UNIVERSITY OF SOUTHAMPTON

Fertility transition in Tanzania:
the impact of marriage and contraception

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A thesis submitted to the University of Southampton
for the Degree of Doctor of Philosophy

Division of Social Statistics

School of Social Sciences

Faculty of Law, Arts and Social Sciences

Southampton, UK.

Submitted: July 2003

Viva voce: August 2003

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

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FERTILITY TRANSITION IN TANZANIA: THE IMPACT OF MARRIAGE AND CONTRACEPTION

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A fertility decline is now well under way in Tanzania with total fertility rates having declined from 7.2 in 1978 (Mturi and Hinde, 1994) to 5.6 in 1996-99 (Mturi and Hinde, 2001). This suggests that Tanzania is at the onset of its fertility transition. Later age at marriage and greater use of modern contraception are thought to be the driving forces behind the decline (Kirk and Pillet 1998). This thesis aims to evaluate the impact of these two factors on the Tanzanian fertility decline, using mainly the 1996 Tanzania Demographic and Health Survey.

Age at first marriage is rising in Tanzania. However, it will only lead to a decline in fertility to the extent that it is not offset by premarital fertility, which is high. To analyse the impact of marriage on fertility, the total fertility is decomposed in its pre- and post-marital parts and a method based on standardisation used. It is estimated that in the twenty years before the survey at least a quarter of the fertility decline among women aged 15-34 is due to a rise in age at marriage. Other countries of eastern and southern Africa are then analysed to include Tanzania in a wider context.

Contraceptive prevalence rates are rising in Tanzania. However, contraception is used mainly to space births rather than to stop childbearing. Therefore, the impact of contraception is not as straightforward as in other parts of the world than sub-Saharan Africa. The proportions of women using contraception in each birth interval and the lengths of the intervals for women spacing and for women not using contraception are estimated using survival analysis. Then, simulation models of women's reproductive life are designed. The mean number of children ever born (CEB) is estimated at 5.71, close to the most recent total fertility rate. It is shown that spacing as practised currently in Tanzania, even if very prevalent, has little impact on the fertility rates whereas stopping, fairly uncommon, has a large impact. Projections are then made to evaluate the most efficient family planning strategies in order to reduce fertility in Tanzania: more and longer spacing or more stopping.

This thesis has not found any evidence that Tanzania is following a new type of fertility transition led by spacing. In fact, the way marriage and contraception affect fertility leads us to conclude that the fertility transition in Tanzania is following the path drawn by Europe, Asia and Latin America. However, this would change if more women were to space for longer.

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Acknowledgements

I would like to thank my supervisors, Andy Hinde for his great enthusiasm and support, and Nyovani Madise for her valuable suggestions. I acknowledge Sally Brailsford for her expertise with the simulation package SIMUL8.

The provision of financial support by the Department of Social Statistics at the University of Southampton and the Economic and Social Research Council is very much appreciated and has certainly helped in engaging in this research.

I acknowledge my fellow research students and the staff in the Department of Social Statistics at the University of Southampton for their suggestions and feedback on this research.

I would like to thank Mr Glaude, my mathematics teacher at secondary school, who taught me rigour and perseverance in solving mathematical problems and always supported and encouraged me.

Special thanks go to Sarah Worley who looked after my daughter whilst I was finishing this research.

My parents and friends have as always been supportive, for which I am very grateful. Most of all, I would like to thank my husband Ian who lived this thesis with me, remained enthusiastic, supportive and loving throughout, and convinced me to resume my research after the birth of our daughter Zoë.

Dedicated to …

Zoë

Chapter 1

Introduction

1.1 The fertility transition in the developing world

A fertility transition refers to a substantial, long-term, irreversible decline in fertility from high levels towards replacement level fertility (Caldwell *et al.*, 1992; Mason, 1997). The fertility transition began during the 1960s or 1970s in most of the developing world, including Asia, Latin America and North Africa. However, there was no evidence of a fertility transition in sub-Saharan Africa until the end of the 1980s (Onuoha and Timæus, 1995).

The fertility transitions observed in Asia, Latin America and North Africa were achieved largely by increased fertility regulation within marriage, through the use of modern contraception or abortion (Cohen, 1998). In some countries, particularly in Asia and in North Africa, rising age at marriage also made an appreciable contribution especially in the early stages of the transition (Cleland *et al.*, 1994; Casterline, 1994). Contraception was used to limit family size and consequently fertility fell mainly at older ages when women had reach their ideal family size. This means that the fall in marital fertility was the largest among women aged 45-49 and progressively smaller for younger ages down to 20-24 (Knodel, 1977). Therefore, Onuoha and Timæus (1995) defined the fertility transition as 'a sustained and usually irreversible decline in fertility driven by the increasing use of contraception, sterilisation and abortion to limit family size'.

1.1.1 The fertility transition in sub-Saharan Africa

Cohen (1998) gives an assessment of the fertility declines in sub-Saharan Africa and classifies them as follows:

- moderate to large declines in Kenya, Rwanda, Zimbabwe, Botswana, South Africa and Côte d'Ivoire;
- smaller declines in Malawi, Tanzania, Zambia, Cameroon, Central African Republic, Burkina Faso, Gambia, Ghana, Mauritania, Senegal and Sierra Leone.

It is believed that the larger declines are well established and indicate the onset of a fertility transition, particularly in Botswana, Kenya and Zimbabwe (Robinson, 1992; Brass and Jolly, 1993; Rutenberg and Diamond, 1993; Kirk and Pillet, 1998). These countries are found in southern and eastern Africa, which seems to be more receptive to a fertility transition than West Africa. Cleland *et al.* (1994) forecast that the fertility declines underway in parts of Africa will spread to other countries.

As in the rest of the developing world, the sub-Saharan Africa fertility declines are achieved through later marriage and increasing contraceptive use (see for example Robinson, 1992 for the case of Kenya; Onuoha and Timæus, 1995 for the case of Senegal; or Mhloyi, 1994 for the case of Zimbabwe). However, Ware (1994) and Locoh and Makdessi (1995) have mentioned that the African transition is unique in the way that contraception is used for spacing rather than stopping purposes. African women use contraception mainly to increase the length of the intervals between births rather than to limit their family size. So, women want to slow down the tempo of their fertility and it is therefore assumed that the quantum falls as well (as explained by Szreter (1996) for the case of England and Wales).

Long birth intervals are embedded in African culture. They are seen as necessary for the health of the mother (so that she can regain her strength before her next pregnancy) and of the child (so that s/he benefits from the effect of breastfeeding for a long period). African women are therefore using modern contraception to maximise their health potential (Bledsoe *et al.*, 1998). The importance of long birth intervals has often been extended to the whole of sub-Saharan Africa whereas Bledsoe's work focuses on West

Africa. In eastern and southern Africa, long birth intervals are still an important factor when taking the decision to use contraception; however, ideas about smaller family size are more accepted (Robinson, 1992). Contrary to West Africa where the cost and burden of raising children rest solely on the mother's shoulders, eastern and southern African fathers are expected to help in raising children, and may be keener to limit their family size. Therefore, the mechanisms behind a fertility transition in southern and eastern Africa are not the same as in West Africa. Southern and eastern Africa may be more receptive to family limitation messages and ready for a fertility transition.

Caldwell *et al.* (1992) argue that the African fertility transition is a new type of transition where a similarity in contraceptive use and fertility decline is found at all ages, both inside and outside marriage because contraception is used for birth spacing. They compare this pattern of fertility decline with the European and Asian fertility transition where the decline was non-existent below age 25, small but increasing with age thereafter, and large after the age 40. Caldwell *et al.* (1992) also point out that contraception for birth spacing is used for achieving the long birth intervals embedded in the African culture rather than to limit family size.

If, as claimed by Caldwell *et al.* (1992), Ware (1994) and Locoh and Makdessi (1995), the African fertility transition is driven by the use of contraception to space births, and since women are spacing births mainly for health reasons (Bledsoe *et al.*, 1998), the African fertility transition would be the first one not to comply with Onuoha and Timæus's definition, which states that contraception is used to limit family size. Onuoha and Timæus's definition implies that a fertility transition is a change in behaviour, i.e. the adoption of contraception, sterilisation or abortion to limit family size. In sub-Saharan Africa, contraception to space births is used mainly for health reasons (rather than for limiting family size), which is not a change in behaviour but a change in the means to achieve the long birth intervals embedded in the African culture. It is worth noting that Szreter (1996, pp.367-439) and Garrett *et al.* (2001) show that spacing played a leading role in the English fertility transition at the turn of the twentieth century. However, in that case, spacing was used as a mean to limit family size, mainly by abstaining for substantial periods of time. There is little evidence that spacing in sub-Saharan Africa is used to limit family size, as was the case in England. Therefore, spacing in the rest of this thesis will refer to the spacing of births to achieve the long birth intervals embedded in the African culture, and not to limit family size.

We can therefore ask whether an African fertility transition driven by spacing, as defined by Caldwell, is really a fertility transition. Could there be a fertility transition without a conscious decision to limit family size? This seems unlikely looking at the evidence from the literature and further analysis in this thesis. Scribner (1994) points out that an increase in contraception to space may not manifest itself as lower fertility. When analysing Demographic and Health Surveys data from 13 sub-Saharan countries, Greene (1998) finds that 'women who use contraceptives for spacing do not have fewer children over their lifetimes than non-users' (p. iv). There is only one country in sub-Saharan Africa showing evidence that using contraception to space births leads to a fertility decline: South Africa. Moultrie and Timæus (2002) suggest that the doubling of the birth interval lengths in 30 years has a large impact on the South African transition. However, South Africa is the only country in the region to have experienced such a change in the birth interval lengths. Such long birth intervals are certainly not observed only to maintain the mother's health, but are likely to be caused by changes in behaviour as well. With the possible exception of South Africa, the African fertility transitions would need to be led by contraception to limit family size as in other parts of the world.

The 'new' type of fertility transition in sub-Saharan Africa could also be argued for in view of the association between the contraceptive prevalence rates (CPRs) and total fertility rates (TFRs), which is considerably stronger for countries worldwide than for countries in sub-Saharan Africa (Freedman and Blanc, 1992). This would imply a 'different' type of fertility transition for sub-Saharan Africa. However, Brown (1996) shows that as sub-Saharan Africa countries move towards more advanced stages of their fertility transition, the correlation between CPR and TFR becomes stronger and in line with the correlations found world-wide. He forecasts a convergence of the sub-Saharan Africa and global associations between CPR and TFR, and challenges the model of a new type of fertility transition in sub-Saharan Africa. As pointed out by Brown, the correlation between CPR and TFR is likely to become stronger as a growing proportion of contraception is used for purposes of family limitation rather than for spacing. Brown's findings imply that a decline in fertility is more strongly correlated to an increase in contraceptive use to stop childbearing than to an increase in contraception to space births.

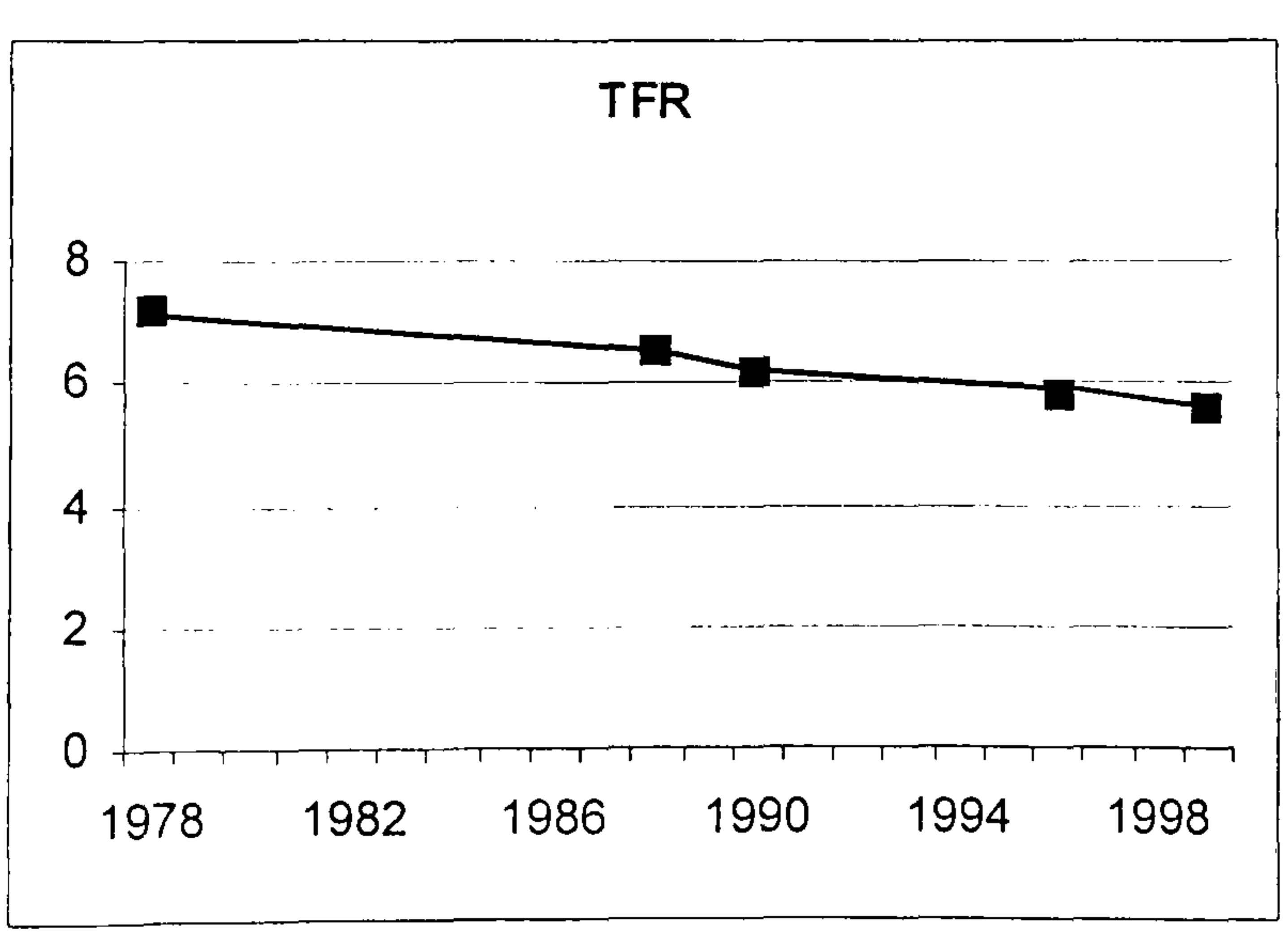
1.2 The fertility transition in Tanzania

Larsen (1997), Hinde and Mturi (1998) and Mturi and Hinde (2001) have documented a fertility decline in Tanzania. The total fertility rates have declined as follows:

- 7.2 in 1978 (Mturi and Hinde, 1994)
- 6.5 in 1988 (Mturi and Hinde, 1994)
- 6.2 in 1989-90 (Mturi and Hinde, 1994)
- 5.8 in 1994-96 (Hinde and Mturi, 2000)
- 5.6 in 1996-99 (Mturi and Hinde, 2001).

These total fertility rates (Figure 1-1) show a steady and convincing downward trend which seems to be the onset of the Tanzanian fertility transition. The total fertility rate fell by 22 per cent between 1978 and 1999, well above the ten per cent threshold fall in fertility suggested by Caldwell *et al.* (1992) as the onset of a fertility transition. As for most fertility transitions, the forces behind the Tanzanian fertility decline are thought to be a rising age at marriage and a reduction of fertility within marriage (Kirk and Pillet, 1998). Hinde and Mturi (2000) also recognise that the AIDS epidemic and the economic hardship experienced during the late 1970s and early 1980s have a role to

Figure 1-1. Trends in the total fertility rate (TFR) in Tanzania, 1978-1999.



play in the Tanzanian fertility decline. However, the way these forces operate has not yet been analysed in detail, nor has their impact on the fertility decline been assessed.

1.3 The proximate determinants of fertility in Tanzania

A review of the proximate determinants of fertility gives some insight into the reasons for the decline. The determinants directly affecting fertility described by Bongaarts (1978) are proportions married, contraception, induced abortion, lactational infecundability, frequency of intercourse, sterility, spontaneous intrauterine mortality, and duration of the fertile period. Any change in fertility level is due to a change in one or more of the proximate determinants. Bongaarts has devised a framework to estimate the impact of the different determinants on the fertility levels. However, this framework is better suited at comparing different countries than focusing on one. Moreover, its assumptions are not met in the case of sub-Saharan Africa where marriage patterns are complex (Reinis, 1992). She concludes that the model yields 'very poor estimates of the fertility-reducing impacts of marriage delay, contraceptive use, and induced abortion' (p. 325). Therefore, we are reviewing the proximate determinants of Tanzanian fertility without using Bongaarts' framework.

Three of the proximate determinants, namely spontaneous intrauterine mortality, the duration of the fertile period and the frequency of intercourse, have not played a role in most fertility transitions outside sub-Saharan Africa. Spontaneous intrauterine mortality and the duration of the fertile period did not vary much between time periods or populations and so did not explain any changes or differences in the fertility levels. Very little was known of the frequency of intercourse and its effect on fertility. When comparing married women in nine African countries, Brown (2000) finds substantial population level differences in mean monthly coital frequency where West Africa has significantly lower levels than eastern and southern Africa. We cannot ignore the impact of these proximate determinants in sub-Saharan Africa any more because the AIDS epidemic has a direct impact on them. Gregson *et al.* (2002) show that HIV affects fertility directly through foetal loss, amenorrhoea and decreased coital frequency due to illness. They also state that all women, irrespective of their HIV status have less extra-marital and premarital sex (i.e. reduce the frequency of intercourse) for fear of becoming infected. Therefore, as the AIDS epidemic grows in sub-Saharan Africa, these three proximate determinants gain more status in explaining a fertility decline. Baschieri (2000) estimates that in the absence of HIV, Tanzanian fertility in 1996 would have been between 1.5 and 2.0 per cent higher than it was. The impact of AIDS on fertility *per se* is not studied here because it is well documented in Gregson (1994), Baschieri (2000) and Gregson *et al.* (2002) for example. However, AIDS will be taken into account in Chapter 4 when determining the impact of contraception on the birth interval lengths.

Hinde and Mturi (1996) analyse breastfeeding duration using the 1991-92 Tanzania Demographic and Health Survey (TDHS). They show that Tanzanian women breastfeed their children for 21 months on average, and that the trend in breastfeeding duration, if any, is towards slightly shorter durations. Therefore, changes in lactational infecundability cannot explain the fertility decline. With respect to sterility, Larsen (1996) shows that childlessness, subfertility and infertility have declined in Tanzania between the 1973 National Demographic Survey and the 1991-92 TDHS, due to an improvement in health care. This would lead to an *increase* in fertility.

The effect of induced abortion on fertility is difficult to assess because it is illegal in Tanzania except if it is performed on medical grounds (Komba and Aboud, 1994). So women are reluctant to admit they have had an abortion. Rwebangira (1994) suggests that 'safe illegal abortions' among teenage girls are common in private clinics. In a study of four public hospitals in Dar es Salaam, Mpangile *et al.* (1993) found that out of 965 women who were screened, 455 (47 percent) had had induced abortions. When studying 300 women with early pregnancy loss admitted to Muhimbili Medical Centre in Dar es Salaam, Justesen *et al.* (1992) found that nearly a third presented an illegally induced abortion. Therefore abortion is likely to have an inhibiting effect on the levels of Tanzanian fertility: first, an abortion leads to a longer interval before a birth; second, illegally performed abortions are risky and can lead to sterility. Unfortunately, there are no nationally representative data available to assess the impact of abortion on fertility and it is unlikely that any data will be available in the near future because of the illegality of abortion.

The remaining two proximate determinants which can affect the Tanzanian fertility decline are the proportions married and contraception. Trends towards later marriage and higher contraceptive use should lead to a decline in fertility as hypothesised by Hinde and Mturi (2000), and Kirk and Pillet (1998). However, the relationships between marriage and fertility on one side and contraception and fertility on the other side are not as straightforward in Tanzania as one might expect. It is clear that understanding the impact of marriage and contraception on fertility is of central importance to the understanding of the Tanzanian fertility transition, which is the focus of this thesis.

The median age at first marriage is rising steadily in Tanzania, from less than 18 years among women aged 45-49 to 19 years among women aged 20-24 in the 1996 Tanzania Demographic and Health Survey (Bureau of Statistics and Macro International, 1997). This rise in age at marriage would lead to a fertility decline to the extent that it is not offset by an increase in premarital fertility which is very common in sub-Saharan Africa (Lesthaeghe and Jolly, 1995). Since premarital fertility is high in sub-Saharan Africa, it is not straightforward to estimate the impact of a rise in age at marriage on fertility. Therefore, the first aim of this thesis is to assess the impact of marriage on fertility in Tanzania in the light of the substantial premarital fertility.

Contraceptive use is increasing in Tanzania: for all women, it increased from 10 percent in 1991-92 to 16 percent in 1996 (Bureau of Statistics and Macro International, 1997). However, Tanzania is still considered as a 'low contraceptive prevalence country' and so very little information on the subject was collected in the Demographic and Health Surveys (DHSs). Because of this lack of information and because it is usually assumed that fertility will decline if contraceptive use increases, very few analyses of the impact of contraceptive use on the Tanzanian fertility decline have been carried out. Moreover, in sub-Saharan Africa, contraception is mainly used to space births rather than to stop childbearing (Caldwell *et al.* 1992). This is very particular to Africa since in most of the other fertility transitions in Asia, Latin America and Europe, contraception was used to stop childbearing. The effect of contraception to space births on fertility is not as straightforward as the effect of stopping. The second aim of the thesis is to assess the impact of contraceptive use for spacing and stopping on fertility levels and the fertility transition.

1.4 Motivations for studying the fertility in Tanzania

Tanzania has been chosen for this research for a number of reasons. Firstly, Tanzania is the fifth most populous country of sub-Saharan Africa, with a population estimated at 35.1 millions in 2002 (UNICEF, 2002). It is therefore important to understand whether it is on the path of a fertility transition.

