Fertility Determinants and Mathematical Model for the Timing of its Convergence to Replacement Level in Nigeria

BY

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This thesis is dedicated to God, the author of life.

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ABSTRACT

High level of female fertility and accelerated population growth have been consistently reported in Nigeria. Population growth stability is achieved when fertility converges to a Replacement Level (RL) attained when the Total Fertility Rate (TFR) is on average of 2.1 children per woman. The unrestraint population growth can lead to a population explosion that might constitute a challenge to achieving sustainable development goals (SDGs). Shifts in age pattern of fertility are central to modelling fertility convergence to RL. However, poor quality of fertility data from the vital registration system in Nigeria is a major limitation to the estimates of the fertility pattern. Therefore, this study used indirect demographic techniques to examine fertility determinants and develop a mathematical model for the timing of its convergence to RL.

Nigeria Demographic and Health Survey data sets of the weighted sample of 2003 (n_1=7620), 2008 (n_2=33385), 2013 (n_3=38948) and 2018 (n_4=41821) were analyzed. Each survey of the secondary data set was a cross-sectional population-based design and a two-stage cluster sampling technique was used to select women aged 15-49 years. Fertility was measured using the information on the history of the selected women's full birth. Analyses were conducted using Bongaarts' revised proximate determinants model with a focus on Postpartum Infecundity-(C_i), Sexual Exposure-(C_m), Contraceptive use-(C_c) and abortion rate-(C_a). Das Gupta five-factor and Oaxaca Blinder decomposition were used to examine the fertility determinants. Age Specific Fertility Rate (ASFR) was modelled with the assumption of uniformity in the percentage contribution of TFR by the observed and the standard ASFR. Annual changes in the age patterns of fertility were employed to develop a model that predict the timing of fertility convergence to replacement level.

Mean children ever born per woman in Nigeria was 3.0±3.2, 3.1±3.1, 3.1±3.0 and 3.1±3.0 in 2003, 2008, 2013 and 2018, respectively. The adjusted estimate of TFR was highest in 2003 (6.1) and least in 2018 (5.6). In 2003 and 2018, C_i's fertility-inhibiting effect (0.69 and 0.70) was highest, and the smallest was C_a (0.94 and 0.93). Decomposition analysis showed that the change observed in TFR between 2003 and 2018 was attributed to C_c-(63%) and C_m-(43%). Risk difference (RD) of high fertility between uneducated-educated women was highest in South-East (RD=56.9; 95%CI=49.1-64.8) and least in North-East (RD=15.0; 95%CI=9.9-20.1). For rural-urban differentials, South-West has the highest RD (12.7; 95%CI=10.2-15.3) and lowest in South-East (RD=1.9; 95%CI=-0.8-4.6). Also, Poor-Rich differentials, RD were highest in South-West (RD=15.9; 95%CI=11.5-20.4) and the least in the North-West (RD=15.9; 95%CI=11.5-20.4). The model developed for predicting the timing of fertility convergence to RL is $f_{rep}(x) = f_t^o(x) + (t - T)\Delta$ The timing of fertility convergence to RL in Nigeria was projected as the year 2089.

Nigeria might not attain fertility replacement level until the next seventy years (2020-2089) if the prevailing fertility pattern persists. Women's education, sexual exposure and contraceptive use are pertinent to fertility reduction to replacement level in Nigeria. Increasing educational opportunities for girls and access to family planning services for women of reproductive age will facilitate quick achievement of replacement level fertility in Nigeria.

Keywords: Replacement level fertility, Determinants of fertility change, Fertility timing

Word count: 496

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LIST OF ABBREVIATIONS

APF	Age Pattern of Fertility
ASFR	Age Specific Fertility Rate
ASMFR	Age Specific Marital Fertility Rate
CBR	Crude Birth Rate
CEB	Children Ever Born
CV	Coefficient of Variation
CWR	Child to Women Ratio
DHS	Demographic and Health Surveys
DT	Demographic Transition
DTT	Demographic Transition Theory
EAs	Enumeration Areas
FC	Fertility Convergence
FCT	Federal Capital Territory
FD	Fertility Decomposition
FT	Fertility Transition
GFR	General Fertility Rate
GNR	Gross Reproductive Rate
LDCs	Least Developed Countries
MDGs	Millennium Development Goals
NBS	National Bureau of Statistics
NDHS	Nigeria Demographic and Health Survey
NPC	National Population Council
NRR	Net Reproductive Rate
PDs	Proximate Determinants
PPR	Parity Progression Ratios
RGM	Relational Gompertz Model
RL	Replacement Level
RLF	Replacement Level Fertility

SD	Standard Deviation
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
TFR	Total Fertility Rate
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
VOC	Value of Children
WPP	World Population Prospects

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Fertility is one of the key indices of population change; and countries across the globe consider fertility rate as a measure of development. Fertility has an effect on population size and its future growth rate as well as the population age structure (Akinyemi and Isiugo-abanihe, 2014). Fertility measures play a major role in population planning, and evaluation of family planning and other public health programmes (Sullivan, 2013). Theories have emphasized the role of fertility in societal accomplishment of Demographic Transition (DT), a situation where a low mortality and low fertility is achieved (Kirk, 1996). While several developed countries have completed their DT, the developing countries are striving to shift from a stage of high mortality and fertility to the next where mortality has just begun to drop (World Population Prospect, 2019).

The experience of the developed countries has shown that demographic transition is a necessary condition for demographic dividend (DD) (Mason et al., 2016). The demographic dividend is the accelerated development that can occur as a result of a rapid decline in mortality and fertility of a country and subsequent shift in population age structure (PRB, 2012). As fertility falls, the working- age population increases; and with a fewer number of young dependent population, a window of opportunity is provided for a country to grow economically (PRB, 2012). Persistent high fertility level will constrict population age structure to broad based pyramid with high youth dependency ratio. This will reduce the investments in children, negatively affect labor productivity and women involvement in economic activities, cause high level of unemployment and poverty rates, and the population will be at higher risk of political instability (Hasan et al, 2020). Thus, reductions in fertility and declining ratios of dependent to working age populations result to demographic dividends if well harnessed (Obi, 2019).

United Nations report shows that the world population will increase from nearly 7.7 billion in 2019 to 8.5 billion in 2030 and further increase to about 9.7 billion by 2050 (UN, 2019). It is expected that more than half of this rise will come from sub-Saharan Africa (SSA); while the larger part of the remaining half will be from Asia. Although, Asia's population growth will not be as a result of current fertility level, which is just little above the replacement level, but due to large population base attributable to high fertility rates in the past decades (UN, 2019). In contrast, the average Total Fertility Rate (TFR) stands at 5.4 in SSA countries; apparently, high fertility persists in the region. Fertility decline in SSA has been considerably slower than the earlier declines observed in Asia, Latin America and the Caribbean, and Northern Africa at comparable stages of the fertility transition (Shapiro and Hinde, 2017). This slower pace of fertility decline may not be unconnected with the stalls in fertility transition observed in many of the SSA countries (Schoumaker, 2019). The population of most African countries remains a young population with people below 25 years accounting for 60 per cent of the total population. Consequently, even if fertility rate declines in Africa, the existing age structure will condition the population growth rate to a high value (WPP, 2019).

The TFR ranges from below three to above six children per woman in Africa (Appendix 1). While some African countries like Morocco, Algeria, Libya, South Africa, Botswana had a fertility level of less than three births per woman; the fertility level in Niger, Mali, Chad, Democratic Republic of the Congo and Somalia, were more than six births per woman. Western African countries like Burkina Faso, Cote d'Ivoire, Gambia, Guinea, Nigeria, and Senegal had fertility level of between five and six births per woman (UN, 2015a). Although, it has been postulated that across countries, fertility level is expected to converge to replacement level (Suse, 2005); however, uncertainty remains on the timing of such convergence to the replacement level. The fertility replacement level is the average of births per woman at which a population will replaces itself without migration. Usually, it is about 2.1 births per woman for developed countries, but it ranges from 2.1 to 3.5 in developing countries because of high child mortality (Espenshade et al., 2003).

In sub-Saharan, countries such as South Africa have progressed in the demographic transition process but Nigeria, the most populous country in the region struggles to achieve a little reduction in fertility despite measures and programmes by the government and international agencies to check its persistent high fertility. In 1990, the demographic survey conducted across Nigeria put

TFR at 6.2; and in 2018, 28 years later, similar survey showed a TFR of 5.3 children per woman on average if the prevailing ASFR in the country holds throughout the childbearing period; an implication that a reduction in TFR by 0.9 has only been achieved in almost three decades. If this fertility trend continues in Nigeria, the attainment of complete demographic transition in Nigeria will lag behind that of countries such as Ghana (TFR= 4.0), Kenya (TFR= 3.9), Gabon (TFR= 3.9), South Africa (TFR= 2.4), and others in several years ahead (PRB, 2017).

Nigeria is the African most populous nation and the seventh most populous country of the World (PRB, 2019). Nigeria's population grew from 56 million in 1963 to above 200 million in 2019 (PRB, 2019); and the population is expected grow to more than 400 million by 2050 if the current fertility and mortality schedules persist (UN, 2019). The rapid growth of the Nigeria's population is facilitated by its high fertility rate amidst socio-cultural behaviours that drive the population growth rate. Therefore, if the world as a community wants to achieve reduction in population growth rate and attain replacement level in few years ahead, the fertility situation in Nigeria is important to reckon with.

It is worrisome that Nigeria is yet to undergo a notable demographic change since the enactment of first national population policy that sought to limit the family size to four by the year 2000. The second national population policy emerged in 2004 due to the failure of 1988 population policy. The 2004 population policy envisaged that by 2015, TFR would minimally fall at a rate of 0.6 children every five year. Going by this target, with TFR of 5.7 in 2003, the TFR was to be around 4.5 in 2018. According to 2018 NDHS report, Nigeria's TFR is 5.3 indicating only 0.4 reduction was recorded in TFR as against 1.2 expected. High fertility has persistently been reported in Nigeria. This confirms that the target of reducing fertility by at least 0.6 children has not been achieved and prospect of rapid fertility decline is in doubt (Shofoyeke, 2014).

Researchers have established the existence of disparities in fertility levels, trends and determinants within countries especially with heterogeneous characteristics like Nigeria. As shown in NDHS reports, TFR was 6.6, 6.1, 5.0, 4.7, 4.0, and 3.9 in North West, North East, North Central, South East, South-South, and South West (ICF Macro and NPC, 2019). Adebowale (2019) documented that while southern region has shown the signs of fertility transition, Hausa/Fulani/Kanuri women who predominantly occupy core North of Nigeria appear to still have pre-transition levels. Based on the sub-regional estimates of mean children ever born (CEB) in Nigeria, it is observed that some regions have consistently reported mean CEB of less than four children while others have above (ICF Macro and NPC, 2019). The differential mainly resulted from cultural requirement and socioeconomic advancement in the regions in Nigeria (Mberu and Reed 2014).

The future trajectory of fertility in Nigeria is very essential. Mortality is declining in Nigeria but its fertility remains high with young population age structure; thus, the country is a pre-demographic dividend (Hasan et al., 2019). With the current high fertility level in Nigeria, there will be large number of children to demand healthcare, education and other services. Meanwhile, Nigeria infrastructure is deficiency and overburdened. Population growth stability and demographic dividend are achievable when fertility converges to a RL (Searchinger et al., 2013). In order to predict this level of fertility in Nigeria; it is important to make assumptions about the future age pattern of fertility. Usually, delay in fertility will initially result to a fall in ASFR at younger ages, and later an increase at older ages. Afterwards, the shift in fertility pattern will lead to low fertility level (De Beer, 2011). Consequently, it was suggested that fertility pattern can be modeled in order to make predictions of when fertility will reach RL (Gerland et al., 2014). Furthermore, the experiences of developed countries indicate that the convergence to RL hinge on how fertility decreases (Sullivan, 2013). Whereas, the rate at which fertility falls rests on the dynamics proximate determinants (PDs) (Feyisetan and Bankole, 2002).

1.2 Problem Statement

Several studies have linked fertility with child and maternal health (WHO, 2007; Rutstein, 2011; Yoder et al., 2013; Duclos et al., 2019). Shorter birth intervals may cause mothers to suffer from nutritional depletion, anaemia, antepartum haemorrhage, cervical insufficiency, premature rupture of membranes and eclampsia (Conde-Agudelo et al., 2012). Nigeria's maternal mortality is one of the highest in the world (WHO, 2010; Meh et al., 2019). Based on NDHS reports, Nigerian's maternal mortality ratio was 545 deaths per 100,000 livebirths in 2013 and 512 deaths per 100,000 livebirths in 2018; while pregnancy-related deaths were 556 per live births in 2018 (ICF Macro and NPC, 2019). This shows maternal mortality is still a critical risk for childbearing women in Nigeria. Likewise, poor child health outcomes such as preterm birth, low birth weight, congenital malformation and neonatal deaths are widespread in Nigeria. (Grisaru-Granovsky, 2009; Aleni, et al., 2019). There is still persistent high childhood mortality rate in Nigeria (Adebowale, 2017).

While efforts have been made to achieve a little reduction in under-five mortality rate from 157 to 132 deaths per 1000 live births between 2008 and 2018, and infant mortality (from 75 to 67 deaths per 1000 live births within the same period); neonatal mortality rate remained unchanged (ICF Macro and NPC, 2019). Akinyemi and colleagues (2015) showed that Nigeria neonatal mortality remained stagnant between 1990 and 2013. These situations are not unconnected with the high level of fertility in Nigeria which has made it one of the worst countries with health indicators in the world.

The Nigeria's population growth rate remains high. It was at the level of 2.6% in 1990 and it remains almost the same in 2020 (2.58%) (PRB, 2020). In 1990, Nigeria population figure was 80 million and in 30 years later, the population is above 200 million (UN, 2019). This growing size of Nigeria population is a critical issue. The unrestraint population growth of Nigeria can lead to population explosion which might constitute a challenge to the health of the populace, environment, and infrastructural development. Akinyemi & Isiugo-Abanihe (2014) opined that most of the developmental issues in Nigeria are traceable to unchecked population growth. Unfortunately, the political will and impetus needed to address Nigeria's population growth rate are currently lacking.

In many of the developing world, the fertility is gradually transiting to RL; whereas, in Nigeria, the fertility level is still a serious concern because her transition is at early stage. TFR of 5.3 in Nigeria is one of the highest in the world (ICF Macro and NPC, 2019). Nigeria's TFR is comparatively higher than even many of the less developed countries (PRB, 2017). Persistence high fertility in Nigeria will cause a lot of young people to enter childbearing age over the coming decades. The Implications of this high fertility on maternal and child health, the pace of economic growth, continuous environmental degradations, and food security challenges are already huge amongst Nigerians (Ogunbiyi, 2012). The health risks and economic challenges of high fertility on Nigerian women remain enormous in the face of poor health facility, poverty and malnutrition.

The pace of fertility decline and fertility transition in Nigeria is abysmally slow if compared with other developing countries with similar age structures in few years ago (Gerland et al., 2017). United Nations projection indicates that almost all the regions of the world would achieve or move towards RL by 2050 with TFR at or below 2.1 (United Nations, 2017). Only sub-Saharan Africa is exempted in this transition; its total fertility rate is put at 3.2 by 2050. Based on the current fertility trend in Nigeria, it is doubtful if the country can achieve TFR of 3.2 by the year 2050. Researchers have doubted whether most of the SSA countries will achieve fertility convergence to RL of 2.1 births per women as it has been projected (Bongaarts, 2002; Mberu and Reed, 2014). Nigeria's TFR will converge to RL at some time, however, the timing is unknown and may be very long.

Estimation of fertility indicators remains a challenge in many developing countries due to uncertainty about data quality (Alkema et al., 2012). Fertility data is of poor quality in Nigeria based on the evaluation of the quality of birth history data from 182 DHS surveys conducted in 69 countries show that fertility data tend to underestimate fertility in the country (Schoumaker, 2014). Fertility estimates in Nigeria rely heavily on information from surveys because of the incompleteness of vital registration system and issues with censuses. The available survey data are prone to non-sampling and sampling errors and it is almost impossible for such data to be without both content and coverage errors (United Nations, 2005).

Factors that drive fertility increase are still prevalent in Nigeria. Santhya and Jejeebhoy, (2015) opined that several developing countries including Nigeria are still lagging behind in postponement of marriage and births, as well as decreasing unplanned pregnancy. Early marriage still thrives in North West of Nigeria despite various conventions against the practice (Kyari and Ayodele, 2014). The mean age at first exposure to sexual activities of 16.9 year in Nigeria is far below world's acceptable age of 18years (Adebowale et al., 2019). Although, the minimum age at marriage in Nigeria is pegged at 18 years according to the Nigeria child rights act; but the implementation is very passive as many young women still marry at ages below 18 years. In fact, the child act right has not been domesticated in 15 of the 36 states of Nigeria. The median age at first marriage and at first sexual intercourse among women aged 20-49 is 19.1years and 17.2years respectively, an indication that many women still married at ages below 18years (ICF Macro and NPC, 2019).

Literature has always reported socioeconomic factors like education, religion, child preference and contraceptive use as main factors influencing childbearing (Tegegne et al., 2019 Mehress et al., 2017; Austin, 2015). In Nigeria, most girls still do not have access to adequate education; and majority of Nigeria's out-of-school children are girls (British Council Nigeria, 2014). More than 5.5 million girls are out-of-school in Nigeria and over 40% women have never being to school before (UNESCO, 2014; NPC, 2009). According to 2018 NDHS report, 39 % of Nigerian women have no education; with the North West (55%) and North East (57%) having the highest percentages of females without any formal education (ICF Macro and NPC, 2019). Child preference still dominates most of Nigeria's societies and the contraceptive prevalence rate is low (Adebowale et al., 2019; Ogboghodo et al., 2017). The fertility rate is high across the religion groups in Nigeria, although higher among Muslims than Christians (Adebowale, 2019; Alaba et al., 2017).

1.3 Justification

High fertility has implications on child health, maternal health, child schooling, economic growth, and natural environment (UN, 2017**).** The risk of mortality in infancy and early childhood is greater for higher-order births and closely-spaced births, and when the mother is over age 35 (Rutstein, 2011; Yoder et al., 2013). Likewise, the risk of maternal mortality is greater at higher parities, and younger and older ages. Moreover, fertility decline reduces the lifetime risk of maternal death simply by reducing the average number of pregnancies each woman experiences (Duclos et al., 2019). Similarly, children from large families attain less schooling - it detracts from the quality of schooling by diluting the expenditure per pupil (British Council Nigeria, 2014; Wietzke, 2020). Fertility decline assists economic growth via favorable changes in the age-structure. High fertility – cause of looming shortages of fresh water in many countries. Population growth has also contributed to global warming (UN, 2017; Akinloye, 2018).

High fertility level and a slower pace of fertility decline will lead to a persistence rapid population growth which might impede the accomplishment of sustainable development goals (Shapiro and Hinde, 2017). In spite of many fertility interventions, policies, and programmes to reduce fertility level, persistent high fertility remains a challenge in Nigeria. The country is faced with population explosion if its fertility level and rate of growth remains unchecked. Whereas, Fertility convergence to a RL will lead to population growth stability and demographic dividend (Searchinger et al., 2013). Also, since sustainable developments are linked with the population size; and the country ultimate population size is connected with year a country achieve RLF (Ogunbiyi, 2012) the need for this study becomes necessary.

The analysis of fertility is pivotal to measuring and understanding the intensity of population growth (Singh and Masuku, 2013). Predominantly, fertility is analyzed in two ways. The first way concerns with estimation of factors that drive fertility and how they influence it while, the second way uses mathematical function to fit fertility pattern (Singh et al., 2015). The latter is attracting attention from demographers because it can easily be explained; and it allows population projection which is very useful to policy makers. Although, this study will consider the two ways but the primary focus is using mathematical curve to model fertility in order to determine the future fertility pattern of Nigeria. It is important to focus research efforts on modeling fertility pattern in order to understand the mechanism on how to modify factors that drive fertility.

Age patterns of fertility are central to the study of fertility transition because the probability of giving birth is critically affected by age (UN, 2015). Although, quite number of works had focused on fertility in Nigeria, but the aspect of age pattern of fertility has not been sufficiently considered in fertility analysis. Thus, there is a need for detailed assessment of the recent changes in APF. Also, shifts in APF and timing of fertility are important to modeling fertility convergence to RL (Udjo, 2005). However, due to age reporting errors and truncation effect; observed age-specific fertility rates may be inappropriate to describe age pattern of fertility. Thus, indirect methods and mathematical curves were used in this study to overcome these challenges.

Reliable fertility data are critical to planning and development of policies targeted at enhancing the health of mother and child in any nation (United Nations, 2017a). In event of inadequate demographic data peculiar to developing countries, the estimates of population dynamics such as fertility are likely to be unreliable. Thus, there is a need to generate refined estimates of fertility as presented in this study. Since 1980's, the onset of sustained fertility transition has been established in at least southern Nigeria and with the hope of spreading across the country (Feyisetan and Bankole, 2002). More than 30 years after, fertility level in Nigeria is still at early phase of FT, yet uncertainty about when fertility will transit to a replacement level persists. Therefore, investigation of Nigeria's fertility transition is important to examine when to expect demographic dividends in Nigeria.

In Nigeria, a number of work has focused on the factors influencing fertility at both the regional and national level (Oyinloye et al.,2017; Alaba et al., 2017; Odior and Alenoghena, 2018). These factors only provide insights into what variables that should be target for policy and programmes on fertility at the current period. Although, factors driving fertility transition in Nigeria have been documented; but it is essential to know if these factors are the same across the regions in Nigeria a country of multi-ethnic group where the level of fertility at the national level may be inadequate to examine its fertility transition. This study, therefore, aimed at identifying fertility determinants and determine mathematical model for the timing of its convergence to replacement level in Nigeria. The study advanced the knowledge of FT in Nigeria at both the regional and national levels.

1.4 Research Question

I. To what extent has age pattern of fertility shifted across the regions of Nigeria?

II. What are the changes in timing of fertility and fertility level overtime in Nigeria?

III. When will Nigeria fertility level converge to replacement level?

IV. What are the factors that could be adjusted to hasten the convergence of fertility to a replacement level at both regional and national levels?

1.5 AIM: To examine the shifts in age patterns of fertility, determine the timing and correlates of convergence of fertility to replacement level in Nigeria.

1.6 Specific Objectives:

The specific objectives are to:

I. describe the shift in age pattern of fertility and fertility trend between 2003 and 2018 across the six geo-political zones of Nigeria;

II. examine changes in the timing of childbearing and its effects on fertility level;

III. develop a mathematical model for the timing of fertility convergence to replacement level in Nigeria;

IV. identify modifying factors for fertility convergence to replacement level in Nigeria; and

V. decompose change and difference in fertility level across the six geo-political zones in Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Several studies have reported persistence high level of fertility in Nigeria. Fertility transition was observed in Nigeria 1980s; however, the country is one of the countries with debatable stalled fertility. With rapid population growth and high fertility, Nigeria will struggle to achieve sustainable development goals (SDGs). Of course, there are variations in fertility levels within the country; and mathematical analysis of fertility to understand the intensity of population growth has not been explored across the regions. In this chapter some of the works that have been done in relation to this study were reviewed. To understand different indicators of fertility, this study reviewed fertility measurement. Fertility levels, shift in age pattern of fertility, and fertility transition, and demographic dividends were also reviewed. Furthermore, the concept of convergence and decomposition with their relevance in fertility were reviewed in this chapter. Also reviewed are fertility theories, mathematical models of fertility, determinants of fertility, fertility and national population policy, as well as fertility and sustainable development goals. Theoretical and conceptual frameworks used in this study were also presented

2.1 MEASUREMENT OF FERTILITY

Fertility and population growth are being studied by the policy makers and planners, because fertility is critical to almost all facet of human life. Fertility is the actual reproductive performance of a woman or groups of women. Measurement of fertility has become indispensable considering the demographic shift and SDGs in the world. Basically, there are two main approaches to understating the past and recent changes in fertility. They are period and cohort approaches.

In most cases, approach to fertility measurement depend on the sources of data. The period measure of fertility analyses fertility in a particular year. It can also be referred to as cross-sectional analysis. The fertility measures through this approach is useful for examining trends. The second approach, cohort measures, consider the fertility of women throughout their reproductive years. There are real and synthetic or hypothetical cohort measures. The real cohort analysis of fertility measures the reproductive history of a group women who are of similar characteristics in a particular period of time. The real cohort measure shows shift in the ages and timing of fertility, and lifetime fertility of each member of the cohort. Because, the real cohort data are always incomplete for young women of reproductive age, so to circumvent this, the synthetic cohorts are often used to understand fertility. The synthetic cohort data provides an estimate of what would happen if the present situation remain unchanged to throughout the reproductive years.

Period Measure of Fertility

2.1.1 Crude Birth Rate (CBR)

This is the number of live birth per 1000 population. Mathematically, it is written as:

$$CBR = \frac{B}{P} \times 1000 \quad \text{..........(2.1)}$$

Where B = the number of live births in a year, and

P = the mid-year population.

While the CBR is a convenient measure of the fertility experience of the entire population, it is not very good for comparing experience of different populations. Although, it can easily be calculated and explained, but it is affected by the composition of the population with respect to age, sex and marital status. The greater the proportion of reproductive age population, the higher the CRB. Palamuleni (2011) showed that the decrease in South Africa's CBR between 1996 and 2001 was principally due to the decrease in the proportion of married women. CBR varies from above 35 per 1000 in developing countries, to below 10 per 1000 in developed countries (Rowland 2003). CBR has been decreasing steadily in Nigeria just like other African countries (Atlas of African Health Statistics, 2018). Between 2000–2015, Nigeria' CBR per 1000 population declined by 4.9%, from 41.3 in 2000 to 39.4 in 2015 (WHO, 2015).

2.1.2 General Fertility Rate (GFR)

This is the yearly number of live births per 1000 women of reproductive age, usually 15-49 years.

$$GFR = \frac{B}{{}_{35}W_{15}} \times 1000 \quad \text{..........(2.2)}$$

Where B = total live births in on year

$_{35}W_{15}$ = total mid-year population of females of reproductive age 15-49 years

GFR is a more refined measure of fertility than the CBR. Just like CBR, it is easy to compute; however, it is still deficient since it still ignores the distribution of women within the reproductive age 15-49 within which the incidence of birth varies quite considerably. The GFR decreased from 194 per 1000 in 2008 to 190 per 1000 in 2013 and 182 per 1000 in 2018. Also, based on GFR estimates, every 1,000 rural women of childbearing age had 50 more children than urban women had in 2008. The 2013 and 2018 GFR estimates indicated that every 1000 rural women of childbearing age had 54 and 52 more children respectively (Ibrahim, 2019).

2.1.3 Child-Woman Ratio (CWR)

This is the number of children per 1000 women of reproductive age.

$$CWR = \frac{{}_{5}P_{0}}{{}_{35}W_{15}} \times 1000 \quad \text{.........(2.3)}$$

Where $_{5}P_{0}$ = number of children aged 0-4

$_{35}W_{15}$ = total mid-year population of females of reproductive age 15-49 years

CWR is a useful index where no statistics on births are available. Just like GFR, it does attribute births to all women irrespective of marital status or whether they had a birth. Based on 2008 NDHS data, the Nigeria's CWR was 818.2 per 1000; and mathematical methods were applied to obtain adjusted result of 690.13 per 1000 (Nwogu and Okoro, 2017).

2.1.4 Age Specific Fertility Rate (ASFR)

ASFR is the number of births in a year to women age x to x+n per 1000 women in aged x to x+n.

$$ASFR = \frac{{}_nB_x}{{}_nW_x} \times 1000 \quad \ldots\ldots\ldots\ldots\ldots(2.4)$$

Where ${}_nB_x$ = number of births in a year to women in age group x, x+n

${}_nW_x$ = mid-year population of women in aged group x, x+n

ASFRs are usually calculated for five-year age group. In many of the fertility studies ASFR is important, because fertility variations according to the age of mother is essential in understanding the family building pattern. Usually, the pattern of ASFR is reasonably similar in all populations. Typically, ASFR is low in the 15-19 age group, highest in the twenties and thirties, the decline to low in the forties.

Synthetic Cohort Measures of Fertility

Synthetic cohort measures of fertility are period measures, but use information about many cohorts. TFR is the most prominent among the synthetic cohort measures.

2.1.5 Total Fertility Rate (TFR)

TFR is the average number of children a woman would have or bear from 15 to 49 if she were to bear children according to the present schedule of ASFRs throughout her reproductive years. TFR is the average number of children per woman. It is used to measure average family size. TFR is obtained by summing over all the ASFRs for each year of the child bearing span.

$$TFR = 5\sum_{i=15-19}^{45-49} ASFR_i \quad \ldots\ldots\ldots\ldots(2.5)$$

Where $ASFR_i$ is the age specific fertility rate for grouped ages

TFR is a good index for measuring fertility change as is independent of the age distribution; and it is considered as the best single cross sectional measure of fertility. It is most sensitive and meaningful measure of fertility. TFR of 2.1 means replacement level fertility, that is an average of two children parents would need to replace themselves and the population remains stable.

2.1.6 The Gross Reproduction Rate (GRR)

This is the average number of daughters a woman would have if she were to pass through a given set of ASFRs during her reproductive ages with no allowance for mortality over this period. While the TFR deals with all births, the GRR measures only daughters. It shows the average number of daughters who would replace their mothers, assuming that the $ASFR^d$ for the recent period remain constant.

$$GRR = 5\sum_{i=15-19}^{45-49} ASFR_i^d \quad \text{..........(2.6)}$$

Or

$$GRR = \frac{TFR}{(1+m)} \quad \text{..........(2.7)}$$

Where $ASFR_i^d$ is the age specific fertility rate for grouped ages, daughters only;

m represents the sex ratio at births, males per female.

GRR is a good indicator for evaluating fertility expected in the future. It shows the level to which the mothers are being replaced by their daughters given that childbearing is not changing from its current level.

2.1.7 The Net Reproduction Rate (NRR)

This is the average number of daughters that a woman will bear if she experiences a given set of age specific fertility rate throughout the reproductive ages with allowance made for mortality of women over their reproductive years.

$$NRR = GRR \times P(\text{a}) \quad \text{..........(2.8)}$$

Where P(a) is obtained from a life table and is the probability of survival from age 0 to the average age of child bearing a; a is calculated from a schedule of ASFRs.

NRR is used to indicate generational replacement. When NRR equals to one, it suggests replacement level fertility and a population growth stability have been achieved. In the case NRR

< 1, the population is not replacing itself and persistent decreasing of fertility population will to drop further. Otherwise holds If NRR > 1.

2.2 FERTILITY LEVEL

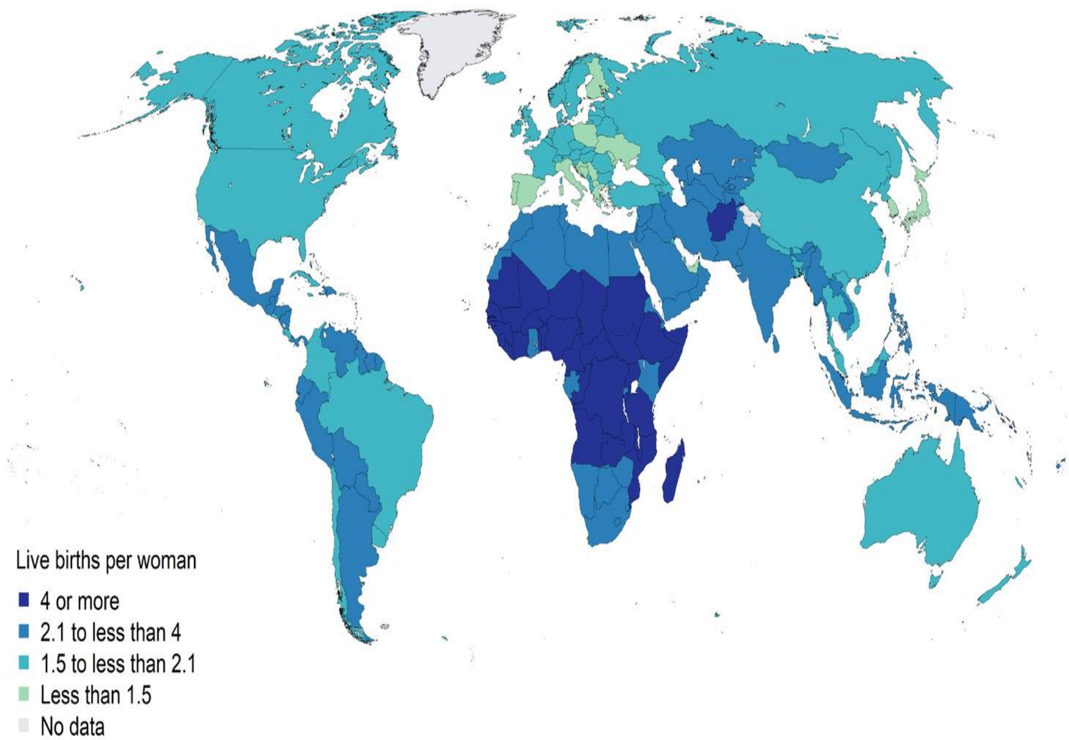
Fertility level, often measure with the TFR, indicates the reproductive behaviour of a woman if she were to experience a set of ASFR throughout her reproductive years. It is used to determine replacement level and development of countries. Globally, the level of fertility dropped from 5.3 children per woman in 1900 to about 2.5 children per woman in 2019. Within 50 years, the world fertility level sharply dropped by half. The world experienced sharpest fall between 1970 and 1980 (Ghosh, 2019). The rapid decline in world fertility was attributed to many factors such as low childhood mortality, greater access and use of contraception, and more women are getting education and employed. The levels of fertility in Australia, Europe, Northern America had been less than two children per woman since 1990 and they have consistently been average of 1.8 children per woman in 2019 across the regions. Between 1990 and 2019, fertility levels decline in Central and Southern Asia from 4.3 to 2.4, in Eastern and South-Eastern Asia from 2.5 to 1.8, in Northern Africa and Western Asia from 4.4 to 2.9, in Latin America and the Caribbean from 3.3 to 2.0, and in Oceania from 4.5 to 3.4. Over the same period, level of fertility also decreased from above six children per woman to below five children per woman in sub-Saharan Africa (UN DESA, 2019).

The TFRs in most of the economically advanced regions of the world are low. In Europe, Ireland (1.98) and France (1.85) have highest fertility rates. This indicates that the fertility rates in Europe is below 2.0. Likewise, countries like the US (1.89) Australia (1.83), China (1.64), South Korea (1.33), Singapore (1.26) and Taiwan (1.22) have fertility rates lower than replacement level (World population review, 2020). The world fertility level has been predicted to drop from 2.5 to 1.9 children per woman by 2100 (WPP, 2019). However, the decline in fertility is not expected to end in Africa soon. African countries, especially the sub-Saharan countries, have persistently have highest level of fertility among the regions of the world.

In 1950, the TFR was above six children per woman in Africa. While it took 19 years for the fertility level to change from six to four children per woman (between 1974 and 1993) in Northern

Africa; but it may take 34 years, from 1995 to 2029, for sub-Saharan African to have the same experience, that is, fertility level dropping from six to four children per woman (UN DESA, 2020). African countries such as Tunisia (2.1), Libya (2.2), Cape Verde (2.3), Seychelles (2.3), South Africa (2.4), Morocco (2.4), and Algeria (2.6) have the lowest estimates of TFR in the region. The ten topmost fertility level are all located in the region: Niger (7.2), Somalia (6.1), Democratic republic of Congo (DRC) (5.9), Mali (5.9), Chad (5.8), Angola (5.6), Burundi (5.5), Uganda (5.4), Nigeria (5.4) and Gambia (5.3) (World Bank, 2019). With the high fertility rates in the countries like Nigeria, DRC, and Angola, Africa is expected to lag behind in achieving fertility transition.

In Nigeria, TFR has been declining gradually from above six live births per woman in 1990 to above five live births in 2018 (ICF Macro and NPC, 2019). However, variation exists in fertility levels across the regions in Nigeria. According to NDHS reports, the North West (6.6) has the highest and South West (3.9) has the lowest. Also, Lagos (3.4) ranked lowest in TFR amongst the 36 states, and Katsina (7.3) topped in TFR (ICF Macro and NPC, 2019). The level of fertility among women aged 15-49 years in Yoruba, Hausa/Fulani and Igbo people groups was 4.4, 8.0 and 4.9 respectively (Adebowale, 2019). Alaba et al., (2017) identified Kano, Yobe, Benue, Edo and Bayelsa states as the hotspots for high fertility in Nigeria. Gap in the reproductive behaviour across women characteristics persist in Nigeria. Fertility levels of uneducated women and those with more than secondary education are little below seven live births per woman and above three live births per woman respectively. The TFR of women living in Urban area was 4.5 children per woman and rural area dwellers was 5.9 children per woman (ICF Macro and NPC, 2019).



Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019*.

Figure 2.1: Total fertility (live births per woman) 2019 according to the medium-variant projection

2.3 SHIFTS IN AGE PATTERN OF FERTILITY(APF)

The APF is essential in understanding fertility transition because the likelihood of a woman given birth within a period is strongly varied by her age (Rowland, 2003; UN,2015). To understand fertility levels and trends, the study of shift in APF is critical (Owusu et al., 2018). APF is simply the percentage contribution of ASFR to the TFR. The ASFRs are used to examine the APF of different populations overtime because the it (ASFR) is affected by age composition of the population. The age pattern of fertility is reasonably similar in all populations. Usually, in a population with natural fertility childbearing begins early though moderately, and continues all through all the reproductive years, highest in the twenties and then decline to moderate levels for women in their forties (Singh et al, 2015).

The APF where women continue childbearing as long as they are able is relatively flat and the population is obviously noted for High fertility. Fertility decline begins as fertility decreases at both early and later ages of reproductive years which makes age pattern of fertility to be more convex. Shift in APF existed in several societies of the world. This is evident based on delay in marriage, postponement of first birth, lower marriage rates, more women being empowered educationally, and a drastic reduction in the demand for wards to support aged generation. Postponement of marriage often reduces fertility at younger ages, and a tendency to limit family size shrink fertility among older ages.

In 1970s, majority of the advanced nations experienced the shift in APF. At early phases of falling in fertility, the rate of falling was more among people in older ages than those in younger ages (Pantazis and Clark, 2018). By 1990, the APF have shifted again in most of the economically advanced regions of the world. The FT has move below RL and the average fertility rates are 1.6 birth per women. The percentage contribution of older women to TFR has shifted upward compared to in 1970s. A similar shift in age pattern of fertility was observed in many of Asian countries and Latin America at the early stage of their fertility decline (UN DESA, 2002). With more women gaining education and entering labour-force, there were delayed in entering motherhood. Most women in developed countries now have their children between the ages of 25-34. The average age of women at their first birth in some of the European countries is about 30 years (UN, 2015). Although, there is clearly different between APF in Africa and other regions but the shift in APF as observed in Africa was not different from other regions of the world

(Bongaats and Casterline, 2012). Ariho et al. (2018) noted that in Uganda, the shift observed in fertility behaviour of the older ages contributed most of the changes in fertility.

In Nigeria just like every other places, the highest fertility is experienced between twenties and early thirties. Similarity in age patterns of fertility were observed in the last four NDHS surveys (2003, 2008, 2013 and 2018). ASFRs which are used to define the APF has been highest among women age 25-29. However, at every age women who were rural dweller bear more children than their counterpart in Urban areas. In 2003, ASFRs in rural area rose sharply from age15-19 years to age 20-24, peaked at age 25-29 and then declined. Whereas, the urban pattern was more steady. While the rural pattern was a broad peak that stretched from age 20-24 to 30-34; in urban areas the peak was concentrated at age 25-29. Similar patterns were observed in the three subsequent surveys ((ICF Macro and NPC, 2004, 2009, 2014 and 2019).

Likewise, shifts in mean age at childbearing are very important to demographers, most especially those who are interested in the future trajectories of fertility. The knowledge about the effects of changes in timing of fertility at all birth orders is essential for the understanding of the past and the future trajectory of reproductive behaviour (Batyra, 2016). Substantial changes in mean age at childbearing are often accompanied with shift in the level of period fertility (Ortega & Kower, 2002). Thus, childbearing is influenced by period, age and lifetime fertility and duration since the last birth. Fluctuation in fertility level occur due to changes in the timing of fertility (tempo) and lifetime fertility of women (quantum) (Bongaarts and Feeney 1998).

Tempo and Quantum of fertility are important components of fertility that the ability to differentiate between them helps to understand and interpret the total fertility rate (Batyra, 2016). Quantum effects occur when fertility changes overtime even if the timing of childbearing remains constant; while Tempo effects alter the period ASFR and bring a transient change in the TFR. Thus, an upward change in the age at birth will lower the level of fertility than the expected (positive tempo effect); and the opposite holds in a case where women transit into motherhood more quickly (negative tempo effect) (Bongaart and Feeney, 1998). The experiences of several nations that have accomplished replacement fertility level established the crucial place of changing in the time when women bore children. For instance, the experience in European countries showed that the delay of first birth accompanied by the postponement of higher birth orders facilitated the accomplishment of low births (Sobotka, 2004; Kohler et al, 2001). Also, for fertility transition in Brazil postponement in second birth, though without postponement in first birth, was identified (Miranda-Ribeiro et al., 2008). Likewise, Batyar (2016) found that there was postponement of births, especially second births among reproductive women in Colombia.

2.4 FERTILITY TRANSITION (FT)

In 1798, Malthus shared his thoughts on principle of population. He pointed out that the ability of human population to replicate its self is limitless, as well as, grows with a geometrically; meanwhile, the ability to provide for the population is narrow and increases arithmetically. He, however, proposed what were knowns as the positive checks of mortality, voluntary acts of limiting number of children by people; deferring time of marriage among others to prevent the growth (Malthus 1976). Although, there were some criticisms about Malthusian thoughts empirically; but ideologically, this Malthusian's ideal has generated of debate among population scientists and demographers (Rothchild, 1995).

In spite of several shortcomings of Malthusian thoughts that had been articulated by population experts (Boserup, 1981 & Howell, 1986) yet Malthus ideas remain important bedrock of demographic transition studies and fertility transition (Bruijn, 2006). Between 1798, when Malthus opined his thought and now, a lot has been achieved in term of fertility control especially in developed countries. Malthus advocated marriage postponement for controlling the growth of population. This was exactly what happened in the Western Europe and indeed, fertility reduction experienced at early stage of advancement in the world was attributable to delay in marriage (Kirk, 1996).

FT is a part of Demographic transition theory (DTT). The DTT describe the movement of mortality and fertility from high levels to low levels. The idea of demographic stages emerged from Laundry in 1909 (Bruijn, 2006). It is worth of note that Thompson (1929) linked modernization with reduction in mortality and fertility. Also, he proposed the three stages of DTT. Meanwhile, it was Blarker (1949) that formulated and described the stages. However, Davis (1945) was the first person to apply the term DT. As early as 18^{th} century, the Western countries had started experiencing DT and it continues till date; meanwhile many of the low-income countries started their DT much later and several of them are still in the early stage of DT (Suse, 2005).

Also, Notestein (1944) in attempt to underscore the importance of DT, he noted that the proponent of small family size started in the developed countries. He pointed out that although it is very difficult to fix fertility reduction to factors, but obviously many were essential. He also stressed further that urban life would deprive a large family of many things. Furthermore, during the period of technology revolution several door of opportunities was opened. Consequently, the benefit of having many children was no longer desirable and cost of raising children increased. The decline in mortality especially at younger ages also aided the reduction in many births. There are two schools of thought about the stages (three-stage and four-stage) in DTT; although, both are based on the change in CBR and CDR over time. The characteristics features of three-stage model include high level of mortality and fertility at first stage which is attributed to no birth control. While mortality and fertility are declining at stage two, and low mortality and fertility level due to family planning at stage three. However, the most appropriate is four-stage model because it allows better understanding of transition between the stages regarding more details (Suse, 2005).

Just like the three-stage model, the first phase of the four-stage model notably has a very high level of fertility and mortality. The lifetime fertility of a woman aged 15-49 is six and above; and an average life span is less than 45years. Lack of family planning, religious beliefs and considering children as an economic asset are responsible for high birth rates. This stage refers to the economic development of Britain as it was in the 18th century and to the developing countries nowadays (Suse, 2005). The second phase is characterized by declining mortality while fertility level remains high. The reduction in mortality was as a result of improved health system. But because it is difficult to change people's perception about reproduction, the fertility is still high. The average CEB to a woman aged 15-49 year is between 4.5 and 6; and the life expectancy ranges from 45 to 65years. Bangladesh and Nigeria of today and Britain of 19th century is linked with this stage.

Furthermore, in the third stage the fertility is falling faster than mortality. This is as result of family planning, women empowerment, improved living welfare packages and low level of childhood mortality. Also, due to advancement in agricultural tools machines reduce the demand for workers. The average CEB to a woman aged 15-49 years was between three and above four children per woman; and average life span ranges from 55 to 65 years. The phase refers to Britain at end of 19th and beginning of 20th century and for China and Brazil. While, in the fourth stage the fertility level equals to mortality. The number of birth is below 2.5 for women aged 15-49 years and life expectancy is above 65years. This is typical of USA, Sweden, Japan, and Britain.

Among the fundamental principles of DTT is that once a country starts along its development trajectory, the associated demographic trends will result to initial declining mortality rates, and then after some delay declining fertility rates. The transition is assumed to progress without interruption, until it stabilizes at replacement level or below, once it commences (Kirk, 1996). This, however, is not the situation is several developing countries. The recent findings depict that fertility in many SSA has not been falling progressively as projected by United Nations (Searchinger et.al., 2013).

Fertility transition, no doubt, had begun in Africa; but the transition is unique. Bongaarts (2013) noted that while the fertility rates in the United State and several European nations started declining significantly in the late nineteenth and early twentieth century; it did not begin in SSA until the 1990s. Fall in childbearing began late in most of the SSA countries in contrast to other developing countries in Asia and Latin America; even the pace of decline is slow (Bongaarts and Casterline, 2013). Also, there is substantial disparity in the duration and magnitude of fertility decline as well as shifts in the timing of births among the sub-Saharan countries (Gerland et al., 2017; Timaus and Moultrie 2008). The estimated fertility level of the region is 5.1; about 19 countries in the region have above the level (United Nations 2015a). However, fertility is persistently high in SSA; though rapid fertility declining is being experienced in Southern Africa.

In SSA, the fertility level ranged between six births per woman and eight per woman before the beginning of downward shift. Analysis of fertility data in 1980s and 1990 indicated that FT was underway in most SSA countries especially, in Eastern and Southern Africa. In 1980, the crude birth rates ranged from low of 25 births per 1000 persons to high of 52 births per 1000 person. Countries like Egypt, Tunisia, Morocco, and South Africa were among those with low crude birth rates. While, Nigeria was among the countries with high crude birth rates. By 1993, considerably falling of fertility had been observed in Northern and Southern Africa countries; but, fertility remained unchanged in Western Africa where Nigeria is located and a rise in number of births was recorded in Central part of the region.

Data from DHS and other sources indicated that fertility transition began in many Africa countries in 1980s (Kalipeni, 1995). For instance, TFR declined in Botswana from 7 to 5 between 1981 and

1988; in Kenyan from 8 to 6.7; in Zimbabwe from 6.5 to 5.5 between 1984 and 1988 (Meekers 1991). Furthermore, fertility level moved from 7 to 6.5 between 1980 and 1992 in Zambia (Gaisie et al., 1993); in Nigeria from 7.4 to 6.2 between 1980 and 1990 (Feyisetan & Bankole, 2003). By 2010, according to the latest DHS reports, TFR of below four live births per woman was reported in just five SSA countries. The countries are South Africa (2.1), Cape Verde (2.9), Lesotho (3.3), Namibia (3.6) and Swaziland (3.8). Whereas, countries like Niger, Mali, Chad, Burkina Faso, Nigeria, Uganda, Burundi, the D.R. Congo, and Zambia have fertility level greater than five children per woman.

Further analyses showed a slow pace in fertility decline in several SSA countries; while in some countries fertility stall had occurred. Low contraceptive use, induced abortion and slow decline in the proportion married are most cited proximate determinants responsible for slow pace of childbearing reduction in SSA (Singh et al., 2017; Tsui et al., 2017; Garenne, 2008). Feyisetan and Bankole (2012) showed that sustained fertility decline had begun in Nigeria. However, the six successive Nigeria NDHS (1990-2018) indicate that fertility remains persistently high in Nigeria. Very little change has occurred in country for almost 28 years. Nigeria is therefore considered one of the big countries with a debatable "stalled fertility transition" (McNicoll, 2011; Bongarts, 2008; Shapiro and Gebreselassie, 2008).

Furthermore, figure 2.2 below depicts the trends of fertility level by sub-regions of SSA (1950-2015). Between 1950 and 1955, across SSA fertility level was above six children per woman. However, starting from that 1950s Southern Africa countries started transiting from high fertility and consistently falling below three children per woman in the 2000s. Meanwhile, in Eastern and Western Africa fertility remained high and transition did not begin until1980s. Also, the fertility decline has been very slow in the two sub-regions. In 2010-2015, TFR is 4.9 and 5.5 in Eastern Africa and Western Africa respectively. Also, fertility started falling much later and even more sluggishly in Central Africa. At 2010–2015, fertility level was 5.8 children per woman in the sub-region.

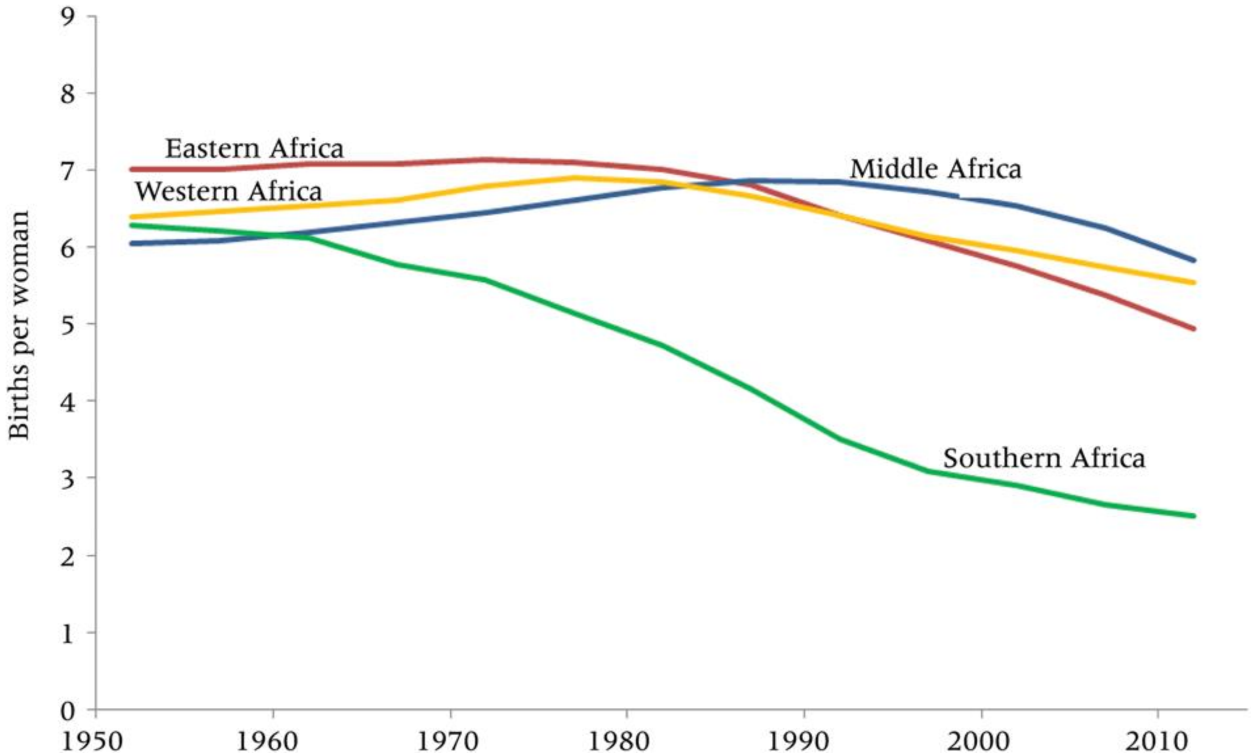


Figure 2.2: Sub-regional trends in total fertility, sub-Saharan Africa, 1950–2015

Trend in total fertility rate of Nigeria from 1955 till date is shown in figure 2.5. according to the figure Nigeria TFR was about 6.25 in 1955 and it remained the same till 1970; thereafter the TFR was gradually increasing until it peaked 1985 which was about 6.8. However, ever since it has started declining although at very slow pace. Between 1985 and 2015, about 3 decades only 0.5 change was observed. Fertility transition to stage is still underway in Nigeria.

