997), Cohen (1998), Kirk and Pillet (1998) and Mturi and Kembo (2011), there is no doubt that there has been fertility decline in Zimbabwe. The report on the 2012 Census (Zimbabwe National Statistics Agency 2012) noted a total fertility rate of 3.8 children per woman, a decline of 2.4 children from the 6.2 children per woman reported after adjusting for underreporting of births in the 1982 Census (Central Statistical Office 1985). Similarly, the Zimbabwe Demographic Health Surveys (ZDHS) also shows a decrease in total fertility from 5.4 children per woman in the 1988-89 ZDHS to 4.1 children per woman in the 2010-11 ZDHS (Zimbabwe National Statistics Agency (ZIMSTAT) and ICF International 2012).

The level of fertility in Zimbabwe is among the lowest in sub-Saharan Africa. From each survey held in the country, be it census or Demographic and Health Survey, a variety of estimates have been published from these data as a result of authors applying different methods to the data. Both direct and indirect estimates have been used to try and produce reliable estimates from these data.

Figure 2.1 Total fertility rate by year of inquiry, multiple sources

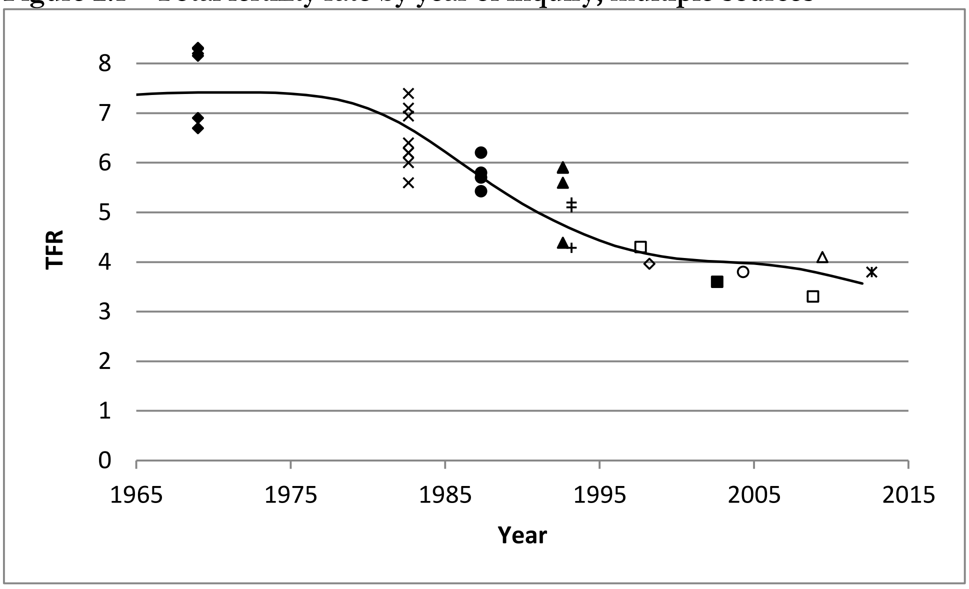


Table 2.1 Total fertility rate by year of inquiry, multiple sources

TFR	*Time*	*Method*		*Author and year of publication*
6.7	1969	Direct estimation	1969 Census	Muhwava and Timæus (1996)
8.3	1969	P/F Ratio method	1969 Census	Muhwava and Timæus (1996)
6.9	1969	Relational Gompertz	1969 Census	Muhwava and Timæus (1996)
8.2	1969	P/F Ratio method	1969 Census	World Bank (1989)
8.2	1969	Stable population method, North level 14	1969 Census	World Bank (1989)
8.3	1969	Stable population method, South level 16	1969 Census	World Bank (1989)
5.6	1982	Direct estimation	1982 Census	Central Statistical Office (1985)
6.2	1982	(Brass method refined by Arriaga) P/F Ratio method	1982 Census	Central Statistical Office (1985)
6.4	1982	P/F Ratio method	1982 Census	Muhwava and Timæus (1996)
6.2	1982	Relational Gompertz	1982 Census	Muhwava and Timæus (1996)
7.4	1982	P/F Ratio method	1982 Census	Mhloyi (1992)
6.0	1982	Rele Child Woman Ratio Method	1982 Census	Mhloyi (1992)
7.1	1982	P/F Ratio method	1982 Census	World Bank (1989)
6.9	1982	Stable population method, South level 17	1982 Census	World Bank (1989)
6.5	1984	Direct Estimation	1984 ZRHS	Udjo (1996)
6.5	1984	Adjustment for true age group	1984 ZRHS	World Bank (1989)
7.5	1984	Gompertz model	1984 ZRHS	Udjo (1996)
5.4	1985-89			World Bank (1989)
5.1	1987	Direct estimation	1987 ICDS	Central Statistical Office (1991)
6.6	1987	Gompertz model	1987 ICDS	Udjo (1996)
5.4	1987	Direct estimation	1988/89 ZDHS	Central Statistical Office and Macro International Inc (1989)
6.2	1987	P/F Ratio method	1988/89 ZDHS	Muhwava and Timæus (1996)
5.8	1987	Relational Gompertz	1988/89 ZDHS	Muhwava and Timæus (1996)
5.7	1987	Adjustment for true age group	1988/89 ZDHS	World Bank (1989)
4.4	1992	Direct estimation	1992 Census	Central Statistical Office (1994)
5.9	1992	(Brass method refined by Arriaga) P/F Ratio method	1992 Census	Zimbabwe National Census Report (1992)
5.9	1992	P/F Ratio method	1992 Census	Muhwava and Timæus (1996)
5.6	1992	Relational Gompertz	1992 Census	Muhwava and Timæus (1996)
4.3	1993	Direct estimation	1994 ZDHS	Central Statistical Office and Macro International Inc (1995)
5.1	1993	P/F Ratio method	1994 ZDHS	Muhwava and Timæus (1996)
5.2	1993	Relational Gompertz	1994 ZDHS	Muhwava and Timæus (1996)
4.3	1997	Relational Gompertz	1997 IDHS	Central Statistical Office (1998)
4	1998	Direct estimation	1999 ZDHS	Central Statistical Office and Macro International Inc (2000)
3.6	2002	Direct estimation	2002 Census	Central Statistical Office (2004)
3.8	2004	Direct estimation	2005/06 ZDHS	Central Statistical Office and Macro International Inc (2007)
3.3	2008	Direct estimation	2008 ICDS	Central Statistical Office (2009)
4.1	2009	Direct estimation	2010/11 ZDHS	Zimbabwe National Statistics Agency (ZIMSTAT) and ICF International (2012)
3.8	2012	Direct estimation	2012 Census	Zimbabwe National Statistics Agency (2012)

Note: 1969 estimates are from the African Population only

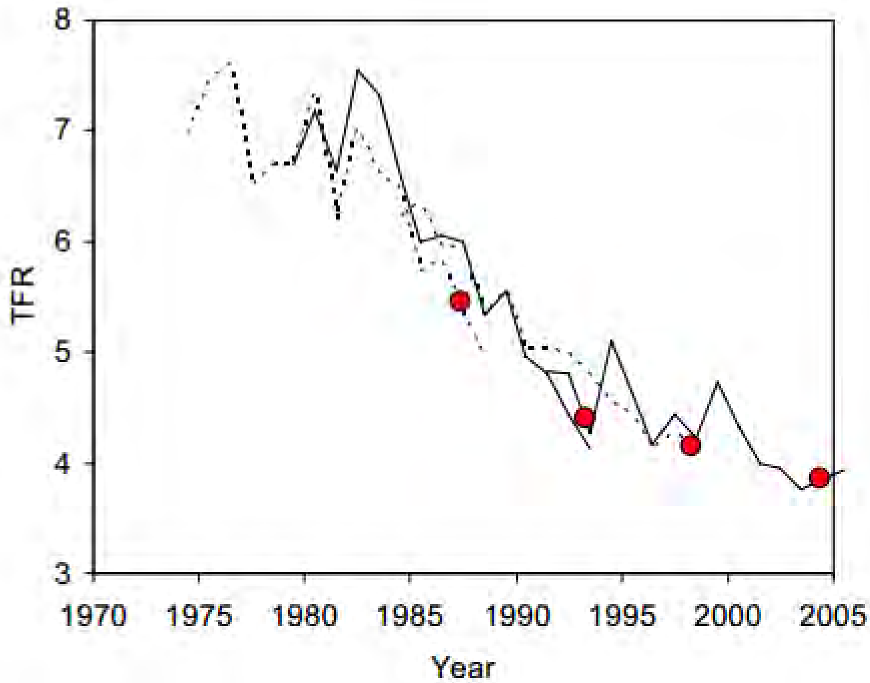
Figure 2.1 and Table 2.1 show the total fertility rates that have been published; derived from a variety of methods and/or sources. The figure shows that despite the wide range of estimates fertility in Zimbabwe has declined, starting in the mid-1970s. Decline was steeper in the 1980s to the mid-1990s, and from the late 1990s a slower rate of fertility decline has been observed. Historically, especially for countries in sub-Saharan Africa where the data has most times been of questionable quality, estimates of fertility have varied considerably. Questions have always arisen when different estimates from the same country for fertility rates have been presented. The concerns are whether the reflected trend is real or spurious or whether there are methodological difficulties in one or both surveys.

Earlier analysis of fertility in Zimbabwe came to different conclusions on whether fertility decline was underway there or not. A debate on the fertility decline in Zimbabwe and Botswana ensued between Thomas and Muvandi (1994) and Blanc and Rutstein (1994) regarding the magnitude of decline. Thomas and Muvandi (1994) argued that differences in the sample composition was responsible for the apparent decline in fertility but Blanc and Rutstein (1994) countered that the differences were not statistically significant. Udjo (1996) described a modest decline in fertility in the country by looking at the surveys between 1980 and 1990. Using life table analysis of birth intervals he concluded that the proportion of women progressing to the 6th and 7th births has decreased, implying that the decline was concentrated among high order births. While Muhwava and Timæus (1996) also made use of parity progression ratios, they noted that parity progression has fallen across all birth orders with the most significant change being in 4th and higher orders. By analysing the censuses and surveys held from 1969 to 1994, they conclude that fertility decline was underway in Zimbabwe, with a slow start in the 1970s and acceleration in the 1980s, which continued into the 1990s.

In recent years, increased interest has been on whether fertility in some countries in sub-Saharan Africa has stalled. Stalling fertility is described by Bongaarts (2008) as: "ongoing fertility transition interrupted by a period of no significant change in fertility before the country reaches the end of the transition". Bongaarts (2008) cites Zimbabwe as one of the countries where there had been no significant change in fertility in the three surveys (1994, 1999, 2006/06 ZDHS) and his conclusion was that fertility had stalled. However, owing to the fact that there is no consistent definition of stalling as put across by Moultrie, Hosegood, McGrath *et al.* (2008), Schoumaker (2009), using the same data concludes that decline in fertility in Zimbabwe had indeed slowed, although it had not stalled. Although the studies above have come to different conclusions about the various aspects of Zimbabwe's fertility, the quality of the data has had positive reviews.

Some earlier analyses of the DHS surveys in Zimbabwe have shown consistency in the fertility levels implied in these surveys. Kirk and Pillet (1998) note that even as the fertility levels in the 1994 ZDHS were higher than those in 1988-89 ZDHS for overlapping periods, the fertility trends shown were consistent. By computing the total fertility rates over the 15 years before each survey and plotting on a graph for the 1988/89, 1994, 1999 and 2005/06 ZDHS (Figure 2.2) visual inspection shows fertility estimates from consecutive surveys match well with each other. This, as Schoumaker (2010) notes, is a result of the data in Zimbabwe being little affected by data quality issues. Annual variations in the total fertility rate are quite small and the total fertility rate for the three years preceding the survey lies along the trend. Indeed there is consistency in the surveys in terms of the fertility rates and the general trend is that of a fertility decline.

Figure 2.2 Comparison across four surveys of retrospective fertility trends in Zimbabwe



Source: Schoumaker (2010)
Note: Solid lines and dotted lines are alternated to represent fertility trends from the four DHS. Large dots represent published values of TFR.

The above section has given a picture of fertility trends and levels in Zimbabwe. A brief view of some comparative studies on fertility has been presented. The next section sets out to answer the question on where the data for fertility comes from and how they are collected.

2.2 Fertility data in Zimbabwe

Demographic data collection has improved in the past three decades in sub-Saharan Africa (Cleland 1996). Almost all the countries in the region have had at least one census carried out. With the introduction of the World Fertility Survey and succeeding it the

Demographic and Health Survey surveys have been carried out in all countries in sub-Saharan Africa. Other surveys, both cross sectional and longitudinal have been conducted in individual countries. Vital registration systems if implemented correctly (wide coverage, compulsory and timely reporting) can capture all births, deaths, marriages and divorces. This wealth of information may be used to calculate accurate fertility estimates in a population. The paucity of data in the vital registration system in Zimbabwe makes it impossible to calculate reliable fertility estimates. In 1994 it was estimated that the completeness of live births registration was 30 per cent in Zimbabwe, United Nations Statistics Division (2012) and more recently the Central Statistical Office (2010) published the national coverage of birth registration to be 38 per cent. No other information is available on the completeness of the vital registration system in Zimbabwe. The main sources used to calculate fertility estimates in Zimbabwe are the census and the surveys.

2.2.1 Census in Zimbabwe

Enumeration in a census in Zimbabwe started as early as 1901 but under colonialism administration it was restricted to the non-African population until 1961/62 when the first census aimed at enumerating the whole population was conducted (World Bank 1989). However, even in this census, the African and non-African population were enumerated at different points in time, a year apart and different questionnaires were administered to each group. As World Bank (1989) notes, no information was collected on fertility and mortality, and because of the innumerate and/or semi-numerate population only broad classification of ages were used. The following census, held in 1969, was also conducted at different times but with a one month lag. Fertility and mortality data was collected only for the African population. The African population made up 95% of the population, so the fertility and mortality of the Africans was taken to be the national average (World Bank 1989). The first census where enumeration of the African and non-African population took place at the same time when the same questionnaire was administered in Zimbabwe was held post- independence in 1982 with subsequent censuses being carried out in 1992, 2002 and 2012. The censuses have collected information on geographic, demographic, social and economic characteristics, migration, fertility and mortality.

2.2.1.1 Lifetime fertility data

Fertility questions are included in the census as they allow for cost effective collection of data, which are used to calculate fertility estimates at a national and sub-national level. The first question in the fertility section is used to filter out women who have ever given birth from those who have not. As it was noted that if the question is simply asked, such as "How many children have you ever borne alive", children who have left home or who died, are more likely to be omitted, so a more refined set of questions were conceived. Following United Nations guidelines (Moultrie 2013b), the questions are typically disaggregated into three parts:

"How many children born alive are:

- Residing in the household?
- Residing elsewhere?
- Have died?"

To guard against underreporting of female children the questions are often also disaggregated by sex. The 1969 census asked women, aged 15 and older, the number of children ever born and those surviving. All censuses following the 1969 census ask the refined question stated above to all women ages 12 to 49, with the only difference in the 1982 census were women aged 12 years and older that were asked. Summing the total of children ever born who reside in the household, residing elsewhere and children who have died will give the total number of children that the woman has ever given birth to. Dividing the total children ever born to women in each age group by the number of women in each age group gives average parities, which are the average number of children ever borne by women (lifetime fertility) in each age group (Moultrie 2013b).

2.2.1.2 Assessment of parity data

The data on lifetime fertility are subject to error. The expectation is that the number of children ever born should increase with age thus average parities should increase systematically with age following a sigmoid shape. If average parities do not increase with age or are below that of the previous age group, this is a sign, in the absence of sustained fertility increase, that some births may have been omitted (Moultrie 2013b). The census allows for a proxy respondent, meaning absent people may be answered for. The proxy respondent may not be a person who is knowledgeable about the household, meaning children residing elsewhere, children from another marriage or children who have died may be omitted from the count. This will most likely lead to an underestimation of parities. Also, because with age comes memory lapse, some births earlier in time may not be reported which is mainly encountered among older women. Lifetime fertility data collected in the census becomes increasingly poorly reported with the age of the mother.

Implausible parities are often found in the data, which may be due to either women misreporting the number of children, or enumerator and/or data entry errors. Moultrie

(2013b) proposes a rule of thumb that may be used to correct such implausible parities. The rule limits women to having one birth after every 18 months from the age of 12 rounded down to the nearest integer. This means that women aged 15-19 are assumed to be able to have had a maximum of five children, by exact age 25 they would have a maximum of eight children and so forth. For women who have reported having more children than allowed by the rule, they are treated as if the information is missing.

Another common problem found in census data is that enumerators fail to record a zero on questions on children ever born, leaving that part blank. Upon processing the responses during data processing the cases are coded as "unknown" or "not stated". It is general consensus that most of these women are probably childless and the enumerator failed to record this (El-Badry 1961; Moultrie 2013b). Not recording these women appropriately leads to an underestimation of childless women, especially among young women and may also affect studies in childlessness. If women with "unknown" number of children are included in the denominator but not the numerator when calculating average parities, it results in an understatement of parities. The el-Badry correction is applied to data on children ever born in order to correct data for these errors caused by the enumerator failing to record zero children and who would rather leave the space blank. El-Badry (1961) states that if a linear relationship exists between the proportion of women who are childless and the women with unstated parities and one assumes a constant proportion of women at each age truly did not state their parities, then estimates of the degree of incidence of the childlessness error can be obtained. Using these estimates one can then adjust the data appropriately to find the proportion of women who are truly childless and the average parities. If less than two per cent of the data are missing in each age group then the el-Badry correction should not be applied. The women with unstated parities are excluded from the calculation of average parities and the assumption made is that these women have the same average parities as women with stated parities (Moultrie 2013b).

2.2.1.3 Current fertility data

A second set of questions included in the census questionnaire are used to calculate current fertility rates in a period just prior to a census, usually a year. Current estimates of fertility are important as they provide the prevailing levels of fertility. Depending on the country one of three questions can be asked to calculate recent fertility. The first option is "*Did you give birth in the last year (or other reference period)?*" Asking this has the disadvantage that multiple births within the period are not captured as a simple yes or no answer is expected. The second option is "*How many children have you given birth to in the last year (or other reference period)?*" The third question asks "*What was the date of your last live birth*" which is the recommended question by the United Nations (2008). Additional questions have been included on the sex and survival status of the last born child, which are used to calculate the sex ratio at birth and child mortality respectively. Censuses in Zimbabwe have used the third question. From the information provided on the month and year of birth, the births that occurred 12 months before the census are derived. Dividing births in each age group by the number of women in that particular age group gives the estimated age specific fertility rates and subsequently the total fertility rate is calculated.

2.2.1.4 Assessment of current fertility

As with parity data, current fertility data is also subject to errors. Data on recent fertility tends to be systematically underreported by all women even when the question asks about the date of the last live birth. Reference period errors may also occur as the person may not be sure of the exact date of birth (month and year). Omissions may also occur if the child died soon after birth.

2.2.2 Surveys in Zimbabwe

Sample surveys carried out in Zimbabwe before the 1980s were not representative as they only covered the population in communal lands and collected cursory data on age (World Bank 1989). With the introduction of the Demographic and Health Surveys, Zimbabwe has carried out five surveys: 1988/89, 1994, 1999, 2005/06 and 2010/11. The surveys have all been conducted by the Zimbabwe National Statistical Agency (ZimStat) formerly known as the Central Statistical Office (CSO). The Demographic and Health Surveys (DHS) are assumed to provide better data, which is also comparable across surveys (Muhwava and Timæus 1996). The comparability of the DHS due to the standardised procedures and questionnaires for collecting demographic and health data across countries has led to it being more common than other surveys.

Zimbabwe is divided into ten provinces, which are divided into districts, and each district is again divided into smaller units called wards. These wards are further divided into enumeration areas. The Demographic and Health Survey uses the information from the most recent census conducted to identify these enumeration areas. For example, the 2010/11 Zimbabwe Demographic and Health survey used the enumeration areas from the 2002 Census. A stratified, two stage cluster design is used to sample for the enumeration areas and then the households (Central Statistical Office and Macro International Inc 1995, 2000, 2007). The sample used in each survey is then assumed to be representative of the whole nation. From the households chosen the woman's questionnaire is administered to all women aged 15-49 that are present the night before the interview. Among other things the questionnaire collects information on background characteristics, birth history, education, fertility preferences and mortality.

All women are asked whether they have ever given birth. To avoid under reporting of children who died soon after birth women who respond that they have never had a live birth are further asked whether they have ever given birth to a child who later died. Each woman who has ever given birth is asked about the number of male and female children who are living with her, are living elsewhere and those who have died. A chronological order of each live birth the woman has ever given birth to is elicited. Details about the name, month and year of birth, sex and survival status of each child are collected. For children who have died, information on age when the child died is collected. The purpose of the birth history is to give a complete chronological record of the respondent's fertility. This has been used to determine fertility levels, trends and determinants. No survey is immune to errors and these have been categorised into sampling and non-sampling errors.

Sampling errors may include differences in the composition of the sample across surveys (Schoumaker 2009). An example could be differences in the composition of educated women interviewed in a survey. If more educated women are interviewed, the fertility calculated may be lower than it actually is. Comparing fertility estimates calculated when there are differences in the composition arising from sampling error will be biased. Weighting has been designed to accommodate to some degree for these differences in sample composition.

One of the non-sampling errors noted from the collection of birth histories is that the respondents omit some of their births. Reasons for omissions include omission of children who have died, children who have moved away, illegitimate children and female children as well as infants (Potter 1977). In addition, some omissions are due to interviewers wanting to reduce their workload (Schoumaker 2011). The effect of omission in fertility estimates depends on whether the omission occurs for a particular period or cohort. Omission of the most recent births across all cohorts results in underestimation of fertility in the most recent period.

A second non-sampling error, described by Arnold (1990), results in the displacement of some births mainly by interviewers when they wish to avoid administering the lengthy health module with questions which are asked to children who were born after a fixed cut-off date. Depending on the extent of displacement recent fertility levels may be underestimated and past levels of fertility overestimated. Knowing the problems usually encountered when one conducts a survey makes one alert to these issues and if corrections can be made, more reliable estimates are obtained.

The census and Demographic and Health Surveys are not directly comparable. As noted above, the questions asked are different, whereas the census only asks summary questions about women ages 15-49 who reside at the household from where the DHS collects detailed birth histories. The census allows for proxy respondents whereas the DHS collects the information from the woman in question. As the DHS does not enumerate the whole country, the fieldworkers are few, which means that intensive training is carried out. With regards to dates where the fertility estimates apply, the census estimates apply to the date of the census whereas the DHS estimates apply 18 months before each survey as a three year period is used to calculate the fertility rates.

2.3 Fertility differentials

The national fertility rates for the country conceal variations in fertility from different sub-populations groups. Substantial fertility differentials exist within the country. No research has been done to check for the consistency in fertility among population sub groups and at sub national levels in Zimbabwe. The Zimbabwe Demographic and Health Survey in 1994 estimated rural fertility to be 4.9 children per woman and urban fertility to be 3.1 children per woman (Central Statistical Office and Macro International Inc 1995). This is the same trend observed in all the surveys carried out, namely that rural fertility is higher than urban fertility. Theories that aim to distinguish between rural and urban fertility point to modernisation as a driver to lower levels of fertility in urban areas compared to rural areas. Accessibility to modern contraception, increased age at marriage, higher levels of education and declining infant and child mortality have been noted to be some of the reasons that lead to lower levels of fertility in urban areas. The main driver of differences have been noted to be the effective and accessibly use of contraception by urban women and the increased age at marriage (Moultrie and Timæus 2002). Of note is that residence is classified by residence at the date of the interview. For women whose residency status changed, the fertility may not be allocated to the correct area where it occurred. Analysing fertility by residence has the obvious limitation that in effect assumes that place of residence does not change over the childbearing period.

The consensus among most researchers is that education generally leads to lower fertility, thus there is a negative relationship between education and fertility (Jejeebhoy

1995; Kirk and Pillet (1998); Kravdal 2002). Education influences fertility through the changing of fertility preferences by influencing individual decisions on the desired family size thereby breaking traditional beliefs and customs. Reasons presented for the lower levels of fertility for educated women are: increased knowledge and use of contraception, increase in the age of marriage, rising aspirations, declining infant and child mortality among other reasons. Education and residency are the variables that overlap in the census and the DHS, and these are the two considered in this study.

First, the chapter gave an overview of fertility rates and background of what is known about fertility in Zimbabwe. Literature was reviewed on comparative studies on fertility held in the country. This chapter also reviewed the methods and questionnaires used to collect data used to calculate fertility rates, and the possible errors encountered in collecting such information has also been included. The next chapter sets out to describe the data, assess the data quality and describe methods which will be used to analyse the data. Investigations are carried out into the consistency of the data, the census relative to the DHS so as to determine whether discrepancies between the two can be used to account for the differences in the fertility estimates.

3 DATA AND METHODS

Investigation into the underlying population used to derive estimates is of great importance as it helps determine the reliability of the estimates derived. By assessing the data, the magnitude and nature of the errors are known and can be taken into account when calculations are done. This chapter gives an evaluation and assessment of the censuses and survey data that have been done to date in Zimbabwe. An in-depth analysis will be carried out for all surveys where the data are available. A description of the methods used in the analysis of the data is also given in this chapter.

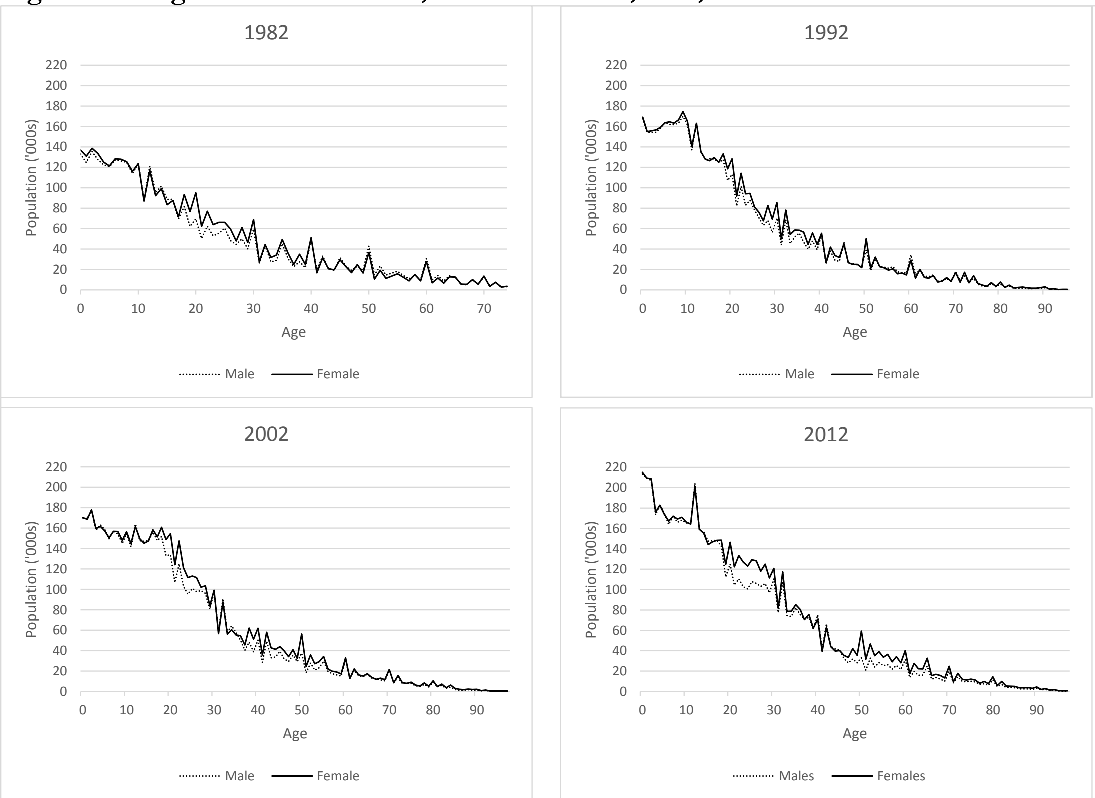
3.1 Assessment of census data

A preliminary assessment of the quality of data from the census is carried out to ascertain the reliability of the data. Age ratios, sex ratios and cohort survival ratios are used to evaluate data in this section.

As most analysis in demography is defined by age and sex, it is particularly important that the quality of these variables are investigated. Age misreporting is one of the errors commonly encountered in census data. Methods used in calculating fertility are sensitive to certain degrees of age misreporting. Misreporting may be as a result of respondents truly not knowing the age or errors in reporting and recording as well as respondents having a tendency to prefer certain ages to others commonly known as age heaping.

At each age, disregarding sharp changes in fertility or mortality, significant levels of migration or other distorting factors a smooth progression of the enumerated population is expected. Tendency to report certain ages at the expense of others is known as age heaping. It usually takes the form of concentrations of the age distribution of the population on ages ending in 0 or 5 although it is not restricted to these only. Visual inspection of the graph of age plotted in single age groups is a good indicator to determine whether there has been age heaping in the data. Sudden spikes in some ages is a sign of age heaping. Some indices have been derived to measure the extent of age heaping but as Moultrie, Dorrington, Hill *et al.* (2013) highlight, visual inspection is as good as using these indices. Figure 3.1 shows the enumerated population by single age and sex from all the censuses held in Zimbabwe.

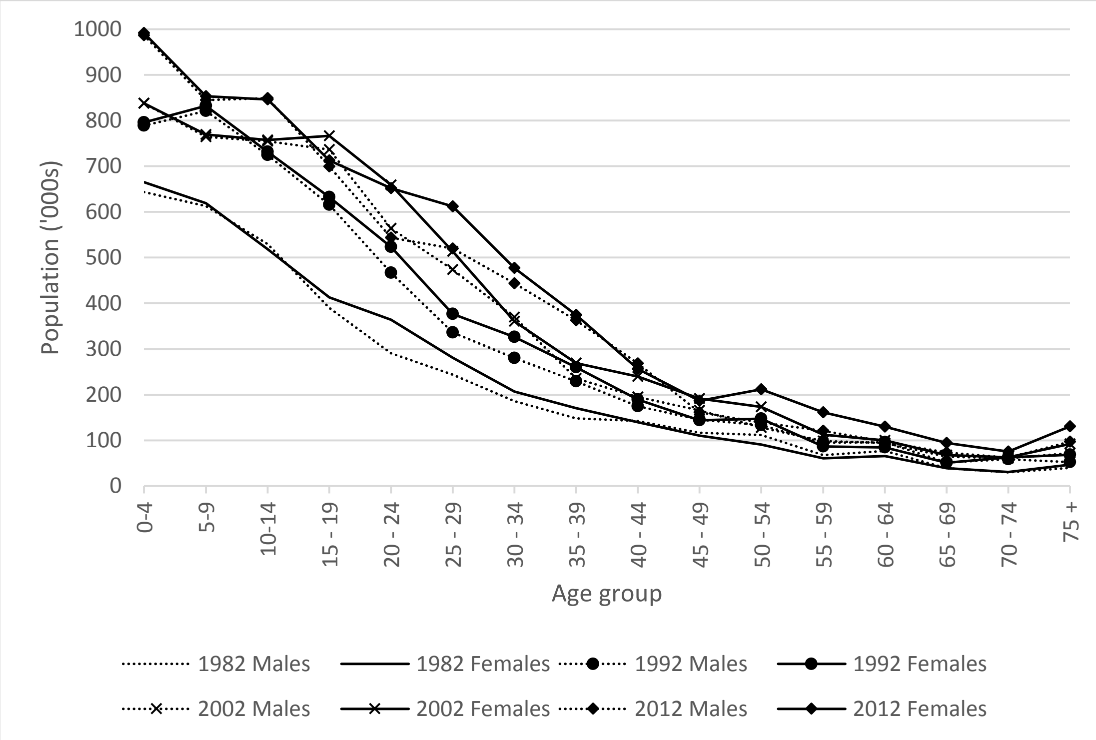
Figure 3.1 Age and sex structure, Zimbabwe 1982, 1992, 2002 and 2012 Censuses



For all the censuses, age heaping is visible for all sexes at ages ending with 0, 2, 5 and 8 as shown in Figure 3.1. Note, except for the 2012 census, the remaining three censuses show an inexplicable decline of children aged zero, which is a sign of undercounting and in the 1992 census the undercount seemed to have been for children aged zero to nine. The 2012 census is odd in that there is a sudden spike in the number of children aged 0-2. The graphs also show a decrease in the number of men enumerated, ages 20 to 30 in the 2002 census and more so in the 2012 census. This may be the result of undercounting of men or migration of these men to look for work in other countries.