Secondly, Tanzania has cultural similarities with Kenya, its northern neighbour, and to a lesser extent with Zimbabwe and Botswana. Since these three countries are in the forefront of the African fertility transition, one might expect Tanzania to follow them and establish a fertility transition (Hinde and Mturi, 2000). Moreover, the mechanisms behind the fertility transition in Tanzania analysed in this thesis are likely to be similar to those behind the transition in Kenya, Zimbabwe and Botswana, and to be transferable to other countries in the region which show the signs of a fertility decline such as Malawi and Zambia.

Thirdly, the data needed for this research are readily available for Tanzania, through the Demographic and Health Survey (DHS) programme. In fact, four DHS-type surveys have been carried out in Tanzania: the DHS of 1991-92 (Bureau of Statistics and Macro International, 1993); the Knowledge, Attitudes and Practices Survey (KAPS) of 1994 (Bureau of Statistics and Macro International, 1995); the DHS of 1996 (Bureau of Statistics and Macro International, 1997); and the Child and Reproductive Health Survey (CRHS) of 1999 (National Bureau of Statistics and Macro International, 2000). The combined use of these data sets, when possible, should make the analysis more convincing and enable real trends to be distinguished from statistical aberrations. It has therefore the potential to produce a clear and detailed picture of fertility change in Tanzania. The data sets will be discussed in more detail in the next section.

Finally, the Government of Tanzania is very interested in reducing fertility in order to reduce the rate of population growth. As early as in 1974, family planning was provided as a component of Maternal and Child Health services. In 1988, the Government adopted a Family Planning Policy and the family planning services were strengthened and extended to all adults, irrespective of marital status or parity (United

Republic of Tanzania, 1992). In 1992, the Government adopted a National Population Policy which called for wider dissemination of family planning information, and encouraged a reduction of fertility. This research will therefore contribute to the evaluation of the Tanzanian Population Policy by looking at the impact of contraception on the fertility decline.

1.5 Data

As mentioned earlier, four DHS-type surveys have been conducted in Tanzania. The 1996 DHS is our main focus because it is recent, has a large sample of 8,120 women aged 15-49 years, and contains the relevant information for this research.

When analysing the effect of marriage on fertility (Chapters 2 and 3), the 1991-92 DHS will be included to check for consistency and give trends over time. The 1994 KAPS will not be used here because of its small sample (4,444 women). However, the 1999 CRHS will be analysed, even if its sample is small (4,029 women), because it is the most recent data set available.

When analysing the effect of contraception on fertility (Chapters 4 and 5), only the 1996 DHS will be used. The 1999 CRHS does not contain the information needed on contraceptive use and its sample is too small. The 1994 KAP sample size is too small, and the 1991-92 DHS is out-of-date. Therefore, the only recent and suitable data set is the 1996 DHS.

1.6 Aims and structure of the thesis

As already discussed, this thesis aims to investigate the impact of marriage and contraception on Tanzanian fertility. It consists of four papers: the first two concentrate on the effect of marriage on fertility whereas the last two concentrate on the effect of contraceptive use on fertility.

The first paper (Chapter 2) estimates the impact of marriage on Tanzanian fertility by decomposing the total fertility into its pre- and post-marital components. The second paper (Chapter 3) applies the method devised in the first paper to a range of southern and eastern African countries, putting the case of Tanzania into context.

The third paper (Chapter 4) investigates the impact of contraceptive use on the length of the birth intervals in Tanzania and estimates the proportions of women spacing and stopping at each parity. Drawing from the conclusions of the third paper, the final paper (Chapter 5) uses simulation models to estimate the impact of spacing and stopping on the Tanzanian fertility decline.

Finally, in the concluding chapter, the findings of the four papers are drawn together. The impact of our results on current knowledge of the fertility transition in Tanzania is then discussed. Areas for further research are also suggested.

Chapter 2

The impact of rising age at marriage on the Tanzanian fertility decline[1]

Abstract

Rising age at marriage is thought to be an important factor in explaining the fertility decline in Tanzania. The relationship between age at marriage and fertility is not straightforward. A rise in age at marriage would lead to a fertility decline to the extent that it is not offset by premarital fertility which is high in Tanzania. Therefore, the aim of this chapter is to evaluate the impact of rising age at marriage on the fertility decline using the 1996 Tanzania Demographic and Health Survey and the 1999 Child and Reproductive Health Survey. First, some background about age at marriage, age at first birth and the proportions of premarital first births is shown. Next, the total fertility is decomposed into its pre- and post- marital parts and each component is examined in detail. We show that premarital fertility is declining; however, since the proportions of unmarried women are increasing, the contribution of premarital fertility remains stable. Finally, the effect of rising age at marriage on the fertility decline is measured using a method based on standardisation. It is estimated that at least a quarter of the fertility decline among women aged 15-34 in Tanzania is due to a rise in age at marriage.

[1] An earlier version of this chapter has been published in *The African Population in the 21st Century* (Lejeune and Hinde, 1999).

2.1 Introduction

As described in Chapter 1, fertility is declining in Tanzania, with the total fertility rate dropping from 7.2 in 1978 to 5.6 for the period 1996-99. At the same time, age at first marriage has risen from 17.4 years among women aged 40-44 to 19.0 years for women aged 20-24 in the 1996 Tanzania Demographic and Health Survey (TDHS) (Bureau of Statistics and Macro International 1997). Therefore this rise in age at first marriage should play a role in the fertility decline.

Contrary to Europe and Asia where a fertility transition has traditionally been seen as a sustained decline of *marital* fertility, attempts to ascertain the role played by changing marriage patterns in the fertility decline in sub-Saharan Africa are complicated by non-marital, especially premarital, fertility. Because of high premarital and extramarital sexuality, as well as high marital instability, non-marital fertility is not negligible (Bongaarts *et al.* 1984). Moreover, premarital fertility seems to be increasing. According to Cohen (1993) and Meekers (1994), whereas age at first marriage is increasing in several sub-Saharan countries, age at first birth is remaining constant, implying an increase in premarital fertility. Lesthaeghe and Jolly (1995), Bledsoe and Cohen (1993), and Gage (1998) noted an increase in premarital teenage fertility in several countries of sub-Saharan Africa, whereas a decline might have been expected due to the widespread trend towards more schooling.

Gage-Brandon and Meekers (1993) note that extra-marital fertility is becoming an important concern in Africa, in terms of responsibility for supporting these children, especially at a time when most African countries are suffering from severe economic crisis. They also argue that 'childbearing before marriage may produce households headed by women, often resulting in poverty during the early stages of reproduction' (Gage-Brandon and Meekers, 1993, p. 14). Premarital childbearing may have serious consequences for the mother in sub-Saharan Africa, and often results in illegal abortion, child abandonment and high mortality rates of children born before marriage. Therefore, marriage is an important event that will allow the mother to rely on some support to help her.

In the presence of high premarital fertility, a rise in age at first marriage may not have a large effect on the levels of fertility. In fact, if premarital fertility rates were as high as marital fertility rates, a rise in age at first marriage would not have any effect on the total fertility rates. Therefore, premarital fertility has to be taken into account when estimating the impact of changes in marriage patterns on fertility in sub-Saharan Africa. As summarised by Lesthaeghe and Jolly (1995), the increase in the proportions of single women in the age-group 15-19 contributes to a lowering of overall fertility, in as much as it is only partially offset by an increase in premarital teenage fertility.

The most widely applied methods for estimating the proportion of the decline in overall fertility that has resulted from changes in nuptiality, are Bongaarts's multiplicative model (Bongaarts, 1978; Bongaarts *et al.*, 1984) and the additive model of Hobcraft and Little (1984). However, both models were designed to compare the effects of the different proximate determinants rather than to analyse one in detail. Moreover, both models assume that there is no fertility outside marriage, which is not the case in sub-Saharan Africa. When evaluating Bongaarts's and Hobcraft and Little's methods, Reinis (1992) shows that '[n]either model works well when women employ stopping behaviour once they have achieved their desired family size. Both models go awry when marriage is delayed, because total marital fertility, implied in both models, is a meaningless measure' (p. 324). She also states that under the assumptions of non-random use of contraception 'the models yield very poor estimates of the fertility-reducing impact of marriage delay' (p. 325). Therefore Bongaarts's and Hobcraft and Little's models are not adequate to estimate the impact of marriage on fertility in Tanzania.

There have been many attempts at reconciling Bongaarts's model with the high levels of premarital fertility found in sub-Saharan Africa. Jolly and Gribble (1993) introduce a measure of births outside marriage in the model, to assess the importance of non-marital fertility. However, this modification is introduced to maintain comparability across cultures in the interpretation of other parameters of the model and is not aimed at directly evaluating the effects of the proportion married on total fertility. Stover (1998) considers the proportion having had sexual intercourse instead of the proportion married, but this simply eclipses premarital fertility and the social concerns attached to it.

Even if it was not performing satisfactorily, in the last twenty years the focus when evaluating the impact of marriage on fertility has been mainly on Bongaarts's model. Therefore, few authors have attempted to examine the impact of marriage on fertility, and none to quantify it. In Botswana rising age at marriage could contribute to the fertility decline by increasing the proportion of never-married women, who have lower fertility and a higher mean age of childbearing compared with those married or living with a partner (Letamo 1996). However, for van de Walle (1993) there is no clear evidence in the WFS or the DHS that the decline in fertility in sub-Saharan Africa is caused by a rise in age at marriage.

Based on the work of Kitagawa (1955), Coale (1967) describes a method of decomposing the fertility into different parts (premarital and post-marital for example). It was not possible in the past to apply this method to African populations because the necessary data were not available. However, the data collected in the late 1980s and 1990s through the Demographic and Health Survey programme allow the use of Kitagawa and Coale's direct method, and its illustration is given in this chapter.

This chapter has three aims. First, we determine trends in age at first marriage and age at first birth, and in the proportion of first births that are premarital in Tanzania over the past 15-20 years. We also examine differentials in the chance of a first birth being premarital. Second, we examine the role played by changes in premarital fertility in the Tanzanian fertility decline using the decomposition of overall fertility into its premarital and post-marital parts proposed by Coale (1967). Third, we assess the impact of nuptiality changes using a simple (and possibly rather old-fashioned) method based on standardisation. This method has the virtues, first, of being straightforward and transparent and, second, of making use of Coale's decomposition and thus following logically and simply from our approach to measuring changes in premarital fertility.

2.2 Data

The data used here come from the Tanzania Demographic and Health Survey (TDHS) conducted in 1996 (Bureau of Statistics and Macro International, 1997). The 1996 TDHS contains information on a sample of 8,120 women aged 15-49 years. The 1999 Tanzania Child and Reproductive Health Survey (TCRHS) data have recently been made available. They will be included in the analysis and the results are shown in Appendix A. However, the sample size was about half the size of the 1996 TDHS with 4,029 women interviewed and therefore the results need to be interpreted with caution.

In the African context, marriage is not a discrete, well-defined event, but rather a process. African marriages are usually marked by four steps: payment of bridewealth, ceremony, cohabitation of spouses and consummation of the marriage. These steps can occur over several months, and not always in the same order (Meekers, 1992). Therefore, the concept of an age at first marriage or a date of marriage is rather vague. To avoid imprecision in the DHSs, the time when a woman started to live with her (first) husband/partner was asked of all non-single women, and recorded as their date of first marriage. Therefore, the DHS date of first marriage may be interpreted as the date when a woman starts her first stable relationship (formalised or not). Here, as in the vast majority of the literature on sub-Saharan Africa, the terms 'marriage' and 'stable relationship' are used interchangeably. In other words, 'marriage' refers to customary marriage, legal marriage and cohabitation[2]. A premarital birth is defined as a birth occurring before the first marriage, and a post-marital birth as occurring after the onset of the first marriage. As noted earlier, a mother is less likely to receive some support for a premarital birth.

Our analysis is especially dependent on data on age at first marriage and age at first birth. It is therefore important to know exactly what these terms mean in the context of the TDHS data, and how they were collected. The 'dates of first marriage' reported in the 1996 TDHS have a good degree of completeness. 63 per cent of ever-married

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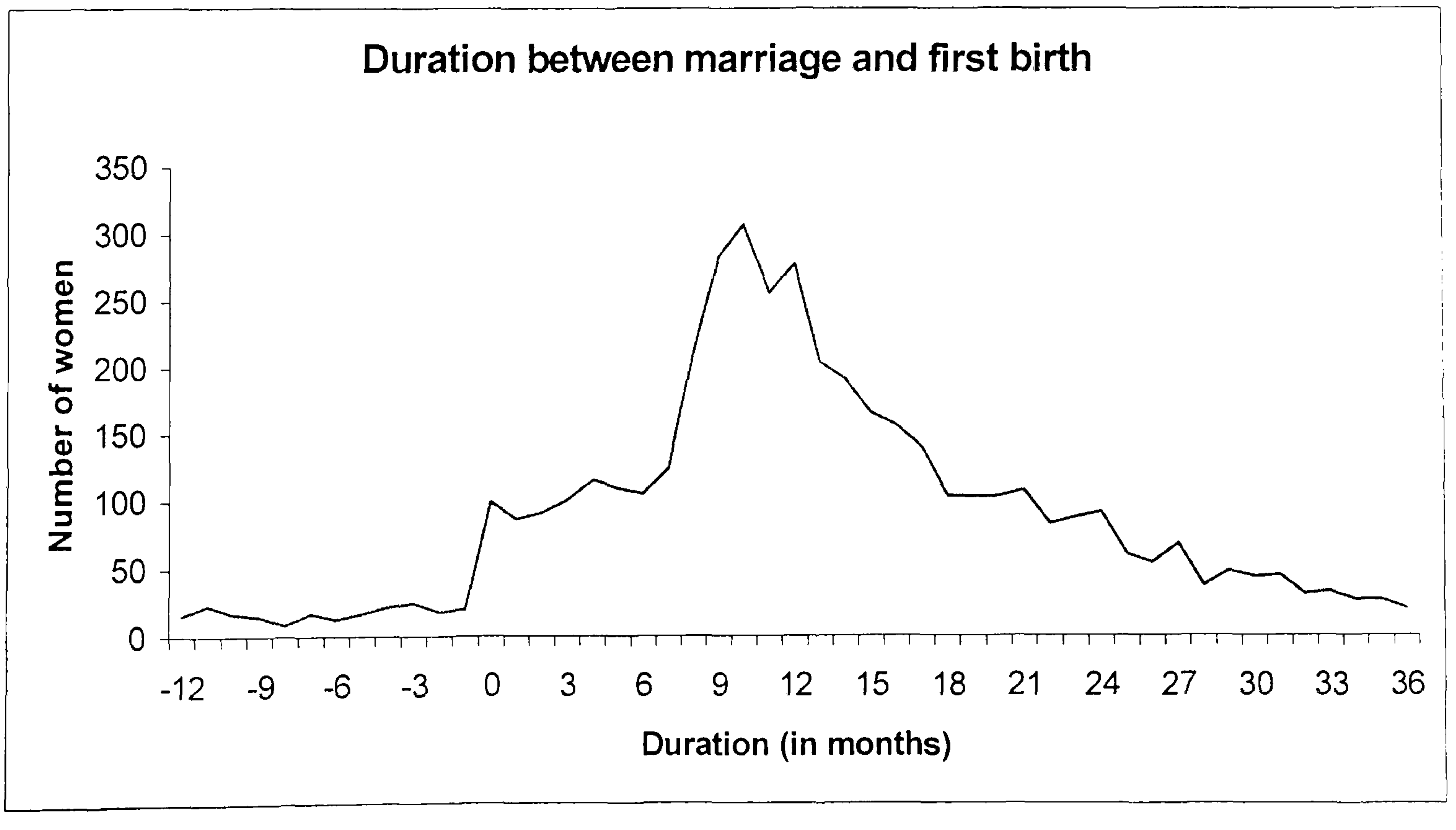
[2] All the authors referenced in this paper are using this shortcut, and therefore the results of the different studies are comparable on this point of view.

women gave the month and year of first cohabitation, 36 per cent gave either the year or their age at first cohabitation, and only one per cent were unable to give any information. Rural, older and less educated women had less complete answers, but in each case fewer than 3 per cent gave no information.

An obvious objection to using the date at first marriage may be that some women displace events to conceal births before cohabitation or to give an ideal sequence of events which is not the reality. This would underestimate the number of premarital births. There is some evidence that this may have happened in the 1996 TDHS: a peak of births occurring the same month as the reported date of marriage is observed, and may be due to displacement of premarital births so that they appear to have occurred after marriage. However, this peak is not very large (see Figure 2-1), and it is possible that part of it is real and due to the 'legitimisation' of premarital conceptions by a marriage before the birth. Another possible problem is the under-reporting of current (probably consensual) unions by young women. Nevertheless, despite these shortcomings of the DHS data, we believe that the reported dates of marriage are sufficiently reliable to be useful in our analysis. It is not possible to determine the extent of these omissions and

Figure 2-1. Duration between marriage and first birth.



displacements. However, if they occurred, the distortions would reduce the number of reported premarital births and would mean that the data understate premarital fertility. Therefore, this chapter presents the minimum estimate of premarital fertility.

Date of first birth is a very well defined event, for which 96 per cent of women gave the month and year; and the remaining 4 per cent gave either the year or their age when giving birth. Here again, older, less educated and rural women gave less complete answers, but in every subgroup we looked at, more than 88 per cent of the births were recorded with the month and year. Problems of displacement of events should be kept in mind here as for first cohabitation.

Older women are prone to omit births that occurred long ago, especially if the child subsequently died. The omission of births by older women may be identifiable if the fertility of women born between 1947 and 1952 (i.e. aged 45-49 at the time of the survey) when they were 15-19, 20-24,... years old is lower than the fertility of women born between 1953 and 1957 (i.e. aged 40-44 at the time of the survey) at the same ages. The diagonals of Table 2-1 show the fertility of Tanzanian women born in different periods when they had the same age. For example, in 1986, women born between 1948 and 1952 were 30-34, and they had given birth to 5.874 children on average by that time. This has to be compared to the 5.951 children ever born in 1991 from women born between 1953 and 1957. At most ages, the fertility of women born between 1948 and 1951 is lower than the fertility of women born between 1953 and

Table 2-1. Children ever born from women at different times.

Women's	Children ever born before...					
date of birth	1996	1991	1986	1981	1976	1971
1978-1982	0.16					
1973-1977	1.17	0.20				
1968-1972	2.61	1.32	0.20			
1963-1967	4.05	2.88	1.39	0.31		
1958-1962	5.37	4.32	2.93	1.52	0.32	
1953-1957	6.72	5.95	4.72	3.32	1.72	0.40
1948-1952	7.24	6.82	5.87	4.70	3.14	1.62

1957, whereas there is a steady decline over time among younger birth cohorts. This may mean that older women are omitting some births. However the lower fertility of older women may also reflect the increase in Tanzanian fertility which occurred before 1978 (Lockwood, 1998; Mturi and Hinde, 1994).

2.3 First marriage and first birth

Tanzania has been experiencing increases in both ages at first marriage and ages at first birth (Lesthaeghe and Jolly, 1995). Cleland *et al* (1994) noted a postponement of first births throughout much of sub-Saharan Africa in the 1980s. Hinde and Mturi (1998) reported a slight increase in the median age at first marriage from 17.9 years in 1991-92 to 18.2 years in 1996, and Lockwood (1998) mentions an increasing trend in the age at first marriage in Rufiji district. The 1996 TDHS data reveal that median age at first marriage has increased from 17.2 years for women aged 40-44 to 19.0 years for women aged 20-24 (Table 2-2). The median age at first birth increased from 18.2 years for women aged 40-44 to 19.8 years for women aged 20-24. The 1999 TCRHS results (Table A-1 in Appendix A) show similar trends.

The ages at first marriage and at first birth are significantly higher in urban areas than in rural areas (Table 2-2). They increase significantly with the level of education. There are significant differences of one year and half a year in ages at first marriage and at first birth respectively between Christians and Moslems, Moslems marrying and giving birth earlier. Islamic societies employ early marriage to assuage worries about female sexual purity and unsanctioned births. In summary, urban, educated, and Christian women tend to marry and have their first child at later ages than rural, non-educated, Moslem women. These trends are confirmed in the 1999 TCRHS (Table A-1 in Appendix A).

Age at first marriage and age at first birth are highly correlated, with a coefficient of correlation of 0.943. However, the age at first birth varies a lot less than the age at first marriage. This may imply that entry into parenthood is not only determined by age at first marriage.

Table 2-2. Median ages at first marriage and first birth, and percentage of premarital first births.