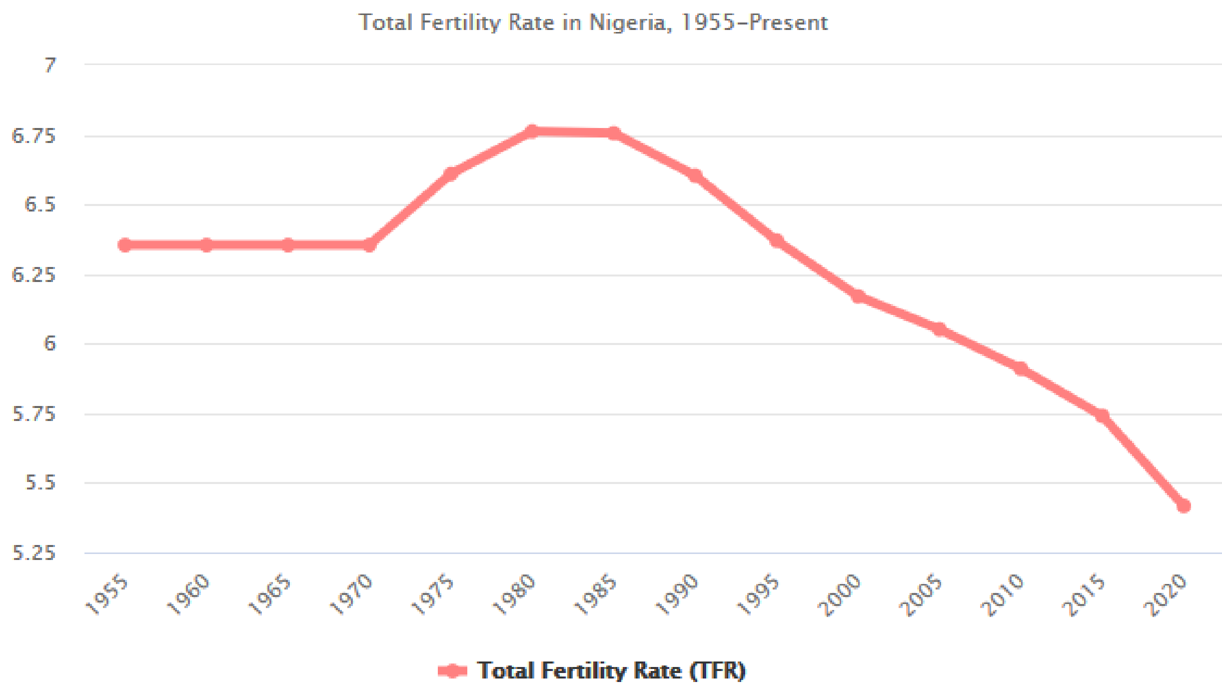


Figure 2.3: Trend in TFR, Nigeria, 1955-2020

2.5 DEMOGRAPHIC DIVIDENDS

The experience of developed countries has shown that demographic transition is a necessary condition for demographic dividend (DD) (Mason et al., 2016). The demographic dividend is the accelerated development that can occur as a result of a rapid decline in mortality and fertility of a country and subsequent shift in population age structure (PRB, 2012). Usually, DD is in two phases: in the first, a fall in fertility leads to rise in the number of workers relative to the number of dependents. If the fertility decline is substantial and sustained, it will lead to the second phase which is an increase in the productivity of each worker. The first dividend benefits can be significant and come early, but it may be missed; while, the second dividend can be delayed but with appropriate policy, the benefits may be huge and permanently boost income and economic development (Mason et al., 2016). The East and South-East Asia are currently benefiting the demographic dividend; while most Latin American countries have missed the window of opportunities to develop. Meanwhile, DD is still being anticipated in Africa, Central Asia, the Middle East and India (Loewe, 2007).

Literature has established a positive effect of an increase in the working-age population on the economic development if the human resources are well harnessed (Kotschy et al., 2020). Recently, Islam (2020) examined the characteristics of demographic changes and the emerging windows of opportunities and challenges for Oman. In the study, he found that the changes in demographic variables has led to shift in Oman population size and age structure which has opened up opportunities for economic development in the country. The dependency ratio has decreased from 98% in 1970 to 32% in 2015. Two opening of demographic dividend period has been observed—first from 1958 to 2000 and the second one has opened in 2010 which will reach its peak during the 2020s and will remain open until 2040. However, for the country to reap the benefits of the emerged demographic dividend, necessary steps need to be taken to develop human resources urgently (Islam, 2020). Whereas, Hasan and colleagues (2020) opined that Nigeria is far from demographic dividends because of its high fertility and young population age structure (Hasan et al., 2020).

According to LI Q and colleagues (2018), the child dependency ratio has not change substantially in SSA compare to Asia and LAC because of the slow pace of fertility decline in the region. For SSA to experience favorable dependency ratio and consequently a demographic dividend opportunity, which, if properly utilized, will spur economic development in the coming decades there is a need for drastic reduction in fertility. As fertility falls, the working- age population increases; and with a fewer number of young dependent population, a window of opportunity is provided for a country to grow economically (PRB, 2012).

2.6 THE CONCEPT AND MEASURES OF CONVERGENCE

The concept of convergence emanated from the earliest model of economic growth and its implications on developmental policy has been established (Lanzieri, 2010). Convergence is mostly used as a concept to describe the change over time of a given indices (for instance. TFR, Income) of group of geographical units (Firebaugh, 2003). In economic context, convergence is the 'process of diminishing in the degree of economic inequality among the countries' (Baumol, 1994). Demographic transition theories suggest convergence in both fertility and mortality indicators across countries. One of the fundamental principles of DTT is that once a country starts along its development trajectory, the associated demographic trends will result to initial declining mortality rates, and then after some delay declining fertility rates. The transition is assumed to progress without interruption, until it stabilizes at replacement level or below, once it commences (Kirk, 1996). Based on the descriptions of the DTT, the concept of convergence is greatly relevant in Demography. Convergence is found to be useful in demographic issues (Lanzieri, 2010). Different models have been used to measure convergence both in economic and demography. The models include sigma convergence, beta convergence, and nonparametric methods of convergence (Dorius, 2010).

Sigma Convergence (σ-Convergence)

This is based its assumption on measure of variability of demographic/ economic indicators. Quah (1993) opined that the discrepancies in demographic / economic indices shrink as time passes. σ-convergence assumes convergence exists as measure of variability decreases. Standard Deviation

(SD) and Coefficient of Variation (CV) are used for estimating σ-convergence. SD is used as index of the absolute σ-convergence and CV is the index of relative σ-convergence.

The absolute σ-convergence model is given as:

$$\sigma_t > \sigma_{t+T} \quad \ldots\ldots.(2.9)$$

Where σ_t is the SD at the time *t*.

If the parameter σ_{t+T} is decrease, it depicts convergence is underway.

The relative σ-convergence is derived by using CV. Coefficient of variation is

estimated as:

$$CV_{\mathrm{t}} > CV_{\mathrm{t+T}} = \sigma_{t+T}/\mu \quad \ldots\ldots\ldots(2.10)$$

Where CV_{t} is the coefficient of variation of the indicator at the time *t*. If the parameter

$CVt + T$ is reduces, it implies evidences of convergence

Absolute β-convergence measure

This is used to examine the bridging in gap between two group where one is growing faster to meet up with the other. In economics, poor areas grow faster than rich areas and therefore catch up it. It is estimated using the following regression model (Barro and Sala-I-Martin, 1992).

$$\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right] = \alpha + \beta \ln(Y_{i,t}) + \varepsilon_{it} \ldots\ldots\ldots.(2.11)$$

Where $\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right]$ is the mean annualized growth rate of the variable y in the state I in the period

(t, t+k)

$Y_{i,t}$ is the value in the initial time t

ε_{it} are the corresponding residuals

Conditional β-convergence

This is different from absolute β-convergence model in that it assumes that all the strata will not share the same characteristic. Therefore, it is recognized that each stratum may be converging base on its characteristic. The additional parameters which estimated the changing conditions make it conditional β-convergence.

$$\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right] = \alpha + \beta \ln\left(Y_{1,i.t} Y_{2,i.t}\right) + \varepsilon_{it} \text{.........}(2.12)$$

Where $\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right]$ is the mean annualized growth rate of the variable y in the state I in the period (t, t+k)

$Y_{i,t}$ is the value in the initial time t

ε_{it} are the corresponding residuals

Y_1 and Y_2 are the varying conditions.

2.6.1 FERTILITY CONVERGENCE (FC)

The concept of convergence is receiving attention in Demography (Lee and Reher, 2011). Wilson (2001) assessed how the drastic change in global fertility that dropped from average of 5.0 to 2.7 births per woman and life expectancy at birth that rose from 46.5 years to 65.4 had led to the convergence of demographic patterns in the world. He found that the world is becoming similar demographically and socially. However, divergent economic persist in the world. He established global demographic convergence with an average global TFR of 2.3 and life expectance of 68 in 2000. Dorius (2008) challenged the idea that the last fifty years of the 20th century was a time of global demographic convergence. To find what cause the change in fertility disparity across the countries, he utilized Gini coefficient, Mean Log Deviation and Theil index. He based his analysis population-weighted σ- and β- convergence. Focusing on absolute and relative fertility convergence, he concluded that though fertility declined significantly during the period, but with considerable disparity. He showed that global fertility transition is not the same with fertility convergence. He opined that in some countries, fertility levels are just transiting to low fertility, the level some countries had achieved earlier.

Furthermore, Wilson (2011) used a different approach from the statistical methods which most literature employed and he found that global fertility convergence has been more swift and explicit compared to global mortality convergence. Herbertsson *et al.* (2000) used both absolute and conditional model to examine population dynamics and convergence in fertility rates. In about one hundred and ninety countries, they established emergence of convergence of fertility level within 20 years (1978-1998). However, Tomka (2002) using another approach, proposed indexes based on standardized differences from the Western European averages, to understand the demographic convergence between Hungary and Western Europe countries. He found that convergence occurred in Hungary at the mid-19th century and divergence was noticed from the mid-20th century. De-Silva and Tenreyro (2015) pointed out that gaps in fertility rates across countries have been closed over the past forty years with fertility levels in most countries converging around replacement level fertility. They went further to say, fertility convergence happened without appreciable convergence in economic variables. They opined that fertility convergence to replacement level has implications for population growth.

Within countries, literatures agreed that number births are usually more among rural dwellers compared to urban dwellers, among illiterate women than literate women, and among women with low socioeconomic status (SES) compare to their counterpart with better SES. This has made fertility convergence analysis important at country level. Franklin (2004), in examine the fertility convergence across Italy's regions found that, fertility convergence was observed across the regions of Italy. However, in 1970s a marginal divergence was noticed. The analysis was based on both σ- and β- convergence models. Borge (2016) discussed the hypothesis of convergence and divergence in mortality and fertility with special focus on subnational levels in Brazil. He concluded the mortality and fertility changes at subnational levels in Brazil present a process of convergence and divergence.

Arokiasamy and Goli (2012) tested FC postulations across sub national geographic units and socioeconomic spectrum of India. They discovered that across Indian states, the trends and patterns of fertility show a strong indication of convergence. Williams and colleagues (2013) assessed the convergence in fertility of South Africans and Mozambicans in rural South Africa between 1993 and 2009. They used ASFR and TFR to examine fertility trends, the shifts ASFR were described using descriptive statistics, and a discrete time event model and survival curves were used to evaluate women parity progression. Their results suggest fertility convergence is underway in the two sub-population. Shubat (2018) used the concept of σ- and β-convergence to examined the fertility convergence at regional level in Russia; he concluded that regional differences in fertility level persist and not declining over time.

2.7 FERTILITY DECOMPOSITION (FD)

In 1980s, the concept of decomposition gained attention in demographic studies. Decomposition seeks to understand the specific components of demographic indicators. For demographic measures, several decomposition approaches have been proposed (Andreev et al., 2018). Decomposition is useful in comparing demographic measures of different geographic units or comparing demographic measures of the same geographic units over time. The origin of decomposition was traced to methods of standardization. Kitagawa (1955) developed a method for decomposition of the gap between CBR and CDR of two groups. The method has been relevant in explaining the gap in demographic indices of two groups (Vladimir, 2003). Blinder (1973) and Oaxaca (1973) proposed a decomposition technique to explain the gap in the means of an outcome variable between two groups. The gap is decomposed into an outcome that is due to differences in observable determinants (endowments) across groups and that is due to differences in effects of these determinants (coefficients) of groups. The use of Blinder-Oaxaca decomposition technique is widely reported in reported in literature (Fairlie, 2006).

Furthermore, Andreev (1982) and Arriaga (1984) proposed a discrete method to decompose the gap between two life expectancies. A six-factor decomposition method was proposed by Das Gupta (1991) and it was based on earlier work by Kitagawa. In 1978, Bongaarts proposed a decomposition to study the TFR, called the PDs of fertility. Bongaarts and Potter (1983) presented a decomposition of the change over time of Bongaarts' proposal. Fairlie (2006) extended the Blinder-Oaxaca decomposition technique to logit and probit models. He opined that the use of Blinder-Oaxaca technique is inappropriate in the case where the dependent variable is dichotomous and the coefficients are from a logit or probit model. According to them, the extended method is suitable for applications where it is not appropriate to fit the outcome as a linear function of the exposure. Recently, Andreev et al., 2018 applied the algorithm to facilitate a numerical decomposition of the gap between TFR and between PPR by mother age and CEB.

Rutayisire and Colleagues (2014), with the use of Oaxaca decomposition analysis, examined the changes in fertility decline in Rwanda. According to them, decomposition technique is an effective instrument in explaining changes even though, it is silent about the causes of the behavioural change. MacQuarrie (2016) used multivariate decomposition technique and other methods to assess the effect of age at marriage on the birth order one, and the consequences of both age at marriage and birth order one interval on the birth order two interval in seven Asia countries. Ariho and colleagues (2018) used multivariate Poisson decomposition techniques to investigate how the changes in childbearing have been between 2006 and 2011 among Uganda women. Also, they went further to check whether the changes were due to changes in women background characteristics or reproductive behavior of Uganda women. Zeman and colleagues (2018) examined the fertility of women cohort 1940-1970 and used decomposition method to explain the changes in fertility due the contribution of shifting in PPR across Europe, North America, Australia, and East Asia. The decomposition analysis considered the progressive nature of fertility as a chain of transitions from low birth order to high birth order. Coutinho and Golgher (2018) utilized Bongaarts framework to decompose fertility levels of 1986, 1996 and 2006 in Brazil. They affirmed that the framework is useful to explore the determinants of total fertility rates.

Shapiro and Tenikue (2017) used Oaxaca decomposition technique to describe the contributions of maternal education and childhood mortality to rural-urban gap in childbearing in SSA. Their result explained the rural-urban differences in reproductive behaviour of SSA. Hellstrand and Colleagues (2019) analyzed the decline in fertility level of Finland, and investigated the effects of the pattern of women who had stopped childbearing for women reproductive age using different methods. They decomposed the variations in the fertility levels estimated using 'conditional age- and parity-specific fertility rates' with application of the stepwise replacement method. Decomposition of the decrease in fertility level illustrate that the pattern was not too different from the conventional, with contribution from all the age groups and birth order; but having birth order one and age group 25-29 as the highest contributors. Otieno et al (2019) used Bongaarts decomposition model to explain the recent FT in some SSA with focus on how family planning services has contributed to the changes in dropping in fertility. A recent study in Zimbabwe, Ndagurwa and Odimegwu (2019) applied the Oaxaca–Blinder decomposition method in a two-sex framework to analyze the the occurrence of stalled fertility. Also, they explored the temporal marital fertility elasticities in relation to the various proximate and background characteristics in Kenya, Rwanda and Zimbabwe.

2.8 FERTILITY THEORIES

2.8.1 Integrated theory of Fertility

Since fertility behavior is influenced by several conditions, integrating different approaches from different academic fields covering diverse aspects is important to fully understanding fertility (Huinink et al., 2015). Theoretical framework of fertility transition should be multi-disciplines based. When it comes to the changes in social structures over time, there is no single theory that is valid universally because of the complexity of social behavior (Helbing, 2012). To address this problem, Boudon (1983) opined that needed framework to understand social process like fertility must be accurately stated and measured. Consequently, projections of future trajectories of social behavior like fertility almost become impossible except the uncertainty of the future is modeled based on the condition of the present. Boudon's idea suggested that general instruments, which can yield some particular social end of certain past condition at a particular location, should be identified. In application of this to the studies of human reproductive behavior, several sister disciplines are to be considered to arrive at integrated conceptual model. (Huinink et al., 2015).

Furthermore, the future levels of fertility are one of the most difficult prediction to make by policy makers. Meanwhile, the effects of fertility rate on social, economic, medical and political landscapes cannot be overemphasized. For instance, the demand for medical care, social services, security, even political views and voting patterns are all rested on the past and present fertility rates of the population. Fertility, as it were, is conditioned by many factors (Feyisetan & Bankole, 2002). As mentioned above, no single factor can explain fertility behavior of a particular country. Due to multifaceted factors influencing fertility, several frameworks had been proposed to describe reproductive behavior. The approaches to fertility comprise but more than: Economical, Psychological, Social and cultural, as well as Biological determinants. The writings of Malthus contributed a great deal to economic theories of fertility especially in the area of population and development analysis (United Nations, 1973).

2.8.2 Economics Theory of Fertility

In Economics approaches to fertility, Leibenstein (1957) opined that the lifetime fertility has to do with the personal choice based on the economic power. Leibenstein was not alone with this view; notably among the proponents of economic theories of fertility were Becker (1991), Schultz (1981) Nerlove (1974), and Willis (1973). In fact, Becker's work went beyond orthodox variables of income and price in describing number of births; he linked quality of children with fertility decisions. He opined that the desired quantity of births is inversely related with income. Since the amount money to spend on each child would like to rise as revenue go up, propensity for more births may fall.

The voice of Easterlin was one the most known economic theories of fertility. He was of the view that fertility practice is forty-year generational, with a cohort that has huge birth are likely to replace themselves in smaller quantity and vice versa. He opined the that the population age structure especially the young-adult ratio is a result of 20-year previous birth. Easterlin went further to enumerate the economic benefits of persons born during the time when birth rates are low as employment opportunities, high salary, and increased promotion at work; while persons born during the time of high fertility are likely suffer some unfavorable economic disadvantage. Basically, his theory was in two part: how birth rates affects dependency ratio; and economic opportunities such as wages and employment rate. Easterlin (1975) stretched economic theories further; he submitted that drive to regulate fertility relies on a condition that the supply of children surpasses their demand. The theory assumes that all determinants of fertility are affected by the forces of demand and supply for children, as well as price to pay to reduce births. He went further to link the desired number of births to how much enjoyment experienced during children were growing up.

2.8.3 Wealth Flow Theory of Fertility

In furtherance to economic theory, Caldwell (1982) expressed in his wealth flow theory that the childbearing behaviour is basically determined by whether wealth move from parents to children or otherwise. He stressed that the fundamental principle that determines the course of how wealth move from one generation to another is the society was structured, especially the traditions and beliefs of the family. Furthermore, Caldwell opined that wealth usually moves from children (younger generation) to parents (older generation) in all communities before modernization. This could explain the reason for the prevalence of high fertility. However, according to him this economic motive is moderated by other factors such as individual, social, and biological reasons.

2.8.4 Diffusion Theory of Fertility

The concept of diffusion was also introduced to explain demographic dynamics. Diffusion is defined as the way discovery of new things are spread from one place or person to other (Retherford & Palmore, 1983). The movement of thoughts and innovations, as well as behaviors were associated with channel of communication established by socio-cultural and economic of a society (Lesthaeghe, 1977; Kirk, 1996). This was demonstrated by Lesthaeghe as he analyzed the decrease in childbearing of Belgium; where he presented that fertility patterns and levels were the same among communities at the borders. Likewise, Kirk (1996) opined that onset of FT in some places was due to their location and business activities. Concept of diffusion was found useful in explaining the acceptance of family planning (Entwisle et al., 1996, Watkins, 1996). Transmission of innovations through communication is more pronounced in birth control than other area of demography; this has been faulted (Greenhalgh, 1995).

2.8.5 Social Network and Fertility

In order to explain fertility behavior, demographers also examined theories of social interactions. Theoretically, social network effects are significant since they are intermittent explanations which interpret the personal choice of childbearing as a social action. Empirically, the way social network brings about quick shift in fertility at larger society makes it essential framework in explications of the fertility outcomes at an individual level (Bernardi & Klarner 2014). It is a general assumption that human reproduction is a social act, and that the social interactions and social structures affect individual beliefs and behaviors. Consequently, fertility models should include social mechanisms (Bernardi and Klarner, 2014). The basic underline condition of theory is that the reproductive behaviour of each person hinge on the fertility behavior of other people and on the structure of their interactions. As argued by Coale and Watkins (1986), decrease in number births of economic advanced regions of the world that began in 1800s was due to both economic-related factors and ideational factors which spread through social networks. Also, a number of demographic literatures had emphasized the prominence position of social connections and emergence of reasoning as important causes in explaining rapid drop in births of European countries (Jayakody et al., 2008).

Social mechanisms had been found to have influence on childbearing behaviour. For example, fertility behavior of a society where a household with large size is rewarded by net benefits the children bring to their parents cannot be the same where the opposite is true (Kohler 2001). Watkins and Danzi (1995) opined that fertility decline among women of Jewish stock in United State of America was earlier than their counterpart of Italian stocks majorly because of their social interactions. Furthermore, scholars had said that fertility decline especially below replacement level currently being experiencing in developed countries is partly due to social learning and social pressure (Kreyenfeld 2010; Kreyenfeld et al., 2012). Also, the interval between births is found to be affected by social support. Social support can aid a quick progression from lower birth order to higher birth order (Balbo and Mills, 2011). Likewise, Bernardi and White (2010) discovered that the kind of relationship that exist within family members is essential in study of reproductive behaviour. Also, Kohler (2001) concluded that for, the structure of social interaction can help the uptake of modern contraception use in rural Africa.

2.8.6 Reproductive Behavior Model

Landry conceived and Henry (1953) improved the idea that in the pre-transition stage fertility, to a very large extent, is a function of physiological ability of women; whereas after achieving RLF, the choice of childbearing is wholly personal. The concept of this natural fertility was later modeled by Bongaarts as model of proximate determinants. He proposed that the level of fertility in any population can be determined by the proportion of women of reproductive age that is married, the effective use of contraception, induced abortion, postpartum infecundability, the frequency of intercourse, the onset of permanent sterility, and spontaneous intrauterine mortality. He argued that the proposition that a woman may likely bear at least fifteen children during her lifetime could be reduced via modification of each of these factors (Bruijn, 2006; Bongaarts, 1978).

Thus suggesting that a change in any of the PDs of fertility will directly affect fertility, even if others remain constant. Accordingly, fertility variations and trends can be attributed to changes in at least one of the PDs (Bongaarts, 2015).

Several studies across the world have applied this Bongaart's framework in the analysis of fertility. Alene and Worku (2009) reported that the fertility-inhibiting effect of postpartum infecundability which was as a result of prolonged breastfeeding was the most important proximate determinant in Ethiopia (Alene and Worku, 2009). A study conducted in Malaysia found that delay in marriage and uptake of contraceptive was the most important proximate determinants of fertility; while postpartum infecundability and abortion played a part in explaining ethnic fertility differentials (Tey and Yew, 2009). To study the changes in fertility across sub-Saharan Africa, Madhavan (2014) analyzed the contributions of the proximate determinants of fertility to overall fertility decline by country and found increasein the proportions of unmarried women and contraceptive use as major factors responsible for fertility decline in SSA (Madhavan, 2014). A Bangladesh study identified contraceptive use as a leading PDs in fertility change (Islam et al., 2014). Across Asia countries, changing marriage pattern and induced abortion were key in reducing fertility among poor women (Majumder and Ram, 2015). Marriage and postpartum infecundabiliity were found to account for the highest inhibiting effect of natural fertility in Zambia [Chola and Michelo, 2016]. Recently, programmes that would promote contraceptive use and breast feeding practices were recommended for rapid fertility decline among Ethiopia women (Laelago et al., 2019). In Nigeria, increased use of contraception and changes in marriage pattern were found to be associated with the fertility decline (Feyisetan and Bankole, 2002). Another study concluded that the richest in Nigeria compared to the poorest were depending more on delayed marriage and contraception for fertility reduction (Finlay et al., 2016; 2018).

2.8.7 The Value of Children (VOC) framework to Fertility

Furthermore, psychology has contributed to demography theory; though, not as impactful as economics, sociology, anthropology and biology (McNicoll,1992). Majorly, there are two psychology thoughts on fertility: "the value of children" and value expectancy models". The value of children can be said it was from Maslowian's view on motivation (Bruijn, 2006). Based on this, Hoffman (1973) conceptualized a framework that showed the motivations of childbearing is a function of satisfactions children add to human needs; as well as the 'economic and non-economic cost of children'. VOC is believed to be a nexus between socio economic and fertility behavior. Fawcett and colleagues (1972) further the discussion on VOC and opined that the relationship between socioeconomic and consideration of children is more of emotional which brought about the concept of the value of children.

The VOC framework to childbearing behavior is an extension of economic framework. The economic framework stresses the price one will pay to raise children, while the VOC framework focus on the paybacks the parents drive from their potential children (Nauck, 2014). The VOC approach was designed to explain the high fertility rates in many developing countries especially as many developed countries were experiencing fertility decline. The approach surfaced in the face of contrasting issues confronting the world: while many developing countries were faced with high fertility rates cum overpopulation, the developed countries' fertility rates continue to decline even below replacement level resulting to aging population. Out of curiosity for a valid and reliable ways to explain reproductive behaviour instead of using economic approach, the VOC approach emerged (Nauck, 2014).

The VOC theory focuses attention on the benefits of children to their parent. Hoffman and Hoffman (1973) listed about nine values parents derive from their children. However, they assumed that the benefits children bring to their parents differs from one society to another; and this has a great influence on fertility decision of each population. Several literatures have documented a number of merits of VOC approach in explaining fertility behavior (Thomson, 2001; Fawcett, 1988; Lesthaeghe and Surkyn, 1988;); however, the framework is vague in deciding whether it is a complete value system. (Friedman et al., 1994; Nauck, 2014).

2.8.8 A Life-Course Theory of Fertility

Just like the VOC model, life-course approach to fertility claims that children afford their parents the opportunities of social relationship and improve their psychological well-being. (Huinink and Kohli 2014). Life-course theory of fertility looks into experiences of the past and hope of tomorrow to understand reproductive behavior. The application of life –course framework to fertility is not recent in demography. In 1970's, the use of life tables, parametric and non-parametric regression analysis were introduced to the study demographic events such as fertility (Courgeau, 2007). Fertility behavior is an event that happen during the course of life-time (Huinink and Feldhaus, 2009). The life is viewed as a complex course that are intertwine with individual well-being and action which childbearing is major. The course of life is entrenched in a changing social and personal characteristics. The society defines the social action (Kohli, 2007); and the relationship between social and cohort dynamics are important during process of life (Mayer, 2004). Therefore, fertility is rooted within social system of the society that condition the individual course of life (Baltes et al., 2006; Heckhausen et al. 2010).

2.9 MODELING FERTILITY

Due to limited data and varying data quality, estimating the demographic indicators is difficult for many developing countries (Alkema et al., 2012). Recent birth estimates often are inaccurate because of inconsistencies resulting from the ambiguity of the actual time when birth occurred in relation to the reference period, and because birth is erroneously carried into or from the reference period when information about births in the past twelve months were being collected (Spoorenberg 2015; Gaisie, 2005). Also, lifetime fertility is vulnerable to mortality errors because women tend to report only the surviving births and not the whole CEB (UN, 2004). Since, in countries where demographic information is incomplete or lacking, estimates of past fertility trends are generally more complex; as such more reliable estimates can be obtained using indirect estimation methods based on model (Moultrie et al., 2013). This has necessitated scholars to develop models suitable for describing APF.

The outlook of ASFR is similar across all societies. To explain this outlook of ASFR, several mathematical models are out there. Many of these models have been used successfully to fit the ASFR in different population. Prominent among the models are:

2.9.1 Hadwiger Function

The Hadwiger distribution proposed by Hadwiger (1940) and it is given by the following function:

$$f(x) = \frac{ab}{c}\left(\frac{c}{x}\right)^{\frac{3}{2}} \exp\left\{-b^2\left(\frac{c}{x}+\frac{x}{c}-2\right)\right\} \text{ ....(2.13)}$$

Where:

x = mother’s age at birth,

a is associated with TF,

b defines the peak of the curve, and

c is related to the mother’s mean at birth.

2.9.2 Gamma function

The Gamma function and Beta Function were proposed by Hoem et al., 1981 is given as:

$$f(x) = R\frac{1}{\Gamma(b)c^{b}}(x-d)^{b-1}\exp\left\{-\left((x-d)/c\right)\right\}, \text{ for } x>d \text{………} (2.14)$$

$$c = \mu - m \text{ and } b = (\mu-d)/c = \sigma^{2}/c^{2} \text{…………………} (2.15)$$

Where:

d is the lower age at birth,

R determines the TFR,

m is the mode,

μ is the mean and

σ^2 is the variance of the density.

2.9.3 The Beta Function:

$$f(x) = R\frac{\Gamma(A+B)}{\Gamma(A)\Gamma(B)}(\beta-\alpha)^{-(A+B-1)}(x-\alpha)^{A-1}(\beta-x)^{B-1}, \text{ for } \alpha < x < \beta \text{ ….}(2.16)$$

The parameters are related to the mean v and the variance τ^2 through the relations

$$\mathrm{B} = \left\{\frac{(v-\alpha)(\beta-v)}{\tau^{2}} - 1\right\}\frac{\beta-v}{\beta-\alpha} \text{ and } \mathrm{A} = \mathrm{B}\frac{v-\alpha}{\beta-v} \text{ ……}(2.17)$$

α and β are interpreted as the boundary of age at birth;

while R determines the level of fertility.

2.9.4 Hadwiger function extended

In 1999 Chandola and others expanded Hadwiger function which is given as:

$$f(x) = am\left(\frac{b_1}{c_1}\right)\left(\frac{c_1}{x}\right)^{\frac{3}{2}} \exp\left\{-b_1^2\left(\frac{c_1}{x}+\frac{x}{c_1}-2\right)\right\} + (1-m)\left(\frac{b_2}{c_2}\right)\left(\frac{c_2}{x}\right)^{\frac{3}{2}} \exp\left\{-b_2^2\left(\frac{c_2}{x}+\frac{x}{c_2}-2\right)\right\} \ldots(2.18)$$

Where:

x = mother's age at birth,

a is related with TF,

b gives the peak of the curve,

c are the level and trend of the mean ages of births outside and inside marriage, and

m determines the relative size of the two component distributions.

2.9.5 Peristera and Kostaki Function

There are three variants of Peristera and Kostaki (2007) parametric models. The first model addresses the fertility pattern of populations that has low early fertility.

$$f(x) = c_1 \exp\left[-\left(\frac{x-\mu}{\sigma(x)}\right)^2\right] \ldots\ldots\ldots(2.19)$$

f(x) is the ASFR at mother's age x;

$\sigma(x) = \sigma_{11}$ if $x \leq \mu$, and $\sigma(x) = \sigma_{12}$ if $x > \mu$.

σ_{11} σ_{12} shows the spread of the distribution before and after its peak respectively.

Also, c_1 depicts the base fertility level curve and is related with TFR,

μ is the location of the distribution

The second and third models include more parameters that are important in adjusting for fertility in populations with distorted fertility pattern. They are presented below:

$$f(x) = c_1 \exp\left[-\left(\frac{x-\mu_1}{\sigma_1}\right)^2\right] + c_2 \exp\left[-\left(\frac{x-\mu_2}{\sigma_2}\right)^2\right] \ldots\ldots.(2.20)$$

Then

$$f(x) = c_1 \exp\left[-\left(\frac{x-\mu_1}{\sigma_1(x)}\right)^2\right] + c_2 \exp\left[-\left(\frac{x-\mu_2}{\sigma_2}\right)^2\right] \ldots\ldots. (2.21)$$

Where f(x) is the ASFR at mother's age x;

$\sigma(x) = \sigma_{11}$ if $x \leq \mu$, and $\sigma(x) = \sigma_{12}$ if $x > \mu$.

σ_{11} and σ_{12} show the spread of the distribution before and after its peak respectively.

c_1 and c_2 are the TFR of the first and the second hump respectively,

μ_1 and μ_2 depict the mean ages of two sub populations the one with earlier fertility and later ages; while σ_1 and σ_2 are the variances of the two humps.

2.9.6 Coale and Trussell Model

ASFR can also be modeled by relating observed fertility schedule with a standard schedule. Coale and Trussell (1974) fitted ASMFR as the product of nuptiality model and marital fertility model. The model is given as:

$$\phi(x) = Mh(x)\delta(x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.22)$$

$$\delta(x) = \exp(mv(x)) \ldots\ldots\ldots\ldots\ldots\ldots..(2.23)$$

Thus, $\phi(x) = Mh(x)\exp(mv(x)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2.24)$

Therefore, $\ln\left(\frac{\phi(x)}{h(x)}\right) = \ln M + mv(x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2.25)$

Where Ø(i) indicates the marital fertility at age i,

h(i) is the natural fertility,

M expresses the level of marital fertility, m is associated with the degree of departure from natural fertility.

Each of the elements in the model show to the extent the observed ASFR vary from the standard schedule. The usefulness was now limited because the interest is on general fertility.

2.9.7 Brass Relational Gompertz fertility model (RGM)

Brass (1974) proposed a relational method between a standard fertility schedule and any other schedule. The model assumed that the cumulative APF follows a Gompertz distribution function.

$$\frac{F(x)}{TF} = \exp(A\exp(Bx)) \text{ ……………………… (2.26)}$$

This suggests log-log transformation of rates directly related with age. Brass improved the fit by using the standard fertility schedule in place of age.

The model, therefore, is given as:

$$\ln\left(-\ln\left({F(x)}/{TF}\right)\right) = A + B\ln\left(-\ln\left({F_s(x)}/{TF_s}\right)\right) \text{……………………(2.27)}$$

The estimation of A and B can be done OLS regression. It was found later that this model has two major shortcomings: first it involves using total fertility (TF) which may be biased. Second shortcoming is the constancy of fertility that was assumed. Nevertheless, the model prompt the standard fertility schedule derived by Booth in 1980. Furthermore, Zaba's Ratio method (1981) was an improved variant of the model proposed by Brass (Moultrie TA et al, 2013).

The RGM refines Brass's P/F ratio method, aimed at estimating ages-specific and total fertility based on the assumption that the ASFR is obtained from the reports of current births, but the fertility level is estimated from the mean CEB reported by the women of younger ages. The purpose of this method is to adjust for errors that associated with in births data. Fertility rate calculated from the current data is frequently so clearly wrong that it is unusable mostly because the level is far too low, but sometimes because it is grossly inflated on the other hand, the reported mean CEB show clear evidence of omission of lifetime fertility of older ages (Moultrie TA et al, 2013).

According to the method, the ratios of the retrospective values (P) to the cumulated current measures (F) is assumed to be equal to one if fertility has remained the same over a period of time and the fertility of women alive and those dead at the time of survey is similar. The deviations from this assumption gives insight about the quality of the data, and useful for the derivation of a refined fertility estimates (Moultrie and Dorrington, 2008). The deviation from one could be attributed to reporting errors when fertility is changing (Moultrie, 2013c). If all births are reported, current fertility would be lower than lifetime fertility when fertility is falling; as such it is expected that P/F ratios and age of the mother directly related. Fertility has been increasing if a falling trend in P/F ratios by maternal' age was observed (Gaisie, 2005). Likewise, Spoorenber opined that increasing trend of P/F ratios with the age of women depicts a likelihood of declining fertility in the past (Spoorenberg, 2015).

2.10 DETERMINANTS OF FERTILITY

Fertility has been found to be influenced by several factors. Generally, the factors affecting fertility can be examined in various ways ranging from socio-cultural and economic to reproductive behavioural factors (Huinink et al., 2015). According to Feyisetan (2012), fertility behavior is determined by biological and social factors. Several studies have established that age at first marriage, age at first birth, childhood mortality, sex preference, religion contraceptive use, women education affect fertility. These factors either have negative or positive effects on childbearing; however, many of the factors are inter-related. Some of such studies were reviewed as follows.

Early marriage and less education are among the main factors responsible for high fertility (Mehress et al., 2017). Adebowale and colleague (2019) identified sex preference, religion and ethnicity as important factors in understanding fertility in Nigeria. In Kenya, Mutwiri (2019) found that region, women educational level, marital status, age at first marriage and age of the mothers have a substantial consequence on fertility. A similar study in Ethiopia by Tegegne et al. (2019) discovered that childbearing is significantly affected by region, age group of respondents, education level, religion, household wealth index, sex of the head of the household, contraceptive use, age at first birth and mass media. Oyinloye et al. (2017) found number of children born to a woman during her lifetime is significantly associated with age at marriage, age at first birth, wealth status and maternal educational level in Burkina Faso, Gambia and Nigeria. Age at marriage, educational status, family type, present age, and preference for male child were found to be main determinants of fertility among the Jat Women of Haryana State, India (Chadiok et al., 2016).

Also, women education, ethnicity, religion, wealth index, family planning use, age at first birth, place of residence, the number of daughters in a household, being gainfully employed, marital status, community and household effects were factors associated with fertility level in Nigeria (Alaba et al., 2017). Fertility decline in sub-Saharan country was principally traced to the desired number of children and increases in the use of modern contraception while postponement of marriage only contributes minimally (Westoff et al., 2013). Awad and Yussof (2017) investigated the major determinants of fertility level in Malaysia, and they found that GDP, infant mortality and women empowerment were main factors responsible for the change in fertility level. In Nigeria, life expectancy, education expenditure, level of per capita income and infant mortality rate were found to be strongly related to total fertility rate (Odior and Alenoghena, 2018).

Furthermore, studies have acknowledged the contributory role of an increasing maternal education in changes observed in FT of SSA (Shapiro et al.,2013; Shapiro and Gebreselassie, 2010; Bongaarts, 2010). Women's education affects fertility through postponement in the timing of initiation of childbearing, reduction in desired parity, uptake of contraceptive use to control fertility and others (Shapiro, 2012). Bbaale and Mpuga (2011) investigated whether association exist between fertility and female education, as well as contraceptive use in Uganda. Their findings confirmed the connection among contraceptive, education and fertility. They opined as level of women education go up, the higher the possibility of up-taking contraception, this will result to fertility reduction. Also they showed that for quick drop in Uganda fertility women education is key. In another study, Bongaarts (2010) explained the educational gap in fertility of SSA and affirmed that educational gaps exist in family size desired, in demand and effective utilization of contraception. Chisadza and Bittencourt (2016) examined the effects of socioeconomic factors on childbearing behaviour in SSA and they found that female education was indirectly related to fertility level across the countries.

Shapiro and Tenikue (2017) identified higher year spent in school and reduction in childhood mortality as the likely factors for rapid falling of fertility in SSA. Ariho and colleagues (2018) opined that women education and marriage age will not cease to be relevant in Uganda fertility decreasing. Yoo (2014) opined that the further drop in childbearing of South Korea was due to the change in maternal educational attainment. Likewise, Adebowale and Palamuleni (2014) found out in their study, ‘childbearing dynamics among married women of reproductive age in Nigeria: re-affirming the role of education’, that fertility and birth progression rates were higher among women with less than secondary education. In recent study among out-of-school unmarried young women living in metropolitan city, south west Nigeria, Adebowale et al (2019) found that unintended Pregnancy, abortion and fertility rate were found to be more prevalent among women with primary education compared with those with secondary education. In the same vein, Bongaats (2017) in his study, ‘the effect of contraception on fertility: is SSA different?’, concluded that just like other regions of the world, an increase in the prevalence of contraceptive use among reproductive women will have an inverse effect on fertility.

Also, fertility is inversely related with contraceptive prevalence. The result of an increase in contraception prevalence is fertility reduction. This was observed by Pullum & Assaf (2016) in the analysis of DHS data of sixteen countries. In a study that compared Uganda and Thailand’s fertility and contraceptive use, it was found that Uganda fertility level remains high because contraceptive is sparsely available and the population is largely rural. In contrast, fertility decline being experienced in Thailand is linked with an efficient provision of family planning services initiated by the government (Lyager, 2010). Likewise, the fertility decline observed in Bangladesh had been linked with the family planning programmes initiated between 1970s and 1980s (Kabeer, 2001). Fertility had continued to decline in Bangladesh.

Age at first marriage is a critical to PDs of fertility (Bongaarts, 1978). Studies had confirmed that age at marriage is negatively related to fertility; such that as if there is a rise in age at marriage number of births reduce (Acharya, 2010). In developed countries where demographic transition had occurred and fertility stabilized at low levels, age at first marriage had been found to be very key. Rutayisire et al. (2014) in their study changes in fertility decline in Rwanda opined that drop in fertility was due to delay in marriage and fall in childhood mortality rates in Rwanda. Also, large family size in SSA has been linked with the practice of early marriage (Kyari & Ayodele, 2014; Haloi, 2014; and Head et al., 2014;).

Also, Solanke (2015) observed a significant association between childbearing behaviour and age at first marriage in Nigeria. Chola and Michelo (2016) observed that marriage was the greatest fertility inhibiting effect on natural fertility in Zambia. They went further to document that reduced sexual exposure via delayed marriage is important factor of fertility decline. Also, Odigmewu and Zerai (1996) found marriage postponement as the major proximate determinant of fertility among Igbo people of Nigeria. In another study conducted by Oyefara (2010) in Osun State, South West Nigeria, he observed that the timing of first childbirth is an important factor to explain fertility gaps.

2.11 FERTILITY AND NIGERIA POPULATION POLICY

Nigeria's population rose rapidly from less than 50million in 1960 to above 100milllion in 1990. With a population above 100 million and a population growth rate of over 3 percent per annum, Nigeria is most the populous country in Africa and the tenth largest country in the world (UN, 1994). In response to surge in population growth rate in Nigeria, the country promulgated its first national population policy in 1988. The policy was ambitious. Among the demographic targets documented in 1988 population policy were: intention to reduce total fertility rate (TFR) from 6 to 4, raise the use of contraceptive to 80 percent, increase mean age at first marriage to 18 years, and reduce population growth rate from 3.3 percent to 2.0 percent by the 2000 (Federal Republic of Nigeria, 1988). Evidence showed that Nigeria was far from achieving these lofty targets after 2000 which necessitated a revisit to the population policy (Mba, 2002). Many reasons were found to be responsible for the failure 1988 National population policy, amongst were lack of political will, financial resources, poor organization, gender issue, and the prolonged political instability (Shofoyeke, 2014).

The second national population policy emerged in 2004 due to the failure of 1988 population policy. The 2004 population policy envisaged that by 2015, TFR would minimally fall at rate of 0.6 children every five years. The population growth rate was expected to decline from 2.9 percent per annum in 2004 to 2 percent or lower, and increase the of modern contraceptive prevalence rate (CPR) by at least 2 percent per annum (National Population Policy, 2004). The assessment of the 2004 population policy revealed that the targets have not been achieved. In 2004, the population growth was in the neighbourhood of 2.9 percent per annum and in 2020 it is about 2.6 percent per annum. The target of the 2004 policy was to reduce population growth rate to minimum of 2.0 percent per annum by 2015; however, in about five years later the population growth rate is 0.6 higher than expected target. Likewise, the TFR was expected to decline by at least 0.6 children every five year. Going by this target, with TFR of 5.7 in 2003, the TFR was to be around 4.5 in

2018. According to 2018 NDHS report, Nigeria's TFR is 5.3 indicating only 0.4 gain was recorded in TFR as against 1.2 expected. High fertility has persistently reported in Nigeria. This confirms that the target of reducing fertility by at least 0.6 children has not been achieved and prospect of rapid fertility decline is in doubt (Shofoyeke, 2014).

According to 2003 NDHS, only 8 percent married of married women in Nigeria were using any form of contraception. With the target of 2 percent increase yearly, contraceptive prevalence among married should be around 36 percent in 2018; whereas, the 2018 NDHS report show that use of any contraceptive prevalence in Nigeria was 12 percent. This show a deficit of 24 percent going by the expected target, which suggest that the target of at least of 2 percent is far from being achieved (Shofoyeke, 2014; Otese et al., 2017). Several studies in Nigeria indicate that knowledge and awareness of contraceptive is very impressive, but the use is still very low among married women (Fagbamigbe et al., 2015; Ogboghodo, 2017; Solanke, 2017; Anaba et al., 2018; Ajayi et al., 2018; Gajida et al., 2019). Meanwhile, the implications of not uptaking contraception include short birth interval, children having children, large family size among others.

Fertility is one of the key indices of population change and measure of development. One of the prominent indicators that distinguishes developed countries from developing countries is the level of fertility. While in developed countries fertility is low, fertility is high in developing countries like Nigeria. This high fertility and couple with other events like 1994 International Conference on Population and Development (ICPD), which acknowledged affirmed the important role of fertility in sustainable development led to the emergency of 2004 national population policy aiming to achieve some demographic goals (Mba, 2002). However, the 2004 national population policy, which revealed government concern to change the reproductive behavior of Nigerians has failed to achieve its aim. The population growth rate and fertility level of Nigeria remain of one the highest in the world. The uptake of contraception is still very low. With the failure of 2004 national population policy, Nigeria has continued to postpone its development and demographic dividend (Akinyemi & Isiugo-Abanihe, 2014).

2.12 FERTILITY AND SUSTAINABLE DEVELOPMENT GOALS (SDGS)

In 2000, Nigeria was among 189 countries across the world that adopted the eight Millennium Development Goals (MDGs) and their indicators to be achieved by the year 2015. Nigeria and many other Africa countries performed poorly in achieving some for the MDGs (Adekola et al., 2017). Due to the failure of many countries especially SSA countries to achieve MDGs, in 2015 the world leaders rolled out 2030 agenda for sustainable development with aim of free humanity from poverty, secure a healthy planet for future generations, and build peaceful, inclusive societies as a foundation for ensuring lives of dignity for all (UN, 2017; Akinloye, 2018). At the center of these SDGs is the population dynamics. Fertility is one of the principal components of population dynamics and it determines the size, structure, and composition of the population in any country (PRP, 2017). Fertility will practically contribute to the achievement of SDGs. There are seventeen goals to be achieved in SDGs and they are listed as follows:

Goal 1: End poverty in all its forms everywhere

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3: Ensure healthy lives and promote well-being for all at all ages

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5: Achieve gender equality and empower all women and girls

Goal 6: Ensure availability and sustainable management of water and sanitation for all

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10: Reduce inequality within and among countries

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12: Ensure sustainable consumption and production patterns

Goal 13: Take urgent action to combat climate change and its impacts

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Population dynamics have direct and indirect impacts on all the goals. Over the years, rapid population growth has been linked to poverty and number of poor people (Cleland, 2006; Beegle, 2016). Several studies have found higher risk of poverty among family with larger size (Mberu and Reed, 2004; Dribe et al., 2017; Wietzke, 2020). High fertility has significant implications for women and their health. Several girls are at risk of poor sexual and reproductive health outcomes in developing countries due to early marriage and childbearing, and high unintended pregnancy (Santhya and Jejeebhoy, 2015). The persistence high fertility due to child marriage in sub-Saharan African countries has contributed in no small measure to population growth which has put heavy burden on limited resources (Wodon, et al., 2017). According to United Nations, the rapid population growth in poorest countries like SSA will make eradication of hunger and poverty a difficult task (UN, 2015). Consequently, fertility will have direct impact on goal 1 and 2. Likewise, fertility is very vital in achieving the goal 3 of the SDGs. High fertility has been found to be associated with high maternal mortality and morbidity. Fertility is an important determinant of maternal health (Khudri, 2016). Maternal mortality ratio remains very high in SSA countries, where high fertility is persistence (Girum and Wasie, 2017). Also, studies have shown that pregnancy after age 18 years helps adolescents' health and promotes healthy children (Fall et al., 2015). Results from multiple studies have shown that for birth spacing of less than 18 months and greater than 60 months are associated with negative health outcomes such as difficult deliveries, preterm birth, low birth weight and increased new born death and these health outcomes have been termed adverse (Agida et al. 2016). Family planning helps mother and child to ensure a heathy life.

To ensure inclusive and equitable quality education and promote lifelong learning opportunities for all especially women and girls, fertility is vital. A negative correction between women education and fertility has been established (Kim, 2016). Adebowale et al. (2017) affirmed that improving women's education may facilitate fertility decline. Kaffenberger and colleagues (2018) found that completing six years of schooling would significantly reduce fertility level. Higher education postpones age at marriage and delay fertility; and vice versa, fertility decline has had impact of girls' education. For goal 5 to be achieved, women must have ability to decide the number, timing and spacing of their children (Starbird, 2016). Also, fertility decline is associated to better well-being for women. Fertility decline has contributed to the empowerment of women and girl. (Stoebenau et al., 2013). Atake and Ali (2019) also opined that empowered women are more likely to desire fewer number of children compared to their peers who are less empowered. Furthermore, climate change is largely dependent on population dynamics. Likewise, the rate of population growth will significant impact on demand for food and forests products, and have implications on infrastructure for health and economic development (starbird et al., 2016).

2.12 THEORETICAL FRAMEWORK

Most researchers used the reproductive behavior model and the socio-economic model to study the fertility levels, patterns, trends and differentials in SSA (Ezeh et al., 2009). Fertility behavior is conditioned by both biological and social factors (Feyisetan and Bankole, 2012).

Reproductive Behavior Model

Davis and Blake (1956) conceptualized in 1950s the proximate determinants of fertility framework to explain fertility change. They proposed eleven variables through which fertility can be explained. Bongaarts (1978) further the framework by collapsing the eleven factors into seven factors namely: the proportion of women of reproductive ages that is married, the use and effectiveness of contraception, induced abortion, postpartum infecundability, the frequency of intercourse, the onset of permanent sterility, and spontaneous intrauterine mortality. Stover (1998) critiqued the model on the basis that only married women were involved. Thus, the Bongaats

(2015) revised model, which accommodates all sexually active women, was adopted in this study. This model has ability to measure the source of change and effects on total fertility rate overtime (Bongaarts, 2008; Shapiro and Gebreselassie, 2008). Based on empirical and theoretical literatures, the four major PDs (the proportion of women of reproductive ages that is sexually exposed, the use and effectiveness of contraception, induced abortion, and postpartum infecundability) were considered in the study.

Socio-Economic Model

The use of this socio- economic model dominate the studies of fertility decline in SSA (Mberu and Reed, 2014). Women education, place of residence, and wealth index of the households have been identified as important driver of fertility decline in SSA (Gerland et al, 2017). Women education particularly has been linked to fertility decline in SSA either directly or via affecting age at marriage and age at first birth (Shapiro and Gebreselassie, 2008). Based on this knowledge, women education, place of residence and wealth index were used to understand the fertility transition in Nigeria.

2.13 CONCEPTUAL FRAMEWORK FOR THE STUDY

For the multivariate analysis of fertility for this study, the reproductive behavior model and the socio-economic model was adapted for the conceptual framework. Fertility rates and rate ratios based on women characteristics were considered in this study. Figure 2.1 shows the conceptual framework used to identify factors that could be modified in order to reduce the time it will take fertility to converge to replacement level. The conceptual framework adapted was based on fertility theories and assumptions concerning the independent factors and intervening factors which are directly and indirectly influencing the fertility behavior. The independent variables were: Maternal Age, Age at first Birth, Age at first Marriage, and Modern Contraceptive Use; and intervening factors were: Educational Level, Place of Residence, and Religion.

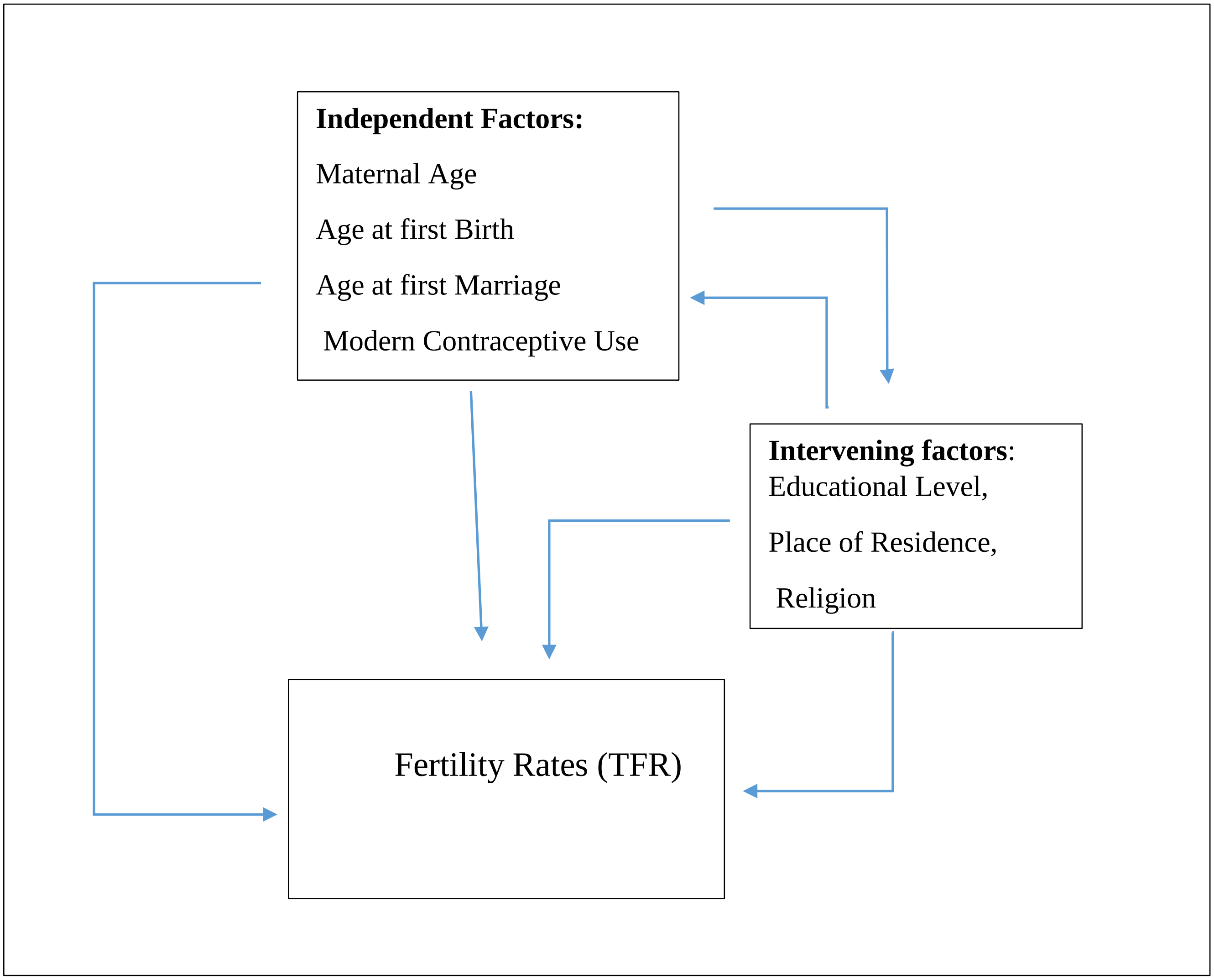


Figure 2.4: Adapted Conceptual Framework

CHAPTER THREE

METHOD AND DATA

3.0 INTRODUCTION

This chapter presents the description of the study area and the sources of data. Also presented in the chapter are details of data collection procedures, sampling design technique, data analysis procedures as well as statistical methods that were employed to achieve the objectives of this study. The detailed procedures of direct estimation of TFR by Moultrie et al. (2013) and Gompertz relational model used to describe the shift in age pattern of fertility were presented. Mathematical model proposed for determining the timing of fertility convergence to replacement was clearly stated in this chapter. Also presented in this chapter are the revised proximate determinants (PDs) of fertility by Bongaarts (2015), a five-factor decomposition method prosposed by Das Gupta (1991), and Oaxaca decomposition. The ethical considerations is also presented.