Figure 3.2 shows the enumerated population in five year age groups by sex. Plotting the data in five year age groups smoothes the single year distributions. The sharp fall in the children ages 0-4 in the 1992 census for both sexes is clearly visible, showing the enumerated children under 5 in the 1992 census being less that those 5-9. This is likely to be due to under-enumeration of children aged 0-4. The 2012 census shows a levelling off in the population in the population ages 5-14. There is a possibility that the children 5-9 were shifted into the 0-4 and 10-14 ages, resulting in the lower enumerated population. There also seems to have been an undercount of children less than 15 in the 2002 census as one would expect the enumerated population in 2002 to be above that in 1992. The deficit of men aged 15 to 34 is clearly observed in the figure for all the censuses. Age ratios are further used to analyse the age structure of the population.

Figure 3.2 Age and sex structure by grouped ages, Zimbabwe 1982, 1992, 2002 and 2012 Censuses

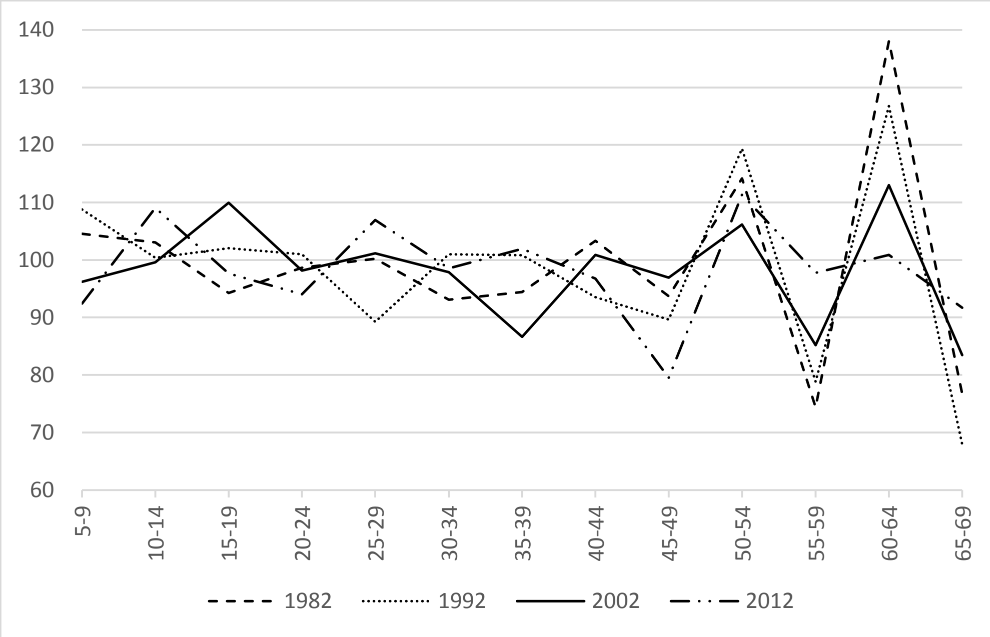


In the absence of significant exogenous factors the enumerated size of a particular cohort should be approximately equal to the average size of the immediately preceding and following cohorts, commonly known as age ratios. Age ratios are used to analyse data for displacements and undercounts. The age ratio algebraically is given as:

$$_5AR_x = \frac{2.{}_5P_x}{{}_5P_{x+n} + {}_5P_{x-n}}.100$$

Errors in the census enumeration are detected by significant departures from 100. Age ratios are shown in Figure 3.3. The age ratios above the age of 50 for all censuses depict an odd picture. The age ratios for the 1982, 1992 and 2002 census show a spike at the 60-64 age group, which has led to the rather low ratios in the adjacent age groups. Again, for all the censuses the low age ratios in the 45-49 and 55-59 age groups can be explained by the high age ratios in the 50-54 age group.

Figure 3.3 Age ratios by sex and five-year age groups, Zimbabwe 1982, 1992, 2002 and 2012 Censuses



Computation of sex ratios by individual age groups and for the country gives information on the differences in sex composition. The sex ratio is defined as the number of males per 100 females:

$$Sex\,ratio = \frac{P_m}{P_f} * 100$$

Sex ratios above 100 are an indication of excess males and a sex ratio of below 100 indicates an excess of females. In sub-Saharan Africa the sex ratio of the total population is estimated to be ranged between 97.9 to 99.7 males per 100 females and 97.1 to 99.5 males per 100 females in Zimbabwe (DESA 2013). Values outside of this range reflect either sex selective abortion or misreporting.

The sex ratio of the whole population tend to lie between 95 and 102 barring significant exogenous factors. The sex ratios of the whole population by year of census are shown in Table 3.1, which are low in comparison with the ones expected. If there is no underreporting of women this may be a sign either of high male mortality, male emigration or a low sex ratio of birth. To further investigate this, sex ratios by age groups are calculated and shown graphically in Figure 3.4. In the absence of age-sex selective migration or other exogenous factors the sex ratio should decline slowly with age from birth to middle ages, and more rapidly thereafter because of excess male mortality relative to female mortality at older ages. The sex ratios depicted in Figure 3.4 for ages greater than 35 do not inspire much confidence in the data. Sex ratios decline with age up to age

15 but from age 15 an erratic trend is observed. In 1982 for those above 40, the sex ratios are implausibly above 100, which shows that there may have been an undercount of females in the census. The same is true for the 1992 census for certain age groups where it is observed that the sex ratios rise. There is, however, a peculiar shape observed for the 2002 and 2012 censuses, which seems to be a cohort-specific spike in the sex ratios observed for ages 30-34 in the 2002 census and ages 40-44 in the 2012 census. The reason for this could, however, not be ascertained.

Figure 3.4 Sex Ratio, Zimbabwe 1982, 1992, 2002 and 2012 Censuses

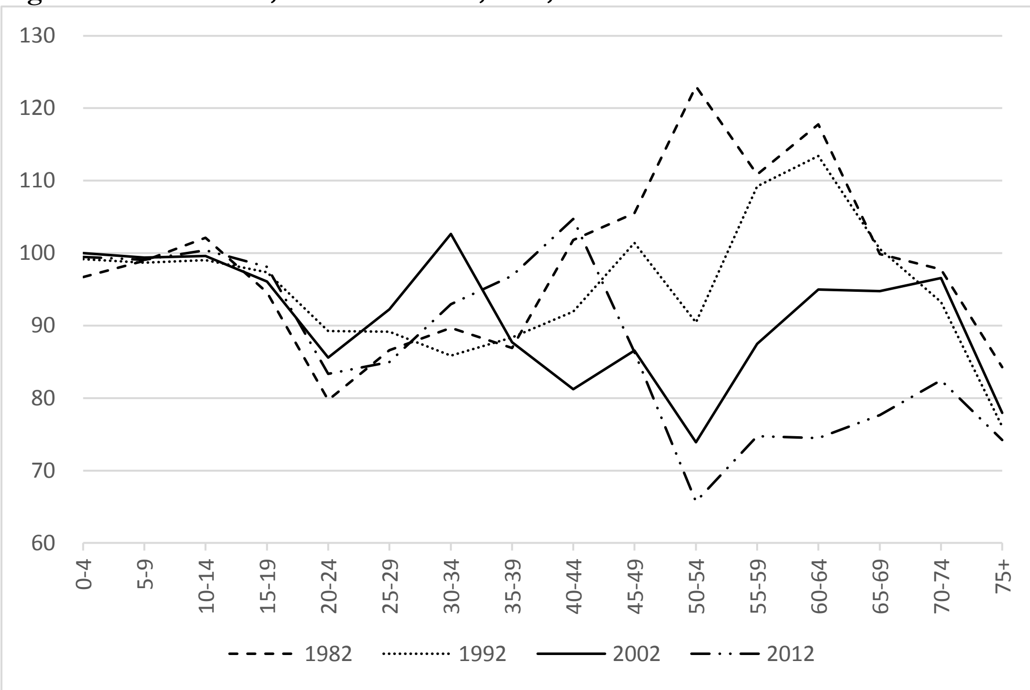


Table 3.1 Sex ratio, Zimbabwe 1982, 1992, 2002, 2012 Censuses

Census	*Sex Ratio*
1982	96.9
1992	95.4
2002	94.0
2012	92.6

The availability of multiple censuses makes it possible to compare the enumerated sizes of birth cohorts in successive censuses. The censuses in Zimbabwe were conducted exactly ten years apart. This for illustration purposes means that the population enumerated when aged 10-14 in the 1992 census will be aged 20-24 in the 2002 census. For the reason that mortality exists, the population 20-24 will be smaller than that in the 1992 census. If the population is affected my mortality alone, a systematic decline is expected in the birth cohorts in each census. Deviation from the systematic decline will point to an error in one or both censuses.

Cohort survival ratios (CSR) measure the proportion of people enumerated at age *x* to *x*+*n* at time t, ${}_nN_x(t)$, in the first census, who are still alive and enumerated in a second census *a* years later when they are aged *x*+*a* to *x*+*n*+*a* at time *t*+*a*, ${}_nN_{x+a}(t+a)$. Thus

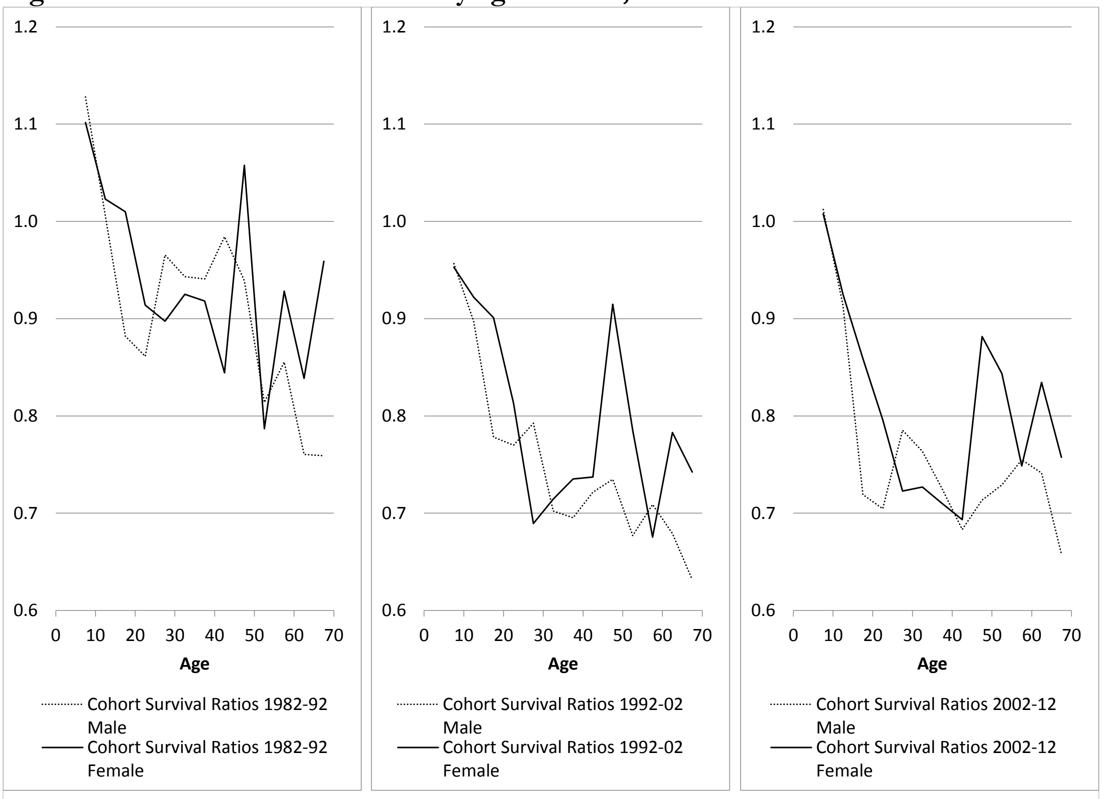
$${}_nCSR_x(a) = \frac{{}_nN_{x+a}(t+a)}{{}_nN_x(t)}$$

In the absence of substantial net migration or changing boundaries or under enumeration of a certain population, survival ratios are expected to increase from early childhood to around age 10 where they reach the maximum. From age 10 the survival ratios are expected to decline gradually and as people age the survival ratios will decline more rapidly. Plotting the cohort survival ratios by sex provides a way to analyse the quality of the data.

Figure 3.5 shows the cohort survival ratios by age and sex for the four census held in Zimbabwe. The cohort survival ratios between the 1982 and 1992 are above one, which implies that there was an undercount for both sexes in the number of children 0 to 20 in the 1982 census. There is a particular shortfall of males age 10-20 (i.e. from 10-14 in 1982 to 20-24 in 1992 and from 15-19 in 1982 to 25-29 in 1992), which is visible in all the census. A possible explanation for this is the migration of young men to look for employment.

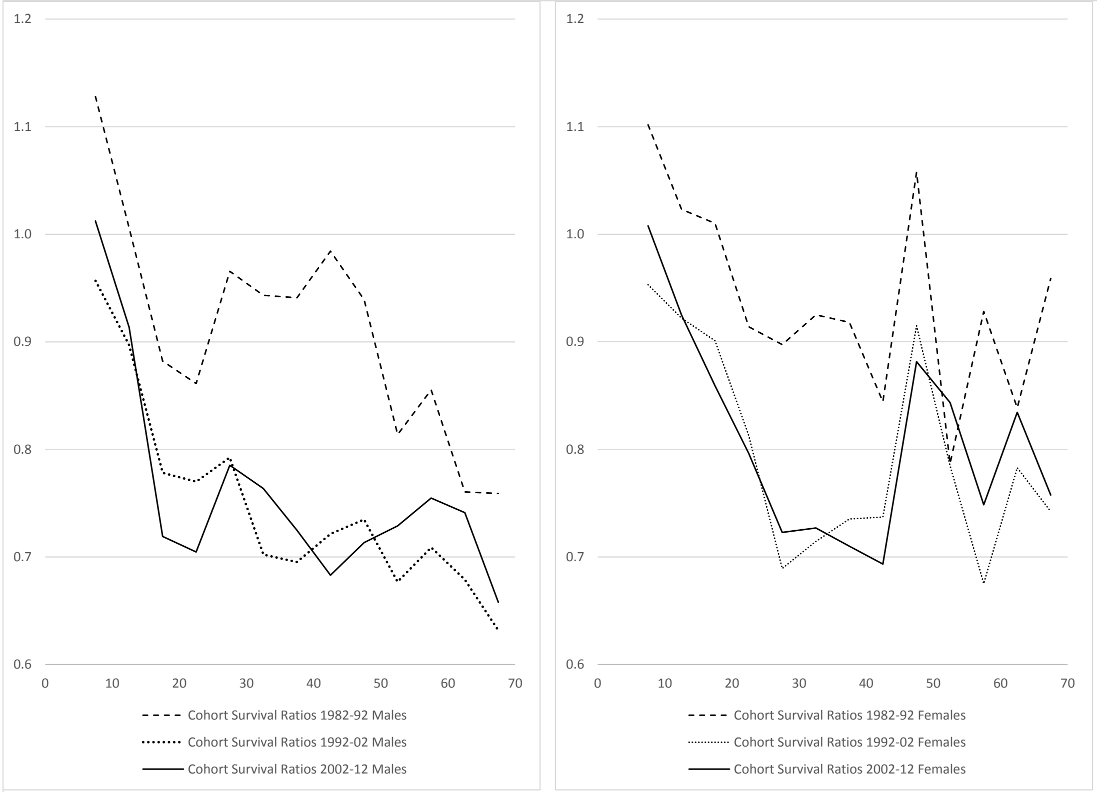
For the reason that at older ages male mortality is higher than female mortality, it is expected that the cohort survival ratios of men will be lower than those of females. Clearly for the Zimbabwean data we observe the cohort survival ratios for men being above those for women, which should not be so. For all the censuses this is observed for the 20-24 males who will be aged 30-34 in the following census.

Figure 3.5 Cohort Survival Ratios by age and sex, Zimbabwe Censuses



The cohort survival ratios for men and women separately are shown in Figure 3.6. There is a decrease in the cohort survival ratios between the 1982 and 1992 and the 1992 and 2002 censuses. This may be attributed to the HIV/AIDS pandemic, which devastated the country. The cohort survival ratios for the 2002-12 have remained almost similar with those in the 1992-2002 census.

Figure 3.6 Cohort Survival Ratios by sex and age, Zimbabwe Censuses



The erratic nature of the age ratios, sex ratios and cohort survival ratios all point to the poor quality of the data. Under enumeration has also been noted to be present in the Zimbabwean census. Exogenous factors have also played a role in trends that have been observed. Shortage of men is partly a result of migration as men search for work beyond borders because of the economic and political crisis in the country. The HIV epidemic contributed to a decline in the cohort survival ratios. The above analysis has not given much confidence in the quality of the data as there are multiple problems which have been identified.

3.2 Assessment of Demographic and Health Survey data

This section provides an assessment of the Demographic and Health Surveys conducted in Zimbabwe. Analysis is done by comparing the number of births reported in each year, birth ratios and sex ratios.

As noted already, to date there have been five Demographic Health Surveys conducted in Zimbabwe. The DHS collects information on all live births born to women aged 15 to 49 at the time of the survey. Although the number of women interviewed has more than doubled from the first survey to the most recent, the proportion of women interviewed in each survey has remained generally the same in each group as expected and shown in Table 3.2.

To determine the quality of the data, an assessment of the date of births (DoB) reported was performed. The DHS imputes dates of key information where they will not be available or inconsistences and the imputed dates are tagged. The proportion of the dates imputed gives an impression of the data quality, having more data imputed may reflect poorly on to the quality of the data. Table 3.3 shows the percentage completeness of date of births reported. The proportion with missing or inconsistent information on either month of birth or year of birth, although minimal has continued to decrease through the surveys.

Table 3.2 Proportions of women interviewed and total women interviewed in each survey, Zimbabwe Demographic and Health Surveys

Age group	*ZDHS 1988*	*ZHDS 1994*	*ZDHS 1999*	*ZDHS 2005*	*ZDHS 2011*
15-19	0.24	0.24	0.24	0.24	0.21
20-24	0.20	0.21	0.22	0.22	0.20
25-29	0.16	0.15	0.18	0.16	0.18
30-34	0.14	0.14	0.11	0.14	0.14
35-39	0.11	0.11	0.11	0.09	0.11
40-44	0.08	0.09	0.08	0.08	0.08
45-49	0.07	0.07	0.06	0.07	0.07
Total women interviewed	4 201	6 128	5 907	8 907	9 171

Table 3.3 Completeness of date of births, Zimbabwe Demographic and Health Surveys

	Completeness of mothers DOB	*Completeness of children's DOB*
ZDHS 1988	89.9	99.4
ZHDS 1994	96.0	99.5
ZDHS 1999	96.9	99.3
ZDHS 2005	98.9	99.3
ZDHS 2011	99.6	98.8

As referred to in previous chapters, the DHS data at times suffers from errors of displacement or omission of births as a result of interviewers desiring to avoid additional questions asked about children born since some cut-off date, which is usually the 1st of January of the fifth year prior to the survey. In order to investigate this phenomenon in the Zimbabwe DHS data, an inspection is done to all births that occurred in each calendar year 10 years prior to each survey. One can plot in single years the number of births that occurred each year for the years preceding each survey. Displacement or omission is recognised by a sharp drop in the number of births in the fifth year whereas there will be an excess of births in the year after the fifth year. For example, if births are shifted from the 2010/11 ZDHS, one would expect a deficit of births in the 2005 and an excess of births in 2004.

By looking at the number of births in each calendar year, there is not much evidence of shifting of births in the first four surveys, seen in Figure 3.7. In the 1994 survey it actually seems that there is a deficit of births recorded in the sixth year before the interview, 1988. There is a sudden increase of births from 1998 to 1999 in the 2005/06 ZDHS, which is odd as a steady increase is expected rather than a sudden spike. Oddly, the 2010/11 ZDHS is the only survey which shows displacement of births from the fifth year to the sixth year.

Figure 3.7 Births by calendar year, 1988, 1994, 1999, 2005, 2011 ZDHS

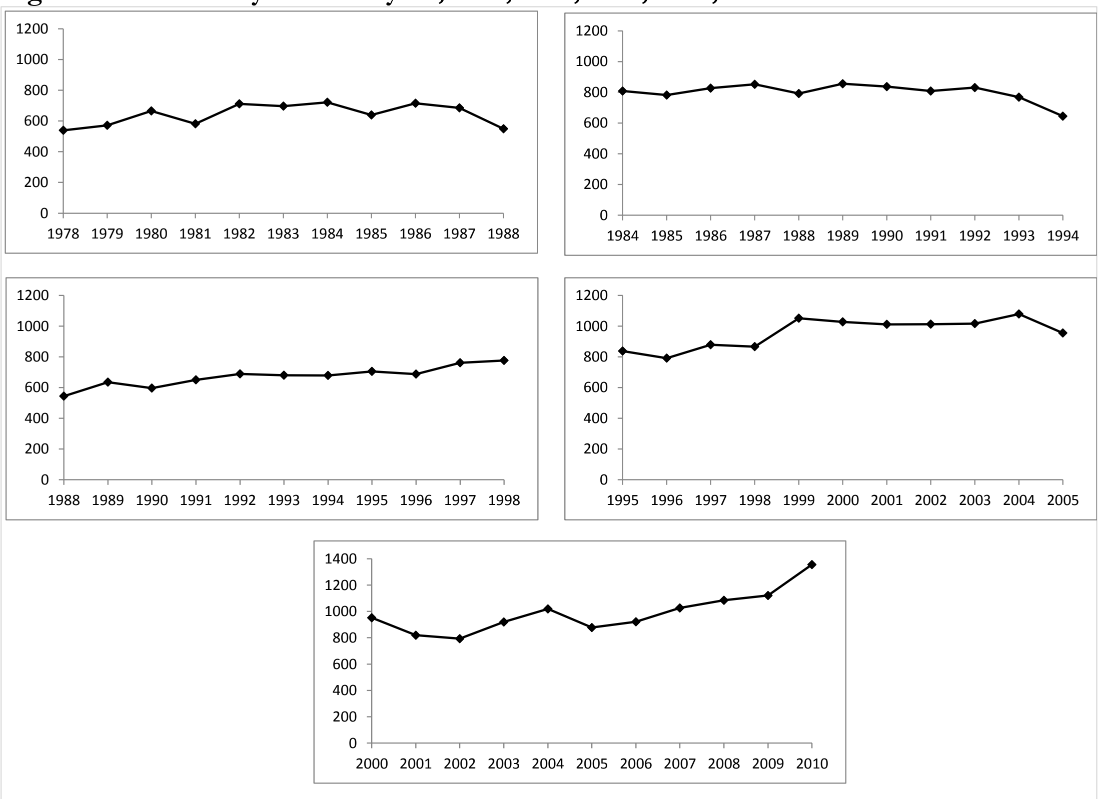
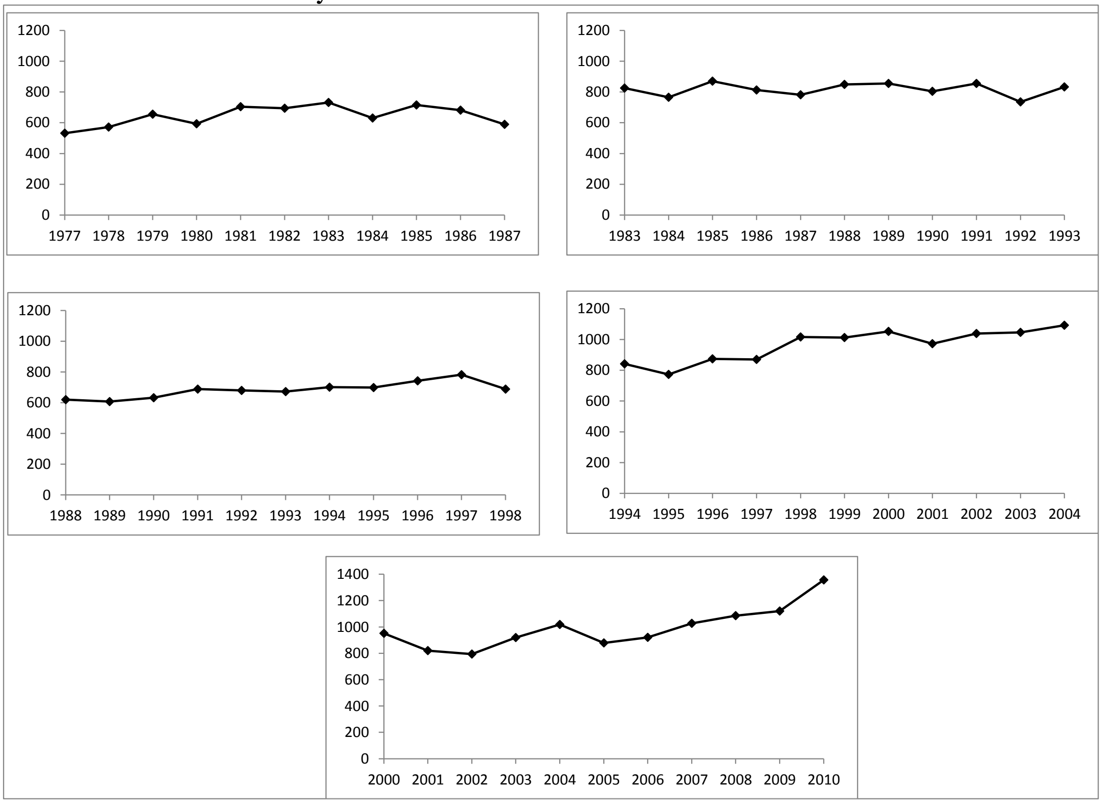


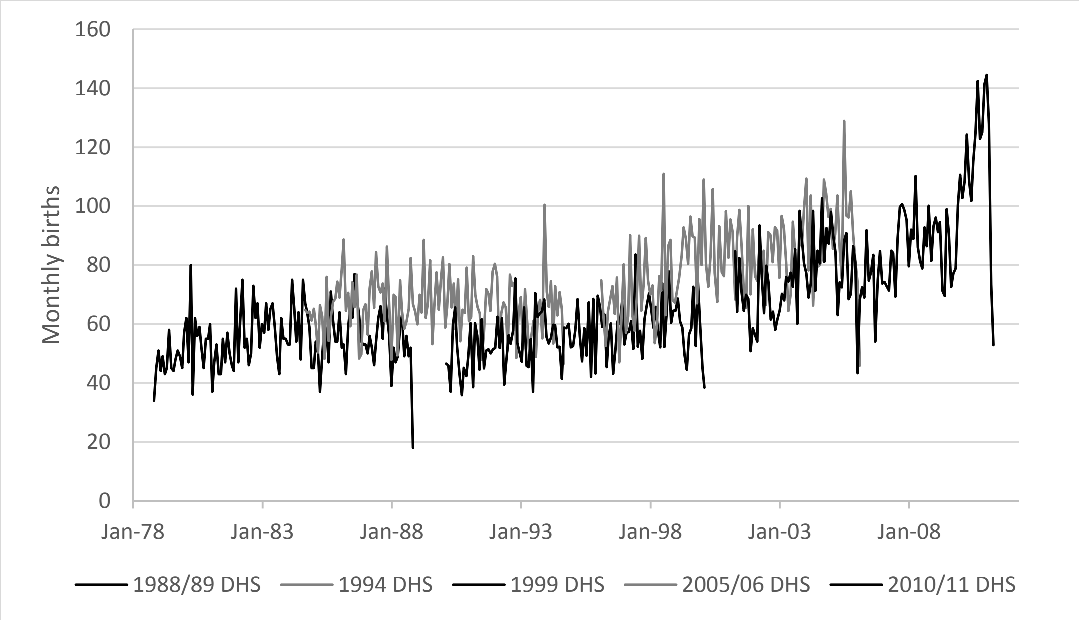
Figure 3.8 shows the births reported yearly from the median date of the interview. The DHS of 1988/89 and 2006/06 show omission of births in the fourth year before the interview. The 2010-11 DHS show again displacement of births from 2005 to 2004, which is the fifth and sixth year respectively.

Figure 3.8 Births yearly from median date of interview, Zimbabwe Demographic and Health Surveys



Further, an investigation is conducted into the births that occurred each month for the ten years before each survey. The reported number of births each month are shown in Figure 3.9. There are monthly fluctuations for all the surveys but overall the number of births in the following and preceding census is consistent. For the periods that overlap, the number of births seems to be slightly higher in the second survey than the first from changes in the sample size as a result from the changes in the sample size. An illustration: the 1994 DHS for the same period as the 1988/89 (overlapping period) DHS shows roughly the same or more births in the 1988/89 DHS.

Figure 3.9 Births reported to women 15-49 years, Zimbabwe Demographic and Health Surveys



To further investigate displacement of births, an analysis is done of birth ratios. Birth ratios are defined as

$$Birth\ Ratio = \frac{2B_t}{B_{t-1} + B_{t+1}}$$

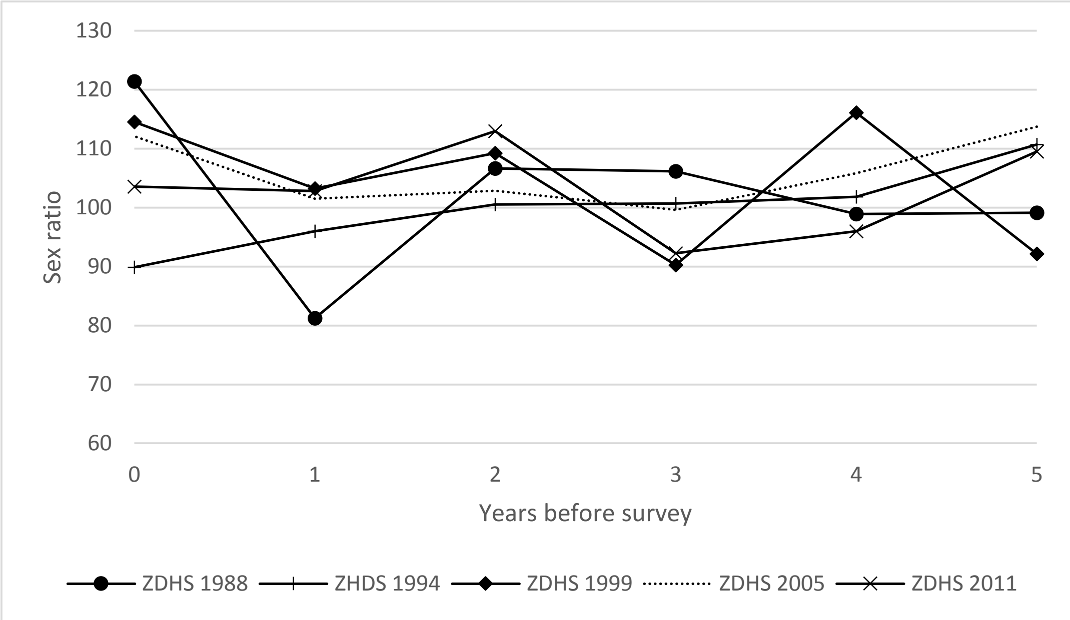
where B_t is the number of births that occur in year *t* and B_{t-1} and B_{t+1} are the number of births occurring in the year before and after year *t* respectively. By using birth ratios one can highlight displacement errors since the birth ratio in the cut-off year will be low while that in the preceding year will be high. Table 3.4 shows the birth ratios calculated for the cut-off year and the year preceding it for all five surveys. In the absence of displacement, one would expect the birth ratios to be 100. A small degree of displacement is visible in the first four surveys except the ZDHS 1994. The birth ratios for the 2010/11 ZDHS show a higher level of displacement of births, which concurs with what was observed from the graphs Figure 3.7 and Figure 3.8.