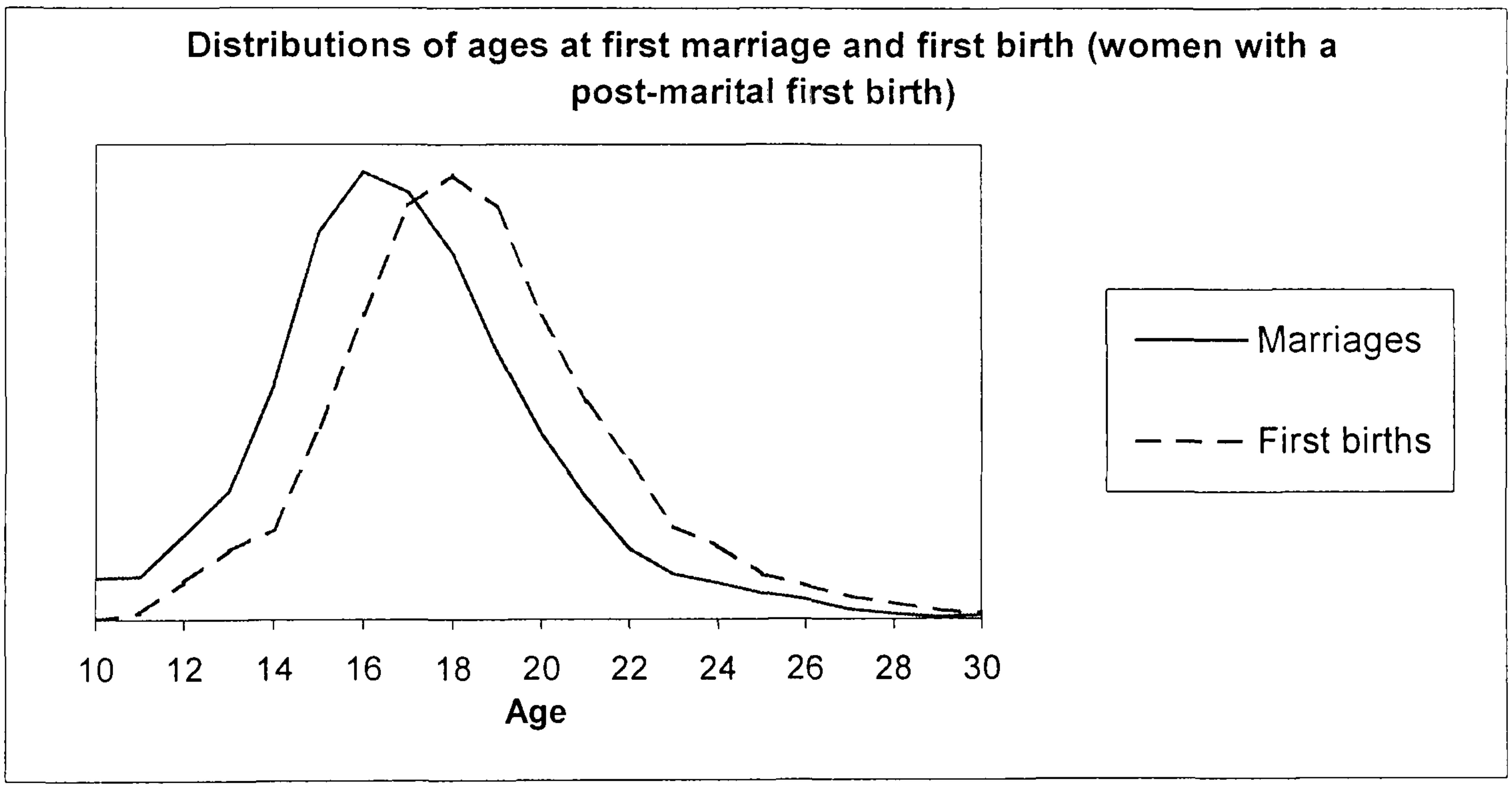
	Median age at first marriage	Median age at first birth	Difference between median age at first birth and marriage	Percentage of first births which were premarital
All	**18.6**	**19.3**	**0.7**	**21.0**
Age cohort				
15-19	19.5	19.6	0.1	36.1
20-24	19.0	19.8	0.8	24.1
25-29	18.6	19.3	0.7	21.7
30-34	18.3	19.1	0.8	22.9
35-39	17.6	18.8	1.2	17.5
40-44	17.2	18.2	1.0	16.1
45-49	17.3	18.9	1.6	13.7
Residence				
Urban	19.2	20.7	1.5	23.9
Rural	18.4	19.3	0.9	20.5
Educational level				
No education	16.9	18.4	1.5	14.8
Primary	18.8	19.5	0.7	24.4
Secondary	22.5	22.8	0.3	23.4
Religion				
Catholic	19.0	19.6	0.6	25.4
Protestant	19.3	19.6	0.3	24.4
Moslem	18.0	19.1	1.1	17.8
None	17.6	18.8	1.2	16.0

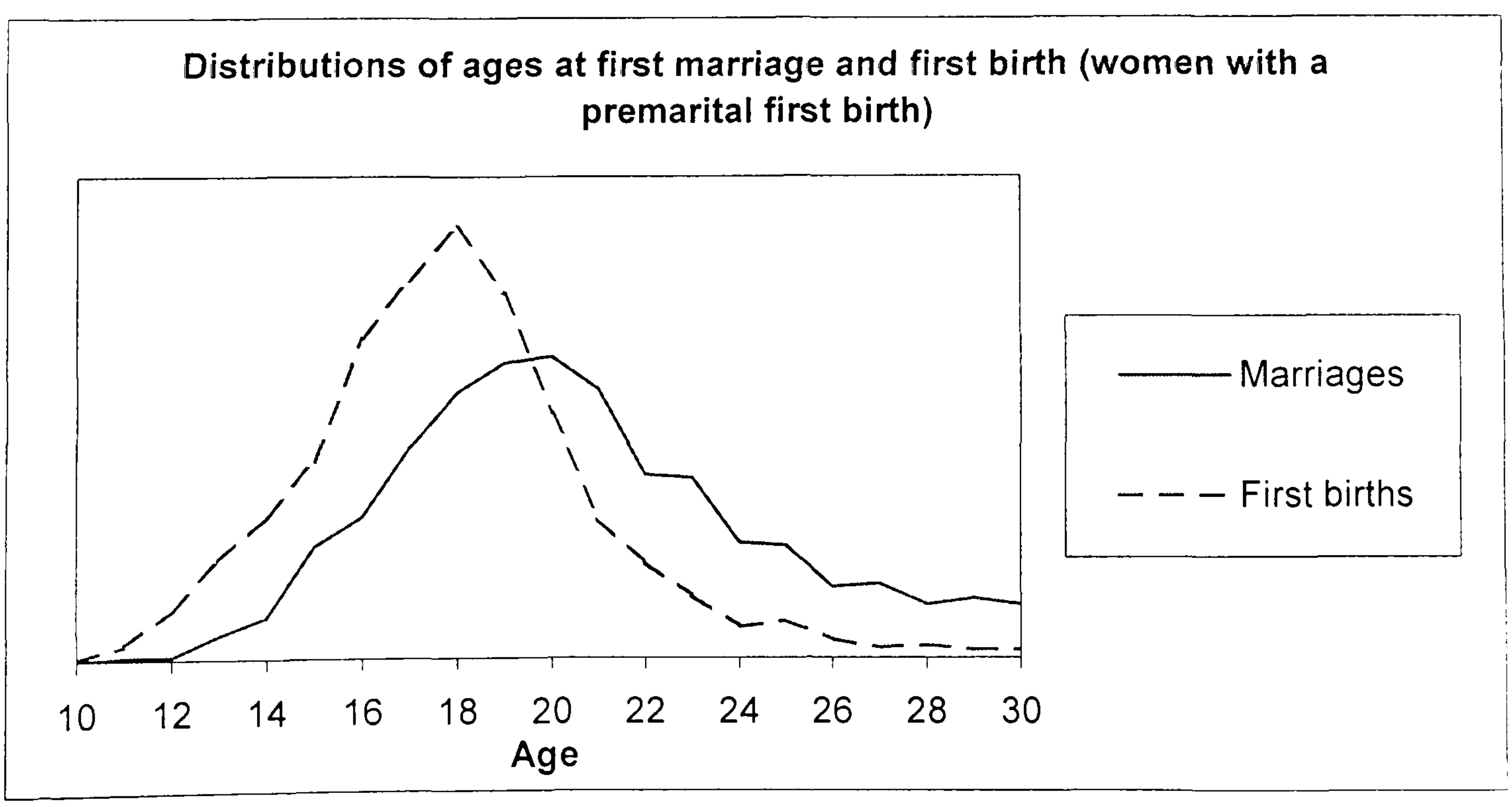
Note: Median ages at first marriage and first birth are estimated using a life table (to avoid the problem of censoring).

2.4 Premarital first births

The median age at first birth is 18.3 years if the birth occurred before first marriage and 18.8 if the birth occurred after first marriage. Here, premarital births refer to births taking place before first marriage or births to never-married women. In other words, they are births to women who have never lived with a partner/husband by the time of the birth. On the other hand, post-marital births include all other births, i.e. to women married, living with a partner, widowed, separated or divorced at the time of the birth. In the case of post-marital first births, the distribution of age at first birth is very similar to the one of age at first marriage, delayed by around one year (Figure 2-2). The case of premarital first births is a lot less clear, with the appearance of a tail of late marrying women. These women could either not marry because they had children, or they found it hard to marry young and thus had premarital births because of their greater exposure.

Figure 2-2. Distributions of ages at first marriage and first birth for women having a premarital and a post-marital first birth.





Among the women surveyed in the 1996 TDHS as a whole, about 21 per cent of first births took place before first marriage, i.e. were premarital (18 per cent in the 1999 TCRHS). The proportion of first births which are premarital decreases with a woman's age at survey (Table 2-2). This result has to be interpreted with caution. Because of censoring, the younger age groups have had (prior to the survey date) a higher proportion of the total number of first births that will occur before marriage than they have of the total number of first births that will occur after marriage. This is because the age at first birth occurring before marriage (median 18.3 years) is lower than age at first birth occurring after marriage (median 18.8 years). In other words, the premarital births in the younger age groups are not yet 'compensated' by marital births: younger women have not had time to have first post-marital births.

A significantly larger proportion of first births is premarital in urban areas (23.9 per cent) than in rural areas (20.5 per cent). Bledsoe and Cohen (1993) found the same trend in different sub-Saharan countries having participated in the first round of the DHSs. Meekers (1994) suggests that the difference is due to a longer exposure to the risk of premarital birth among urban women because age at first marriage is higher there.

The proportion of first births which is premarital is significantly higher for women with some education than for women without education (Table 2-2). The difference between women without education and with education is to be expected: educated women marry later and so have a longer exposure to the risk of premarital birth. Moreover, women having been at school – primary or secondary – are more emancipated, more reticent to a control of their sexual life by their family, and more ready to face the life of a lone mother. The similarity between women with primary and secondary education is a bit surprising since women with secondary education marry two years later than women with primary education, and greater education has been found to be associated with more reported premarital sexual activity (Bledsoe and Cohen, 1993). This may be due to a more widespread use of contraception and abortion among women with secondary schooling, which would mean that even if they are more sexually active, they can prevent a birth better. Since abortion is illegal in Tanzania, few data are available and it is difficult to determine the levels of abortions by education status. However, the difference in the proportions having ever used a modern method of contraception between women with primary and secondary education is small compared with non-educated women: 11.1 per cent for women without education, 28.6 for primary education, and 33.8 for secondary education. If contraception and abortion cannot explain the similarity in the level of premarital births, it probably means that since primary schooling has already a large influence on premarital fertility, further schooling does not increase the proportion of first births occurring before marriage.

Christian women have a higher proportion of first births that are premarital than Moslems. This can be explained again by the later age at marriage of Christian women, and also by the important concerns of Islamic societies about female sexual purity and unsanctioned births.

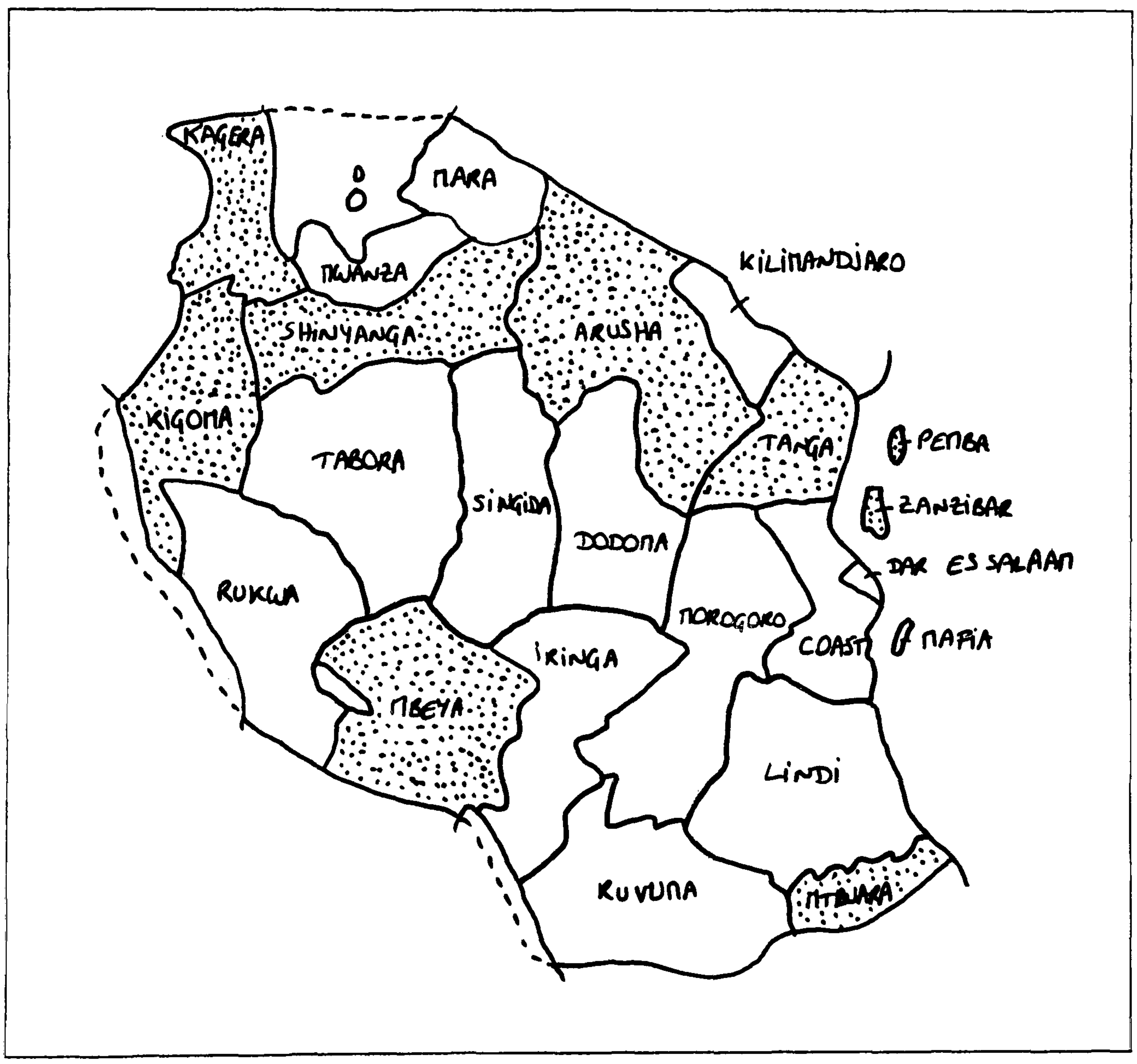
We performed a logistic regression on the probability of a premarital first birth. The variables entered in the models were age, place of residence, education, region, religion, date of first marriage, date of first birth and age at first birth. The results of the best fitting model are shown below.

Variable	β	Significance	Exp β	95% CI for β
EDUC	0.45	0	1.57	[1.30,1.91]
SECTOR	-0.65	0	0.52	[0.44,0.62]
BIRTH1	-0.0041	0	0.9959	[0.9950,0.9967]
MARR	0.30	0	1.35	[1.32,1.38]
CONST	-3.28	0		

EDUC=0 if the women has no education, and 1 if she has some education;
SECTOR=0 in Kagera, Kigoma, Shinyanga, Arusha, Tanga, Pemba, Zanzibar, Mbeya and Mtwara (these regions are shaded on Figure 2-3); and 1 elsewhere (these sectors are artificial, but the best for the logistic regression);
BIRTH1 is the *date* of first birth (in century months);
MARR is the age at first marriage (in years).
For EDUC and SECTOR, "0" is the reference category.

Thus women with some education, living in SECTOR 1, who had their first child a long time ago, and who married at older ages have a higher proportion of premarital first births. Age, place of residence (urban or rural), religion and *age* at first birth are not significant when the above four variables are taken into account. A surprising result is that the probability of premarital first births tends to decrease over time, when education, sector and date of first birth are controlled for. The next section attempts to explain this.

Figure 2-3. Map of Tanzania.



Source: Adapted from Bureau of Statistics and Macro International Inc (1997).

2.5 Premarital and post-marital fertility

We first look at the ASFRs and TFRs, decomposed by the status of the women at births (i.e. not yet or already married). For a given age group i of women we call BP_i and

BM_i the number of births occurring respectively before and after marriage; and EP_i and EM_i the exposure respectively before and after marriage. So:

$$ASFR_i = \frac{BP_i + BM_i}{EP_i + EM_i}$$

Therefore, the premarital component of $ASFR_i$ is:

$$ASFR_i(P) = \frac{BP_i}{EP_i + EM_i} \; ; \qquad (1)$$

and the post-marital component of the $ASFR_i$ is:

$$ASFR_i(M) = \frac{BM_i}{EP_i + EM_i} \, .$$

Jolly and Gribble (1993) have also called the $ASFR_i(M)$ the age-specific union fertility rate. This is however not a true rate (because the numerator and denominator do not correspond), but a component of the ASFR.

Therefore:

$$ASFR_i = ASFR_i(P) + ASFR_i(M). \qquad (2)$$

Garenne *et al.* (2000) have used a similar decomposition of the age-specific fertility rates into a premarital and a marital component to show that the distribution underlying South African fertility is bimodal with a mode of premarital fertility and a mode of marital fertility.

We define the TFR as the sum of the ASFRs for that period from age 15 to 44. Women aged 45-49 are not taken into account so that comparisons between periods are possible, and because of problems of displacement and omissions of births among older women. We also consider four-year periods in the analysis. This is done because additional questions were asked for children born in the five years preceding the survey (1991-1996) and so some births were displaced from the fifth to the sixth year preceding the survey (from 1991 to 1990) to avoid longer questionnaires. This displacement is well illustrated in Hinde and Mturi (2000). Using four-year periods means that these two years are in the same period (1987-1991). The computation of the ASFRs is done using exact number of events and exact exposure, as shown in Appendix B.

Table 2-3 shows the ASFRs and the TFRs together with their components of premarital and post-marital births. The ASFRs show a decline at all ages from the early 1980s. The same decline occurred in the post-marital birth components, ASFR(M)s, especially for women aged 15-19. The premarital birth components, ASFR(P)s, show stable trends for all women. The decomposition of the TFRs shows a stable trend in premarital fertility, and a decline in post-marital fertility. This leads to a declining total fertility in which the proportion of premarital births becomes slightly more important (5.6 per cent of all births in 1985-88, 5.4 per cent in 1989-92, and 6.3 per cent in 1993-96). Table A-2 in Appendix A presents the results for the 1999 TCRHS and shows similar trends.

Table 2-3. ASFRs and TFRs decomposed by births before and after first marriage.

Age-group	93-96	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.137= 0.035+0.103	0.142= 0.025+0.117	0.159= 0.031+0.128	0.163= 0.028+0.135	0.181= 0.027+0.155	0.206= 0.023+0.182	0.218= 0.028+0.190	0.187= 0.019+0.168
20-24	0.257= 0.020+0.237	0.276= 0.022+0.254	0.280= 0.022+0.258	0.284= 0.025+0.259	0.302= 0.017+0.285	0.324= 0.018+0.306	0.297= 0.017+0.280	(0.288)= 0.030+0.258
25-29	0.256= 0.009+0.247	0.269= 0.010+0.260	0.280= 0.011+0.269	0.288= 0.008+0.280	0.278= 0.009+0.269	0.301= 0.012+0.289	(0.218)= 0.055+0.164	
30-34	0.214= 0.004+0.210	0.229= 0.004+0.226	0.253= 0.004+0.249	0.258= 0.004+0.254	0.294= 0.006+0.288			
35-39	0.160= 0.001+0.159	0.200= 0.004+0.196	0.200= 0.004+0.196	0.219= 0.008+0.211				
40-44	0.088= 0.001+0.087	0.110= 0.002+0.108	(0.195)= 0.004+0.190					
TFR	**5.56= 0.35+5.21**	**6.14= 0.33+5.81**	**6.83= 0.38+6.45**					

Note: ASFRs are in brackets when less than 250 years of exposure. Cell entries are in the form ASFR = ASFR(P) + ASFR(M).

2.5.1 *Premarital fertility*

Consider the age-specific premarital fertility rate ($ASPFR_i$) among women in age-group i:

$$ASPFR_i = BP_i / EP_i. \quad (3)$$

The ASPFRs show a declining trend for women aged 20-24, 30-34 and 35-39, but no trend for other women (Table 2-4). For the 1999 TCRHS (Table A-3, Appendix A), most rates are to be taken with caution since the exposures were small. However, they give the same trends as the 1996 TDHS, increasing our confidence in the results.

The ASPFRs can be linked to the premarital components of the ASFRs, the ASFR(P)s. If PP_i is the proportion never married in an age group i we have:

$$PP_i = \frac{EP_i}{EP_i + EM_i},$$

or :

$$EP_i = PP_i * (EP_i + EM_i). \quad (4)$$

Table 2-4. ASPFRs.

Age-group	93-96	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.049	0.038	0.049	0.047	0.048	0.048	0.055	0.037
20-24	0.087	0.108	0.105	0.127	0.111	0.119	0.096	(0.123)
25-29	0.120	0.117	0.155	(0.133)	0.059	(0.162)	(0.483)	
30-34	(0.105)	(0.110)	(0.143)	(0.163)	(0.181)			
35-39	(0.078)	(0.182)	(0.173)	(0.295)				
40-44	(0.054)	(0.167)	(0.166)					

Note: ASPFRs are in brackets when less than 250 years of exposure.

The proportion ever married is therefore $PM_i = 1 - PP_i$. Note that PP_i and PM_i are the proportions of *exposure* respectively pre- and post- marriage (not the proportions of *women* never and ever married).