3.1 DESCRIPTION OF THE STUDY AREA

This study was based on a nationally representative sample that covered all the six geopolitical zones in Nigeria. The country is made up of 36 states and a Federal Capital Territory, grouped into six geopolitical zones: North Central, North East, North West, South East, South South, and South West. There are 774 constitutionally recognized local government areas (LGAs) in the country (ICF Macro and NPC, 2019). Nigeria is the most populous country in Africa and the 14th largest in land mass. The 2006 Population and Housing Census conducted in Nigeria placed the country's population at 140,431,790 (NPC, 2006), but the current estimate is above 200 million (UN, 2019).

According to 2018 NDHS report, the level of fertility in Nigeria is 5.3. In Nigeria, the age specific fertility rate peaked among women aged 25-29 years, and the mean children ever born was 3.0. In the country, the half of women aged 25-49 years give birth for the first time before age 21 years;

and about 19% of teenage women have begun childbearing (ICF Macro and NPC, 2019). The population growth rate in Nigeria 2.58 % and high fertility has sustained this high growth rate in Nigeria . Nigeria is a multi-ethnic country with the three major ethnic groups being; Hausa/Fulani, Igbo and Yoruba. The culture in Nigeria is defined mainly by ethnicity and sometimes by religious groups (Christianity, Islam and Traditional). Childbearing is a common practice in Nigeria but the magnitude varies according to cultural diversities. Polygamy is very common among the Muslims and early marriage is prevalent in the North.

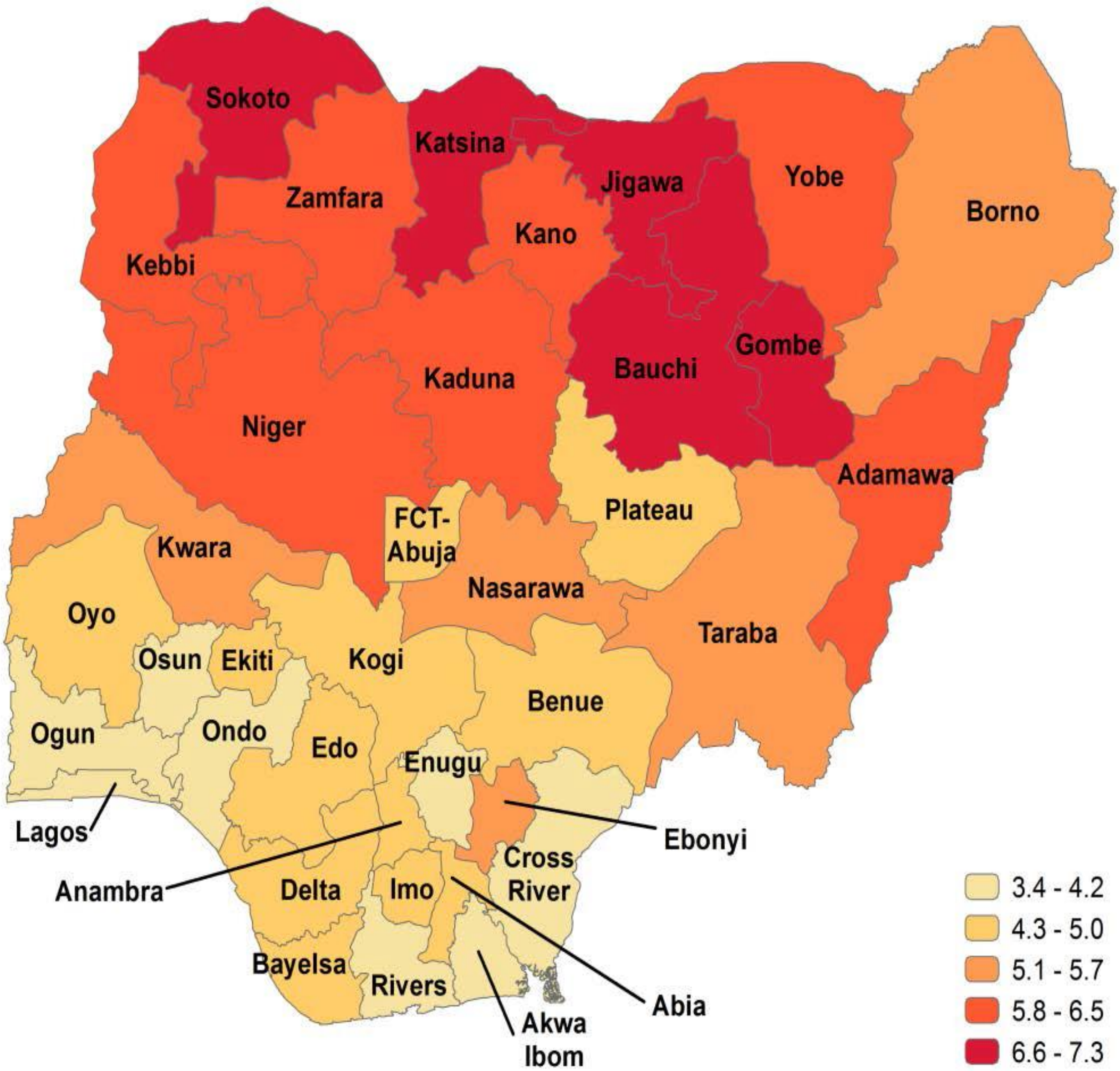


Figure 3.1 Nigeria Map by state with fertility level

3.2 DATA SOURCES

The study used the 2003, 2008, 2013 and 2018 Nigeria Demographic and Health Survey datasets to achieve the research objectives. Data collected were highly comparable over time because of the standardization in sampling procedures, data collection methodologies and coding. The number of households interviewed in 2003, 2008, 2013, and 2018 were 7864, 34070, 40680 and 42000 respectively. The number of women aged 15-49 years interviewed for these year periods used in the study were 7620, 33385, 38948, 41821 respectively (ICF Macro and NPC, 2004, 2009, 2014 and 2019). The analyses were based on this secondary data which were assessed on the web platform of the data originators.

3.3 SAMPLING TECHNIQUE

The 2003 NDHS utilized the sampling frame designed for the 1991 population census while the 2008, 2013 and 2018 NDHS programme adopted the sampling frame designed for the 2006 population and housing census but with slight modification. The primary sampling unit (PSU) as defined in all the survey rounds was a cluster defined on the basis of Enumeration Areas (EAs) from the 1991 and 2006 EA census sampling frames. Samples for the 2003 and 2008 surveys were selected using stratified two-stage cluster design consisting of 365 clusters in 2003 NDHS (ICF Macro and NPC, 2004) and 888 clusters in 2008 NDHS (ICF Macro and NPC, 2009). The 2013 NDHS sample was selected using a stratified three-stage cluster design consisting of 904 clusters, 2018 NDHS was selected in two stages from the sampling frame (ICF Macro and NPC, 2014). The 2018 sample was selected using a stratified two-stage cluster design coving 1,400 clusters.

In 2013, at the first stage, 893 localities were selected with probability proportional to size and with independent selection from each sampling stratum. In the second stage, one EA was randomly selected from most of the selected localities. In a few larger localities, more than one EA was selected. In total, 904 EAs were selected. After the selection of the EAs and before the main survey, a household listing operation was carried out in all of the selected EAs (ICF Macro and NPC, 2014). For 2018 NDHS, at the first stage, 1400 EAs were selected; and a household listing which served as sampling frame were conducted in the selected EAs. In second stage, 30 households were selected from each cluster by an equal probability systematic sampling (ICF Macro and NPC, 2019).

3.4 STUDY DESIGN

The design for the data collection was cross-sectional and as for this study, analytical approach was used to achieve the study objectives.

3.5 STUDY POPULATION

Women of reproductive age (15-49 years) were studied. In this regard, the individual records data were used in the analysis.

3.6 STUDY VARIABLES

3.6.1 DEPENDENT VARIABLE

The dependent variable was fertility measured through information obtained from women aged 15-49 years on their full birth history. An important outcome of this study is TFR defined as average number of children a woman would have if she were to bear children according to the present schedule of age specific fertility rates throughout her reproductive ages. It is one of the synthetic cohort measures and a good index for measuring fertility change as it is independent of the age distribution.

To estimate TFR from survey data containing birth histories, two sets of data were used: the data set in which there is one record per woman and another with one record per child. The women's data set were used to produce the denominator of the fertility rate while child's data set were used for the estimation of the numerator of the fertility level. The information used in women's data set was the month and year of each women's birth; the month and year of interview and sampling weights necessary for adjustment of data. Similarly, the child's month and year of birth as well as mother's date of birth were used.

Other dependable variable of this study is the total number of children ever born (CEB). CEB is the lifetime fertility were obtained from information provided by women aged 15-49 years on their full birth history. It is a discrete number in DHS data set. However, it was categorized into two in this study as low if a woman has less than 5 children and high if otherwise. The categorization was based on the 1988 population policy revised in 2004 which emphasized the need to maintain four children at family level.

3.6.2 INDEPENDENT VARIABLES

The independent variables were: Educational Level, Maternal Age, Age at first Birth, Age at first Marriage, Place of Residence, Religion, Modern Contraceptive Use. The operational definition of educational level was the highest level of school the respondent attended at the time of survey. We used literacy to denote women education in this study because it is essential in measuring a population's level of education. Literacy is defined as the ability to both read and write a short, simple statement about one's own life. We, therefore, categorized education as having no formal education (Illiterate) for those who cannot read and write and have not completed primary education while educated (if they can read and write and have a minimum of completed primary education - Literate). The maternal age was the age of the mothers as of the last birthday. Other variables used were: maternal Age (15-19, 20-24…, 45-49), age at first birth, age at first marriage, place of residence (urban, rural), religion, modern contraceptive. The age at first marriage and age at first birth were count data in years. We re-categorized them as < 20 year (teenagers) and ≥ 20 year. Religion was categorized as Christian, Islam and others. Likewise, the wealth index was re-grouped as poor, middle and rich.

Variable	**Coded**	**Re-coded**
Maternal Age (V012)	15, 16,17…., 49	15-19 20-24…, 45-49
Educational Level (V106)	None Primary Secondary Higher	Same
Religion (V130)	1. Catholic 2. Other Christian 3. Islam 4. Traditionalist 96 Other	**v130new** Christian Islam Other
Wealth Index (V190)	1. Poorest 2. Poorer 3. Middle 4. Richer 5. Richest	**v190new** Poor Middle Rich
Place of Residence (V025)	1. Urban 2. Rural	Same
Age at First Marriage (V511)	12, 13, 14….(Years)	**v511new** <20years 20 and above year
Age at First Birth (V212)	12, 13, 14….(Years)	**v212new** <20years 20 and above year
Modern Contraceptive Use (V313)	0. No Method 1. Folkloric Method 2. Traditional Method 3. Modern Method	**v313new** No Method Modern Method

3.7 DATA MANAGEMENT AND ANALYSIS PATTERN

SPSS was used to process and merge the data sets, while STATA was used to analyze the data. Excel was employed to draw some of the graphs and R was utilized for the decomposition analysis because of the quality of forest plots and other graphs presented. Also, Population Analysis Spreadsheets (PAS) were used for the Gompertz model. Analyses were done for Nigeria as an entity and the six regions in the country.

3.7.1 Data Exposition

Two sets of data were used in the study. These are: women data set (individual recode) and children data set (child recode). All the variables needed in both women data set and children data set for the study were extracted with the use of SPSS. The variables used to estimate the numerator of TFR, the month (b2) and year (b3) of child's birth, were extracted from children data set with the ID variable (caseid) and sorted according to the ID variable for matching. The women data set from where denominator of TFR was estimated was then opened, and ensured that the same ID variable was available after which the two files were merged together.

Sample weights were applied to each case to adjust for differences in probability of selection. Weighting is important in order to increase the extent of representativeness in the sample; and it decreases biasness in the sample selection. The weight variable used was v005 divided by 1,000,000.

3.7.2 Variables Extracted

Variables	**Code**
The month of interview	V006
The year of interview	V007
The month of woman's birth	V009
The year of woman's birth	V010
Age in 5-year groups	V013
Age at first birth	V212
Age at first cohabitation	V511
Currently pregnant	V213
Contraceptive use	V311
Months of breastfeeding	M5_1
Months of amenorrhea	M7_1
Months of abstinence	M9_1
Place of residence (v025)	V025
Region (v024)	V024
Religion (v130)	V130
Education level (v106)	V106
Wealth quintile (v190)	V190
Currently/formerly/ never in union	V502

3.8 ADDRESSING THE OBJECTIVES:

Objective one: to describe the shift in age pattern of fertility and fertility trend between 2003 and 2018. The estimation of Gompertz model parameters was used to achieve these objectives. The processes involved in the estimation of these parameters are outlined below.

GOMPERTZ MODEL

The age-specific fertility rates were derived from estimated Gompertz parameters and observed total fertility rates. This was attained by following the procedures known as "Ratio method" developed by Zaba (1981). The average parities, ${}_5P_x$, of women in each age group (x, x+5) for x = 15, 20, ------- 45, and age-specific fertility rates were generated using the following procedures.

Direct Estimation (Moultrie et al., 2013)

Step 1: Births of children by age of mother at birth and year of birth were generated. The age of the mother at birth of a given child was calculated using:

$$x = \text{int}\left(\frac{12\left(Y_B^c - Y_B^m\right) + \left(M_B^c - M_B^m - b\right)}{12}\right) \ldots\ldots\ldots\ldots (3.1)$$

The age of mother at birth x was cross-tabulated with the year of birth of child to produce the numerator of the fertility rates (number of births $B_x(t)$). This was extracted from children data set (Child recode).

Step 2: Calculation of the age of women at the start of the year in which she was interviewed. This was obtained with the use of women's data set (individual recode). It is given as:

$$x_I = Y_I^m - Y_B^m - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Thereafter, the exposure to the risk of childbearing ($E_x(t)$) was estimated. This was derived through aggregation of equations 3.3 and 3.4.

$$E(x_I - 1, Y_I - 1) = \frac{M_B^m - 0.5}{12} \ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

$$E(x_I, Y_I - 1) = 1 - \frac{M_B^m - 0.5}{12} \ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

The Age-specific fertility rates for five-year age groups in year t were generated using equation 3.5:

$$f(i,t) = \frac{\sum_{a=5i+10}^{5i+14} B_a(t)}{\sum_{a=5i+10}^{5i+14} E_a(t)} \text{ .... (3.5)}$$

Where the terms are:

Y_B^c - The year of child's birth

Y_B^m - The year of mother's birth

M_B^c - The month of child's birth

M_B^m - The month of mother's birth

Y_I^m - The year of the mother was interviewed

b – equals to 1 if the day of interview was greater than 15, and 0 if was less than or equal to 15.

Then the fertility standard developed by Booth (1984) was chosen to fit the model as follows:

$z(x) – e(x) = \alpha + \beta g(x) + c/2(\beta-1)^2$ …………(3.6)

$z(i) – e(i) = \alpha + \beta g(i) + c/2(\beta-1)^2$ …………(3.7)

Where:

$$z(x) = Y(x) = -\ln\left(-\ln\left(\frac{F(x}{F(x+5)}\right)\right) \text{..................(3.8)}$$

$$g(x) = \frac{Y^s(x+5).\exp(Y^s(x)) + Y^s(x).\exp(Y^s(x+5))}{\exp(Y^s(x)) - \exp(Y^s(x+5))} \text{ .... (3.9)}$$

$$e(x) = gompit\left(\frac{Y^s(x)}{Y^s(x+5)}\right) - g(x) \text{.............(3.10)}$$

Plots of z(x) – e(x) against g(x), and z(i) – e(i) against g(i) (on the same set of axes) that almost on the same line were used to fit the model. The values of α (intercept) and β (slope) are the parameters. Level of fertility (TFR) were estimated indirectly by applying the above derived parameters (α & β) to the current fertility gompits. The anti-gompit of the fitted values were taken to produce a cumulative fertility distribution. These proportions were multiplied up by an estimate of total fertility derived from the standard parity gompits to produce the absolute cumulated fertility distribution. The adjusted ASFRs were obtained by differencing and division of cumulated fertility by 5.

The parameters α & β for the time periods were compared; α indicates the location of fertility and β shows the spread in relation with the standard. Also, the results of the ASFRs were graphed on the same axis for comparison.

Objective two: To examine changes in the timing of childbearing and how it affects fertility level across the six geo-political zones in Nigeria.

THE TIMING OF CHILDBEARING

The changes in the timing of childbearing were examined by calculating the corresponding mean ages at birth of different births orders of the study time periods. Further analysis of how changes in the timing of childbearing (Tempo effect) have affected the trend in the TFR between 2003 and 2018 were conducted. In order to assess the Tempo effects on TFR, the adjTFR measure developed by Bongaarts and Feeney (1998) was applied.

$$adjTFR = \sum adjTFR_i \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.11)$$

$$adjTFR_i = TFR_i \big/ (1 - r_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.12)$$

Where TFR_i is the order-specific fertility; and r_i equals to rate of change in the mean age at birth order i. If adjusted TFR is greater than observed TFR, this suggests an increase in the mean age at birth and a decrease in the mean age at birth if otherwise. However, if there are no changes both adjusted and unadjusted will be the same.

The level of fertility is influenced by changes in timing of childbearing (Tempo) and children ever born (Quantum). This was demonstrated under the assumption that total fertility that would have been observed in a given year had there been no change in the timing of births during that year. This observed TFR may be estimated by dividing the observed TFR at each birth order by the change in mean age at childbearing at each order during the year. If there has been a recent increase in the age at childbearing, the observed TFR will be lower than what it would have been in the absence of change in the age at childbearing. The adjustment formula was applied to birth rate of each order separately and the results were combined to obtain an estimate of the tempo effect for births.

Objective three: to determine the timing of fertility convergence to replacement level in Nigeria. This was achieved by modeling age specific fertility pattern between 2003 and 2018. Age specific fertility rates for each period was estimated using indirect method of estimation of fertility as earlier discussed.

This was achieved by modeling age specific fertility pattern. A standard age schedule that was at replacement level was assumed. The percentage contribution of each age specific fertility rates to the TFR was assumed to be the same in both observed age schedule and the standard age schedule. Therefore, the TFR for time periods 2003 and 2018 were decomposed into age specific fertility rates as showing in equation (3.18) and subsequently $f^{o}_{t=15}$ (3.19) was derived. The projection was based on yearly change; therefore, linear interpolation method was used to derive $f^{o}_{t=1}$

The standard age schedule of fertility used in this study was derived by finding the average of 21 countries whose total fertility rates (TFR) were at replacement level fertility (Appendix II).

Procedure:

The assumption of uniformity in the percentage contribution of TFR by ASFRs of the observed and the standard is presented as:

$$\frac{f^{o}(x)}{5\sum f^{o}(x)}\times 100 = \frac{f^{s}(x)}{5\sum f^{s}(x)}\times 100 \text{ ……..(3.13)}$$

The modeled ASFRs were derived as follows:

$$f^{o}(x) = \left(\frac{f^{s}(x)}{5\sum f^{s}(x)}\times 100\right) \div \frac{100}{5\sum f^{o}(x)} \text{ ………..(3.14)}$$

Since $TFR = 5\sum f(x)$

$$f^{o}(x) = \left(\frac{f^{s}(x)}{5\sum f^{s}(x)} \times 100 \right) \times \frac{TFR^{o}}{100} \text{ ....(3.15)}$$

$$f^{o}(x) = \frac{TFR^{o}}{5} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \text{..................(3.16)}$$

$$\boxed{f^{o}(x) = 0.2TFR^{o} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \text{..........(3.17)}}$$

$$f_{t}^{o}(x) = 0.2TFR_{t}^{o} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \text{..........(3.18)}$$

$$f_{t-15}^{o}(x) = 0.2TFR_{t-10}^{o} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \text{..........(3.19)}$$

Then, equation (3.23) was obtained through linear interpolation

$$f_{t-1}^{o}(x) = \frac{(f_{t}(x) - f_{t-15}(x))(t-1-t+15)}{t-t+15} + f_{t-15}(x)$$

or

$$f_{t-1}^{o}(x) = \frac{(f_{t}(x) - f_{t-15}(x))14}{15} + f_{t-15}(x) \text{ ....(3.20)}$$

$$0.93 f_{t}(x) - 0.93 f_{t-15}(x) + f_{t-15}(x) \text{ ....(3.21)}$$

$$0.93 f_{t}(x) + 0.07 f_{t-15}(x) \text{ ....(3.22)}$$

$$f_{t-1}^{o}(x) = 0.19 \left(TFR_{t}^{o} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \right) + 0.01 \left(TFR_{t-10}^{o} \left(\frac{f^{s}(x)}{\sum f^{s}(x)} \right) \right) \text{....(3.23)}$$

The yearly decrease in ASFR is therefore given as:

$$\Delta = f_t^o(x) - f_{t-1}^o(x) \text{........}(3.24)$$

With this difference, the time it will take Nigeria to converge at replacement level can be projected using:

$$f_{rep}(x) = f_t^o(x) + (t - T)\Delta \text{.........}(3.25)$$

Therefore: TFR at replacement level is

$$TFR_{rep} = 5\sum f_{rep}(x) \text{ ....}(3.26)$$

The estimated TFR_{rep} was compared with the value produced by the UN-model in represented in equation (3.19).

UN Model using sum of two 3-parameters logistic growth pulses for annual decline in TFR

$$\Delta TF = \frac{k_1}{1 + \exp\left[-\frac{Ln(81)}{\Delta t_1}(TF - t_{m1})\right]} + \frac{k_2}{1 + \exp\left[-\frac{Ln(81)}{\Delta t_2}(TF - t_{m2})\right]} \text{ .... } (3.27)$$

The parameters for 'slow/slow' countries like Nigeria are given as:

$k_1 = -0.112730$, $\Delta t_1 = 5.027900$, $t_{m1} = 5.768830$, $k_2 = 0.147540$, $\Delta t_2 = 2.754150$, $t_{m2} = 3.211780$

Objective Four: T**o** identify factors that can be modified in order to reduce the time it will take fertility to converge to replacement level. This was achieved by performing multivariate analyses of fertility using Stata module for fertility rates from birth histories (tfr2) by Schoumaker (2013).

Stata Module for Fertility Rates from birth histories by Schoumaker (2013)

The tfr2 module uses Poisson regression to estimate fertility rates and to compute rate ratios. According to the Poisson model, the probability that random variable Y_i is equal to the observed number of births (y_i) is assumed to follow a Poisson distribution with mean (μ_i) (Trussell and Rodriguez 1990).

$$P(Y_i = y_i / \mu_i) = \frac{\exp(\mu_i)\mu_i^{y_i}}{y_i!} \text{ .... } (3.28)$$

The mean μ_i can be broken down into the product of fertility rate (λ_i) and exposure (t_i)

$$\mu_i = \lambda_i t_i \text{ .... } (3.29)$$

Logarithm of equation above

$$\log(\mu_i) = \log(t_i) + \log(\lambda_i) \text{ ....} (3.30)$$

The regression model consists of modeling the logarithm of rates (λ_i) as a linear combination of independent variables. In tfr2, independent variables include a function of age and possibly additional covariates.

$$\log(\lambda_i) = \alpha + f(age) + g(\text{cov}ariates) \text{ ....} (3.31)$$

Replacing log(λ_i) in (3.22) by (3.23), the Poisson regression that is estimated becomes:

$$\log(\mu_i) = \log(t_i) + \alpha + f(age) + g(\text{cov}ariates) \text{ ......} (3.32)$$

After fitting the model in (3. 25) age specific fertility rate can be computed as the product of the exponentials of the functions of age and covariates (regression coefficient)

$$\lambda_i = \exp[f(age)] * \exp[g(\text{cov}ariates)] \text{..............} (3.33)$$

Objective Five: To decompose change and difference in fertility level across the six geo-political zones in Nigeria.

Decomposition of Change in Fertility Level

The Revised Proximate Determinants (PDs) of Fertility Model by Bongarrts

Bongaart’s model was used to estimate the indices of the proximate determinants of fertility. There are four main PDs. The indices of each PDs ranges from 0 to 1 with smaller values showing greater effects and 1 indicating no inhibiting effect. The total fecundity rate which is the average number of lives births born to a woman was estimated to be 15.3, if she remains married throughout her reproductive years in the absence of contraception, no any induced abortion, and she does not breastfeed her children (Bongarrts, 2015).

The first step was the calculation of proximate determinants of fertility for each time period:

$$TFR = C_m C_c C_i C_a TF \quad \text{………………(3.34)}$$

C_m is sexual exposure index

$$C_m = \sum C_m(a) W_m(a) \quad \text{………………(3.35)}$$

$$C_m(a) = m(a) + x(a) \quad \text{…………………..(3.36)}$$

$$W_m(a) = \frac{f_m(a)}{\sum f_m(a)} \quad \text{………………… (3.37)}$$

$$f_m(a) = Cc(a) C_i(a) C_a(a) f_f(a) \quad \text{……………..(3.39)}$$

C_c is contraception index

$$Cc = \sum Cc(a) Wc(a) \quad \text{………………… (3.40)}$$

$$C_c(a) = 1 - r(a) \times u(a) \times e(a) \quad \text{……………….(3.41)}$$

$$Wc(a) = \frac{f_n(a)}{\sum f_n(a)} \approx \frac{f_f(a)}{f_f(a)} \quad \text{……………….(3.42)}$$

C_i is Postpartum Infecundability Index

$$C_i = \sum C_i(a) W_i(a) \quad \text{………………(3.43)}$$

$$C_i(a) = \frac{20}{18.5 + i(a)} \quad \text{………………. (3.44)}$$

Abortion Index

$$C_a = \sum C_a(a) W_a(a) \approx \frac{TFR}{TFR + bTAR} \quad \text{…………………..(3.45)}$$

$$C_a(a) = \frac{f(a)}{f(a) + bar(a)} \text{ ……………. (3.46)}$$

$$b = \frac{14}{18.5 + i(a)} \text{ ………………….(3.47)}$$

The abortion index was estimated using abortion rate produced by Sedgh et al (2012b), because of paucity of information on abortion in developing countries (Bongarrt, 2015). The estimates of TAR were 30 times abortion rate per 1000.

TAR= Total abortion rate

TF = total fecundity rate

f_f (a) = fecundity rate

f_m(a) = fertility rate exposed women

f_n(a) = natural exposed fertility,

m(a) = proportion married/union

x(a) = extramarital exposure

u(a) = contraception prevalence (exposed women)

o(a) = overlap with postpartum infecundability

e(a) = average effectiveness

r = fecundity adjustment

i(a) = average duration of postpartum infecundability

ar(a) = abortion rate, a = age

TFR was estimated using this method for both 2003 and 2018 in order to derive the change in TFR.

The indices of the four major PDs were estimated for the survey 2003 and 2018. Decomposition of the change in observed TFR between the two time periods was used to determine the contributions of each index to the change.

A decomposition of the change in TFR

A five- factor decomposition method proposed by Das Gupta (1991) were used to decompose the change in TFR between 2003 and 2018

If $T_1 = TFR_{2003}$ and a_1, b_1, c_1, d_1, & e_1 represent the five proximate determinants in 2003

$T_2 = TFR_{2018}$ and a_2, b_2, c_2, d_2, & e_2 represent the five proximate determinants in 2018

The change in TFR

$T_2 - T_1$ = a-effect + b-effect + c-effect + d-effect +e-effect……(3.48)

a-effect = $Q(a_2 - a_1)$

Where Q is a function of b_1, c_1, d_1, e_1 b_2, c_2, d_2, e_2 given by:

$$Q = \frac{b_2c_2d_2e_2 + b_1c_1d_1e_1}{5} + \frac{b_2c_2d_2e_1 + b_2c_2d_1e_2 + b_2c_1d_2e_2 + b_1c_2d_2e_2 + b_1c_1d_2e_2 + b_1c_2d_1e_1 + b_2c_1d_1e_1}{20} + \frac{b_2c_2d_1e_1 + b_2c_1d_1e_1 + b_2c_1d_1e_2 + b_1c_1d_2e_2 + b_1c_1d_2e_2 + b_1c_2d_1e_2 + b_1c_2d_2e_1}{30} \quad (3.49)$$

b-effect = $Q(b_2 - b_1)$

Where Q is a function of a_1, c_1, d_1, e_1, a_2, c_2, d_2, e_2 given by:

$$Q = \frac{a_2c_2d_2e_2 + a_1c_1d_1e_1}{5} + \frac{a_2c_2d_2e_1 + a_2c_2d_1e_2 + a_2c_1d_2e_2 + a_1c_2d_2e_2 + a_1c_1d_2e_2 + a_1c_2d_1e_1 + a_2c_1d_1e_1}{20} + \frac{a_2c_2d_1e_1 + a_2c_1d_1e_1 + a_2c_1d_1e_2 + a_1c_1d_2e_2 + a_1c_1d_2e_2 + a_1c_2d_1e_2 + a_1c_2d_2e_1}{30} \quad (3.50)$$

d-effect = $Q(d_2 - d_1)$

Where Q is a function of a_1, b_1, d_1, e_1, a_2, b_2, d_2, e_2 given by:

$$Q = \frac{a_2b_2c_2e_2 + a_1b_1c_1e_1}{5} + \frac{a_2b_2c_2e_1 + a_2b_2c_1e_2 + a_2b_1c_2e_2 + a_1b_2c_2e_2 + a_1b_1c_2e_2 + a_1b_2c_1e_1 + a_2b_1c_1e_1}{20} + \frac{a_2b_2c_1e_1 + a_2b_1c_1e_1 + a_2b_1c_1e_2 + a_1b_1c_2e_2 + a_1b_1c_2e_2 + a_1b_2c_1e_2 + a_1b_2c_2e_1}{30} \quad (3.51)$$

e-effect = $Q(e_2 - e_1)$

Where Q is a function of a_1, b_1, c_1, d_1, a_2, b_2, c_2, e_2 given by:

$$Q = \frac{a_2b_2c_2d_2 + a_1b_1c_1d_1}{5} + \frac{a_2b_2c_2d_1 + a_2b_2c_1d_2 + a_2b_1c_2d_2 + a_1b_2c_2d_2 + a_1b_1c_2d_2 + a_1b_2c_1d_1 + a_2b_1c_1d_1}{20} + \frac{a_2b_2c_1d_1 + a_2b_1c_1d_1 + a_2b_1c_1d_2 + a_1b_1c_2d_2 + a_1b_1c_2d_2 + a_1b_2c_1d_2 + a_1b_2c_2d_1}{30} \quad (3.52)$$

Projection of Future Fertility level

Having estimated the effect of the PDs on the changes of TFR, the factors to be modified in order to reduce the time of fertility convergence to replacement level were identified.

The Bongaart model was used to project the required contraceptive prevalence rate for fertility level to reach replacement level.

Assumption: the indices of all PDs remain constant except contraception

Therefore:

$$\frac{TFR_2}{TFR_1} = \frac{C_{c2}}{C_{c1}} \text{……….(3.53)}$$

$$TFR_2 = \frac{C_{c2}}{C_{c1}} \times TFR_1 \text{….(3.54)}$$

$$TFR_2 = \frac{(1 - r(a) \times u_2 \times e_2)}{(1 - r(a) \times u_1 \times e_1)} \times TFR_1 \text{….(3.55)}$$

$$u_2 = \frac{1}{r(a) \times e_2} \times \left(1 - \frac{2.1 \times C_{c1}}{TFR_1}\right) \text{……(3.56)}$$

Decomposition of differences in fertility level

Oaxaca Decomposition

We computed the risk difference in high fertility (≥5) between women who were educated and those who were uneducated. A risk difference (RD) greater than 0 (RD > 0) suggests that high fertility was more prevalent among women with no formal education (pro-illiterate inequality). Conversely, a negative risk difference indicates that high fertility was prevalent among educated women (pro-literate inequality). Finally, we used logistic regression method to conduct the Blinder-Oaxaca decomposition analysis [30, 31]. We chose this method because it allows quantification of the gap between the “advantaged” and the “disadvantaged” groups.

Blinder-Oaxaca decomposition assumed that y is explained by a vector of determinants, x, according to logistic regression model. This explains the gap in the means of outcome variable between two groups. The gap is decomposed into that part that is due to group differences in the magnitudes of the determinants of the outcome in one hand, and group differences in the effects of these determinants on the other hand.

This study considered fertility differentials among uneducated-educated, rural-urban, and poor-rich women.

Let y be the outcome variable (CEB which was classified as high fertility if CEB>5; and normal fertility if CEB<5); p and q the two groups (uneducated-educated, rural-urban, and poor-rich women. It is assumed that y is explained by a vector of determinants, x, according to logistic regression model

$$y_i = \begin{cases} \beta^p x_i + \varepsilon_i{}^p \\ \beta^q x_i + \varepsilon_i{}^q \end{cases} \quad \text{.......(3.57)}$$

Where the vectors of β parameters include intercepts.

The gap between the mean outcomes y^q and y^p, is

$$y^q - y^p = \beta^q x^q - \beta^p x^p \quad \text{.....(3.58)}$$

Where x^q and x^p are the explanatory variables at the means for the p and q. In this study the explanatory variables were maternal age, educational level, religion, wealth index, place of residence, age at first marriage, age at first birth, ever used modern contraceptive.

If there are just two x's, x_1 and x_2

It can be written as follows:

$$y^q - y^p = (\beta_0^q - \beta_o^p) + (\beta_1{}^q x_1{}^q - \beta_1{}^p x_1{}^p) + (\beta_2{}^q x_2{}^q - \beta_2{}^p x_2{}^p) = G_0 + G_1 + G_2 \quad \text{....(3.59)}$$

The gap in y between p and q can be said to be

(i) differences in the intercepts (G_0)

(ii) differences in x_1 and β_1 (G_1)

(iii) differences in x_2 and β_2 (G_2)

To estimate the overall gap or the gap specific to any one of the x's is attributable to differences in the x's

The gap between the two outcomes were expressed as:

$$y^q - y^p = \Delta x \beta^p + \Delta \beta x^q = E + (CE + C) \quad \text{.....(3.60)}$$

Or

$$y^q - y^p = \Delta x \beta^q + \Delta \beta x^p = (E + CE) + C \quad \text{.....(3.61)}$$

Where $\Delta x = x^q - x^p$ and $\Delta\beta = \beta^q - \beta^p$

The gap in the mean outcomes was from a gap in endowments (E) {the part that is due to group differences in the magnitudes of the determinants of the outcome}, a gap in coefficient (C) { the part that is due to group differences in the effects of these determinants}, and a gap arising from the interaction of endowments and coefficients (CE).

3.9 ETHICAL CONSIDERATIONS

Proper approval to download and use NDHS data was obtained from ORC Macro International, the agency responsible for Demographic and Health survey globally. The authorization letter to use the data set is attached. The National Health Research Ethics Committee of Nigeria (NHREC) and the ICF institutional Reviewed and approved the survey protocols of each round since 2008. The assigned number for the survey rounds was NHREC/01/01/2007. The same number applied for other survey rounds. At the point of data collection, the data originators sought informed consents from the respondents and they were assured of confidentiality and anonymity of the information they provide. There was no identifier in the raw data that can be used to link a particular respondent to the information she provides.

CHAPTER FOUR

RESULTS

4.0 Introduction

The results of this study were presented in different parts. The first part involves the description of the study participants according to their background information. The assessment of shifts in age patterns of fertility and estimation of refined fertility level were described in the second part, while the result of timing of childbearing trend analyses; and timing of fertility convergence to replacement level were also presented. The chapter also contains the presentation of the rate ratios from multivariate analyses of fertility. Thereafter, the result of decomposition of the changes in fertility level, and differences in fertility were also shown.

4.1 Description of study variables

Table 4.1 shows the Nigeria's mean number of children ever born (CEB) to women aged 15-49 and 40-49 in 2003, 2008, 2013 and 2018 surveys. The variations in mean CEB were presented in the first four columns, and the subsequent three columns show the magnitude of change observed in the inter-survey periods. CEB is a measure of past fertility. In Nigeria, the mean number of CEB to women aged 15-49 was 3.0 in 2003 and upwardly shift to 3.1 in 2008; while mean CEB to women aged 40-49 fell from 6.7 to 6.1 within the 15-years period. Between 2008 and 2018, the mean CEB remain constant in Nigeria. In 2003, North East has highest mean CEB of 3.9 per woman among women aged 15-49, but declined to 3.4 per woman in 2018 with a 5.5 % and 5.6 % decline between 2008-2013 and 2013-2018 respectively. However, the mean CEB to North West women (15-49 years) rose from 3.7 in 2003 to 4.0 in 2008 and later declined marginally to 3.9 in 2018. Between 2008 and 2018, fertility level was highest among North West women. Women of the South West region have consistently had the lowest fertility levels across all the survey years, though fertility was stalled between 2003 and 2013 in the region. In North Central, fertility decline was observed between 2003 and 2013, but stalled between 2013 and 2018. Between 2003 and 2018, while the mean CEB to women age 15-49 only decreased from 2.5 to 2.4 in South South, it increased from 2.4 to 2.5 in South East. Across the six geopolitical zones fertility decline was observed among women aged 40-49.

Table 4.1: Mean number of children ever born (CEB) to women aged 15-49 and 40-49 in Nigeria and across the region and percentage change in the year periods

	2003 (μ±σ)	2008 (μ±σ)	2013 (μ±σ)	2018 (μ±σ)	% Change (2003-2008)	% Change (2008-2013)	% Change (2013-2018)
Mean number of children ever born (CEB) to women aged 15-49 in Nigeria and across the region							
Nigeria	3.0±3.2	3.1±3.1	3.1±3.0	3.1±3.0	3.8	0.0	0.0
North Central	3.0±3.1	2.9±2.9	2.6±2.6	2.7±2.7	-2.1	-11.8	7.9
North East	3.9±3.4	3.9±3.3	3.7±3.3	3.4±3.2	-0.6	-5.5	-5.6
North West	3.7±3.3	4.0±3.3	4.0±3.4	3.9±3.5	9.1	-0.3	-1.6
South East	2.4±3.1	2.5±3.0	2.5±2.9	2.5±2.6	7.3	-0.8	0.5
South South	2.5±3.1	2.5±2.8	2.4±2.7	2.4±2.5	0.0	-1.7	-0.2
South West	2.0±2.4	2.3±2.4	2.4±2.4	2.3±2.2	13.6	5.4	-3.5
Mean number of children ever born (CEB) to women aged 40-49 in Nigeria and across the region							
Nigeria	6.7±3.1	6.6±3.0	6.3±3.0	6.1±3.0	-0.9	-4.7	-4.2
North Central	7.0±2.8	6.4±2.7	5.6±2.4	5.7±2.5	-8.8	-11.8	2.0
North East	7.5±3.5	7.4±3.3	7.3±3.3	7.2±3.1	-0.5	-2.3	-1.0
North West	6.8±3.6	7.7±3.2	7.8±3.1	8.3±3.0	12.9	1.7	6.3
South East	6.3±2.8	6.1±2.8	5.6±3.0	4.7±2.6	-4.4	-7.6	-15.7
South South	6.8±2.7	6.3±2.8	5.7±2.6	4.7±2.6	-7.9	-9.2	-16.4
South West	5.4±2.3	5.1±2.1	4.9±2.1	4.6±2.0	-7.1	-3.0	-7.3

Table 4:2 shows total fertility rates of the Nigerian women according to background characteristics (2003-20018). TFR of Women who had no education declined between 2008 (7.3) and 2018 (6.7), while fertility level increased amongst women with higher education during the same period. Decline in fertility level was observed among women living in the rural areas just as it was in urban areas between 2008 and 2018. The pattern of decline was similar across women characteristics

Table 4.2: Trend in Total Fertility Rates by Women Characteristics, Nigeria 2003-2018

	2003 TFR	2008 TFR	2013 TFR	2018 TFR
Education				
None	6.7	7.3	6.9	6.7
Primary	6.3	6.5	6.1	5.8
Secondary	4.7	4.7	4.6	4.4
Higher	2.8	2.9	3.1	3.4
Type of Residence				
Rural	6.1	6.3	6.1	5.9
Urban	4.9	4.7	4.6	4.5
Religion				
Christian	4.5	4.7	4.5	4.2
Islam	6.7	6.9	6.5	6.2
Others	6.9	6.4	6.3	5.4
Wealth Index				
Poor	6.4	7.1	6.8	6.4
Middle	5.7	5.9	5.7	5.6
Rich	5	4.5	4.4	4.2
Modern Contraception				
No	5.7	5.8	5.7	5.3
Yes	5.6	5.1	4.2	5.3
Age at first Marriage				
<20 years	6.8	7	6.7	6.6
20 year and	6	5.9	5.7	5.4

Table 4:3 shows percentage distribution of the women according to background characteristics across the survey rounds (2003-20018) in Nigeria. Women who had no education contributed the highest proportion of the women in 2003 (41.6%), 2008 (35.8%) and 2013 (37.8%). However, the percentage of women with secondary education was highest in 2018 (39.7%). The percentage of women was higher in the rural areas than the urban areas in all the time periods; although, those that were resident in Urban area increased from 34.5% in 2003 to 45.8% in 2018. The percentage of those who are poor remain unchanged between 2003 and 2013; but marginally decline to 36.5% in 2018 from about 37.4%. Furthermore, modern contraceptive prevalence rate upwardly changed between 2003 and 2013 from 8.8 to 11.2; but decline to 10.51 in 2018. Likewise, the percentage of women had their first marriage and first birth at age 20 years and above increased from 21.3% to 34.4% and 33.2% to 43.77% respectively between 2003 and 2018.

Table 4.3: Percentage distribution of respondents according to background characteristics Nigeria 2003, 2008, 2013 & 2018

Background Characteristics	2003 %	2003 No of Women	2008 %	2008 No of Women	2013 %	2013 No of Women	2018 %	2018 No of Women
Education								
None	41.6	3171	35.8	11942	37.8	14729	34.9	14603
Primary	21.4	1628	19.7	6566	17.3	6734	14.4	6039
Secondary	31.1	2370	35.7	11904	35.8	13927	39.7	16583
Higher	5.9	451	8.9	2974	9.1	3558	11.0	4596
Place of Residence								
Urban	34.5	2629	35.8	11934	42.1	16414	45.8	19163
Rural	65.5	4991	64.2	21451	57.9	22534	54.2	22658
Religion								
Christian	48.0	3654	53.6	17907	46.8	18237	46.0	19217
Islam	50.7	3862	44.4	14826	51.7	20149	53.5	22372
Others	1.4	104	2.0	652	1.4	561	0.5	232
Wealth Index								
Poor	37.4	2853	37.2	12428	37.4	14560	36.5	15267
Middle	19.9	1513	19.0	6341	19.2	7486	19.6	8207
Rich	42.7	3254	43.8	14616	43.4	16902	43.9	18347
Modern Contraceptive Use								
No	91.2	6940	89.5	29884	88.9	34606	89.5	37424
Yes	8.8	680	10.5	3501	11.1	4342	10.5	4397
Age at First Marriage								
<20 years	78.7	4484	69.9	17455	71.1	21056	65.6	20515
20 years and above	21.3	1211	30.2	7533	28.9	8566	34.4	10756
Age at First birth								
<20 years	66.7	3510	57.9	13558	59.4	16393	56.2	16840
20 years and above	33.23	1747	42.1	9846	40.6	11222	43.8	13109

Percentage distribution of the women according to background characteristics in the survey rounds (2003-20018) for South West is presented in table 4.4. More than half of the women reported that they have secondary education in 2003 (54.2 %), 2008 (50.9%), 2013 (54.8%), and 2018 (57.1%). Majority of women reported that they live in Urban areas. The proportion of urban residents increased from 73.2 percent in 2003 to 80.96 percent in 2018. The proportion of rich women increased from 77.5% to 81.6% between 2003 and 2013; but decline to 79.1% in 2018. Furthermore, modern contraceptive use among women aged 15-49 increased from19.4% in 2003 to 23.0% in 2013; but decreased to below 19% in 2018. Likewise, the percentage of women had their first marriage and first birth at aged 20 years and above increased from 54.7% to above 65% and 66.3% to 69% respectively between 2003 and 2018.

Table 4.4: Percentage distribution of respondents according to background characteristics South West 2003, 2008, 2013 & 2018

Background Characteristics	2003 %	2003 No of Women	2008 %	2008 No of Women	2013 %	2013 No of Women	2018 %	2018 No of Women
Education								
None	10.8	104	12.0	813	8.4	531	7.9	575
Primary	24.0	230	20.9	1422	19.4	1224	14.6	1060
Secondary	54.2	519	50.9	3456	54.8	3463	57.1	4148
Higher	11.0	106	16.2	1098	17.4	1097	20.4	1483
Place of Residence								
Urban	73.1	701	61.6	4182	76.8	4850	81.0	5883
Rural	26.8	257	38.4	2608	23.2	1465	19.0	1384
Religion								
Christian	63.3	606	64.3	4367	64.0	4040	60.6	4402
Islam	35.7	342	34.6	2345	35.0	2208	39.2	2851
Others	1.0	10	1..1	77	1.1	66	0.2	13
Wealth Index								
Poor	15.2	145	13.0	879	7.3	464	8.7	629
Middle	7.4	71	13.2	897	11.1	698	12.2	888
Rich	77.5	742	73.8	5014	81.6	5153	79.1	5750
Modern Contraceptive Use								
No	80.6	773	80.9	5491	77.0	4861	81.6	5930
Yes	19.4	186	19.1	1298	23.0	1454	18.4	1336
Age at First Marriage								
<20 years	45.3	262	43.8	2003	42.1	1886	34.7	1744
20 years and above	54.7	316	56.2	2568	57.9	2599	65.3	3282
Age at First birth								
<20 years	36.1	199	35.8	1581	34.5	1510	31.0	1566
20 years and above	63.9	352	64.2	2835	65.5	2869	69.0	3490

Table 4.5 shows percentage distribution of the women according to background characteristics in South South 2003, 2008, 2013 & 2018. The proportion of women with secondary education steadily increased between 2003 (52.0%) and 2018 (63.8%). Also, women that were living in urban area increased from 29.1% in 2003 to above 41% in 2018. In all the survey rounds, most of the women practice Christianity as religion. Likewise, the proportion of rich women increased from 53.2% to 66.9% between 2003 and 2018. Furthermore, modern contraceptive prevalence rate upwardly changed between 2003 and 2013 from 14.6 to 19.2; but decline to 15.5 by 2018. The percentage of women had their first marriage and first birth at aged 20 years and above increased from 33.7% to about 56% and 39.3% to 60.2% respectively between 2003 and 2018.

Table 4.5: Percentage distribution of respondents according to background characteristics South South 2003, 2008, 2013 & 2018

Background Characteristics	2003		2008		2013		2018	
	%	No of Women	%	No of Women	%	No of Women	%	No of Women
Education								
None	8.1	108	6.0	331	5.0	249	4.7	225
Primary	30.3	406	25.3	1385	23.2	1144	15.8	765
Secondary	52.0	697	56.5	3090	57.6	2845	63.8	3089
Higher	9.7	130	12.2	667	14.2	704	15.7	761
Place of Residence								
Urban	29.1	390	33.0	1808	38.7	1913	41.7	2017
Rural	70.9	952	67.0	3665	61.3	3029	58.3	2823
Religion								
Christian	97.0	1302	95.6	5231	96.4	4766	96.2	4652
Islam	1.2	16	2.6	143	2.0	100	1.9	94
Others	1.8	24	1.8	99	1.5	76	1.9	94
Wealth Index								
Poor	28.6	383	18.4	1007	8.9	440	11.8	571
Middle	18.2	245	21.4	1169	24.2	1196	22.0	1067
Rich	53.2	714	60.2	3297	66.9	3306	66.2	3202
Modern Contraceptive Use								
No	85.4	1146	82.7	4526	80.8	3994	84.5	4091
Yes	14.6	196	17.3	947	19.2	949	15.5	749
Age at First Marriage								
<20 years	66.4	507	55.5	1843	52.2	1580	44.0	1389
20 years and above	33.6	257	44.5	1479	47.8	1446	56.0	1767
Age at First birth								
<20 years	60.7	481	51.7	1718	50.1	1544	39.8	1291
20 years and above	39.3	312	48.3	1605	49.9	1539	60.2	1955

Table 4.6 shows percentage distribution of the women according to background characteristics in South East 2003, 2008, 2013 & 2018. The data indicates that percentage of women with secondary education increased from 55.5% in 2003 to 61.8% in 2018. Majority (59.6 %) of the women were rural dwellers in 2003, but by 2018, more than 72 % of the women reported that they are living urban area. Most of the women in the region were Christians. The proportion of rich women dropped 66.6% to 58.6% between 2003 and 2013; but by 2018, it increased to 61.8%. Furthermore, the proportion of women currently using modern contraceptive prevalence rate upwardly changed from 11.1% in 2003 to 14.4% in 2013. However, the uptake of modern contraceptive declined to 10.6% in 2018. Likewise, between 2003 and 2018 the percentage of women who had their first marriage and first birth at aged 20 years and above increased from 50.4% to 64.8% and 56.3% to 69.0% respectively.

Table 4.6: Percentage distribution of respondents according to background characteristics South East 2003, 2008, 2013 & 2018

Background Characteristics	2003		2008		2013		2018	
	%	No of Women	%	No of Women	%	No of Women	%	No of Women
Education								
None	7.7	57	6.3	256	5.2	235	4.2	211
Primary	24.8	182	23.4	958	21.0	940	18.5	919
Secondary	55.5	409	57.3	2345	59.6	2668	61.8	3067
Higher	12.1	89	13.0	532	14.2	634	15.4	766
Place of Residence								
Urban	40.4	298	44.0	1801	70.3	3149	72.9	3618
Rural	59.6	439	56.0	2290	29.7	1327	27.1	1345
Religion								
Christian	97.2	716	96.8	3961	98.1	4391	99.2	4926
Islam	0.4	3	0.3	11	0.3	14	0.2	7
Others	2.4	18	2.9	119	1.6	71	0.6	30
Wealth Index								
Poor	17.5	129	13.8	563	16.5	739	14.8	735
Middle	15.9	117	26.1	1069	24.9	1114	23.4	1661
Rich	66.6	491	60.1	2460	58.6	2623	61.8	3067
Modern Contraceptive Use								
No	88.9	655	89.6	3667	85.6	3833	89.4	4438
Yes	11.1	81	10.4	424	14.4	643	10.6	525
Age at First Marriage								
<20 years	49.6	196	42.9	1032	43.9	1165	35.2	1158
20 years and above	50.4	200	57.1	1373	56.1	1486	64.8	2130
Age at First birth								
<20 years	43.7	159	37.4	863	39.7	1024	31.0	999
20 years and above	56.3	205	62.6	1443	60.3	1554	69.0	2223

Table 4.7 shows percentage distribution of the women according to background characteristics in North West 2003, 2008, 2013 & 2018. Majority of the women had no education in 2003 (75.1%), 2008 (74.2%), 2013 (69.4 %) and 2018 (63.8 %). Likewise, majority of the women were rural dwellers in all they survey rounds 2003 (72.2%), 2008 (79.6%), 2013 (71.3%), and 2018 (69.3%). The religion of most of the women was Islam. Proportion of women who were rich declined from 28.3% to 20.9% between 2003 and 2013; thereafter, upwardly change to about 22% in 2018. Furthermore, modern contraceptive prevalence rate upwardly changed between 2003 and 2018 from 3.3 to 5.3; indicating gain of 2% in 15 years. In all the year periods, most of the women married before age 20 years (93.7% in 2003, 91.7% in 2008, 91.2% in 2013 and 88.3% in 2018). In the same vein, majority of the women had their first birth before age 20years (79.0% in 2003, 74.2% in 2008, 76.1% in 2013 and 76.4% in 2018).

Table 4.7: Percentage distribution of respondents according to background characteristics North West 2003, 2008, 2013 & 2018

Background Characteristics	2003 %	2003 No of Women	2008 %	2008 No of Women	2013 %	2013 No of Women	2018 %	2018 No of Women
Education								
None	75.1	1572	74.2	5953	69.4	8240	63.8	7796
Primary	11.8	248	11.8	948	11.6	1382	11.2	1369
Secondary	10.9	229	11.4	916	16.5	1956	95.5	2515
Higher	2.2	46	2.6	205	2.5	299	4.5	545
Place of Residence								
Urban	27.8	583	20.4	1638	28.7	3402	30.7	3755
Rural	72.2	1512	79.6	6384	71.3	8474	69.3	8470
Religion								
Christian	4.8	101	7.7	618	9.5	1132	7.0	851
Islam	94.8	1986	90.2	7238	89.3	10605	92.4	11302
Others	0.4	8	2.1	166	1.2	139	0.6	72
Wealth Index								
Poor	47.2	988	62.7	5031	63.4	7524	58.5	7145
Middle	24.5	514	17.0	1362	15.7	1867	18.7	2287
Rich	28.3	592	20.3	1629	20.9	2486	22.8	2792
Modern Contraceptive Use								
No	96.7	2025	97.5	7824	95.9	11390	94.7	11573
Yes	3.3	70	2.5	197	4.1	486	5.3	651
Age at First Marriage								
<20 years	93.7	1827	91.6	6778	91.2	9487	88.3	9001
20 years and above	6.3	123	8.4	619	8.8	914	11.7	1199
Age at First birth								
<20 years	79.0	1340	74.2	4902	76.1	7114	76.4	7157
20 years and above	21.0	355	25.8	1709	23.9	2236	23.6	2208

Table 4.8 shows percentage distribution of the women according to background characteristics in North East 2003, 2008, 2013 & 2018. Majority of the women had no education in 2003 (67.8%), 2008 (68.1%), 2013 (64.1%) and 2018 (56.1%). Likewise, majority of the women were rural dwellers in all they survey rounds 2003 (72.5%), 2008 (73.7%), 2013 (72.6%), and 2018 (71.3%). Also, majority of the women were poor (58.4% in 2003, 69.5% in 2008, 64.4% in 2013 and 60.5%). Furthermore, most of the women did not use modern contraceptive in 2003 (97.1%), 2008 (96.5%), 2013 (97.3%) and 2018 (93.1%). In all the year periods, most of the women married before age 20 years (91.0% in 2003, 88.2% in 2008, 84.7% in 2013 and 83.5% in 2018). In the same vein, majority of the women had their first birth before age 20years (78.8% in 2003, 73.6% in 2008, 70.4% in 2013 and 72.2% in 2018).