Table 3.4 Birth ratios by survey year, Zimbabwe Demographic and Health Surveys

Year of survey	*5 years before the survey*	*6 years before the survey*
ZDHS 1988	97.2	111.3
ZHDS 1994	104.0	91.9
ZDHS 1999	95.6	104.3
ZDHS 2005	99.4	110.4
ZDHS 2011	92.1	113.2

The sex ratio can be used to assess data for sex selective omission in the DHS birth histories. Sex ratio at birth usually lie in the range of 100 to 106 males per 100 females and values which are outside this range are usually a sign of sex selective omission of births. As shown in Figure 3.10, the sex ratio are quite erratic which calls to question the quality of the data.

Figure 3.10 Sex ratio for periods before the survey, Zimbabwe Demographic and Health Surveys



3.3 Analysis of background characteristics of women aged 15-49

Background characteristics of the women aged 15-49 in the census and surveys are given in this section and shown in Table 3.5. The data released for the Demographic and Health Survey includes a weighting variable, which is used to make sample data representative of the entire population. The Demographic and Health Survey distribution presented in Table 3.5 are weighted as appropriate, implying that comparisons between Demographic and Health Survey data and census data can be done.

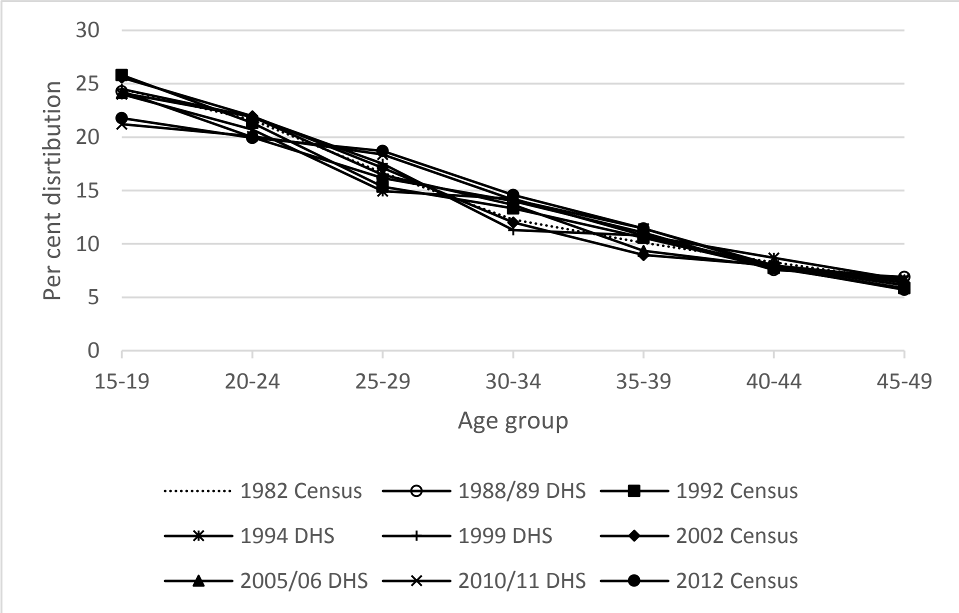
Table 3.5 Background characteristics of all women 15-49, Zimbabwe censuses and surveys

	1982 Census	*1988/89 DHS*	*1992 Census*	*1994 DHS*	*1999 DHS*	*2002 Census*	*2005/06 DHS*	*2010/11 DHS*	*2012 Census*
Age group									
15-19	24.5	24.3	25.8	24.0	24.5	25.6	24.2	21.2	21.8
20-24	21.6	20.0	21.3	20.7	21.9	22.0	21.9	20.1	19.9
25-29	16.7	16.2	15.4	14.9	17.5	17.1	16.5	18.4	18.7
30-34	12.3	14.0	13.3	14.2	11.3	12.0	13.6	14.1	14.6
35-39	10.1	11.0	10.6	10.8	10.8	9.0	9.4	11.5	11.4
40-44	8.3	7.6	7.7	8.7	7.9	8.0	7.8	8.0	7.8
45-49	6.6	6.9	5.9	6.6	6.1	6.4	6.6	6.8	5.7
Average age	28.2	28.4	27.9	28.5	28.0	27.8	28.1	28.8	28.5
Residence									
Urban		33.5	33.9	32.2	38.6	35.7	39.3	38.7	
Rural		66.5	66.1	67.8	61.4	64.3	60.7	61.3	
Education									
No education		13.5	12.7	11.1	6.7	5.7	4.3	2.3	6.3
Primary		55.9	50.0	47.3	40.2	36.6	32.6	28.0	24.6
Secondary		29.7	34.1	40.0	50.2	53.0	60.1	65.1	60.2
Higher		0.9	3.2	1.6	2.8	4.6	3.0	4.6	6.2
Missing		0.0	0.1	0.0	0.0	0.1	0.0	0.0	2.6

3.3.1 Age

The distribution of the women by age is shown in Figure 3.11. Overall there seems to be consistency between the proportion of women interviewed in the census and DHS, with similar proportions of women being observed in each age group. The 2012 census shows a decrease in the proportion of women aged 15-24 and an increase in the proportion aged 25-29.

Figure 3.11 Age distribution of women 15-49 by age group



3.3.2 Residence

Rural/urban differentials have implications on fertility estimates. The 1992 Census shows a more urbanised population that the 1988/89 and 1994 ZHDS. The census of 2002, on the other hand, shows a less urbanised population than the two ZDHS following and preceding the census. Migration to urban areas has been observed by the overall increase in the proportion of the population residing in urban areas. In the 1988/89 ZDHS 33.5 per cent of the population resided in urban areas whereas in the 2010/11 ZDHS 38.7 resided in urban areas (Table 3.5). As there is no data from the 2012 census, the population by residence for that period is not available.

3.3.3 Education

The highest level of education attained by women has increased with time, with greater proportions of women attaining primary, secondary and higher education (Table 3.5). In earlier surveys most women had only completed primary education but from the 1999 ZDHS a change is seen where the greatest proportion is seen to have completed secondary education. For any further analysis which includes education, secondary and higher education will be combined because of the small numbers of women with higher education.

3.4 Methods

The above section has looked at the demographic characteristics. The following section describes the methods used to calculate fertility directly and indirectly. The methods described are dependent on the available data. The method used to calculate cohort period fertility rates from birth history data is also described. An outline of the method used to calculate both conventional and projected parity progression ratios is also shown.

3.4.1 The relational Gompertz model

Using the fertility estimates derived from the births in the 12 months preceding the census and the average parities, one may apply the relational Gompertz model to adjust and correct fertility distributions for the underreporting of births and errors in the data on lifetime fertility. Omission or over-counting of recent births does not affect the shape of the fertility distribution but only affects the level of the fertility reported, although if mothers exaggerate their ages, fertility rates reported for older women may be exaggerated (Zaba 1981). As women age they tend to under-report the number of children that they have had by omitting children that have died or children residing elsewhere. The relational Gompertz method helps in assessing the quality of the data for both parity and fertility rates, provides estimates of the correct level of fertility as well as gives evidence of fertility trends.

The transformation used as a basis for the relationship between the average parities and the cumulated fertility is based on Gompertz transformation, often referred to in the literature as a 'gompit':

$$Y(x) = -In[-\ln(G(x))]$$

Brass showed than an approximately linear relationship exists between the gompits of the standard fertility cumulants and the gompits of a defined standard.

$$Y(x) = \alpha + \beta Y^s(x)$$

where $Y^s(x)$ is the gompit of the standard fertility cumulants. If the fertility schedules are the same then α=0 and β=1. Alpha (α) represents the extent to which the mean age of childbearing in the population differs from the standard: negative values of alpha make the mean age older. Beta (β) represents the extent to which the spread of childbearing differs from the spread in the population: the spread of the distribution is narrower for larger values. Limitations of the method are that it requires total fertility as input, which is not logical as one is trying to calculate the total fertility. The second problem is that it assumes constant fertility over time. Zaba (1981) addressed the limitations of the above approach by showing that the model can be expressed as:

$$z(x) - e(x) = \alpha + \beta g(x) + \frac{c}{2}(\beta - 1)^2$$

where $e(x)$, $g(x)$ and c are functions of the chosen standard and $z(x)$ if the gompit of the ratios of the adjacent cumulated period fertility measures. The same relationship is used for parity data, as shown below:

$$z(i) - e(i) = \alpha + \beta g(i) + \frac{c}{2}(\beta - 1)^2$$

The plot of $z(i)$-$e(i)$ against $g(i)$should be a straight line. Estimates of α and β found after fitting process are used to transform the gompits of the standard into the fitted gompits. The points derived from the parity data are known as *P*-points and *F* points are the points derived from the fertility rates. A diagnosis of errors in the present in the data can be done by using the table below:

Table 3.6 Errors in the data from plot of $z(i)$-$e(i)$ against $g(i)$

True trend in fertility level	*Type of error present in data*	*Effect on plots of y values*
Constant	None	'*F*' points and '*P*' points lie on one straight line
Constant	Omission of children ever born by older women	'*P*' points curve upwards at older ages
Constant	Exaggeration of number of current births to older women	'*F*' points curve downwards at older ages
Constant	Age exaggeration	'*F*' points and '*P*' points both curve downwards at older ages
Falling	None	'*P*' line has gentler slope and lower intercept than '*F*' line
Rising	None	'*P*' line has steeper slope and higher intercept than '*F*' line

Source: Zaba (1981)

3.4.2 Description of tfr2

Schoumaker (2013) published a STATA module, *tfr2*, that can be used to calculate age specific fertility rates and total fertility rates from birth history data collected in Demographic and Health Surveys. The module can also be used to reconstruct fertility trends as well as for the estimation of fertility differentials. Three year estimates computed by five year age groups are calculated from the module but single year estimates can also be calculated. Three year estimates are calculated so as to avoid fluctuations caused by small numbers if calculated for single years. In order to calculate the age specific fertility rates the period of exposure must be calculated for each woman. The data is first transposed into a person period data file where each woman's data is transposed into many lines which represent the period of exposure in each age group and the number of births that occurred within each period. Poisson regression is used to compute the age specific fertility rates for observations where the women were aged above 15. The model is given as

$$In\ \mu_i = In\ t_i + \sum_{k=1}^{K} \beta_k x_{ki}$$

where μ_i is the expected number of children born in each time segment, t_i is the length of the time segment (exposure), and x_{ki} are the explanatory variables (Schoumaker 2009). In applying Poisson regression the number of births over the course of the sub-period is the dependant variable and the five year age groups the independent variables (Schoumaker 2009). The offset variable which is a variable whose coefficient is equal to one is used to control for exposure (length of the segment). Taking the exponent of the regression coefficients of age groups and then summing and multiplying by five gives the total fertility rate for the reference period.

Using the same principle noted above, reconstruction of fertility trends over a period of 15 years preceding the survey can be done. The data are organised by calendar year and subdivided when a woman passes from one age group to the next. The assumption used in this case is that fertility schedule is constant. As Schoumaker (2013) notes, reconstructing fertility trends can be used to evaluate data quality: erratic drops in the total fertility rate, especially at the year of cut-off of the lengthy health module provides evidence of displacement/omission of births by interviewers in order to avoid the health module.

3.4.3 Cohort Period Fertility Rates

Cohort-period fertility rates (CPFRs) measure the fertility of a cohort of women (grouped into quinquennial age groups) in a defined period (grouped in five year periods before the survey) (Moultrie 2013a). Periods of five years and cohorts of width of five years are considered so as to reduce sampling errors and the effects of age misstatement (Goldman and Hobcraft 1982). Calculation of CPFRs allow for the computation of P/F ratios from birth histories, help in assisting to identify problems in the data, and give total fertility rates for the two five year periods preceding the survey (Moultrie 2013a). The assumption is made that there is no differential fertility between women interviewed at the survey and those not interviewed as a result of death or migration. Computation of CPFRs requires a tabulation of the number of births that have occurred in five year periods before the survey by the age group of the mother. The number of women in each age group at the time of the survey is also required. Cohort period fertility rates are then calculated based on the age of the mother at the time of the survey given as:

$$f_{i,j} = \frac{1}{5}\left(\frac{B_{i,j}}{N_i}\right)$$

where i denotes the age group and j is the successive five year period before the survey. The results of the above step are then transposed so the data are classified by age at the end of each period rather than the survey date.

$$f^*_{k,j} = f_{k+j,j}$$

Measures of cohort fertility (*P*) are calculated by summing up the diagonal of each cohort:

$$P_{k,j} = 5.\sum_{z=0}^{k-1} f^*_{k-j,z+j} = 5.\sum_{z=0}^{k-1} f_{k+j,z+j}$$

By cumulating rates in each column, period fertility (*F*) are obtained:

$$F_{k,j} = 5.\sum_{z=1}^{k} f^*_{z.j} = 5.\sum_{z=1}^{k} f_{z+j,j}$$

The two estimates of fertility are then obtained from this stage where, $F_{7,0}$ is the total fertility rate for 0-4 years before the survey assumed to apply 2.5 years before the survey. Fertility in the oldest age group is generally very low and if one assumes that the fertility in this group is unchanging 0-4 and 5-9 years before the survey (Moultrie 2013a), one can calculate a second estimate of total fertility, which applies 5-9 years before the survey (7.5 years before the survey). The equation is given as:

$$TF_1 = F_{6,1} + 5.f^*_{7,0}$$

P/F ratios are then calculated as:

$$\frac{P}{F}(k,j) = \frac{P_{k,j}}{F_{k,j}} = \frac{5.\sum_{z=0}^{k-1} f^*_{k-j,z+j}}{5.\sum_{z=1}^{k} f^*_{z.j}} = \frac{5.\sum_{z=0}^{k-1} f_{k+j,z+j}}{5.\sum_{z=1}^{k} f_{z+j,j}}$$

By looking at the P/F ratios it is possible to determine an approximate date for the start of the fertility decline as well as to assess omission and displacement errors (Moultrie 2013a). Diagnosis is done by looking at the P/F ratio for periods before the survey. P/F ratios close to one in every age group imply that fertility has been constant and increases in the P/F ratios by age of mother imply fertility decline is underway. If in period j before the survey fertility has been constant in all age groups and in period j-1 there is an increase in the P/F ratio by age group this implies that fertility decline began approximately at the date dividing the two periods. If the P/F ratio in a diagonal departs uncharacteristically from the trend in the P/F ratio in any period then this is representative of age misstatement or omissions in births if observed in the oldest age group.

The cohort period fertility rates also permit the assessment of the quality of the data. Potter effects result from women bringing births closer to the date of the survey but reporting recent births correctly (Potter 1977). This has been noted to mainly occur when birth histories are collected in the order that the births occurred rather than from youngest to oldest. This results in correct fertility rates for the recent period, underestimation of fertility in the period further back in time and exaggerated fertility in the period in-between. Brass effects are a result of older women reporting their children as being older that they actually are. Because children are reported as older this results in overestimation of fertility for periods further back in time and underestimation in the most recent periods, resulting in a false sense of fertility decline. Reading along the rows from right to left in the table showing the cohort period fertility rates will show whether Brass or Potter effects exist. Brass effects are observed by implausibly high last values and Potter effects are observed by uncharacteristic patterns in the middle periods. As already noted, displacement or omissions may occur when the interviewer wishes to skip the lengthy health module. Omission and displacement may be observed by an exaggeration of fertility decline in the recent period preceding the survey and P/F ratios, which show a much greater fertility decline.

3.4.4 Parity progression ratios

Age specific fertility rates and total fertility rates are the most frequently used and most intuitive measures of fertility but they can be affected by changes in the timing of births, commonly referred to as tempo effects. This means that short-term changes in fertility are not readily identified by these measures. Potter's effect arises when women incorrectly report births of children by pushing them further back than they should be. This affects fertility measures as it gives a false sense of fertility decline. Parity progression ratios are robust towards tempo effects and misreporting of dates of birth (Feeney and Yu 1987). Parity progression ratios show the proportion of women who had at least *i* live births who then progress to *i+1* children (Preston, Heuveline and Guillot 2001).

Conventional cohort parity progression ratios are calculated for cohorts of women who have completed, or are close to completing their childbearing. The use of using age cohorts has the advantage that the parity progression ratios reflect the progression of a real cohort of women and that it is possible to view the process of family formation (Ní

Bhrolcháin 1987). For women who have not completed their childbearing the data are incomplete (censored) as the information collected only goes up to the survey date. These data also suffer from selection bias as women predisposed to having children faster provide more information than other women. As a result of these two biases, parity progression ratios for women who have not completed childbearing cannot provide a reliable perspective on family formation dynamics. The method of projected parity progression ratios (PPPRs) has been designed to cater for the women who have not completed childbearing. PPPRs give the proportion of women who are expected to progress from parity *i* to parity *i*+1 by the end of their childbearing and these can be used to provide some insight into likely future fertility dynamics.

3.4.4.1 *Parity progression ratios and projected parity progression ratio from census data*

This section describes the procedure outlined by Moultrie and Zaba (2013) to calculate (projected) parity progression ratios from census data. Tabulations of the number of children ever born by age group of the mother, ${}_5N_x(i)$ and the number of births in the last year by mothers' age and parity denoted, ${}_5B_x(i)$ are required. Denoting the highest parity as π, the number of women ever attaining parity i or higher, ${}_5W_x(i)$ for each age group is the sum of all women who have reached parity i and or greater and is shown algebraically as:

$${}_5W_x(i) = \sum_{j=1}^{\Pi} {}_5N_x(j)$$

The highest parity ever attained is denoted as π. It then follows that the proportion of women in each age group who have at least *i* children, ${}_5M_x(i)$ is given by:

$${}_5M_x(i) = \frac{1}{{}_5N_x} . \sum_{j=1}^{\Pi} {}_5N_x(j)$$

The parity progression ratio, ${}_5a_x(i)$ is obtained by dividing the proportion of women in each age group who have had at-least $i+1$ children by those who have had at-least i children given as:

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

For women who have completed or are close to the end of their childbearing, those aged 45-49, the parity progression ratios are calculated as normal. The following steps detail how to calculate projected parity progression ratios for women who have yet to complete their childbearing. Age-order specific fertility rates (AOSFRs) are calculated from the births in the last year as reported by age group and number of women as:

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

Implicit in this calculation is the assumption that women can have at most one birth in the past year. In order to project the parity progression ratios, we have to assume further that these age-order specific fertility rates will continue to apply in the future. Cumulating age order specific fertility rates for order i and each age group and multiplying by five gives the total order fertility rate (TOFR):

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

The quantity ${}_5TOFR_{45}(i) - {}_5TOFR_x(i)$ measures the additional proportion of women expected to achieve parity i between age *x+5* and the end of childbearing assuming AOSFR remain the same in the future. Because the census collects information on the age of the mother and not the age at the time of the birth, there is an approximate half-year shift, which means the cumulated fertility rates apply to ages 19.5, 24.5 etc. The proportions ever attaining each parity apply roughly to the midpoint of each age group. Interpolation is required to shift the age order rates so that they apply at the central age of each age group. Linear interpolation is inappropriate in this case because of the sigmoid nature of the AOSFRs. The gompit transform is used to transform the sigmoid function into a straight line. First, before interpolation, the proportion of the total order specific rate achieved by the upper limit of the age group is calculated for each age group as:

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

The shifted proportion of the TOFR to the conventional midpoint is given as:

$$ {}_5\theta_x^* = \exp\left(-\exp\left[-\left[\left(0.4.\left\{-\ln\left(-\ln\left({}_5\theta_x(i)\right)\right)\right\} + 0.6\left\{-\ln\left(-\ln\left({}_5\theta_x(i)\right)\right)\right\}\right)\right]\right]\right) $$

Moultrie and Zaba (2013) suggest that when ${}_5\theta_x^*(i) < 0.3$ the projected parity progression ratios should be ignored as there is too large a projected component and significant uncertainty resulting in the projected parity progression ratio. Where ${}_5\theta_x^*(i) < 0.5$, results should be treated with caution. The next step is to calculate the additional proportion of women expected to achieve parity i and this is given by:

$$_5TOFR_{45}(i) - _5TOFR_x(i) = _5TOFR_{45}(i).(1 - _5\theta_x^*(i))$$

The proportion of women in each age group who are expected to have at least i children is derived by adding the additional proportion of women expected to achieve parity i in the future to the proportion of women aged in each age group who have had i or more births:

$$_5M_x^* = _5M_x(i) + _5TOFR_{45}(i).(1 - _5\theta_x^*(i))$$

Dividing the expected proportions of women in each age group projected to achieve at least parity $i+1$ with that of at least parity i the projected parity progression ratios are obtained (shown below)

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

3.4.4.2 Parity progression ratios and projected parity progression ratio from DHS data

Parity progression ratios (both conventional and projected) can also be calculated using data from birth histories. In order to cater for the fact that for young women the data are select, a method proposed by Brass and Juárez (1983) is used to calculate PPPRs using birth histories. The method controls for selection effects by truncating the data; the experience of one cohort is truncated and compared to the adjacent younger cohort (indices of relative change).

Two tabulations are required to calculate PPPRs from survey data. The first is a tabulation of the number of women by age group who have had i children, C(x, x+5). A second table is required which shows the number of women by age group who have had i children but excludes births to women for the five year period before the survey (truncated), C(x+5, x+10). Truncation makes the two cohorts comparable as they refer to childbearing up to the same age. Parity progression ratios are then calculated for each cohort and parity for both the truncated and un-truncated data. Indices of relative change, defined as the ratio of the parity progression ratio in the un-truncated cohort to the parity progression ratio in the truncated cohort are calculated. An example of how to calculate the index is shown below for the first two age groups and where n is parity.

$$Index(1,n) = \frac{PPR(15-19,n)}{PPR^t(20-24,n)}$$
$$Index(2,n) = \frac{PPR(20-24,n)}{PPR^t(25-29,n)}$$

The index of relative change is an indicator of the changes in fertility between the truncated and un-truncated cohorts. An index which is less than one implies that fertility of the younger cohort has fallen relative to the older cohort fertility five years previously. The indices of relative change are then chained together to derive PPPRs. If few women have experienced the parity progression in question, the indices of relative change derived from these are unreliable. As a rule of thumb, if the proportion of women who have undergone a given parity progression is greater than 80 per cent then the degree of credibility is high. If, on the other hand, the proportion of women is between 65-80 per cent, a lesser degree of confidence and for anything less than 65 per cent the results are considered as unreliable and cannot be trusted (Moultrie, Dorrington, Hill *et al.* 2013). The assumption made is that the ratio of values with equivalent censoring is the same as the ratio of corresponding values without censoring.

PPPRs are obtained iteratively by multiplying the indices of relative change to the parity. Considering the parity progression ratio for the women 45-49 to be the base, the projected parity progression ratio for the women 40-44 will be obtained by multiplying the PPPRs of the base year and the index of relative change for women 40-44. The process is repeated iteratively as shown below:

$$\begin{aligned}
&PPPR(7,n) = PPPR(7,n)\\
&PPPR(6,n) = PPPR(7,n) * Index(6,n)\\
&PPPR(5,n) = PPPR(6,n) * Index(5,n)\\
&\vdots\\
&PPPR(1,n) = PPPR(2,n) * Index(1,n)
\end{aligned}$$

An advantage of calculating PPPRs is that projected completed fertility rates can be derived. These can be compared to the total fertility rates obtained from direct estimation of fertility from subsequent birth history data.

An appraisal into the accuracy of the census and survey data has been presented as in all demographic analysis an appraisal of the base data is highly important as it points to the reliability of the estimates. The methods described in this chapter are applied to the data and the results are presented in Chapter Four.

4 ANALYSIS

The objective of this chapter is to examine fertility trends in Zimbabwe over time. Changes in the age specific fertility rates (ASFR), total fertility rate (TFR), cohort-period fertility rates (CPFRs) and (projected) parity progression ratios are examined and discussed.

4.1 Estimates of fertility from census data

4.1.1 1982 Census

The official date for the 1982 census was the 18th of August. No dataset is available to the public from the census thus the data used in this analysis is from the published census report.

The census report for 1982 estimated the total fertility rate as 5.6 children per woman (Central Statistical Office 1985). In order to correct the census data for errors commonly found in fertility data associated with too few or too many births being reported in the reference period, and the under-reporting of lifetime fertility and errors of age reporting among older women, the relational Gompertz method was applied. As alluded to in the previous chapter, the plot of $z(i)$-$e(i)$ against $g(i)$ can be used to diagnose errors present in the data. An analysis of the plot (Figure 4.1) shows the F points curving downward at the oldest ages signifying age exaggeration. The P points curve upward, meaning there has been parity omission, and because the F points are almost in line with the P points there is no real sign of fertility decline. The plot of the P/F ratio, Figure 4.2 does not show a clear trend of fertility decline, the older cohorts have almost constant fertility and a sharp drop is observed for the 30-34 age group, which rises again for the younger cohorts. The expectation is that if there is fertility decline, the P/F ratios will increase systematically by age as the cumulated lifetime fertility would be greater than cumulated current fertility (Moultrie, Dorrington, Hill *et al.* 2013). The evidence shows no clear trend of fertility decline in 1982. The corrected total fertility rate after applying the relational Gompertz method is 6.3 children per woman. Table 4.1 shows the published average parities and age specific fertility as well as the adjusted age specific fertility rates from the 1982 census.

The mean number of children ever born among women age 45-49 is estimated to be 6.6 children per woman (Central Statistical Office 1985). A plot of the average parities by age group of women has a sigmoid shape (Figure A.1). Of interest is how the parities of the women 40-44 and 45-49 flattens out, which is a sign that there was underreporting of children in those ages. Overall, the average parities and total fertility rate show fertility being three times higher than replacement level fertility.

Figure 4.1 Plot of *z*()-*e*() against *g*(), all data points, Zimbabwe 1982 Census

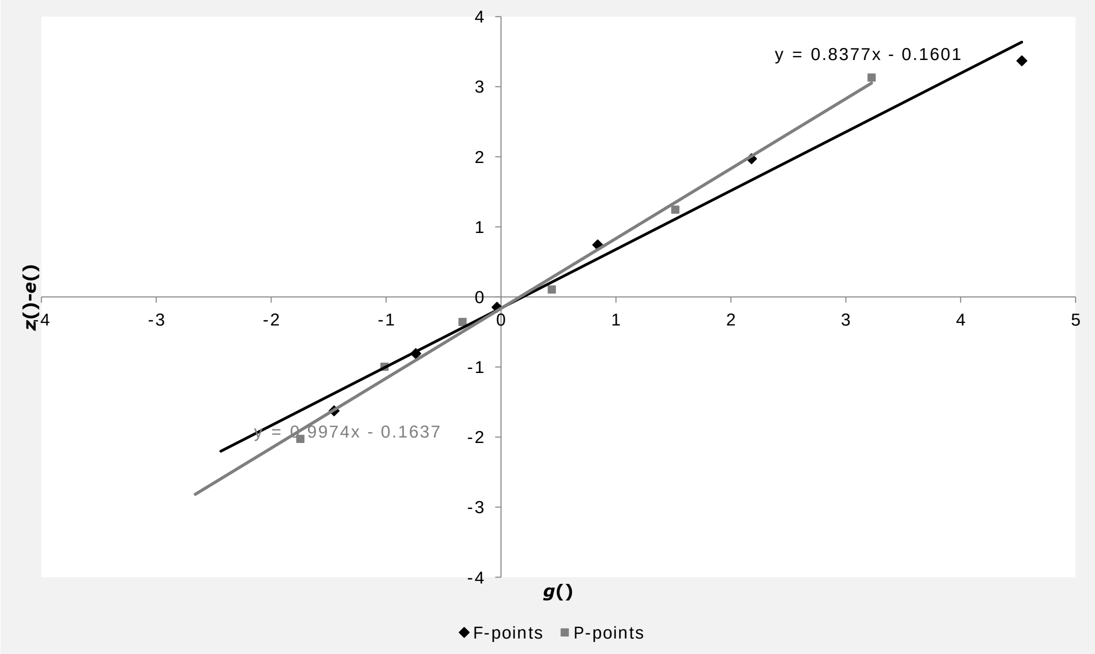


Figure 4.2 P/F ratio, Zimbabwe 1982 census

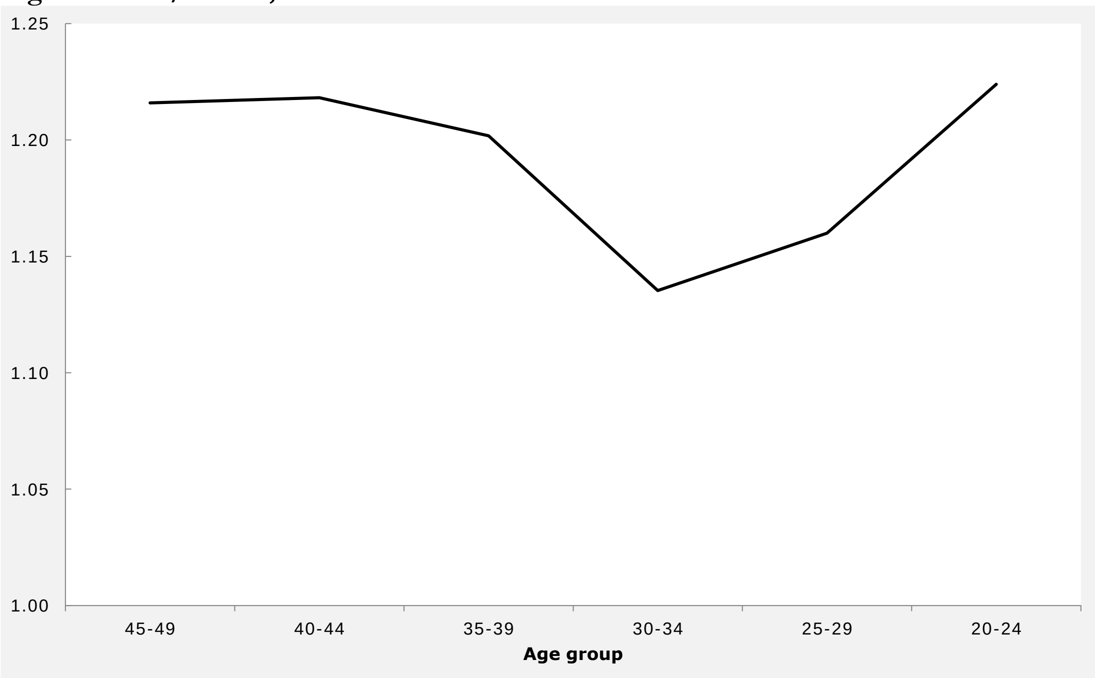


Table 4.1 Average Parities and ASFR, Zimbabwe 1982

Age group	Published Average Parities	Published ASFR	Adjusted ASFR
15-19	0.185	0.091	0.155
20-24	1.512	0.258	0.280
25-29	2.903	0.253	0.281
30-34	4.175	0.225	0.243
35-39	5.567	0.165	0.187
40-44	6.421	0.093	0.095
45-49	6.639	0.038	0.015
Total fertility rate		5.6	6.3

4.1.2 1992 Census

The 1992 census, officially held on the 18th of August sought information from women aged 12 to 49 about the number of live births they have had (living elsewhere, living in household and those who have died). For consistency with other censuses and also considering that the fertility rates of those aged 12-14 is quite low only women aged 15 to 49 are considered.

Although the proportions are quite small and do not have a significant bearing on the results there is need to highlight some discrepancies which were noticed. A small proportion, 0.04% of the women who reported having a live birth in the 12 months before the survey had the total number of children ever born being less than the total number of births in the 12 months before the survey. Furthermore, some women reported the same number of children ever born as the number of births in the last year for parities greater than three. These errors may be attributed to the process of data entry done manually and/or respondents not understanding the question asked.