Using (1), (3) and (4), we have:

$$PP_i * ASPFR_i = \frac{EP_i}{EP_i + EM_i} * \frac{BP_i}{EP_i} = ASFR(P)_i. \quad (5)$$

Consider first women aged below 30 years. Looking at the cumulative ASPFRs from 15 to 29 years old (Table 2-5), the fertility of unmarried women has declined since the 1980s, while the premarital birth component of the ASFRs has remained stable. These measures describe the following situation. Mathematically, using (5), PP is increasing, ASPFR is decreasing, and so ASFR(P) remains stable (Table A-4, Appendix A, gives similar results for the 1999 TCRHS). The decline in ASPFRs means that the fertility of unmarried women, during a fixed period (one year for example), is declining. In other words, women have a lower risk of having a premarital birth per year of premarital exposure. On the other hand, age at marriage is increasing, leading to a longer exposure to the risk of premarital birth. Therefore, women are at lower risk of having a premarital birth, but for longer. So, both trends compensate and the average number of premarital births a woman has during her life remains stable.

Table 2-5. Cumulative ASPFRs and ASFR(P)s from age 15 to 29.

	93-96	89-92	85-88	81-84	77-80
Cumulative ASPFR	1.28	1.31	1.54	1.54	1.09
Cumulative ASFR(P)	0.32	0.28	0.32	0.31	0.27

Consider now women aged above 30. These women form a small anomalous group of women who do not marry before they are 30 (less than 3 per cent of women aged 30-44). The picture is very clear: the number of premarital births has declined by nearly a half. However, the decline for older women does not have a great effect on the TFRs: the proportions never-married in these age-groups are very small.

2.5.2 *Post-marital fertility*

We now look at the age-specific marital fertility rates:

$$ASMFR_i = BM_i / EM_i.$$

The ASMFRs show a steady decline from the mid-1980s for women aged 15-44 and the total marital fertility rates, TMFRs, lead to the same conclusion of a decline in marital fertility (Table 2-6). The same trends are found using the 1999 TCRHS (Table A-5, Appendix A) for most age-groups, but an increase in the ASMFRs among women aged 15-19 in the last two periods.

Comparing the ASMFRs and the marital birth component of the ASFRs helps to understand the situation. Here, we concentrate on women aged 15-29 because nearly all women aged 30-44 are married, and so both measures show the same picture for this group. Analogously to (5), calling PM_i the proportion ever married in age group i, we

Table 2-6. ASMFRs and TMFRs.

Age-group	93-96	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.342	0.346	0.352	0.341	0.349	0.358	0.384	0.357
20-24	0.309	0.320	0.327	0.322	0.337	0.360	0.341	(0.340)
25-29	0.267	0.283	0.289	0.297	0.320	0.313	(0.185)	
30-34	0.218	0.233	0.256	0.261	0.297			
35-39	0.162	0.200	0.201	0.217				
40-44	0.088	0.110	(0.200)					
TMFR	**6.93**	**7.46**	**8.10**					

Note: ASMFRs are in brackets when less than 250 years of exposure.

have the following relationship:

$$PM_i * ASMFR_i = ASFR(M)_i. \quad (6)$$

Looking at Table 2-7, the cumulative ASMFRs show a nine per cent decline between the periods 1977-80 and 1993-96, while the marital birth components of the ASFRs show a 17 per cent decline between the same periods. The decline in the ASMFRs is due to changes in the proximate determinants of fertility other than marriage. The marital birth component of the ASFRs is the average number of marital births women have during a particular period. This will decline if marital fertility is falling, and will also decline if the age at marriage is increasing. So, it seems that a high proportion of the decline in the marital component of fertility (close to half) is explained by changes in age at marriage. However, as we shall see in the next section this is a substantial over-estimate of the proportion of the decline in fertility due to changes in nuptiality.

Table 2-7. Cumulative ASMFRs and ASFR(M)s from age 15 to 29.

	93-96	89-92	85-88	81-84	77-80
Cumulative ASMFR	4.59	4.75	4.84	4.80	5.03
Cumulative ASFR(M)	2.94	3.16	3.28	3.51	3.55

The picture from the 1999 TCRHS is different (Table A-6, Appendix A). Here, the cumulative ASMFRs do not show any decline between the periods 1980-83 and 1996-99, whereas the marital components of the ASFR show a 18 per cent decline. This suggests that the entire decline in marital fertility is explained by changes in marriage patterns. However, the stable trends in the cumulative ASMFRs are due to the rise in marital fertility among women aged 15-19 in the last two periods. Therefore the proportion of the fertility decline explained by changes in marriage is probably pushed upwards by the recent rise in adolescent marital fertility, and the result has to be taken with caution.

2.6 Proportion of the decline in fertility explained by changes in nuptiality

2.6.1 Method

We need the ASPFR, ASMFR, and ASFR for each age-group in two periods, which we call T and τ, T being the more recent and reference period. For any period t, using (2), (5) and (6), we have:

$$ASFR_{ti} = ASFR(P)_{ti} + ASFR\ (M)_{ti} = PP_{ti} * ASPFR_{ti} + PM_{ti} * ASMFR_{ti},$$

which is Coale's (1967) decomposition of fertility at any age into two components: premarital fertility and post-marital fertility.

Using direct standardisation, we define a standardised ASFR for period τ, $SASFR_{(\tau/T)}$, as:

$$SASFR_{(\tau/T)} = PP_T * ASPFR_\tau + PM_T * ASMFR_\tau,$$

where the subscripts i have been dropped for clarity. This is what the fertility would have been in period τ if the proportions married had been the same as in period T. So, if there was no change in nuptiality, $SASFR_{(\tau/T)}$ and $ASFR_\tau$ should be equal.

We can then write:

$$\underbrace{ASFR_\tau - ASFR_T}_{\text{Change in fertility} = CF} = \underbrace{[ASFR_\tau - SASFR_{(\tau/T)}]}_{\text{Change in fertility due to marriage} = CFM} + \underbrace{[SASFR_{(\tau/T)} - ASFR_T]}_{\text{Change in fertility due to other factors} = CFOF}$$

Kitagawa (1955) first explained this method of decomposing a difference between two rates into its different parts. Therefore the difference between $ASFR_\tau$ and $SASFR_{(\tau/T)}$ (CFM) is an estimate of the change in fertility in that age-group due to changes in marriage patterns. The difference between $SASFR_{(\tau/T)}$ and $ASFR_T$ (CFOF) is the change in fertility due to other factors than marriage (such as contraception, post-partum abstinence, breastfeeding, abortion or sterility). The quantity CFM/CF can, in some cases, be used to measure the proportion of the change in fertility in any age-group explained by changes in marriage patterns. In other cases, however, CFM/CF lies outside the range (0, 1), as we will see in the case of Tanzania.

2.6.2 Application using 1996 TDHS data.

We will compare the most recent period of 1993-96 to all other periods (it is also possible to compare adjacent periods). Table 2-8 shows the SASFRs using the marriage pattern in the period 1993-96 as a reference, CFs, CFMs and the ratios CFM/CF. The CFs are computed from Table 2-3 and the CFMs from Table 2-3 and Panel A from Table 2-8. Table A-7 in Appendix A presents the same measures using the 1996 TCRHS, the reference period being 1996-99.

Table 2-8. SASFRs, CF, CFM, CFM/CF.

A. Standardised age-specific fertility rates (SASFRs).

Age-group	93-96	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.137	0.131	0.140	0.135	0.139	0.141	0.154	0.133
20-24	0.257	0.271	0.275	0.277	0.284	0.304	0.284	
25-29	0.256	0.271	0.279	0.285	0.300	0.301		
30-34	0.214	0.228	0.252	0.257	0.293			
35-39	0.160	0.200	0.200					
40-44	0.088	0.111						

B. Change in fertility, CF.

Age-group	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.005	0.021	0.026	0.044	0.068	0.081	0.050
20-24	0.019	0.023	0.027	0.045	0.067	0.040	
25-29	0.014	0.024	0.032	0.022	0.045		
30-34	0.015	0.039	0.044	0.080			
35-39	0.040	0.040					
40-44	0.023						

C. Change in fertility due to marriage, CFM.

Age-group	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	0.012	0.019	0.028	0.043	0.064	0.064	0.054
20-24	0.005	0.005	0.007	0.018	0.020	0.013	
25-29	-0.001	0.001	0.003	-0.022	0.000		
30-34	0.001	0.001	0.001	0.001			
35-39	0.000	0.000					
40-44	0.000						

D. CFM/CF.

Age-group	89-92	85-88	81-84	77-80	73-76	69-72	65-68
15-19	2.354	0.887	1.083	0.971	0.946	0.795	1.091
20-24	0.274	0.212	0.275	0.395	0.297	0.321	
25-29	-0.109	0.022	0.091	-0.988	-0.007		
30-34	0.060	0.032	0.030	0.013			
35-39	-0.001	-0.003					
40-44	-0.006						

To illustrate the method, consider three examples. For women aged 20-24 years, CFM/CF = 0.212 when comparing 1993-96 and 1985-88. So, 21 per cent of the decline in fertility is explained by a change in marriage patterns. For women aged 15-19, CFM/CF = 1.083 when comparing 1993-96 and 1981-84. In this case, we have:

$$CF = CFM + CFOF$$

$$\Leftrightarrow 0.163 - 0.137 = [0.163 - 0.135] + [0.135 - 0.137]$$

$\Leftrightarrow 0.026 = 0.028 + [-0.02]$

This means that the other factors tend to increase fertility. Without these other factors, the change in fertility would have been eight per cent higher. The other factors thwart the effect of marriage on fertility. Therefore, in the case of a fertility decline, a ratio CFM/CF higher than 1 is found when other factors act against the decline; whereas in the case of a rise in fertility, the ratio is higher than 1 when the other factors lower fertility.

Finally, consider the periods 1977-80 and 1993-96, with women aged 25-29. Here:

$CF = CFM + CFOF$

$\Leftrightarrow 0.278 - 0.256 = [0.278 - 0.300] + [0.300 - 0.256].$

$\Leftrightarrow 0.022 = -0.022 + 0.044$

This time, marriage has a positive effect on fertility, whereas the other factors have a strong negative effect that counterbalances the effect of marriage. The decline of fertility would have been doubled without marriage effect. Therefore, in the case of a fertility decline, a negative ratio CFM/CF is found when marriage acts against the decline; whereas in the case of a rise in fertility, the ratio is negative when marriage lowers fertility.

In the age-group 15-19 years, changes in marriage patterns explain most of or even a bit more than the visible decline in fertility for nearly all periods (Table 2-8D). Marriage has a strong negative effect on fertility. We can note that the decline between 1989-92 and 1993-96 is smaller than with the other periods, and therefore its interpretation is subject to larger variations. It is not surprising that marriage has a strong effect in this age-group, since this is the age range where the increase in age at first marriage takes place. These results are comparable to those from the 1999 TCRHS (Table A-7D, Appendix A) where the changes in marriage explain all and even more than the decline in fertility among adolescents. As we get closer to the survey, marriage explains more of the fertility decline suggesting that marriage is having an increasing role in leading the fertility decline among adolescents.

In the age group 20-24 years, changes in marriage patterns explain between 20 and 30 per cent of the decline in fertility. This figure is around 50 per cent for the 1999 TCRHS (Table A-7D, Appendix A). For the older age-groups (aged 25-44 years), the proportions married are very high (more than 90 per cent), and stable over time. So little of the decline can be explained by changes in nuptiality. This is reflected by the values of CFM/CF. The 1999 TCRHS gives a slightly different picture for older women: ten to 20 per cent of the decline among women aged 25-29 is explained by changes in marriage. This suggests that, age at marriage rising, the effect of nuptiality on fertility is now being felt in the next age-group, i.e. 25-29 years old. For older women, little of the decline is explained by marriage.

To estimate the overall proportion of the fertility decline accounted for by changes in nuptiality, we sum the $SASFR_{i(\tau/T)}$s to estimate what the total fertility rate would be in period τ assuming the nuptiality patterns of period T, and thereby decompose the differences in the TFRs between the two periods. Given the nature of the DHS sample, this method of estimation necessarily involves omitting older age groups from the summation for comparisons involving periods far from the survey date. It seems reasonable to attempt it, however, at least for periods as far back as 1977-80 (comparing to 1993-96 in each case), since for these periods we have information about women aged up to 35 years. The results are shown (using in each case only fertility for women aged 15-34 years) in Table 2-9.

Table 2-9. Estimated proportion of the decline due to nuptiality for women aged 15-34 years.

Period	TFRs			Estimated proportion of the decline due to nuptiality
	1993-96	Summed from SASFRs	Observed in period	
1977-80	4.32	5.08	5.28	(5.28-5.08)/(5.28-4.32)=0.21
1981-84	4.32	4.77	4.97	(4.97-4.77)/(4.97-4.32)=0.31
1985-88	4.32	4.73	4.86	(4.86-4.73)/(4.86-4.32)=0.24
1989-92	4.32	4.51	4.58	(4.58-4.51)/(4.58-4.32)=0.27

These results suggest that about a quarter of the decline in Tanzanian fertility in the period 1977-96 is explained by changes in marriage patterns. In fact, the proportions in the table above overestimate the contribution of nuptiality to the overall decline, as they exclude the age groups 35-44 years, in which changing nuptiality makes very little contribution.

Using the 1999 TCRHS data set (Table A-8, Appendix A), it is estimated that around 40 to 50 per cent of the decline in fertility among women aged 15-34 between 1980 and 1999 is explained by changes in marriage patterns. Part of the large discrepancy between the two surveys is probably genuine: as age at marriage increases, the impact of age at marriage on the fertility decline increases, other factors remaining the same. The discrepancy is also explained by a difference in the TFR and the TFR(P) between the two surveys. Comparing roughly the same periods (i.e. 1993-96 for the 1996 TDHS and 1992-95 for the 1999 TCRHS), the TFR in the 1999 survey is higher than in the 1996 survey (5.98 vs 5.56); and the TFR(P) in the latter survey is lower than in the former survey (0.24 vs 0.35). So, premarital fertility is lower in the 1999 survey. Therefore, the impact of a rise in age at marriage is more marked as it is less attenuated by premarital fertility.

The differences in the TFR and TFR(P) levels between the two surveys are two-fold. Firstly, the lower TFR(P) in 1999 is likely to be partly due to a better reporting of early unions in 1999 as the questionnaire emphasises that the date of *first* union is asked. Therefore, women may have reported earlier unions in the 1999 survey, and by doing so, some births which were premarital in the 1996 survey became post-marital by the 1999 survey as age at marriage was brought backward (the median age at marriage dropped slightly from 18.6 years in 1996 to 18.3 in 1999). Secondly, the data quality is probably better in the 1996 DHS. The 1999 survey was an interim survey of half the size of the 1996 DHS. The other Tanzanian interim survey, the 1994 TKAPS of a similar size to the 1999 TCRHS, proved to be misleading: the contraceptive prevalence proved to be too high and the TFR too low in the light of the 1991-92 and 1996 DHS results (Table 2-10). The 1999 survey may suffer the same drawbacks as the earlier interim survey, and therefore the results of the 1999 survey should be taken with caution. The 1996 survey is probably more accurate and of better quality on the whole.

Table 2-10. **Comparison of the four Tanzanian surveys.**

	1991-92 DHS	1994 KAPS	1996 DHS	1999 CRHS
Contraceptive prevalence rate (all methods, married women only)	10.4	20.4	18.4	25.4
TFR 15-49	6.25	5.56	5.82	5.55

Sources: Bureau of Statistics and Macro International Inc. (1993), Bureau of Statistics and Macro International Inc. (1995), Bureau of Statistics and Macro International Inc. (1997), and National Bureau of Statistics and Macro International Inc. (2000).

2.7 Conclusions

In Tanzania, urban, educated and Christian women tend to marry and have their first child later than rural, non-educated and Moslem women. The age at first birth varies less between sub-populations than does the age at first marriage. Urban, educated and Christian women are more likely to have had a premarital first birth than rural, non-educated and Moslem women.

Over the past 20 years in Tanzania, overall fertility has declined. The relative contribution of premarital fertility to overall fertility has increased because its absolute contribution has remained stable. If we ignore trends in the small group of never-married women aged 30-44 and focus on the younger women aged 15-29, the apparent stability of the absolute contribution of premarital fertility results from a decreased risk of premarital birth *per year of exposure* among never-married women, and a trend of longer exposure to the risk of premarital birth due to increasing age at marriage.

Changes in nuptiality and in the other proximate determinants are affecting fertility. Overall, about one quarter of the decline in fertility for ages 15-34 is explained by changes in nuptiality. However, in the age group 15-19 years, where changes in the age at marriage have the largest effect, the decline in fertility is completely explained by changes in marriage patterns. For the age-group 20-24 years, 20 to 30 per cent of the fertility decline is due to changes in nuptiality. These proportions are even higher when considering the 1999 TCRHS rather than the 1996 TDHS. This suggests that changes in marriage are having an increasing effect on fertility trends in Tanzania.

Chapter 3

The impact of rising age at marriage on fertility in southern and eastern Africa[3]

Abstract

This chapter examines the trends in marriage and fertility in nine countries of southern and eastern Africa using DHS data. First, some background about the age at marriage, age at first birth and the proportion of premarital first births is shown. Next, the total fertility is decomposed into its pre- and post-marital parts. Then, pre- and post-marital adolescent fertility are examined in more detail. Finally, the effect of rising age at marriage on the fertility declines is measured. It is estimated that around one sixth to one third of the fertility decline is due to rising age at marriage, depending on the country.

[3] A version of this chapter has been published in the European Journal of Population (Harwood-Lejeune, 2000).

3.1 Introduction

This chapter extends the analysis of Chapter 2 by including Tanzania and other countries of southern and eastern Africa, namely Kenya, Madagascar, Malawi, Mozambique, Namibia, Uganda, Zambia and Zimbabwe. By extending the analysis in this way, it will be possible to position Tanzania among neighbouring countries.

A fertility decline has now been well established in some countries of the region: Kenya (Robinson, 1992), Zimbabwe (Brass and Jolly, 1993), Botswana (Rutenberg and Diamond, 1993), Tanzania (Hinde and Mturi, 2000) and South Africa (Caldwell and Caldwell, 1993). Cohen (1998) identified later marriage and greater use of modern contraception as being the driving forces behind the African fertility declines. However, as for Tanzania, non-marital fertility is not negligible due to high premarital and extramarital sexuality, as well as high marital instability. Bongaarts *et al.* (1984) point out that 'exposure to childbearing outside marriage, particularly before first marriage, is appreciable in Africa' (p.521). So, the effect of rising age at marriage on a fertility decline is attenuated by premarital fertility. This paper attempts to determine the trends in age at marriage, in premarital fertility and in post-marital fertility in nine countries of southern and eastern Africa, and how these relate to the fertility declines. It will then be possible to place Tanzania in a larger context and to determine whether it follows the same paths as neighbouring countries.

The analysis is divided into four sections. The first includes some background about the ages at first marriage and at first birth, and about the proportions of first births which are premarital in southern and eastern Africa. The second considers the decomposition of fertility into its pre- and post-marital parts. The third section analyses the evolution of pre- and post-marital adolescent fertility. The fourth attempts to measure the effect of rising age at first marriage on fertility.

3.2 Data

This analysis uses the most recent Demographic and Health Survey (DHS) available for nine countries of Southern and Eastern Africa: Kenya (1998), Madagascar (1997), Malawi (1992), Mozambique (1997), Namibia (1992), Tanzania (1996), Uganda (1995), Zambia (1996), and Zimbabwe (1994). The Tanzania DHS of 1991-92 and the Tanzania Child and Reproductive Health Survey (CRHS) of 1999 have been added, so that three data sources are available for Tanzania, and the consistency of the results can be checked. The analysis is based on the dates of birth of the respondents and their children, and on the respondents' age at first marriage. When evaluating pre-1990 DHS surveys (DHS-I), Blanc and Rutenberg (1990) state that the quality of data on first union and on first birth for women aged 20 to 44 is satisfactory in most surveys; and Arnold (1990, p. 108) states that 'reasonably complete and accurate information on births has been obtained in all DHS countries'. The quality of data improved even further in the next round of surveys (DHS-II) (Gage, 1995; Marckwardt and Rutstein, 1996). Since the surveys analysed here come from the second and third rounds of DHSs, the accuracy of the information is thought to be reasonable for our purpose. Moreover, only the fertility of women aged up to 39 will be analysed, and so under-reporting or mis-reporting of events by older women is not relevant here.

The dates of marriage are open to more criticism. The problems encountered arise mainly because marriage is a process rather than a discrete, well-defined event in Africa, and because some women may displace events to avoid reporting they had a birth before marriage. These problems are discussed in length in Chapter 2 and will therefore not be examined here. However, it is worth repeating here that if they occurred, the distortions would reduce the number of premarital births.

3.3 Background: ages at first marriage and at first birth, and premarital childbearing

There are differences in the median age at first marriage[4] between countries (Table 3-1): from under 18 years in Mozambique, Uganda and Malawi; to more than 19 years in Zimbabwe and Kenya (ignoring for now the exceptional situation in Namibia). Differences in the age at first birth are less pronounced, but still visible: from just under 19 years in Zambia and Uganda, to close to 20 years in Zimbabwe and Kenya and just under 21 years in Namibia. Kirk and Pillet (1998) also find smaller differences between countries in average ages at first birth than ages at first marriage. The higher the age at first marriage and at first birth, the smaller the interval between the two. Thus the difference ranges from nearly one and a half years in Mozambique to virtually zero in Kenya. The percentage of first births which are premarital varies considerably as well: from 13 % in Malawi to 32 % in Kenya. The results of the three surveys in Tanzania are broadly consistent.

The pattern in Namibia is quite different to all the other countries studied. The median age at first marriage is more than 24 years and the median age at first birth is close to 21 years, leading to a negative interval between marriage and first birth of around three and a half years. With these results, it is not surprising that more than half (56%) of first births are premarital in Namibia. Here, as in the rest of this chapter, Namibia will play the role of an outsider which could be due to the cultural and historical differences between Namibia and the rest of the countries studied.

Kirk and Pillet (1998) point out that age at marriage and age at first birth are lowest in the countries with no evidence of a fertility decline and highest in those with a well-established fertility decline. This is confirmed here: the countries with a well-established fertility decline (Kenya and Zimbabwe) have a higher age at marriage, a higher age at first birth, a smaller interval between the two, and a higher percentage of premarital births than the countries with no evidence of a fertility decline (Uganda for

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[4] This refers to the median age at first marriage for women aged 15 to 49, computed using a life table to avoid the censoring problem.

example). Tanzania, where a smaller (than Kenya and Zimbabwe) but definite decline in fertility has been documented, occupies an intermediate position.