Table 4.8: Percentage distribution of respondents according to background characteristics North East 2003, 2008, 2013 & 2018

Background Characteristics	2003		2008		2013		2018	
	%	No of Women	%	No of Women	%	No of Women	%	No of Women
Education								
None	67.8	927	68.1	2902	64.1	3711	56.1	3924
Primary	16.5	226	15.5	659	13.7	791	12.7	843
Secondary	13.3	182	14.3	609	17.0	980	21.9	1455
Higher	2.4	33	2.2	93	4.9	284	6.2	414
Place of Residence								
Urban	27.5	376	26.3	1120	27.4	1579	28.7	1902
Rural	72.5	991	73.7	3143	72.6	4187	71.3	4734
Religion								
Christian	15.9	218	20.9	893	16.0	925	18.4	1223
Islam	82.4	1126	77.4	3300	83.0	4788	81.6	5413
Others	1.7	23	1.6	70	1.0	54	0.01	0.62
Wealth Index								
Poor	58.4	799	69.5	2961	64.4	3715	60.5	4012
Middle	19.2	263	16.1	687	15.4	886	19.5	1294
Rich	22.4	306	14.4	614	20.2	1165	20.0	1330
Modern Contraceptive Use								
No	97.1	1328	96.5	4114	97.3	5610	93.1	6176
Yes	2.9	39	3.5	148	2.7	156	6.9	461
Age at First Marriage								
<20 years	91.0	1090	88.2	3292	84.7	4171	83.5	4341
20 years and above	9.0	108	11.8	441	15.3	755	16.5	858
Age at First birth								
<20 years	78.8	857	73.6	2514	70.4	3088	72.2	3531
20 years and above	21.2	230	26.4	901	29.6	1299	27.8	1360

Table 4.9 shows percentage distribution of the women according to background characteristics in North Central 2003, 2008, 2013 & 2018. The data indicates that percentage of women with secondary education increased from 29.9% in 2003 to 31.8% in 2018. Majority of the women were rural dwellers in 2003 (74.9%), 2008 (70.8%), 2013 (72.7%) and 2018 (66.2%). Majority of the women in the region were Christians. The proportion of rich women marginally increased from 36.4% to 38.9% between 2003 and 2013; but by 2018, it dropped to 37.5%. Furthermore, the proportion of women currently using modern contraceptive prevalence rate upwardly changed from 9.6% in 2003 to 11.7% in 2013. However, the uptake of modern contraceptive declined to 11.5% in 2018. Likewise, between 2003 and 2018 the percentage of women who had their first marriage and first birth before age 20 years and above decreased from 74.4% to 65.5% and 61.9% to 55.1% respectively.

Table 4.9: Percentage distribution of respondents according to background characteristics North Central 2003, 2008, 2013 & 2018

Background Characteristics	2003		2008		2013		2018	
	%	No of Women	%	No of Women	%	No of Women	%	No of Women
Education								
None	35.9	403	35.5	1686	31.6	1763	31.8	1871
Primary	30.0	336	25.2	1194	22.5	1253	18.4	1083
Secondary	29.9	335	31.3	1488	36.2	2016	39.2	2309
Higher	4.2	47	8.0	379	9.7	540	10.6	628
Place of Residence								
Urban	25.1	281	29.2	1386	27.3	1521	33.8	1988
Rural	74.9	840	70.8	3361	72.7	4051	66.2	3903
Religion								
Christian	63.4	711	59.8	2838	53.5	2982	53.7	3163
Islam	34.7	389	37.7	1789	43.7	2434	45.9	2705
Others	1.9	21	2.5	121	2.8	156	0.4	23
Wealth Index								
Poor	36.4	408	41.9	1987	30.1	1678	36.9	2176
Middle	27.2	304	24.4	1157	31.0	1726	25.6	1510
Rich	36.4	408	33.7	1603	38.9	2168	37.5	2205
Modern Contraceptive Use								
No	90.4	1013	89.8	4261	88.3	4918	88.5	5216
Yes	9.6	108	10.2	487	11.7	654	11.5	675
Age at First Marriage								
<20 years	74.4	601	70.4	2507	67.0	2768	65.5	2882
20 years and above	25.6	206	29.6	1053	33.0	1366	34.5	1521
Age at First birth								
<20 years	61.9	474	59.4	1980	55.1	2114	55.1	2295
20 years and above	38.1	292	40.6	1353	44.9	1726	44.9	1872

4.2 Assessment of shifts in Age Patterns of Fertility and Estimation of Refined Fertility Levels

The results of the application of the relational Gompertz model to current births and children ever born reported in DHS 2003-2018 for Nigeria are shown in table 4.9. The CEB is a measure of lifetime fertility. According to the Table, panel-1 indicates the cumulated current births to age 50 years was 5.5 children per woman and the average parities (Lifetime fertility) of age 50 years was 6.5 children per woman in 2018. The cumulated recent births should be equivalent to the lifetime fertility. However, the cumulated current births to age 50 years (5.5) was smaller than reported average parities (6.5) which indicate that the recent births reported in 2018 were not completed.

Panel-2 shows that in 2013, the cumulated current births to age 50 years is 5.7 and the average parities of aged 50 years are 6.8. Since, cumulated current births to age 50 years (5.7) is less than lifetime fertility (6.8) in panel-2, this suggests recent births in 2013 were underreported as well. The pattern is the same in panel-3 and panel-4. Panel-3 shows 2008 data, the cumulated current births to aged 50 years was 5.8 and the average parities of aged 50 years was 7.0. Panel-4 shows 2003 data, the cumulated current births to aged 50 years was 5.8 and the average parities of aged 50 years was 7.0. Furthermore, at face value the reports indicate that current fertility declined from 5.8 in 2003 to 5.5 in 2018; and lifetime fertility dropped from 7.0 children per woman in 2003 to 6.5 children per woman in Nigeria.

Table 4.10: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for Nigeria 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
2018													
15(0)	0.1036				-2.3278	0.9688		0.1764			-2.6738	1.0289	
20(1)	0.2445	0.5181	0.2976	-0.192	-1.3753	1.3539	-1.5462	1.2527	0.1407	-0.673	-1.7469	1.2846	-1.9578
25(2)	0.2571	1.7409	0.5753	0.5926	-0.676	1.4127	-0.8201	2.6470	0.4733	0.2902	-1.0159	1.424	-1.1338
30(3)	0.2287	3.0262	0.7257	1.1377	0.0393	1.275	-0.1373	3.8888	0.6807	0.9553	-0.3349	1.3717	-0.4163
35(4)	0.1636	4.1699	0.8360	1.7197	0.945	0.9157	0.8040	4.8729	0.7981	1.4891	0.4406	1.1404	0.3487
40(5)	0.0745	4.9879	0.9305	2.6312	2.3489	0.3966	2.2346	5.8572	0.8319	1.6929	1.5162	0.7022	0.9907
45(6)	0.0298	5.3603	0.9729	3.5953	4.8086	0.0012	3.5941	6.3573	0.9213	2.5018	3.2238	0.2705	2.2313
50		5.5094											
2013													
15(0)	0.1082				-2.3278	0.9688		0.2112			-2.6738	1.0289	
20(1)	0.2359	0.5410	0.3144	-0.1457	-1.3753	1.3539	-1.4996	1.2101	0.1745	-0.557	-1.7469	1.2846	-1.8419
25(2)	0.2610	1.7205	0.5687	0.5718	-0.6748	1.4127	-0.8409	2.5966	0.4660	0.2699	-1.0159	1.4240	-1.1541
30(3)	0.2557	3.0255	0.7029	1.0428	0.0393	1.275	-0.2322	3.9587	0.6559	0.8634	-0.3349	1.3717	-0.5083
35(4)	0.1735	4.3040	0.8323	1.6950	0.945	0.9157	0.7793	5.2526	0.7537	1.2630	0.4406	1.1404	0.1226
40(5)	0.0822	5.1714	0.9264	2.5707	2.3489	0.3966	2.1741	5.9003	0.8902	2.1517	1.5162	0.7022	1.4495
45(6)	0.0304	5.5824	0.9735	3.6183	4.8086	0.0012	3.6171	6.7522	0.8738	2.0035	3.2238	0.2705	1.7330
50		5.7342											

Table 4.10 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.1384				-2.3278	0.9688		0.2484			-2.6738	1.0289	
20(1)	0.2309	0.6918	0.3747	0.0186	-1.3753	1.3539	-1.3353	1.2453	0.1994	-0.4776	-1.7469	1.2846	-1.7622
25(2)	0.2656	1.8462	0.5816	0.6125	-0.6748	1.4127	-0.8002	2.6194	0.4754	0.2963	-1.0159	1.4240	-1.1277
30(3)	0.2398	3.1744	0.7258	1.1381	0.0393	1.2750	-0.1369	4.0759	0.6426	0.8161	-0.3349	1.3717	-0.5556
35(4)	0.1589	4.3735	0.8462	1.7901	0.9450	0.9157	0.8744	5.4115	0.7532	1.2608	0.4406	1.1404	0.1204
40(5)	0.0844	5.1681	0.9245	2.5451	2.3489	0.3966	2.1485	6.3017	0.8587	1.8820	1.5162	0.7022	1.1798
45(6)	0.0430	5.5899	0.9629	3.2762	4.8086	0.0012	3.2750	6.9873	0.9019	2.2704	3.2238	0.2705	1.9999
50		5.8051											
							2003						
15(0)	0.1462				-2.3278	0.9688		0.2264			-2.6738	1.0289	
20(1)	0.2381	0.7312	0.3805	0.0344	-1.3753	1.3539	-1.3195	1.0977	0.2063	-0.4565	-1.7469	1.2846	-1.7411
25(2)	0.2726	1.9216	0.5850	0.6235	-0.6748	1.4127	-0.7892	2.6976	0.4069	0.1063	-1.0159	1.4240	-1.3177
30(3)	0.2511	3.2845	0.7235	1.1280	0.0393	1.2750	-0.1470	4.2394	0.6363	0.7940	-0.3349	1.3717	-0.5777
35(4)	0.1618	4.5399	0.8488	1.8080	0.9450	0.9157	0.8923	5.7682	0.7350	1.1778	0.4406	1.1404	0.0374
40(5)	0.0787	5.3489	0.9315	2.6453	2.3489	0.3966	2.2487	6.4345	0.8964	2.2134	1.5162	0.7022	1.5112
45(6)	0.0163	5.7424	0.9860	4.2597	4.8086	0.0012	4.2585	6.9854	0.9211	2.4992	3.2238	0.2705	2.2287
50		5.8241											

Figure 1 depicts fitting the relational Gompertz model to current births (F-points) and average parities (P-points) in Nigeria. In 2018, it seems F and P points were more dispersed at the oldest ages compared to other year periods. This suggests that the quality of data was poorer at older ages in 2018 compared to survey rounds. However, some of the F-points lie above the P-points signifying a declining trend of fertility in Nigeria. For 2013, the F-points and P-points show greater convergence on a straight line than other years, which suggests the data is more reliable compared to other years. A visual inspection suggests similarity in 2003 and 2008 data. The points appear inconsistence in 2003 and 2008 surveys which suggest age exaggeration and underreported current births at younger ages. Also, he upward curve of the P points at the oldest age groups in 2003 and 2008 indicates underreporting of lifetime fertility at these ages.

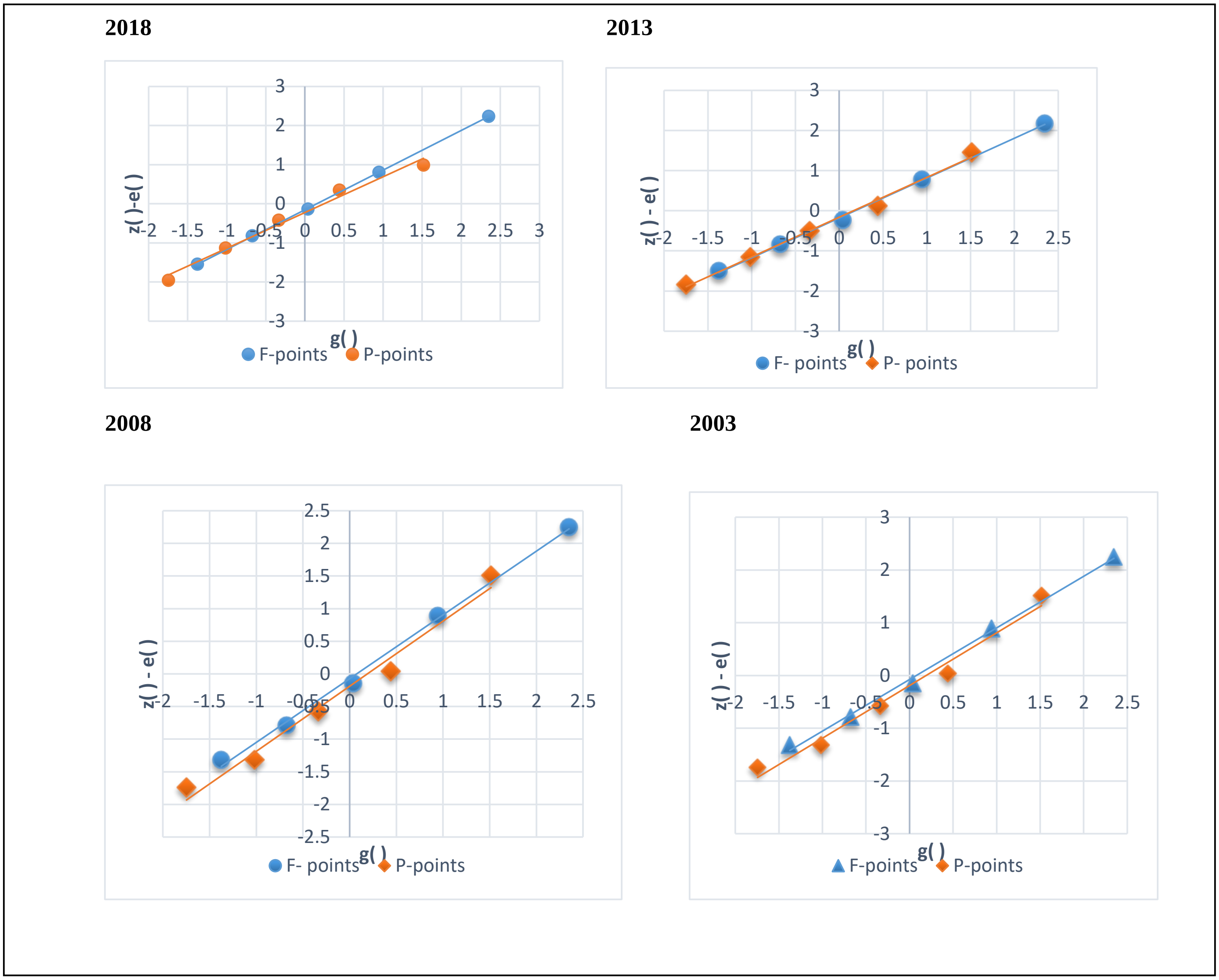


Figure 4.1: Lines fitted to the P-points and F-points, Nigeria

Tables 4.11 shows estimated implied fertility level, estimated age specific fertility rates and estimated TFR in Nigeria. Average parity is considered to be more accurate at younger than at older ages, because older women are more likely to have recall and omissions bias. While, current fertility from survey could be too low to use and sometime it is grossly inflated. In line of these errors as discussed above, estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the table, average implied fertility level was 5.7 and estimated TFR is 5.6 for 2008. In 2013, 2008, and 2003 the average implied fertility levels are 6, 6.2 and 6.2 respectively. Likewise, the estimated TFR in the year periods are 2018(5.6), 2013(5.9), 2008 (6.1) and 2003(6.1). The adjusted TFRs in the survey rounds indicate that fertility levels were underestimated in NDHS reports. However, fertility trends appear consistent in both adjusted TFRs and estimates from NDHS reports. Also, the adjusted TFRs demonstrate that fertility level has changed from 6.1 in 2003 to 5.6 in 2018.

Table 4.11: Estimated implied fertility level Estimated ASFRs and total fertility rates Nigeria

Age (x) (i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-1.8918	0.0013	0.0074	0.0015
20(1)	-1.0833	-1.2049	0.0356	0.1764	4.9584	-0.6913	-0.8145	0.1046	0.5855	0.1198
25(2)	-0.3124	-0.4372	0.2126	1.2528	5.8926	0.0256	-0.1006	0.3309	1.8532	0.2626
30(3)	0.3541	0.2265	0.4505	2.6470	5.8752	0.7000	0.5710	0.5684	3.1829	0.2754
35(4)	1.0579	0.9274	0.6733	3.8888	5.7759	1.4787	1.3464	0.7709	4.3171	0.2350
40(5)	1.9561	1.8218	0.8507	4.8729	5.7283	2.6260	2.4889	0.9203	5.1539	0.1733
45(6)						4.8097	4.6634	0.9906	5.5474	0.0815
	Ave. Implied Fertility Level = 5.7						Estimated TFR = 5.6			
					2013					
15(0)						-1.7731	-1.9255	0.0011	0.0063	0.0013
20(1)	-1.0833	-1.2422	0.0313	0.2112	6.7401	-0.6913	-0.8539	0.0955	0.5729	0.1133
25(2)	-0.3124	-0.4786	0.1991	1.2101	6.0775	0.0256	-0.1438	0.3152	1.8909	0.2636
30(3)	0.3541	0.1815	0.4343	2.5966	5.9786	0.7000	0.5242	0.5532	3.3191	0.2856
35(4)	1.0579	0.8787	0.6601	3.9587	5.9969	1.4787	1.2955	0.7605	4.5630	0.2488
40(5)	1.9561	1.7683	0.8431	5.2526	6.2298	2.6260	2.4319	0.9159	5.4953	0.1864
45(6)						4.8097	4.5948	0.9899	5.9397	0.0889
	Ave. Implied Fertility Level = 6.0						Estimated TFR = 5.9			

Table 4.11 Continue

Age (x) (i)	Ys(i)	Y(i)	Anti gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-1.8302	0.0020	0.0121	0.0024
20(1)	-1.0833	-1.1752	0.0392	0.2484	6.3342	-0.6913	-0.8030	0.1073	0.6653	0.1306
25(2)	-0.3124	-0.4432	0.2106	1.2453	5.9120	0.0256	-0.1222	0.3230	2.0029	0.2675
30(3)	0.3541	0.1898	0.4373	2.6194	5.9901	0.7000	0.5182	0.5512	3.4177	0.2830
35(4)	1.0579	0.8581	0.6544	4.0759	6.2281	1.4787	1.2577	0.7525	4.6657	0.2496
40(5)	1.9561	1.7110	0.8347	5.4115	6.4832	2.6260	2.3471	0.9088	5.6345	0.1938
45(6)						4.8097	4.4208	0.9880	6.1259	0.0983
Ave. Implied Fertility Level = 6.2					Estimated TFR = 6.1					
					2003					
15(0)						-1.7731	-1.8983	0.0013	0.0078	0.0016
20(1)	-1.0833	-1.2121	0.0347	0.2264	6.5211	-0.6913	-0.8221	0.1028	0.6372	0.1259
25(2)	-0.3124	-0.4452	0.2100	1.0977	5.2276	0.0256	-0.1089	0.3279	2.0329	0.2791
30(3)	0.3541	0.2179	0.4474	2.6976	6.0292	0.7000	0.5620	0.5655	3.5059	0.2946
35(4)	1.0579	0.9180	0.6708	4.2394	6.3201	1.4787	1.3366	0.7689	4.7675	0.2523
40(5)	1.9561	1.8115	0.8492	5.7682	6.7921	2.6260	2.4779	0.9195	5.7010	0.1867
45(6)						4.8097	4.6503	0.9905	6.1410	0.0880

The results of the application of the relational Gompertz model to current births and children ever born reported in NDHS 2003-2018 for South West are shown in table 4.12. Panel-1 indicates the cumulated current births to aged 50 years was about 4.0 and the average parities of aged 50 years was 4.6 in 2018. This show that the different between lifetime fertility (4.6) and current fertility is 0.6 in 2018. This suggests that current fertility level was underreported in 2018. Likewise, the 2013 data as shown in Panel-2 indicate that the current fertility (4.5) was 0.6 less than lifetime fertility (5.1), which point to underestimation of fertility level in 2013. Panel-3 shows 2008 results, the lifetime fertility (5.5) was greater than current fertility (4.5) by 1.0. Like other years, the 2008 data underreported fertility level. The panel 4 which show 2003 data revealed a greater underreporting of current births compared to other year period in this study. The cumulated current births to aged 50 years was 4.1 and the average parities of aged 50 years was 5.8 in 2003.

Table 4.12: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for South West 2018, 2013, 2008, 2003 and the standard schedule

2018

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
15(0)	0.0365				-2.3278	0.9688		0.0428			-2.6738	1.0289	
20(1)	0.1710	0.1826	0.1760	-0.5523	-1.3753	1.3539	-1.9062	0.6646	0.0644	-1.0090	-1.7469	1.2846	-2.2936
25(2)	0.1941	1.0376	0.5167	0.4150	-0.6748	1.4127	-0.9977	1.6677	0.3985	0.0834	-1.0159	1.4240	-1.3406
30(3)	0.1931	2.0083	0.6753	0.9349	0.0393	1.2750	-0.3401	2.5728	0.6482	0.8357	-0.3349	1.3717	-0.5360
35(4)	0.1282	2.9739	0.8227	1.6336	0.9450	0.9157	0.7179	3.4060	0.7554	1.2710	0.4406	1.1404	0.1306
40(5)	0.0480	3.6150	0.9378	2.7449	2.3489	0.3966	2.3483	4.2064	0.8097	1.5556	1.5162	0.7022	0.8534
45(6)	0.0279	3.8549	0.9650	3.3353	4.8086	0.0012	3.3341	4.6229	0.9099	2.3600	3.2238	0.2705	2.0895
50		3.9947											
							2013						
15(0)	0.0604				-2.3278	0.9688		0.0732			-2.6738	1.0289	
20(1)	0.1761	0.3018	0.2552	-0.3116	-1.3753	1.3539	-1.6655	0.7244	0.1011	-0.8294	-1.7469	1.2846	-2.1140
25(2)	0.2392	1.1823	0.4972	0.3583	-0.6748	1.4127	-1.0544	1.9355	0.3742	0.0173	-1.0159	1.4240	-1.4067
30(3)	0.2150	2.3780	0.6886	0.9861	0.0393	1.2750	-0.2889	2.9559	0.6548	0.8594	-0.3349	1.3717	-0.5123
35(4)	0.1201	3.4532	0.8519	1.8308	0.9450	0.9157	0.9151	3.9288	0.7524	1.2569	0.4406	1.1404	0.1165
40(5)	0.0735	4.0535	0.9169	2.4442	2.3489	0.3966	2.0476	4.5851	0.8569	1.8677	1.5162	0.7022	1.1655
45(6)	0.0148	4.4211	0.9835	4.0957	4.8086	0.0012	4.0945	5.0650	0.9053	2.3073	3.2238	0.2705	2.0368
50		4.4953											

Table 4.12 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.0612				-2.3278	0.9688		0.0754			-2.6738	1.0289	
20(1)	0.1910	0.3061	0.2428	-0.3476	-1.3753	1.3539	-1.7015	0.6991	0.1079	-0.8006	-1.7469	1.2846	-2.0852
25(2)	0.2484	1.2609	0.5038	0.3775	-0.6748	1.4127	-1.0352	1.7904	0.3905	0.0615	-1.0159	1.4240	-1.3625
30(3)	0.2034	2.5029	0.7110	1.0758	0.0393	1.2750	-0.1992	2.9669	0.6035	0.6830	-0.3349	1.3717	-0.6887
35(4)	0.1453	3.5200	0.8290	1.6735	0.9450	0.9157	0.7578	4.0048	0.7408	1.2040	0.4406	1.1404	0.0636
40(5)	0.0478	4.2463	0.9467	2.9046	2.3489	0.3966	2.5080	4.7146	0.8494	1.8130	1.5162	0.7022	1.1108
45(6)	0.0129	4.4854	0.9858	4.2497	4.8086	0.0012	4.2485	5.5162	0.8547	1.8513	3.2238	0.2705	1.5808
50		4.5499											
							2003						
15(0)	0.0379		15(0)	0.0379		15(0)	0.0379		15(0)	0.0379		15(0)	0.0379
20(1)	0.1466	0.1897	20(1)	0.1466	0.1897	20(1)	0.1466	0.1897	20(1)	0.1466	0.1897	20(1)	0.1466
25(2)	0.2014	0.9226	25(2)	0.2014	0.9226	25(2)	0.2014	0.9226	25(2)	0.2014	0.9226	25(2)	0.2014
30(3)	0.2059	1.9298	30(3)	0.2059	1.9298	30(3)	0.2059	1.9298	30(3)	0.2059	1.9298	30(3)	0.2059
35(4)	0.1367	2.9595	35(4)	0.1367	2.9595	35(4)	0.1367	2.9595	35(4)	0.1367	2.9595	35(4)	0.1367
40(5)	0.0768	3.6430	40(5)	0.0768	3.6430	40(5)	0.0768	3.6430	40(5)	0.0768	3.6430	40(5)	0.0768
45(6)	0.0174	4.0268	45(6)	0.0174	4.0268	45(6)	0.0174	4.0268	45(6)	0.0174	4.0268	45(6)	0.0174
50		4.1136	50		4.1136	50		4.1136	50		4.1136	50	

Figure 2 depicts the fitting of the relational Gompertz model to current births (F-points) and average parities (P-points) in South West. Based on F-points and P-points, it appears that 2018, 2013 and 2008 data were similar. It seems that in the three survey rounds, some of the F-points lie above the P-points which signifying fertility has started falling in south west since 2008. However, inconsistence was observed at younger ages in 2018 and 2008 which indicated age exaggeration and underestimation of current fertility at those ages. In 2013, a greater convergence on a straight line was observed at younger ages. For 2003, the P-points lie above F-points at older ages which suggest some parity were omitted in those ages.

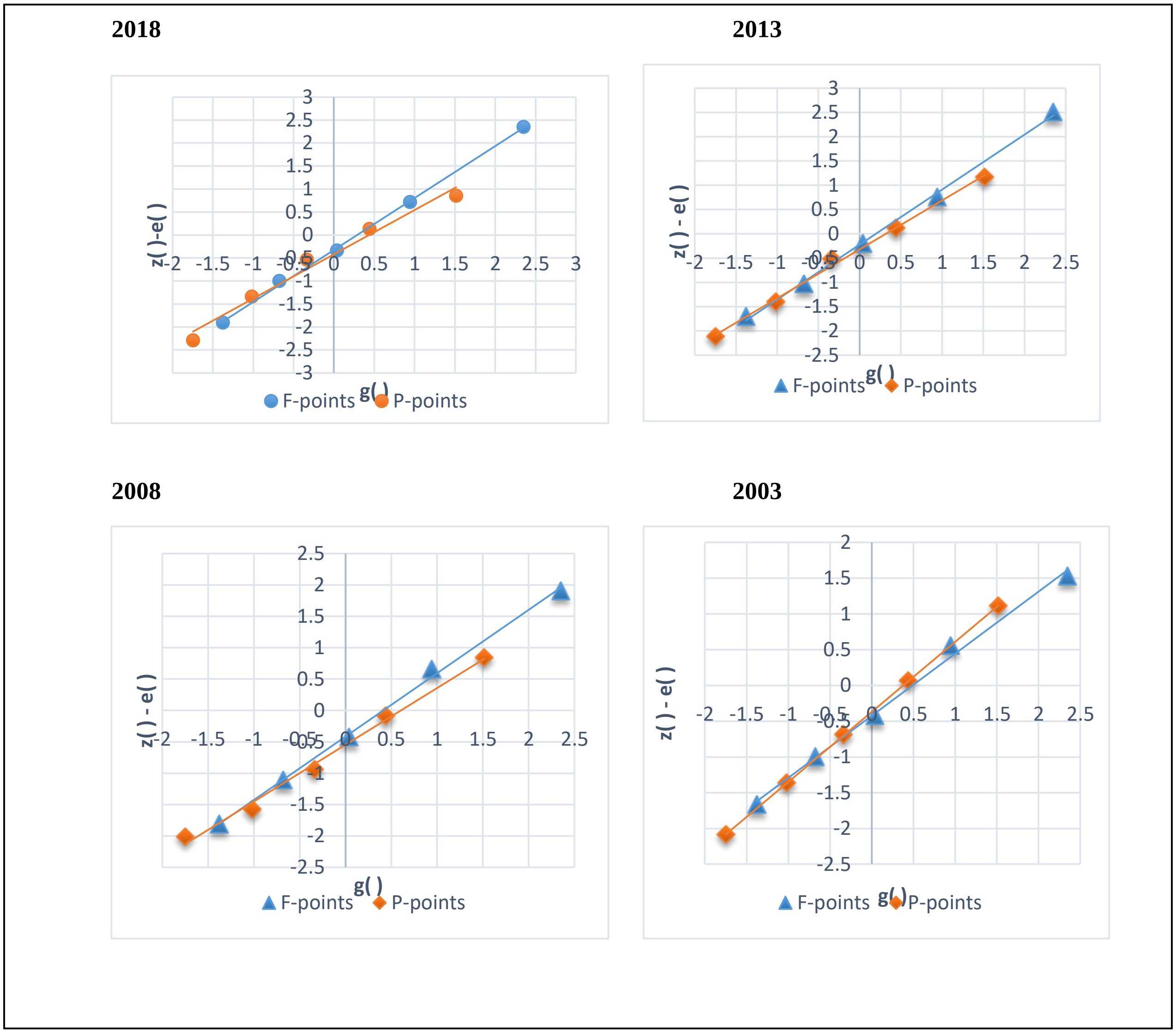


Figure 4.2: Lines fitted to the P-points and F-points, South West

To adjust for errors discussed above, a straight line was fitted to the best points derived from the application of GRM. The Gompertz parameters were used to produce implied fertility levels from average parities. The estimated implied fertility levels were applied as adjustment factor to current data. As presented in table 4.13, the South West average implied fertility level was 4.1 in 2018. In 2013, 2008, and 2003 the average implied fertility levels were 4.6, 4.6 and 5.1 respectively. Likewise, the estimated TFR in the year periods were 4.1(2018), 4.5(2013), 4.6(2008) and 5.0(2003). The adjusted TFRs in the survey rounds indicate that fertility levels were underestimated in NDHS reports. The fertility levels in South West declined from 5.0 in 2003 to 4.1 in 2018.

Table 4.13: Estimated implied fertility level Estimated ASFRs and total fertility rates South West

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-2.2639	0.0001	0.0003	0.0001
20(1)	-1.0833	-1.5026	0.0112	0.0428	3.8275	-0.6913	-1.0700	0.0542	0.2221	0.0444
25(2)	-0.3124	-0.6519	0.1467	0.6646	4.5294	0.0256	-0.2789	0.2667	1.0935	0.1743
30(3)	0.3541	0.0837	0.3986	1.6677	4.1835	0.7000	0.4654	0.5337	2.1883	0.2190
35(4)	1.0579	0.8604	0.6551	2.5728	3.9275	1.4787	1.3248	0.7665	3.1428	0.1909
40(5)	1.9561	1.8517	0.8547	3.4060	3.9849	2.6260	2.5910	0.9278	3.8039	0.1322
45(6)						4.8097	4.6634	0.9906	4.0615	0.0515
A Ave. Implied Fertility Level = 4.1							Estimated TFR = 4.07			
					2013					
15(0)						-1.7731	-1.8983	0.0001	0.0006	0.0001
20(1)	-1.0833	-1.4348	0.0150	0.0732	4.8770	-0.6913	-0.8221	0.0644	0.2963	0.0591
25(2)	-0.3124	-0.5971	0.1625	0.7244	4.4564	0.0256	-0.1089	0.2841	1.3070	0.2021
30(3)	0.3541	0.1272	0.4146	1.9355	4.6690	0.7000	0.5620	0.5463	2.5128	0.2412
35(4)	1.0579	0.8920	0.6638	2.9559	4.4532	1.4787	1.3366	0.7715	3.5489	0.2072
40(5)	1.9561	1.8681	0.8569	3.9288	4.5848	2.6260	2.4779	0.9281	4.2695	0.1441
45(6)						4.8097	4.6503	0.9931	4.5681	0.0597
Ave. Implied Fertility Level = 4.6							Estimated TFR = 4.5			

Table 4.13 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-2.2010	0.0001	0.0006	0.000110
20(1)	-1.0833	-1.4170	0.0162	0.0732	4.5279	-0.6913	-1.1141	0.0475	0.2207	0.0440
25(2)	-0.3124	-0.6121	0.1581	0.7244	4.5808	0.0256	-0.3939	0.2270	1.0547	0.1668
30(3)	0.3541	0.0837	0.3986	1.9355	4.8553	0.7000	0.2837	0.4710	2.1879	0.2266
35(4)	1.0579	0.8185	0.6433	2.9559	4.5946	1.4787	1.0661	0.7087	3.2922	0.2209
40(5)	1.9561	1.7563	0.8414	3.9288	4.6694	2.6260	2.2187	0.8970	4.1669	0.1749
45(6)						4.8097	4.4127	0.9880	4.5896	0.0845
Ave. Implied Fertility Level = 4.64						Estimated TFR = 4.6				
					2003					
15(0)						-1.7731	-2.1985	0.0001	0.0006	0.0001
20(1)	-1.0833	-1.5262	0.0100	0.0596	5.9360	-0.6913	-1.1441	0.0433	0.2186	0.0436
25(2)	-0.3124	-0.7749	0.1141	0.4759	4.1696	0.0256	-0.4455	0.2099	1.0599	0.1683
30(3)	0.3541	-0.1253	0.3219	1.5269	4.7432	0.7000	0.2118	0.4453	2.2485	0.2377
35(4)	1.0579	0.5606	0.5651	2.9200	5.1677	1.4787	0.9707	0.6847	3.4576	0.2418
40(5)	1.9561	1.4360	0.7883	4.1368	5.2478	2.6260	2.0889	0.8835	4.4619	0.2008
45(6)						4.8097	4.2171	0.9854	4.9761	0.1028
Ave. Implied Fertility Level = 5.05						Estimated TFR = 5.0				

The results of the application of the relational Gompertz model to current births and children ever born reported in DHS 2003-2018 for South South are shown in table 4.14. Panel-1 of the table indicates that cumulated current births to aged 50 years (4.1) was about 1.0 less than the average parities of aged 50 years (5.1) in 2018. Likewise, the 2013 data as presented in Panel-2 show that the cumulated current births to aged 50 years (4.4) was about 1.2 less than the average parities of aged 50 years (5.6). The panel-3 shows that the cumulated current births to aged 50 years was 4.5 children per woman and the average parities of aged 50 years was 6.5 per children per woman in 2008. The 2003 data presented in panel 4, show that the average parities of aged 50 years (6.8) was 2.1 greater than the cumulated current births to aged 50 years (4.7). In all the survey rounds, there was evidence of underestimation currents data; however, the magnitude of underestimation of current fertility was highest in 2008 data and followed by 2003 data. The table also show that fertility declined between 2003 and 2018.

Table 4.14: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for South South 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
2018													
15(0)	0.0604				-2.3278	0.9688		0.1058			-2.6738	1.0289	
20(1)	0.1716	0.3021	0.2605	-0.2966	-1.3753	1.3539	-1.6505	0.7871	0.1344	-0.6964	-1.7469	1.2846	-1.9810
25(2)	0.2092	1.1599	0.5258	0.4418	-0.6748	1.4127	-0.9709	1.8533	0.4247	0.1550	-1.0159	1.4240	-1.2690
30(3)	0.2085	2.2061	0.6791	0.9493	0.0393	1.2750	-0.3257	2.6615	0.6963	1.0163	-0.3349	1.3717	-0.3554
35(4)	0.1152	3.2487	0.8494	1.8126	0.9450	0.9157	0.8969	3.6022	0.7388	1.1951	0.4406	1.1404	0.0547
40(5)	0.0406	3.8247	0.9497	2.9632	2.3489	0.3966	2.5666	4.2336	0.8509	1.8232	1.5162	0.7022	1.1210
45(6)	0.0180	4.0274	0.9781	3.8103	4.8086	0.0012	3.8091	5.0698	0.8351	1.7134	3.2238	0.2705	1.4429
50		4.1176											
2013													
15(0)	0.0839				-2.3278	0.9688		0.1258			-2.6738	1.0289	
20(1)	0.1686	0.4193	0.3322	-0.0971	-1.3753	1.3539	-1.4510	0.7638	0.1648	-0.5896	-1.7469	1.2846	-1.8742
25(2)	0.2084	1.2621	0.5478	0.5078	-0.6748	1.4127	-0.9049	1.6107	0.4742	0.2929	-1.0159	1.4240	-1.1311
30(3)	0.1952	2.3039	0.7024	1.0407	0.0393	1.2750	-0.2343	2.9912	0.5385	0.4796	-0.3349	1.3717	-0.8921
35(4)	0.1397	3.2799	0.8244	1.6447	0.9450	0.9157	0.7290	4.2117	0.7102	1.0724	0.4406	1.1404	-0.0680
40(5)	0.0595	3.9784	0.9304	2.6295	2.3489	0.3966	2.2329	5.2523	0.8019	1.5105	1.5162	0.7022	0.8083
45(6)	0.0171	4.2759	0.9804	3.9234	4.8086	0.0012	3.9222	5.5547	0.9456	2.8826	3.2238	0.2705	2.6121
50		4.3613											

Table 4.15: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for South South 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)- e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2018						
15(0)	0.0604				-2.3278	0.9688		0.1058			-2.6738	1.0289	
20(1)	0.1716	0.3021	0.2605	-0.2966	-1.3753	1.3539	-1.6505	0.7871	0.1344	-0.6964	-1.7469	1.2846	-1.9810
25(2)	0.2092	1.1599	0.5258	0.4418	-0.6748	1.4127	-0.9709	1.8533	0.4247	0.1550	-1.0159	1.4240	-1.2690
30(3)	0.2085	2.2061	0.6791	0.9493	0.0393	1.2750	-0.3257	2.6615	0.6963	1.0163	-0.3349	1.3717	-0.3554
35(4)	0.1152	3.2487	0.8494	1.8126	0.9450	0.9157	0.8969	3.6022	0.7388	1.1951	0.4406	1.1404	0.0547
40(5)	0.0406	3.8247	0.9497	2.9632	2.3489	0.3966	2.5666	4.2336	0.8509	1.8232	1.5162	0.7022	1.1210
45(6)	0.0180	4.0274	0.9781	3.8103	4.8086	0.0012	3.8091	5.0698	0.8351	1.7134	3.2238	0.2705	1.4429
50		4.1176											
							2013						
15(0)	0.0839				-2.3278	0.9688		0.1258			-2.6738	1.0289	
20(1)	0.1686	0.4193	0.3322	-0.0971	-1.3753	1.3539	-1.4510	0.7638	0.1648	-0.5896	-1.7469	1.2846	-1.8742
25(2)	0.2084	1.2621	0.5478	0.5078	-0.6748	1.4127	-0.9049	1.6107	0.4742	0.2929	-1.0159	1.4240	-1.1311
30(3)	0.1952	2.3039	0.7024	1.0407	0.0393	1.2750	-0.2343	2.9912	0.5385	0.4796	-0.3349	1.3717	-0.8921
35(4)	0.1397	3.2799	0.8244	1.6447	0.9450	0.9157	0.7290	4.2117	0.7102	1.0724	0.4406	1.1404	-0.0680
40(5)	0.0595	3.9784	0.9304	2.6295	2.3489	0.3966	2.2329	5.2523	0.8019	1.5105	1.5162	0.7022	0.8083
45(6)	0.0171	4.2759	0.9804	3.9234	4.8086	0.0012	3.9222	5.5547	0.9456	2.8826	3.2238	0.2705	2.6121
50		4.3613											

Figure 4.3 depicts the fitting of the relational Gompertz model to current births (F-points) and average parities (P-points) in South South. Based on F-points and P-points, it appears that current fertility was underestimated at younger ages in 2018. However, it was observed that since some of the F-points lie above the P-points which signifying fertility has started falling in south south from 2008. In 2013 and 2008, it looks like the lifetime fertility were underreported in the two surveys; though, it also suggested a decline in fertility. In 2003, inconsistence was observed at younger ages which indicated age exaggeration and underestimation of current fertility at those ages.

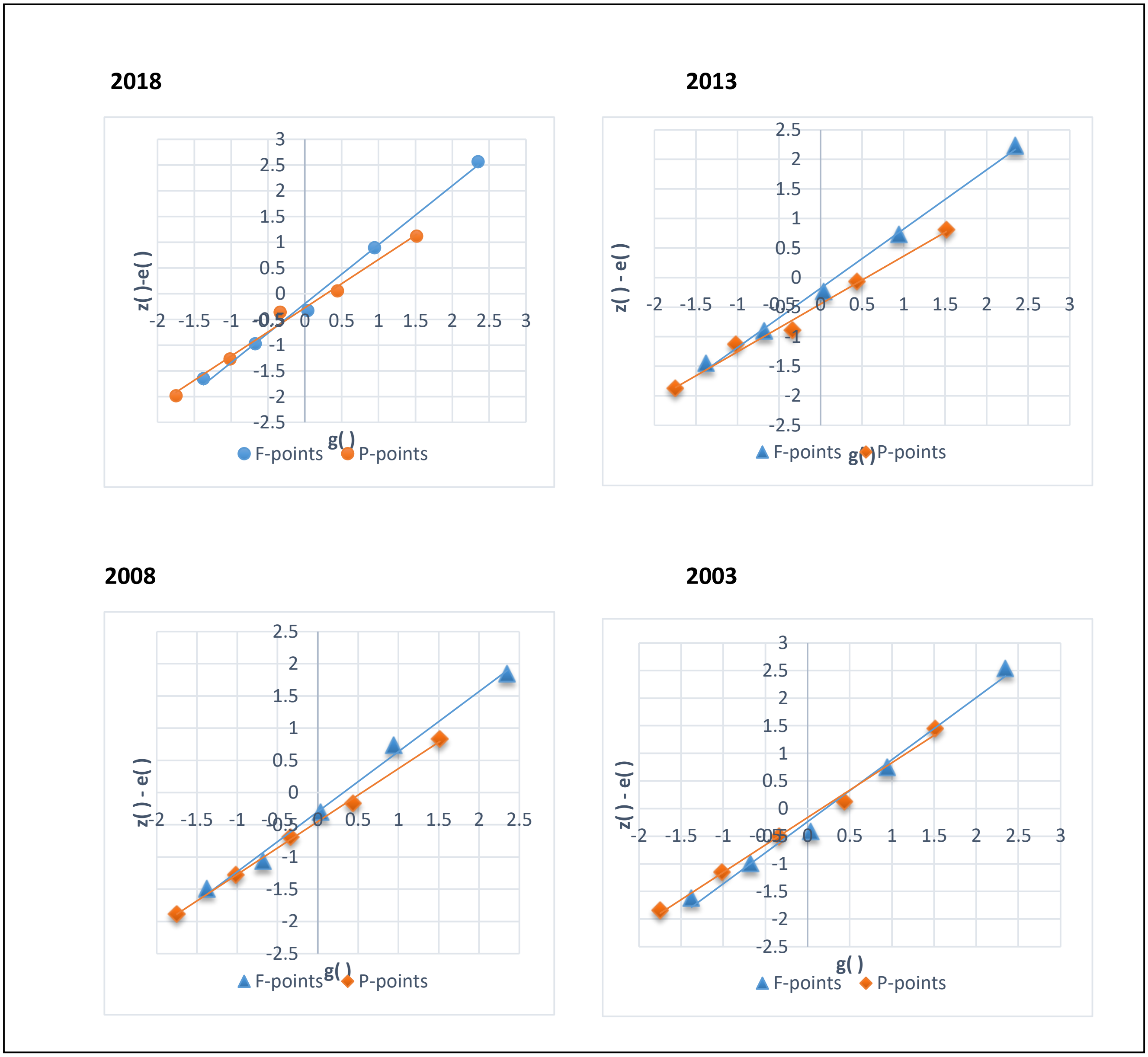


Figure 4.3: Lines fitted to the P-points and F-points, South-South

Tables 4.15 the show estimated implied fertility level, estimated age specific fertility rates and estimated TFR in South South. Estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the table, average implied fertility level was 4.3 and estimated TFR is 4.2 for 2018. In 2013, 2008, and 2003 the average implied fertility levels are 4.8, 5.6 and 5.9 respectively. Likewise, the estimated TFR in the year periods are 2013(4.7), 2008(5.4) and 2003(5.8). The estimated TFR across the survey rounds reveals that South South fertility levels were underreported in NDHS reports. In South South region, fertility level dropped from 5.8 children per woman in 2003 to 4.2 children per woman in 2018 which indicate about 1.6 gain was achieved in 15 years.

Table 4.15: Estimated implied fertility level Estimated ASFRs and total fertility rates South South

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-2.0631	0.0004	0.0016	0.0003
20(1)	-1.0833	-1.3248	0.0233	0.1058	4.5505	-0.6913	-0.9052	0.0844	0.3544	0.0706
25(2)	-0.3124	-0.4997	0.1924	0.7871	4.0907	0.0256	-0.1379	0.3173	1.3327	0.1957
30(3)	0.3541	0.2137	0.4459	1.8533	4.1560	0.7000	0.5839	0.5725	2.4046	0.2144
35(4)	1.0579	0.9670	0.6837	2.6615	3.8927	1.4787	1.4174	0.7848	3.2961	0.1783
40(5)	1.9561	1.9283	0.8647	3.6022	4.1659	2.6260	2.6453	0.9315	3.9122	0.1232
45(6)						4.8097	4.9825	0.9932	4.1713	0.0518
	Ave. Implied Fertility Level = 4.3						Estimated TFR = 4.2			
					2013					
15(0)						-1.7731	-1.9551	0.0009	0.0041	0.0008
20(1)	-1.0833	-1.3080	0.0248	0.1258	5.0846	-0.6913	-0.9403	0.0772	0.3707	0.0733
25(2)	-0.3124	-0.5849	0.1661	0.7638	4.5972	0.0256	-0.2679	0.2706	1.2988	0.1856
30(3)	0.3541	0.0402	0.3827	1.6107	4.2089	0.7000	0.3647	0.4994	2.3970	0.2196
35(4)	1.0579	0.7004	0.6087	2.9912	4.9138	1.4787	1.0951	0.7157	3.4353	0.2077
40(5)	1.9561	1.5429	0.8075	4.2117	5.2155	2.6260	2.1713	0.8922	4.2827	0.1695
45(6)						4.8097	4.2196	0.9854	4.7299	0.0894
	Ave. Implied Fertility Level = 4.8						Estimated TFR = 4.7			

Table 4.15 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-1.9506	0.0009	0.0051	0.0010
20(1)	-1.0833	-1.3321	0.0226	0.1348	5.9606	-0.6913	-0.9806	0.0695	0.4033	0.0796
25(2)	-0.3124	-0.6408	0.1499	0.8379	5.5912	0.0256	-0.3377	0.2462	1.4277	0.2049
30(3)	0.3541	-0.0432	0.3520	1.9924	5.6603	0.7000	0.2670	0.4650	2.6971	0.2539
35(4)	1.0579	0.5879	0.5738	3.3044	5.7589	1.4787	0.9653	0.6833	3.9629	0.2532
40(5)	1.9561	1.3933	0.7802	4.8187	6.1765	2.6260	1.9940	0.8727	5.0618	0.2198
45(6)						4.8097	3.9522	0.9810	5.6896	0.1256
	Ave. Implied Fertility Level = 5.6							Estimated TFR = 5.4		
					2003					
15(0)						-1.7731	-2.0633	0.0004	0.0023	0.0005
20(1)	-1.0833	-1.3320	0.0226	0.2112	9.3321	-0.6913	-0.9164	0.0821	0.5005	0.0996
25(2)	-0.3124	-0.5148	0.1876	1.2101	6.4494	0.0256	-0.1565	0.3106	1.8944	0.2788
30(3)	0.3541	0.1918	0.4380	2.5966	5.9280	0.7000	0.5585	0.5643	3.4425	0.3096
35(4)	1.0579	0.9379	0.6761	3.9587	5.8554	1.4787	1.3840	0.7783	4.7479	0.2611
40(5)	1.9561	1.8901	0.8598	5.2526	6.1091	2.6260	2.6002	0.9284	5.6634	0.1831
45(6)						4.8097	4.9152	0.9927	6.0554	0.0784
Ave. Implied Fertility Level = 5.9						Estimated TFR = 5.8				

The results of the application of the relational Gompertz model to current births and children ever born reported in NDHS 2003-2018 for South East are shown in table 4.15. The cumulated current births to aged 50 years (4.7) and the average parities of aged 50 years (4.9) in 2018 were presented in panel-1. The 2018 data show that lifetime fertility was 0.2 greater than current fertility. In 2013 data as shown in panel-2, the cumulated current births to aged 50 years (4.7) was about 1.6 less than the average parities of aged 50 years (6.3). Also, the panel-3 that show 2008 data indicates that the cumulated current births to aged 50 years (4.7) was about 2.1 less than the average parities of aged 50 years (6.8). While in 2003 data, the cumulated current births to aged 50 years was 4.3 children per woman and that the average parities of aged 50 years was 7.2 children per woman indicating about 2.9 gap between the lifetime and current fertility. The South East data in all year periods fertility levels were underreported. As revealed by the result, he magnitude of underreporting of fertility levels are as follows: 2003 (2.9), 2008 (2.1), 2013 (1.6) and 2018 (0.2). This shows fertility levels estimation was better in 2018 NDHS reports compared to other year periods at least for South East.

Table 4.16: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for South East 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2018						
15(0)	0.0406				-2.3278	0.9688		0.0905			-2.6738	1.0289	
20(1)	0.1953	0.2032	0.1723	-0.5646	-1.3753	1.3539	-1.9185	0.7207	0.1256	-0.7296	-1.7469	1.2846	-2.0142
25(2)	0.2664	1.1797	0.4697	0.2802	-0.6748	1.4127	-1.1325	2.0006	0.3602	-0.0208	-1.0159	1.4240	-1.4448
30(3)	0.2323	2.5116	0.6838	0.9674	0.0393	1.2750	-0.3076	2.9525	0.6776	0.9436	-0.3349	1.3717	-0.4281
35(4)	0.1449	3.6729	0.8352	1.7146	0.9450	0.9157	0.7989	3.8616	0.7646	1.3152	0.4406	1.1404	0.1748
40(5)	0.0553	4.3974	0.9408	2.7970	2.3489	0.3966	2.4004	4.4511	0.8676	1.9515	1.5162	0.7022	1.2493
45(6)	0.0148	4.6740	0.9844	4.1517	4.8086	0.0012	4.1505	4.8905	0.9102	2.3630	3.2238	0.2705	2.0925
50		4.7481											
							2013						
15(0)	0.0491				-2.3278	0.9688		0.0727			-2.6738	1.0289	
20(1)	0.1644	0.2454	0.2298	-0.3855	-1.3753	1.3539	-1.7394	0.6042	0.1203	-0.7503	-1.7469	1.2846	-2.0349
25(2)	0.2452	1.0675	0.4655	0.2683	-0.6748	1.4127	-1.1444	1.6889	0.3578	-0.0275	-1.0159	1.4240	-1.4515
30(3)	0.2747	2.2933	0.6254	0.7563	0.0393	1.2750	-0.5187	3.1054	0.5439	0.4959	-0.3349	1.3717	-0.8758
35(4)	0.1419	3.6671	0.8379	1.7326	0.9450	0.9157	0.8169	4.1657	0.7455	1.2250	0.4406	1.1404	0.0846
40(5)	0.0552	4.3763	0.9406	2.7936	2.3489	0.3966	2.3970	5.1085	0.8154	1.5895	1.5162	0.7022	0.8873
45(6)	0.0101	4.6525	0.9893	4.5279	4.8086	0.0012	4.5267	6.2607	0.8160	1.5927	3.2238	0.2705	1.3222
50		4.7031											

Table 4.16 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)- e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.0667				-2.3278	0.9688		0.2112			-2.6738	1.0289	
20(1)	0.1786	0.3336	0.2720	-0.2639	-1.3753	1.3539	-1.6178	1.2101	0.1745	-0.5573	-1.7469	1.2846	-1.8419
25(2)	0.2300	1.2264	0.5161	0.4132	-0.6748	1.4127	-0.9995	2.5966	0.4660	0.2699	-1.0159	1.4240	-1.1541
30(3)	0.2504	2.3765	0.6550	0.8600	0.0393	1.2750	-0.4150	3.9587	0.6559	0.8634	-0.3349	1.3717	-0.5083
35(4)	0.1518	3.6284	0.8270	1.6612	0.9450	0.9157	0.7455	5.2526	0.7537	1.2630	0.4406	1.1404	0.1226
40(5)	0.0481	4.3873	0.9480	2.9299	2.3489	0.3966	2.5333	5.9003	0.8902	2.1517	1.5162	0.7022	1.4495
45(6)	0.0064	4.6279	0.9931	4.9747	4.8086	0.0012	4.9735	6.7522	0.8738	2.0035	3.2238	0.2705	1.7330
50		4.6600											
							2003						
15(0)	0.0230				-2.3278	0.9688		0.0556			-2.6738	1.0289	
20(1)	0.1579	0.1152	0.1273	-0.7234	-1.3753	1.3539	-2.0772	0.4934	0.1126	-0.7811	-1.7469	1.2846	-2.0657
25(2)	0.2351	0.9049	0.4350	0.1834	-0.6748	1.4127	-1.2293	1.4632	0.3372	-0.0835	-1.0159	1.4240	-1.5075
30(3)	0.1816	2.0802	0.6961	1.0153	0.0393	1.2750	-0.2597	2.8308	0.5169	0.4157	-0.3349	1.3717	-0.9560
35(4)	0.1587	2.9884	0.7902	1.4462	0.9450	0.9157	0.5305	4.4605	0.6346	0.7881	0.4406	1.1404	-0.3523
40(5)	0.0757	3.7819	0.9090	2.3497	2.3489	0.3966	1.9531	5.6885	0.7841	1.4139	1.5162	0.7022	0.7117
45(6)	0.0206	4.1604	0.9759	3.7127	4.8086	0.0012	3.7115	7.2090	0.7891	1.4402	3.2238	0.2705	1.1697
50		4.2632											

Figure 4.4 depicts the fitting of the relational Gompertz model to current births (F-points) and average parities (P-points) in South East. In 2018, 2013 and 2008, some of the F-points lie above the P-points signifying fertility has started falling in south east since 2008. However, it was observed that P-points lies above F-points at the younger ages which indicates that current fertility were underreported at those ages. Likewise, in 2013, 2008 and 2003, the P-points and F-points were more disperse at older ages compared to 2018 data which suggests that the quality of data reported were poorer 2013, 2008 and 2003. Also, in 2003 data current fertility was underestimated at younger ages.