Implausible parities which are italicised in Table 4.2 were corrected using the rule of thumb suggested by Moultrie (2013b). Women who have more children than those stated by this rule of thumb have the information on the number of children ever born recorded as missing. As shown in Table 4.3 the proportion of women who had implausible parities was very low. Table 4.3 also shows that the proportion missing of the data is quite negligible and can be ignored from calculation of average parities. An el-Badry correction is unnecessary in this case and the assumption is made at this point that the average parity of the women with stated parities is the same as that of women with unstated parities. The average parities are calculated and shown in Table 4.3.

The average parities show that by the end of childbearing women would on average have had 6.7 children per woman. The calculated average parities are similar to those published by the Census 1992 Report. The Zimbabwe Demographic Report (1995) estimated women 45-49 on average having 6.6 children per woman, which makes the calculated value here plausible. Plotting the average parities in each group produces a sigmoid shaped graph as expected (Figure A.1). Very low levels of fertility are suggested by the average parities for women in the age group 15-19 and the largest parity increments are occurring to women in their 20s and 30s. Using the same data age specific fertility rates can be calculated for 1992.

Table 4.2 Total children ever born by age group of mother, Zimbabwe 1992 Census

	Age group of mother							
Parity	*15-19*	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*	*Total*
0	533,587	181,586	41,507	16,782	9,636	6,599	5,555	795,252
1	81,341	175,690	64,635	21,356	10,409	5,982	4,127	363,540
2	14,496	108,979	87,731	37,020	17,021	9,766	6,696	281,709
3	2,140	39,383	81,826	53,134	23,695	12,246	8,364	220,788
4	453	11,972	56,840	66,026	33,589	16,262	10,434	195,576
5	114	3,163	27,206	57,956	41,182	20,820	12,981	163,422
6	*33*	1,080	10,739	38,535	42,721	25,449	15,958	134,515
7	*9*	292	3,662	19,950	34,204	26,015	17,427	101,559
8	*1*	104	1,282	9,095	23,056	23,503	17,771	74,812
9	*1*	*25*	459	3,742	12,844	17,908	15,368	50,347
10	*2*	*10*	119	1,560	6,236	12,075	12,141	32,143
11	*0*	*7*	33	576	2,789	6,547	7,727	17,679
12	*1*	*2*	6	223	1,197	3,449	4,481	9,359
13	*0*	*0*	*6*	79	507	1,532	2,266	4,390
14	*0*	*1*	*1*	11	174	679	1,084	1,950
15	*0*	*0*	*0*	10	56	262	453	781
16	*0*	*0*	*1*	*2*	24	95	216	338
17	*0*	*0*	*0*	*1*	8	33	79	121
18	*0*	*0*	*0*	*0*	2	10	33	45
19	*0*	*0*	*0*	*0*	*2*	2	10	14
20	*0*	*0*	*0*	*0*	*0*	0	3	3
21	*0*	*1*	*0*	*0*	*0*	2	2	5
Missing	332	766	442	241	203	273	265	2,522
Total	632,510	523,061	376,495	326,299	259,555	189,509	143,441	2,450,870

Table 4.3 Correction of parity data and calculation of proportion of women of parity zero, and parity not stated, Zimbabwe 1992 Census

	Age group of mother							
Parity	*15-19*	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*	*Total*
0	533,587	181,586	41,507	16,782	9,636	6,599	5,555	795,252
1	81,341	175,690	64,635	21,356	10,409	5,982	4,127	363,540
2	14,496	108,979	87,731	37,020	17,021	9,766	6,696	281,709
3	2,140	39,383	81,826	53,134	23,695	12,246	8,364	220,788
4	453	11,972	56,840	66,026	33,589	16,262	10,434	195,576
5	114	3,163	27,206	57,956	41,182	20,820	12,981	163,422
6	0	1,080	10,739	38,535	42,721	25,449	15,958	134,515
7	0	292	3,662	19,950	34,204	26,015	17,427	101,559
8	0	104	1,282	9,095	23,056	23,503	17,771	74,812
9	0	0	459	3,742	12,844	17,908	15,368	50,347
10	0	0	119	1,560	6,236	12,075	12,141	32,143
11	0	0	33	576	2,789	6,547	7,727	17,679
12	0	0	6	223	1,197	3,449	4,481	9,359
13	0	0	0	79	507	1,532	2,266	4,390
14	0	0	0	11	174	679	1,084	1,950
15	0	0	0	10	56	262	453	781
16	0	0	0	0	24	95	216	338
17	0	0	0	0	8	33	79	121
18	0	0	0	0	2	10	33	45
19	0	0	0	0	0	2	10	14
20	0	0	0	0	0	0	3	3
21	0	0	0	0	0	2	2	5
Missing	379	812	450	244	205	273	265	2,522
Total	632,510	523,061	376,495	326,299	259,555	189,509	143,441	2,450,870
Proportion Missing	0.06%	0.16%	0.12%	0.07%	0.08%	0.14%	0.18%	
Proportion Childless	84%	35%	11%	5%	4%	3%	4%	
Average Parities	0.188	1.120	2.540	4.024	5.280	6.263	6.738	

The age specific fertility rates are calculated as the estimated number of births to women in each group that occurred from 18 August 1991 to 18 August 1992 divided by the number of women in that particular age group. To calculate the births that occurred in August 1991, an assumption is made that births are uniformly distributed over the days of a month. The estimated number of births in the year before the census will be given as the sum of all the births reported between September 1991 to August 1992, plus $(1 - \frac{18}{31})$ of the births in August 1991. The directly calculated total fertility is 4.7 children per woman, which is similar to that published in the Zimbabwe 1992 Census report (Central Statistical Office 1994). In comparison to the average parity of the 45-49 women, 6.7

children per woman, the total fertility rate is low, which suggests that by the early 1990s, fertility decline was well under way. The relational Gompertz method is again applied to the 1992 data to obtain adjusted age specific and total fertility rates and identify common errors and trends in the data.

Table 4.4 Births reported in each month by age of mother at census date, Zimbabwe 1992 Census

	Age group of mother						
Month	*15-19*	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*
Aug-91	3646	9570	6521	4849	3167	1387	447
Sep-91	4193	10604	7027	5446	3501	1440	473
Oct-91	3853	9786	6614	5028	3361	1408	423
Nov-91	3899	9677	6579	4918	3293	1384	400
Dec-91	4366	10650	7319	5709	3740	1608	516
Jan-92	4558	9788	6686	5274	3380	1414	420
Feb-92	3917	8694	6197	4629	2956	1141	366
Mar-92	3991	8724	5907	4416	2958	1149	315
Apr-92	4313	8680	5948	4471	2719	1073	307
May-92	4544	8895	5960	4567	2699	1010	243
Jun-92	5034	9569	6374	4847	3023	1210	331
Jul-92	5140	9145	6188	4445	2711	995	268
Aug-92	3735	6079	4040	2926	1825	707	205
Estimated births in a year	53,190	114,613	77,784	58,866	37,596	15,165	4,469
Number of women	632,510	523,061	376,495	326,299	259,555	189,509	143,441
ASFR	0.084	0.219	0.207	0.180	0.145	0.080	0.031

The diagnostic plot shown in Figure 4.3 shows F-points curving down at older ages which is a sign of age exaggeration. In addition, the F-points lie above the P-points, showing that fertility has been falling. This is corroborated by the plot of the P/F ratio, which shows a downward trend and which is a clear trend of fertility decline (Figure 4.4). The corrected total fertility rate after applying the relational Gompertz method is 5.4 children per woman.

The 1992 census report published both a direct and indirect estimate of total fertility in 1992. The total fertility rate derived directly was reported as 4.7 children per woman and the indirect estimate was 5.9 children per woman (Central Statistical Office 1994). The differences between the published indirect estimate and that estimated above may be attributed to the adjustment factors used in calculation, as here the method used is that formulated by Brass and modified by Zaba whereas the census report used by the method refined by Arriaga (Central Statistical Office 1994). Table 4.5 shows the estimates derived and those published by Central Statistical Office (1994).

Figure 4.3 Plot of *z*()-*e*() against *g*(), all data points, Zimbabwe 1992 Census

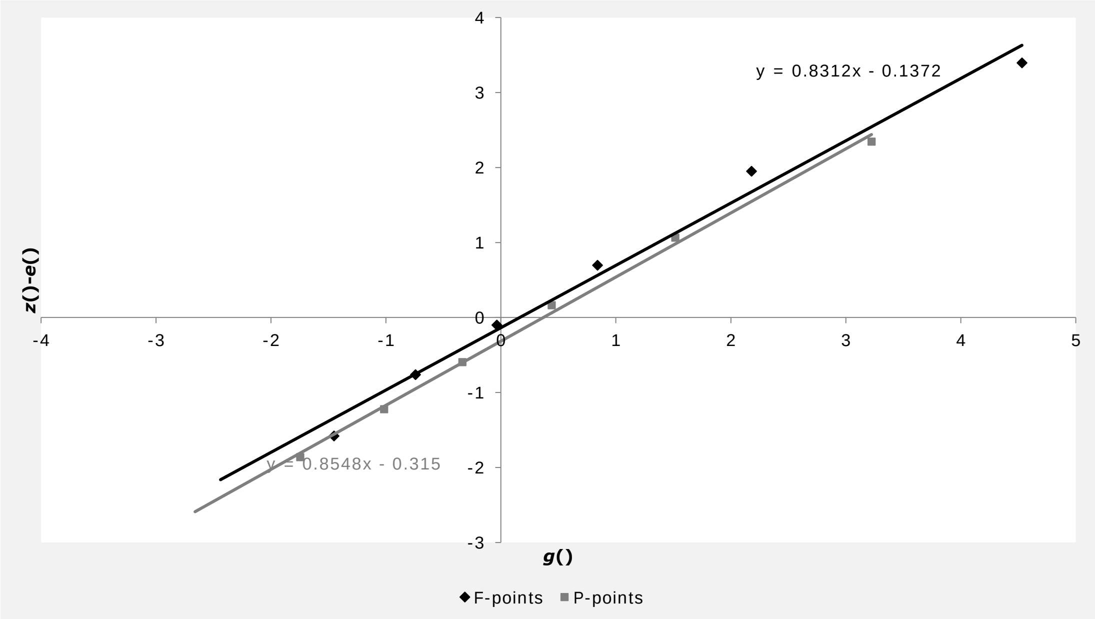


Figure 4.4 P/F ratios, Zimbabwe 2002 Census

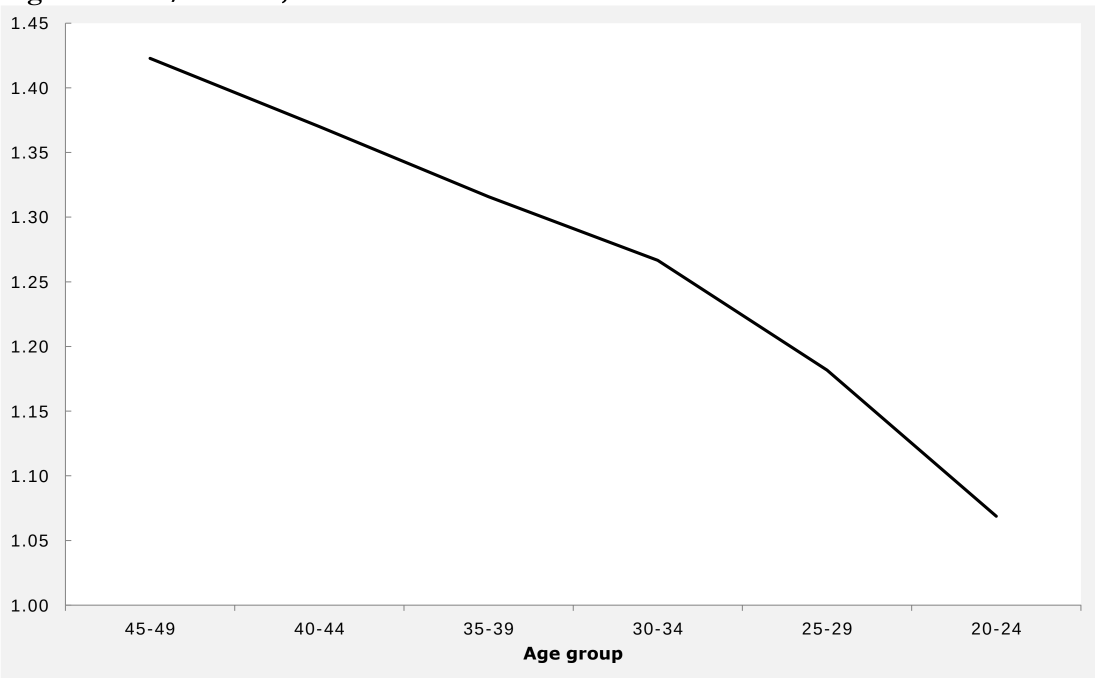


Table 4.5 Average Parities and ASFR, Zimbabwe 1992

	Average parity		*Age specific fertility rates*		
Age group	*Published*	*Adjusted*	*Published*	*Published adjusted*	*Adjusted*
15-19	0.189	0.188	0.099	0.124	0.111
20-24	1.119	1.120	0.223	0.279	0.239
25-29	2.537	2.540	0.204	0.256	0.252
30-34	4.021	4.024	0.177	0.222	0.218
35-39	5.278	5.280	0.141	0.176	0.164
40-44	6.262	6.263	0.074	0.092	0.080
45-49	6.738	6.738	0.026	0.033	0.011
Total fertility			4.7	5.9	5.4

In addition to calculating the age specific and total fertility rates, parity progression ratios and projected parity progression ratios can be calculated to analyse the proportions of women who reach a given parity and those who progress to have another child. The procedure for calculating these has been discussed in the previous chapter.

The cumulated (projected) parity progression ratios and the (projected) parity progression ratios are shown in Table 4.6 and Table 4.7 respectively. The red italicised values are to be treated with caution as the proportion of order fertility achieved by that age is less than half. By the end of childbearing 0.961 of the women had had a child. The (projected) parity progression ratios for the cohorts show 40-44 and 45-49 are almost similar but variances start to occur in the 35-39 age group. From age 25 to 39 a systematic decline in the proportion of women in each younger cohort expected to progress to the next parity is observed, which is indicative of fertility decline. Changes are mainly seen for women who are expected to have reached parity three and above. While 91 per cent of 45-49 women had had at-least 3 children, 82 per cent of the women 30-34 are expected to have at-least 3 children which may be result of parity limitation (Table 4.6).

These data point to fertility decline in Zimbabwe. From the calculation of parity progression ratios, cohort fertility rates can also be calculated. The women 45-49 have had 6.7 children per woman whereas the women 30-34 by the end of childbearing are expected to have had 4.6 children per woman. As can be seen, these rates are declining across the age groups, which also points to fertility decline.

Table 4.6 **Projected proportions expected to attain each parity, Zimbabwe 1992 Census**

Parity (i)	*20-24*	*25-29*	*Projected* *30-34*	*35-39*	*40-44*	*Completed* *44-49*
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.000
1	0.9583	0.9550	0.9672	0.9697	0.9678	0.961
2	*(0.7705)*	0.8487	0.9176	0.9330	0.9369	0.932
3		0.7204	0.8400	0.8773	0.8874	0.886
4		*(0.6208)*	0.7381	0.8014	0.8263	0.827
5			0.6138	0.7014	0.7473	0.754
6			*(0.4932)*	0.5756	0.6459	0.664
7				0.4399	0.5204	0.552
8				*(0.3132)*	0.3890	0.430
9				*(0.2120)*	0.2674	0.306
10					0.1694	0.199
11					0.0931	0.114
12+					*(0.0656)*	0.060
CFR			4.570	5.823	6.517	6.687

Table 4.7 **Projected parity progression ratios, Zimbabwe 1992 Census**

Parity (i)	*20-24*	*25-29*	*Projected* *30-34*	*35-39*	*40-44*	*Completed* *45-49*
0	0.958	0.955	0.967	0.970	0.968	0.961
1	*(0.804)*	0.889	0.949	0.962	0.968	0.970
2		0.849	0.915	0.940	0.947	0.950
3		*(0.862)*	0.879	0.913	0.931	0.934
4			0.832	0.875	0.904	0.912
5			*(0.804)*	0.821	0.864	0.880
6				0.764	0.806	0.832
7				*(0.712)*	0.747	0.780
8				*(0.677)*	0.687	0.712
9					0.633	0.650
10					0.550	0.574
11					*(0.705)*	0.528

4.1.3 2002 Census

The official date for the 2002 census was the 18th of August. The data on lifetime fertility was adjusted for implausible parities using the same rule of thumb stated above (Moultrie 2013b). As highlighted in red in Table 4.8 a negligible proportion of women had reported implausible parities and this is corrected and shown in Table 4.9. The proportion of childless women declines sharply with age but of note is that from age 35 it levels off at about five percent. The women 35-39 in the 1992 census are the women 45-49 in the 2002 census. From the analysis of parities in the 1992 census, four percent of the women ages 35-39 were reported to be childless but in the 2002 census five per cent of the women 45-49 are childless. This is clearly inconsistent as it is the same cohort of women ten years later, one would expect that the proportion of childless women would either remain the same or decrease.

The proportion of women with missing information on children ever born in the 15-19 age group is 0.32 per cent and 0.18 per cent of the women aged 20-24. These proportions are insignificant and can be ignored from any calculations; by so doing one is assuming that the average parity of women with unstated parities is the same as those with stated parities. An el-Badry correction is not necessary in this case.

The average parities calculated and shown in Table 4.9 are almost identical to those published in the census 2002 report. The number of children ever born on average to women ages 45-49 is estimated to be 5.7 children per woman, which is a decline of one child from the 6.7 children per woman in 1992. Parities increase monotonically with age; as expected and there is no internal inconsistency (Figure A.1). Consistency is also shown when one compares the average parities of the women 35-39 in the 1992 census to that of the women 45-49 in the 2002 census, 5.3 in 1992 to 5.7 in 2002.

Table 4.8 Total children ever born by age group of mother, Zimbabwe 2002 Census

	Age group of mother							
Parity	*15-19*	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*	*Total*
0	650,873	230,897	64,792	26,005	13,561	10,953	9,682	1,006,763
1	95,676	235,080	114,280	40,981	17,067	9,951	6,717	519,752
2	15,691	140,899	161,261	80,121	33,209	17,457	10,968	459,606
3	1,741	37,670	101,849	84,030	46,329	25,826	15,217	312,662
4	388	9,778	46,006	63,142	50,832	36,056	21,062	227,264
5	66	2,165	15,894	34,578	41,311	37,758	25,220	156,992
6	*18*	864	6,019	17,799	29,676	34,762	27,266	116,404
7	*8*	235	1,756	7,495	17,753	26,199	24,217	77,663
8	*7*	88	770	3,358	9,832	17,877	19,215	51,147
9	*1*	*34*	316	1,283	4,855	10,761	13,425	30,675
10	*0*	*17*	118	619	2,326	6,210	8,755	18,045
11	*0*	*4*	36	237	1,024	3,038	4,668	9,007
12	*0*	*2*	17	149	441	1,487	2,466	4,562
13	*0*	*1*	*4*	46	158	669	1,209	2,087
14	*0*	*0*	*4*	24	100	274	540	942
15	*0*	*0*	*3*	9	42	155	276	485
16	*0*	*0*	*0*	*0*	1	0	3	4
17	*0*	*0*	*0*	*0*	0	2	1	3
18	*0*	*0*	*0*	*0*	1	0	0	1
Missing	2,421	1,139	668	415	279	292	261	5,474

Table 4.9 Correction of parity data and calculation of proportion of women of parity zero, and parity not stated, Zimbabwe 2002 Census

	Age group of mother							
Parity	*15-19*	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*	*Total*
0	650,873	230,897	64,792	26,005	13,561	10,953	9,682	1,006,763
1	95,676	235,080	114,280	40,981	17,067	9,951	6,717	519,752
2	15,691	140,899	161,261	80,121	33,209	17,457	10,968	459,606
3	1,741	37,670	101,849	84,030	46,329	25,826	15,217	312,662
4	388	9,778	46,006	63,142	50,832	36,056	21,062	227,264
5	66	2,165	15,894	34,578	41,311	37,758	25,220	156,992
6	0	864	6,019	17,799	29,676	34,762	27,266	116,404
7	0	235	1,756	7,495	17,753	26,199	24,217	77,663
8	0	88	770	3,358	9,832	17,877	19,215	51,147
9	0	0	316	1,283	4,855	10,761	13,425	30,675
10	0	0	118	619	2,326	6,210	8,755	18,045
11	0	0	36	237	1,024	3,038	4,668	9,007
12	0	0	17	149	441	1,487	2,466	4,562
13	0	0	0	46	158	669	1,209	2,087
14	0	0	0	24	100	274	540	942
15	0	0	0	9	42	155	276	485
16	0	0	0	0	1	0	3	4
17	0	0	0	0	0	2	1	3
18	0	0	0	0	1	0	0	1
Missing	2,455	1,197	679	415	279	292	261	5,578
Total	766,890	658,873	513,793	360,291	268,797	239,727	191,168	2,999,539
Proportion Missing	0.32%	0.18%	0.13%	0.12%	0.10%	0.12%	0.14%	
Proportion Childless	85%	35%	13%	7%	5%	5%	5%	
Average Parities	0.176	1.045	2.076	3.024	4.100	5.076	5.701	

The age specific fertility rates for 2002 are calculated from births in the last 12 months (18 August 2001 to 18 August 2002) and the number of women in each age group. The distribution of births in the last year by age of mother show the most number of children being born to women in ages 20-24, 34 per cent followed by those 24-29 with 24 per cent. The sex ratio at birth can be used as an indicator of the quality of the births data reported in the 12 months preceding the survey. A sex ratio at birth of 103 was calculated for the 2002 census data, which is within the plausible range.

Table 4.10 Births reported in each month by age of mother at census date, Zimbabwe 2002 Census

Month	Age of mother at census						
	15-19	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*
Aug-01	4027	10623	7728	4295	2337	1293	347
Sep-01	4390	11862	8701	4806	2723	1426	372
Oct-01	4128	10646	7753	4415	2416	1225	342
Nov-01	4191	10510	7627	4400	2447	1269	339
Dec-01	4888	10956	7876	4636	2600	1298	333
Jan-02	4350	9812	7051	4102	2231	1064	245
Feb-02	4040	9051	6465	3690	1956	839	206
Mar-02	4565	9608	6781	3804	1978	838	207
Apr-02	4733	9673	6804	3697	1890	874	211
May-02	5259	10194	7065	3993	1991	891	206
Jun-02	5764	10655	7345	4061	2040	976	215
Jul-02	5993	10786	7442	3928	2089	900	203
Aug-02	3922	6837	4815	2614	1318	564	123
Estimated births in last year	57912	125045	88966	49947	26659	12706	3148
Number of women	766890	658873	513793	360291	268797	239727	191168
ASFR	0.076	0.190	0.173	0.139	0.099	0.053	0.016

Direct estimation of fertility yields a TFR of 3.7 children per woman, which is similar to the value of 3.6 published in the Zimbabwe 2002 Census report (Central Statistical Office 2004). These results compared to the average parities which show that by the end of childbearing women would have had 5.7 children per woman, show that there has been a dramatic fertility decline. In order to obtain a more accurate estimate of fertility, the relational Gompertz method was applied as it corrects errors usually found in recent fertility data.

The lines fitted to the *P*-points and *F*-points give information on errors present in the data. Figure 4.5 shows the *F*-points curving downward at the older ages, an indicating of exaggeration of births or age exaggeration by older women. Since the *F*-points lie above the *P*-points this is an indication that fertility is declining. Applying the relational Gompertz method yields a TFR of 4.2 children per woman. The P/F ratios show that fertility for older women had been declining as indicated by the downward trend, but for younger women (20-30) there is evidence of stalling fertility, as shown by the flat trend (Figure 4.6).

Table 4.11 shows the published and adjusted parities, age specific and total fertility rates derived from the 2002 census. Clearly, fertility decline is underway in Zimbabwe with a decrease in the average parities for the women who have completed their childbearing and also a decrease in the total fertility rates in Zimbabwe.

Figure 4.5 Plot of z()-e() against g(), all data points, Zimbabwe 2002 Census

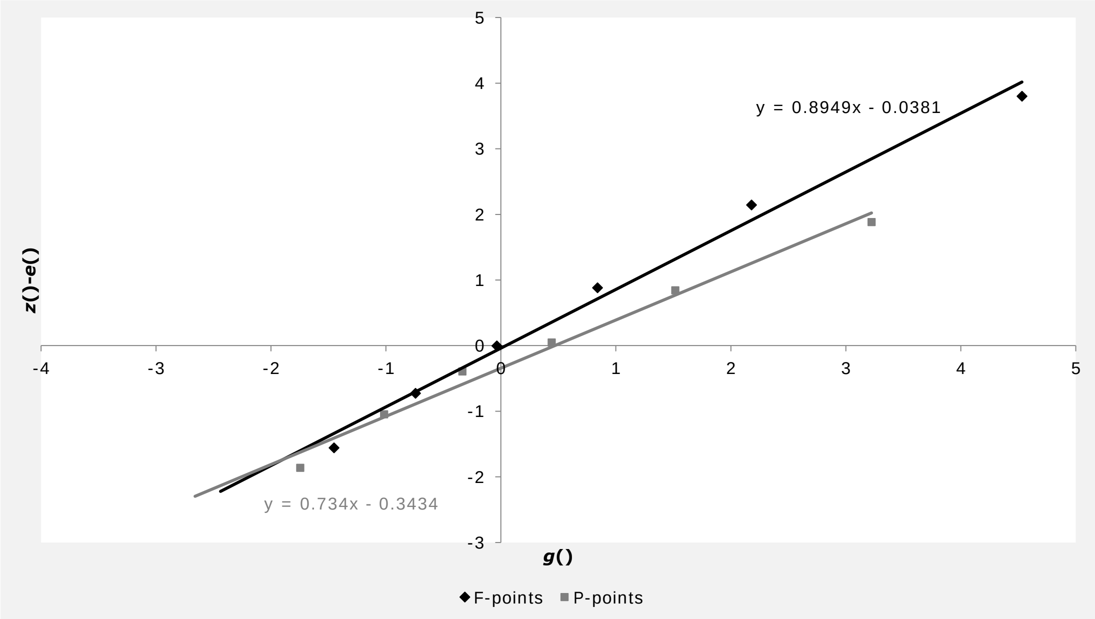


Figure 4.6 P/F ratio, Zimbabwe 2002 Census

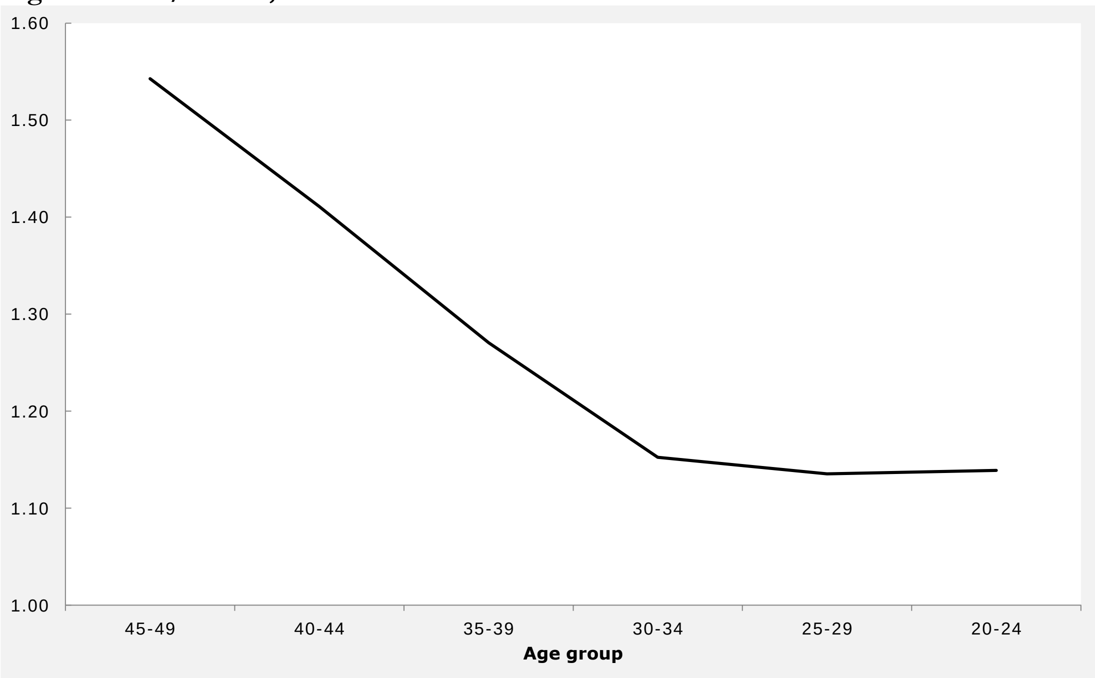


Table 4.11 Average parities and ASFR, Zimbabwe 2002 Census

	Average parity		*Age specific fertility rates*	
Age group	*Published*	*Adjusted*	*Published*	*Adjusted*
15-19	0.178	0.176	0.073	0.107
20-24	1.046	1.045	0.183	0.206
25-29	2.073	2.076	0.167	0.200
30-34	3.021	3.024	0.134	0.162
35-39	4.096	4.100	0.096	0.115
40-44	5.070	5.076	0.051	0.052
45-49	5.693	5.701	0.016	0.007
Total fertility			3.6	4.2

Parity progression ratio show 0.949 of the women 45-49 had had a first birth (Table 4.13). Across all age groups approximately five per cent of women are projected not to have any children. Fifty three per cent of women aged 45-49 have had at least six children whereas the projected proportion of women expected to attain parity six declines to 33 per cent in the 35-39 age group (Table 4.12). The (projected) parity progression ratios show changes at parities three to seven between the women who have completed their childbearing and those who are expected to reach the parities. The changes may be attributed to limitation of fertility and is a clear sign of fertility decline. The cohort fertility rates also point to fertility decline. By the end of childbearing the women aged 30-34 are expected to have had 3.4 children per woman, a decline of 2.3 children per woman from the 5.7 children per woman for women who are currently aged 45-49.

Table 4.12 Projected proportions expected to attain each parity, Zimbabwe, 2002 Census

			Projected			*Completed*
Parity (i)	*20-24*	*25-29*	*30-34*	*35-39*	*40-44*	*45-49*
0	1.000	1.000	1.000	1.000	1.000	1.000
1	0.950	0.950	0.949	0.956	0.957	0.949
2	*(0.866)*	0.862	0.870	0.898	0.916	0.914
3		*(0.670)*	0.704	0.787	0.845	0.857
4			0.524	0.636	0.741	0.777
5			*(0.366)*	0.468	0.596	0.667
6				0.331	0.444	0.535
7				*(0.219)*	0.302	0.392
8				*(0.142)*	0.193	0.265
9					0.114	0.164
10					0.065	0.094
11					0.033	0.048
12+					0.021	0.024
CFR			3.4	4.4	5.2	5.7

Table 4.13 Projected parity progression ratios, Zimbabwe 2002 Census

Parity (i)	20-24	25-29	Projected 30-34	35-39	40-44	Completed 45-49
0	0.950	0.950	0.949	0.956	0.957	0.949
1	(0.911)	0.908	0.917	0.939	0.957	0.963
2		(0.777)	0.809	0.875	0.922	0.937
3			0.744	0.808	0.877	0.907
4			(0.699)	0.736	0.805	0.858
5				0.708	0.745	0.802
6				(0.660)	0.679	0.733
7				(0.651)	0.640	0.676
8					0.593	0.620
9					0.568	0.572
10					0.514	0.511
11					0.627	0.491

4.1.4 2012 Census

The 2012 census was held exactly ten years after the 2002 census with the official date being the 18th of August 2012. As there is no dataset available to the public, the analysis is done using the published tables. While communicating with the ZimStat, it was reported that there were problems with the fertility results in the 2012 census report published and ZimStat was revising the published estimates (personal communication). No new estimates had been published by the time of submission of this dissertation.