Table 3-1. Median ages at first marriage and first birth, and percentage of premarital first births.

	Median age at first marriage	Median age at first birth	Interval between median ages at marriage and first birth	Percentage of first births which are premarital
Uganda (1995)	17.75	18.83	1.08	20
Mozambique (1997)	17.75	19.17	1.42	19
Malawi (1992)	17.92	19.00	1.08	13
Zambia (1996)	18.08	18.75	0.67	22
Tanzania (1991-92)	18.08	19.00	0.92	21
Tanzania (1996)	18.58	19.33	0.75	21
Tanzania (1999)	18.33	19.25	0.92	18
Madagascar (1997)	18.75	19.50	0.75	23
Zimbabwe (1994)	19.33	19.75	0.42	24
Kenya (1998)	19.67	19.75	0.08	32
Namibia (1992)	24.42	20.75	-3.67	56

Notes: Medians are computed using a life table to avoid any censoring problem.

Countries are classified by the median age at first marriage.

In all nine countries studied, educated and urban women have higher ages at marriage and first birth (Appendix D). In most, they also have higher proportions of premarital first births than non-educated and rural women. Christian women tend also to have higher ages at marriage and first births, and higher proportions of premarital first births than Moslem women.

A late age at first marriage thus tends to be associated with a high proportion of births which are premarital. Meekers (1994) suggests that a late age at first marriage implies a long exposure to the risk of premarital birth and so a high premarital fertility. This hypothesis may reveal to be true for sub-Saharan Africa. However, it is not applicable to all populations, as for example in historical England (Laslett, 1980) where premarital births remained rare even with a very high age at first marriage.

In all nine countries, age at first marriage is rising, as can be derived from the trends in the proportions of ever-married women aged 15-19 and 20-24 (Table 3-2). Bledsoe and Cohen (1993) and Lesthaeghe and Jolly (1995) also found a postponement of first marriages through much of sub-Saharan Africa. The results for the three Tanzanian sureys are consistent: the proportion in period 2 for the 1991-92 survey, i.e. 1980-83 (38 %) is nearly equal to the proportion in period 1 for 1996 survey, i.e. 1981-84 (39 %), and similarly for the other periods. The 1999 Tanzania CRHS results are slightly higher than the DHSs ones, but the trends are similar. This may be due to slight differences in the questionnaires: in the 1999 TCRHS, more emphasis was put on the fact that the date of *first* marriage is asked. This would lead to better reporting of early unions, and hence higher proportions of ever-married women, as shown in Table 3-2.

Table 3-2. Proportions of ever-married women aged 15-19 and 20-24.

	Women aged 15-19				**Women aged 20-24**			
Periods *	1	2	3	4	1	2	3	4
Kenya (1998)	0.31	0.27	0.22	0.19	0.76	0.70	0.68	0.62
Madagascar (1997)	0.35	0.36	0.35	0.34	0.74	0.72	0.72	0.69
Malawi (1992)	0.48	0.47	0.45	0.38	0.89	0.89	0.88	0.82
Mozambique (1997)	0.51	0.50	0.46	0.42	0.84	0.84	0.83	0.81
Namibia (1992)	0.14	0.12	0.12	0.09	0.44	0.42	0.38	0.35
Tanzania (1991-92)	0.46	0.38	0.35	0.32	0.87	0.82	0.78	0.79
Tanzania (1996)	0.39	0.36	0.34	0.30	0.81	0.79	0.79	0.77
Tanzania (1999)	0.39	0.37	0.33	0.29	0.84	0.82	0.80	0.74
Uganda (1995)	0.48	0.42	0.41	0.44	0.85	0.84	0.81	0.80
Zambia (1996)	0.45	0.39	0.38	0.32	0.86	0.83	0.80	0.76
Zimbabwe (1994)	0.36	0.29	0.27	0.23	0.82	0.79	0.74	0.68

* The periods refer to the four periods of four years preceding the year of the survey (in brackets in the table), 1 being the oldest period. The periods are pictured in Appendix E.

3.4 Total fertility and its pre- and post-marital components

In this section, the total fertility is decomposed into its pre- and post-marital parts, as in Chapter 2. However, it would be tedious to compare nine tables of ASFRs, one for each country, and then nine tables for the ASPFRs and nine tables for the ASMFRs. Therefore, the method devised in Chapter 2 is extended here to make comparisons easier by having only a few figures for each country. This is done by considering the total fertility rate (TFR) and decomposing it in its premarital and post-marital parts. First, the main definitions and results from Chapter 2 are repeated here for convenience. Next, the TFR will be decomposed into its pre- and post-marital parts. Last, the methods will be applied to the nine countries under investigation.

As a reminder, some equations of Chapter 2 are repeated here. For each age-group i, BP_i and BM_i are the number of births occurring respectively pre- and post- first marriage; and EP_i and EM_i are the exposure respectively pre- and post- marriage. The proportion never married in age-group i is PP_i, where:

$$PP_i = \frac{EP_i}{EP_i + EM_i}.$$

The proportion ever married is therefore $PM_i = 1 - PP_i$.

The age-specific fertility rate in age-group i ($ASFR_i$) is:

$$ASFR_i = \frac{BP_i + BM_i}{EP_i + EM_i} = \frac{BP_i}{EP_i + EM_i} + \frac{BM_i}{EP_i + EM_i} = ASFR_i(P) + ASFR_i(M),$$

(1)

where $ASFR_i(P) = BP_i/(EP_i+EM_i)$ is called the premarital component of the $ASFR_i$ and $ASFR_i(M) = BM_i/(EP_i+EM_i)$ the post-marital component.

The age-specific premarital fertility rate for age-group i ($ASPFR_i$) is defined by the equation

$$ASPFR_i = BP_i/EP_i,$$

and we can link the $ASFR_i(P)$ and the $ASPFR_i$:

$$PP_i * ASPFR_i = ASFR_i(P).$$
(2)

Similarly, the age-specific post-marital fertility rate for age-group i ($ASMFR_i$) is:

$$ASMFR_i = BM_i/EM_i,$$

and

$$PM_i * ASMFR_i = ASFR_i(M).$$
(3)

For applying the method to Africa, only women aged 15 to 39 years old are considered. The reason is to allow comparisons between different periods: since the DHSs are retrospective surveys, the data are truncated respectively 0-5 and 5-10 years prior to the survey for women aged 45-49 and 40-44 at the time of the survey.

The total fertility rates for women aged 15 to 39 are considered. Summing over the ages 15 to 39, equation (1) becomes:

$$TFR = \sum_{i=15}^{39} ASFR_i = \sum_{i=15}^{39} ASFR_i(P) + \sum_{i=15}^{39} ASFR_i(M) = TFR(P) + TFR(M).$$
(4)

Four-year periods are considered because in the DHSs additional questions were asked for children born either in the three years (DHS-III) or in the five years (DHS-II) preceding the survey. To avoid these longer questionnaires, some births were displaced from the third to the fourth (DHS-III), or from the fifth to the sixth (DHS-II) year preceding the survey. These two years are in the same four-year window, and therefore four-year periods largely avoid contamination of the time trend caused by birth displacement.

The total fertility rates and their pre- and post-marital components, as described by equation (4), are shown in the first series of graphs (Figures 3-1 to 3-9). The countries showing a decline in fertility are Kenya, Malawi, Namibia, Tanzania (for the three surveys), Zambia, Zimbabwe; and Uganda in a smaller measure. The fertility decline is clearly due to a decline in the post-marital component of fertility, whereas the premarital component is relatively stable. Therefore, the premarital component becomes an increasing part of the total fertility in these countries. The remaining two countries, Madagascar and Mozambique, do not show any clear evidence of a fertility decline; as suggested by the switchback fertility rates, the lack of a trend may be due to poorer data quality in these two countries.

Figure 3-1. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Kenya.

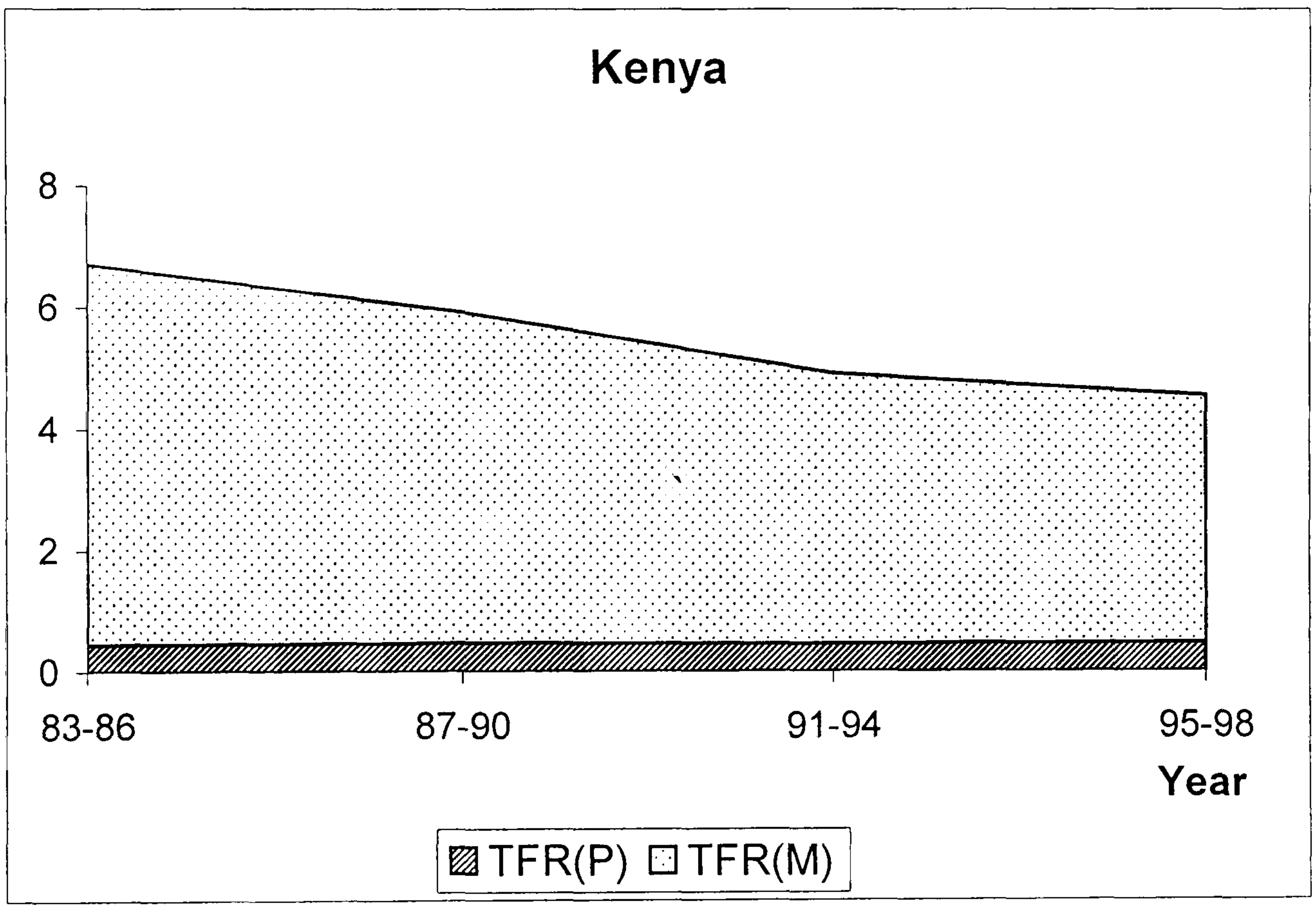


Figure 3-2. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Madagascar.

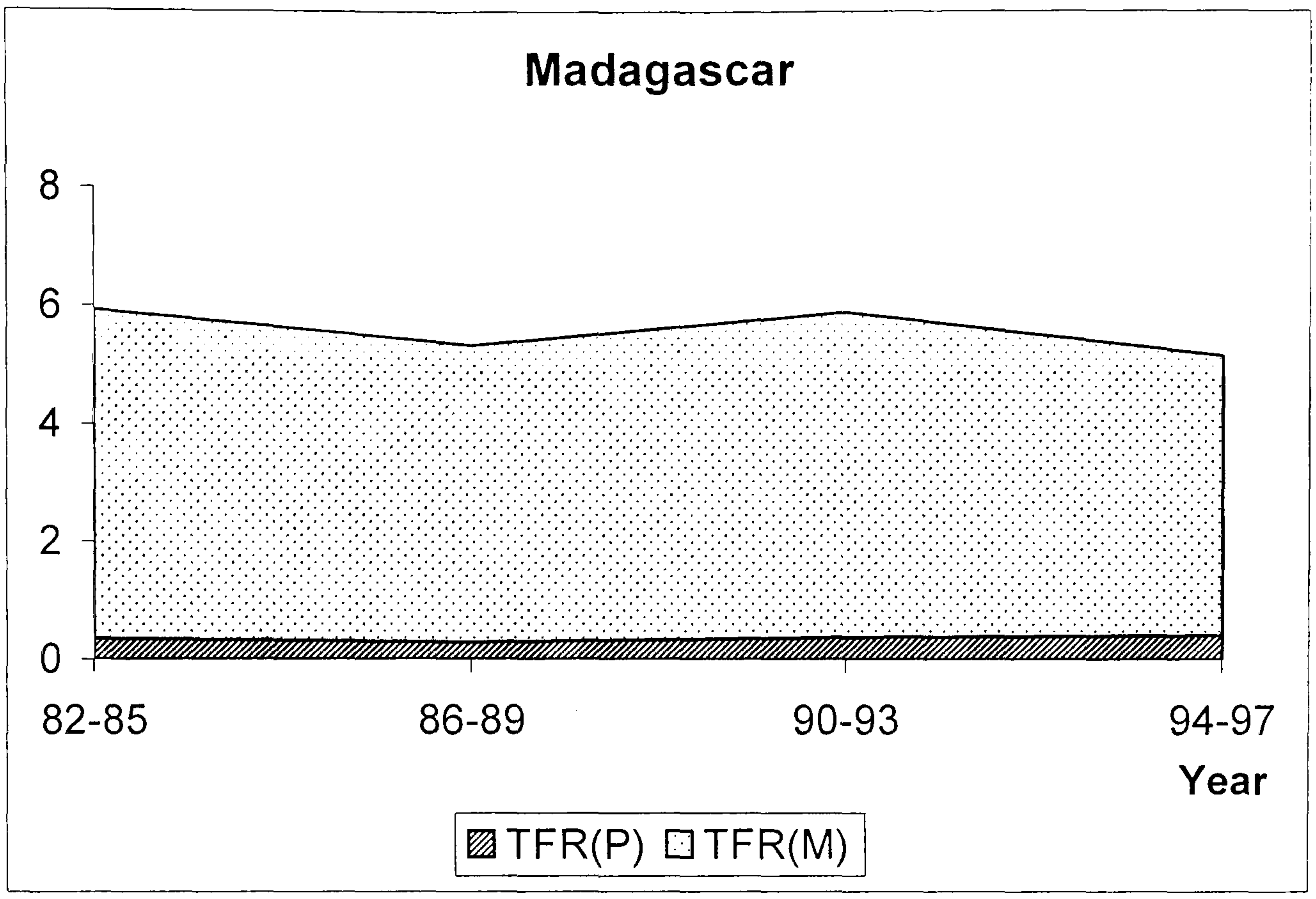


Figure 3-3. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Malawi.

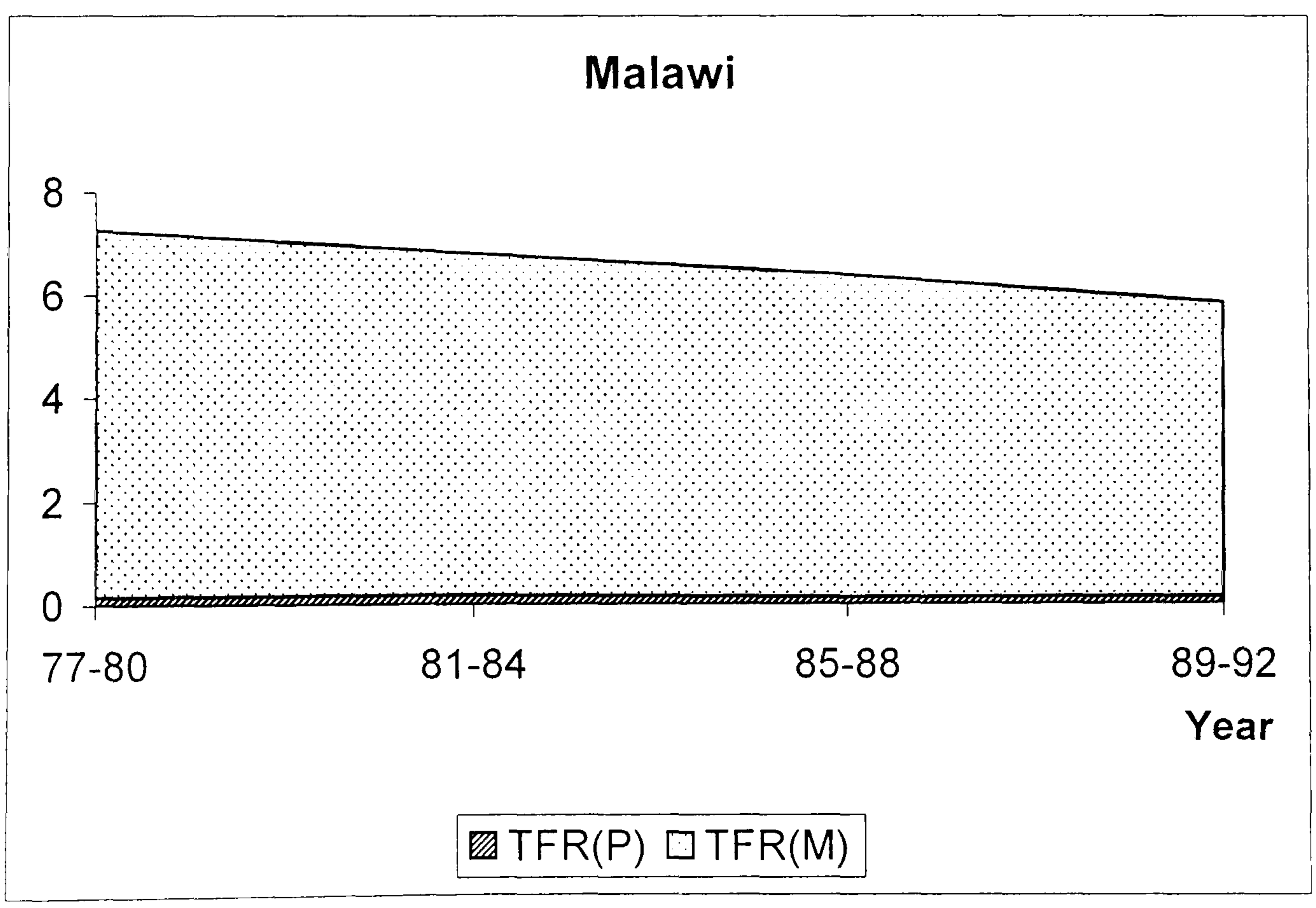


Figure 3-4. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Mozambique.

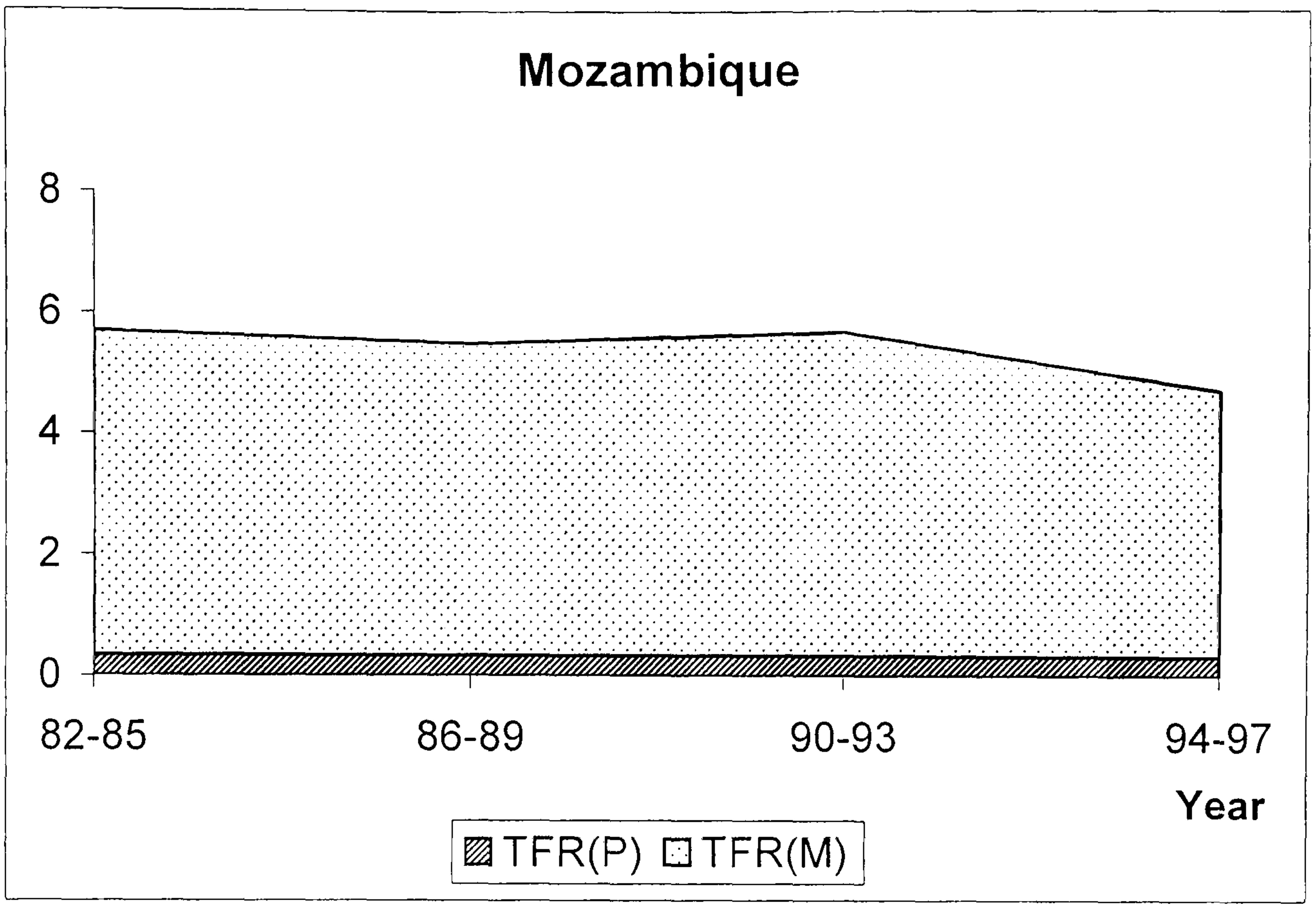


Figure 3-5. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Namibia.