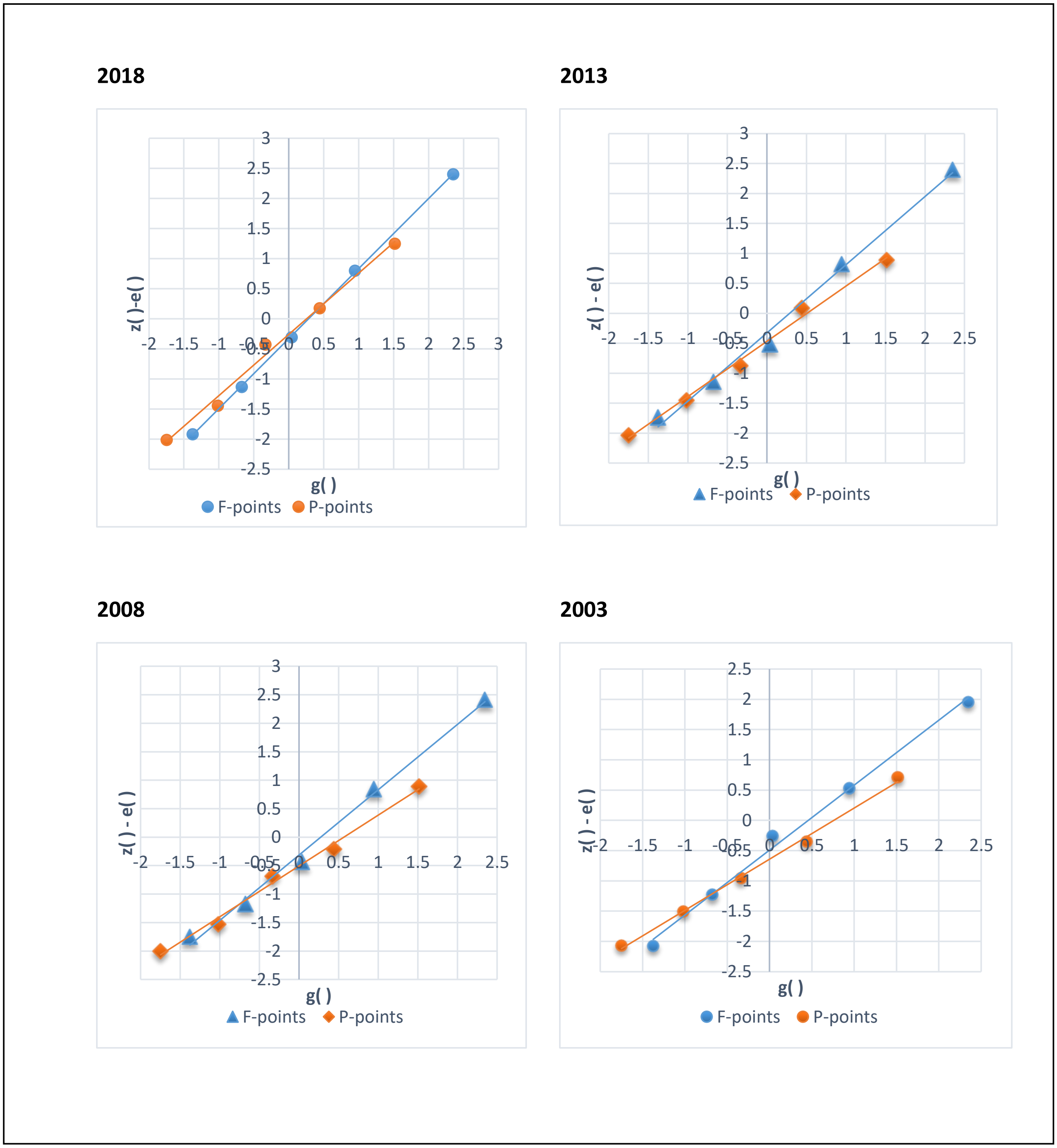


Figure 4.4: Lines fitted to the P-points and F-points, South East

Tables 4.17 the show estimated implied fertility level, estimated age specific fertility rates and estimated TFR in South East. Estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the table, average implied fertility level was 4.5 and estimated TFR was 4.4 children per woman in 2018. In 2013, 2008, and 2003 the average implied fertility levels are 4.8, 5.1 and 5.2 respectively. Likewise, the estimated TFR in the year periods were 2013(4.7), 2008(5.0) and 2003(5.1). The estimated TFRs show that fertility level declined from 5.1 children per woman in 2003 to 4.4 children per woman in 2018.

Table 4.17: Estimated implied fertility level Estimated ASFRs and total fertility rates South East

2018

Age x(i)	**Ys(i)**	**Y(i)**	**Anti-gompit**	**P(i)**	**Implied fertility level**	**Ys(x)**	**Y(x)**	**Anti-gompit**	**Adjusted * F(x)**	**Estimated ASFR**
15(0)						-1.7731	-2.1717	0.0002	0.0007	0.0001
20(1)	-1.0833	-1.4195	0.0160	0.0905	5.6573	-0.6913	-0.9919	0.0674	0.3170	0.0633
25(2)	-0.3124	-0.5787	0.1680	0.7207	4.2894	0.0256	-0.2101	0.2912	1.3686	0.2103
30(3)	0.3541	0.1482	0.4222	2.0006	4.7384	0.7000	0.5254	0.5536	2.6019	0.2467
35(4)	1.0579	0.9157	0.6702	2.9525	4.4056	1.4787	1.3747	0.7765	3.6497	0.2095
40(5)	1.9561	1.8953	0.8605	3.8616	4.4878	2.6260	2.6259	0.9302	4.3719	0.1444
45(6)						4.8097	5.0075	0.9933	4.6687	0.0594
Ave. Implied Fertility Level = 4.5						Estimated TFR = 4.4				
2013										
15(0)						-1.7731	-2.2444	0.0001	0.0004	0.0001
20(1)	-1.0833	-1.5163	0.0105	0.0727	6.9180	-0.6913	-1.1026	0.0492	0.2362	0.0472
25(2)	-0.3124	-0.7026	0.1328	0.6042	4.5508	0.0256	-0.3459	0.2434	1.1681	0.1864
30(3)	0.3541	0.0009	0.3682	1.6889	4.5870	0.7000	0.3660	0.4998	2.3991	0.2462
35(4)	1.0579	0.7437	0.6217	3.1054	4.9952	1.4787	1.1879	0.7372	3.5387	0.2279
40(5)	1.9561	1.6918	0.8318	4.1657	5.0082	2.6260	2.3988	0.9132	4.3833	0.1689
45(6)						4.8097	4.7037	0.9910	4.7567	0.0747
Ave. Implied Fertility Level = 4.8						Estimated TFR = 4.7				

Table 4.17 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-2.2448	0.0001	0.0004	0.0001
20(1)	-1.0833	-1.5196	0.0104	0.0788	7.6112	-0.6913	-1.1074	0.0485	0.2473	0.0494
25(2)	-0.3124	-0.7091	0.1311	0.6158	4.6988	0.0256	-0.3537	0.2407	1.2274	0.1960
30(3)	0.3541	-0.0083	0.3648	1.8772	5.1454	0.7000	0.3554	0.4961	2.5303	0.2606
35(4)	1.0579	0.7317	0.6181	3.1123	5.0353	1.4787	1.1741	0.7341	3.7440	0.2427
40(5)	1.9561	1.6760	0.8294	4.6247	5.5763	2.6260	2.3804	0.9116	4.6493	0.1811
45(6)						4.8097	4.6763	0.9907	5.0527	0.0807
	Ave. Implied Fertility Level = 5.1							Estimated TFR = 5.0		
					2003					
15(0)						-1.7731	-2.2870	0.0001	0.0003	0.0001
20(1)	-1.0833	-1.6071	0.0068	0.0556	8.1498	-0.6913	-1.2207	0.0337	0.1956	0.0391
25(2)	-0.3124	-0.8472	0.0970	0.4934	5.0875	0.0256	-0.5141	0.1879	1.0896	0.1788
30(3)	0.3541	-0.1903	0.2983	1.4632	4.9048	0.7000	0.1507	0.4231	2.4541	0.2729
35(4)	1.0579	0.5035	0.5464	2.8308	5.1809	1.4787	0.9183	0.6708	3.8909	0.2874
40(5)	1.9561	1.3888	0.7793	4.4605	5.7238	2.6260	2.0491	0.8791	5.0988	0.2416
45(6)						4.8097	4.2016	0.9851	5.7138	0.1230
	Ave. Implied Fertility Level = 5.2							Estimated TFR = 5.1		

The results of the application of the relational Gompertz model to current births and children ever born reported in NDHS 2003-2018 for North West are shown in Table 4.17. According to the Table, panel-1 indicates that the cumulated current births to age 50 years (7.0) was about 1.7 less than the average parities of age 50 years (8.7) in 2018. Panel-2 where 2013 data was presented show that lifetime fertility (9.5) about 2.3 higher than current fertility in North West. Based on 2008 data presented in Panel-3, the cumulated current births to age 50 years was 7.5 children per woman and the average parities of aged 50 years were 9.1 children per woman. In 2003, the cumulated current births to aged 50 years was 6.9 children per woman and the average parities of aged 50 years were 7.6 children per woman. The table suggests underreporting of current was prevalent in North West in all the survey rounds. Notably, the average parities to age 50 years was the lowest in 2003 data which indicate a poorer quality of data compared to other year periods.

Table 4.18: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for North West 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2018						
15(0)	0.1496				-2.3278	0.9688		0.2656			-2.6738	1.0289	
20(1)	0.3096	0.7482	0.3258	-0.1146	-1.3753	1.3539	-1.4685	1.7323	0.1344	-0.6964	-1.7469	1.2846	-1.9810
25(2)	0.3012	2.2964	0.6039	0.6846	-0.6748	1.4127	-0.7281	3.5763	0.4247	0.1550	-1.0159	1.4240	-1.2690
30(3)	0.2625	3.8023	0.7434	1.2158	0.0393	1.2750	-0.0592	5.3506	0.6963	1.0163	-0.3349	1.3717	-0.3554
35(4)	0.2159	5.1145	0.8257	1.6531	0.9450	0.9157	0.7374	6.7085	0.7388	1.1951	0.4406	1.1404	0.0547
40(5)	0.1102	6.1938	0.9183	2.4626	2.3489	0.3966	2.0660	7.9252	0.8509	1.8232	1.5162	0.7022	1.1210
45(6)	0.0509	6.7448	0.9637	3.2964	4.8086	0.0012	3.2952	8.6547	0.8351	1.7134	3.2238	0.2705	1.4429
50		6.9991											
							2013						
15(0)	0.2031				-2.3278	0.9688		0.3262			-2.6738	1.0289	
20(1)	0.3013	1.0154	0.4026	0.0946	-1.3753	1.3539	-1.2593	1.6721	0.1951	-0.4912	-1.7469	1.2846	-1.7758
25(2)	0.2989	2.5218	0.6279	0.7649	-0.6748	1.4127	-0.6478	3.4947	0.4785	0.3049	-1.0159	1.4240	-1.1191
30(3)	0.2682	4.0164	0.7497	1.2446	0.0393	1.2750	-0.0304	5.0080	0.6978	1.0222	-0.3349	1.3717	-0.3495
35(4)	0.1874	5.3572	0.8511	1.8250	0.9450	0.9157	0.9093	6.9650	0.7190	1.1091	0.4406	1.1404	-0.0313
40(5)	0.1073	6.2943	0.9214	2.5033	2.3489	0.3966	2.1067	7.7168	0.9026	2.2778	1.5162	0.7022	1.5756
45(6)	0.0455	6.8310	0.9677	3.4177	4.8086	0.0012	3.4165	9.5451	0.8085	1.5482	3.2238	0.2705	1.2777
50		7.0586											

Table 4.18 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.2442				-2.3278	0.9688		0.4602			-2.6738	1.0289	
20(1)	0.3162	1.2208	0.4357	0.1854	-1.3753	1.3539	-1.1685	1.8367	0.2506	-0.3250	-1.7469	1.2846	-1.6096
25(2)	0.2970	2.8018	0.6536	0.8549	-0.6748	1.4127	-0.5578	3.3647	0.5459	0.5019	-1.0159	1.4240	-0.9221
30(3)	0.2715	4.2870	0.7595	1.2906	0.0393	1.2750	0.0156	5.0562	0.6655	0.8983	-0.3349	1.3717	-0.4734
35(4)	0.1915	5.6447	0.8550	1.8534	0.9450	0.9157	0.9377	6.5242	0.7750	1.3668	0.4406	1.1404	0.2264
40(5)	0.1166	6.6023	0.9188	2.4692	2.3489	0.3966	2.0726	8.2923	0.7868	1.4279	1.5162	0.7022	0.7257
45(6)	0.0709	7.1855	0.9530	3.0340	4.8086	0.0012	3.0328	9.1425	0.9070	2.3269	3.2238	0.2705	2.0564
50		7.5397											
							2003						
15(0)	0.2366				-2.3278	0.9688		0.4619			-2.6738	1.0289	
20(1)	0.3124	1.1828	0.4309	0.1722	-1.3753	1.3539	-1.1817	1.7904	0.2580	-0.3037	-1.7469	1.2846	-1.5883
25(2)	0.3078	2.7448	0.6407	0.8094	-0.6748	1.4127	-0.6033	3.6811	0.4864	0.3274	-1.0159	1.4240	-1.0966
30(3)	0.2680	4.2837	0.7617	1.3012	0.0393	1.2750	0.0262	5.1701	0.7120	1.0797	-0.3349	1.3717	-0.2920
35(4)	0.1601	5.6239	0.8754	2.0166	0.9450	0.9157	1.1009	7.0240	0.7361	1.1828	0.4406	1.1404	0.0424
40(5)	0.0635	6.4246	0.9529	3.0317	2.3489	0.3966	2.6351	7.1883	0.9771	3.7667	1.5162	0.7022	3.0645
45(6)	0.0287	6.7421	0.9792	3.8611	4.8086	0.0012	3.8599	7.5733	0.9492	2.9532	3.2238	0.2705	2.6827
50		6.8855											

Figure 4.5 depicts the fitting of the Gompertz relational model to current births (F-points) and average parities (P-points) in North West. A visual inspection of F-points and P-points across the survey rounds suggests a very poor quality of fertility data. In 2018, all the F-points lie above P-points which indicates age exaggeration and underreported of current fertility in younger ages. Inconsistence was observed in 2013 data. Underreported of current at younger ages and parity omission at older ages were observed in 2013 data. The while, it appears that children ever born were over stated in 2008, the P-points that lie above F-points at older ages suggest some parity were omitted at those ages in 2003.

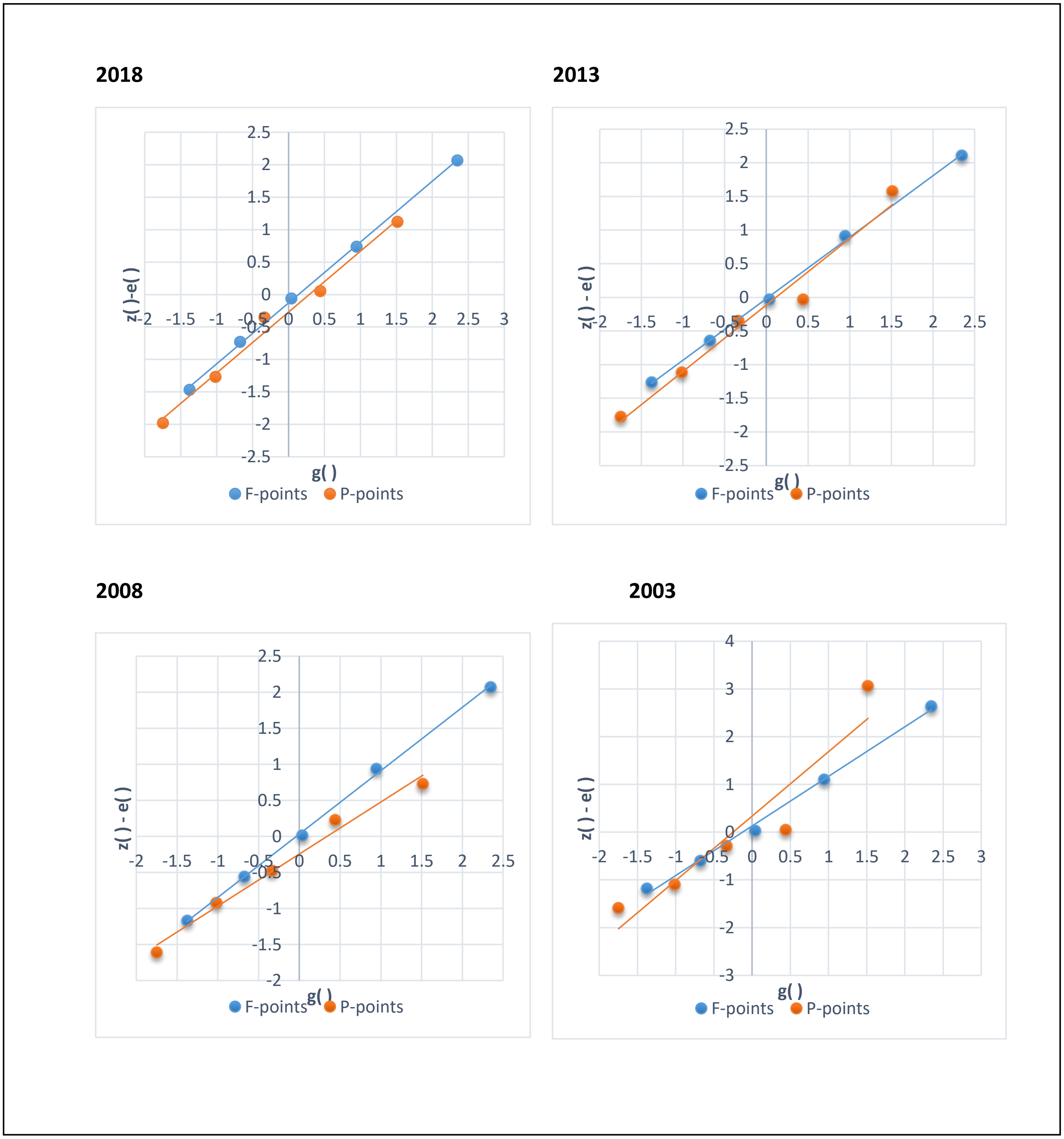


Figure 4.5: Lines fitted to the P-points and F-points, North West

The estimated implied fertility level, estimated age specific fertility rates and estimated TFR of North West were presented in Table 4.19. Estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the table, the estimated TFR was lowest in 2003 (6.9). In 2018, 2013, and 2008, the estimated TFR were 7.0 children per woman in 2018, 7.1 children per woman in 2013 and 7.5 children per woman in 2003. Based on the result, about 0.6 increase of fertility level was observed between 2003 and 2008; while in 10 years (2008-2018) 0.5 fall in fertility was observed in North West. This indicate fertility level was stalled in North West in the past 15 years.

Table 4.19: Estimated implied fertility level Estimated ASFRs and total fertility rates North West

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-1.7630	0.0029	0.0209	0.0042
20(1)	-1.0833	-1.0919	0.0508	0.2656	5.2288	-0.6913	-0.7104	0.1307	0.9279	0.1814
25(2)	-0.3124	-0.3418	0.2448	1.7323	7.0771	0.0256	-0.0129	0.3631	2.5783	0.3301
30(3)	0.3541	0.3067	0.4791	3.5763	7.4647	0.7000	0.6433	0.5912	4.1977	0.3239
35(4)	1.0579	0.9915	0.6900	5.3506	7.7540	1.4787	1.4010	0.7816	5.5497	0.2704
40(5)	1.9561	1.8655	0.8566	6.7085	7.8318	2.6260	2.5173	0.9225	6.5497	0.2000
45(6)						4.8097	4.6420	0.9904	7.0319	0.0964
Ave. Implied Fertility Level = 7.1							Estimated TFR = 7.0			
					2013					
15(0)						-1.7731	-1.7649	0.0029	0.0215	0.0043
20(1)	-1.0833	-1.1078	0.0484	0.3262	6.7349	-0.6913	-0.7343	0.1244	0.9208	0.1799
25(2)	-0.3124	-0.3733	0.2340	1.6721	7.1464	0.0256	-0.0513	0.3490	2.5827	0.3324
30(3)	0.3541	0.2617	0.4631	3.4947	7.5460	0.7000	0.5912	0.5748	4.2538	0.3342
35(4)	1.0579	0.9322	0.6746	5.0080	7.4242	1.4787	1.3331	0.7682	5.6849	0.2862
40(5)	1.9561	1.7879	0.8459	6.9650	8.2335	2.6260	2.4261	0.9154	6.7740	0.2178
45(6)						4.8097	4.5065	0.9890	7.3188	0.1089
Ave. Implied Fertility Level = 7.2							Estimated TFR = 7.1			

Table 4.19 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-1.5631	0.0084	0.0642	0.0128
20(1)	-1.0833	-0.9889	0.0680	0.4602	6.7691	-0.6913	-0.6626	0.1437	1.0923	0.2056
25(2)	-0.3124	-0.3472	0.2429	1.8367	7.5620	0.0256	-0.0659	0.3437	2.6118	0.3039
30(3)	0.3541	0.2076	0.4437	3.3647	7.5830	0.7000	0.4955	0.5437	4.1324	0.3041
35(4)	1.0579	0.7934	0.6362	5.0562	7.9480	1.4787	1.1437	0.7271	5.5262	0.2788
40(5)	1.9561	1.5411	0.8072	6.5242	8.0823	2.6260	2.0987	0.8846	6.7230	0.2394
45(6)						4.8097	3.9164	0.9803	7.4502	0.1454
Ave. Implied Fertility Level = 7.6						Estimated TFR = 7.5				
					2003					
15(0)						-1.7731	-1.8588	0.0016	0.0113	0.0023
20(1)	-1.0833	-1.0601	0.0558	0.4619	8.2824	-0.6913	-0.6062	0.1599	1.1031	0.2184
25(2)	-0.3124	-0.1674	0.3066	1.7904	5.8398	0.0256	0.2239	0.4496	3.1024	0.3998
30(3)	0.3541	0.6043	0.5790	3.6811	6.3576	0.7000	1.0048	0.6934	4.7847	0.3365
35(4)	1.0579	1.4192	0.7851	5.1701	6.5850	1.4787	1.9065	0.8619	5.9472	0.2325
40(5)	1.9561	2.4593	0.9181	7.0240	7.6510	2.6260	3.2349	0.9614	6.6337	0.1373
45(6)						4.8097	5.7635	0.9969	6.8784	0.0489
Ave. Implied Fertility Level = 7.0						Estimated TFR = 6.9				

The results of the application of the relational Gompertz model to current births and children ever born reported in DHS 2003-2018 for North East are shown in table 4.19. According to the table, panel-1 indicates that the lifetime fertility (7.4) and current fertility (6.3) were different by 1.1 2018. Panel-2 which show 2013 indicate that current fertility was 6.4 children per woman and lifetime fertility was 7.1 children per woman. Likewise, 2008 and 2003 as presented in Panel-3 and panel-4 show that current fertility was underreported with just 0.3 and 0.1 respectively. Based on the data, although the current fertility levels were underreported but the magnitude of underreporting was minimal at least in 2003 and 2008.

Table 4.20: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for North East 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	**f(x)**	**F(x)**	**F(x)/ F(x+5)**	**z(x)**	**g(x)**	**e(x)**	**z(x)-e(x)**	**p(i)**	**p(i)/ p(i+1)**	**z(i)**	**g(i)**	**e(i)**	**z(i)-e(i)**
						2018							
15(0)	0.1406				-2.3278	0.9688		0.2391			-2.6738	1.0289	
20(1)	0.2782	0.7029	0.3357	-0.0876	-1.3753	1.3539	-1.4415	1.5553	0.1537	-0.6274	-1.7469	1.2846	-1.9120
25(2)	0.2817	2.0938	0.5978	0.6646	-0.6748	1.4127	-0.7481	3.1927	0.4871	0.3296	-1.0159	1.4240	-1.0944
30(3)	0.2438	3.5024	0.7418	1.2083	0.0393	1.2750	-0.0667	4.6751	0.6829	0.9640	-0.3349	1.3717	-0.4078
35(4)	0.1865	4.7216	0.8351	1.7133	0.9450	0.9157	0.7976	6.0665	0.7706	1.3450	0.4406	1.1404	0.2046
40(5)	0.1002	5.6542	0.9186	2.4659	2.3489	0.3966	2.0693	7.0784	0.8571	1.8691	1.5162	0.7022	1.1669
45(6)	0.0367	6.1555	0.9710	3.5267	4.8086	0.0012	3.5255	7.4172	0.9543	3.0628	3.2238	0.2705	2.7923
50		6.3391											
							2013						
15(0)	0.1864				-2.3278	0.9688		0.3345			-2.6738	1.0289	
20(1)	0.2945	0.9322	0.3877	0.0538	-1.3753	1.3539	-1.3001	1.6582	0.2017	-0.4706	-1.7469	1.2846	-1.7552
25(2)	0.2634	2.4046	0.6461	0.8283	-0.6748	1.4127	-0.5844	3.1500	0.5264	0.4437	-1.0159	1.4240	-0.9803
30(3)	0.2499	3.7217	0.7487	1.2398	0.0393	1.2750	-0.0352	4.6641	0.6754	0.9352	-0.3349	1.3717	-0.4365
35(4)	0.1799	4.9710	0.8468	1.7939	0.9450	0.9157	0.8782	6.1384	0.7598	1.2922	0.4406	1.1404	0.1518
40(5)	0.0905	5.8705	0.9284	2.5998	2.3489	0.3966	2.2032	6.9940	0.8777	2.0365	1.5162	0.7022	1.3343
45(6)	0.0209	6.3232	0.9838	4.1130	4.8086	0.0012	4.1118	7.1390	0.9797	3.8863	3.2238	0.2705	3.6158
50		6.4275											

Table 4.19 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.2302				-2.3278	0.9688		0.4068			-2.6738	1.0289	
20(1)	0.3067	1.1512	0.4288	0.1664	-1.3753	1.3539	-1.1875	1.8516	0.2197	-0.4157	-1.7469	1.2846	-1.7003
25(2)	0.3089	2.6846	0.6348	0.7886	-0.6748	1.4127	-0.6241	3.4620	0.5348	0.4687	-1.0159	1.4240	-0.9553
30(3)	0.2780	4.2291	0.7526	1.2582	0.0393	1.2750	-0.0168	5.1082	0.6777	0.9442	-0.3349	1.3717	-0.4275
35(4)	0.1899	5.6191	0.8555	1.8571	0.9450	0.9157	0.9414	6.5851	0.7757	1.3705	0.4406	1.1404	0.2301
40(5)	0.1037	6.5686	0.9268	2.5771	2.3489	0.3966	2.1805	7.1637	0.9192	2.4744	1.5162	0.7022	1.7722
45(6)	0.0553	7.0872	0.9625	3.2637	4.8086	0.0012	3.2625	7.6917	0.9314	2.6434	3.2238	0.2705	2.3729
50		7.3635											
							2003						
15(0)	0.2637				-2.3278	0.9688		0.5085			-2.6738	1.0289	
20(1)	0.2930	1.3184	0.4737	0.2914	-1.3753	1.3539	-1.0625	1.7863	0.2847	-0.2283	-1.7469	1.2846	-1.5129
25(2)	0.3141	2.7833	0.6393	0.8042	-0.6748	1.4127	-0.6085	3.6872	0.4845	0.3219	-1.0159	1.4240	-1.1021
30(3)	0.3162	4.3540	0.7336	1.1719	0.0393	1.2750	-0.1031	5.5470	0.6647	0.8956	-0.3349	1.3717	-0.4761
35(4)	0.1916	5.9350	0.8610	1.8994	0.9450	0.9157	0.9837	6.8000	0.8157	1.5912	0.4406	1.1404	0.4508
40(5)	0.0865	6.8931	0.9409	2.7989	2.3489	0.3966	2.4023	7.3571	0.9243	2.5415	1.5162	0.7022	1.8393
45(6)	0.0237	7.3257	0.9841	4.1330	4.8086	0.0012	4.1318	7.4609	0.9861	4.2687	3.2238	0.2705	3.9982
50		7.4441											

Figure 4.6 depicts the fitting of the Gompertz relational model to current births (F-points) and average parities (P-points) in North East. Just like North West, a visual inspection of F-points and P-points across the survey rounds suggests a very poor quality of fertility data. In 2018 and 2013, all the F-points lie above P-points which indicates age exaggeration and underreported of current fertility in younger ages. Inconsistence was observed in 2008 and 2003 data. Underreported of current at younger ages and parity omission at older ages were observed in both 2008 and 2003 data.

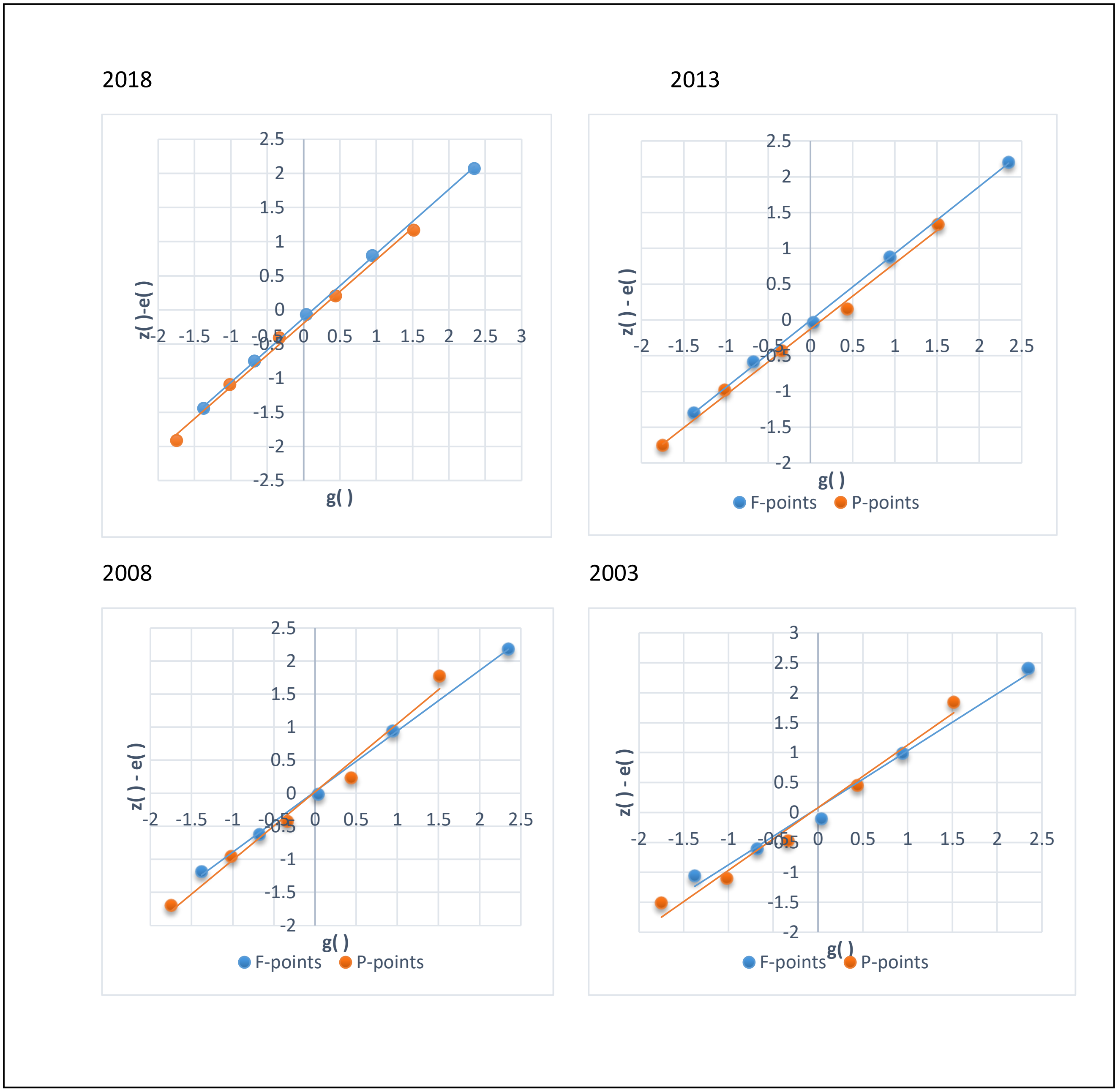


Figure 4.6: Lines fitted to the P-points and F-points, North East

Tables 4.21 the show estimated implied fertility level, estimated age specific fertility rates and estimated TFR in North East. Estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the table, average implied fertility level was 4.5 and estimated TFR is 4.4 for 2018. In 2013, 2008, and 2003 the average implied fertility levels are 4.8, 5.1 and 5.2 respectively. Likewise, the estimated TFR in the year periods are 2013(4.7), 2008(5.0) and 2003(5.1).

Table 4:21: Estimated implied fertility level Estimated ASFRs and total fertility rates North East

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-1.8569	0.0017	0.0116	0.0023
20(1)	-1.0833	-1.1852	0.0380	0.2391	6.2991	-0.6913	-0.8035	0.1072	0.7491	0.1475
25(2)	-0.3124	-0.4345	0.2135	1.5553	7.2853	0.0256	-0.1054	0.3292	2.3010	0.3104
30(3)	0.3541	0.2145	0.4462	3.1927	7.1548	0.7000	0.5514	0.5620	3.9287	0.3255
35(4)	1.0579	0.8999	0.6659	4.6751	7.0207	1.4787	1.3097	0.7634	5.3365	0.2816
40(5)	1.9561	1.7746	0.8440	6.0665	7.1875	2.6260	2.4269	0.9155	6.3992	0.2125
45(6)						4.8097	4.5534	0.9895	6.9168	0.1035
		Ave. Implied Fertility Level = 7.0						Estimated TFR = 6.9		
					2013					
15(0)						-1.7731	-1.7293	0.0036	0.0246	0.0049
20(1)	-1.0833	-1.0818	0.0523	0.3345	6.3904	-0.6913	-0.7144	0.1297	0.8946	0.1740
25(2)	-0.3124	-0.3586	0.2390	1.6582	6.9381	0.0256	-0.0418	0.3525	2.4323	0.3076
30(3)	0.3541	0.2667	0.4649	3.1500	6.7752	0.7000	0.5909	0.5748	3.9658	0.3067
35(4)	1.0579	0.9271	0.6732	4.6641	6.9283	1.4787	1.3215	0.7659	5.2846	0.2637
40(5)	1.9561	1.7697	0.8433	6.1384	7.2787	2.6260	2.3979	0.9131	6.3004	0.2032
45(6)						4.8097	4.4467	0.9884	6.8196	0.1038
Ave. Implied Fertility Level = 6.9							Estimated TFR = 6.8			

Table 4.21 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted* F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-1.7069	0.0040	0.0291	0.0058
20(1)	-1.0833	-1.0399	0.0591	0.4068	6.8877	-0.6913	-0.6609	0.1442	1.0382	0.2018
25(2)	-0.3124	-0.2946	0.2612	1.8516	7.0892	0.0256	0.0323	0.3797	2.7341	0.3392
30(3)	0.3541	0.3499	0.4942	3.4620	7.0050	0.7000	0.6843	0.6039	4.3477	0.3227
35(4)	1.0579	1.0304	0.6999	5.1082	7.2988	1.4787	1.4373	0.7885	5.6774	0.2659
40(5)	1.9561	1.8989	0.8609	6.5851	7.6488	2.6260	2.5466	0.9246	6.6574	0.1960
45(6)						4.8097	4.6580	0.9906	7.1320	0.0949
	Ave. Implied Fertility Level = 7.2							Estimated TFR = 7.1		
					2003					
15(0)						-1.7731	-1.7069	0.0044	0.0323	0.0065
20(1)	-1.0833	-1.0087	0.0644	0.5085	7.8911	-0.6913	-0.6609	0.1561	1.1551	0.2246
25(2)	-0.3124	-0.2432	0.2793	1.7863	6.3948	0.0256	0.0323	0.4018	2.9735	0.3637
30(3)	0.3541	0.4186	0.5179	3.6872	7.1195	0.7000	0.6843	0.6270	4.6396	0.3332
35(4)	1.0579	1.1175	0.7210	5.5470	7.6933	1.4787	1.4373	0.8061	5.9652	0.2651
40(5)	1.9561	2.0094	0.8745	6.8000	7.7756	2.6260	2.5466	0.9333	6.9065	0.1883
45(6)						4.8097	4.6580	0.9921	7.3418	0.0871
	Ave. Implied Fertility Level = 7.4							Estimated TFR = 7.3		

The results of the application of the relational Gompertz model to current births and children ever born reported in NDHS 2003-2018 for North Central are shown in table 4.21. Panel-1 of the table indicates that cumulated current births to aged 50 years (5.2) was about 0.8 less than the average parities of aged 50 years (6.0) in 2018. Likewise, the 2013 data as presented in Panel-2 show that the cumulated current births to aged 50 years (5.3) was about 0.9 less than the average parities of aged 50 years (6.2). The panel-3 shows that the cumulated current births to aged 50 years was 5.6 children per woman and the average parities of aged 50 years was 6.8 per children per woman in 2008. The 2003 data presented in panel 4, show that the average parities of aged 50 years (6.0) was 2.0 greater than the cumulated current births to aged 50 years (8.0). In all the survey rounds, there was evidence of underestimation current fertility; however, the magnitude of underestimation of current fertility was highest in 2003 data. The table also show that fertility declined between 2003 and 2018.

Table 4.22: The gompit of the ratios of adjacent cumulated period fertility measures and average parities for North Central 2018, 2013, 2008, 2003 and the standard schedule

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)- e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2018						
15(0)	0.0870				-2.3278	0.9688		0.1479			-2.6738	1.0289	
20(1)	0.2363	0.4351	0.2691	-0.2720	-1.3753	1.3539	-1.6259	1.1032	0.1341	-0.6978	-1.7469	1.2846	-1.9824
25(2)	0.2552	1.6167	0.5589	0.5416	-0.6748	1.4127	-0.8711	2.4982	0.4416	0.2017	-1.0159	1.4240	-1.2223
30(3)	0.2104	2.8928	0.7334	1.1708	0.0393	1.2750	-0.1042	3.8740	0.6449	0.8239	-0.3349	1.3717	-0.5478
35(4)	0.1506	3.9447	0.8397	1.7444	0.9450	0.9157	0.8287	4.7064	0.8231	1.6367	0.4406	1.1404	0.4963
40(5)	0.0683	4.6979	0.9322	2.6568	2.3489	0.3966	2.2602	5.4867	0.8578	1.8746	1.5162	0.7022	1.1724
45(6)	0.0228	5.0394	0.9779	3.8005	4.8086	0.0012	3.7993	6.0354	0.9091	2.3506	3.2238	0.2705	2.0801
50		5.1533											
							2013						
15(0)	0.1500				-2.3278	0.9688		0.1577			-2.6738	1.0289	
20(1)	0.2556	0.7502	0.3699	0.0055	-1.3753	1.3539	-1.3484	1.1113	0.1419	-0.6691	-1.7469	1.2846	-1.9537
25(2)	0.2136	2.0283	0.6551	0.8603	-0.6748	1.4127	-0.5524	2.4390	0.4556	0.2408	-1.0159	1.4240	-1.1832
30(3)	0.2076	3.0963	0.7489	1.2408	0.0393	1.2750	-0.0342	3.8758	0.6293	0.7697	-0.3349	1.3717	-0.6020
35(4)	0.1337	4.1345	0.8608	1.8981	0.9450	0.9157	0.9824	4.9413	0.7844	1.4152	0.4406	1.1404	0.2748
40(5)	0.0648	4.8029	0.9368	2.7290	2.3489	0.3966	2.3324	5.5800	0.8855	2.1073	1.5162	0.7022	1.4051
45(6)	0.0253	5.1269	0.9759	3.7138	4.8086	0.0012	3.7126	6.1671	0.9048	2.3021	3.2238	0.2705	2.0316
50		5.2534											

Table 4.22 Continue

Age (x)(i)	f(x)	F(x)	F(x)/ F(x+5)	z(x)	g(x)	e(x)	z(x)-e(x)	p(i)	p(i)/ p(i+1)	z(i)	g(i)	e(i)	z(i)-e(i)
							2008						
15(0)	0.1251				-2.3278	0.9688		0.2184			-2.6738	1.0289	
20(1)	0.2328	0.6253	0.3494	-0.0502	-1.3753	1.3539	-1.4041	1.0811	0.2020	-0.4698	-1.7469	1.2846	-1.7544
25(2)	0.2490	1.7896	0.5897	0.6383	-0.6748	1.4127	-0.7744	2.5071	0.4312	0.1731	-1.0159	1.4240	-1.2509
30(3)	0.2123	3.0348	0.7409	1.2041	0.0393	1.2750	-0.0709	3.9270	0.6384	0.8012	-0.3349	1.3717	-0.5705
35(4)	0.1634	4.0964	0.8338	1.7048	0.9450	0.9157	0.7891	5.2731	0.7447	1.2216	0.4406	1.1404	0.0812
40(5)	0.0740	4.9132	0.9300	2.6227	2.3489	0.3966	2.2261	5.9492	0.8864	2.1150	1.5162	0.7022	1.4128
45(6)	0.0577	5.2832	0.9482	2.9337	4.8086	0.0012	2.9325	6.8388	0.8699	1.9708	3.2238	0.2705	1.7003
50		5.5718											
							2003						
15(0)	0.1183				-2.3278	0.9688		0.1694			-2.6738	1.0289	
20(1)	0.2394	0.5917	0.3308	-0.1010	-1.3753	1.3539	-1.4549	1.0246	0.1654	-0.5876	-1.7469	1.2846	-1.8722
25(2)	0.2984	1.7887	0.5452	0.4999	-0.6748	1.4127	-0.9128	2.6820	0.3820	0.0384	-1.0159	1.4240	-1.3856
30(3)	0.2147	3.2807	0.7535	1.2621	0.0393	1.2750	-0.0129	4.1481	0.6466	0.8299	-0.3349	1.3717	-0.5418
35(4)	0.1532	4.3541	0.8504	1.8201	0.9450	0.9157	0.9044	5.7857	0.7170	1.1004	0.4406	1.1404	-0.0400
40(5)	0.1414	5.1199	0.8787	2.0455	2.3489	0.3966	1.6489	6.7750	0.8540	1.8461	1.5162	0.7022	1.1439
45(6)	0.0335	5.8267	0.9721	3.5636	4.8086	0.0012	3.5624	7.9551	0.8517	1.8290	3.2238	0.2705	1.5585
50		5.9941											

Figure 4.6 depicts the fitting of Gompertz relational model to the current births (F-points) and average parities (P-points) in North Central. In 2018, some of the F-points lie above the P-points signifying falling fertility. In 2013, the P-points lie above F-points at all ages which indicate age exaggeration, underreported of current fertility at younger ages and omission of CEB at older ages. 2003, the P-points lie above F-points which suggest some parity were omitted. In 2008, it appears that current fertility was underestimated; however, there was evidence of falling fertility. The F and P points were more disperse in 2003 which indicate a poorer quality of data compared to other year periods.

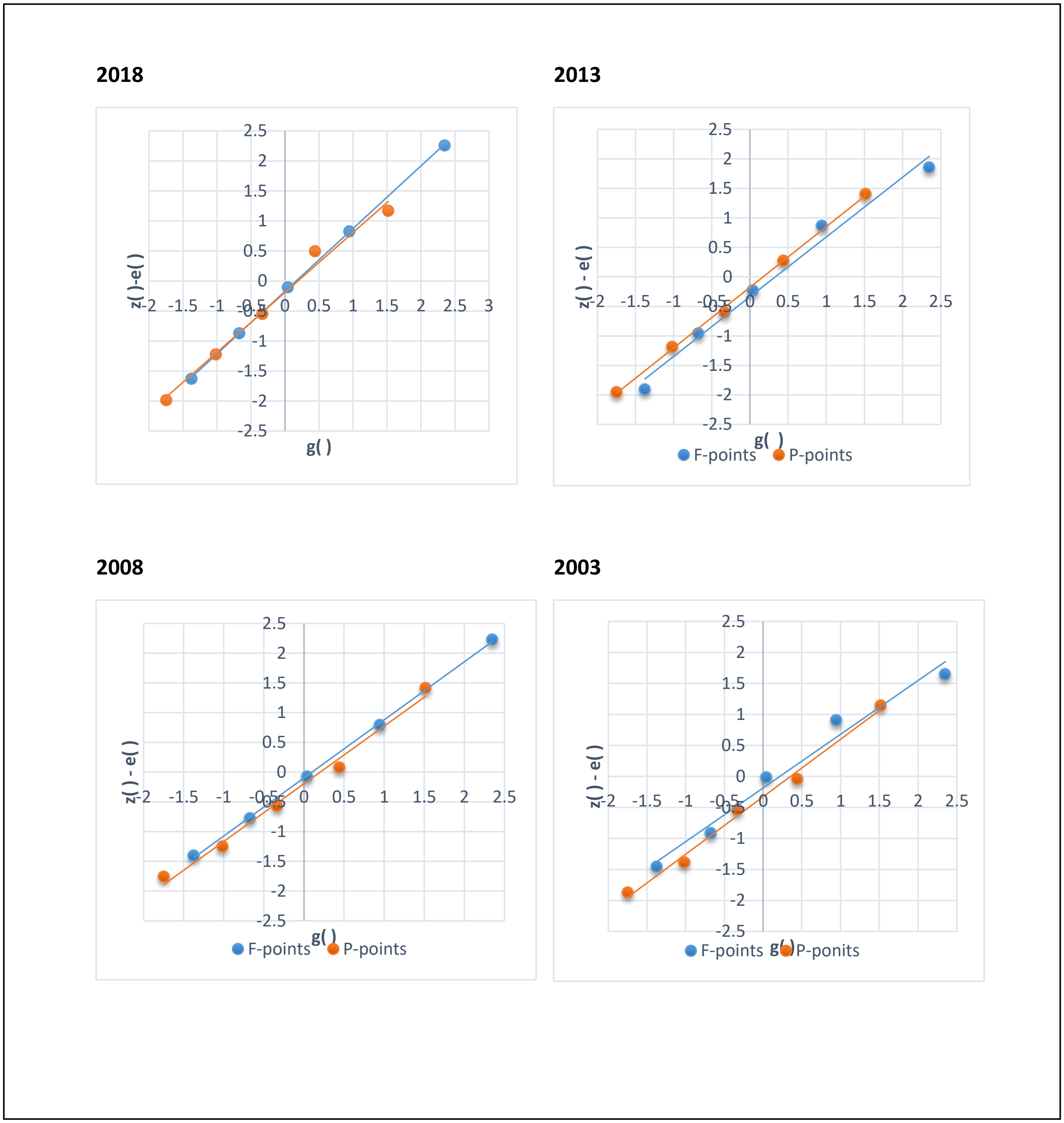


Figure 4.7: Lines fitted to the P-points and F-points, North Central

Estimated implied fertility level, estimated age specific fertility rates and estimated TFR in North Central were presented in Table 4.23. Estimated implied fertility levels were calculated from average parities and applied as adjustment factor to current data. According to the results, estimated TFR were as follows: 2018 (5.0), 2013(5.1), 2008(5.7) and 2003(6.3). The results indicate that fertility declined between 2003 and 2018. The change in fertility level was more between 2003 and 2013 compare to between 2008 and 2018. Only 0.1 drop was observed in fertility in the last five years (2013-2018). However, a substantial fertility decline was observed in the North West.

Table 4.23: Estimated implied fertility level Estimated ASFRs and total fertility rates North Central

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2018					
15(0)						-1.7731	-1.8550	0.0017	0.0085	0.0017
20(1)	-1.0833	-1.1723	0.0396	0.1479	3.7378	-0.6913	-0.7844	0.1118	0.5668	0.1117
25(2)	-0.3124	-0.4094	0.2218	1.1032	4.9735	0.0256	-0.0749	0.3404	1.7257	0.2318
30(3)	0.3541	0.2503	0.4590	2.4982	5.4422	0.7000	0.5926	0.5753	2.9167	0.2382
35(4)	1.0579	0.9468	0.6784	3.8740	5.7103	1.4787	1.3633	0.7743	3.9256	0.2018
40(5)	1.9561	1.8358	0.8526	4.7064	5.5202	2.6260	2.4988	0.9211	4.6700	0.1489
45(6)						4.8097	4.6600	0.9906	5.0222	0.0705
	Ave. Implied Fertility Level = 5.1						Estimated TFR = 5.0			
					2013					
15(0)						-1.7731	-2.0430	0.0004	0.0029	0.0006
20(1)	-1.0833	-1.3485	0.0212	0.1577	7.4226	-0.6913	-0.9538	0.0746	0.4775	0.0949
25(2)	-0.3124	-0.5723	0.1699	1.1113	5.5400	0.0256	-0.2320	0.2833	1.8133	0.2672
30(3)	0.3541	0.0987	0.4041	2.4390	5.0351	0.7000	0.4470	0.5275	3.3761	0.3126
35(4)	1.0579	0.8073	0.6401	3.8758	5.0546	1.4787	1.2310	0.7468	4.7793	0.2806
40(5)	1.9561	1.7116	0.8348	4.9413	5.9192	2.6260	2.3861	0.9121	5.8375	0.2117
45(6)						4.8097	4.5846	0.9898	6.3350	0.0995
	Ave. Implied Fertility Level = 5.2						Estimated TFR = 5.1			

Table 4.23 Continue

Age x(i)	Ys(i)	Y(i)	Anti-gompit	P(i)	Implied fertility level	Ys(x)	Y(x)	Anti-gompit	Adjusted * F(x)	Estimated ASFR
					2008					
15(0)						-1.7731	-1.8846	0.0014	0.0080	0.0016
20(1)	-1.0833	-1.2080	0.0352	0.2184	6.2037	-0.6913	-0.8235	0.1024	0.5941	0.1172
25(2)	-0.3124	-0.4519	0.2078	1.0811	5.2034	0.0256	-0.1204	0.3237	1.8775	0.2567
30(3)	0.3541	0.2018	0.4416	2.5071	5.6767	0.7000	0.5411	0.5587	3.2405	0.2726
35(4)	1.0579	0.8921	0.6638	3.9270	5.9161	1.4787	1.3048	0.7624	4.4222	0.2363
40(5)	1.9561	1.7730	0.8438	5.2731	6.2491	2.6260	2.4301	0.9157	5.3113	0.1778
45(6)						4.8097	4.5719	0.9897	5.7403	0.0858
	Ave. Implied Fertility Level = 5.8						Estimated TFR = 5.7			
					2003					
15(0)						-1.7731	-1.8673	0.0015	0.0100	0.0020
20(1)	-1.0833	-1.2080	0.0311	0.1694	5.4412	-0.6913	-0.8898	0.0876	0.5644	0.1109
25(2)	-0.3124	-0.4519	0.1775	1.0246	5.7720	0.0256	-0.2420	0.2798	1.8018	0.2475
30(3)	0.3541	0.2018	0.3881	2.6820	6.9115	0.7000	0.3674	0.5003	3.2220	0.2840
35(4)	1.0579	0.8921	0.6058	4.1481	6.8471	1.4787	1.0711	0.7099	4.5717	0.2699
40(5)	1.9561	1.7730	0.8004	5.7857	7.2281	2.6260	2.1078	0.8856	5.7031	0.2263
45(6)						4.8097	4.0809	0.9833	6.3321	0.1258
	Ave. Implied Fertility Level = 6.4						Estimated TFR = 6.3			

The estimates of the Gompertz parameters for Nigeria and regions for the period 2003-2018 are shown table 4.24. The beta values (β) measure the pace of childbearing; a value greater than one implies that childbearing is concentrated in a narrow age range. While Alpha values (α) are measures of the location or timing of childbearing with the standard. Increasing negative values of α depict a later onset and late end of childbearing. As can been seen from Table 2.23, in 2018 the β values are less than 1 in Nigeria, North Central, North West and North East which indicate that the distribution of childbearing was wide. However, childbearing was concentrated in narrower age in South West 2018 (1.1036), South East 2018 (1.0906), and South South 2018 (1.0703) compared to other regions.

Also, the estimated values of α are negative for Nigeria as whole and all the regions in 2018. The Gompertz parameters suggest two distinct patterns of fertility distribution in Nigeria. It appears there is a shift in pattern of childbearing in South West, South East and South South; while there is no shift in the country as whole and Northern regions. Based on the values α, a later onset and late end of childbearing was observed among women of South West 2018 (-0.3070), South East 2018 (-0.238) and South South (-0.1653) compared North West 2018 (-0.0378), North Central (-0.1002) and North East (-0.1303). The trend in location of fertility based α values were not consistent in all the regions.

Table 4.24: Gompertz Parameters by Regions for the Period 2003-2018

	2003	2008	2013	2018
BETA VALUES				
South West	0.9746	0.9479	1.0867	1.1036
South South	1.0601	0.8967	0.938	1.0703
South East	0.9857	1.0514	1.0555	1.0906
North East	1.1579	0.8324	0.9527	0.9738
North West	0.993	0.9669	0.9382	0.9730
North Central	0.9036	0.9808	1.0068	0.9897
Nigeria	0.9948	0.9398	0.9902	0.9958
ALPHA VALUES				
South West	-0.4704	-0.2449	-0.2919	-0.3071
South South	-0.1836	-0.3607	-0.3607	-0.1653
South East	-0.5393	-0.3806	-0.3729	-0.238
North East	0.1943	-0.0872	-0.0757	-0.1303
North West	0.067	0.0075	-0.0658	-0.0378
North Central	-0.2651	-0.1455	-0.2578	-0.1002
Nigeria	-0.1344	-0.1529	-0.1188	-0.1261

Figure 4.8 illustrates the trends in total fertility rates resulting from the application of relational Gompertz model. The results, according to the figure, show a marginal decline in Nigeria; a slow decline South West and North East. In South East, it appears fertility decline was rapid between 2003 and 2013, but stalled between 2013 and 2018. Also, accelerated fertility decline was observed in South South and North Central compared to other regions. Inconsistence was observed in North West. However, the level of fertility has been consistently lowest in the South West, and highest in the North West, except in 2003 where North East was highest.