The total fertility rate for the country was estimated to be 3.8 children per woman (Zimbabwe National Statistics Agency 2012). The relational Gompertz model is applied to the 2012 data to correct the shape of the fertility distribution arising from underreporting of births and age reporting errors and to determine the true level of fertility after correcting the fertility distribution. Figure 4.7 enables one to explore data for errors and changes in fertility. The F-points curve downwards at the older ages, which is a sign of age exaggeration by older women. No clear trend in fertility can be deduced from the graph. The P-points are highly suspect as an odd shape is shown. The implied total fertility rate after applying the relational Gompertz is 4.0 children per woman, an increase of 0.2 children per woman from that initially published. The series of P/F ratios in Figure 4.8 indicate that fertility had been declining but stalled for women aged 25-40. There has been a sharp increase in fertility for women 20-24.

Figure 4.7 Plot of *z*()-*e*() against *g*(), all data points, Zimbabwe 2012 Census

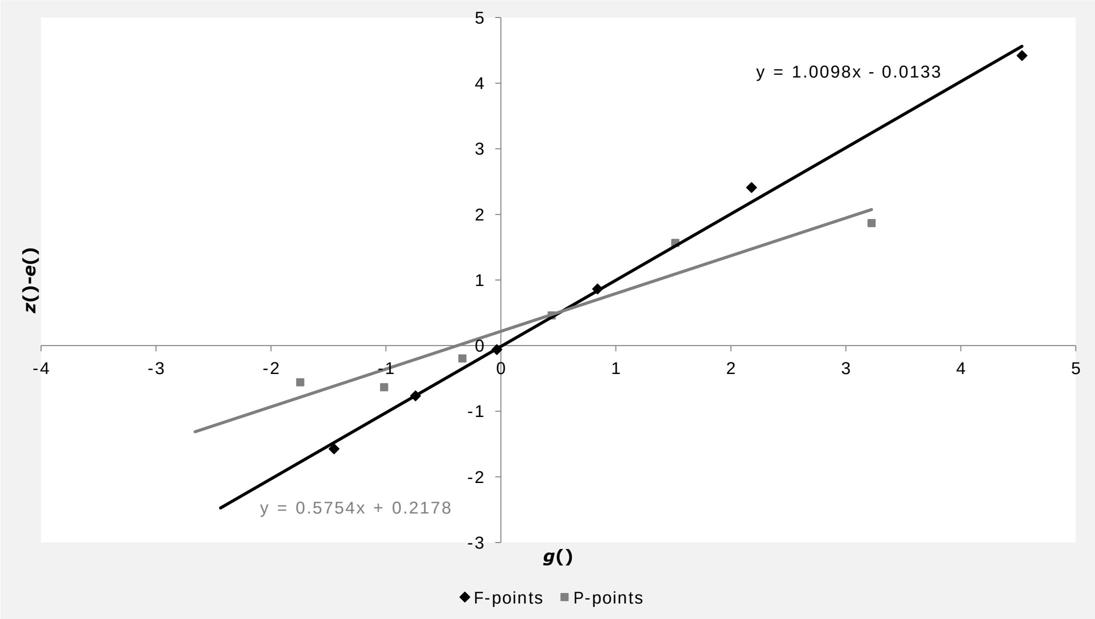


Figure 4.8 P/F ratio, Zimbabwe 2012 census

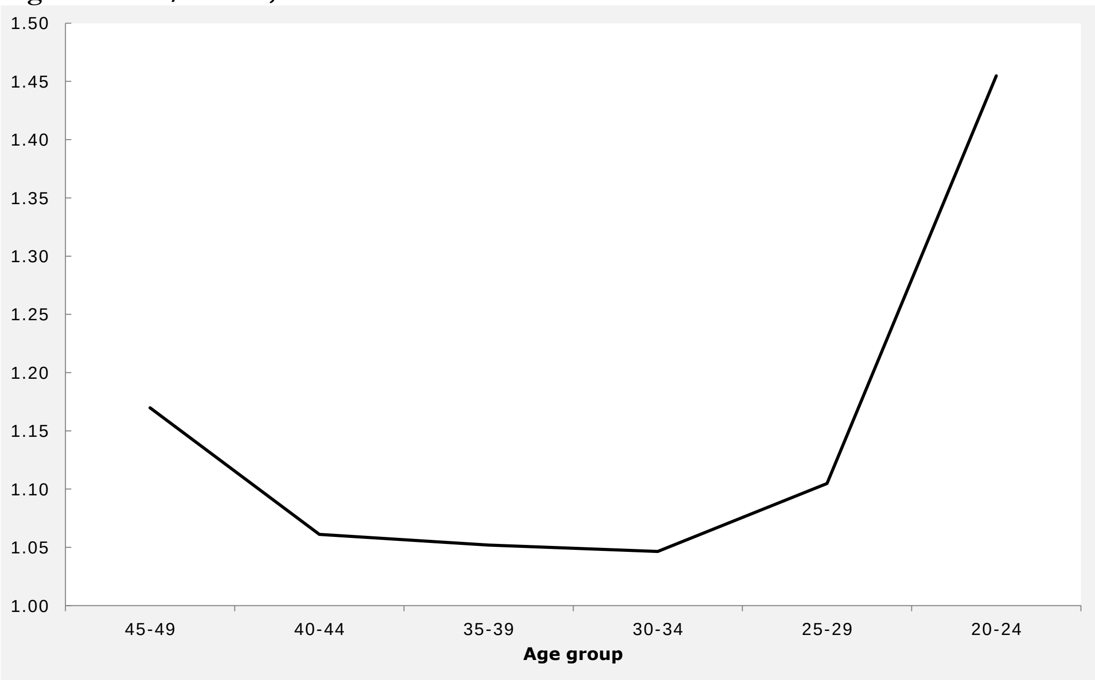


Table 4.14 Average parities and ASFR, Zimbabwe 2012 Census

	Average parities	*Published ASFR*	*Estimated ASFR*
15-19	0.841	0.075	0.095
20-24	1.363	0.193	0.206
25-29	2.145	0.184	0.200
30-34	2.921	0.153	0.156
35-39	3.574	0.106	0.104
40-44	3.964	0.042	0.042
45-49	4.460	0.009	0.005
Total fertility rate		3.8	4.0

4.2 Census fertility rates

This section is set out to give an overall analysis of fertility in Zimbabwe from the censuses conducted. The age specific and total fertility rates which are unadjusted and adjusted for all the censuses are shown in Table 4.15. There is no doubt that there has been a fertility decline in Zimbabwe with the adjusted total fertility showing a decline of 2.3 children per woman from 6.3 children per woman in the 1982 census to 4.0 children per woman in the 2012 census. The effect of the adjusting fertility rates in the censuses results in higher levels of total fertility for all the censuses as expected and shown in Figure 4.9. Figure 4.10 shows the age specific fertility rates estimated for the four censuses, which have been adjusted and unadjusted and standardised. Standardising by imposing a TFR of one and redistributing the age specific fertility rates removes confounders and allows for comparison of the shapes of the fertility distributions. The shape of fertility distribution has remained the same over time. Peaks in childbearing are being attained at ages 20-24 in 1982, 2002 and 2012 and ages 25-29 in 1992. Fertility has shifted to being concentrated in the younger ages of 20 to 35.

Table 4.15 Age specific fertility rates for women 15-49, Zimbabwe Censuses

	1982 Census		*1992 Census*		*2002 Census*		*2012 Census*	
Age group	*Unadjusted*	*Adjusted*	*Unadjusted*	*Adjusted*	*Unadjusted*	*Adjusted*	*Unadjusted*	*Adjusted*
15-19	0.091	0.155	0.084	0.111	0.076	0.107	0.075	0.095
20-24	0.258	0.280	0.219	0.239	0.190	0.206	0.193	0.206
25-29	0.253	0.281	0.207	0.252	0.173	0.200	0.184	0.200
30-34	0.225	0.243	0.180	0.218	0.139	0.162	0.153	0.156
35-39	0.165	0.187	0.145	0.164	0.099	0.115	0.106	0.104
40-44	0.093	0.095	0.080	0.080	0.053	0.052	0.042	0.042
45-49	0.038	0.015	0.031	0.011	0.016	0.007	0.009	0.005
TFR	5.6	6.3	4.7	5.4	3.7	4.2	3.8	4.0

Figure 4.9 Total fertility rate, Zimbabwe censuses

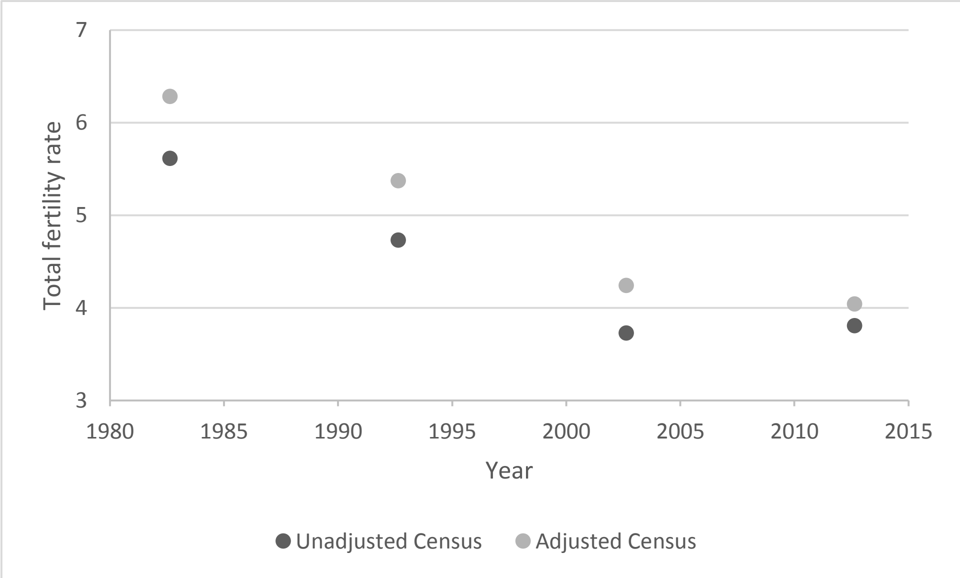
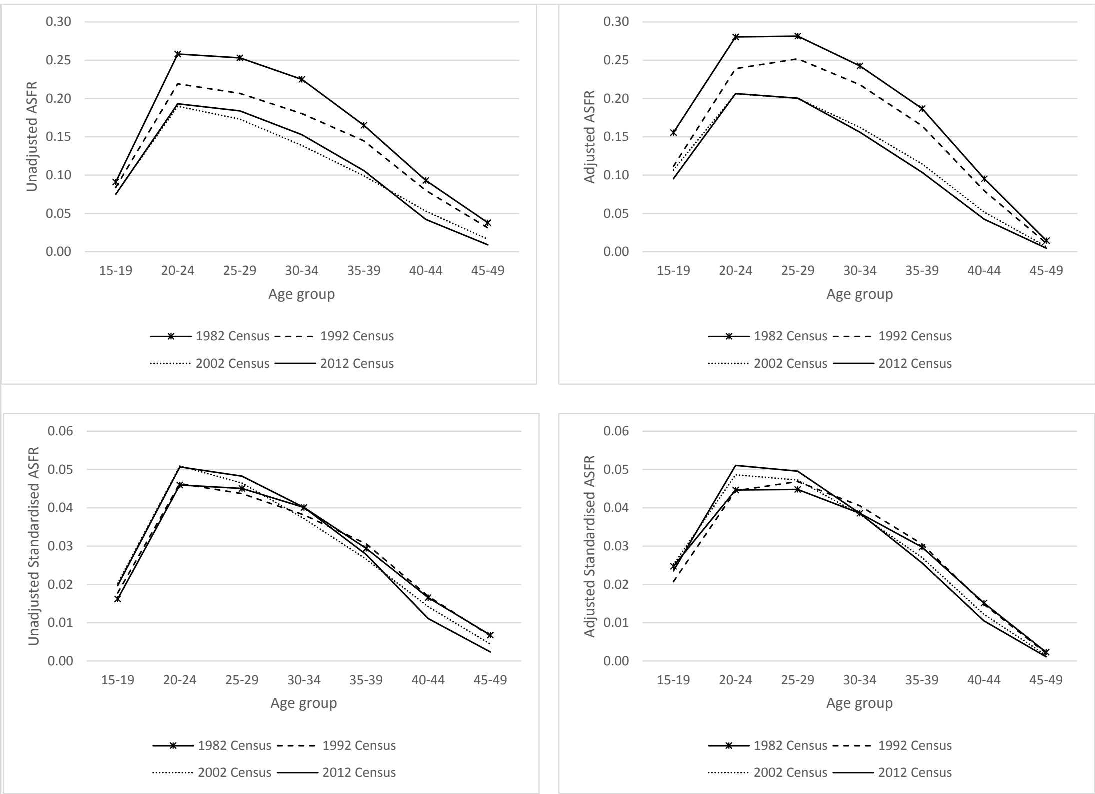


Figure 4.10 Trends in fertility, unadjusted and adjusted age specific fertility rates, Zimbabwe Censuses



Average parities

The average parities observed for the women who have completed childbearing are shown in Figure 4.11. The time period where these rates apply was determined by using the method suggested by Feeney (1991). Average parities seem to have remained generally the same for the cohorts of women born before 1975. From 1975 there has been a decrease in the average number of children that women have. This shows that fertility decline roughly began in the mid-1970s and has continued to decline.

Figure 4.12 shows the average parities for four censuses held in Zimbabwe. As already suspected the average parities for the women ages 45-49 were clearly understated in the census of 1982 as they are below those of the women 45-49 in the 1992 census. Average parities are observed to increase systematically with age as expected in all the censuses. An odd picture is observed in the average parities of the women in the 2012 census. The mean number of children ever born to women aged between 15 and 30 has increased uncharacteristically from the observed trend, particularly for the women 15-19. This increase is likely ascribable to an error in the data as also shown in the relational Gompertz method.

Figure 4.11 Average parity by birth cohort, Zimbabwe

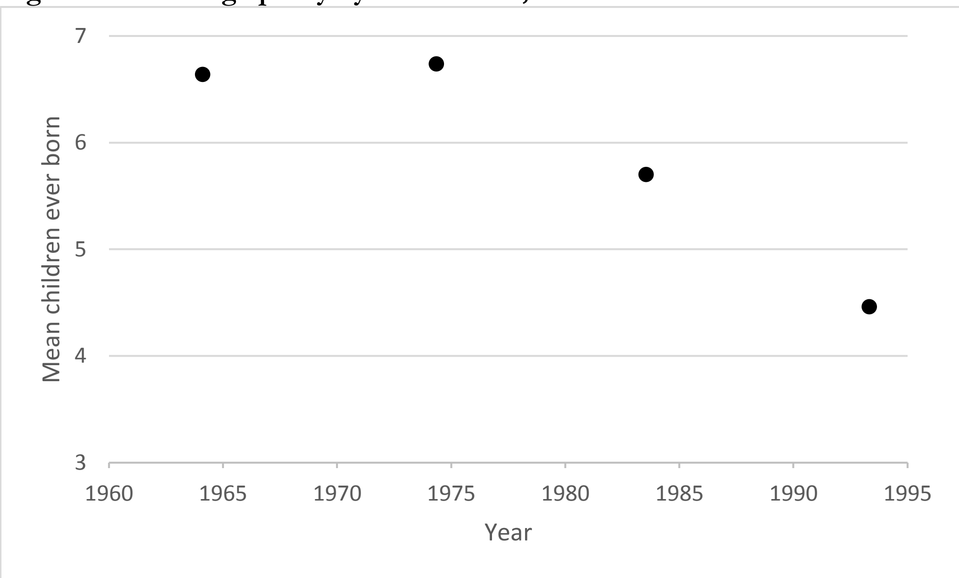
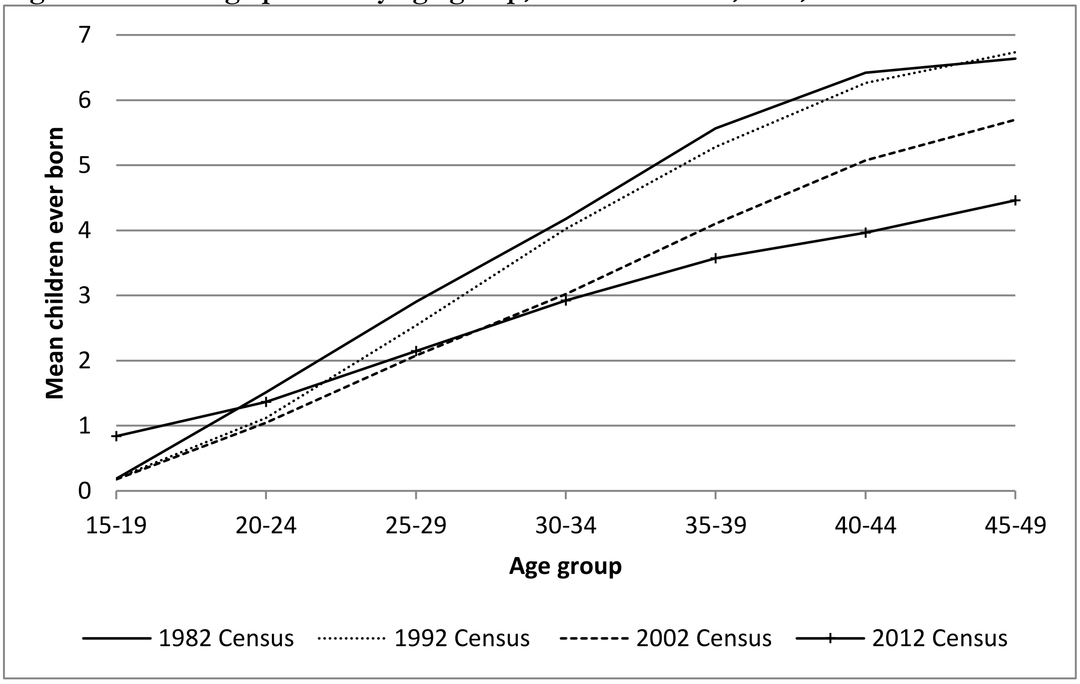
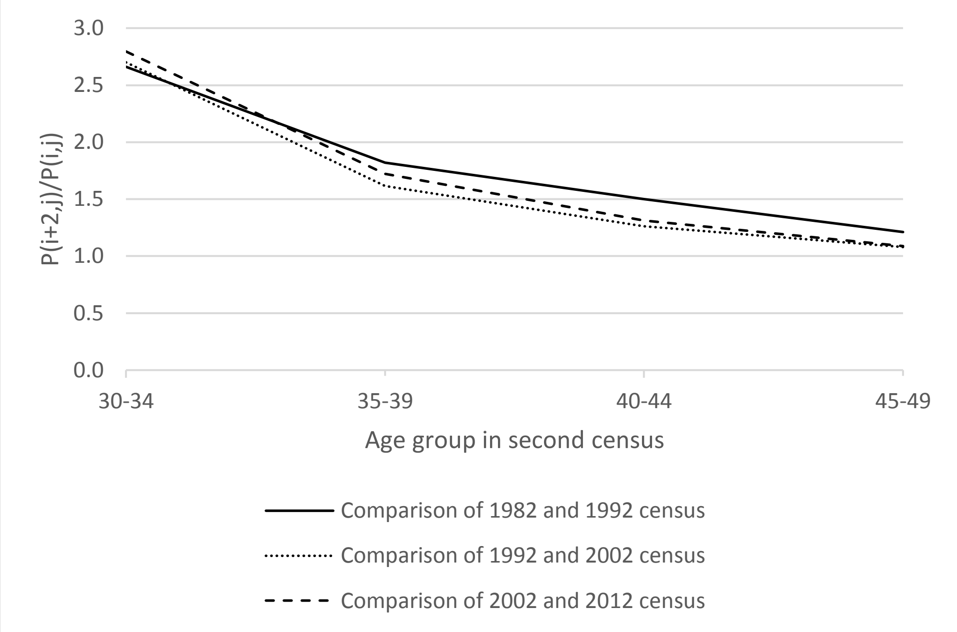


Figure 4.12 Average parities by age group, Zimbabwe 1982, 1992, 2002 and 2012 census



By comparing the average parities for the same cohort of women in one census to the one immediately following it, ratios can be deduced, which can be used to diagnose for errors in the data. If the ratio calculated is above one it means that the average parities in the second census are greater than those in the first, implying the parities do not suffer from serious errors. The ratios are calculated and shown in Figure 4.13. For all ages the average parities are above one, meaning that parities do not suffer from serious errors. The ratio observed for the last age group is very close to one in all the comparisons. This is a clear sign that there has been underreporting of children ever born by older women.

Figure 4.13 Comparison of average parities, Zimbabwe 1982, 1992, 2002 and 2012 census

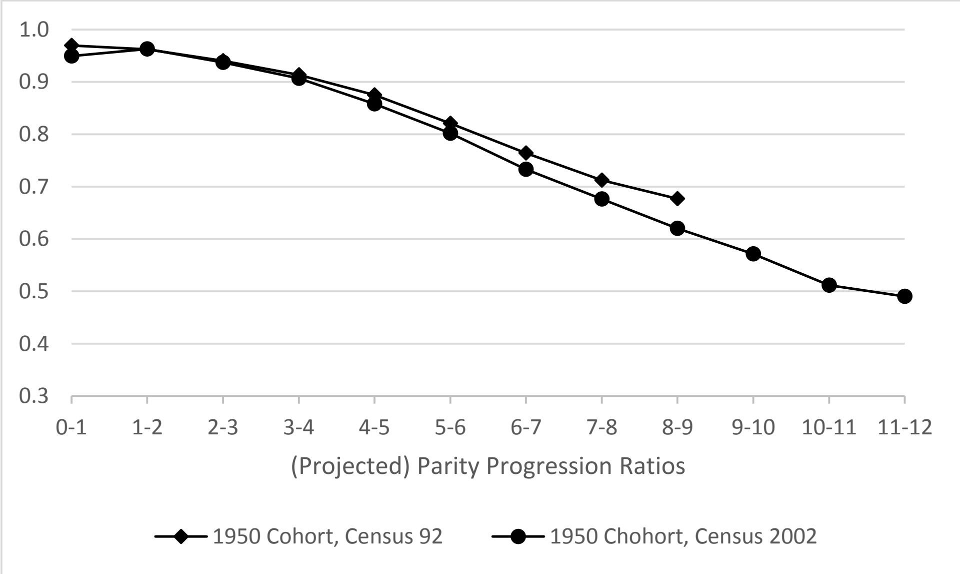


(Projected) parity progression ratios

This section compares the parity progression ratios and the projected parity progression ratios in the two censuses where data is available. In order to plot the projected parity progression ratios by birth cohort the assumption is made that women aged [x, x+5) at the time of the inquiry were approximately aged x+2.5 years at that time. The year of birth is then given by subtracting x+2.5 years from the median date of the survey or the census date.

Figure 4.14 shows a comparison of the projected parity progression ratios for women ages 35-39 in the 1992 census to the parity progression ratios when they are approximately aged 45-49 in the 2002 census. The parity progression ratios show that 95 per cent of the women had progressed to have a child whereas the projected parity progression ratios show that 97 per cent of the women had had a child. From the forth birth going on, the projected parity progression ratio of the women 35-39 are higher than the parity progression ratios of women 45-49, the reason being parity limitation as fewer women are progressing to those parities. The rest of the points are consistent with each other. This makes one have some confidence in the data as the same story is being depicted.

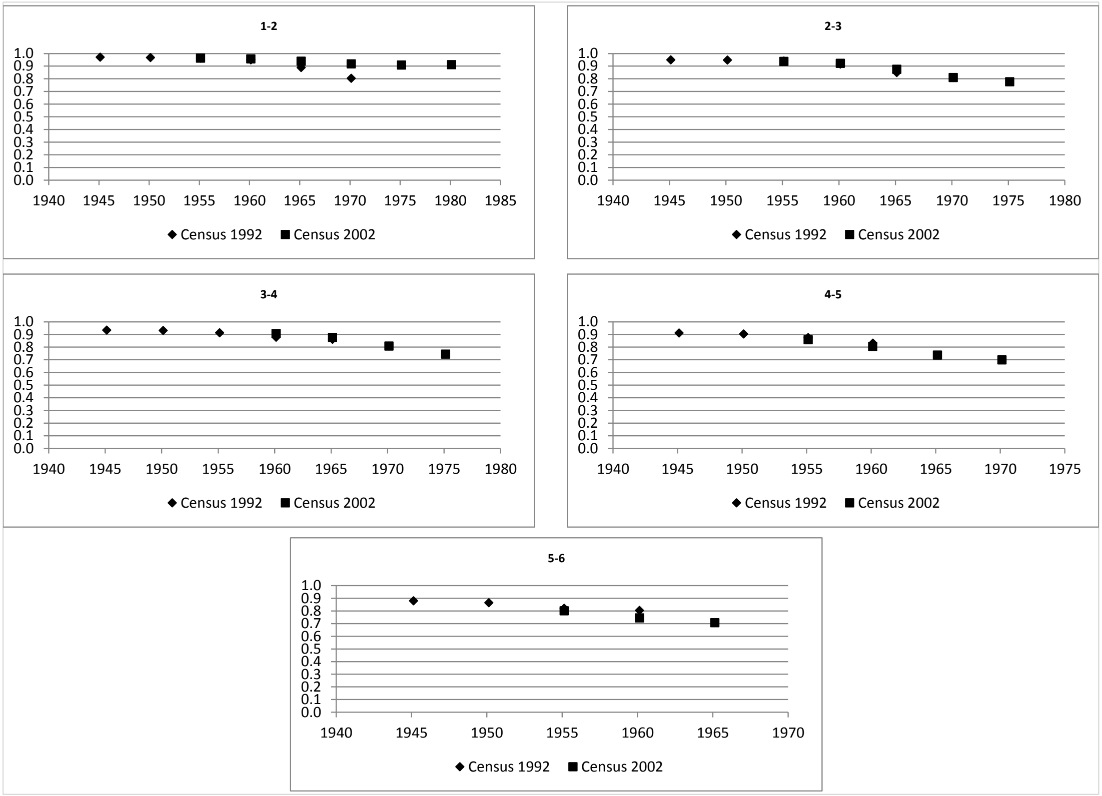
Figure 4.14 (Projected) parity progression ratio by parity, Zimbabwe 1992 and 2002 Censuses



A comparison of the 1992 and 2002 (projected) parity progression ratios is shown in Figure 4.15. The only problem noticed in the projected parity progression ratios is from the first to second birth, where the ratios in the 1992 census are lower than those from the 2002 census. An example is that in the 1992 census for the cohort of women born approximately in 1965, 89 per cent were expected to have a second child. On the other hand, for the same cohort of women in the 2002 census 94 per cent were expected to have a second birth. Clearly there is a problem in the projected parity progression ratios in 1992.

Disregarding the (projected) parity progression ratios from a first to second birth, the other plots show a notable consistency in the ratios. The same cohort reported the same or close to the same projected parity progression ratio. This may undermine the case for errors in the 1992 parity progression ratios from first to second birth. Given the deficiencies and errors in the 1992 and 2002 data, the method of projected parity progression ratios is proven here to be robust to these errors and therefore rather good. Fertility decline is observed to have begun with the women born in the 1960s as shown by the downward slope in the projected parity progression ratios.

Figure 4.15 Trends in projected parity progression ratios by birth cohort and parity, Zimbabwe 1992 and 2012 Censuses



Fertility of population groups

Fertility levels have been known to differ across populations and sub-populations. Proximate factors account for variation in fertility among populations and population subgroups. The literature has highlighted that education and residence play an influential part in the level of fertility.

Education has been noted in the literature to have a negative relationship to fertility. With time the fertility rates have decreased across all education levels, as seen in Figure 4.16. For the two most recent surveys, the fertility rates for women with primary education have been higher than those of women with no education. The level of fertility for the women with primary and secondary education in the two most recent surveys has remained generally the same.

Fertility in urban areas has been shown to be lower than in rural areas in the literature. An analysis of the 1992 and 2002 fertility rates by residence shows rural fertility as being higher than urban fertility across the censuses. The 2012 census report did not publish any results on fertility by residence and as there is no data we could not produce fertility by residence in 2012. Fertility decline is seen to have occurred in both population sub-groups (Figure 4.17).

Figure 4.16 Total fertility rate by education of mother

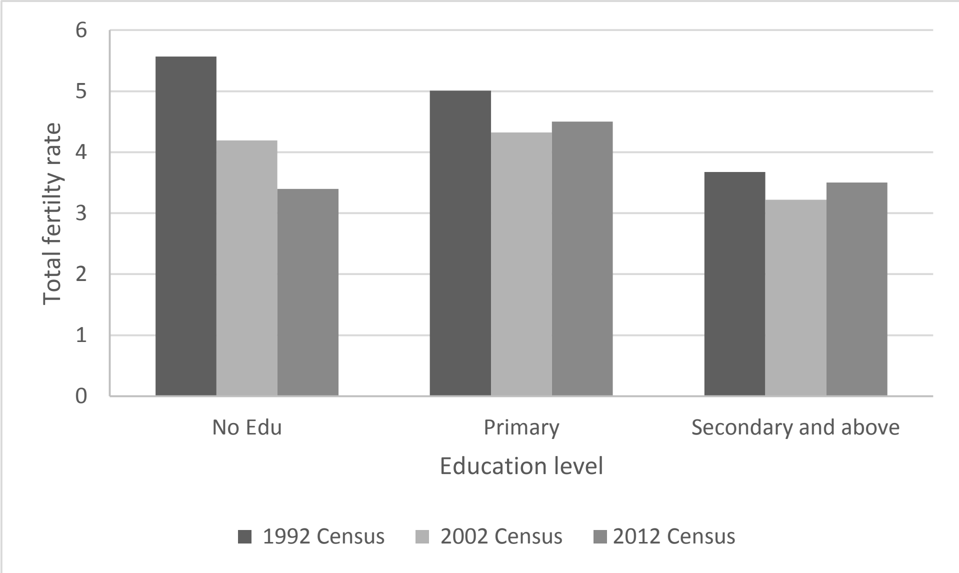
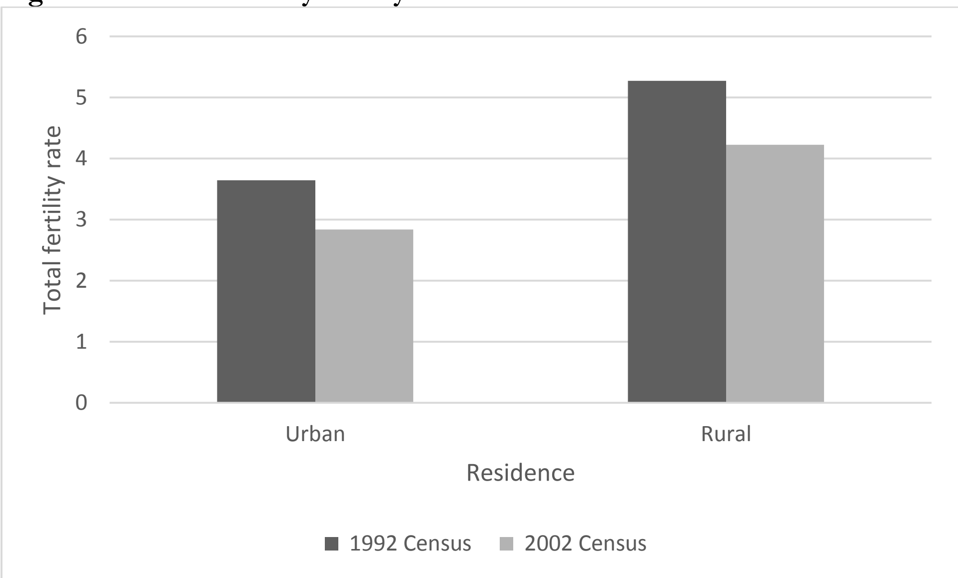


Figure 4.17 Total fertility rate by residence



4.3 Trends in Zimbabwe fertility 1960 - 2012

The children currently aged *x* are the survivors of the births that occurred *x* years ago. Using life table survival probabilities, the number of births that occurred *x* years ago can be calculated for each of the 15 to 20 years preceding a census. This method of estimation is known as reverse survival.