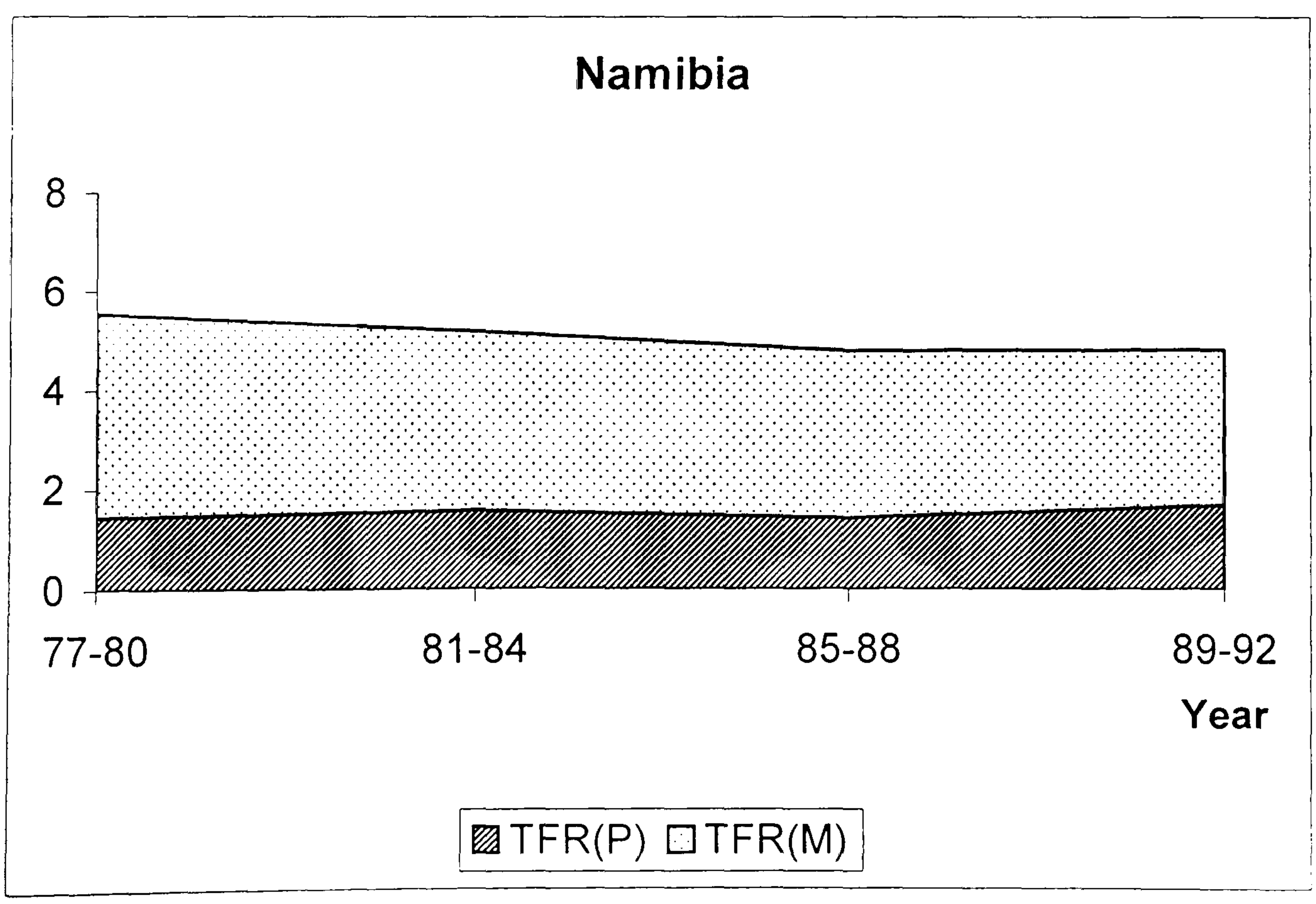
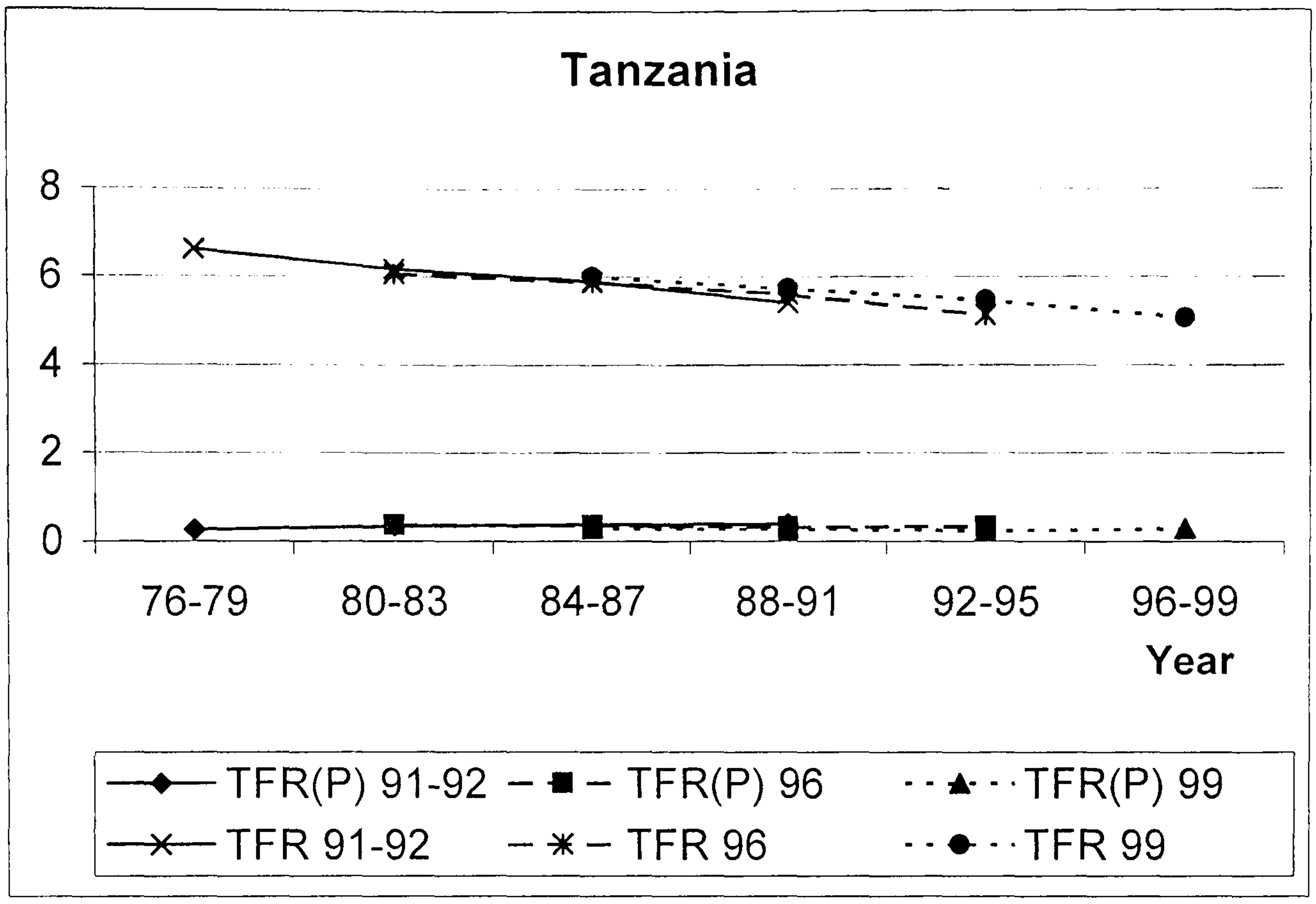


Figure 3-6. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Tanzania.



Note: The periods for the 1996 TDHS have been displaced by one year to match those of the 1991-92 TDHS and 1999 TCRHS (the periods are pictured in Appendix E).

Figure 3-7. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Uganda.

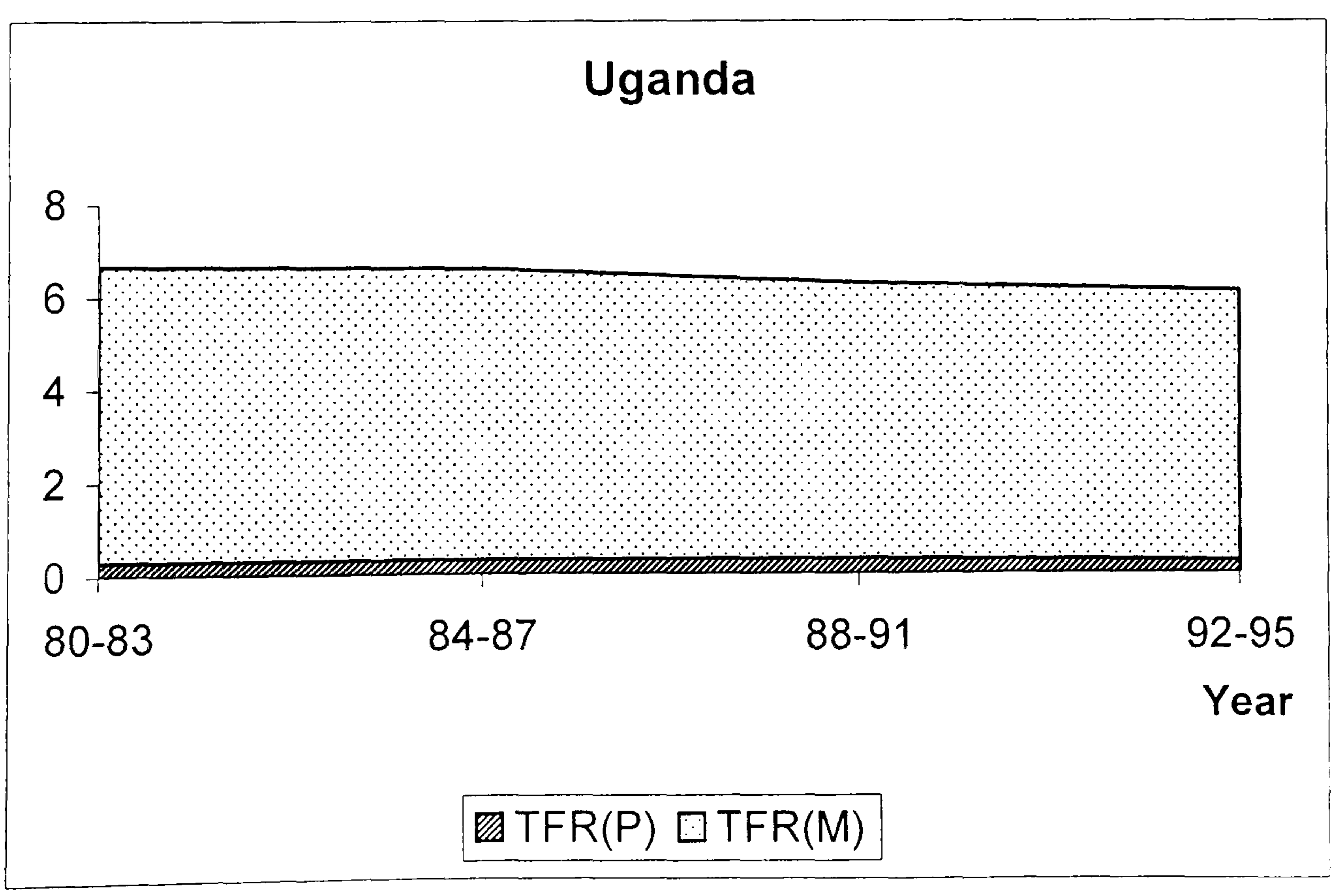


Figure 3-8. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Zambia.

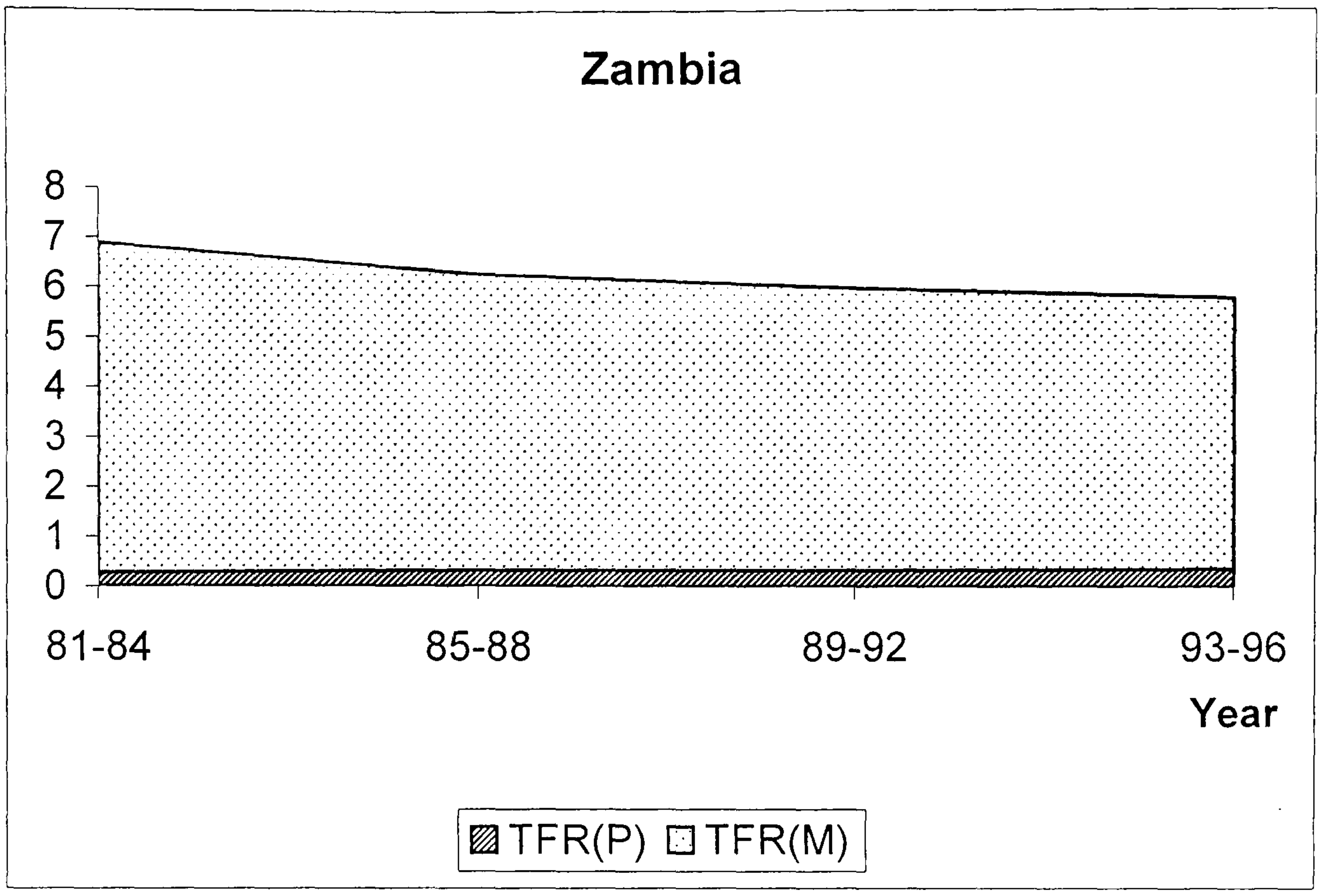
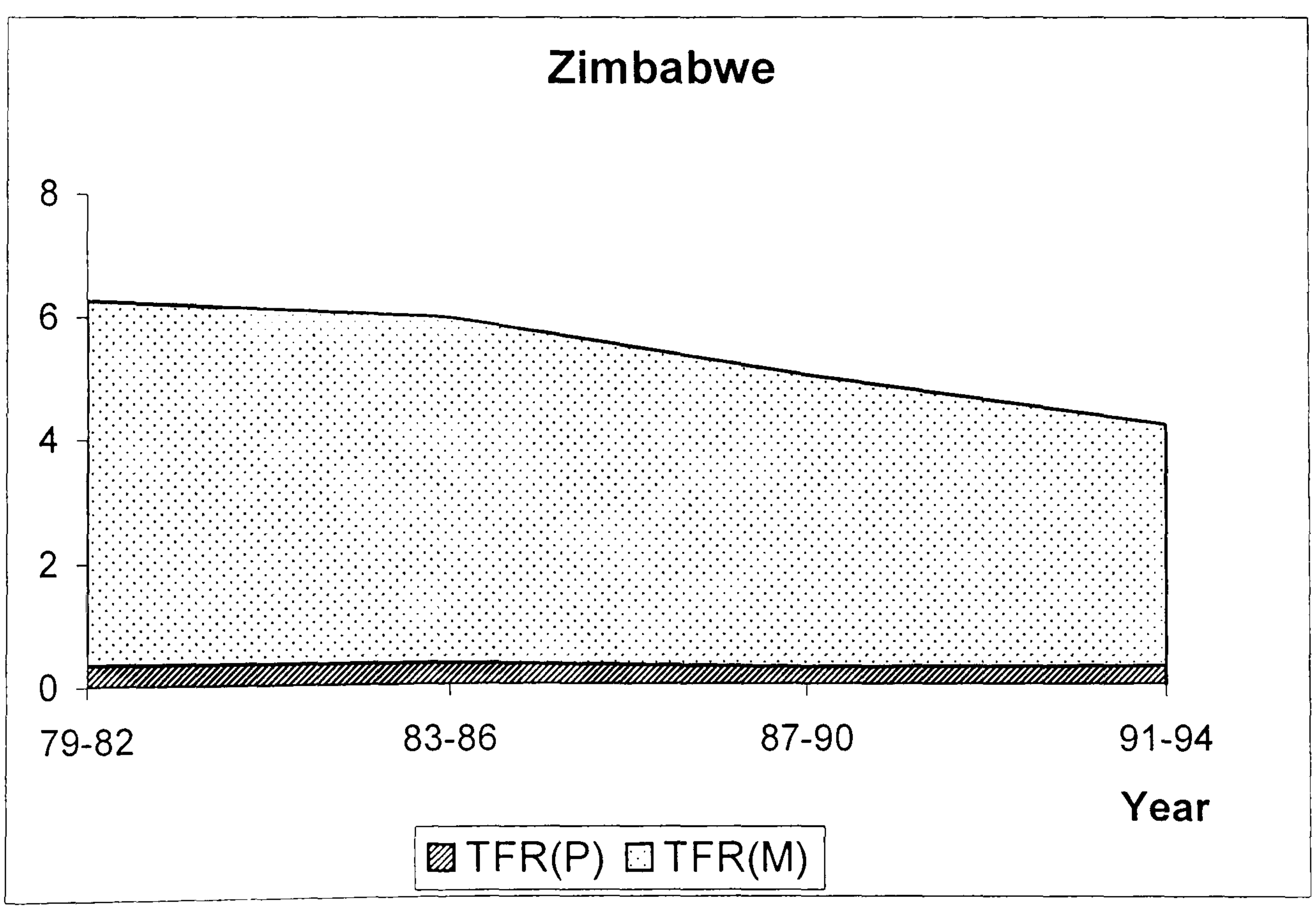


Figure 3-9. Total fertility rates from 15 to 39 years old and their pre- and post-marital components - Zimbabwe.