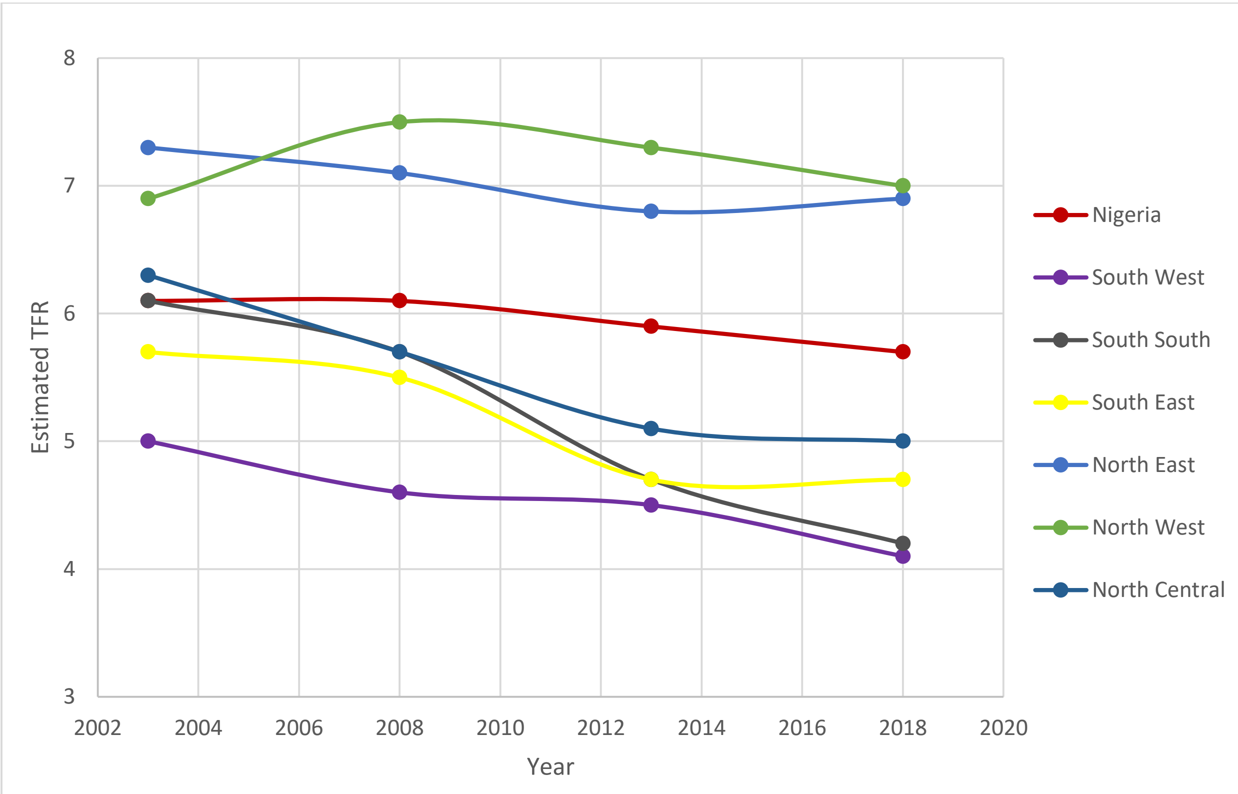


Figure 4.8: Trend in Estimated Total Fertility Rates by Nigeria and Regions 2003- 2018

Figures 4.9 show the Estimated and observed Age specific fertility rates by Age group for Nigeria, period 2003-2018. From the figure, the Estimated ASFRs in periods 2003-2018 were lower than the observed at the younger ages; but the observed ASFRs were lower at older ages than the fitted ASFRs. In the four survey rounds, the observed ASFRs peaked at aged 25-29 years and fitted ASFRs peaked at aged 30-34 years. Based on the curve of the estimated ASFRs, there is no striking difference among the periods which indicate a similar pattern of fertility exist between 2003 and 2018 in Nigeria.

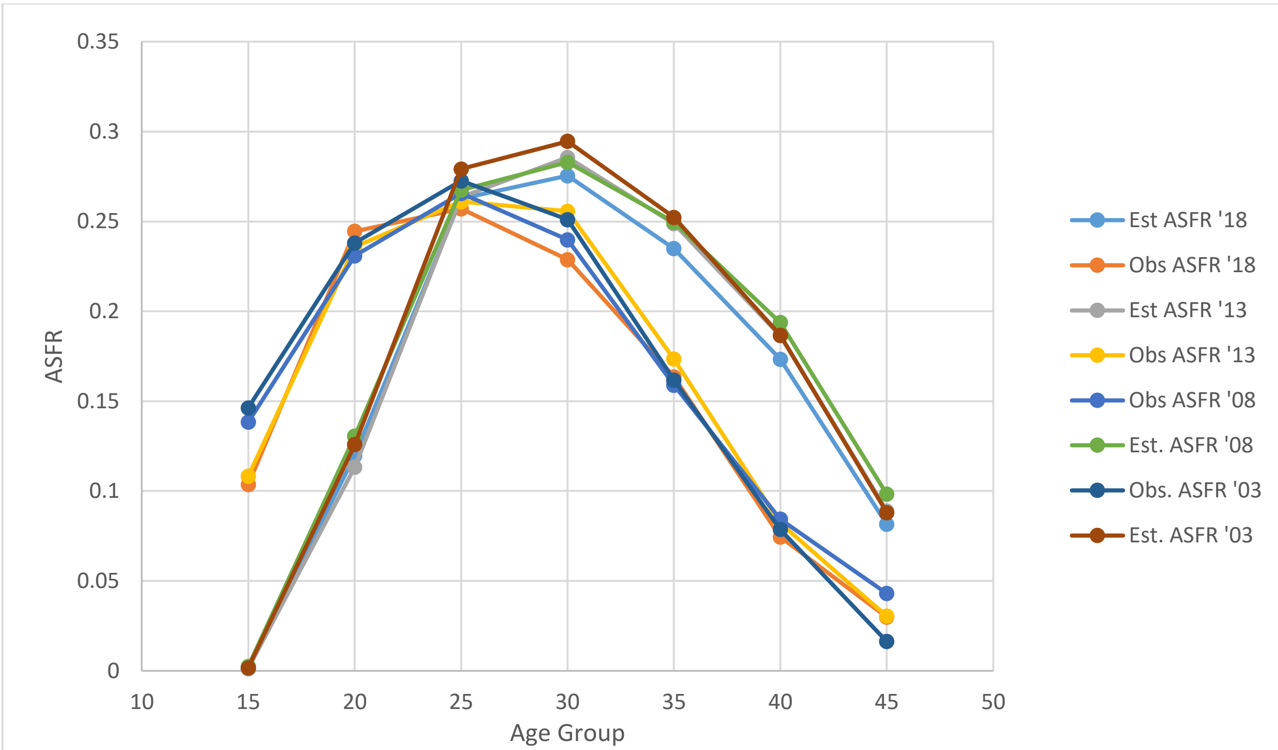


Figure 4.9: Age Specific Fertility Rates Observed and Estimated by years, Nigeria 2003-2018

Figures 4.10 show the Estimated and observed Age specific fertility rates by Age group for the six regions, 2003-2018. In North Central (NC), the estimated ASFRs curves reveal inconsistence in the shifts of age pattern in the time periods. At younger ages, the curves of the estimated ASFRs for the year periods lie on each other, however, they began to be differentiated at aged group 25-20 with estimated ASFRs 2018 as lowest and followed by 2008. At aged group 30-34 and 35-39, 2003 curve was lower than 2013 curve. Nevertheless, the curves of estimated ASFRs show that there was a shifts in age pattern of fertility at older ages in NC between 2003 and 2018.

For North East (NE), the Estimated ASFRs in periods 2003-2018 were lower than the observed at the younger ages, but lower at older ages than the fitted ASFRs. From the figure, the curve of estimated ASFRs in periods 2003-2018 were similar indicating there was no shift in age pattern of fertility in the region between 2003 and 2018. The estimated ASFRs for the periods peaked at age group 25-29 years. In North West, inconsistence in the shifts of age pattern of fertility was observed with the estimated ASFRs for 2003 being the lowest at older ages.

According to the curve, the South East (SE) estimated ASFRs for 2018, 2013, 2008 and 2003 were almost the same at younger ages, but varies at older ages. As expected, at later years the 2003 estimated ASFRs were the highest; while that of 2013 and 2008 were closed. The estimated ASFRs for 2018 were the lowest. It shows there have been shifts in age pattern of fertility in South East between 2003 and 2018. For South South, the curve of the estimated ASFRs for the periods revealed inconsistence in the shifts of age pattern. For instance, the older ages ASFRs 2013 were lower than that of 2008; in fact, that of 2003 were higher than 2008. However, a shift in age pattern of fertility was observed in SS between 2003 and 2018. Lastly in South West (SW), the curve of the estimated ASFRs for the periods differ at the older ages with ASFRs 2018 being the lowest and 2003 was the highest. This indicates a shifts in age pattern of fertility between 2003 and 2018 in SW.

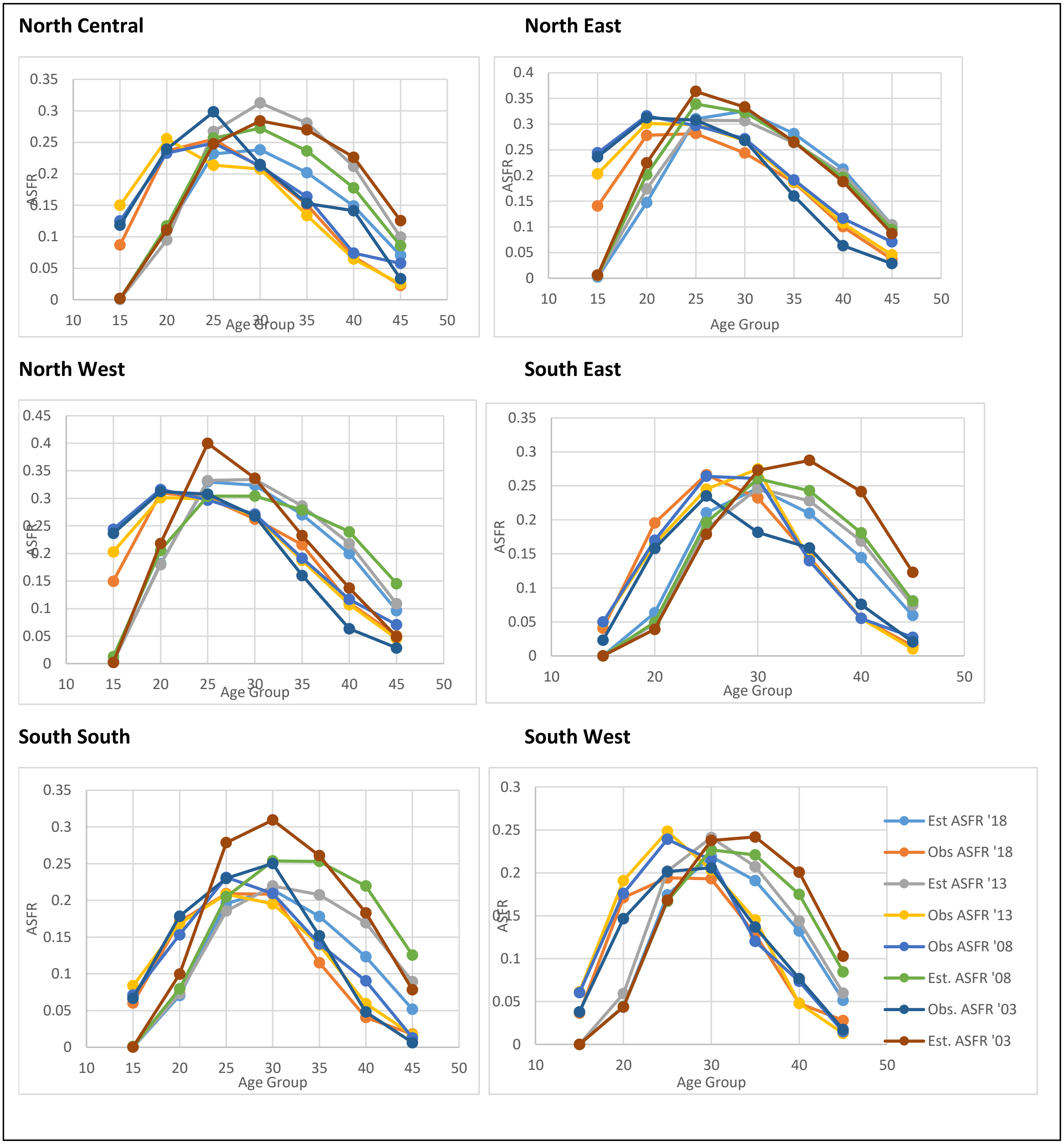


Figure 4.10: Age Specific Fertility Rates Observed and Estimated by years, 2003- 2018

4.3 Timing of Childbearing Trend Analyses

Figure 4.11 depicts the mean age at childbearing (MAB) at birth order 1, 2, 3 and 4. The figure shows the trend in timing of childbearing, Nigeria and the six geo-political zones. In the four birth orders, the mean ages at childbearing were lowest in North West and East. The mean age at first birth marginally increased between 2003 and 2018 in Nigeria. This indicates that the timing of childbearing has not changed substantially in Nigeria. The mean age at first birth was highest in South East 2003 and 2008; but the same with South West in 2013. In 2018, SW has highest mean age at order 1. Across the regions, it appears that the mean age remains unchanged between 2003 and 2008. Whereas, the mean age at first birth appears to increase more in NC compared to other zones. Nonetheless, there was at least a marginal increase in mean age at first birth order across the regions. It appears that the mean age at second birth (MA2B) marginally increased in Nigeria between 2003 and 2018. In NE, NW, and NC it seems the MA2B was static. Meanwhile, a persistence increase of MA2B was observed in SS; whereas, in SE the MA2B rose between 2003 and 2013, but fell between 2013 and 2018. In SW, the MA2B increased between 2003 and 2018; but the rate of increase was minimal compared to that of SS.

In Nigeria, the mean age at third birth order (MA3B) increased between 2003 and 2008; but stalled between 2008 and 2018. The same pattern was observed in NC. Furthermore, at third birth order the mean age of NE and NW were differentiated. An increase in MA3B was observed in NE between 2003 and 2018; while, in NW the timing of childbearing at third birth order remains unchanged. In 2003, the MA3B was almost the same in SW and SE; however, while there was increase in the MA3B between 2003 and 2018 in SW, the MA3B in SE decrease between 2003 and 2018. Also, there was a steady increase in SS MA3B between 2003 and 2018. At birth order four, inconsistence was observed in the trend of timing of childbearing in Nigeria, NC, SS, and SE. However, the mean age at fourth birth (MA4B) was clearly highest in SW; while NW and NE had the lowest MA4B. Between 2003 and 2018, timing of childbearing did not change in Nigeria and across the regions except SW where marginal increase was observed.

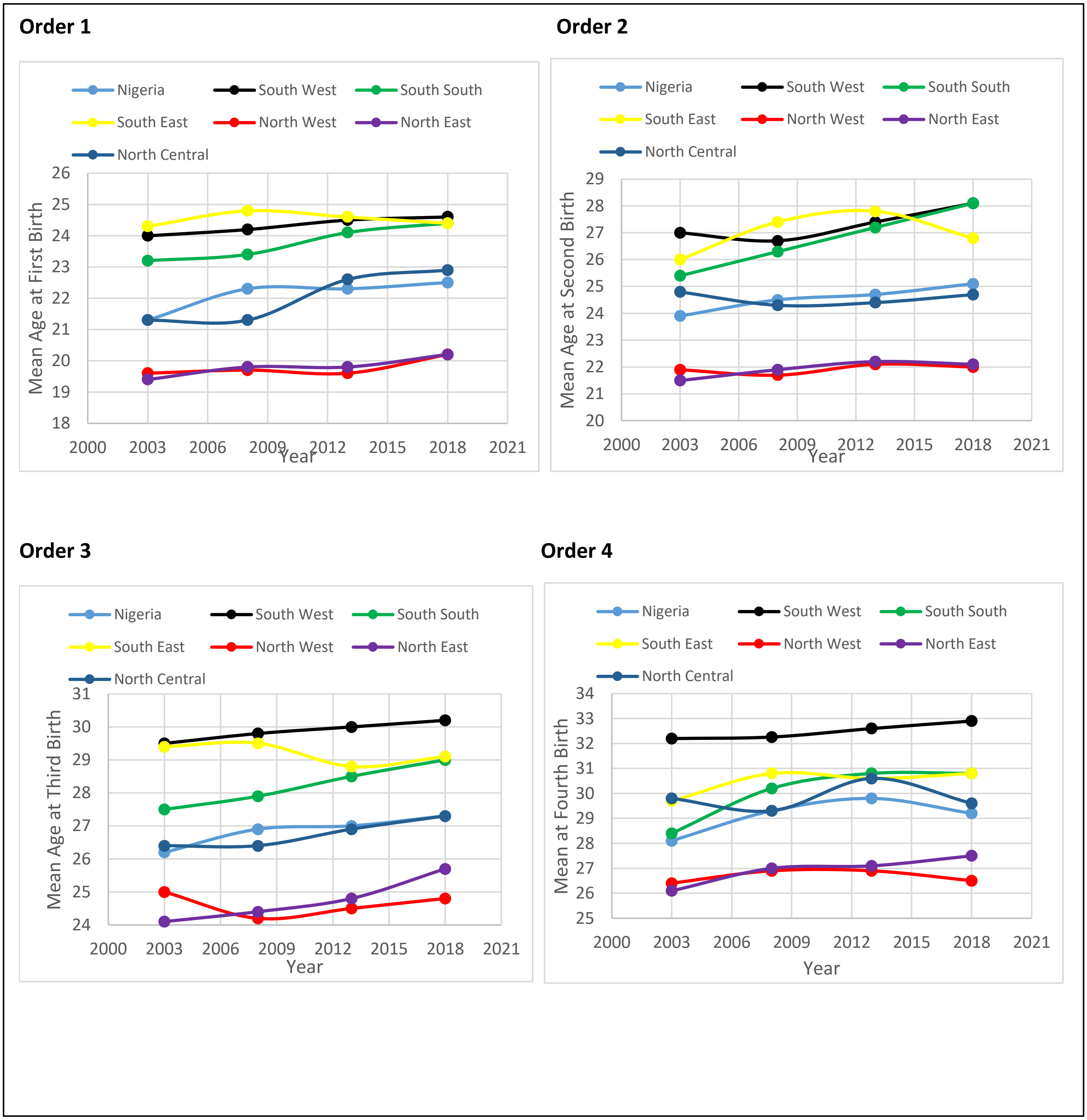


Figure 4.11: The mean age at childbearing (MAB)

Table 4.25 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for Nigeria periods 2003- 2018. According to the result, TFRobs (0.85) and TFRadj (0.86) at first birth order were almost the same in 2018. Likewise, in 2013 both TFRs were similar; however, in 2008 a marginal difference was observed in TFRobs (0.85) and TFRadj (0.89). At second birth order, TFRobs was 0.92 and TFRadj was 0.94 in 2018. In 2013, TFRobs and TFRadj were 0.95 and 0.96 respectively; and in 2008 TFRobs equals to 0.85 and TFRadj equals to 0.87. The third birth order followed the same pattern with that of second birth order; meanwhile, there were inconsistence with higher birth orders.

Figure 4.12 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, Nigeria 2008-2018. This helps to examine the tempo effect in the change of fertility level. The figure shows that tempo-adjusted TFR was higher than observed TFR in 2008 indicating an increase in the mean age at childbearing between 2003 and 2008. Whereas, the TFRobs and TFRadj appear to be equal in 2013 and 2018 which suggest constant mean age at childbearing. This reflects that the timing of childbearing has not change in Nigeria.

Table 4.25: TFR and tempo- adjusted TFR by birth Order, Nigeria

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	0.85	0.86	1.00	1.00	0.85	0.89
2	0.92	0.94	0.95	0.96	0.85	0.87
3	0.79	0.80	0.83	0.83	0.78	0.80
4	0.68	0.67	0.77	0.78	0.73	0.76
5	0.58	0.57	0.64	0.65	0.61	0.61
6	0.45	0.44	0.54	0.55	0.5	0.51
7	0.35	0.34	0.41	0.42	0.41	0.42
8	0.26	0.25	0.33	0.34	0.34	0.35
9	0.19	0.18	0.23	0.22	0.3	0.35
10+	0.14	0.14	0.15	0.15	0.18	0.19

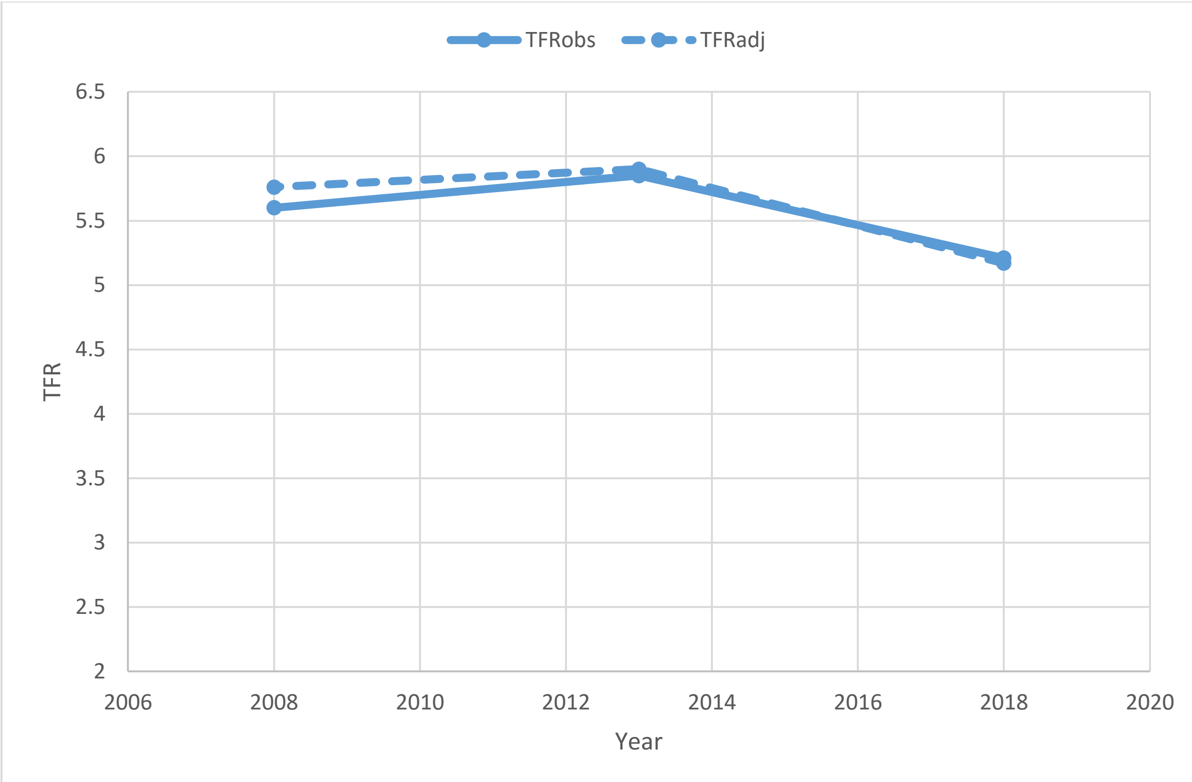


Figure 4.12: Observed TFR and tempo- adjusted TFR for all birth orders combined, Nigeria

Table 4.26 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for South West periods 2003- 2018. From the result, TFRobs (1.08) and TFRadj (1.08) at first birth order were equal in 2018.Whereas, in 2013 and 2008 marginal difference were observed in both TFRobs (1.02), TFRadj (1.03) and TFRobs (0.93), TFRadj (0.94) respectively. At second birth order, TFRobs was 1.01 and TFRadj was 1.04 in 2018. In 2013, TFRobs and TFRadj were 0.96 and 0.99 respectively; and in 2008 both TFRobs and TFRadj equal to 0.9. The trend in both TFRobs and TFRadj shows inconsistence in higher birth orders.

Figure 4.13 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, South West 2008-2018. The figure shows that tempo-adjusted TFR is less than observed TFR in 2008 indicating a decrease in the mean age at childbearing between 2003 and 2008. Whereas, the TFRadj was significanly higher than TFRobs in 2013; and in 2018 both TFRs were alsmost the same. The figure suggests a postponement of births between 2008 and 2013.

Table 4.26: TFR and tempo- adjusted TFR by birth Order, South West

	2018		2013		2008	
Order	**TFRobs**	**TFRajd**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	1.08	1.08	1.02	1.03	0.93	0.94
2	1.01	1.04	0.96	0.99	0.9	0.9
3	0.73	0.73	0.79	0.80	0.83	0.84
4	0.45	0.45	0.66	0.67	0.72	0.72
5	0.43	0.44	0.45	0.74	0.47	0.35
6	0.21	0.22	0.32	0.36	0.25	0.23
7	0.12	0.12	0.14	0.15	0.19	0.19
8	0.07	0.07	0.12	0.12	0.12	0.12
9	0.02	0.02	0.06	0.06	0.06	0.06
10+	0.0002	0.0002	0.04	0.04	0.03	0.03

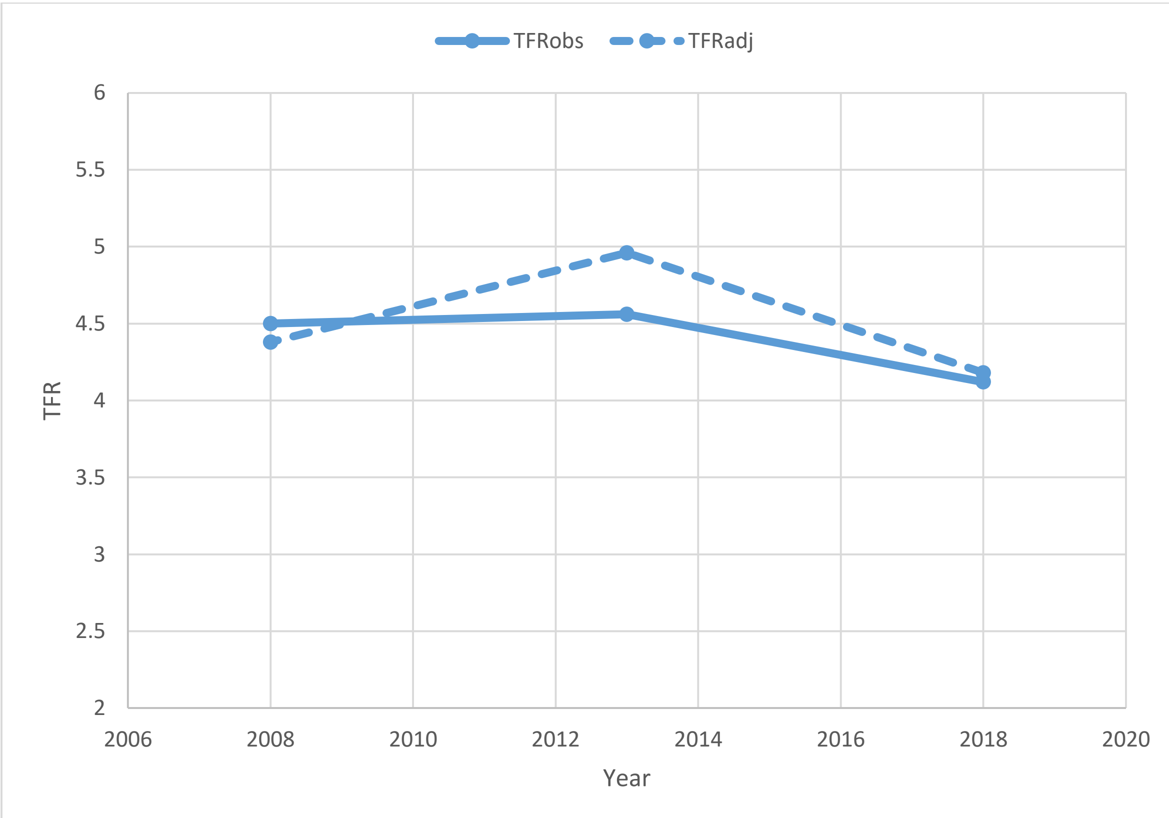


Figure 4.13: TFR and tempo- adjusted TFR for all birth orders combined, South West

Table 4.27 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for South East periods 2003- 2018. Based on the result, TFRobs (1.02) and TFRadj (1.03) at first birth order were not substantially different from each other in 2018.Whereas, in 2013 and 2008 marginal difference were observed in both TFRobs (0.93), TFRadj (0.96) and TFRobs (0.83), TFRadj (0.84) respectively. At second birth order, the change observed was more tangible than in first birth orders in the time periods. The TFRobs was 1.02 and TFRadj was 1.05 in 2018. In 2013, TFRobs and TFRadj were 0.86 and 0.89 respectively; and in 2008, TFRobs equals to 0.73 and TFRadj equal to 0.76. The trend in both TFRobs and TFRadj appear the same in higher birth orders.

Figure 4.14 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, South South 2008-2018. The figure shows that tempo-adjusted TFR was higher than observed TFR in all the time periods indicating an increase in the mean age at childbearing between 2003 and 2018.

Table 4.27: TFR and tempo- adjusted TFR by birth Order, South South

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	1.02	1.03	0.93	0.96	0.83	0.84
2	1.02	1.05	0.86	0.89	0.73	0.76
3	0.66	0.67	0.67	0.68	0.68	0.69
4	0.55	0.55	0.57	0.58	0.58	0.62
5	0.35	0.35	0.44	0.44	0.49	0.51
6	0.24	0.24	0.38	0.39	0.41	0.41
7	0.14	0.15	0.31	0.30	0.34	0.36
8	0.11	0.11	0.23	0.23	0.21	0.22
9	0.07	0.07	0.08	0.08	0.2	0.24
10+	0.04	0.04	0.05	0.05	0.12	0.13

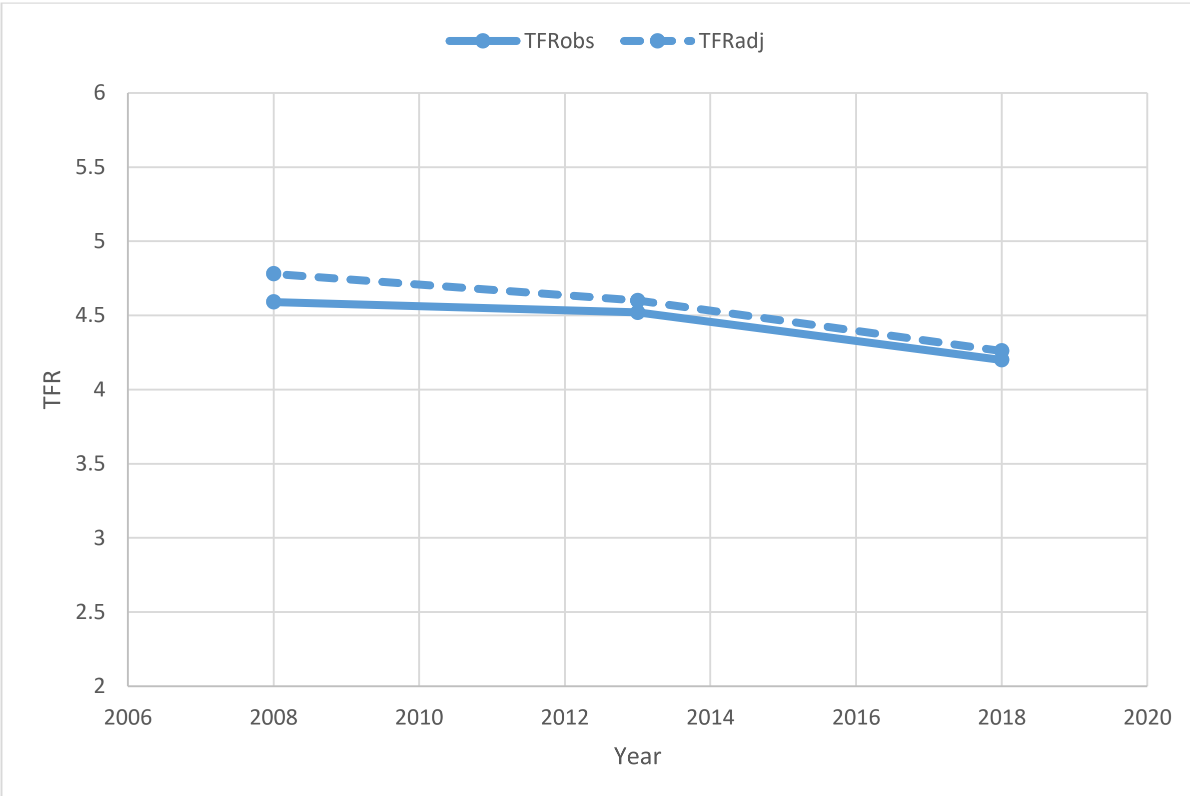


Figure 4.14: TFR and tempo- adjusted TFR for all birth orders combined, South South

Table 4.28 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for South East periods 2003- 2018. According to the result, both TFRobs and TFRadj at first birth order were equal to one in 2018.Whereas, in 2013 and 2008 marginal difference were observed in both TFRobs (0.91), TFRadj (0.92) and TFRobs (0.92), TFRadj (0.91) respectively. At second birth order, the change observed was more tangible than in first birth orders in the time periods. The TFRobs was 0.89 and TFRadj was 0.86 in 2018. In 2013, TFRobs and TFRadj were 0.83 and 0.84 respectively; and in 2008, TFRobs equals to 0.8 and TFRadj equal to 0.85. The trend in both TFRobs and TFRadj appear the same in higher birth orders.

Figure 4.15 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, South East 2008-2018. The figure shows that tempo-adjusted TFR was almost the same with the observed TFR in all the time periods indicating a stable mean age at childbearing between 2003 and 2018.

Table 4.28: TFR and tempo- adjusted TFR by birth Order, South East

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	1.0	1.0	0.92	0.91	0.9	0.92
2	0.89	0.86	0.83	0.84	0.8	0.85
3	0.78	0.79	0.72	0.70	0.73	0.73
4	0.70	0.70	0.57	0.57	0.68	0.71
5	0.59	0.61	0.45	0.45	0.51	0.52
6	0.37	0.39	0.4	0.40	0.49	0.47
7	0.19	0.19	0.29	0.28	0.31	0.29
8	0.09	0.09	0.27	0.27	0.18	0.17
9	0.08	0.08	0.11	0.11	0.13	0.14
10+	0.002	0.002	0.08	0.08	0.06	0.06

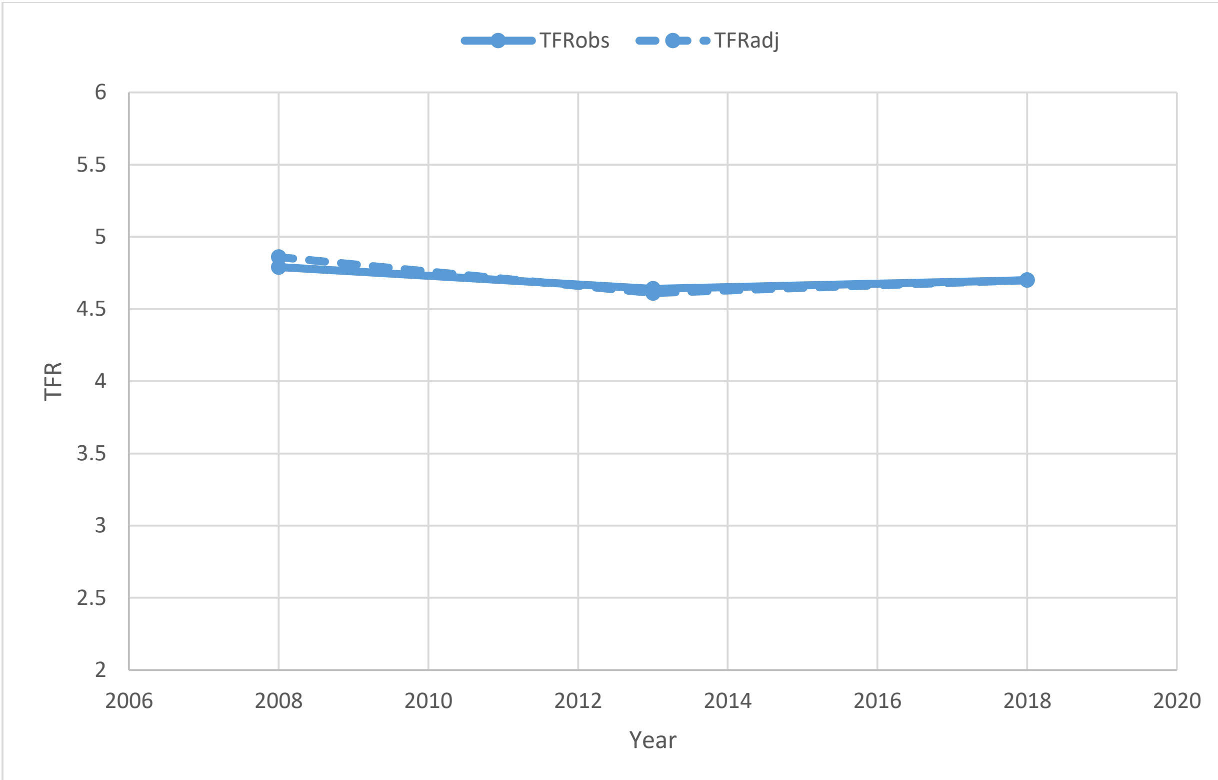


Figure 4.15: TFR and tempo- adjusted TFR for all birth orders combined, South East

Table 4.29 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for North West periods 2003- 2018. According to the result, at first birth order the TFRobs (0.75) was less than TFRadj (0.77) in 2018.Whereas, in 2013 and 2008 similar patterns were observed in both TFRobs (0.78), TFRadj (0.78) and TFRobs (0.84), TFRadj (0.84) respectively. At second birth order the TFRobs was 0.79 and TFRadj was 0.79 in 2018. In 2013, TFRobs and TFRadj were 0.8 and 0.82 respectively; and in 2008, TFRobs equals to 0.91 and TFRadj equal to 0.9. The trend in both TFRobs and TFRadj appear inconsistent in higher birth orders.

Figure 4.16 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, North West 2008-2018. The figure shows that tempo-adjusted TFR lies above observed TFR in 2008 suggesting an increase in MAB between 2003 and 2008; however, in 2013 and 2018 the adjusted and observed TFR lie on each other indicating a stable mean age at childbearing between 2008 and 2018.

Table 4.29: TFR and tempo- adjusted TFR by birth Order, North West

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	0.75	0.77	0.78	0.78	0.84	0.84
2	0.79	0.79	0.8	0.82	0.91	0.90
3	0.77	0.78	0.75	0.76	0.83	0.80
4	0.71	0.70	0.76	0.76	0.81	0.83
5	0.70	0.68	0.71	0.72	0.78	0.80
6	0.66	0.65	0.67	0.67	0.66	0.68
7	0.61	0.60	0.6	0.59	0.59	0.62
8	0.53	0.52	0.51	0.51	0.6	0.64
9	0.39	0.39	0.42	0.39	0.52	0.59
10+	0.35	0.35	0.29	0.29	0.36	0.35

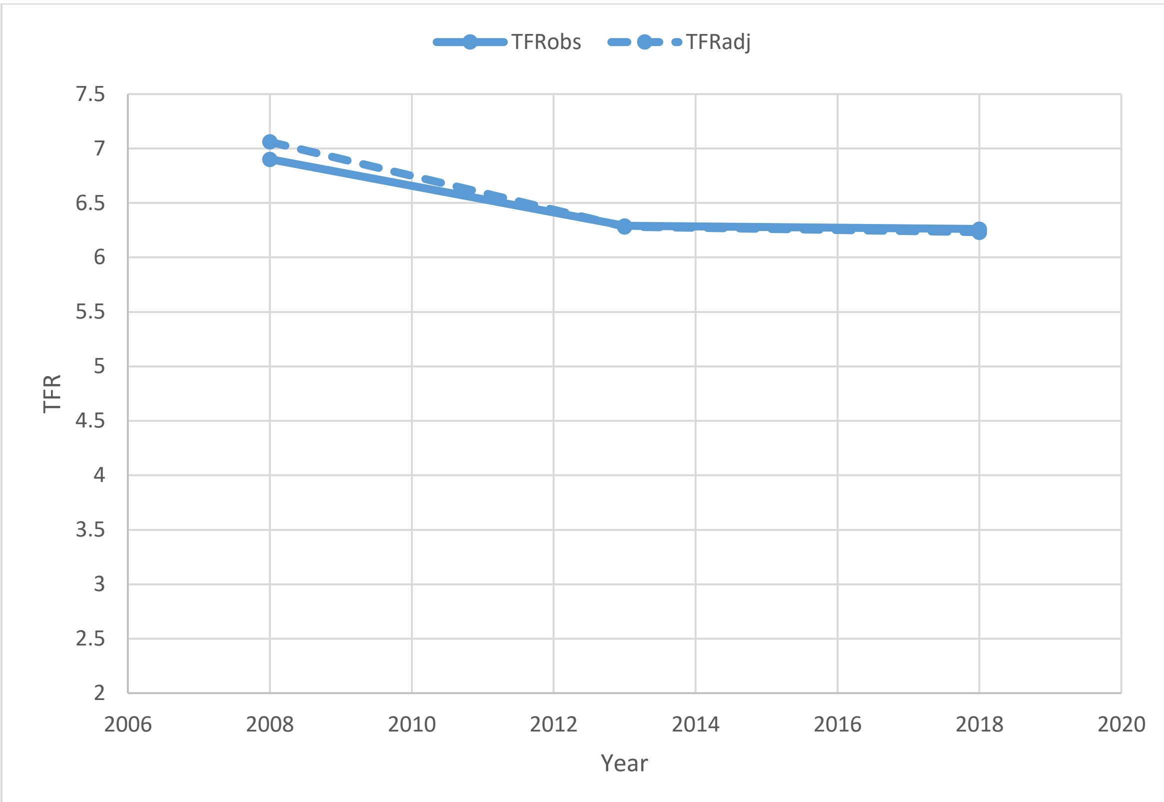


Figure 4.16: TFR and tempo- adjusted TFR for all birth orders combined, North West

Table 4.30 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for North East periods 2003- 2018. According to the result, at first birth order the TFRobs (0.78) was less than TFRadj (0.80) in 2018.Whereas, in 2013 a similar pattern was observed in both TFRobs (0.82) and TFRadj (0.82); but in 2013 TFRobs (0.79) was less than TFRadj (0.81). At second birth order both TFRobs and TFRadj was 0.79 in 2018. In 2013, TFRobs and TFRadj were 0.81 and 0.82 respectively; and in 2008, TFRobs equals to 0.83 and TFRadj equal to 0.85. The trend in both TFRobs and TFRadj appear inconsistent in higher birth orders.

Figure 4.17 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, North East 2008-2018. The figure shows that tempo-adjusted TFR lies on observed TFR in 2008 and 2013 suggesting a constant in MAB between 2003 and 2013; however, in 2018 the adjusted lie a little above observed TFR lie indicating an increase of mean age at childbearing between 2008 and 2018.

Table 4.30: TFR and tempo- adjusted TFR by birth Order, North East

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	0.78	0.80	0.82	0.82	0.79	0.81
2	0.79	0.79	0.81	0.82	0.83	0.85
3	0.83	0.86	0.75	0.76	0.79	0.80
4	0.73	0.74	0.68	0.68	0.86	0.89
5	0.67	0.68	0.72	0.73	0.78	0.76
6	0.61	0.61	0.6	0.61	0.73	0.76
7	0.55	0.57	0.59	0.60	0.61	0.61
8	0.40	0.40	0.48	0.48	0.56	0.56
9	0.31	0.32	0.35	0.32	0.53	0.63
10+	0.26	0.26	0.22	0.22	0.37	0.42

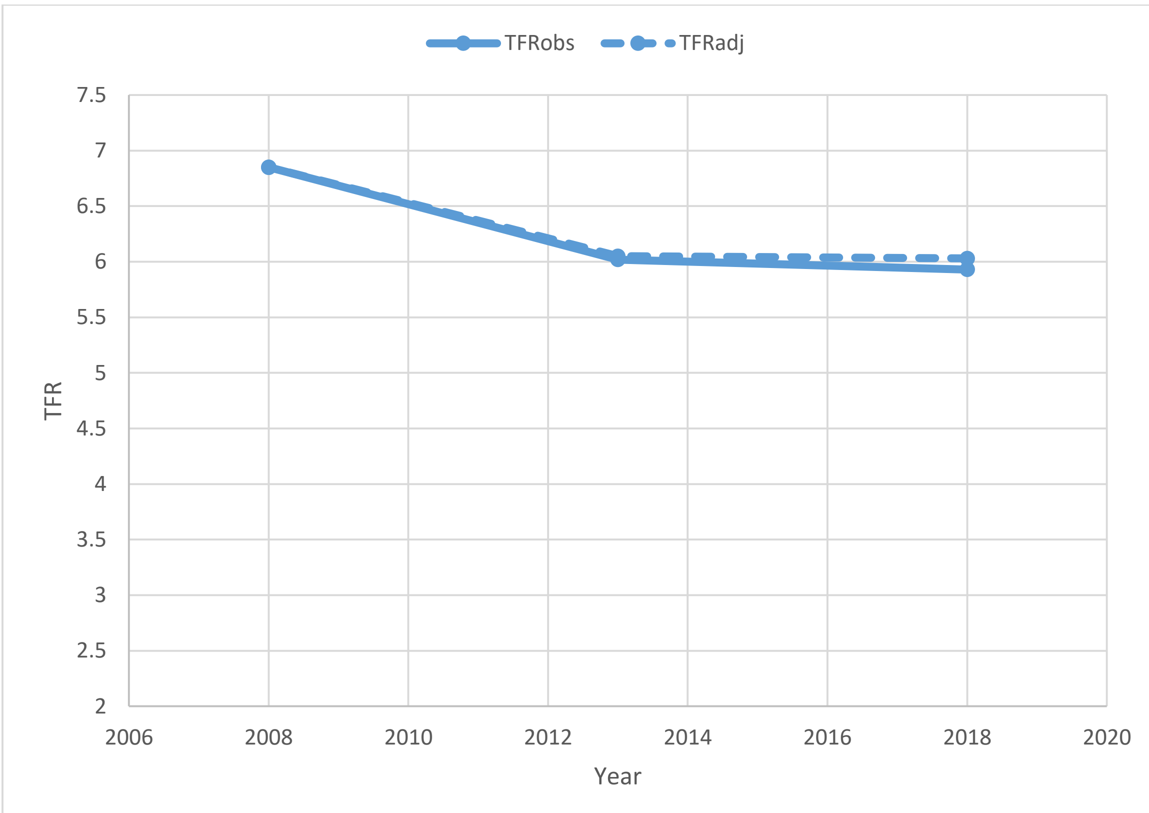


Figure 4.17: TFR and tempo- adjusted TFR for all birth orders combined, North East

Table 4.31 shows the observed total fertility rate (TFRobs) and tempo- adjusted total fertility rate (TFRadj) by birth orders for North Central periods 2003- 2018. From the result, TFRobs (0.93) and TFRadj (0.94) at first birth order were almost the same in 2018.Whereas, in 2013 marginal difference was observed in both TFRobs (0.82), TFRadj (0.88); and in 2008 TFRobs (0.75), TFRadj (0.75) were equal. At second birth order, TFRobs was 0.89 and TFRadj was 0.9 in 2018. In 2013, both TFRobs and TFRadj were equal to 0.87; and in 2008 both TFRobs and TFRadj were 0.8 and 0.78 respectively. The trend in both TFRobs and TFRadj shows inconsistence in higher birth orders.

Figure 4.18 compares Observed TFR and tempo-adjusted TFR for all birth orders combined, North Central 2008-2018. The figure shows that tempo-adjusted TFR lie above observed TFR in 2008 and 2013 indicating an increase in the mean age at childbearing between 2003 and 2013. Whereas, in 2018 both TFRs were alsmost the same. The figure suggests a postponement of births between 2003 and 2018.

Table 4.31: TFR and tempo- adjusted TFR by birth Order, North Central

	2018		2013		2008	
Order	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**	**TFRobs**	**TFRadj**
1	0.93	0.94	0.82	0.88	0.75	0.75
2	0.89	0.90	0.87	0.87	0.8	0.78
3	0.78	0.79	0.78	0.80	0.73	0.73
4	0.68	0.66	0.68	0.71	0.66	0.65
5	0.58	0.58	0.66	0.67	0.63	0.63
6	0.48	0.46	0.62	0.64	0.54	0.54
7	0.29	0.28	0.32	0.33	0.45	0.44
8	0.24	0.24	0.26	0.26	0.36	0.36
9	0.10	0.10	0.16	0.15	0.31	0.38
10+	0.05	0.05	0.05	0.05	0.12	0.13

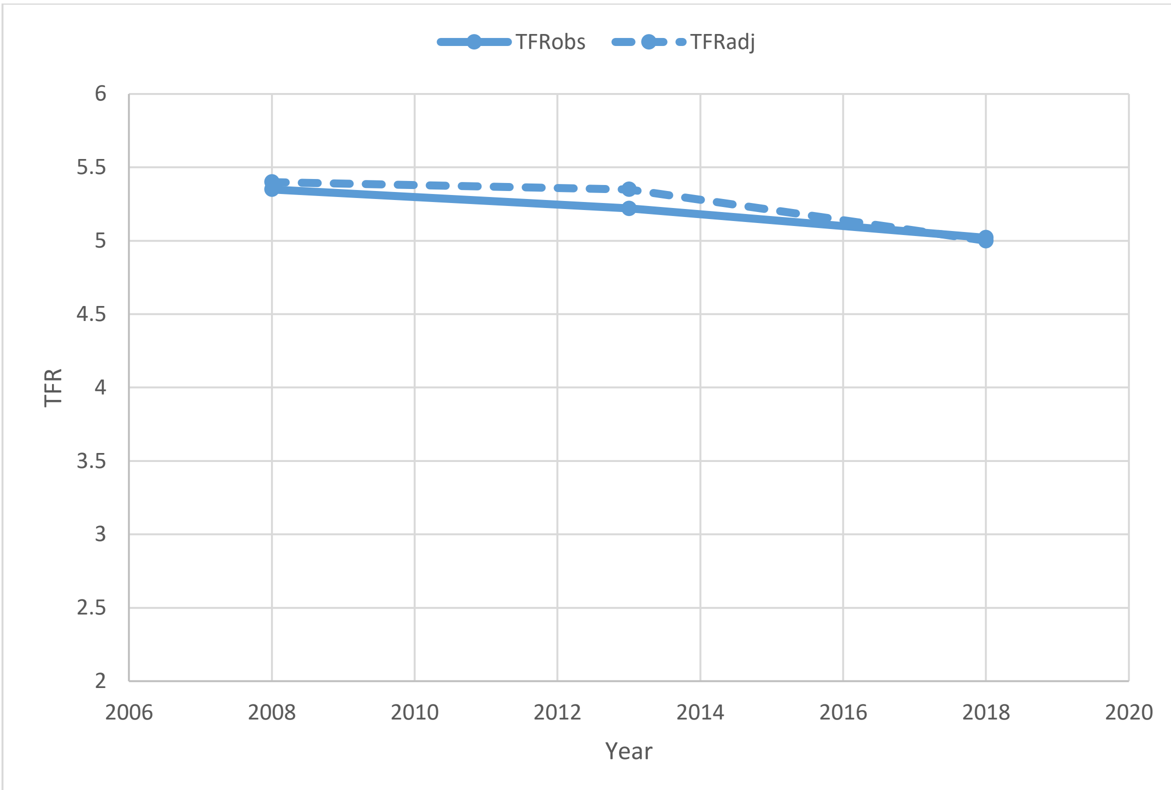


Figure 4.18: TFR and tempo- adjusted TFR for all birth orders combined, North Central

4.4 Timing of Fertility Convergence to Replacement Level

Tables 4.32 and Figure 4.19 & 4.20. show the estimated annual change in ASFR used for projection, Estimated and UN model of years of convergence to transitional stage and replacement level. Based on the result at each age group, the annual change in South South were the highest: 15-19 (0.001038), 20-24 (0.00382), 25-29 (0.00417), 30-34 (0.00305), 35-39 (0.0015), 40-44 (0.000389), and 45-49 (0.000031); and followed by South West. Also, the values of North East and North West were not different. According to the result, the estimated year of convergence to replacement level in Nigeria, South West, South South, South East, North West, North East, and North Central are 2089, 2040, 2036, 2040, 2112, 2108, and 2069 respectively. While, UN model give year of convergence to replacement level for Nigeria and six regions as: Nigeria (2073), South West (2061), South South (2062), South East (2062), North West (2086), North East (2083), and North Central (2065).