The procedure for reverse survival as described by Timæus and Moultrie (2013) was used to derive the total fertility rate for the 15 years preceding the 1992 and 2002 census. Estimates of cohort survival factors are derived from children ever born and surviving in the census and/or direct estimates cohort analysis in birth histories. These cohort survival factors are used to adjust the census count to account for those who have died resulting in births that occurred x years ago. The female age distribution is also "reverse survived" to obtain the number of women of reproductive age at a period prior to the census. The assumption made when applying the method is that the population should be closed to migration and that of the age groups in question there has been no differential under-enumeration in the age groups considered.

A fertility schedule may be obtained from the census data in the inquiry one is interested in. A second fertility schedule can be obtained from a census which was held in the 10 to 15 years before the first inquiry. Interpolation between the two schedules will result in an annual series of standardised rates, which can be used. By making use of the fertility schedule(s) which describes the age pattern of fertility in the population, the number of births and the age distribution of women of reproductive age the total fertility can be estimated for each year for the 15 years preceding the census.

The main advantage of using reverse survival is that it only requires the age sex distribution of the population, which is readily available from all censuses. However, the quality of reverse survival estimates relies heavily on the accuracy of the reported age distribution of the population. Age misreporting or differential completeness of enumeration affecting certain age groups create bias in the estimates obtained (United Nations 1983). The consistency of estimates from successive censuses provides a reliable diagnostic of the quality of the estimates.

Estimates of adult and under five mortality for 0-4, 5-9, 10-14 years before each census were obtained from the World Bank (2014). The fertility schedules required for apportioning the births for the 1992, 2002 and 2012 census were derived from parameters of a relational Gompertz model of fertility from the census. As the 1969 census is not very reliable, and also considering that fertility was roughly constant at around this time, only one relational Gompertz model was used for the age pattern of fertility in 1982.

Figure 4.18 Trends in total fertility, Zimbabwe

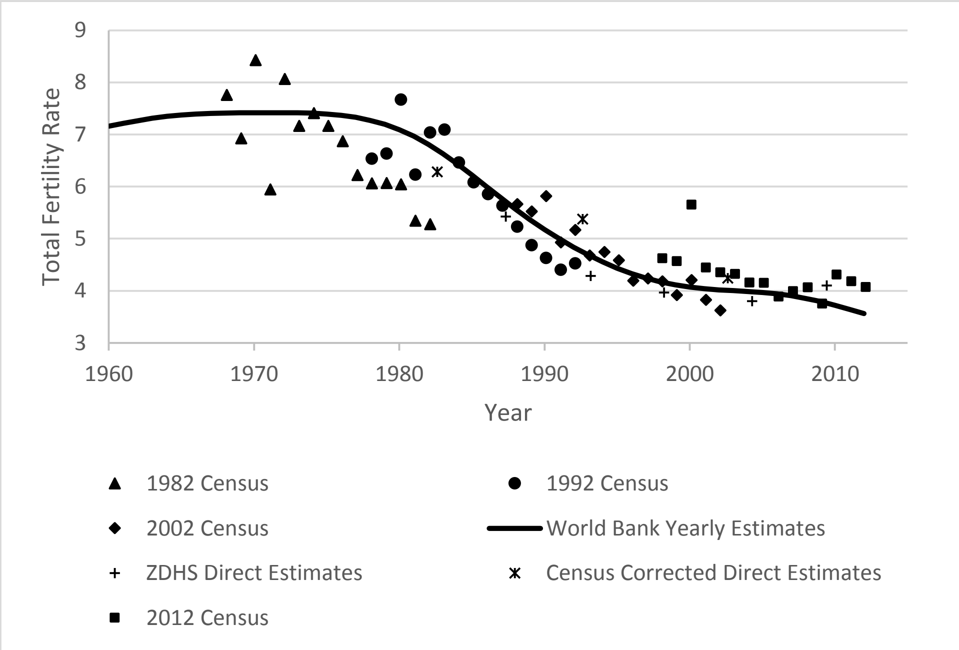


Figure 4.18 shows the total fertility rate derived from applying the reverse survival method to the 1982, 1992 and 2002 Zimbabwe census data. Also shown are the ZDHS total fertility rates for the three years before each survey and the corrected total fertility rates from the censuses held. As shown clearly in the 1982 census, the age structure has an effect on the total fertility rate. Age 10 and 12 was preferred over age 11, which clearly is shown by the low fertility rate eleven years before the census in 1971. The results from the 1982 census do not give much confidence in the data and the estimates are lower compared to the World Bank estimates. The jump in the total fertility in 1970 and 1972 is clearly a result of heaping at ages 10 and 12 in the 1982 census, which has affected the total fertility rates in the years preceding and succeeding. Significant under-enumeration of young children, more so for children aged 0 and 1, has led to very low estimates of fertility. The reverse survival estimates from the 1992, 2002 and 2012 census generally concur with the World Bank yearly estimates and the DHS estimates. The 2012 census shows a sudden jump in the total fertility rate in 2000, which is a result of age heaping of the 12 year olds in the census. The fertility rates for 2012 are slightly higher than those from the World Bank and are inconsistent with the overall trend. Higher levels of mortality are required to bring these levels down. This may not necessarily be the case as the mortality levels may not be that high in Zimbabwe. The overall trend shown is that of fertility decline. Rapid fertility decline seems to have started in the late 1970s early

1980s to the end of the 1990s. This is consistent with the parities, which showed that fertility decline in Zimbabwe started around 1975.

4.4 Estimates of fertility from Demographic and Health Survey data

The age specific and total fertility rates from the Demographic and Health Surveys are presented in this section. The method used to derive ASFRs and TFR as set out in Schoumaker (2013) and described in the previous chapter is used to derive these measures. As noted, the method derives ASFRs and TFR for the three years preceding the survey because the number of events may otherwise be too small to produce reliable estimates.

For all the surveys, the TFR derived using the method set out by Schoumaker (2013) is the same as that published in the Zimbabwe Demographic Health Survey publications. Figure 4.19 shows the standardised and unstandardised ASFR for the Zimbabwe DHS. The standardised ASFR show that the proportion of fertility in the younger age groups has increased over time whereas from ages 35 the rates decrease over time. The shape of the fertility distribution has remained the same with the peak childbearing age being at age 20-24. There has been a general decline in the ASFR in the years although one notices that the ASFR for the ZDHS 2011 are above those of the ZDHS 2005 except for the last two age groups. From the available data one may deduce that there was a steep fertility decline from 1988 to 1994 (Figure 4.20).

Figure 4.19 Age specific fertility rates, Zimbabwe 1988-89, 1994, 1999, 2005-06, 2010-11 DHS

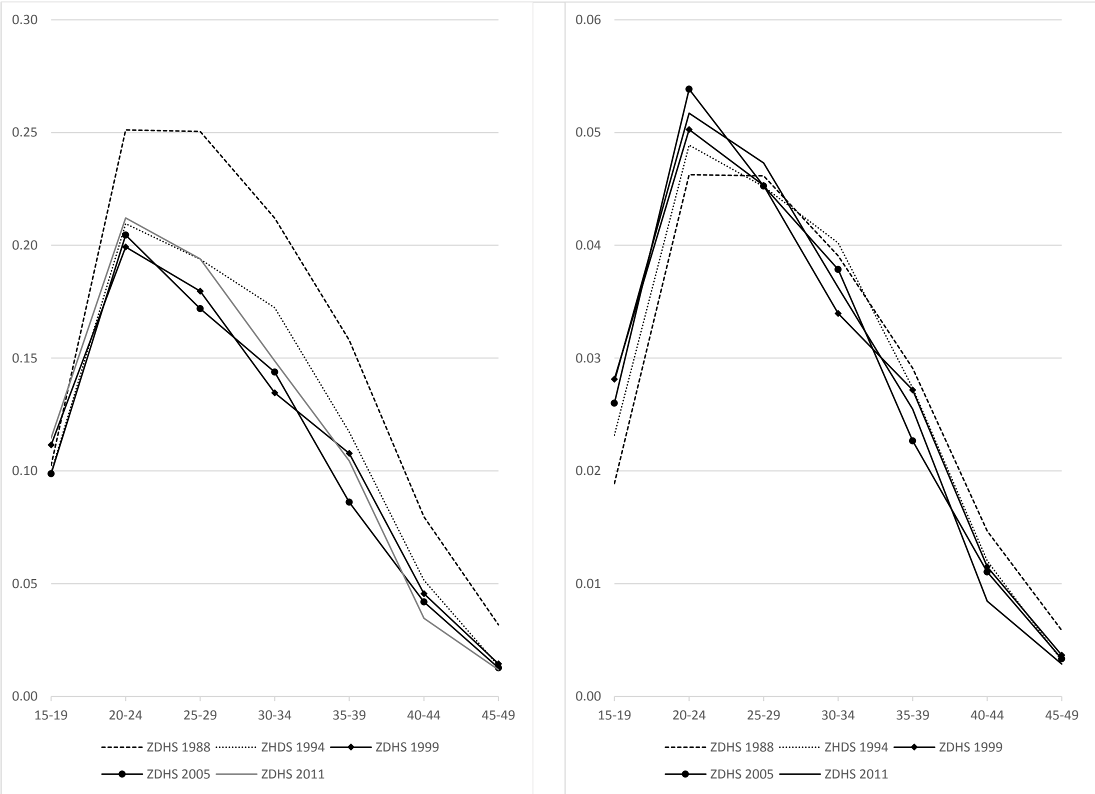
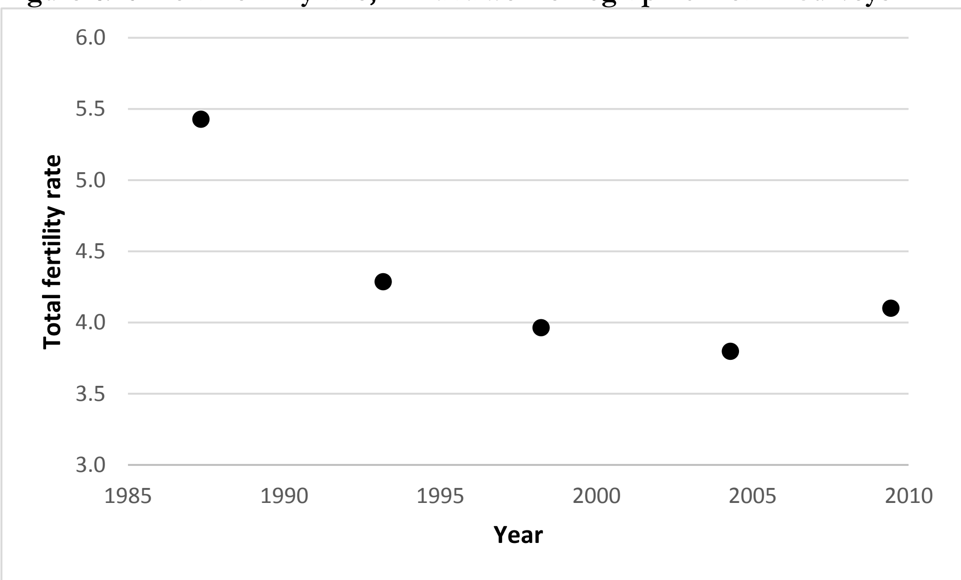


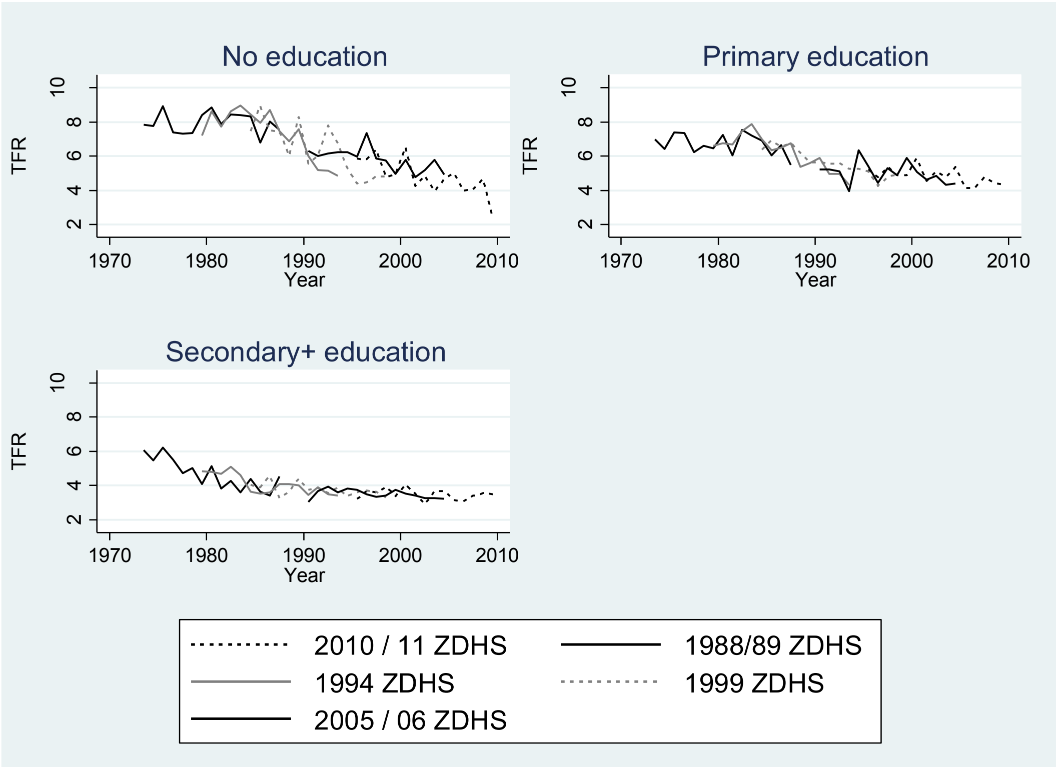
Figure 4.20 Total fertility rate, Zimbabwe Demographic Health Surveys



4.4.1 Consistency of DHS among population sub-groups

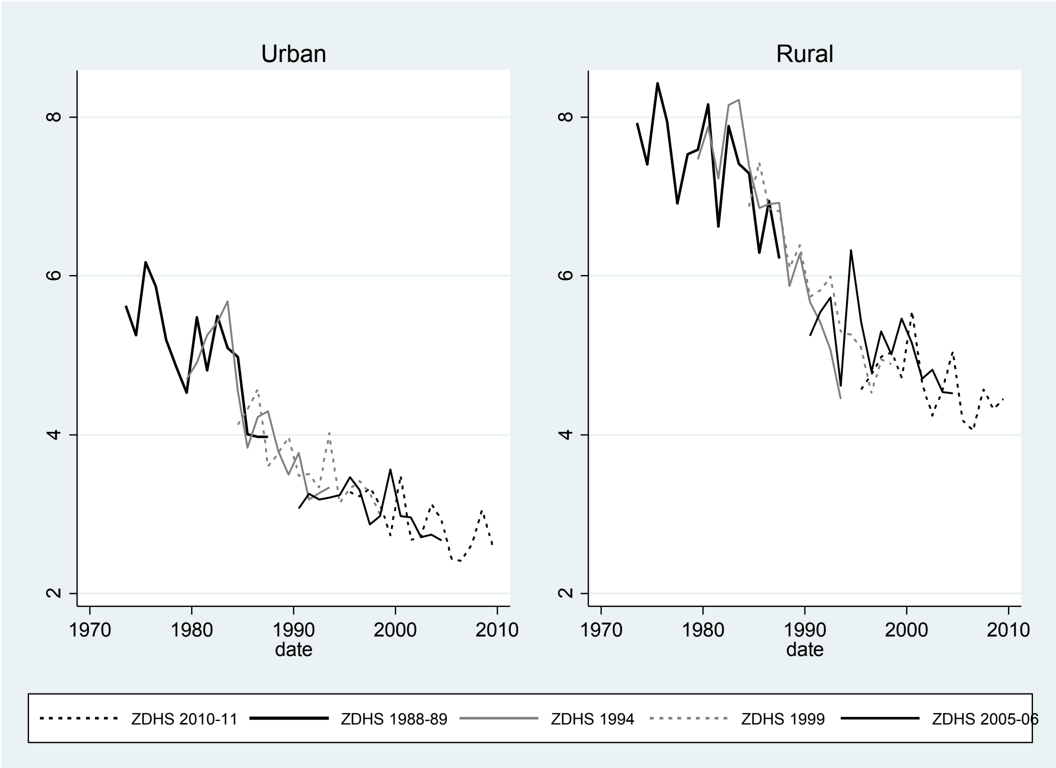
Schoumaker (2010) shows the apparent consistency in the ZDHS fertility rates at national level. This section sets out to look at whether the apparent consistency is also present for different populations groups. Figure 4.21 shows the trends in fertility by educational level attained at the time of the survey. Because the sample of women with higher education is very small, secondary and higher education have been combined into one. As seen, there is consistency in the total fertility rates by education in all the education groups. Fertility is seen to be highest in the women with no education and lowest in those with higher education in all years. Substantive decline in fertility has been observed for women with no education. For women with secondary and higher education decline is observed from the 1980s to around 1990. The level of fertility for women with secondary and higher education seems to have stalled.

Figure 4.21 Trends in fertility by educational level



The literature shows that there are differentials between urban and rural fertility. Figure 4.22 shows fertility trends by residence. The results from the ZDHS 1988-89 show the most variability but overall one can note that there is consistency in the results. Rural fertility is significantly higher than urban fertility. Parallel declines in fertility in urban and rural areas are observed.

Figure 4.22 Trends in fertility by place of residence



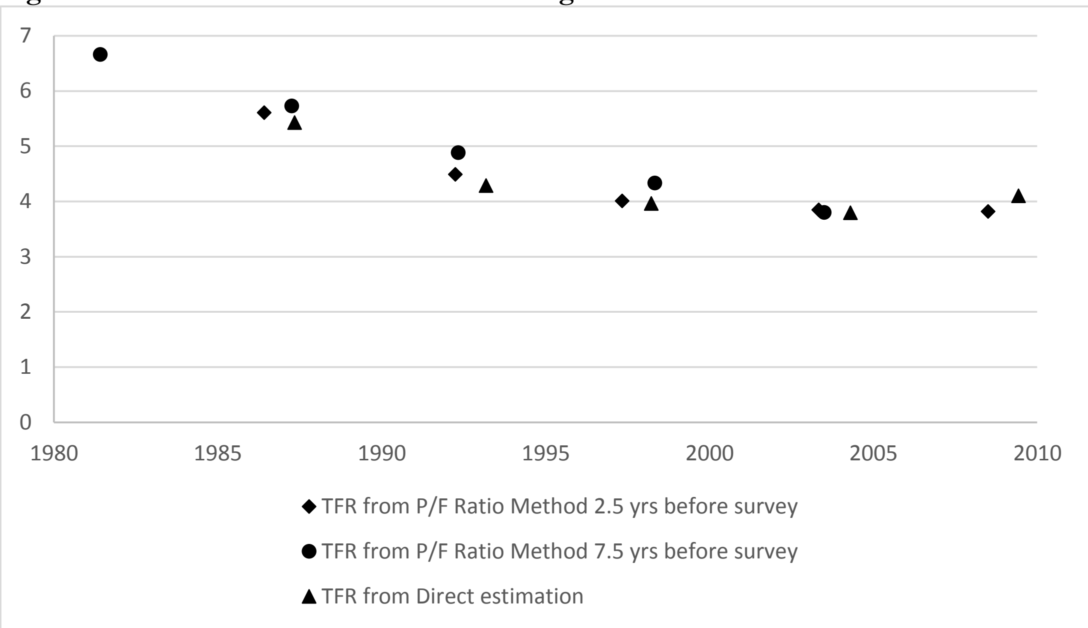
4.4.2 Cohort period fertility rates

This section presents the results obtained from calculating cohort period fertility rates. Cohort period fertility rates are calculated to corroborate evidence to support results from direct estimates of fertility. Calculations of cohort period fertility rates can also help assess the quality of the data from the birth histories. As the census does not collect information on full birth histories, any calculation of cohort period fertility rates from these data is precluded. The calculated cohort period rates and P/F ratios are presented in Table C.1-Table C.5 (in Appendix).

By analysing the cohort period fertility rates derived in each survey, an assessment into the quality of the data can be made. Brass effects (as described in Section 3.4.3) are observed in the two most recent surveys (highlighted in red). Omission of more distant fertility in the surveys can be observed. For example, in the 1994 survey the oldest women (the 1945-49 cohort) at the younger ages have lower or almost the same fertility than those of younger cohorts.

The method yields two measures of total fertility, which apply 2.5 and 7.5 years before the survey. Figure 4.23 shows these measures of total fertility at the points where they apply as well as the points derived from the direct estimation of total fertility. Of note is that the total fertility from the cohort period fertility rate method 7.5 years before the survey are slightly higher than those from the direct estimation and cohort period fertility rate method 2.5 years before the survey although they apply to almost the same period in time, with only one exception. This may be as a result of displacement of births by interviewers or by women (Brass effect). The consistency of the total fertility from the 2.5 years before the survey with those from direct estimation is clear and show the same picture. This demonstrates that the DHS are consistent with each other.

Figure 4.23 TFR Derived from the DHS using direct and indirect estimation

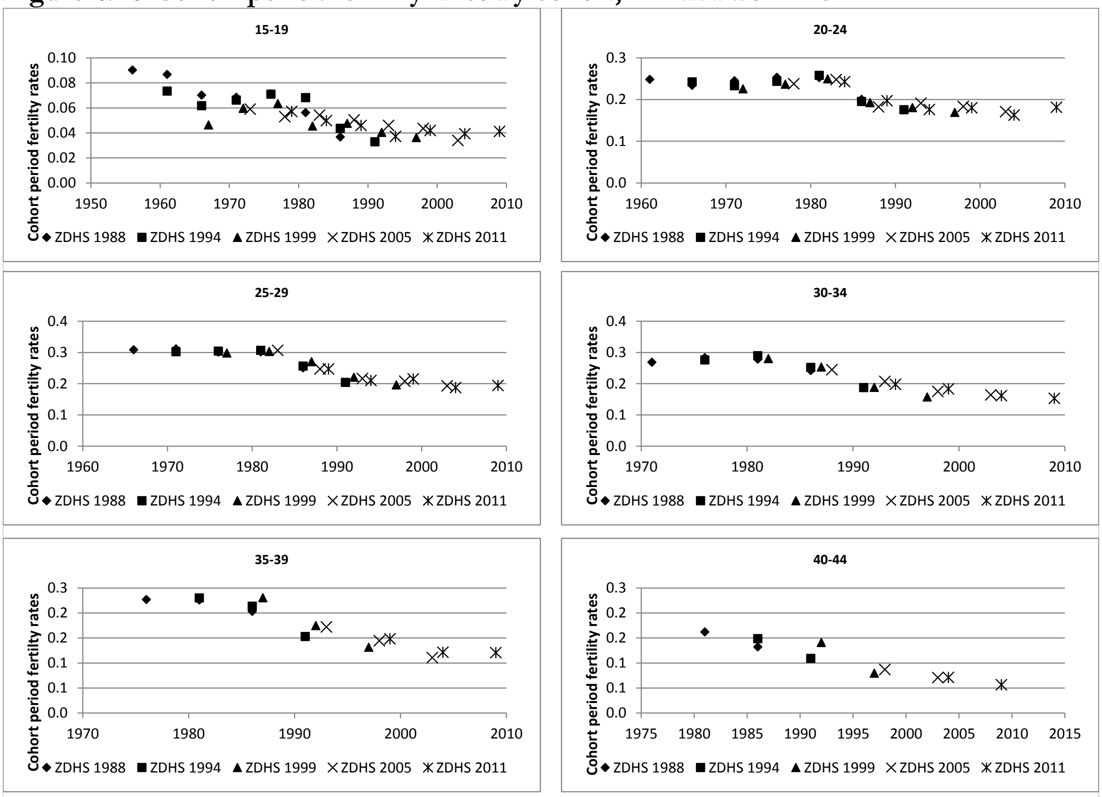


The P/F ratios derived from the 1988 ZDHS imply that fertility decline may have started five years before the survey. This is shown by the P/F ratios in the most recent period, increasing consistently with age, whereas there is no such trend in the ratios 5-9 years before the survey. Looking across the major diagonal of the P/F ratios of the 35-39 age group one notices that they depart from the overall trend, which is a sign of age misstatement by women. The P/F ratios for the 1994 ZDHS substantiate results obtained from the 1988 ZDHS that fertility decline began five years before the survey, which is 10 years before the 1994 ZDHS in 1983. The trend in P/F ratio in the 1999 ZDHS point to fertility decline in 0-9 years before the survey. The same is observed in the P/F ratio from the 2005-06 ZDHS fertility decline in the 0-9 years before the survey. No clear trend of fertility decline is observed in the 2010-11 ZDHS.

From the analysis of CPFRs, consistency has been noted in the total fertility rates derived from all the ZDHSs. Fertility decline is suggested to have started in 1983 and continued to decline to 2005. The most recent survey did not show any changes in fertility.

A comparison of cohort period fertility rates by age group at the time of the survey is shown in Figure 4.24. Cohort period fertility rates for women aged 15-19 at different surveys show that decreasing fertility rates starting in the 1970s. The points for the women 15-19 are a bit scattered, which may be as a result of different progressions into childbearing. A clearer trend is observed for women aged 20 and older. These points show fertility increasing or levelling off before the 1980s. Fertility decline seems to have started in the 1980s. Of note is that from the late 1990s there seems to have been a stall in fertility as the cohort period fertility rates do not show a downward trend in fertility but seem to level off. This is consistent with what was observed in the plot of TFR. Also observed is that for the cohort period fertility rates, which apply to the same period in time, the points knit well with each other. They lie in close range or on top of each other. This does not apply to the 15-19, which may be explained as above.

Figure 4.24 Cohort period fertility rates by cohort, Zimbabwe DHS



Plotting the cohort period fertility rates by the time before the survey gives a clearer view of when fertility decline commenced and the trend in fertility. As shown in Figure 4.25, fertility decline began 0-4 years before the 1988/89 ZDHS as this is where a consistent fall in cohort period fertility rates is observed. This is corroborated by both the cohort period fertility rates in the 1994 and 1999 ZDHS. The cohort period fertility rates also show clearly that fertility has since stalled in Zimbabwe as they have levelled off. By looking at the cohort period fertility rates in the 2005/06 ZDHS it is observed that the stall may have begun about 5-9 years before the survey and the ZDHS of 2010/11 substantiates this.

Figure 4.25 Trends in cohort-period fertility rates for each DHS

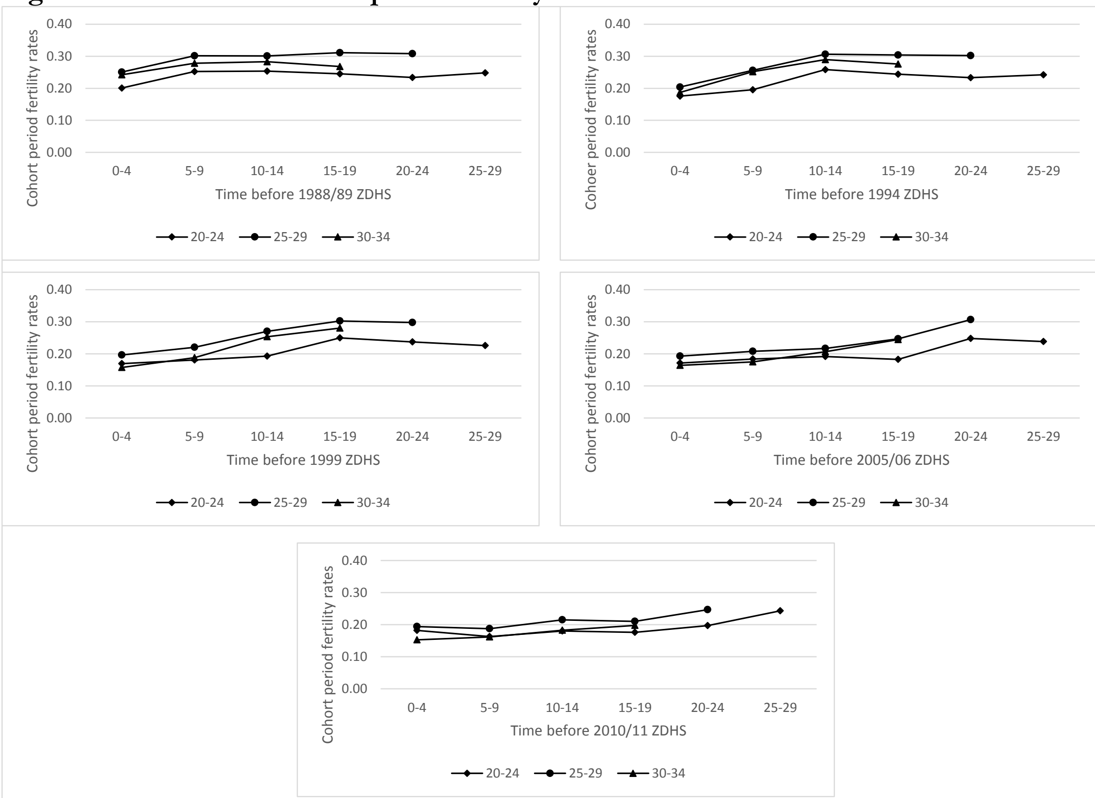
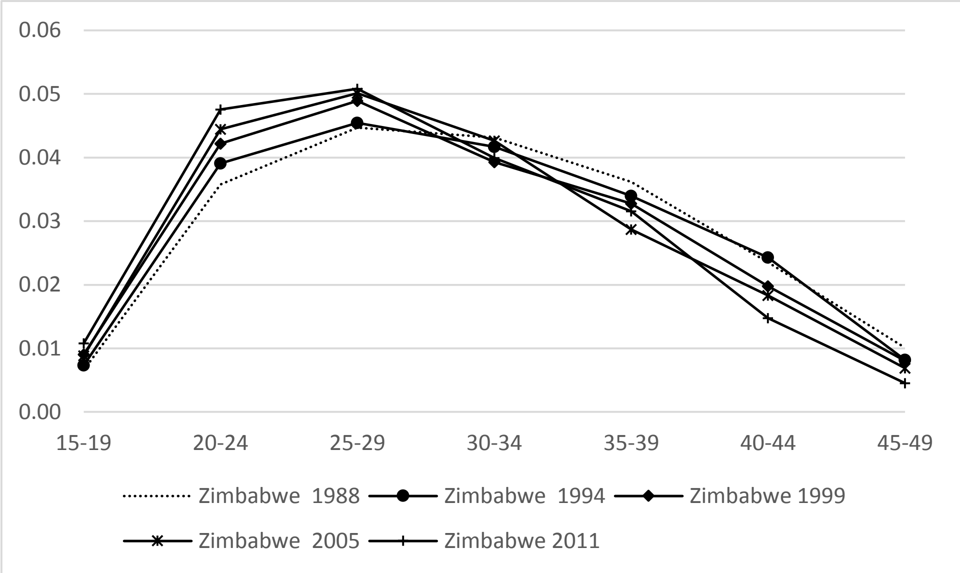


Figure 4.26 shows standardised cohort period fertility rates for 0-4 years before the survey for each Demographic and Health Survey done in Zimbabwe. These show the proportion of women having children at older ages decreasing whereas more women are having children at the younger ages. The picture shown is the same as that depicted in the age specific fertility rates for the Demographic and Health Surveys that fertility rates of older women have decreased and increased for younger women.