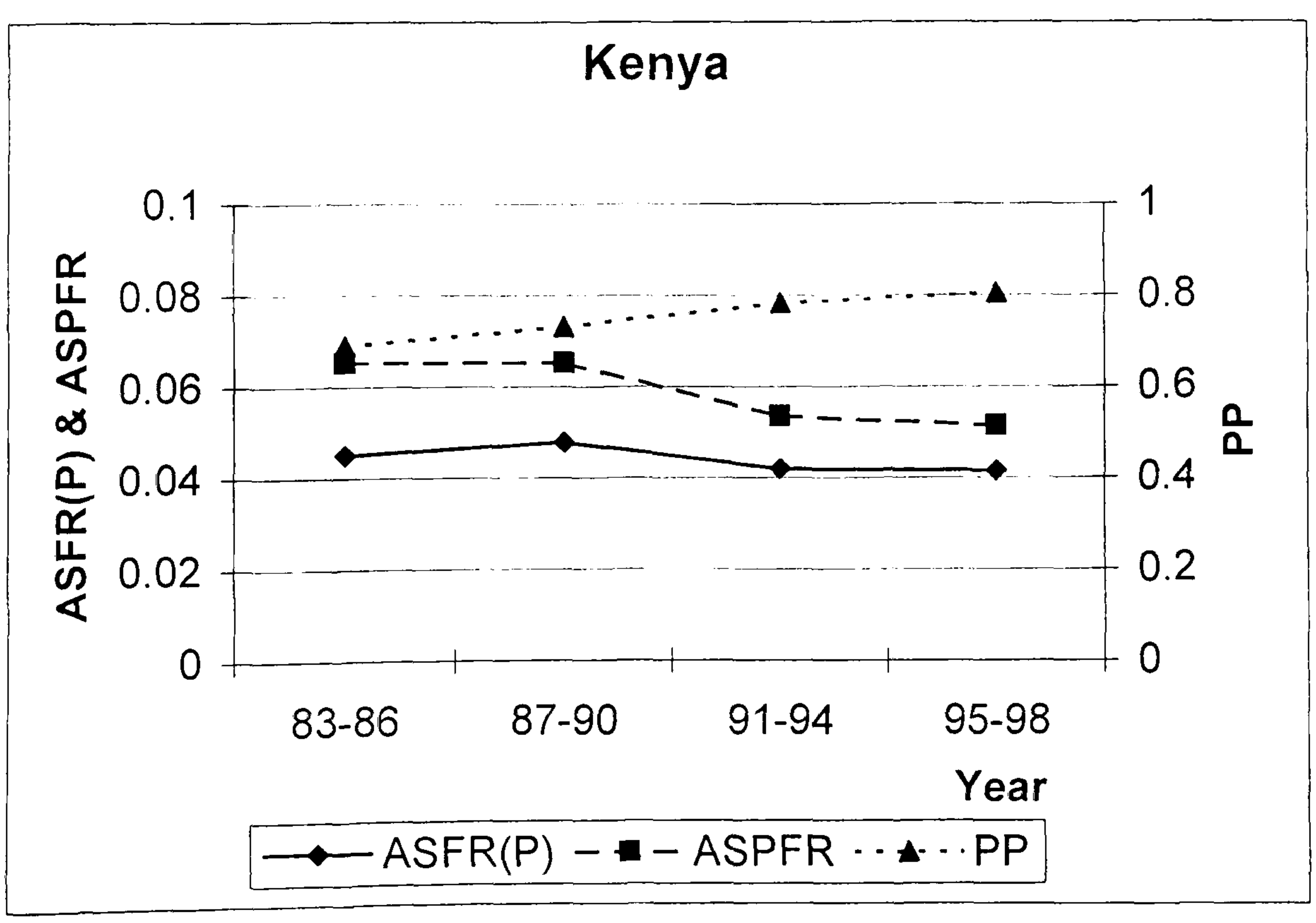


3.5 Pre- and post-marital adolescent fertility

A more detailed analysis of the premarital and post-marital components of fertility may reveal how they are affected by rising age at marriage. This is relatively straightforward with the decomposition devised earlier. However, since equations (2) and (3) are multiplicative relationships, it is not possible to sum over ages 15 to 39 as was done with equation (1)[5]. Therefore the analysis has to be done age-group by age-group. Since the median age at first marriage lies between 15 and 19 years old in all countries except Namibia, the age-group 15 to 19 is chosen to illustrate trends.

Using equation (2), the premarital component of the fertility is the product of the proportion never-married by the premarital fertility. The second series of graphs (Figures 3-10 to 3-20) pictures the premarital component of the ASFR, ASFR(P), the age-specific premarital fertility rate (ASPFR) and the percentage never-married (PP) for women aged 15 to 19 years.

Figure 3-10. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Kenya.



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[5] The reason is that $\sum_i (PP_i * ASPFR_i)$ is different from $\left(\sum_i PP_i\right) * \left(\sum_i ASPFR_i\right)$.

Figure 3-11. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Madagascar.

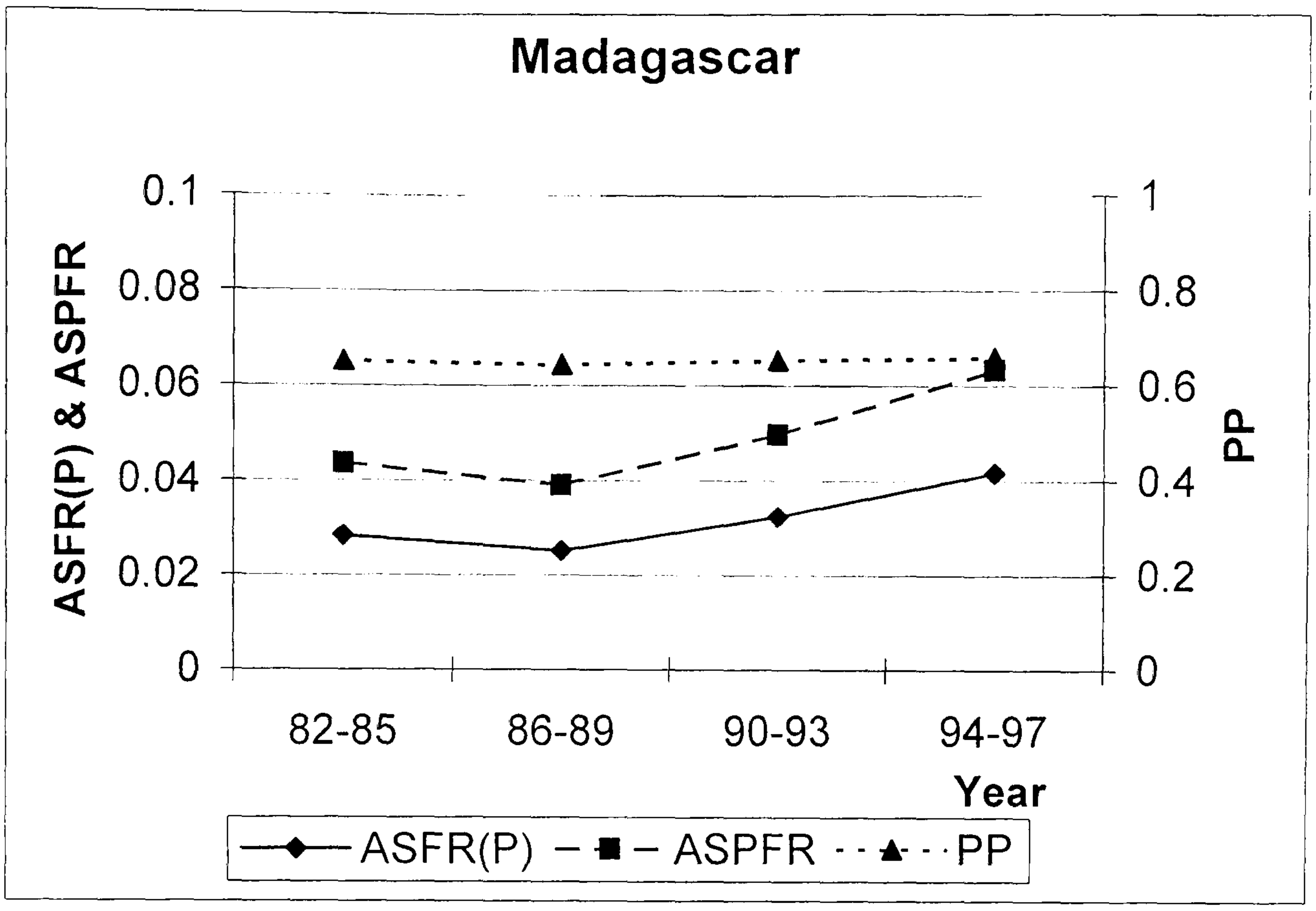


Figure 3-12. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Malawi.

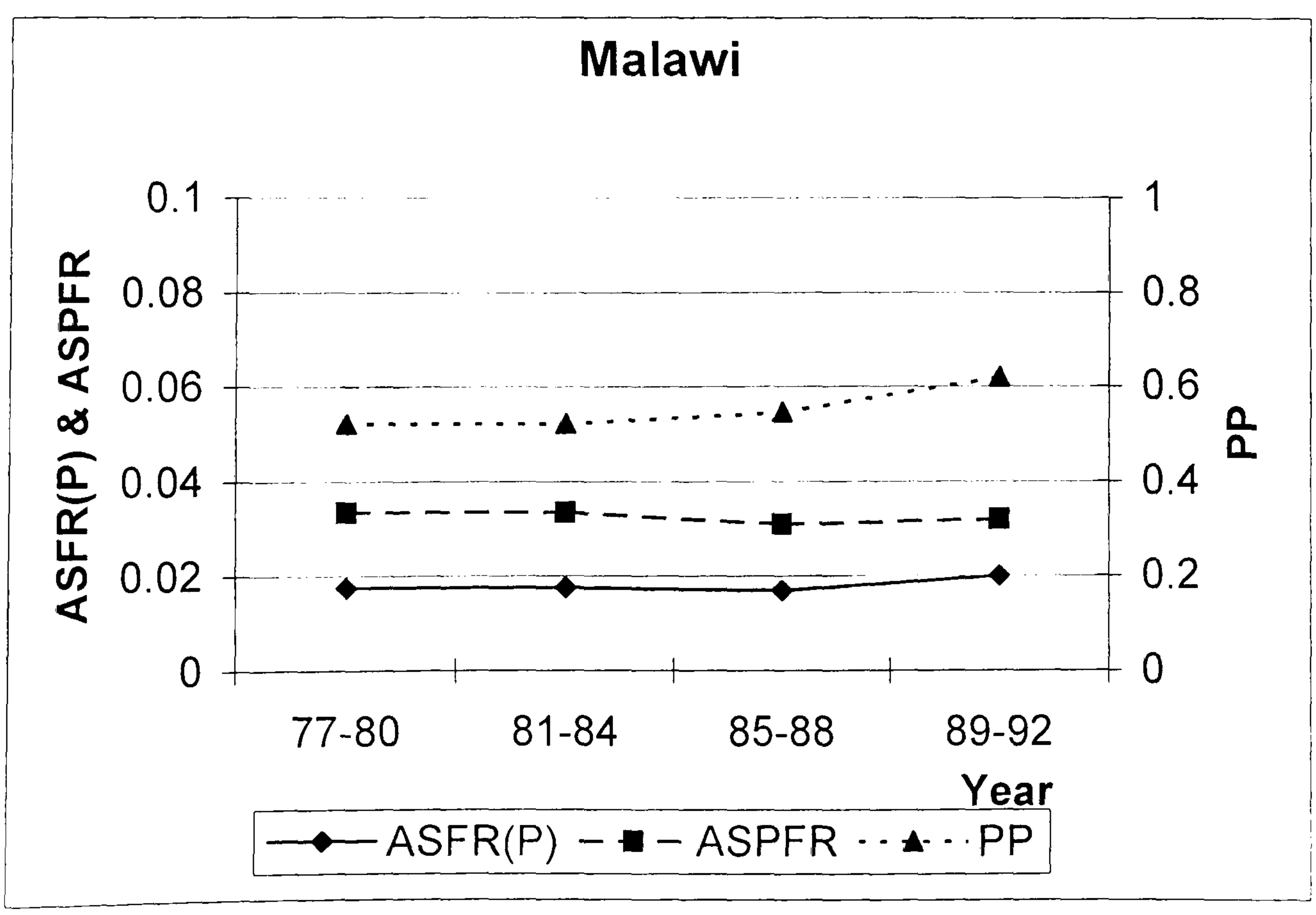


Figure 3-13. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Mozambique.

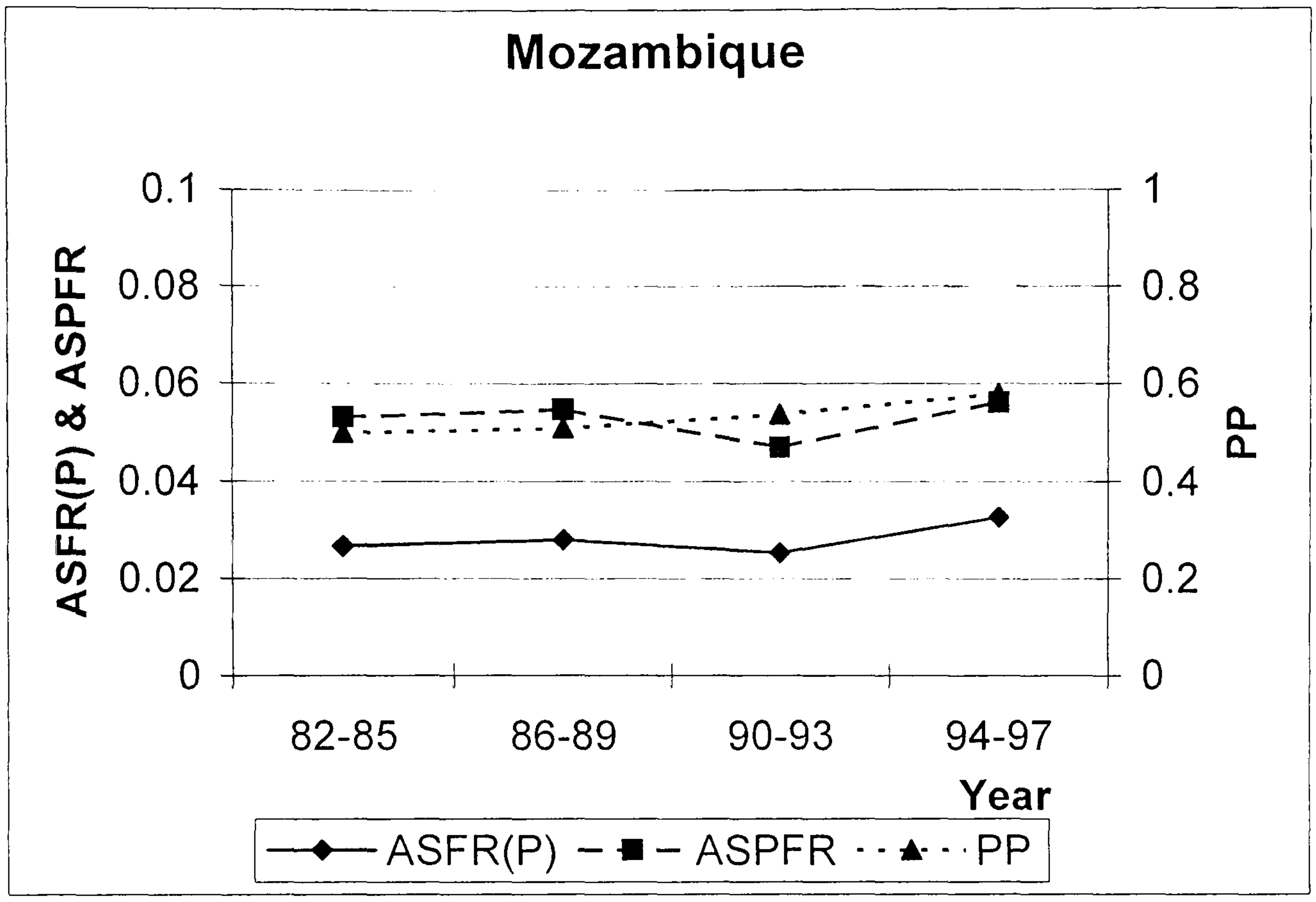


Figure 3-14. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Namibia.

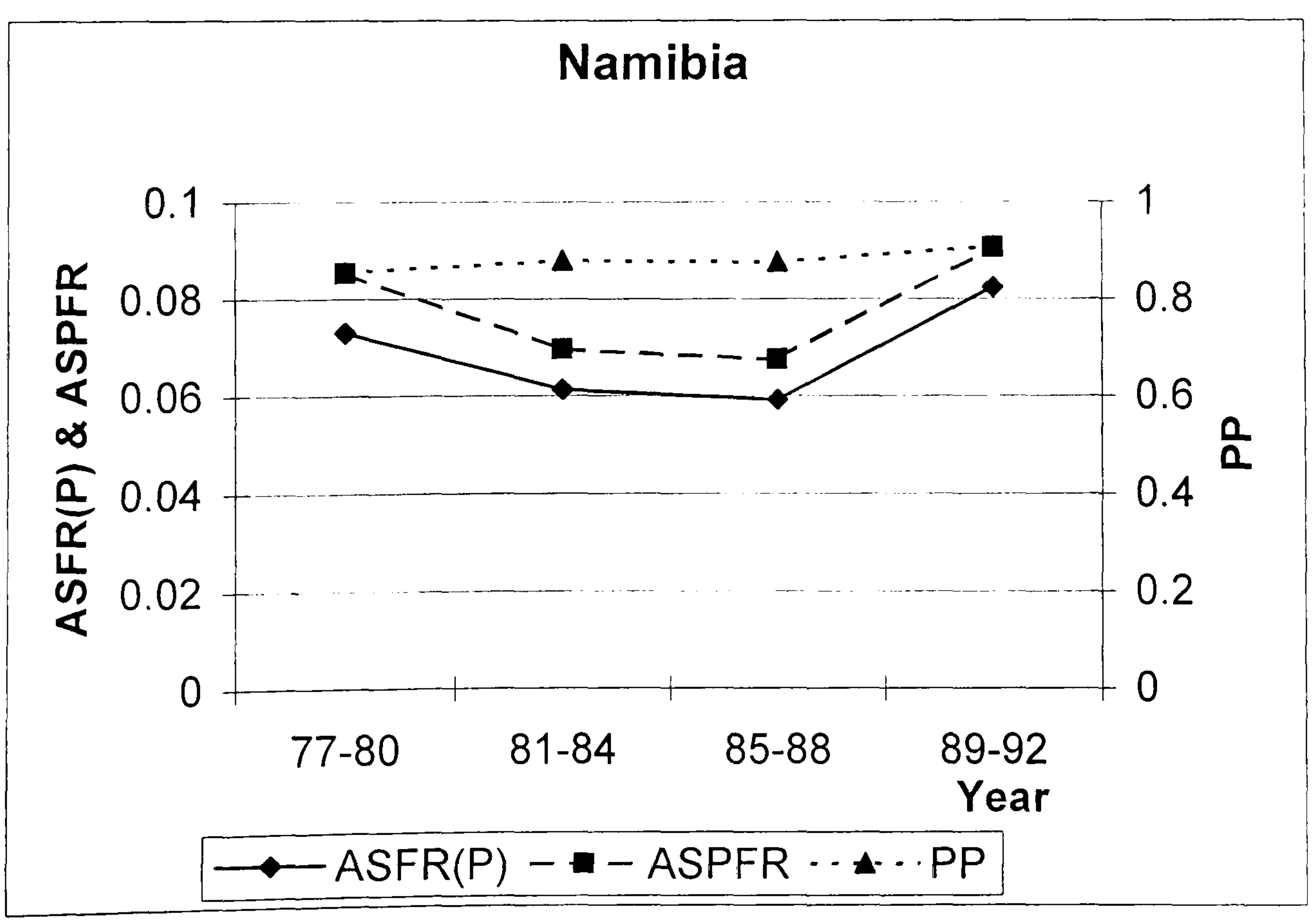


Figure 3-15. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) – Tanzania 1991-92.

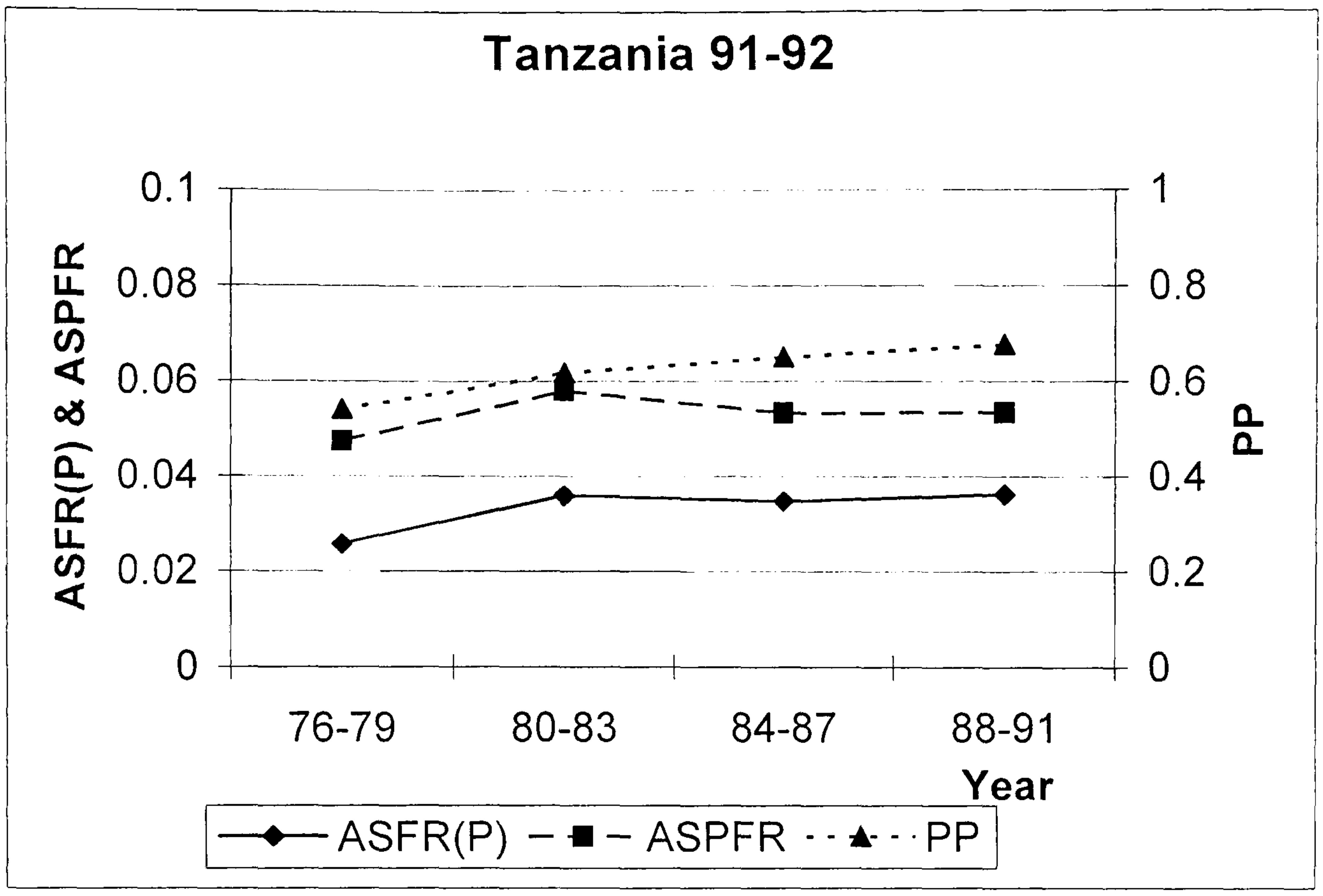


Figure 3-16. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) – Tanzania 1996.