Table 4.32: Estimated Annual Change in ASFR used for Projection

	15	20	25	30	35	40	45
Nigeria	0.000741	0.00273	0.00298	0.002175	0.001073	0.000278	0.000022
South West	0.001379	0.005078	0.005543	0.004046	0.001995	0.000517	0.000042
South South	0.001824	0.006716	0.007331	0.005352	0.002639	0.000683	0.000055
South East	0.001186	0.004368	0.004768	0.003481	0.001716	0.000444	0.000036
North West	0.000741	0.00273	0.00298	0.002175	0.001073	0.000278	0.000022
North East	0.000741	0.00273	0.00298	0.002175	0.001073	0.000278	0.000022
North Central	0.00089	0.003276	0.003576	0.002611	0.001287	0.000333	0.000027

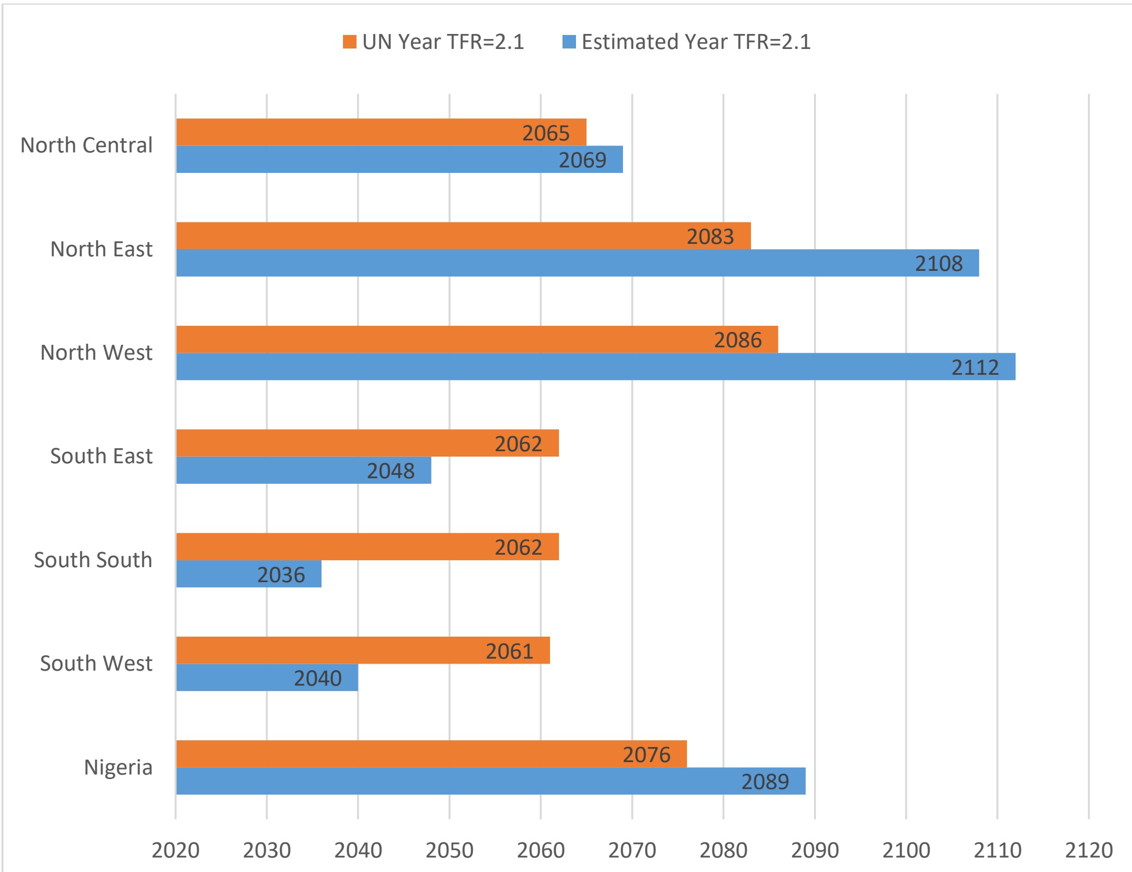


Figure 4.19: Estimated and UN model of Years of convergence to Replacement level

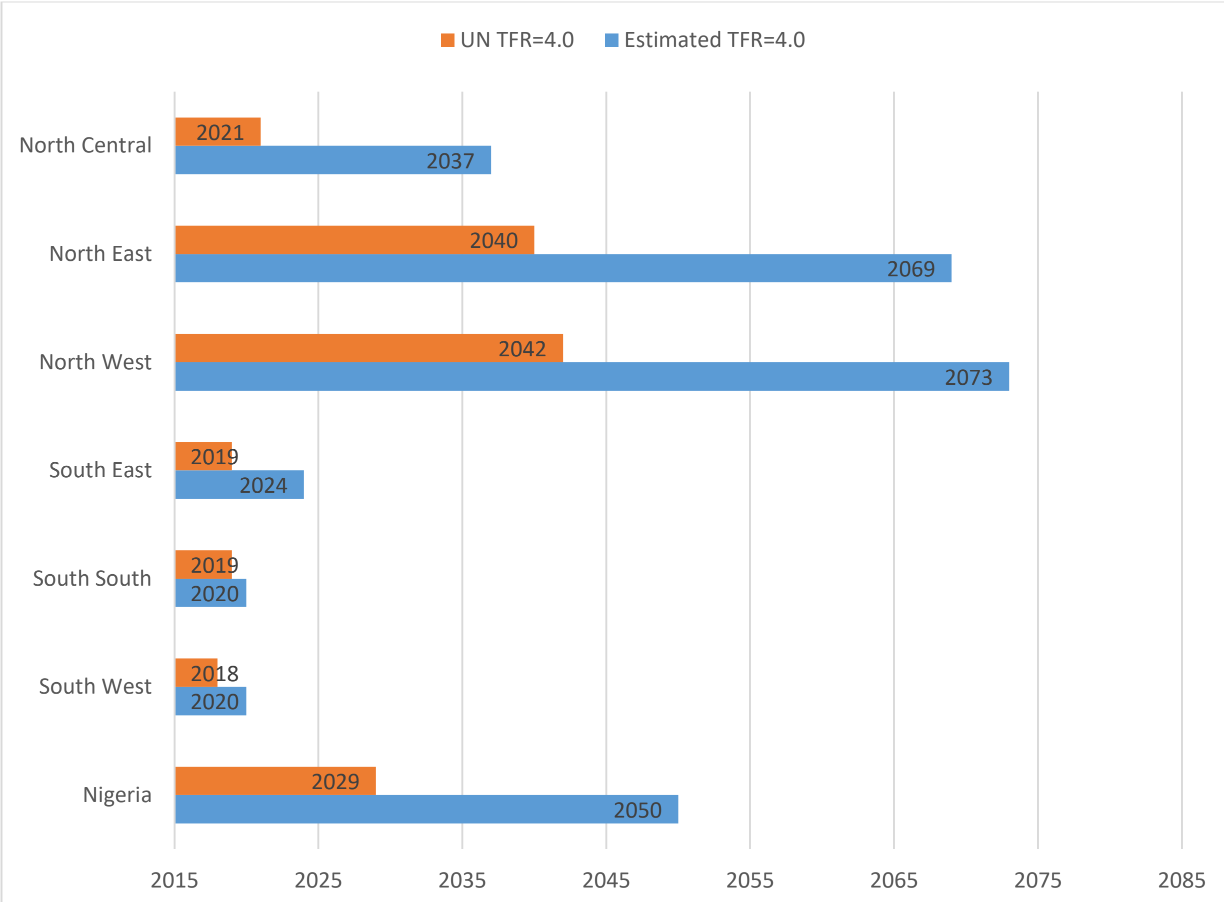


Figure 4.20: Estimated and UN model of Years of convergence to Transitional stage

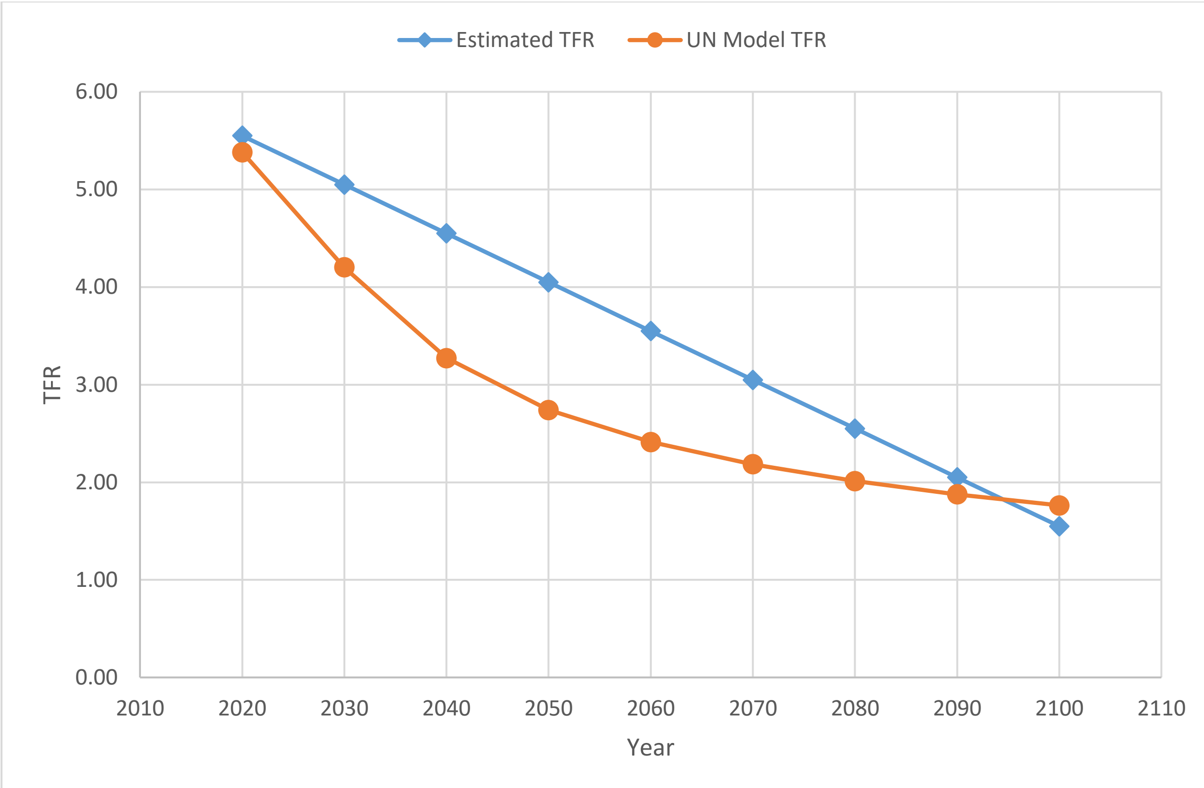


Figure 4.21: Projection of TFR by Estimated and UN Model, Nigeria

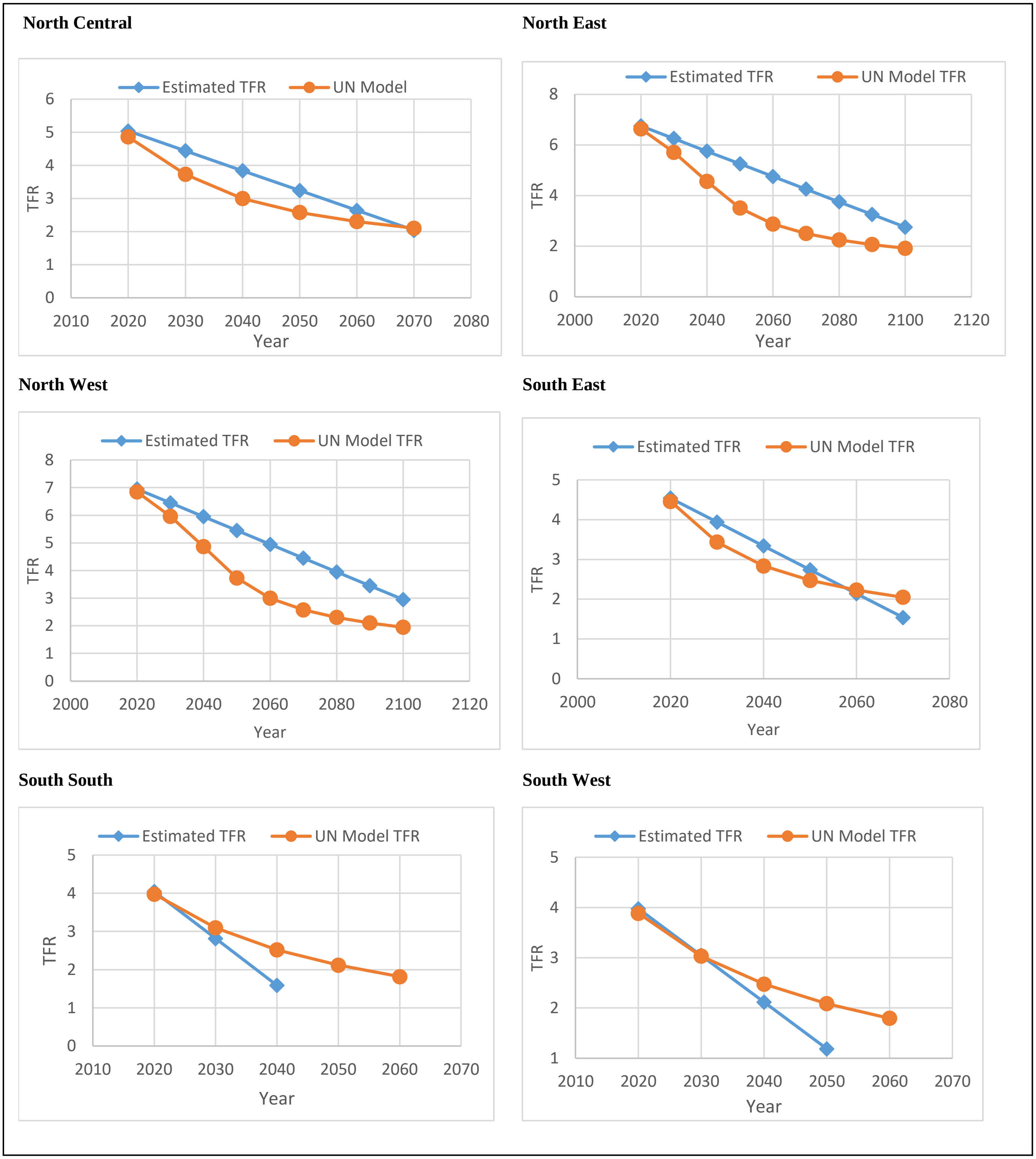


Figure 4.22: Projection of TFR by Estimated and UN Model, all region

4.5 Multivariate Analyses of Fertility Level

Table 4.33 shows the Ratio Rates of total fertility rate (TFR) by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, Nigeria 2003, 2008, 2013 & 2018. According to the result, in 2018 the rate ratios of women with higher education compared to those with no education is 0.67; this indicates that highly educated women's fertility is about 33% lower than women with no education in Nigeria. The women who reside in rural areas were 1.08 times more likely to be exposed to the risk of fertility than their counterpart in urban area. Also, based on the result fertility is higher among women who practice Islam than those that are Christian. Similarly, the rate ratio of rich women compared to the poor women is 0.87. As expected, the risk of fertility is higher among women who were not using modern contraceptive than those that were using. The pattern of result is the same in the year periods; and the variable were significant.

Table 4.33: Ratio Rates of Fertility levels by Background Variables, Nigeria 2003, 2008, 2013 & 2018

	Rate Ratios			
Background Variables	**2003**	**2008**	**2013**	**2018**
	RR	**RR**	**RR**	**RR**
Education				
None (ref.)				
Primary	1.07	0.99	1.01	0.95**
Secondary	0.72***	0.69***	0.78***	0.82***
Higher	0.49***	0.49***	0.59***	0.67***
Place of Residence				
Urban (ref.)				
Rural	1.07*	1.02	1.06***	1.08***
Religion				
Christian (ref.)				
Islam	1.43***	1.19***	1.18***	1.24***
Others	1.36**	1.12**	1.12*	1.12
Wealth Index				
Poor (ref.)				
Middle	0.97	0.94***	0.92***	0.96**
Rich	0.93	0.89***	0.88***	0.87***
Modern Contraceptive Use				
No (ref.)				
Yes	1.2***	1.1	0.9***	1.17***

*p < 0.1; ** p < 0.05; *** p < 0.01

Table 4.34 shows the Ratio Rates of TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, South West 2003, 2008, 2013 & 2018. The result indicates that the risk of fertility amongst women with higher education was 23% lower than those without any formal education in 2018. The women who reside in rural were 1.17 times more likely to be exposed to the risk of fertility than their counterpart in urban area. Also, based on the result fertility was higher among women who practice Islam compared to those who are Christian. Similarly, the rate ratio of women from the rich household compared to the poor women was 0.86 which suggests fertility was higher among women from poor household than those from rich household. As revealed in the result, the risk of fertility was significantly higher among women who were currently using modern contraceptive (1.19) than those that were not using in 2018.

Table 4.34: Ratio Rates of Fertility levels by Background Variables, South West 2003, 2008, 2013 & 2018

Background	Rate Ratios			
Variable	2003	2008	2013	2018
	RR	RR	RR	RR
Education				
None (ref.)				
Primary	1.14	1.05	1.04	1.0
Secondary	0.85	0.83**	0.89	0.91
Higher	0.48***	0.56***	0.71***	0.77***
Place of Residence				
Urban (ref.)				
Rural	0.96	1.17	1.15**	1.17***
Religion				
Christian (ref.)				
Islam	1.19*	1.02	1.07	1.15***
Others	1.33	0.75	1.02	0.42
Wealth Index				
Poor (ref.)				
Middle	1.04	0.9	1.02	0.98
Rich	0.87	0.98	0.92	0.86*
Modern Contraceptive Use				
No (ref.)				
Yes	1.24*	1.15**	0.85***	1.19***

*p < 0.1; ** p < 0.05; *** p < 0.01

Table 4.35 shows the Ratio Rates of TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, South South 2003, 2008, 2013 & 2018. The 2018 data shows that fertility among women with higher education was equal to 31% fertility of women with no education. The data show that there was no gap between rural-urban fertility in South South. Also, the data indicates that the rate ratios of women who were rich compared to those that were poor 0.77. This indicate that fertility level was higher among poor women when compared with rich women. Similarly, the risk of fertility is 16 % higher among women who were not using modern contraceptive than those that were using in 2013.

Table 4.35: Ratio Rates of Fertility level by Background Variables, South South 2003, 2008, 2013 & 2018

	Rate Ratios			
Background Variables	**2003**	**2008**	**2013**	**2018**
	RR	**RR**	**RR**	**RR**
Education				
None (ref.)				
Primary	1.31	1.12	0.99	0.92
Secondary	1.12	0.89	0.81**	0.93
Higher	0.87	0.51***	0.54***	0.69***
Place of Residence				
Urban (ref.)				
Rural	1.32**	1.06	1.01	0.99
Religion				
Christian (ref.)				
Islam	1.12	1.22	0.94	1.28*
Others	1.03	1.17	0.73	1.22**
Wealth Index				
Poor (ref.)				
Middle	0.83	0.93	0.99	0.86**
Rich	0.79	0.82***	0.86**	0.77***
Modern Contraceptive Use				
No (ref.)				
Yes	1.18	0.92	0.84***	1.02

*p < 0.1; ** p < 0.05 *** p < 0.001

Table 4.36 shows the Ratio Rates of TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, South East 2003, 2008, 2013 & 2018. In 2018 and 2013, the rate ratios of women with higher education compared to those with no education were 0.80 and 0.62 respectively. This indicates that highly educated women' fertility was 38% lower than women with no education in 2013 and it was significant. The fertility differentials among uneducated and educated women shrink in 2018 compared to 2013; and it was not significant. Similarly, the rate ratio of rich women compared to the poor women is 0.82 which suggests a higher risk of fertility among the poor women compared to the rich women. Expectedly, the risk of fertility is 21% significantly higher among women who were not using modern contraceptive than those that were using in 2013. However, in 2018 the risk of fertility was higher among those using modern contraceptive compared to those not using.

Table 4.36: Ratio Rates of Fertility level by Background Variables, South East 2003, 2008, 2013 & 2018

	Rate Ratios			
Background Variables	**2003**	**2008**	**2013**	**2018**
	RR	**RR**	**RR**	**RR**
Education				
None (ref.)				
Primary	1.08	1.11	1.17	1.21
Secondary	0.73	0.93	1.01	1.11
Higher	0.48**	0.6***	0.62***	0.80
Place of Residence				
Urban (ref.)				
Rural	0.93	0.98	1.07	1.09**
Religion				
Christian (ref.)				
Islam	0.000001	0.86	0.93	1.34
Others	1.22	1.22*	1.12	0.94
Wealth Index				
Poor (ref.)				
Middle	0.85	0.86*	0.8***	0.88*
Rich	0.69**	0.84**	0.86**	0.82***
Modern Contraceptive Use				
No (ref.)				
Yes	1.34*	1.18**	0.79***	1.29***

*p < 0.1; ** p < 0.05 *** p < 0.001

Table 4.37 shows the Ratio Rates TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, North West 2003, 2008, 2013 & 2018. The result indicates that fertility of women with higher education was 50% and 39% significantly lower than women with no education in 2013 and 2018 respectively. In 2013, the women who resides in rural are 1.15 times more likely to be exposed to the risk of fertility than their counterpart in urban area. The same pattern was observed in all the year periods. There was no notable different in fertility of rich and poor women in all the survey rounds. The risk of fertility was higher among women who were using modern contraceptive than those that were not using. This was observed in all the year periods.

Table 4.37: Ratio Rates of Fertility level by Background Variables, North West 2003, 2008, 2013 & 2018

Background Variables	Rate Ratios			
	2003	2008	2013	2018
	RR	RR	RR	RR
Education				
None (ref.)				
Primary	1.21**	1.07	0.99	0.98
Secondary	0.9	0.68***	0.7***	0.68***
Higher	0.57**	0.52***	0.5***	0.61***
Place of Residence				
Urban (ref.)				
Rural	1.08	1.07	1.15***	1.12***
Religion				
Christian (ref.)				
Islam	1.42**	1.4***	1.49***	1.36***
Others	1.35	1.25*	1.5	1.21
Wealth Index				
Poor (ref.)				
Middle	0.6	1.04	0.99	1.04
Rich	0.99	0.99	1.02	0.95
Modern Contraceptive Use				
No (ref.)				
Yes	1.32*	1.33***	1.08	1.27***

*p < 0.1; ** p < 0.05 *** p < 0.001

Table 4.38 shows the Ratio Rates of TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, North East 2003, 2008, 2013 & 2018. Just like North West, fertility of women with higher education was 49% and 44% significantly lower than women with no education in 2013 and 2018 respectively. In 2018, the women who resides in rural are 1.12 times more likely to be exposed to the risk of fertility than their counterpart in urban area. Similar pattern was observed in all the year periods except 2008. There was no notable different in fertility of rich and poor women in 2018. The risk of fertility was higher among women who were using modern contraceptive than those that were not using. This was observed in all the year periods.

Table 4.38: Ratio Rates of Fertility level by Background Variables, North East 2003, 2008, 2013 & 2018

Background Variable	Rate Ratios			
	2003	2008	2013	2018
	RR	RR	RR	RR
Education				
None (ref.)				
Primary	1.06	0.99	1.05	0.97
Secondary	0.84	0.65***	0.8***	0.77***
Higher	0.48***	0.43***	0.51***	0.56***
Place of Residence				
Urban (ref.)				
Rural	1.08	0.97	1.03	1.12**
Religion				
Christian (ref.)				
Islam	1.42***	1.2***	1.2***	1.27***
Others	1.51	1.13	1.19	0.0002
Wealth Index				
Poor (ref.)				
Middle	1.01	0.96	0.91**	1.03
Rich	1	0.91	0.91	0.98
Modern Contraceptive Use				
No (ref.)				
Yes	1.41*	1.24***	1.23**	1.29***

*p < 0.1; ** p < 0.05 *** p < 0.001

Table 4.39 shows the Ratio Rates of TFR by Education, Place of Residence, Religion, Wealth Index and Modern Contraceptive Use, North Central 2003, 2008, 2013 & 2018. Highly educated women' fertility was 16% lower than women with no education; and it is significant. The rural – urban fertility gap was observed with rural areas having higher fertility. Similarly, the rate ratio of rich women compared to the poor women was 0.81 and 0.82 in 2013 and 2018 respectively. This suggests a higher risk of fertility among the poor women compared to the rich women in NC. Though not significant, the risk of fertility was higher among women who were using modern contraceptive than those that were not using in 2018. This pattern was noticed in 2013 as well.

Table 4.39: Ratio Rates of Fertility level by Background Variables North Central 2003, 2008 & 2013

Background Variables	**Rate Ratios**			
	2003	**2008**	**2013**	**2018**
	RR	**RR**	**RR**	**RR**
Education				
None (ref.)				
Primary	1.08	1	0.99	0.99
Secondary	0.74**	0.66***	0.79***	0.93
Higher	0.4***	0.51***	0.62***	0.84**
Place of Residence				
Urban (ref.)				
Rural	1.22**	0.97	1.07	1.09**
Religion				
Christian (ref.)				
Islam	1.25**	1.11**	1.18***	1.28***
Others	1.23	1.19	1.16	0.95
Wealth Index				
Poor (ref.)				
Middle	0.97	0.89***	0.89**	0.88***
Rich	1.11	0.82***	0.81***	0.82***
Modern Contraceptive Use				
No (ref.)				
Yes	1.15	1.1	1.1	1.09*

*p < 0.1; ** p < 0.05 *** p < 0.001

4.6 Decomposition of the change in Fertility Level

Table 4.40 shows the estimated proximate determinants and total fertility rate by regions and Nigeria, 2003 & 2018. As indicated in the table, the Estimated TFR based on estimated proximate determinants for Nigeria and regions are as follows: Nigeria 2003 (6.0), Nigeria 2018 (5.59), North Central 2003 (5.72), North Central 2018 (5.48), North East 2003 (6.87), North East 2018 (6.54), North West 2003 (7.25), North West 2018 (6.85), South East 2003 (5.06), South East 2018 (4.86), South South 2003(5.04), South South 2018 (4.36), South West 2003 (4.88), South West 2018 (4.26). In 2003, fertility inhibiting effect of Postpartum Infecundity was the greatest in Nigeria (0.69); North Central (0.67), North East (0.68), North West (0.68) and South South (0.72). However, in the South East (0.70) it was delay in sexual exposure; and it was contraceptive use in South West (0.70). In 2018, the pattern was almost remained the same in the Northern region and South East; but it was delay in sexual exposure that has highest inhibiting effects on fertility in South West (0.68) and South South (0.65). Notably, abortion rate has the smallest fertility inhibiting effect across the regions in the year periods.

Table 4.40: Estimated Proximate Determinants and Total Fertility Rate (TFR) by Regions and Nigeria, 2003 & 2018

	Sexual Exposure Index	Contraception Index	Postpartum Infec index	Abortion Index	Total Fecundity	Estimated TFR
Nigeria 2003	0.7938	0.8324	0.6898	0.9409	14	6.00
Nigeria 2018	0.7691	0.7950	0.7040	0.9281	14	5.59
North Central 2003	0.7951	0.8148	0.6689	0.9430	14	5.72
North Central 2018	0.7791	0.7826	0.69442	0.9242	14	5.48
North East 2003	0.8315	0.9111	0.6791	0.9540	14	6.87
North East 2018	0.8639	0.8384	0.6845	0.9426	14	6.54
North West 2003	0.8877	0.9017	0.6774	0.9546	14	7.25
North West 2018	0.8830	0.8462	0.6981	0.9378	14	6.85
South East 2003	0.7048	0.7711	0.7174	0.9265	14	5.06
South East 2018	0.6572	0.7659	0.7569	0.9107	14	4.86
South South 2003	0.7386	0.7330	0.7195	0.9251	14	5.04
South South 2018	0.6491	0.7266	0.7318	0.9023	14	4.36
South West 2003	0.7331	0.7000	0.7347	0.9251	14	4.88
South West 2018	0.6812	0.6822	0.7282	0.9002	14	4.26

Table 4.41 shows the decomposition of change in TFR by Regions and Nigeria, 2003-2018. According to the result, change in TFR between 2003 and 2018 across the regions are given as follows from highest to the lowest: South South (-0.68), South West (-0.62), North West (-0.40), North West (-0.33), North Central (-0.24) and South East (-0.20) as well as Nigeria (-0.41). Based on the decomposition analyses, sexual exposure index and contraceptive use contributed the most to the change across the regions. For instance, the percentage contribution of sexual exposure in South South, South West, South East, and Nigeria were 87.04%, 52.89%, 172.85% and 43.53% respectively. However, it is worthy of note that the prevalence of contraceptive use reduced in between 2003 and 2018 in North West. Furthermore, most of the change observed in North central (92.04%) and Nigeria (63.31%) was attributable to contraceptive use.

Futhermore, table 4.41 shows estimated contraceptive prevalence required to achieve replacement level of fertility. As indicated in the table, the required contraceptive prevalence rate to achieve replacement fertility level in Nigeria, North Central, North West, North East, South East, South South and South West are 0.69, 0.68, 0.72, 0.71, 0.67, 0.69 and 0.69 respectively.

Table 4.41: Decomposition of Change in TFR by Regions and Nigeria, 2003-2018

	Estimated TFR	Change in TFR	Cm-effect (% contr.)	Cc-effect (% contr.)	Ci-effect (% contr.)	Ca-effect (% contr.)	Residual (% contr.)
Nigeria 2003	6.00	-0.41	-0.18012	-0.26196	0.116093	-0.07805	-0.0097
Nigeria 2018	5.59		43.53	63.31	-28.06	18.86	2.35
North Central 2003	5.72	-0.24	-0.11192	-0.22202	0.20593	-0.11108	-0.0021
North Central 2018	5.48		46.40	92.04	-85.37	46.05	0.89
North East 2003	6.87	-0.33	0.271535	-0.54953	0.052318	-0.07977	-0.0262
North East 2018	6.54		-81.87	165.69	-15.77	24.05	7.90
North West 2003	7.25	-0.40	-0.03678	-0.44021	0.20851	-0.12328	-0.0049
North West 2018	6.85		9.27	110.97	-52.56	31.08	1.24
South East 2003	5.06	-0.20	-0.34108	-0.03299	0.261906	-0.08397	-0.0012
South East 2018	4.86		172.85	16.72	-132.74	42.56	0.58
South South 2003	5.04	-0.68	-0.59608	-0.04048	0.078255	-0.11506	-0.0115
South South 2018	4.36		87.04	5.91	-11.43	16.80	1.67
South West 2003	4.88	-0.62	-0.32947	-0.11559	-0.03988	-0.1223	-0.0156
South West 2018	4.26		52.89	18.56	6.40	19.64	2.51

Table 4.42: Estimated Prevalence of Contraceptive Required to achieve Replacement Level

	Future TFR	Current TFR	Contraceptive Index	Required Contraceptive Prevalence
Nigeria	2.1	5.59	0.795	0.69
North Central	2.1	5.48	0.7826	0.69
North West	2.1	6.87	0.8462	0.73
North East	2.1	6.54	0.8384	0.72
South East	2.1	4.86	0.7659	0.66
South South	2.1	4.36	0.7266	0.64
South West	2.1	4.26	0.6822	0.65

4.7 Explaining the Differences in Fertility

Figures 4.23 and 4.24 show the risk difference between women who were uneducated and educated in high fertility across the six regions in the year periods 2003, 2008, 2013 and 2018. The results quantify the gap between the uneducated and educated women with high fertility. A risk difference greater than 0 suggests that high fertility is prevalent among women who are uneducated. As revealed by the result, high fertility is prevalent among women with no education across the regions and the time periods. The result is statistically significant across the regions. As indicated in figure 4.39, the six regions at different time periods are pro-uneducated inequality. Furthermore, as illustrated in the figures educated-uneducated risk difference was highest in South East 2003 (56.92) and lowest in North East 2003 (14.99). Also, to be noted in the figures is the risk differences in South West 2003 (41.20), South South 2003 (37.9), South East 2003 (56.92), and North Central (25.9) are higher than that of South West 2013 (27.3), South South 2013 (30.5), South East 2013 (50.1), and North Central 2013 (22.8).

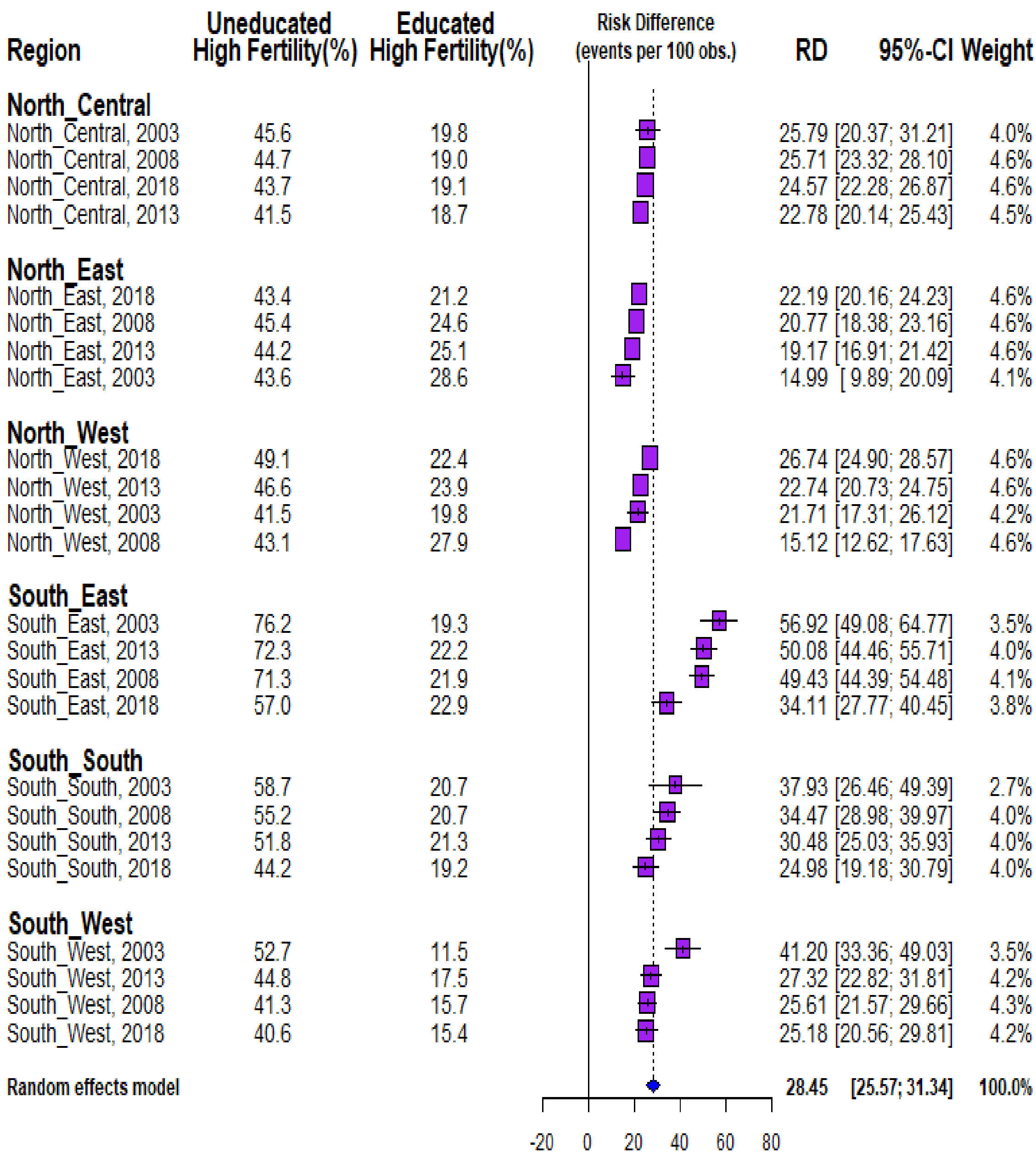


Figure 4.23: Risk Difference between women who are Uneducated and Educated in High Fertility by Regions between 2003 and 2018

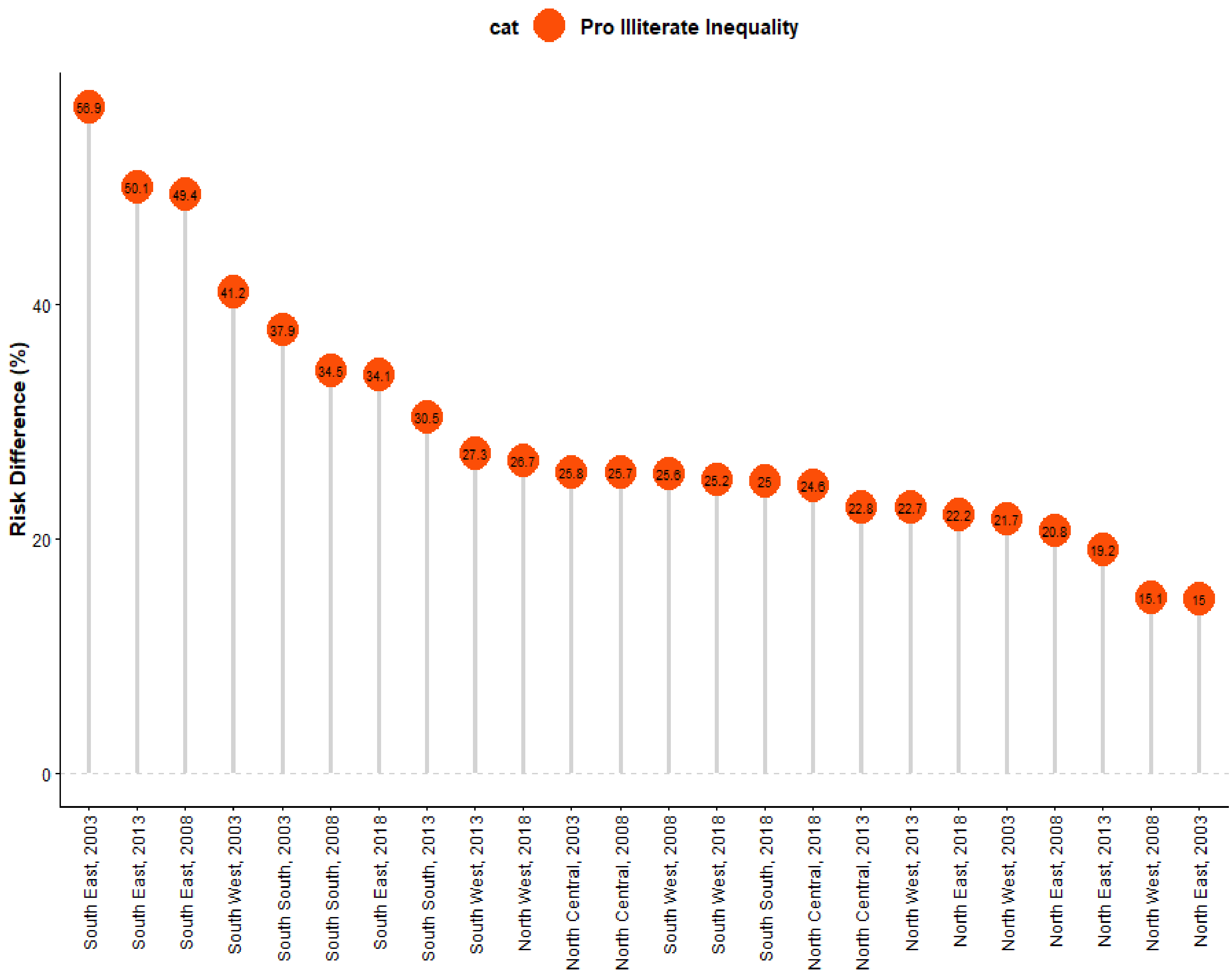


Figure 4.24: Graph showing the Risk Difference between women who are Uneducated and Educated in High Fertility by Regions

Figures 4.25 shows the scatter plot of rate of high fertility and risk difference between women who were uneducated and educated in high fertility. Though high fertility and pro-illiterate inequality exist in all the regions and the year periods yet the scatter plot was still divided into four based on the magnitude of the rate of high fertility and risk difference. First, higher rate of high fertility and high pro-illiterate inequality; where no region really belong except South East that is close. Second, higher rate of high fertility but low pro-illiterate inequality where North East and North West belong. Thirdly, lower rate of high fertility but high pro-illiterate inequality where there are South West 2003, South South 2003 and South South 2008. Lastly, lower rate of high fertility and low pro-illiterate inequality where South West 2008, South West 2013 and South South 2013.

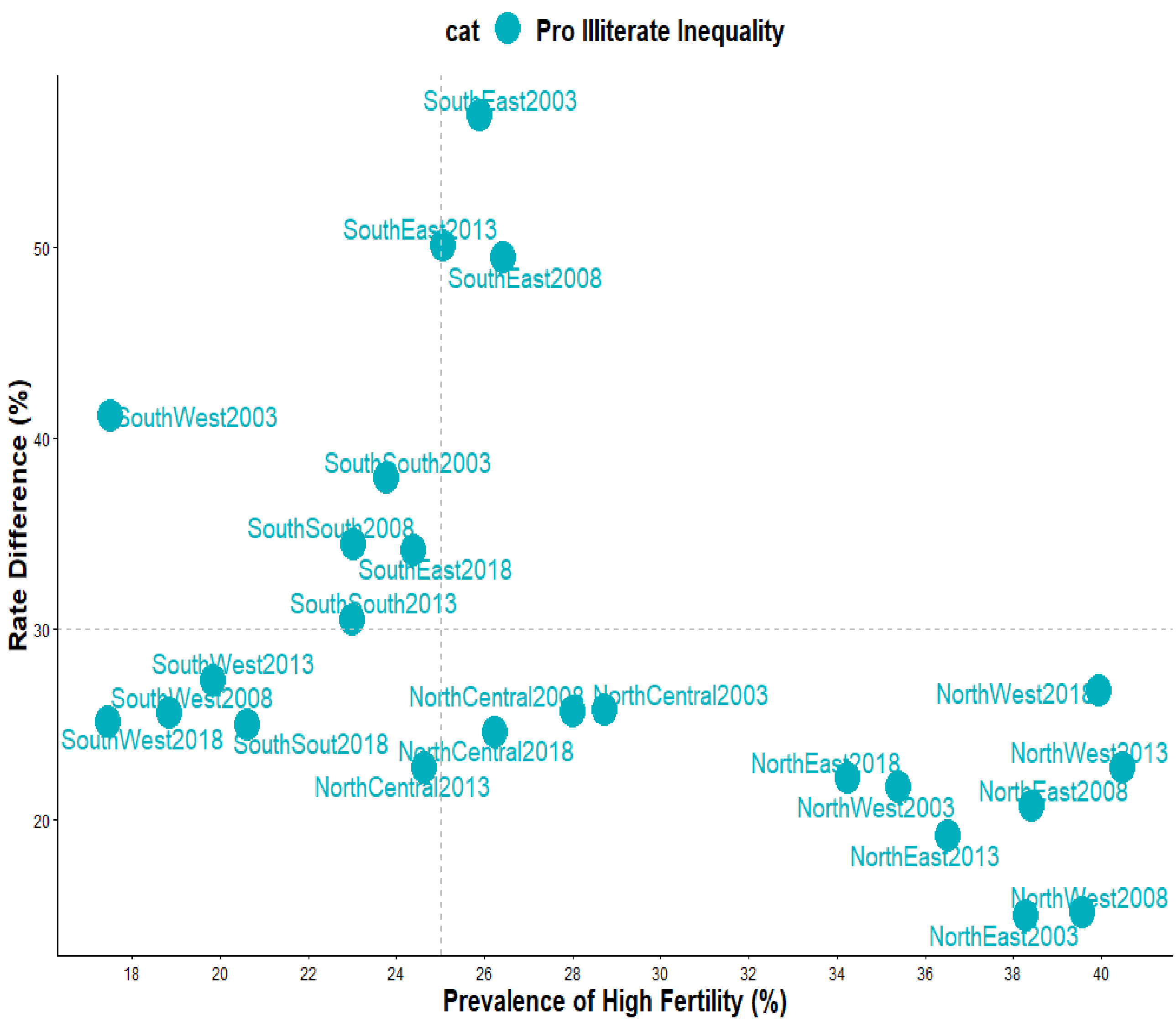


Figure 4.25: Scatter plot of rate of High Fertility and Risk Difference between women who were Uneducated and Educated in High Fertility

Figures 4.26 shows detailed decomposition of the part inequality that was caused by compositional effects of the determinants of high fertility to the total gap between women who were uneducated and educated in High fertility by regions and year periods. The figures indicate that maternal age, wealth index, and age at first birth are important factors responsible for the inequality between the high fertility of women who were educated and those that were uneducated across the regions and the year periods. For instance, in South West 2013 wealth index was the major factor responsible for the total gap in high fertility between women who were educated and their counterpart who were not educated; followed by maternal age, then age at first marriage, place of residence, age at first marriage and modern contraceptive use. In North West 2013, the major factor is maternal age, then religion, age at first birth, wealth index and socio economic status with same cluster.

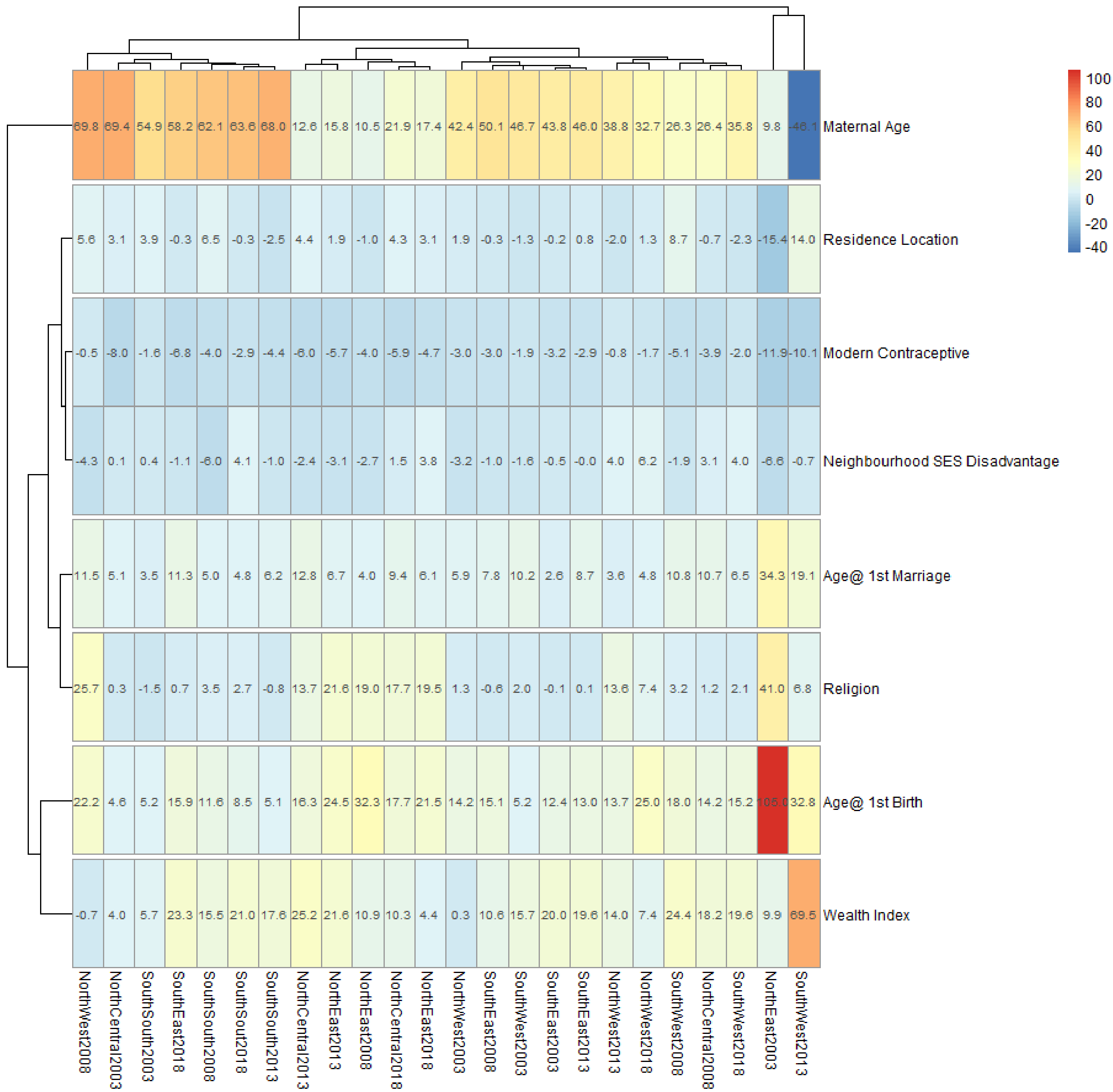


Figure 4.26: Detailed Decomposition of the part inequality that was caused by compositional effects of the determinants by regions and year periods

Figures 4.27 and 4.28 show the risk difference between women who were Poor and No-poor in high fertility across the six regions in the year periods 2003, 2008 and 2013. As indicated in the result, high fertility is prevalent among women who were poor across the regions and the time periods. The result is statistically significant across the regions. As shown in figure 4.45, the six regions at different time periods are pro-poor inequality. Furthermore, as illustrated in the figures Poor - No poor risk difference was highest in South West 2013 (15.91) and lowest in North West 2008 (5.72). Also, to be noted in the figures are the risk differences of South East 2013 (14.9), South East 2008 (14.4), South West 2008 (14.2), and South East 2003 (12.2).

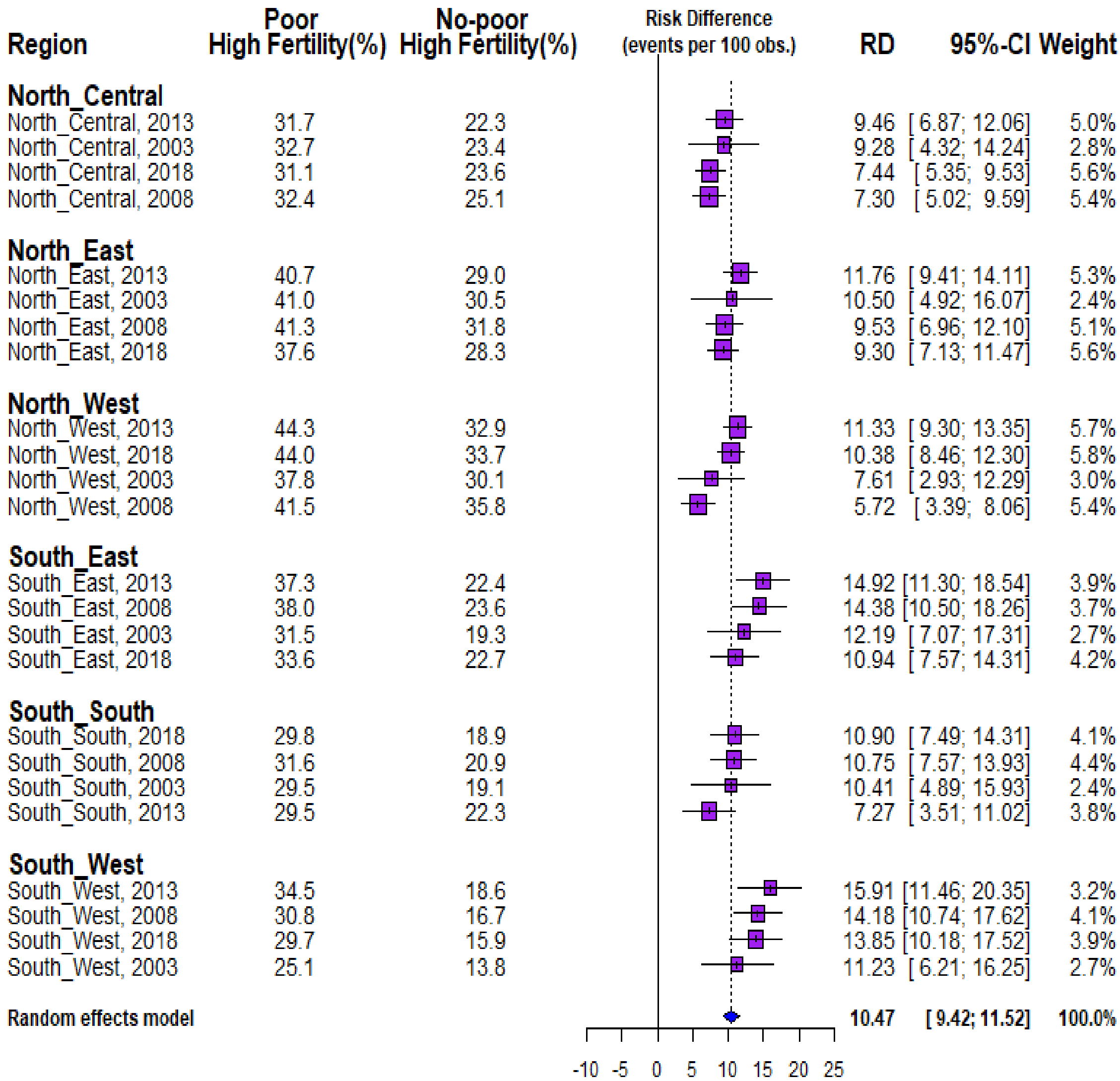


Figure 4.27: Risk Difference between women who are Poor and No-poor in High Fertility by Regions between 2003 and 2018

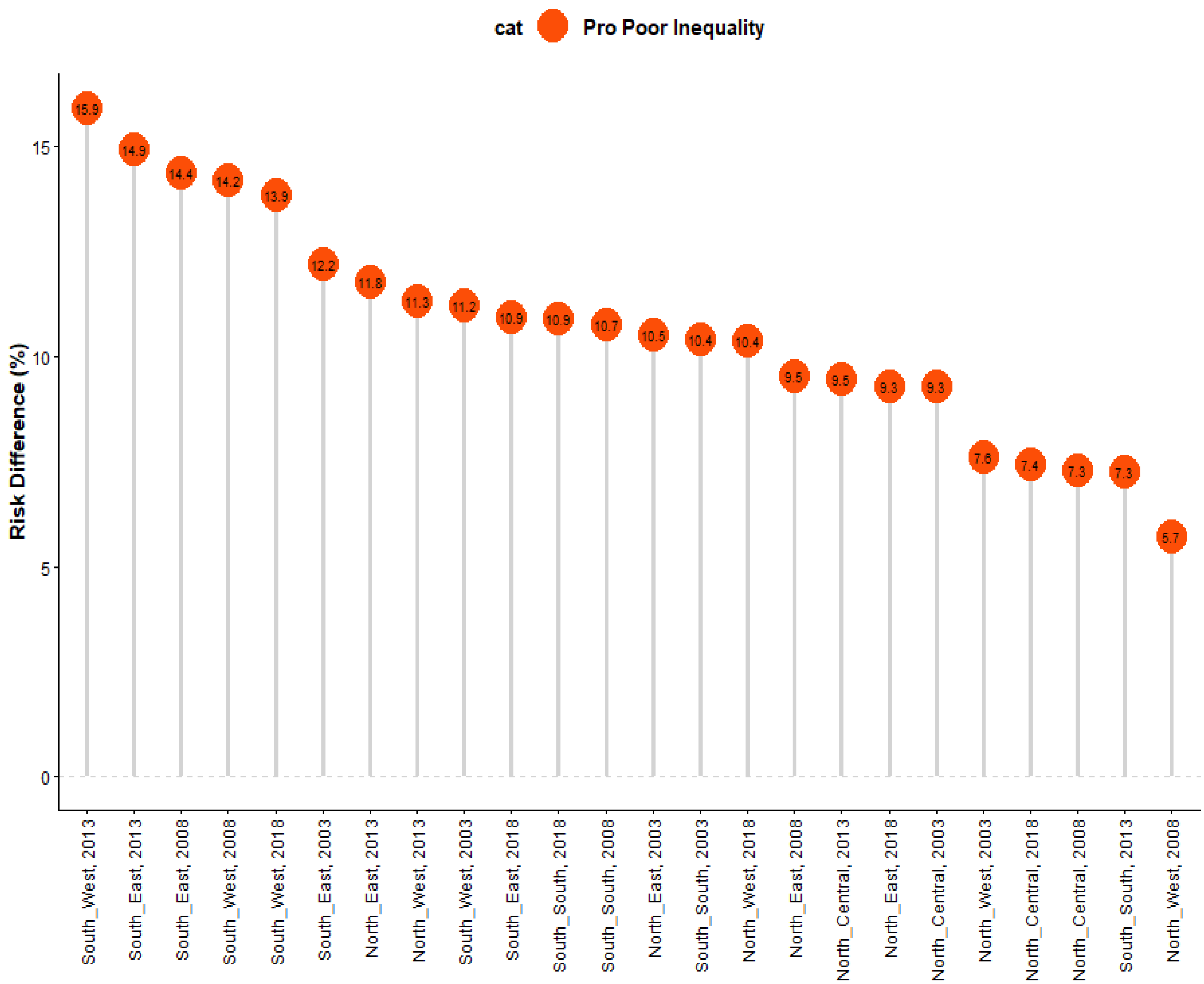


Figure 4.28: Graph showing the Risk Difference between women who are Poor and No-poor in High Fertility by Regions and year periods

Figures 4.29 shows the scatter plot of rate of high fertility and risk difference between women who were poor and no-poor in high fertility. Though high fertility and pro-illiterate inequality exist in all the regions and the year periods yet the scatter plot was still divided into four based on the magnitude of the rate of high fertility and risk difference. First, higher rate of high fertility and high pro-poor inequality; where North East 2013, North West 2013, and North East 2003. Second, higher rate of high fertility but low pro-poor inequality where North West 2008 and North East 2008 belong. Thirdly, lower rate of high fertility but high pro-illiterate inequality where there are South West, South East and South South. Lastly, lower rate of high fertility and low pro-illiterate inequality where North Central belong.