Figure 4.26 Standardised CPFR for women 15-49, 5 years before each survey

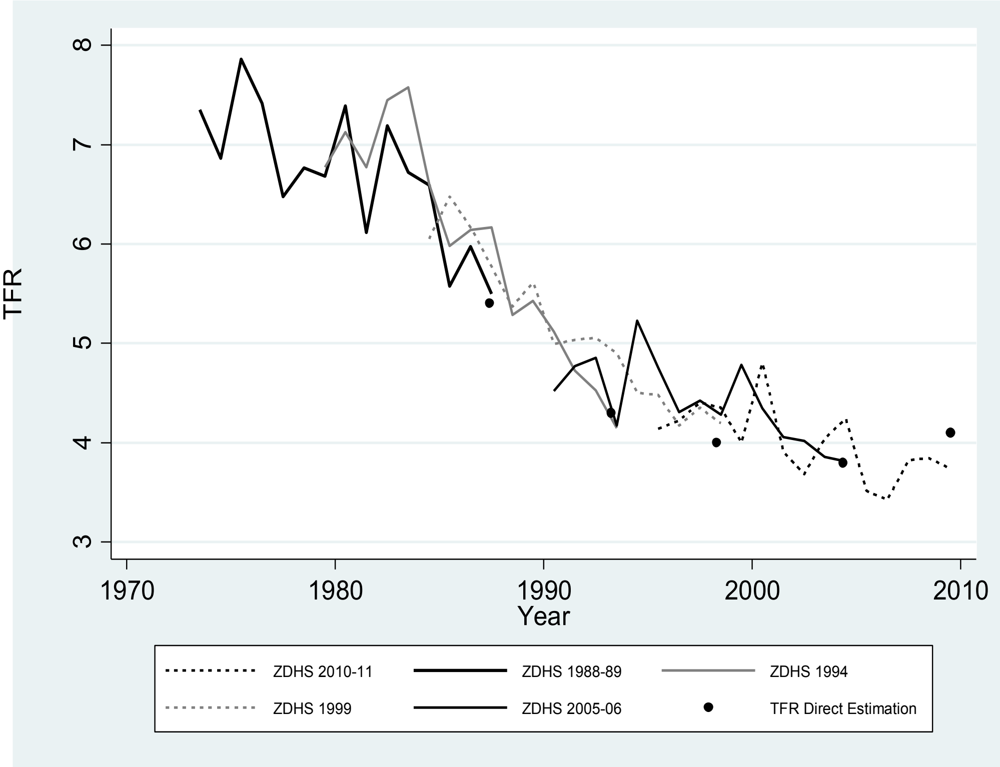


The calculation of cohort period fertility rates has shown that fertility decline began 0-4 years before the 1988/89 ZDHS survey. The stall in fertility has been noted to have begun roughly 5-9 years before the 2005/06 ZDHS.

4.4.3 Trends in fertility from DHS data

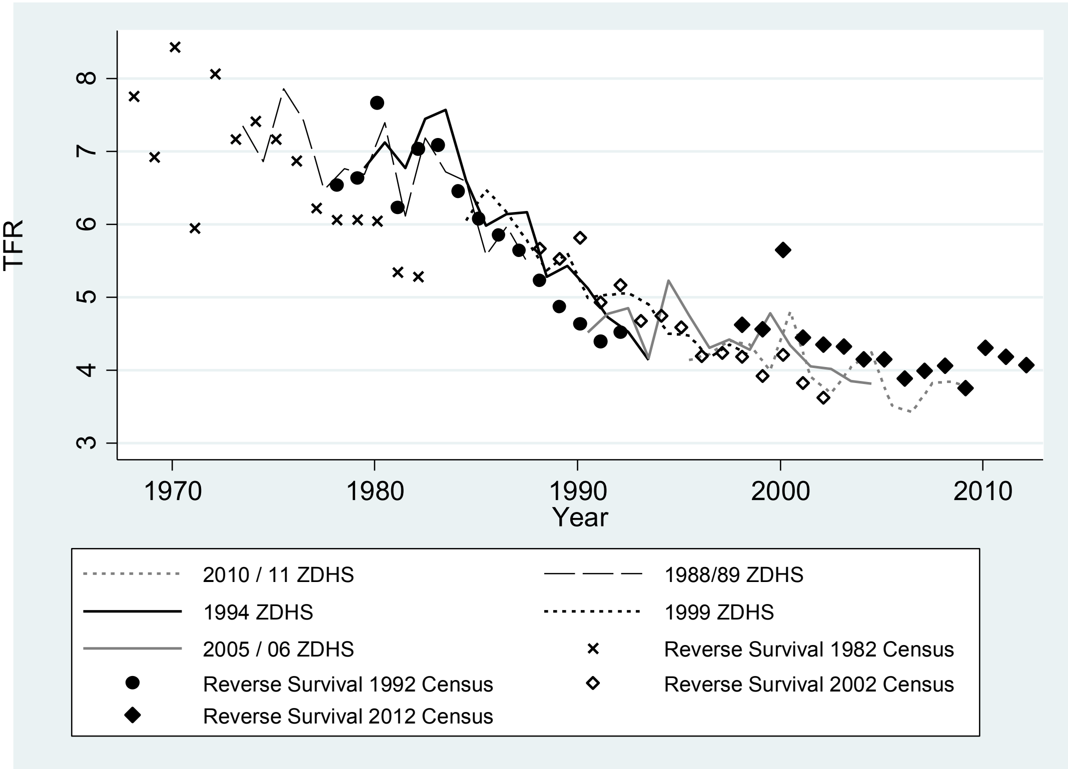
As referred to in previous chapters, the DHS data at times suffers from errors of displacement or omission of births as a result of interviewers desiring to avoid the lengthy health module. Displacement or omission is recognised by a sharp drop in the TFR in the year. To investigate this, a plot in single years of the TFRs by single years was done for all the years. As observed in Figure 4.27, although there are some yearly variations there seems to be consistency in the total fertility rate calculated yearly. The published total fertility rates also lie in close proximity to the one year total fertility rates. There has been fertility decline in Zimbabwe with the greatest decline being observed from the early 80s to the early 90s. Beyond the early 90s fertility decline seems to have slowed down.

Figure 4.27 Comparisons across five surveys of retrospective fertility trends (by single years) in Zimbabwe



A comparison is also done between the single year total fertility from the Demographic and Health Survey and the total fertility estimates derived from reverse survival in the census, shown in Figure 4.28. There is a remarkable agreement between the total fertility in the three recent censuses and the total fertility from the DHS. This inspires confidence about the quality of the age distribution in the three most recent censuses. The total fertility from the 1982 census have already been deemed problematic and again the errors in the age distribution are highlighted in this plot.

Figure 4.28 Trends in total fertility, Zimbabwe Censuses and Demographic and Health Surveys



4.4.4 (Projected) Parity Progression Ratios

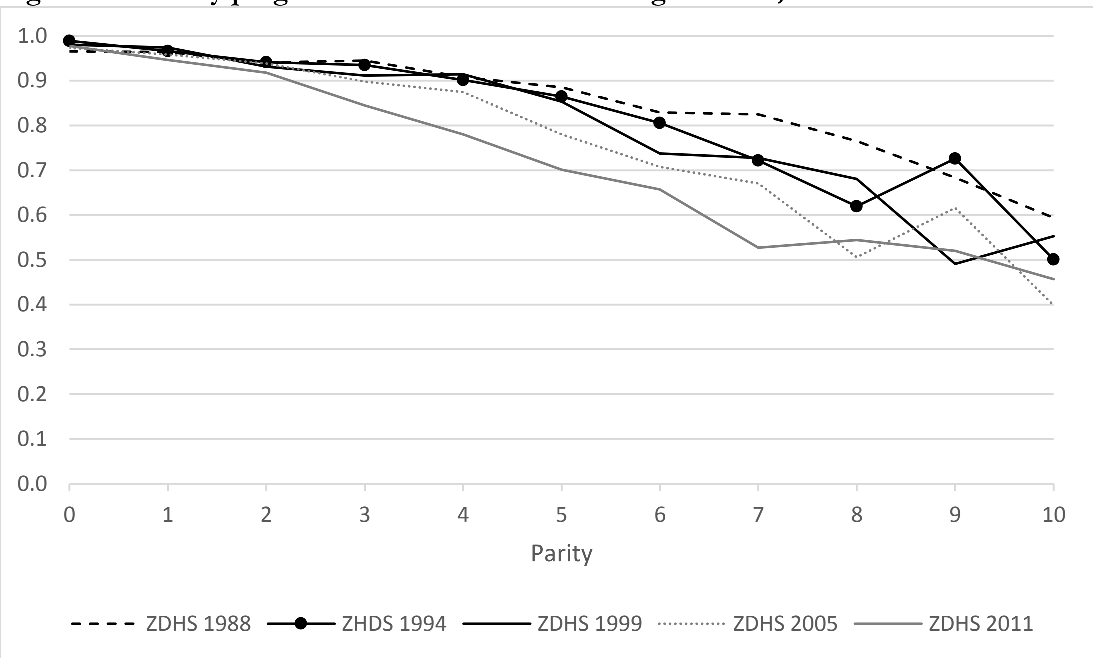
The analysis of parity progression ratios complements with that already carried out using total fertility and CPFRs. PPRs robustness to errors, which arise as a result of timing and location in time of births, provides a different appreciation to fertility from that from period measures. The procedure on calculating parity progression ratios has been described in detail in the previous chapter.

Table 4.16 below shows the parity progression ratios for women aged 45-49 for all DHS surveys. The ratios start off quite high, with 90.8 per cent of women progressing from the fourth child to the fifth in the 1988 ZDHS whereas in the 2010-11 ZDHS, 78 per cent of the women progressed to have a fifth child. For all the surveys as we progress from one parity to the next the number of women who move on to the next parity decreases. Figure 4.29 shows that for all surveys progression to parity two for the women aged 45-49 follows the same pattern and the differences become more pronounced from the third parity. Earlier surveys show more women progressing to higher parities whereas the recent surveys have less women progressing to higher parities. This points to fertility decline being a result of parity limitation.

Table 4.16 Parity progression ratios for all women aged 45-49, DHS

CEB	ZDHS 1988	ZHDS 1994	ZDHS 1999	ZDHS 2005	ZDHS 2011
0	0.966	0.989	0.981	0.974	0.978
1	0.964	0.966	0.974	0.959	0.946
2	0.941	0.941	0.931	0.939	0.918
3	0.945	0.935	0.912	0.898	0.844
4	0.908	0.902	0.915	0.874	0.780
5	0.885	0.864	0.853	0.780	0.701
6	0.829	0.806	0.737	0.708	0.657
7	0.825	0.722	0.728	0.670	0.527
8	0.765	0.619	0.680	0.506	0.544
9	0.683	0.726	0.491	0.616	0.520
10	0.594	0.501	0.553	0.399	0.457
MCEB	6.9	6.6	6.3	5.7	4.9

Figure 4.29 Parity progression ratios for all women aged 45- 49, DHS



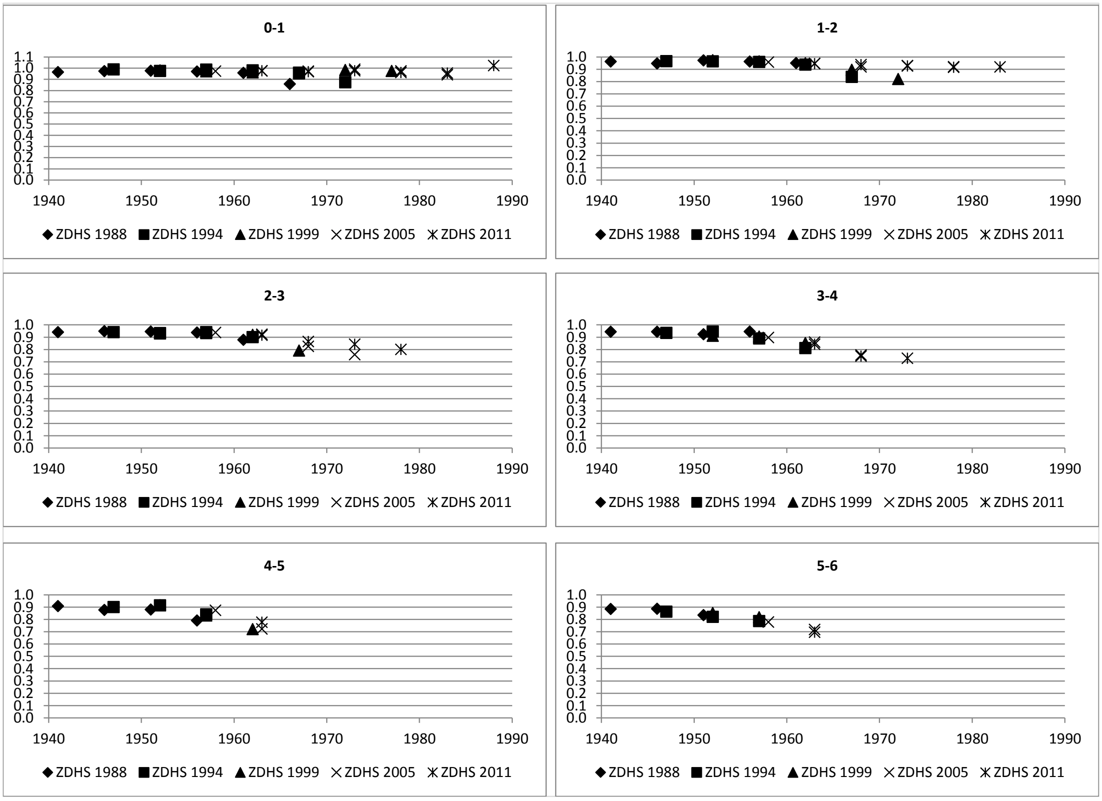
The method proposed by Brass and Juárez (1983) described in the previous chapter is used to calculate projected parity progression ratios (PPPRs) using birth histories. The method controls for selection effects by truncating the data, when the experience of one cohort is truncated and compared to the adjacent younger cohort (indices of relative change). The indices of relative change are then chained together to derive PPPRs. Projected parity progression ratios are calculated on the assumption that future progression will be at the same rate as that observed currently. If few women have experienced the parity progression in question, the indices of relative change derived from these are unreliable. As a rule of thumb if the proportion of women who have undergone a certain parity progression is greater than 80%, then the degree of credibility is high as extrapolation will be done for less than 20 per cent of the women who have not experienced the progression in question. If, on the other hand, the proportion of women is between 65-80%, a lesser degree of confidence and for anything less than 65% the results are considered as unreliable and should not be trusted.

The projected parity progression ratios for all the DHS conducted in Zimbabwe are shown in the Appendix in Table D.1. The projected parity progression ratios depicted exclude those where only a small proportion of women have experienced the parity progression in question; less than 65 per cent of the women have undergone the parity progression of interest (these are italicised in Table D.1). There is approximately a five year gap between the surveys, which means comparisons can be done for the PPPRs from the same birth cohort. This means, for example, that the women aged 35-39 (birth cohort of approximately 1951) in the 1988 DHS will be approximately aged 40-44 in the 1994 DHS. By comparing the projected parity progression ratios in the DHS, an analysis of the births of order seven and under will be done as fertility in Zimbabwe is low and few women progress to even higher parities.

The overall consistency between the projected parity progression ratios for all the DHS can best be observed in Figure 4.30. Except for progression to the first birth, a gradual decline at all parities is observed. There is a reasonable consistency between the results from all the surveys. For the same cohort of women, the PPPRs lie on top of each other or in close proximity to each other, as shown in the figure. This is a sign of good quality data and gives confidence in the data. Values of PPPRs greater than one are observed in the 2010/11 Zimbabwe DHS for women aged 15-19 and 20-24 for progression to parities one and two. This may be a result of fewer births reported by the younger women. Another plausible explanation is that the women in the younger ages misreported the births in those cohorts.

The downward trend in the PPPRs is a sign of fertility decline. Progression to a second birth is almost definite for anyone who has ever had a child, as shown by the ratios being close to one. From the third and higher births there has been a decline in the projected parity progression ratios for all women, meaning fewer and fewer women have three or more children. Fertility decline seems to have started with the women born in the 1960s as indicated by the downward slope in the PPPRs. This is the same picture which was shown in the census projected parity progression ratios, that fertility decline began with the cohort born in the 1960s. The projected parity progression ratios for the younger cohorts seem to have changed. They show a flat trend, which is a sign that there has been no further fertility decline. This supports the observation made from the cohort period fertility rates that fertility in Zimbabwe has stalled.

Figure 4.30 Projected parity progression ratios by birth cohort and parity, Zimbabwe 1988-89, 1994, 1999, 2005-06, 2010-11 DHS



The calculated projected parity progression ratios have corroborated the results from the CPFRs and the census. Fertility decline in Zimbabwe seems to have started with the cohort of women born in the 1960s. Also shown here is that fertility has since stalled in Zimbabwe.

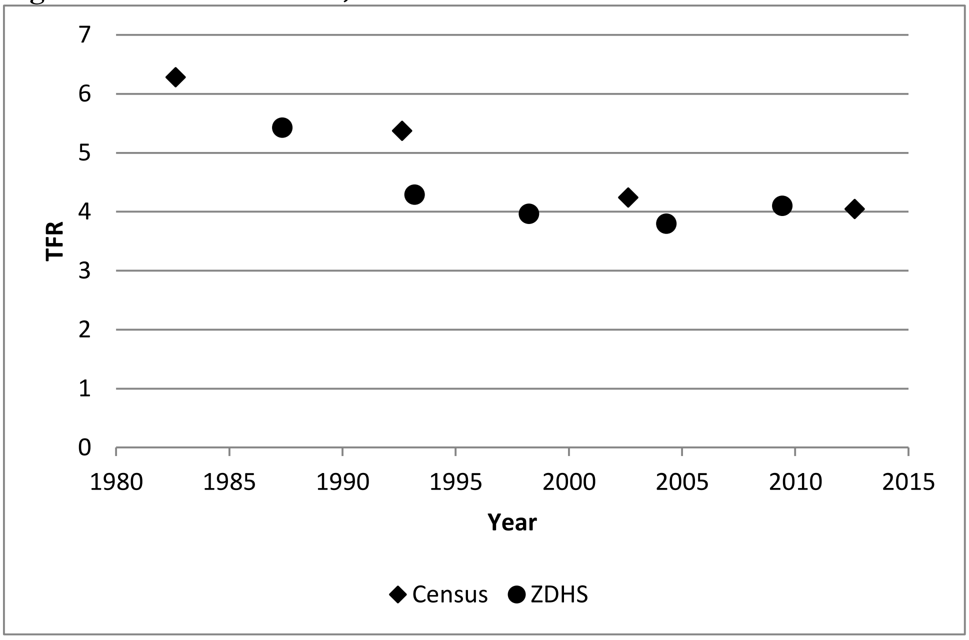
4.5 Comparison of DHS and Census fertility rates

The preceding section has calculated the fertility levels for the census and Zimbabwe Demographic and Health Surveys on an individual basis and looked at the trends in the fertility and projected parity progression ratios described by each method. This section is set out to present a comparison of the fertility rates and trends observed in the census with those from the Demographic and Health Surveys.

4.5.1 Comparison of fertility rates

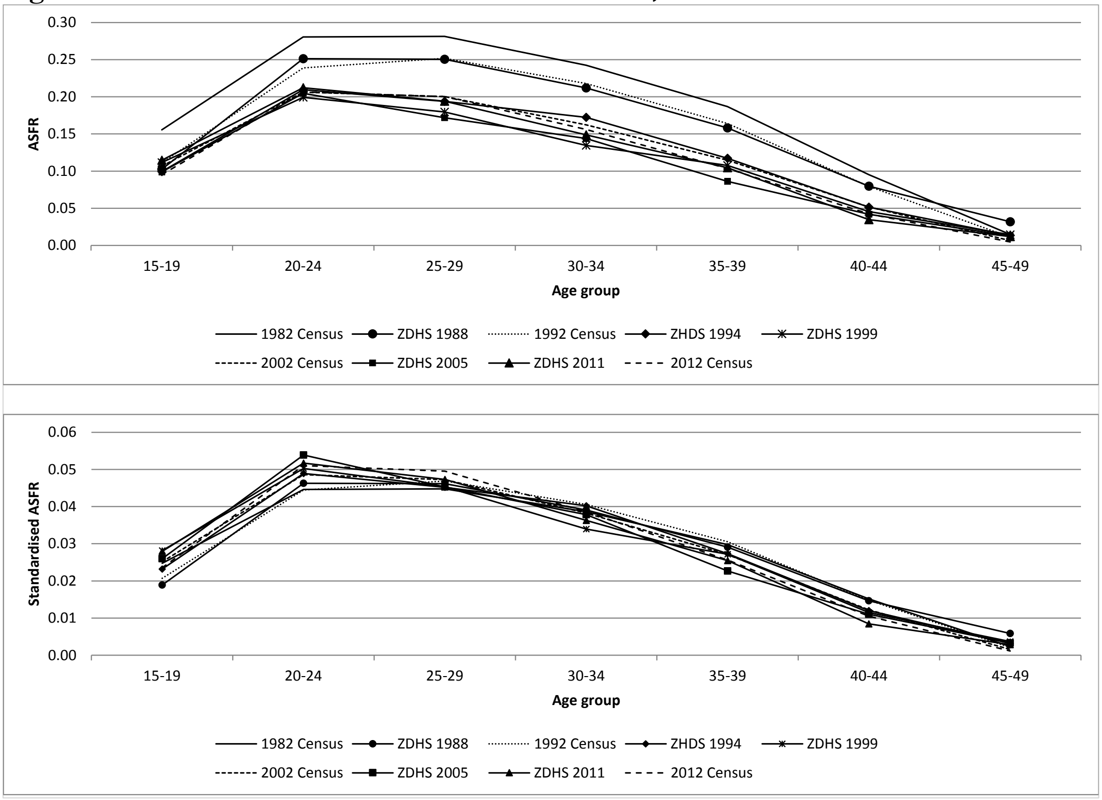
Figure 4.31 shows the total fertility rates for the census and DHS in the years in which they apply. The trend shows that there has been fertility decline in Zimbabwe. The TFR for the 1992 Zimbabwe census clearly lies out of line with the other points, which is likely to be a result of errors in the data. To a lesser extent the TFR implied by the 2002 census does not also lie in line with the other estimates. Although this is the case, more similarities than differences are shown. Fertility has stalled at about four children per woman, and it seems the stall started in the mid-1990s.

Figure 4.31 Corrected TFR, Zimbabwe Census and DHS



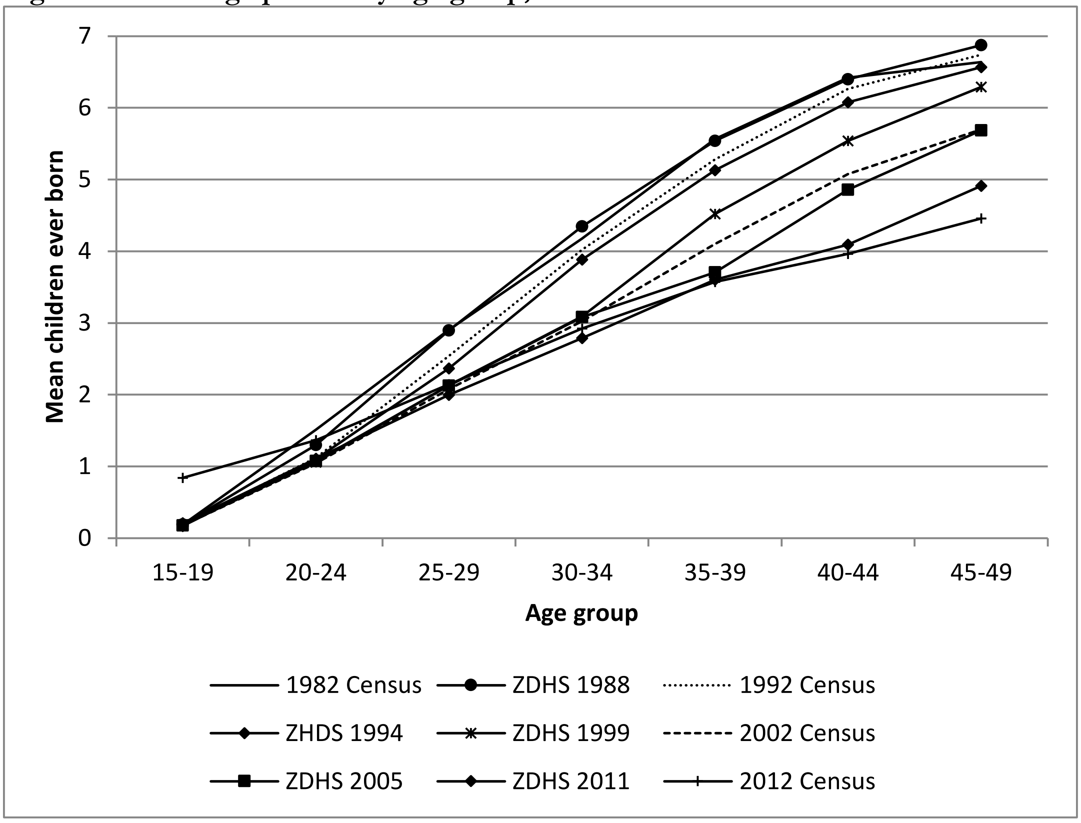
The standardised ASFR for all surveys and censuses are shown in Figure 4.32. Over time fertility has shifted from being concentrated in the 20-24 and 25-29 age groups to the 20-24 age group. The proportion of fertility has increased in the younger age groups and slightly decreased in the older age groups. The age specific fertility rates show the standard demographic pattern from being flat to peaked over time. In recent years the shape of the fertility distribution has remained rather the same, which points to stalling fertility.

Figure 4.32 Unstandardised and standardised ASFR, Zimbabwe Census and DHS



A plot of the average parities for all the surveys and censuses in Zimbabwe shows a sigmoid shape as expected (Figure 4.33). The average parities reported in the 1982 census and the ZDHS 1988 are very similar, of which given the timing this should not be so. It is possible that women in the 1982 census did not report all children ever born, which resulted in the underestimation of the parities. The average parities of women aged 45-49 in the 1988 ZDHS are 0.2 of a child higher than the 1982 census. The oddity in the average parities of the 2012 women aged 15-19 is again clearly picked up as it clearly lies out of line with the rest of the other points. Overall, in comparison to each other, the average parities are plausible in the census and DHS.

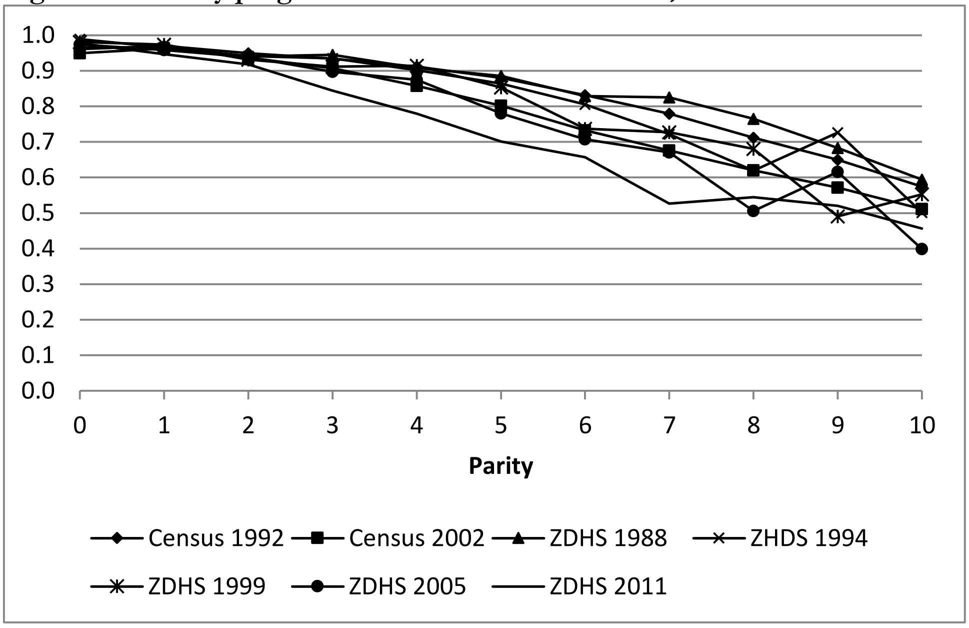
Figure 4.33 Average parities by age group, Zimbabwe DHS and Census



4.5.2 Comparison of Parity Progression Ratios

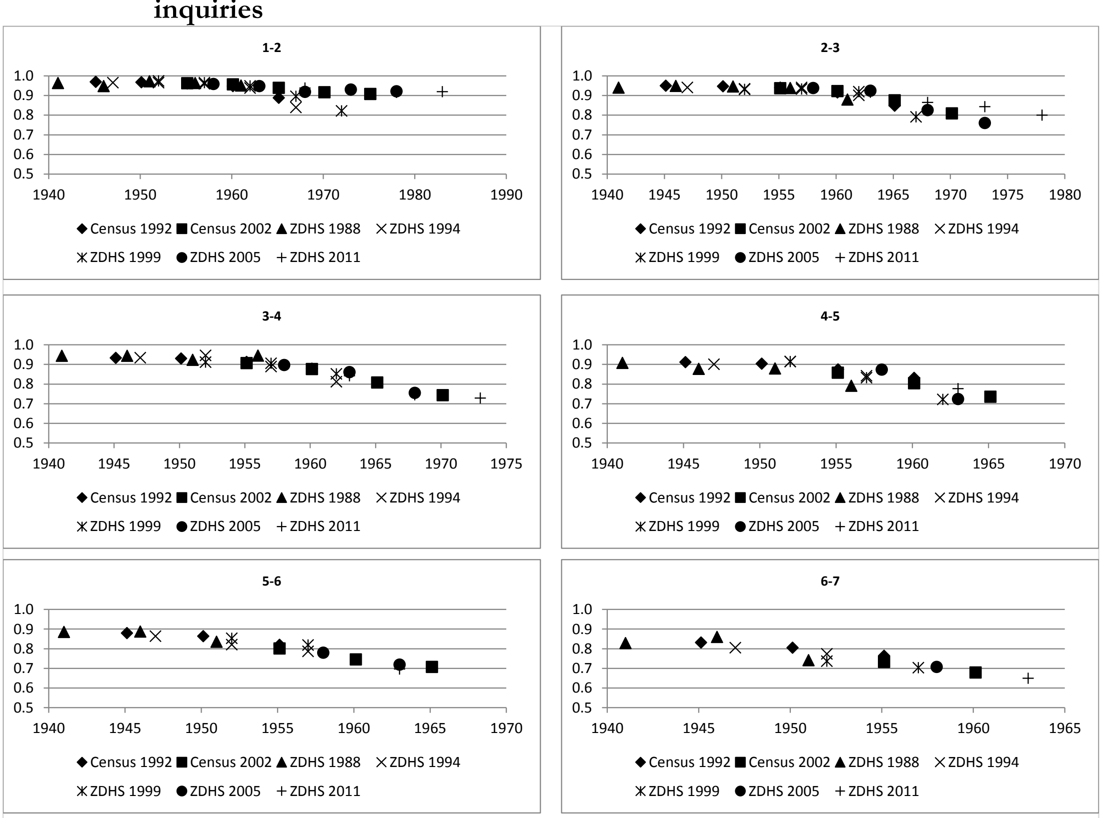
For women aged 45-49, parity projection ratios are plotted, as shown in Figure 4.34. Of note is that the ratios for progression to first and second birth are quite similar for the census and Demographic and Health Survey. High proportions of women become mothers and go on to have a second child. Variation begins in the number of women who progress to have a third child. There are smaller proportions of women who progress to have three children and even lower who progress to four. Over the years the proportion of women who have progressed to have three children has decreased, and this goes for even higher parities. The erratic parity progression ratios observed at the higher parities are a result of a smaller group of women progressing to these parities.

Figure 4.34 Parity progression ratios for women 45-49, Zimbabwe Census and DHS



A comparison of the Zimbabwe census and DHS projected parity progression ratios shows the census projected parity progression ratios being in line with those projected in the DHS. This is observed for progression to all parities, as shown in Figure 4.35. Fertility decline is again observed at about the same years for both the census and the DHS. With time, especially for higher parities, fewer women are expected to progress to these high parities.