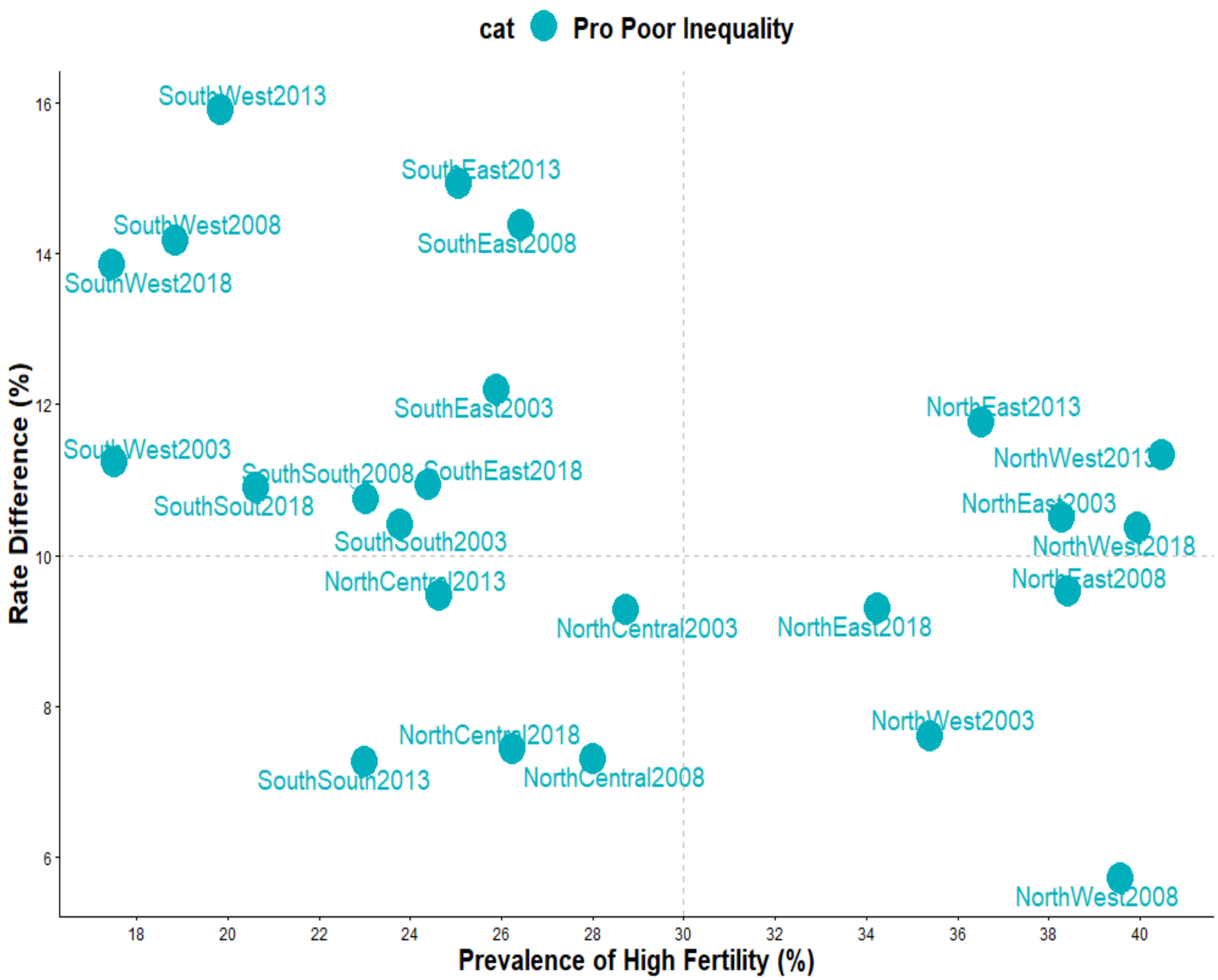


Figure 4.29: Scatter plot of rate of High Fertility and Risk Difference between women who are Poor and No-poor in High Fertility

Figures 4.30 shows detailed decomposition of the part inequality that was caused by compositional effects of the determinants of high fertility to the total gap between women who were from poor household and those who were from non-poor households by regions and year periods. The figures indicate that maternal age, maternal education and age at first birth are contributing factors for high fertility differentials among women from the poor households and those from non-poor households. For instance, in North Central 2008 maternal age and education were the major factor responsible for the total gap in high fertility among the women groups (Poor and non-poor). In South West 2013, the major factor is maternal age and residence location.

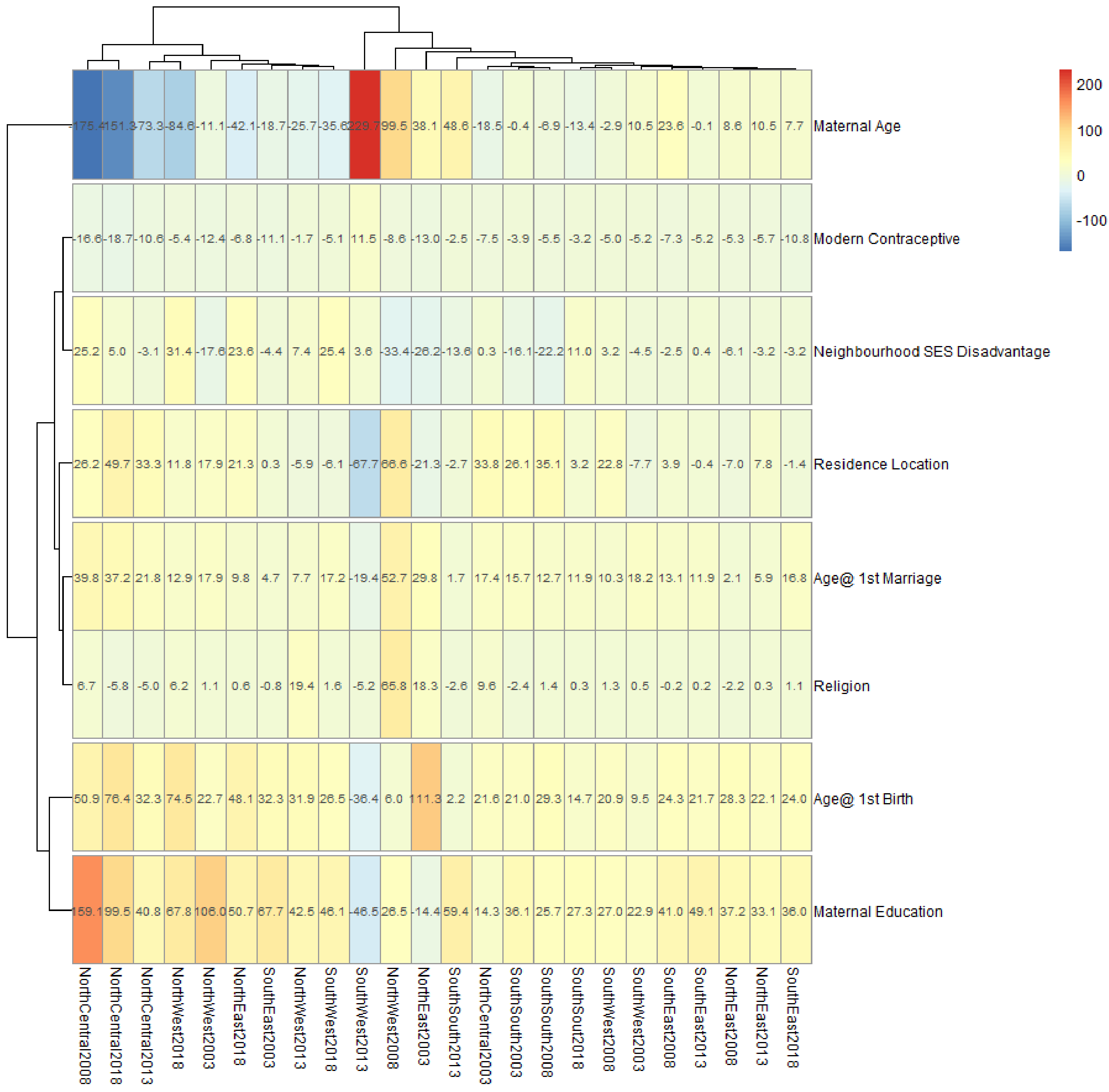


Figure 4.30: Detailed Decomposition of the part inequality that was caused by compositional effects of the determinants by regions and year periods (Poor and Non-Poor)

Figures 4.31 and 4.32 show the risk difference between women who from rural and urban areas in high fertility across the six regions in the year periods 2003, 2008 and 2013. According to the result, apart from South East 2003 high fertility is prevalent among women from rural area across the regions and the time periods. The results from South South 2013, North West 2003, North East 2003, South East 2013 and South East 2003 were not statistically significant. Furthermore, as illustrated in the figures rural-uban risk difference was highest in South West 2013 (12.74) and lowest in South East 2013 (1.87). Also, to be noted is that South East 2003 (-4.23) is pro-urban inequality though not statistically significant.

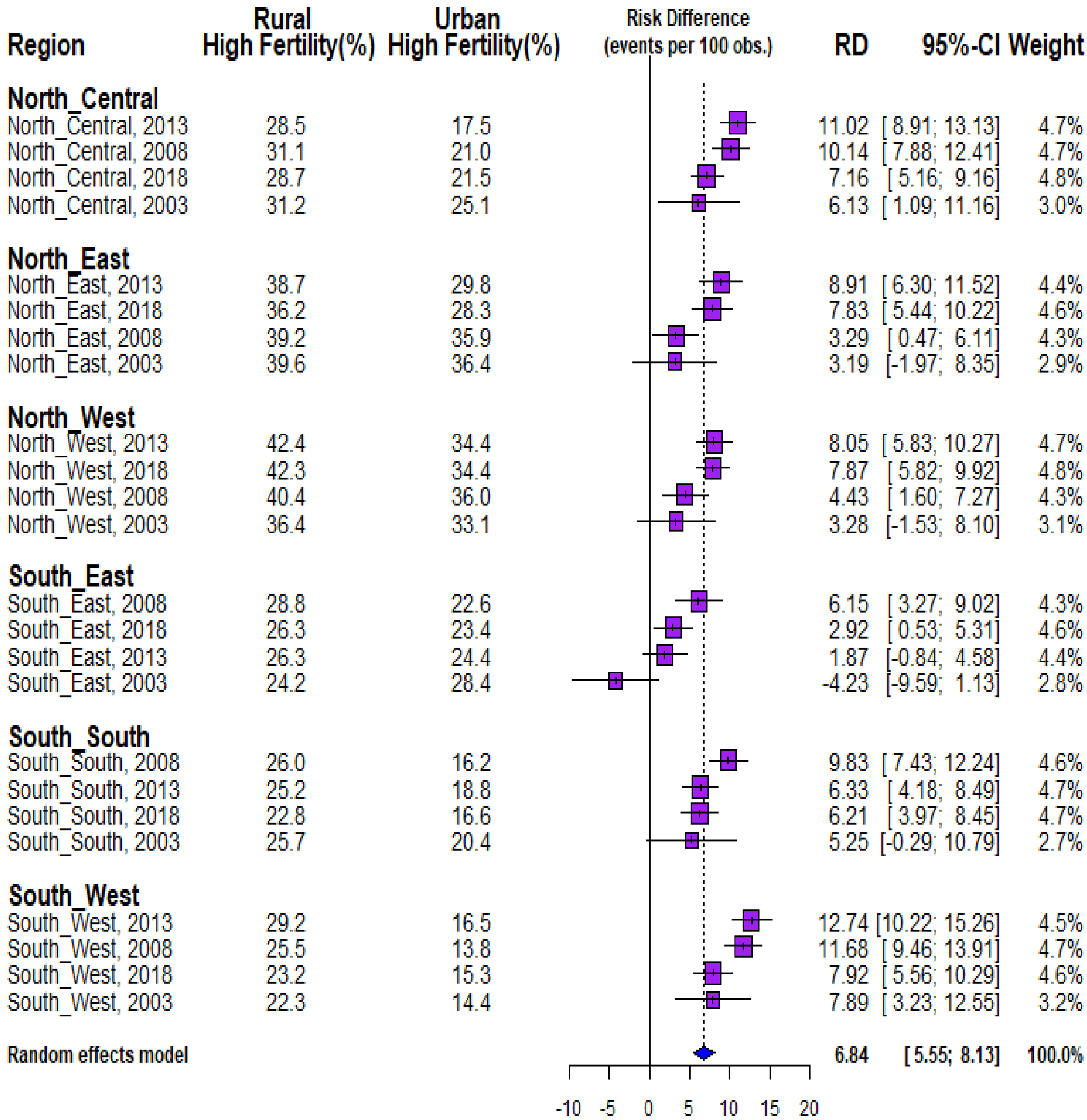


Figure 4.31: Risk Difference between women from Rural and Urban Areas in High Fertility by Regions between 2003 and 2018

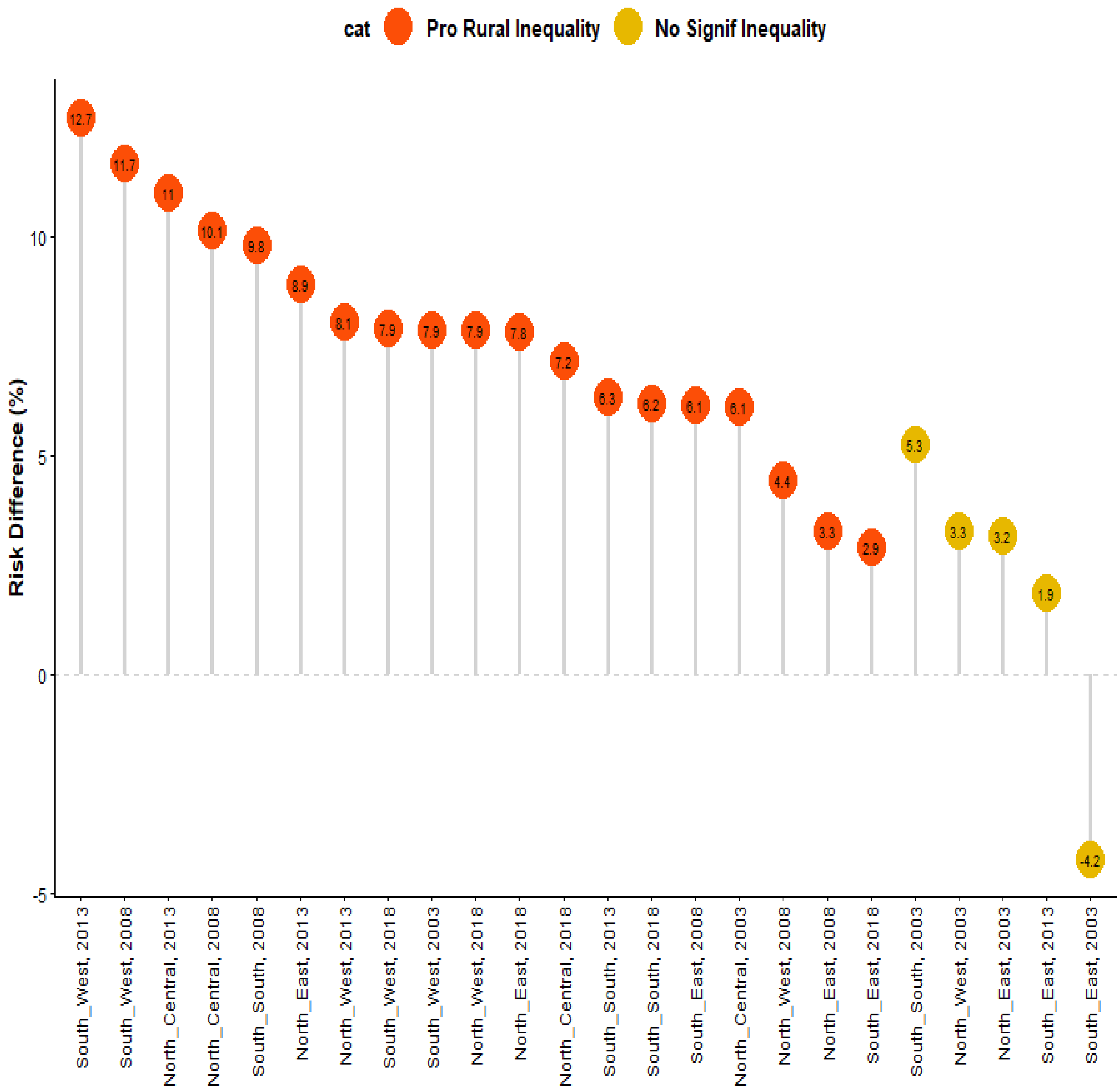


Figure 4.32: Graph showing the Risk Difference between Women from Rural and Urban Areas in High Fertility by Regions and year periods

Figures 4.33 shows the scatter plot of rate of high fertility and risk difference between women from rural and urban areas in high fertility. Though high fertility and pro-rural inequality exist in all the regions and the year periods except South East 2003 yet the scatter plot was still divided into four based on the magnitude of the rate of high fertility and risk difference. First, higher rate of high fertility and high pro-poor inequality; where North East 2013, North West 2013, and North East 2003. Second, higher rate of high fertility but low rural where North West 2008 and North East 2008 belong. Thirdly, lower rate of high fertility but high pro-rural inequality where there are South West, South South, North Central. Lastly, lower rate of high fertility and low pro-illiterate inequality where South East belong.

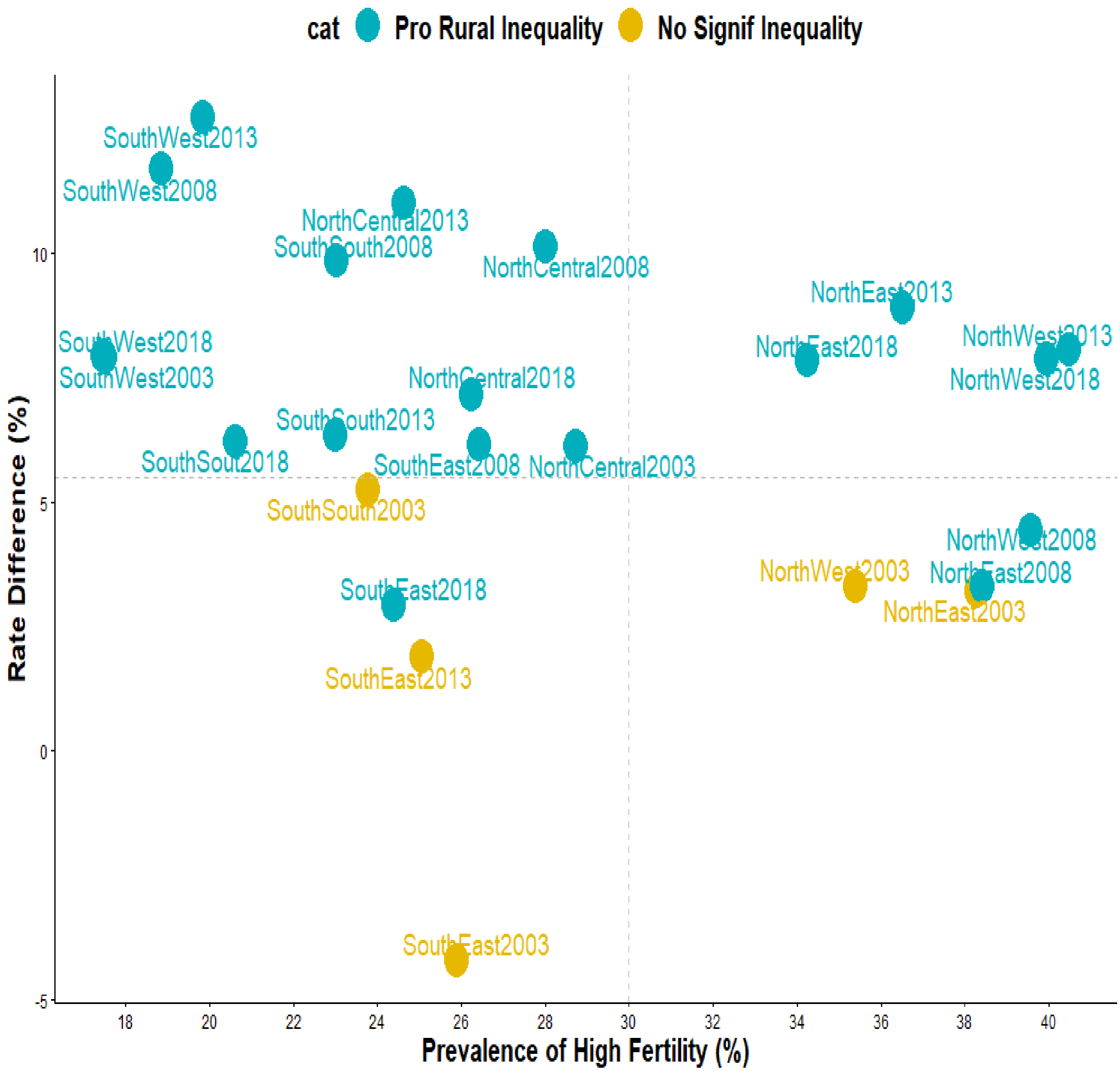


Figure 4.33: Scatter plot of rate of High Fertility and Risk Difference between Women from Rural and Urban Areas in High Fertility

Figures 4.34 shows detailed decomposition of the part inequality that was caused by compositional effects of the determinants of high fertility to the total gap between women who were resident rural and urban in High fertility by regions and year periods. The figures indicate that maternal age, wealth index, and age at first birth are important factors responsible for the inequality between the high fertility of women who were rural and urban residence across the regions and the year periods. For instance, in North West 2018 and North East 2018 maternal age was the major factor responsible for the total gap in high fertility between women who were rural residence and their counterpart who were urban residence; followed by age at first birth, maternal education.

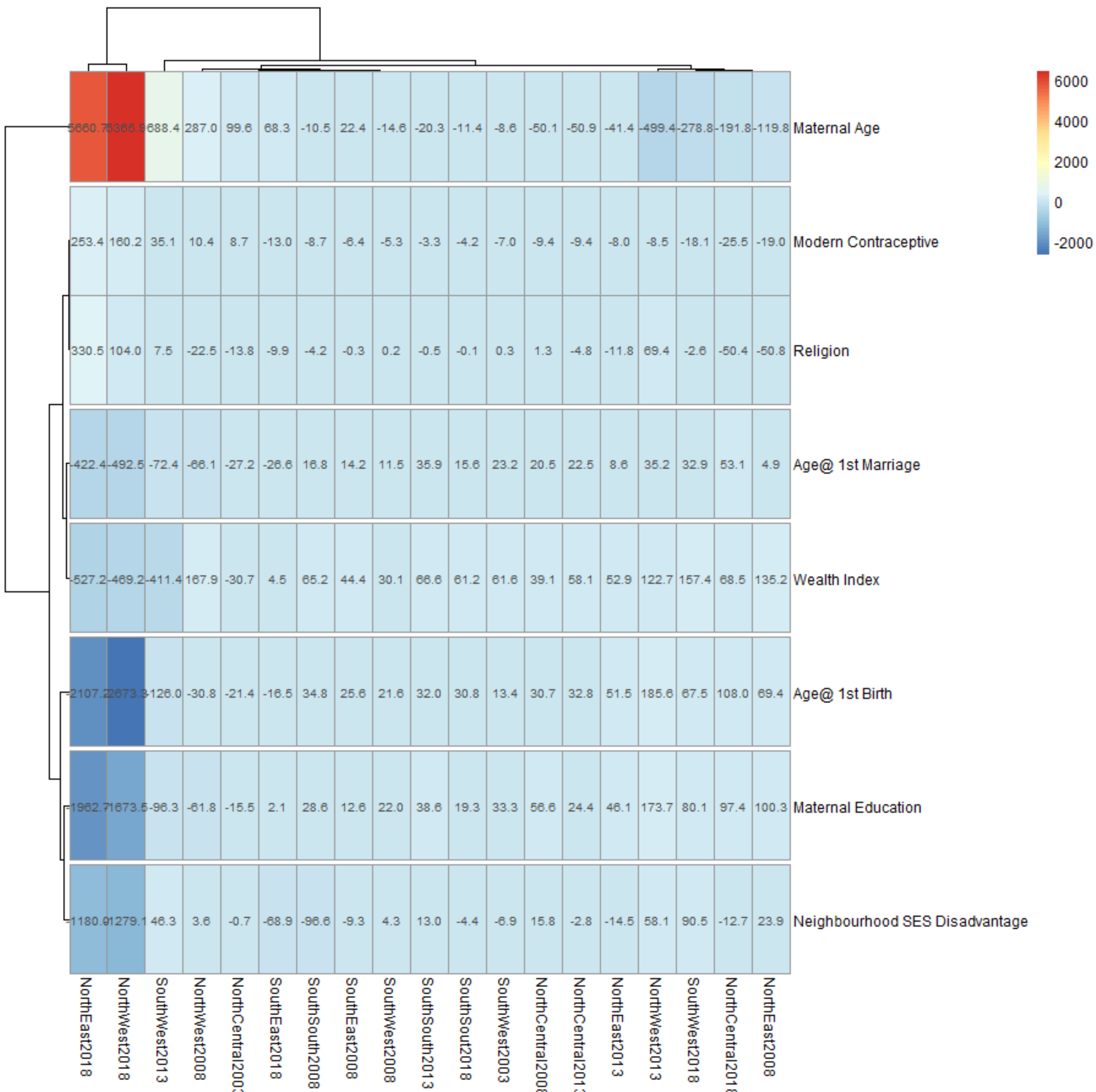


Figure 4.34: Detailed Decomposition of the part inequality that was caused by compositional effects of the determinants by regions and year periods (Rural and Urban)

CHAPTER FIVE

DISCUSSION

5.0 Discussion

This study addressed four main questions. It examined how the change in age pattern of fertility has been in Nigeria; and also determined how the shift in age pattern and timing of fertility has resulted to changes in fertility level overtime in Nigeria. The study further revealed when Nigeria fertility level would converge to replacement level. Lastly, the factors to be adjusted in order to hasten the convergence to replacement level were also identified. Provision of answers to the questions were necessary considering their importance on accomplishment of sustainable development goals (SDGs 1,3 and 5). To understand the intensity of population growth, this study used mathematical curve to predict the timing of fertility convergence to replacement level; and more importantly the fertility driven factors that could be modified in order to hasten fertility transition in Nigeria were identified. This study also examined the shifts in age patterns of fertility and projected the future trajectory of fertility level in Nigeria and in each of the six regions in Nigeria.

5.1 Shift in Age Pattern and Timing of Childbearing

Shift in age pattern and timing of fertility is pertinent to changes in the level of fertility over time. Similar age pattern of fertility in Nigeria between 2003 and 2018 was established in this study. This pattern was also observed in all the regions in the northern part of Nigeria between 2003 and 2018. However, a shift in age pattern of fertility was found in the regions in the south (south east, south west and south south). The observed shift in age pattern of fertility between 2003 and 2018 was indication of early onset of childbearing in the Northern regions, and late termination of fertility in the Southern regions of Nigeria. This finding corroborates the outcome of previous studies conducted in Nigeria (Adebowale et al., 2016; UN, 2015). Difference in socio-cultural landscape that can influence fertility in the northern and southern part of Nigeria is a possible reason for north-south variability in age pattern of fertility.

In Nigeria, total fertility rate estimated indirectly due to errors in birth reporting minimally declined from 6.1 in 2003 to 5.7 in 2018; the change of 0.4 recorded in our findings corroborate with the change documented in NDHS reports. However, our estimated TFR was inconsistent with that of NDHS reports, but in line with that obtained by an international study (World Fertility Patterns, 2015). The level of fertility was highest in North West and lowest in South West, and this pattern was consistent between 2003 and 2018. This finding is in line with earlier studies conducted in Nigeria (Adebowale, 2019). The northern region dominated by people of Hausa/Fulani origin, mainly uneducated and predominantly Muslim. These groups have been marked as fertility drivers in Nigeria. This study further revealed that the decline of TFR was more rapid among women of South South compared to the rest of the rest of the regions. This may not be unconnected with literacy level (ability to read and write) which was the highest in the region (ICF Macro and NPC, 2019); and decline of under-five mortality was more rapid in the region compared to other regions (Akinyemi, 2014).

The values of Gompertz relation model (GRM) parameters (α and β) used to provide a good-fit fall within the estimated the recommended ranges by Moultrie and colleagues (Moultrie et a., 2013). Except for South East 2003 and South West 2003 data, all the regions in the year periods performed well. In Nigeria as a whole and across the six regions, the diagnostic plots of the GRM indicated that F-points lie above the P-points, which suggests there is a fertility decline in the past. This finding is in agreement with a national study that show a decline in fertility in Nigeria (ICF Macro and NPC, 2019).

The postponement of first birth has not changed significantly, and the mean age at first birth obtained in this study echoes the slow pace of fertility transition in Nigeria. The mean age at first birth only increased slightly from 21.3 years in 2003 to 22.5 years in 2018, with the Southern and Northern region having mean age at first birth of 24years and 20years respectively. This finding was in agreement with the outcome of Fagbamigbe and Idemudia (2016) which reported that early first childbirth as being prevalent in Nigeria. Furthermore, the changing pattern of timing of childbearing in higher birth orders was not different from that of first birth. There is no evidence of an increase in postponement of births in Nigeria (Timaeus and Moultrie, 2020). Examining the effect of changes in timing of childbearing on fertility level, the findings from this study confirm that changes in timing of childbearing would result to changes in fertility level. In 2008, Tempo-adjusted TFRs were greater than the observed TFRs in first, second and third birth orders as well as for all births combined in Nigeria. The difference observed suggests a decline in timing of childbearing between 2003 and 2008. However, the observed TFRs were almost the same with Tempo-adjusted TFR for all births combined in Nigeria for 2013 and 2018. The analysis demonstrated that the timing of childbearing has not really changed in Nigeria; thus, its effect on fertility level is negligible. The findings complement the outcome of existing research on fertility changes where changes in timing of childbearing is expected before changes in fertility level (Batyra, 2016; Miranda-Ribeiro et al., 2008; Sobotka, 2004).

5.2 Year of Convergence to Replacement Level Fertility

The TFR in Nigeria has been declining in the past three decades but the pace of declining is low (ICF Macro and NPC, 2019). The persistent reduction in TFR is an indication that TFR will reduce to a replacement level. However, the timing of convergence of TFR to replacement level is yet to be adequately documented in Nigeria. The analysis from this study revealed that it would take seventy years (in the year 2089) for the TFR to converge to replacement level in Nigeria. This timing will have implications on achieving SDGs; particularly, goal 1, 2, 3, 4 and 5. Persistent high fertility level and slow pace of decline will constrain population age structure to a broad based pyramid with high youth dependency ratio. With this situation, the ratio of working age adults to dependents will be low. This will reduce the investments in children, negatively affect labor productivity and women involvement in economic activities, cause high level of unemployment and poverty rates, and the population will be at higher risk of political instability (Hasan et al, 2020).

Rapid reductions in fertility and declining ratios of dependent to working age populations will provide a window of opportunity for economic development and poverty reduction which is demographic dividends. However, high fertility has implications on child health, maternal health, economic growth, and natural environment (UN, 2017**.** This suggests that the risk of mortality in infancy and early childhood as well as amongst mothers would not reduce substantially early in Nigeria (Rutstein, 2011; Yoder et al., 2013; Duclos et al., 2019). Similarly, window of opportunity for economic development and poverty reduction available for Nigeria could be missed with this timing of fertility convergence to RL (British Council Nigeria, 2014; Wietzke, 2020). With the fertility level higher than 2.1 for the next seventy years in Nigeria, the country would lag behind in ending poverty and hunger in all its forms; and achieving food security and improved nutrition as well as promoting sustainable agriculture would also be difficult. Similarly, ensuring healthy lives and promote well-being for all at all ages; ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all; and achieving gender equality and empower all women and girls might not be achievable in Nigeria as contained in the SDGs.

Variation exists in the timing of TFR convergence to replacement level across the regions in Nigeria with South South region attaining replacement level (in the year 2036) earlier than any other regions in Nigeria. The delay in this fertility transition will be mostly expected in the North West region (in the year 2112). Nigeria is a multi-ethnic country with diverse culture and religion. Although, childbearing is a common practice in Nigeria but the magnitude varies according to cultural diversities. Polygamy is very common among the Muslims and early marriage is prevalent in the North. Also drivers of fertility such as female education, women empowerment, contraceptive uptake, and high fertility desire varies across the regions of Nigeria. The level of these factors across Nigeria may explain the observed variation in the timing of fertility convergence to RL. The finding presented in this study exempted Nigeria from countries of the world that will achieve or close to replacement level by 2050 (United Nations, 2017). It also provided an answer to Reed and Mberu (2014) concern about whether Nigeria's TFR is to be anticipated quickly or otherwise (Reed and Mberu, 2014).

5.3 Identifying the Correlates of Fertility

Further objective of this study was to identify the modifiable factors that can lead to reduction in the time to achieve fertility convergence to replacement level. The results of multivariate analyses of fertility performed by comparing fertility rates within educational level showed that highly educated women experienced lower fertility than women with no education in Nigeria. Similar pattern was observed across all they survey rounds. This confirmed that women education is an important factor to be considered for hasten convergence of fertility to replacement level in Nigeria as documented in literature (Shapiro et al.,2013; Shapiro and Gebreselassie, 2010; Bongaarts 2010). Likewise, women who resides in the rural areas were more likely to bear more children than their counterparts in the urban areas. Also, based on the result fertility is higher among women who practice Islam than those that are Christian. Similarly, the rate ratio of rich women compared to the poor women is 0.92 though not significant. As expected, the risk of fertility is significantly higher among women who were not using modern contraceptive than those that were using.

According to the result, in 2018 the rate ratios of women with higher education compared to those with no education is 0.67; this indicates that highly educated women' fertility is about 33% lower than women with no education. The women who reside in rural were 1.08 times more likely to be exposed to the risk of fertility than their counterpart in urban area. Also, based on the result fertility is higher among women who practice Islam than those that are Christian. Similarly, the rate ratio of rich women compared to the poor women is 0.87. As expected, the risk of fertility is higher among women who were not using modern contraceptive than those that were using. The pattern of result is the same in the year periods; and the variable were significant.

Estimation of total fertility rates using Bongarrt model are plausible (Tey et al.,2011); and the model helps to quantify the effects of the proximate determinants on fertility (Alene & Worku, 2009). The estimated TFRs for Nigeria in 2003 (6.0) and 2018 (5.6) were not too different from the estimates from Worldometers. The change of 0.4 observed was the same with the change documented in NDHS report (ICF Macro and NPC, 2019). The estimates across the regions as indicated in the study- North Central 2003 (5.72), North Central 2018 (5.48), North East 2003 (6.87), North East 2018 (6.54), North West 2003 (7.25), North West 2018 (6.85), South East 2003 (5.06), South East 2018 (4.86), South South 2003(5.04), South South 2018 (4.36), South West 2003 (4.88), South West 2018 (4.26)- are plausible estimates (Tey et al., 2011). Based on the result of this model the highest change was observed in South South (-0.68) and lowest in South East (-0.20) (ICF Macro and NPC, 2019). The level of fertility was highest in the North West and lowest in South West, and this pattern was consistent in 2003 and 2018. The northern region dominated by people of Hausa/Fulani origin, mainly illiterates and predominantly Muslim. These groups have been marked as fertility drivers in Nigeria.

The findings of this objective identified three proximate determinants of fertility that have played important roles in Nigeria's fertility level in 2003 and 2018. In both 2003 and 2018, fertility inhibiting effect of Postpartum Infecundity was the greatest in Nigeria, North Central, North West and North East. While, in South East, South-South and South West it was delayed sexual exposure and contraceptive use that were greatest inhibitor of natural fertility. This indicates that postpartum infecundability (breastfeeding), delayed sexual exposure, and contraception are important predictors of fertility outcome in Nigeria (Tey et al., 2012; Islam et al., 2014; Chola and Michelo, 2016; Laelago et al., 2019; Rutaremwa et al., 2015; Palamuleni, 2017). The fertility-inhibiting effects of contraceptive use and sexual exposure increased in Nigeria between 2003 and 2018. In 2003, C_c was 0.8324 but decreased to 0.7850 in 2018; while a minimal changed was observed in C_m between 2003 (0.7938) and 2018 (0.7691). The change in C_c reflected an increase in contraceptive use prevalent rate among Nigeria reproductive women as documented in NDHS reports (ICF Macro and NPC, 2019).

Based on the result of this model, the highest change was observed in South-South (-0.68) and lowest in South East (-0.20). The huge change observed in South-South compares to other regions may not be unconnected with literacy level (ability to read and write) which was the highest in the region (ICF Macro and NPC, 2019) and decline of under-five mortality was more rapid in the region compared to other regions (Akinyemi et al., 2015). However, meagre change noticed in South East remains a puzzle that needs a second look because reproductive women of South-South and South East have similar characteristics. Furthermore, the results of this study also revealed that the little change observed in the Northern region was majorly due to a marginal increase in the prevalent of Contraceptive use in the regions (ICF Macro and NPC, 2019). Given the relatively early marriage that still persists in the two regions, the fertility level remains above six. Postponement of marriage played a major role in reducing fertility in Southern regions. This finding is in agreement with the results of previous analyses carried out by different researchers.

The results of the decomposition presented in this study show that the change observed in the level of fertility was majorly caused by delayed sexual exposure and contraception. This finding established the importance of contraceptive use and age at first sexual debut in facilitating fertility reduction (Chola and Michelo, 2016; Acharya, 2010; Bongaarts, 2017). The contribution of sexual exposure to change observed in TFRs of Southern regions between 2003 and 2018 reflects postponement in the age of first marriage. This is not surprising in Southern region of Nigeria because of women with a higher level of education. Women's education affects fertility via postponement of the onset of childbearing and contraceptive use (Shapiro, 2012). Furthermore, the results of this study also revealed that the little change observed in the Northern region was majorly due to a marginal increase in the prevalent of contraceptive use in the regions (ICF Macro and NPC, 2019). Given the relatively early marriage that persists in the North West and North East, the fertility level remains above six.. The contribution of sexual exposure to change observed in TFRs of Southern regions between 2003 and 2018 reflects postponement in age of first marriage. This is not surprising in Southern region of Nigeria because of women with higher level of education. Women's education affects fertility via postponement of onset of childbearing contraceptive use (Shapiro, 2012).

The study went further to identify the pattern of high fertility using the pooled data of 2003, 2008, 2013 and 2018 NDHS. Also, the study obtained the educated-uneducated, poor-rich and rural-urban gaps across the various correlates of high fertility. Noticeable regional differences were observed in high fertility between educated and uneducated women. The prevalence of high fertility was more among uneducated women across the regions and the year periods. The greatest pro-illiterate inequality was observed in South East 2003 and the least was in North East 2003. The magnitude of inequalities observed in literate-illiterate high across the regions underscore the importance of women education in reducing fertility (Shapiro and Tenikue, 2017). Urgent intervention is needed to encourage women education in Nigeria.

Several factors explained high fertility in Nigeria including high rate of illiteracy which accounted for higher risk of fertility compared to literate women. This could be supported by the fact that uneducated women have tendency of initiating childbearing earlier and the year of exposure to the risk of childbearing would be more among uneducated women (Chisadza and Bittencourt, 2016;; Adebowale et al., 2017). Also, the educated women are likely to adopt small family size and they are able to manage their fertility better than uneducated women (Ojo and Adesina, 2014). In the decomposition analysis, maternal age, wealth index, and age at first birth are important factors explaining the inequality between the high fertility of women who were educated and those that were uneducated across the regions and the year periods. This finding collaborated the established relationship between women education and maternal age, wealth index and age at first birth ((Yoo, 2014; Oyinloye et al., 2017).

In the analysis of poor- non poor gaps, it was discovered in the study that the risk of high fertility was more among women who were from poor household. This result cut across the regions and the year periods. The greatest pro-illiterate inequality was observed in South East 2003 and the least was in North East 2003. The gap that exists between the women among women who were from poor and non-poor households confirmed wealth index as a correlate of fertility. Maternal age and education as well as age at first birth were major factors that explain the gaps. This is understandable because women who started childbearing later are likely to be richer than those that started childbearing early. Likewise, those with higher education are expected to be richer compared with those with non or primary education.

Furthermore, the study established that there is risk difference between women from rural and urban areas in high fertility across the six regions. Based on the findings of the study, apart from South East 2003 high fertility is prevalent among women from rural area across the regions and the time periods. The results from South South 2013, North West 2003, North East 2003, South East 2013 and South East 2003 were not statistically significant. The gap suggests place of residence contribute to risk of high fertility in Nigeria Alaba et al, 2017; Reed and Mberu, 2014). The result indicates that maternal age and education, wealth index, and age at first birth are important factors responsible for the inequality between the high fertility of women who were rural and urban residence across the regions and the year periods. This is not surprising because women who are residents of rural area are likely to have less education, marry early, and poorer than their counterparts in urban area.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Summary

Analysis of fertility is fundamental to understanding the intensity of population growth. With persistent high level of fertility being reported in Nigeria, population growth stability and demographic dividend which are achievable when fertility converges to a replacement level remains a mirage in the country. Considering the vital roles of fertility in achieving SDGs especially goals 1, 3 and 5, it is necessary to document the detailed reproductive behavior and future trajectories across the six geopolitical zones of Nigeria. Predominantly, fertility is analyzed in two ways. The first way concerns the estimation of factors that drive fertility and how they influence fertility; while, the second way uses mathematic functions to fit fertility pattern. The latter is attracting attention from demographers because it can be easily explained; and it allows population projection which is very useful for policy makers.

Shifts in age pattern of fertility are central to modelling fertility convergence to RL. Numerous studies had focused on fertility in Nigeria, but shifts and modelling of age patterns of fertility have not been sufficiently considered. However, poor data quality on fertility in Nigeria is a major limitation to the estimates of age pattern of fertility and modelling fertility patterns. Thus, indirect methods and mathematical models are imperative to overcome these challenges. This study, therefore, used indirect methods and mathematical models to assess the shift in age pattern of fertility between 2003 and 2013; and examine changes in the timing of childbearing and how it affects fertility level across the six geo-political zones in Nigeria. Furthermore, the study determined the timing of fertility convergence to replacement level in Nigeria; and identified factors that could be modified in order to reduce the time it will take fertility to converge to replacement level.

This study was an analytical cross-sectional study through the analysis of secondary datasets of the 1990, 2003, 2008 and 2013 Nigerian Demographic and Health Survey. Fertility was measured from information on the full births history of women aged 15-49. The parameters (β-pace of childbearing and α-location of fertility) of the Gompertz Relational Model were used to assess the shift in age pattern of fertility. The timing of childbearing at different births orders were examined with the use of mean ages at birth. Age-specific fertility rates were modeled by assuming a standard age schedule that is at replacement level; and related the standard with the observed fertility estimates. Annual changes in the age patterns were derived by interpolation and these were used to predict Nigeria's timing of fertility convergence to replacement level. Bongaarts' revised proximate determinants model; a five-factor decomposition method by Das Gupta; and Oaxaca decomposition as well as the use of rate ratio for multivariate analyses of fertility were employed to identify the correlates of fertility.

6.2 Conclusion

The indirect techniques and mathematical models adopted in this study provided plausible estimates of fertility level and clearly described the future trajectory of fertility in Nigeria. Similarity of a relative wide spread of fertility distribution exist in Nigeria as an entity, and in Northern regions. There have not been substantial shifts in age patterns of fertility between 2003 and 2018 in Nigeria. Shifts in age patterns of fertility were observed in Southern regions; but in the core North of the country, there were no shifts. Also, the study demonstrated that the timing of childbearing has not really changed in Nigeria; this is evident in the change in the fertility level observed in the country. This study has also revealed that fertility levels are still high in Nigeria. There were regional differentials in fertility levels and trends. The driver of fertility level in Nigeria remains North West and North East. Notably, Southern regions are moving to the point of transiting to second phase of transition that is where TFR equals 4.0; while, fertility levels are above 6 children per woman in North West and North East. The level of fertility in Nigeria as indicated by TFR implies that, if the current trend persists, Nigeria is faced with a population explosion that is expected to make its population size above 450 million people by 2050.

The study has revealed that Nigeria would not attain replacement level fertility until the next seventy years if the prevailing pattern of fertility persists. The differences that exist in fertility between the Southern and Northern parts of Nigeria were also apparent in the year of convergence to replacement level fertility. While convergence of replacement level fertility is expected in the Southern region before 2050, it should not be expected in core north of Nigeria until the turn of another century. Furthermore, the study showed that the change in fertility level between 2003 and 2018 in Nigeria was due to the delay in sexual exposure which was observed in the Southern region and marginal rise in modern contraceptive use across the regions. There were educational, rural-urban, and poor-rich differentials in fertility levels and trends across the regions. In all the regions, the prevalence of high fertility was more among women who were uneducated, poor and rural dwellers. and an increase in the proportion of women with higher education level; as well as substantial rise in contraceptive prevalent rate a rapid convergence to replacement level fertility can be observed in Nigeria and across the regions. Maternal age at first marriage educational level, wealth index and age at first birth were important factors found to be responsible for the fertility differentials established in this study. For rapid fertility convergence to replacement level in Nigeria and across the regions, delay in sexual exposure, an increase in the proportion of women with higher education, postponement of age at marriage and substantial rise in the use of modern contraceptive are not negotiable.

6.3 Recommendation

The findings of this study have important implications for planning with regard of meeting basic demands, such as housing, education, and health care. To avoid the crises that may arise as a result of population explosion due to high fertility level and population growth, immediate actions to reduce fertility drastically be put in place. With a consistent and rapid fertility decline, Nigeria will have a fewer number of children to cater for; and a larger proportion will be in economically productive age bracket. This is the demographic dividend that Nigeria can benefit from if something urgent is done about its fertility level. Fertility decline could be accelerated in Nigeria with a substantial investment in female education. Policies that will constrict the spread of fertility distribution across the region in Nigeria especially in the Northern region must be urgently put in place. Programmes that focus on increasing educational opportunities for girls should be organized. Also, increasing access to family planning services for women of reproductive age, and encouraging the use of contraceptive should be considered as a matter of necessity in the country. Fertility reduction in Nigeria is critical to achieving the SDGs; therefore, adequate attentions must be paid to the findings of this study.

6.4 Contribution to Knowledge

Persistent high fertility level in Nigeria is as a result of the age pattern and timing of fertility that have not shifted. This is a contribution to the understanding of how the age pattern and timing of fertility affect fertility levels across the six geopolitical zones in Nigeria. Modelling fertility prediction is still at preliminary stage in Nigeria. Most studies rely on UN model for projecting fertility levels in Nigeria. However, this study developed a fertility model which is suitable for predicting the timing of fertility convergence in Nigeria and it is flexible to use elsewhere. This is a major contribution to the study of fertility transition. Also, this study went further to document the drivers of fertility change in each region of Nigeria. These findings have advanced the knowledge of fertility in Nigeria at both the regional and national levels.

6.5 Study Limitation

The study was based on cross-sectional study design; and high rates of error particularly non-sampling errors are associated with this type of study design. More so that the information collected were self-reported, some cultural beliefs and practices might affect the information on fertility behavior. There are tendencies of underreporting of births due to omission and displacement which could lead to under-estimation of fertility. Also, there are could be misclassification of timing of births because of recall bias. Establishing causality using survey data is difficult. Furthermore, Bongarrts and Feeney (1998) opined that census and vital registration data are better than survey data in measuring tempo effects. Survey samples might be too small to obtain plausible estimates; and it would not allow the possibility of measuring the accurate size of tempo effects. Other limitations include unavailability of some key variables that may influence fertility behaviour – gender inequality, women status and empowerment, culturally-laden fertility norms. However, this study made use of models that allowed the data to be refined for plausible estimates. Also the study aimed at detecting the existence of tempo effect to understand the whether there have been changes in the timing of births. For projection of total fertility rate, an assumption that the estimates of the countries used were accurate was part of the limitations of this study. Also, this study assumed a constant age patterns of fertility decline in Nigeria.

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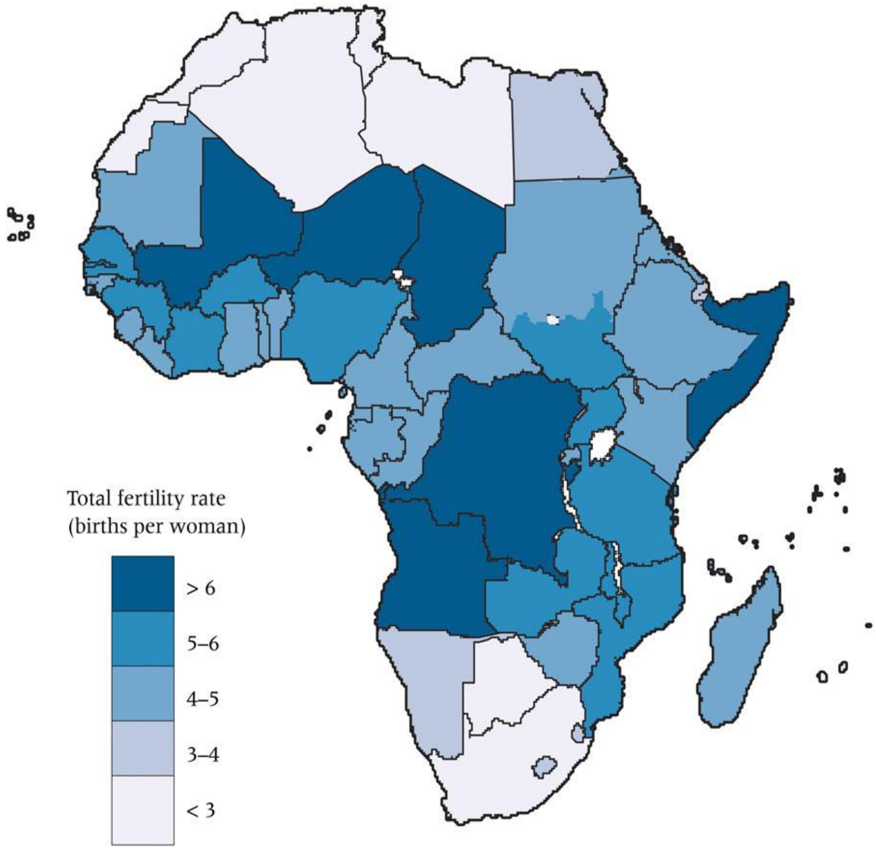
APPENDICES



SOURCE: United Nations 2015a

Appendix I: Total fertility levels in Africa, 2010–2015

Appendix II: Standard Age schedule of Fertility

Country	Year	TFR	ASFR per 1000						
			15-19	20-24	25-29	30-34	35-39	40-44	45-49
Bahrain	2008	2.06	12	85	124	106	59	24	3
Belarus	1985	2.08	33	174	125	58	22	4	0
China, Macao SAR	1970	2.04	3	68	130	90	78	35	4
Cyprus	1995	2.03	17	114	136	91	40	8	1
Dominica	2003	2.10	48	111	75	89	70	25	1
France	2009	2.07	12	63	138	128	60	12	1
Gibraltar	2002	2.04	27	67	137	123	44	10	0
Greenland	2011	2.07	41	104	117	98	49	5	0
Iceland	1995	2.08	23	94	129	111	51	9	1
Japan	1970	2.10	4	97	209	86	20	3	0
Kazakhstan	1995	2.10	48	161	119	59	27	6	1
Lithuania	1985	2.10	22	158	136	66	28	8	0
New Zealand	2011	2.06	26	72	105	122	71	15	1
Puerto Rico	1995	2.07	75	124	110	71	28	6	..
Russian Federation	1985	2.05	47	164	112	60	23	4	0
Saint Kitts and Nevis	2001	2.08	74	127	88	83	36	8	0
Switzerland	1970	2.09	23	125	137	83	38	10	1
Tunisia	2007	2.05	6	54	119	127	78	24	2
Ukraine	1970	2.09	35	174	103	69	29	7	1
United States of America	2008	2.08	41	103	115	99	47	10	1
Viet Nam	2005	2.08	28	138	130	75	36	9	1
			31	113	124	90	44	12	1

Appendix III

ICF

Jul 25, 2018

Tubosun Olowolafe
University of Ibadan
Nigeria
Phone: 08033936388
Email: tubosun.olowolafe@gmail.com
Request Date: 07/25/2018

Dear Tubosun Olowolafe:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Fertility Patterns and Mathematical modeling":

Nigeria

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. Users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: archive@dhsprogram.com.

Sincerely,

Bridgette Wellington

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program