Figure 4.35 Projected parity progression ratios, Zimbabwe Census and DHS, all inquiries



4.6 Discussion

The aim of the chapter was to investigate the fertility levels and trends in Zimbabwe as portrayed by the censuses and Demographic and health surveys held in Zimbabwe. The findings from this analysis are presented in this section and aim to explain the results in depth.

First, an investigation into the apparent consistency in the yearly total fertility shown in the Demographic and Health Surveys is observed to be present among women from different backgrounds i.e. residence and education levels. Yearly fluctuations in total fertility were observed but the overall picture shown was a consistent decline in total fertility by education status of the women, which is consistent with the increase in the education level attained by women. This shows that in Zimbabwe education is inversely related to fertility, as many authors have suggested ((Jejeebhoy (1995); Kravdal 2002)). The most plausible explanation for this inverse relationship in Zimbabwe is that with the increase in education in Zimbabwe the fertility rates began to decline. An increase in education results in increased contraception use and tilts fertility preferences toward fewer children as women are involved in the labour market. The total fertility by place of residence was also observed to be consistent, and as expected urban total fertility was observed to be lower than rural total fertility in both the census and the DHS. The differences in the fertility rates by residence have been attributed to the effective use of contraception by women in urban areas as well as higher ages at first birth Moultrie and Timæus (2002). In this regard, it was concluded that the total fertility from the Demographic and Health Surveys was consistent among sub-population groups investigated.

Fertility decline in Zimbabwe has clearly occurred, which is clearly shown by both the census and the Zimbabwe Demographic and Health Surveys. Upon correction of the census data, it was noted that fertility declined from 6.3 children per woman in the 1982 census to 4.0 children per woman in the 2012 census. This shows a decline of 2.3 children per woman in two decades. The Zimbabwe Demographic and Health Surveys shows a decline of 1.3 children per woman from the 5.4 children per woman in the 1988/89 ZDHS to 4.1 children per woman in the 2010/11 ZDHS. Of note is that in the DHS there is a clear consistency between the fertility rates obtained from the direct and indirect estimation of fertility. Overall, the corrected fertility rates from the census and those from direct estimation in the ZDHS of fertility are consistent with each other, as shown in Figure 4.31.

Cohort period fertility rates point to fertility decline in Zimbabwe, starting approximately five years before the 1988/89 ZDHS. By looking at the projected parity progression ratios it was noted that fertility decline began with the cohorts of women born roughly in the 1960s. This points to fertility decline being roughly in the 1980s and confirms the results from the cohort period fertility rates. From the total fertility rates it is observed that the steepest decline occurred between the 1980s to mid-1990s. From the mid-1990s to present there has been a stall in fertility in Zimbabwe. The total fertility rates and the projected parity progression ratios all point to a stall in fertility in Zimbabwe.

By looking at the parity progression ratios it was noted that decline occurred to women in all age groups and in all parities. The most decline was seen in higher parities, which concurs with what Muhwava and Timæus (1996) and Udjo (1996) concluded in their studies. Also noted is that the decline had been greater among younger women.

5 CONCLUSION

The study set out to compare the fertility rates from the Zimbabwean censuses and those from the Zimbabwe Demographic and Health surveys. The hypothesis by Schoumaker (2010) that data from the Zimbabwe Demographic and Health Survey had less errors was investigated to see whether this was true for population sub-groups. A comparison of the fertility rates and (projected) parity progression ratios of the census and the Zimbabwe Demographic and Health Survey was carried out. This was done to investigate whether there is consistency in the fertility rates from all the censuses and Zimbabwe Demographic and Health surveys conducted in Zimbabwe. In this chapter, a discussion into the results obtained and possible explanations are presented.

The total fertility presented in the country conceals wide variations in the levels and trends in fertility between population sub-groups. Following up on Schoumaker (2010) work, an investigation into whether the consistency in the total fertility was also presented by residence and education showed the consistency being present. In Zimbabwe it was observed that education is inversely related to fertility and women in the urban areas have lower levels of fertility than those residing in the rural areas.

Cohort period fertility rates were applied to further investigate the apparent consistency of the Zimbabwean Demographic and Health Survey. Applying the method derives two measures of fertility for each survey which, when plotted, it was observed that they mapped together for the periods where they overlapped. This shows that the data from the Zimbabwe Demographic and Health Survey are fairly consistent and further builds to the consistency of the data to what Schoumaker (2010) had done. Of note is that the consistency in the cohort period fertility rates existed even as there were some problems noted in the data, such as omission. The cohort period fertility rates show a decline of 2.8 children per woman from 6.7 children per woman in 1981 to 3.8 children per woman in 2008.

Overall, fertility in Zimbabwe declined from 6.3 children per woman in 1982 to 4.0 children per woman in 2012. The fertility estimates from consecutive inquiries match very well, roughly lying in the same trend regardless of whether it's the census or Demographic and Health Survey. This highlights the fact that although there are problems in the data, reliable estimates can still be obtained. Fertility decline began in the late 1970s and the greatest decline was observed to have occurred from the 1980s to the mid-1990s.

The analysis of consistency of fertility data was further investigated using (projected) parity progression ratios as they are more robust to some of the errors usually found. The results show a gradual decline in the parities from parity two and higher. Fertility decline is more pronounced at higher parities. Fertility decline is observed to be in part due to parity limitation as fewer and fewer women progress to above parity three which is the same as what Muhwava and Timæus (1996) and Udjo (1996) concluded. The (projected) parity progression ratios from the census alone were consistent with all the censuses held, and combining these with those from the Zimbabwe Demographic and Health Survey a produced a clear, consistent trend of ratios across surveys. Comparison of the (projected) parity progression ratios further reinforces the conclusions drawn that there is consistency between the census and DHS.

An observation made from these data are that fertility has stalled in Zimbabwe. The cohort period fertility rates show that from the late 1990s fertility roughly stalled at about four children per woman as it seems to fluctuate around this value. The plot of the total fertility rate by year for both the census and Zimbabwe Demographic and Health Surveys also show the same picture. To add weight to this, parity progression ratios show a levelling of the ratios, which points to stalling fertility. This is consistent to what Bongaarts (2008) observed, which is that fertility in Zimbabwe had stalled. Stalls in fertility can be attributed to the lengthening of birth intervals as women postpone having another child due to uncertainty about the future (Moultrie and Timaeus 2013). Besides using contraception to simply stop or space having a child, Timaeus and Moultrie (2008) argue that women also use contraception to postpone or delay having another child. The delay has led to longer birth intervals which are causing fertility stalls. Using Zimbabwe Demographic and Health Surveys, Sayi (2009) showed that birth intervals increased to 55 months by the year 2000 from 28 months in the 1960s. This may be used to explain the stall in fertility in Zimbabwe.

With regard to the methods used, the relational Gompertz method showed that fertility was underestimated in all the surveys. Adjustment using the relational Gompertz method generates reasonable estimates of fertility even when the census data are not of good quality. Projected parity progression ratios for Zimbabwe have been observed to be consistent across the censuses and Demographic and Health Survey even when there were problems identified in the data. The robustness of the use of the method of projected parity progression ratios, even when they are problems with the data, shows that they can be relied upon to give reliable measures of changes in fertility. The research has shown that projected parity progression ratios provide a very powerful way of detecting stalling fertility. The 1982 census and the 2012 census show that reverse survival method is affected by the quality of the count of young children. The method is highly sensitive to age misreporting, and fertility estimated derived from data with these errors will be biased.

Availability of the 2012 census would have helped to further investigate the consistency of the census and Zimbabwe Demographic and Health Survey. Effort was made to get either a 10 per cent sample of the data or just simple tables from the Zimbabwe Statistical Office but limited assistance was offered. In relation to the overall findings, availability of the 2012 census data would have assisted to further investigate whether fertility in Zimbabwe had not changed significantly in recent years (stalling fertility).

The study has shown that at national level fertility has stalled in Zimbabwe. Of interest is to further investigate whether the stall is also present for different population groups, such as by residence or education. The research had clearly shown a different way of identifying stalls in fertility. It would also be of interest to investigate this for other countries in sub-Saharan Africa where fertility stalls are suspected to see whether the same result is obtained.

Overall, the analysis has shown that even in a poor developing country and with careful estimation of fertility, the census fertility rates can be remarkably consistent with the Demographic and Health Survey estimates. The census and Demographic and Health Survey data in Zimbabwe have been noted to suffer from errors but the fertility rates calculated are consistent with each other. These include the total fertility rate and the (projected) parity progression ratios which clearly show the same trend. The method of parity progression ratios is observed to be robust to errors and deficiencies found in census and Demographic and Health Survey data. Using projected parity progression ratios, fertility decline in Zimbabwe is observed to be a result of parity limitation at higher parities. The research has also added to contention that using the (projected) parity progression ratios stalls in fertility may be investigated. Stalls in fertility in Zimbabwe are observed to have started in the mid-1990s and fertility has stalled at about 4 children per woman.

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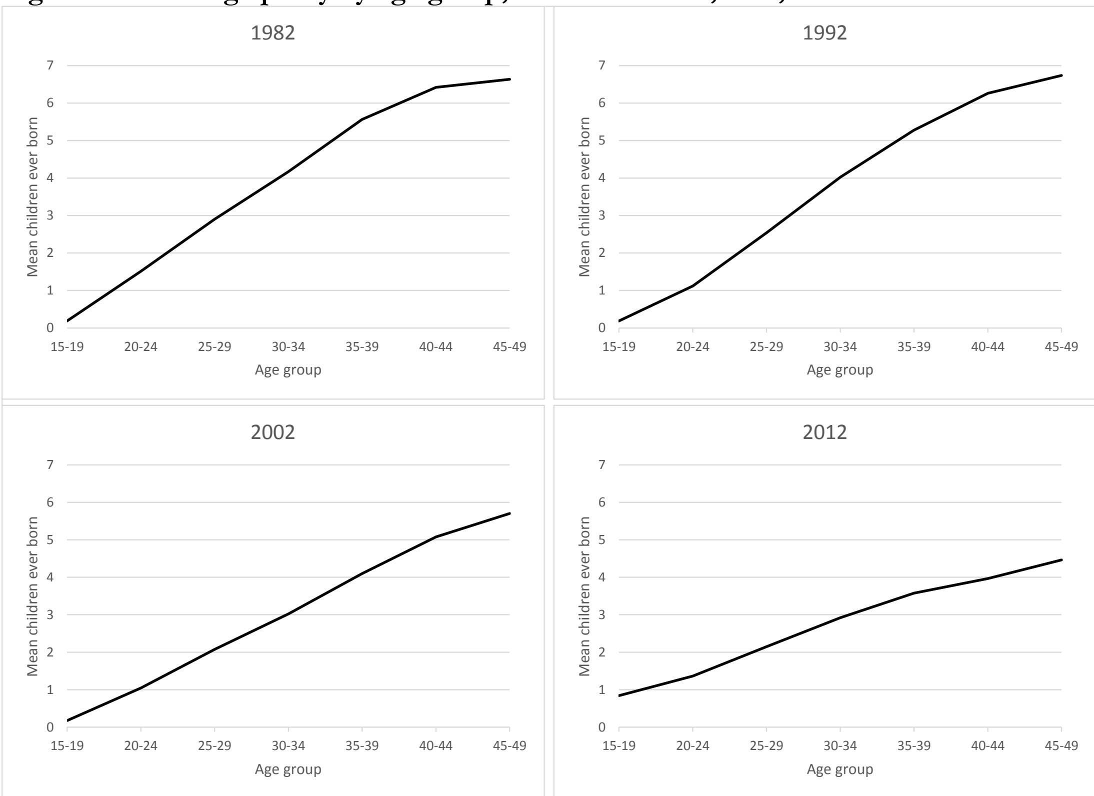
Appendix A Average parities by age, Zimbabwe Censuses

Figure A.1 Average parity by age group, Zimbabwe 1982, 1992, 2002 and 2012 Censuses



Appendix B Fertility rates for the three years preceding each Zimbabwe DHS

Table B.1 ASFR and TFR Unstandardised for the three years preceding each survey

Age group	*ZDHS 1988-9*	*ZDHS 1994*	*ZDHS 1999*	*ZDHS 2005*	*ZDHS 2010*
15-19	0.102	0.099	0.112	0.099	0.115
20-24	0.251	0.210	0.199	0.205	0.212
25-29	0.250	0.194	0.180	0.172	0.194
30-34	0.212	0.172	0.135	0.144	0.149
35-39	0.158	0.117	0.108	0.086	0.104
40-44	0.080	0.052	0.046	0.042	0.035
45-49	0.032	0.014	0.015	0.013	0.012
TFR	5.4	4.3	4.0	3.8	4.1

Table B.2 ASFR and TFR Standardised for the three years preceding each survey

Age group	*ZDHS 1988-9*	*ZDHS 1994*	*ZDHS 1999*	*ZDHS 2005*	*ZDHS 2010*
15-19	0.094	0.116	0.141	0.130	0.140
20-24	0.231	0.244	0.251	0.269	0.259
25-29	0.231	0.226	0.227	0.226	0.237
30-34	0.195	0.201	0.170	0.189	0.181
35-39	0.146	0.137	0.136	0.113	0.127
40-44	0.073	0.060	0.057	0.055	0.042
45-49	0.029	0.016	0.018	0.017	0.014
TFR	1	1	1	1	1

Appendix C Cohort period fertility rates for each Zimbabwe DHS

Table C.1 Cohort period fertility rates for women aged 15-49, ZDHS 1988-89

	Years prior to survey		*0-4*	*5-9*	*10-14*	*15-19*	*20-24*	*25-29*	*30-34*
	Age group of cohort at survey								
A		No. WOMEN				NUMBER OF BIRTHS			
	15-19	1,021.0	188.0	4.0					
	20-24	840.0	843.0	236.0	12.0				
	25-29	679.0	851.0	857.0	242.0	15.0			
	30-34	589.0	713.0	888.0	747.0	202.0	10.0		
	35-39	464.0	471.0	646.0	698.0	569.0	163.0	22.0	
	40-44	318.0	210.0	359.0	450.0	495.0	372.0	138.0	11.0
	45-49	290.0	82.0	235.0	329.0	389.0	447.0	360.0	131.0
B	COHORT PERIOD FERTILITY RATES								
	15-19		0.037	0.001					
	20-24		0.201	0.056	0.003				
	25-29		0.251	0.252	0.071	0.004			
	30-34		0.242	0.302	0.254	0.069	0.003		
	35-39		0.203	0.278	0.301	0.245	0.070	0.009	
	40-44		0.132	0.226	0.283	0.311	0.234	0.087	0.007
	45-49		0.057	0.162	0.227	0.268	0.308	0.248	0.090
C	Age group of cohort at end of period								
	COHORT PERIOD FERTILITY RATES								
	15-19		0.037	0.056	0.071	0.069	0.070	0.087	0.090
	20-24		0.201	0.252	0.254	0.245	0.234	0.248	
	25-29		0.251	0.302	0.301	0.311	0.308		
	30-34		0.242	0.278	0.283	0.268			
	35-39		0.203	0.226	0.227				
	40-44		0.132	0.162					
	45-49		0.057						
D	CUMULATIVE FERTILITY OF COHORTS AT END OF PERIOD (P)								
	15-19		0.184	0.281	0.356	0.343	0.351	0.434	0.452
	20-24		1.285	1.619	1.611	1.578	1.604	1.693	
	25-29		2.872	3.119	3.082	3.160	3.234		
	30-34		4.329	4.474	4.575	4.576			
	35-39		5.489	5.704	5.710				
	40-44		6.365	6.521					
	45-49		6.803						
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)								
	15-19		0.184	0.281	0.356	0.343	0.351	0.434	0.452
	20-24		1.188	1.543	1.625	1.569	1.521	1.675	
	25-29		2.441	3.051	3.129	3.126	3.062		
	30-34		3.652	4.443	4.544	4.467			
	35-39		4.667	5.572	5.679				
	40-44		5.327	6.382					
	45-49		5.610	6.665					
F	P / F RATIOS								
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000
	20-24		1.082	1.049	0.992	1.005	1.054	1.011	
	25-29		1.177	1.022	0.985	1.011	1.056		
	30-34		1.186	1.007	1.007	1.024			
	35-39		1.176	1.024	1.006				
	40-44		1.195	1.022					
	45-49		1.213						

Table C.2 Cohort period fertility rates for women aged 15-49, ZDHS 1994

		Years prior to survey						
		0-4	*5-9*	*10-14*	*15-19*	*20-24*	*25-29*	*30-34*
Age group of cohort at survey								
A	No. WOMEN				NUMBER OF BIRTHS			
15-19	1,471.6	242.9	5.4					
20-24	1,269.4	1,114.3	276.9	6.2				
25-29	914.8	933.8	893.8	311.9	23.3			
30-34	871.0	815.6	1,115.9	1,124.4	309.3	18.9		
35-39	661.5	504.9	833.8	1,012.9	806.6	219.1	14.5	
40-44	532.4	290.5	568.0	770.9	808.9	621.5	164.5	11.4
45-49	407.3	75.1	302.7	468.4	561.7	615.0	493.7	149.7
B COHORT PERIOD FERTILITY RATES								
15-19		0.033	0.001					
20-24		0.176	0.044	0.001				
25-29		0.204	0.195	0.068	0.005			
30-34		0.187	0.256	0.258	0.071	0.004		
35-39		0.153	0.252	0.306	0.244	0.066	0.004	
40-44		0.109	0.213	0.290	0.304	0.233	0.062	0.004
45-49		0.037	0.149	0.230	0.276	0.302	0.242	0.073
Age group of cohort at end of period								
C COHORT PERIOD FERTILITY RATES								
15-19		0.033	0.044	0.068	0.071	0.066	0.062	0.073
20-24		0.176	0.195	0.258	0.244	0.233	0.242	
25-29		0.204	0.256	0.306	0.304	0.302		
30-34		0.187	0.252	0.290	0.276			
35-39		0.153	0.213	0.230				
40-44		0.109	0.149					
45-49		0.037						
D CUMULATIVE FERTILITY OF COHORTS AT END OF PERIOD (P)								
15-19		0.165	0.218	0.341	0.355	0.331	0.309	0.367
20-24		1.096	1.318	1.646	1.551	1.476	1.579	
25-29		2.339	2.927	3.082	2.996	3.089		
30-34		3.864	4.342	4.444	4.468			
35-39		5.106	5.511	5.618				
40-44		6.057	6.362					
45-49		6.546						
E CUMULATIVE FERTILITY WITHIN PERIODS (F)								
15-19		0.165	0.218	0.341	0.355	0.331	0.309	0.367
20-24		1.043	1.195	1.632	1.574	1.499	1.521	
25-29		2.064	2.476	3.163	3.094	3.008		
30-34		3.000	3.737	4.611	4.473			
35-39		3.763	4.804	5.761				
40-44		4.309	5.547					
45-49		4.493	5.731					
F P / F RATIOS								
15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000
20-24		1.051	1.103	1.009	0.985	0.985	1.038	
25-29		1.133	1.182	0.974	0.968	1.027		
30-34		1.288	1.162	0.964	0.999			
35-39		1.357	1.147	0.975				
40-44		1.406	1.147					
45-49		1.457						

Table C.3 Cohort period fertility rates for women aged 15-49, ZDHS 1999

			Years prior to survey						
			0-4	*5-9*	*10-14*	*15-19*	*20-24*	*25-29*	*30-34*
	Age group of cohort at survey								
A		No. WOMEN				NUMBER OF BIRTHS			
	15-19	1,446.6	262.4	2.5					
	20-24	1,294.2	1,094.9	262.1	9.7				
	25-29	1,034.4	1,014.6	934.7	246.4	5.6			
	30-34	667.7	525.9	735.3	643.6	152.0	6.3		
	35-39	637.0	418.6	599.0	860.9	795.5	202.3	3.7	
	40-44	465.7	184.7	406.9	589.6	704.9	552.1	138.7	1.6
	45-49	361.5	58.4	254.3	416.5	506.4	538.1	408.3	84.0
B	COHORT PERIOD FERTILITY RATES								
	15-19		0.036	0.000					
	20-24		0.169	0.041	0.001				
	25-29		0.196	0.181	0.048	0.001			
	30-34		0.158	0.220	0.193	0.046	0.002		
	35-39		0.131	0.188	0.270	0.250	0.064	0.001	
	40-44		0.079	0.175	0.253	0.303	0.237	0.060	0.001
	45-49		0.032	0.141	0.230	0.280	0.298	0.226	0.046
	Age group of cohort at end of period								
C	COHORT PERIOD FERTILITY RATES								
	15-19		0.036	0.041	0.048	0.046	0.064	0.060	0.046
	20-24		0.169	0.181	0.193	0.250	0.237	0.226	
	25-29		0.196	0.220	0.270	0.303	0.298		
	30-34		0.158	0.188	0.253	0.280			
	35-39		0.131	0.175	0.230				
	40-44		0.079	0.141					
	45-49		0.032						
D	CUMULATIVE FERTILITY OF COHORTS AT END OF PERIOD (P)								
	15-19		0.181	0.203	0.238	0.228	0.318	0.298	0.232
	20-24		1.049	1.142	1.192	1.566	1.483	1.362	
	25-29		2.123	2.293	2.918	2.997	2.851		
	30-34		3.080	3.858	4.263	4.252			
	35-39		4.516	5.137	5.404				
	40-44		5.534	6.107					
	45-49		6.269						
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)								
	15-19		0.181	0.203	0.238	0.228	0.318	0.298	0.232
	20-24		1.027	1.106	1.202	1.477	1.503	1.427	
	25-29		2.008	2.207	2.554	2.990	2.992		
	30-34		2.796	3.148	3.820	4.391			
	35-39		3.453	4.022	4.972				
	40-44		3.850	4.725					
	45-49		4.011	4.887					
F	P / F RATIOS								
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000
	20-24		1.021	1.032	0.991	1.061	0.987	0.954	
	25-29		1.057	1.039	1.143	1.002	0.953		
	30-34		1.102	1.226	1.116	0.968			
	35-39		1.308	1.277	1.087				
	40-44		1.437	1.293					
	45-49		1.563						

Table C.4 Cohort period fertility rates for women aged 15-49, ZDHS 2005-06

			Years prior to survey						
			0-4	*5-9*	*10-14*	*15-19*	*20-24*	*25-29*	*30-34*
	Age group of cohort at survey								
A		No. WOMEN				NUMBER OF BIRTHS			
	15-19	2,151.5	366.2	12.5					
	20-24	1,952.1	1,669.1	424.1	8.1				
	25-29	1,466.4	1,414.2	1,347.0	336.7	19.3			
	30-34	1,215.5	997.5	1,263.8	1,163.3	306.7	14.3		
	35-39	834.0	460.9	729.0	903.0	761.4	226.1	8.8	
	40-44	698.9	246.6	503.8	723.0	862.0	866.6	185.3	8.4
	45-49	588.5	78.0	255.6	506.2	719.4	902.2	700.5	173.5
B	COHORT PERIOD FERTILITY RATES								
	15-19		0.034	0.001					
	20-24		0.171	0.043	0.001				
	25-29		0.193	0.184	0.046	0.003			
	30-34		0.164	0.208	0.191	0.050	0.002		
	35-39		0.111	0.175	0.217	0.183	0.054	0.002	
	40-44		0.071	0.144	0.207	0.247	0.248	0.053	0.002
	45-49		0.026	0.087	0.172	0.244	0.307	0.238	0.059
	Age group of cohort at end of period								
C	COHORT PERIOD FERTILITY RATES								
	15-19		0.034	0.043	0.046	0.050	0.054	0.053	0.059
	20-24		0.171	0.184	0.191	0.183	0.248	0.238	
	25-29		0.193	0.208	0.217	0.247	0.307		
	30-34		0.164	0.175	0.207	0.244			
	35-39		0.111	0.144	0.172				
	40-44		0.071	0.087					
	45-49		0.026						
D	CUMULATIVE FERTILITY OF COHORTS AT END OF PERIOD (P)								
	15-19		0.170	0.217	0.230	0.252	0.271	0.265	0.295
	20-24		1.072	1.148	1.209	1.184	1.505	1.485	
	25-29		2.113	2.249	2.267	2.738	3.018		
	30-34		3.070	3.141	3.773	4.240			
	35-39		3.693	4.493	5.101				
	40-44		4.846	5.535					
	45-49		5.667						
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)								
	15-19		0.170	0.217	0.230	0.252	0.271	0.265	0.295
	20-24		1.025	1.136	1.187	1.165	1.511	1.455	
	25-29		1.990	2.176	2.269	2.399	3.044		
	30-34		2.810	3.050	3.304	3.621			
	35-39		3.363	3.770	4.164				
	40-44		3.716	4.205					
	45-49		3.848	4.337					
F	P / F RATIOS								
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000
	20-24		1.046	1.011	1.019	1.016	0.996	1.020	
	25-29		1.062	1.034	0.999	1.142	0.991		
	30-34		1.092	1.030	1.142	1.171			
	35-39		1.098	1.192	1.225				
	40-44		1.304	1.316					
	45-49		1.473						

Table C.5 Cohort period fertility rates for women aged 15-49, ZDHS 2010-11

			Years prior to survey						
			0-4	*5-9*	*10-14*	*15-19*	*20-24*	*25-29*	*30-34*
	Age group of cohort at survey								
A		No. WOMEN				NUMBER OF BIRTHS			
	15-19	1,944.9	401.3	2.4					
	20-24	1,841.2	1,673.5	363.0	2.9				
	25-29	1,686.4	1,637.4	1,372.4	354.1	3.3			
	30-34	1,295.9	989.4	1,213.9	1,167.0	241.0	5.3		
	35-39	1,050.6	633.8	849.7	1,130.3	925.7	241.8	5.0	
	40-44	732.3	206.5	444.8	669.6	768.7	721.8	182.7	4.5
	45-49	619.6	53.6	219.5	458.9	612.5	764.2	753.1	177.3
B	COHORT PERIOD FERTILITY RATES								
	15-19		0.041	0.000					
	20-24		0.182	0.039	0.000				
	25-29		0.194	0.163	0.042	0.000			
	30-34		0.153	0.187	0.180	0.037	0.001		
	35-39		0.121	0.162	0.215	0.176	0.046	0.001	
	40-44		0.056	0.121	0.183	0.210	0.197	0.050	0.001
	45-49		0.017	0.071	0.148	0.198	0.247	0.243	0.057
	Age group of cohort at end of period								
C	COHORT PERIOD FERTILITY RATES								
	15-19		0.041	0.039	0.042	0.037	0.046	0.050	0.057
	20-24		0.182	0.163	0.180	0.176	0.197	0.243	
	25-29		0.194	0.187	0.215	0.210	0.247		
	30-34		0.153	0.162	0.183	0.198			
	35-39		0.121	0.121	0.148				
	40-44		0.056	0.071					
	45-49		0.017						
D	CUMULATIVE FERTILITY OF COHORTS AT END OF PERIOD (P)								
	15-19		0.206	0.197	0.210	0.186	0.230	0.249	0.286
	20-24		1.106	1.024	1.086	1.111	1.235	1.501	
	25-29		1.995	2.023	2.187	2.285	2.735		
	30-34		2.787	2.996	3.199	3.723			
	35-39		3.599	3.807	4.464				
	40-44		4.089	4.818					
	45-49		4.905						
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)								
	15-19		0.206	0.197	0.210	0.186	0.230	0.249	0.286
	20-24		1.115	1.011	1.110	1.067	1.216	1.465	
	25-29		2.086	1.948	2.186	2.117	2.449		
	30-34		2.850	2.756	3.101	3.105			
	35-39		3.453	3.364	3.841				
	40-44		3.735	3.718					
	45-49		3.821	3.805					
F	P / F RATIOS								
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000
	20-24		0.992	1.013	0.978	1.041	1.016	1.025	
	25-29		0.956	1.039	1.000	1.079	1.117		
	30-34		0.978	1.087	1.032	1.199			
	35-39		1.042	1.132	1.162				
	40-44		1.095	1.296					
	45-49		1.283						

Appendix D Projected parity progression ratios, ZDHS

Table D.1 Projected parity progression ratios, Zimbabwe DHS

Age group	*0-1*	*1-2*	*2-3*	*3-4*	*4-5*	*5-6*	*6-7*	*7-8*	*8-9*	*9-10+*
ZDHS 1988/89										
15-19	*0.631*	*0.431*								
20-24	0.859	*0.785*	*0.764*	*0.887*						
25-29	0.958	0.952	0.880	*0.910*	*0.670*	*0.685*	*0.438*			
30-34	0.971	0.963	0.939	0.946	0.792	*0.811*	*0.791*	*0.640*	*0.570*	
35-39	0.978	0.972	0.946	0.924	0.880	0.836	0.742	*0.695*	*0.707*	*0.682*
40-44	0.975	0.948	0.949	0.944	0.878	0.888	0.861	0.819	*0.674*	*0.654*
45-49	0.966	0.964	0.941	0.945	0.908	0.885	0.829	0.825	0.765	0.683
ZDHS 1994										
15-19	*0.702*	*0.499*								
20-24	0.875	*0.786*	*0.491*	*0.277*						
25-29	0.960	0.839	*0.692*	*0.659*	*0.689*	*0.882*	*0.536*			
30-34	0.981	0.938	0.901	0.812	*0.718*	*0.738*	*0.674*	*0.562*	*0.703*	
35-39	0.987	0.960	0.941	0.889	0.843	0.787	*0.720*	*0.516*	*0.695*	*0.338*
40-44	0.976	0.966	0.934	0.947	0.915	0.821	0.774	0.669	*0.595*	*0.594*
45-49	0.989	0.966	0.941	0.935	0.902	0.864	0.806	0.722	*0.619*	*0.726*
ZDHS 1999										
15-19	*0.891*	*0.504*	*0.613*							
20-24	0.975	*0.718*	*0.529*	*0.452*	*1.356*					
25-29	0.984	0.822	*0.693*	*0.592*	*0.435*	*0.867*	*1.964*			
30-34	0.954	0.896	0.791	*0.687*	*0.616*	*0.570*	*0.547*	*0.213*		
35-39	0.963	0.949	0.920	0.853	0.723	*0.672*	*0.740*	*0.599*	*0.519*	*0.726*
40-44	0.973	0.965	0.934	0.906	0.833	0.819	0.703	*0.620*	*0.652*	*0.340*
45-49	0.981	0.974	0.931	0.912	0.915	0.853	0.737	0.728	0.680	*0.491*
ZDHS 2005/06										
15-19	*0.761*	*0.776*								
20-24	0.941	*0.846*	*0.675*	*0.404*						
25-29	0.975	0.922	*0.700*	*0.572*	*0.720*	*0.491*	*0.500*			
30-34	0.991	0.931	0.760	*0.756*	*0.580*	*0.523*	*0.317*	*0.857*	*0.384*	
35-39	0.975	0.919	0.825	0.756	*0.591*	*0.612*	*0.593*	*0.543*	*0.421*	*0.421*
40-44	0.976	0.948	0.925	0.861	0.724	0.719	*0.650*	*0.594*	*0.555*	*0.352*
45-49	0.974	0.959	0.939	0.898	0.874	0.780	0.708	0.670	*0.506*	*0.616*
ZDHS 2010/11										
15-19	*1.046*	*1.205*								
20-24	1.025	*0.957*	*0.732*	*0.466*						
25-29	0.958	0.919	0.734	*0.712*	*0.573*	*0.503*	*0.250*			
30-34	0.963	0.916	0.801	*0.647*	*0.531*	*0.520*	*0.493*	*0.235*		
35-39	0.977	0.928	0.844	0.729	*0.573*	*0.517*	*0.560*	*0.480*	*0.356*	*0.805*
40-44	0.970	0.939	0.865	0.746	*0.652*	*0.630*	*0.555*	*0.492*	*0.515*	*0.530*
45-49	0.978	0.946	0.917	0.843	0.777	0.697	0.650	*0.512*	*0.516*	*0.463*

Note: Highlighted figures are based on incomplete parity transitions, and should be interpreted with caution.
Note: Figures in italics are based on incomplete parity transitions, and so should ignored.