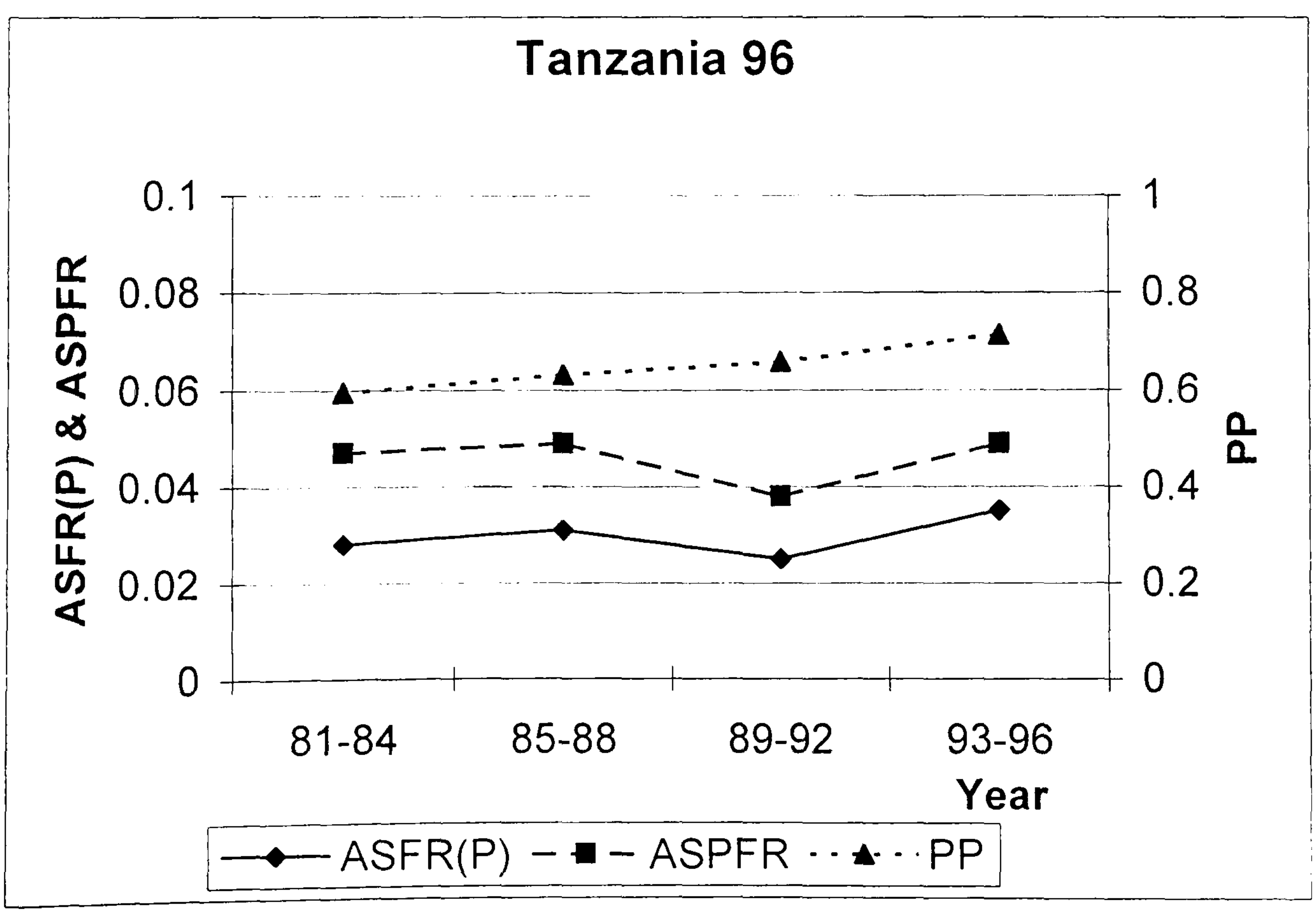


Figure 3-17. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) – Tanzania 1999.

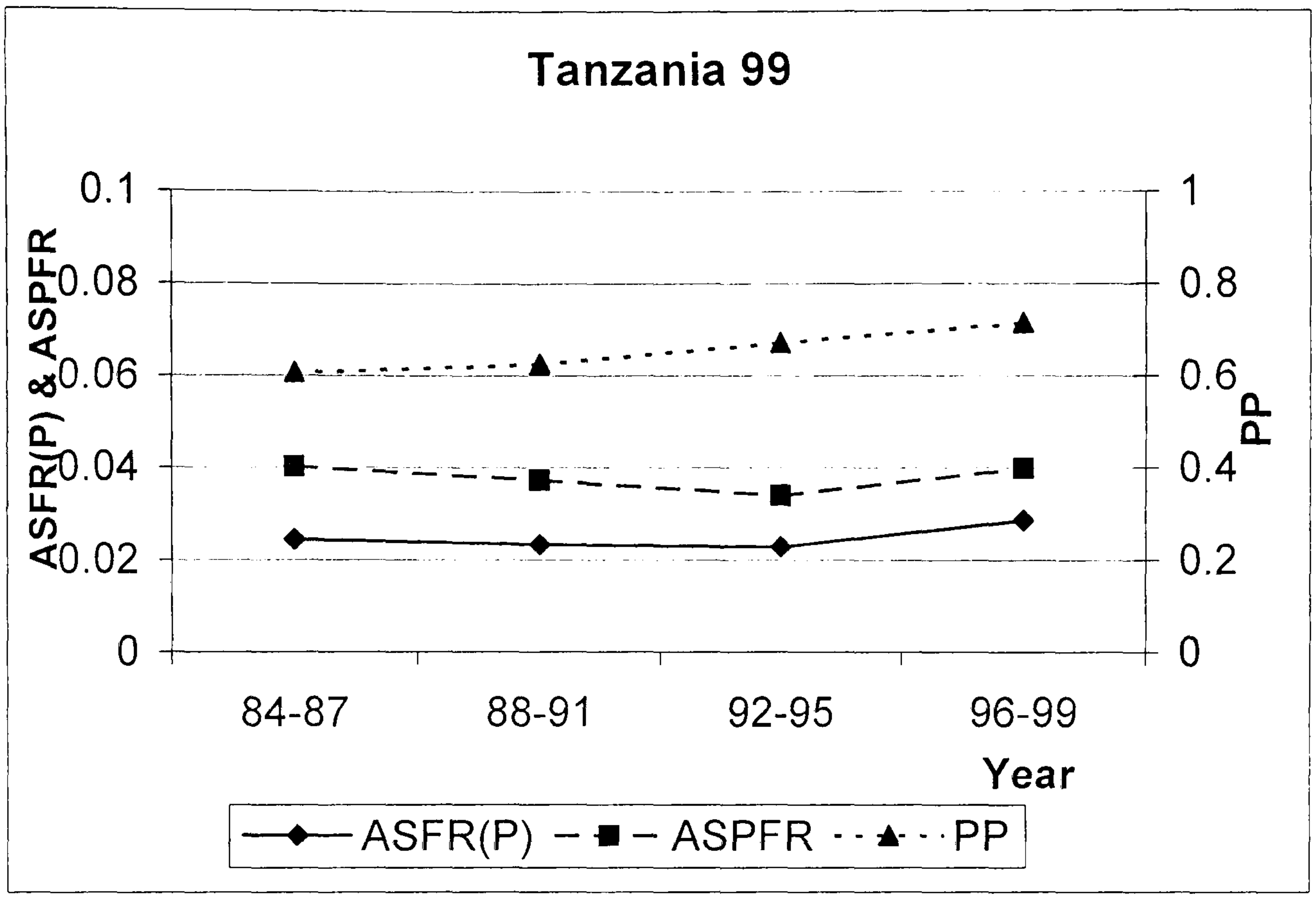


Figure 3-18. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Uganda.

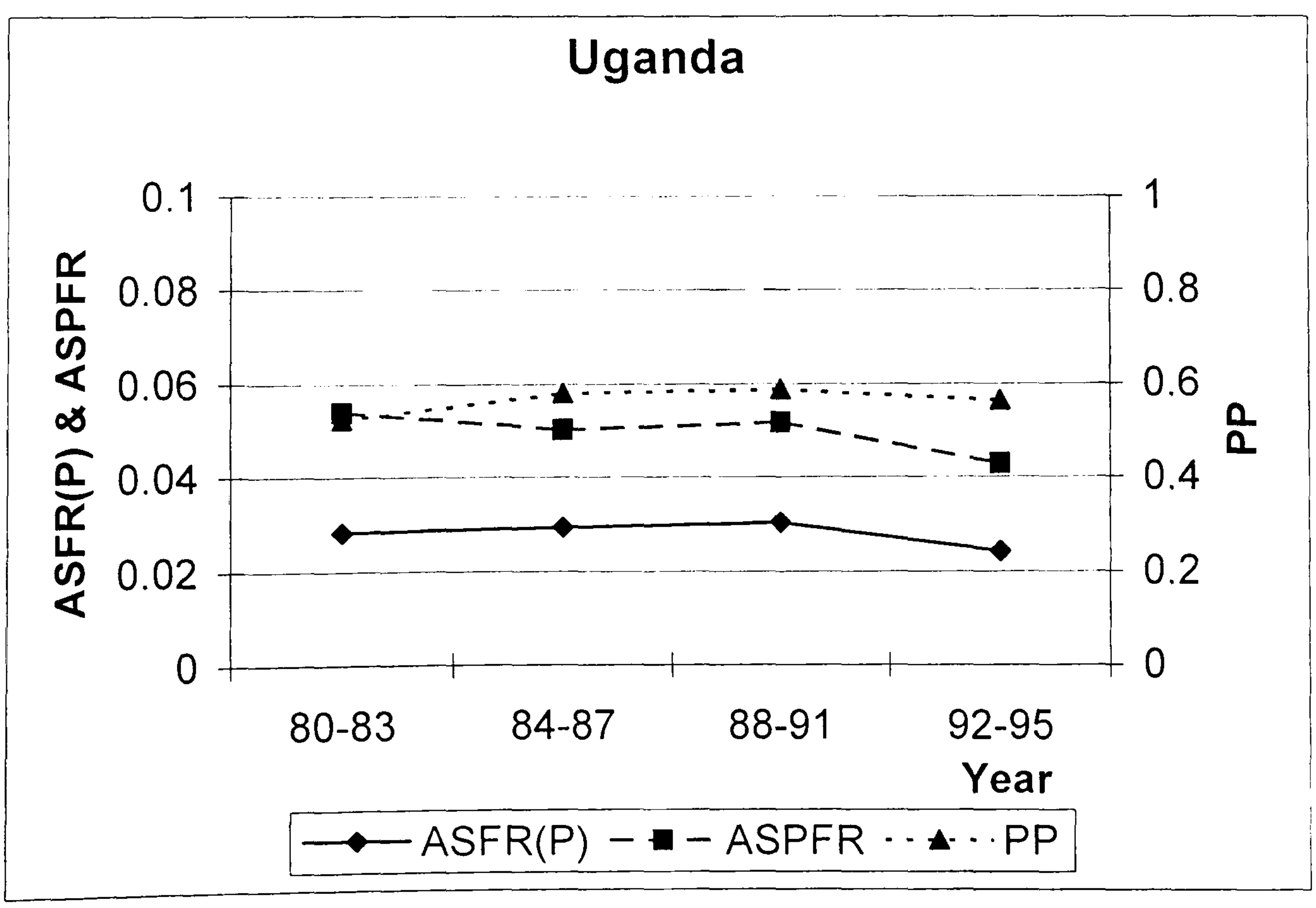


Figure 3-19. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Zambia.

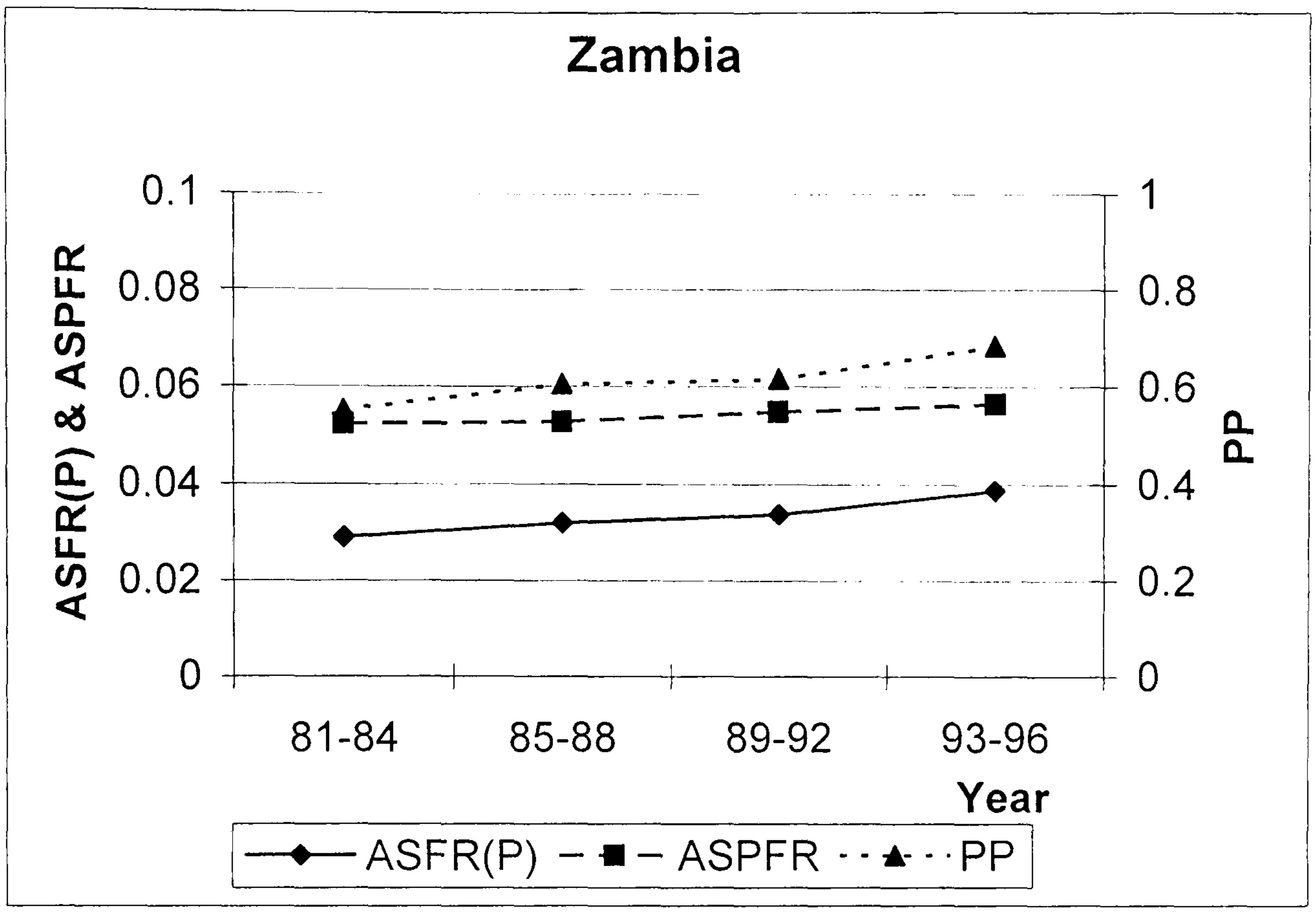
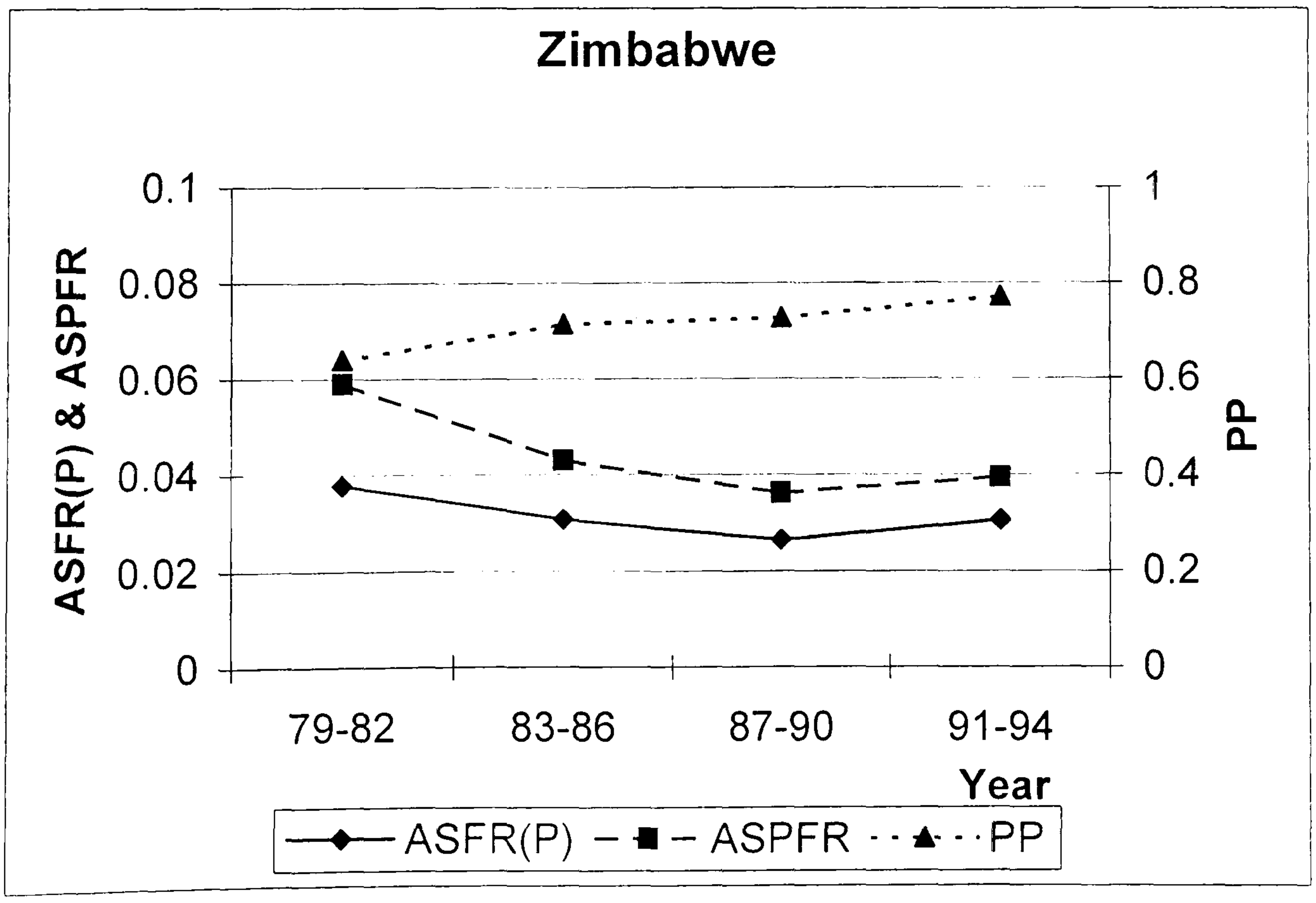


Figure 3-20. Premarital components of the ASFRs, 15 to 19 years old (ASFR(P)) and their decompositions in the ASPFRs and the proportions never-married (PP) - Zimbabwe.



Because of the westernisation and modernisation of African societies, and the slackening of the familial authority, it is thought that premarital adolescent fertility will increase. Bledsoe and Cohen (1993), Meekers (1994) and Gage (1998) find results in that direction. Figures 3-10 to 3-20 show a rather different picture. Except in Zambia and Madagascar, the premarital component of adolescent fertility shows a stable or even decreasing trend over time. In Zambia and Madagascar, the proportion of never-married women and the premarital fertility are rising which inevitably leads to a rise in the premarital component of the adolescent fertility by equation (2).

Ignoring Zambia and Madagascar, all countries show an increase in the proportion of adolescents never-married (Figures 3-10 to 3-20). Moreover, the premarital component of adolescent fertility is stable. This means that the number of women at risk of premarital birth is increasing, but the number of premarital births remains the same. Therefore, each woman has a lower risk of premarital birth; in other words, the premarital adolescent fertility has to be declining. Mathematically, using equation (2), PP_i is increasing and $ASFR_i(P)$ is stable, therefore $ASPFR_i$ should be declining. This phenomenon is well illustrated by the situation in Kenya and Zimbabwe. The same principle applies in the other countries, but there is too much variability to see it clearly on the graphs. The three surveys in Tanzania give roughly the same results and hence suggest that the trends observed are real.

A similar analysis can be done for post-marital adolescent fertility, using equation (3). Similar to Figures 3-10 to 3-20, the third series of graphs (Figure 3-21 to 3-31) pictures the post-marital component of the ASFR, ASFR(M), the age-specific post-marital fertility rate (ASMFR) and the percentage ever-married (PM) for women aged 15 to 19. Except in Madagascar, Mozambique and Uganda, the post-marital component of fertility is declining. This may be explained by a decline in the proportion of ever-married adolescents, whereas the post-marital fertility rate is roughly stable. In other words, the post-marital component of fertility is declining because the number of adolescents at risk of post-marital birth is declining, and each of them has the same risk in different periods. Mozambique and Uganda do not show any clear pattern. Madagascar shows a slight increase in the post-marital component of adolescent fertility. The results of the three Tanzanian surveys are consistent.

Figure 3-21. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) - Kenya.

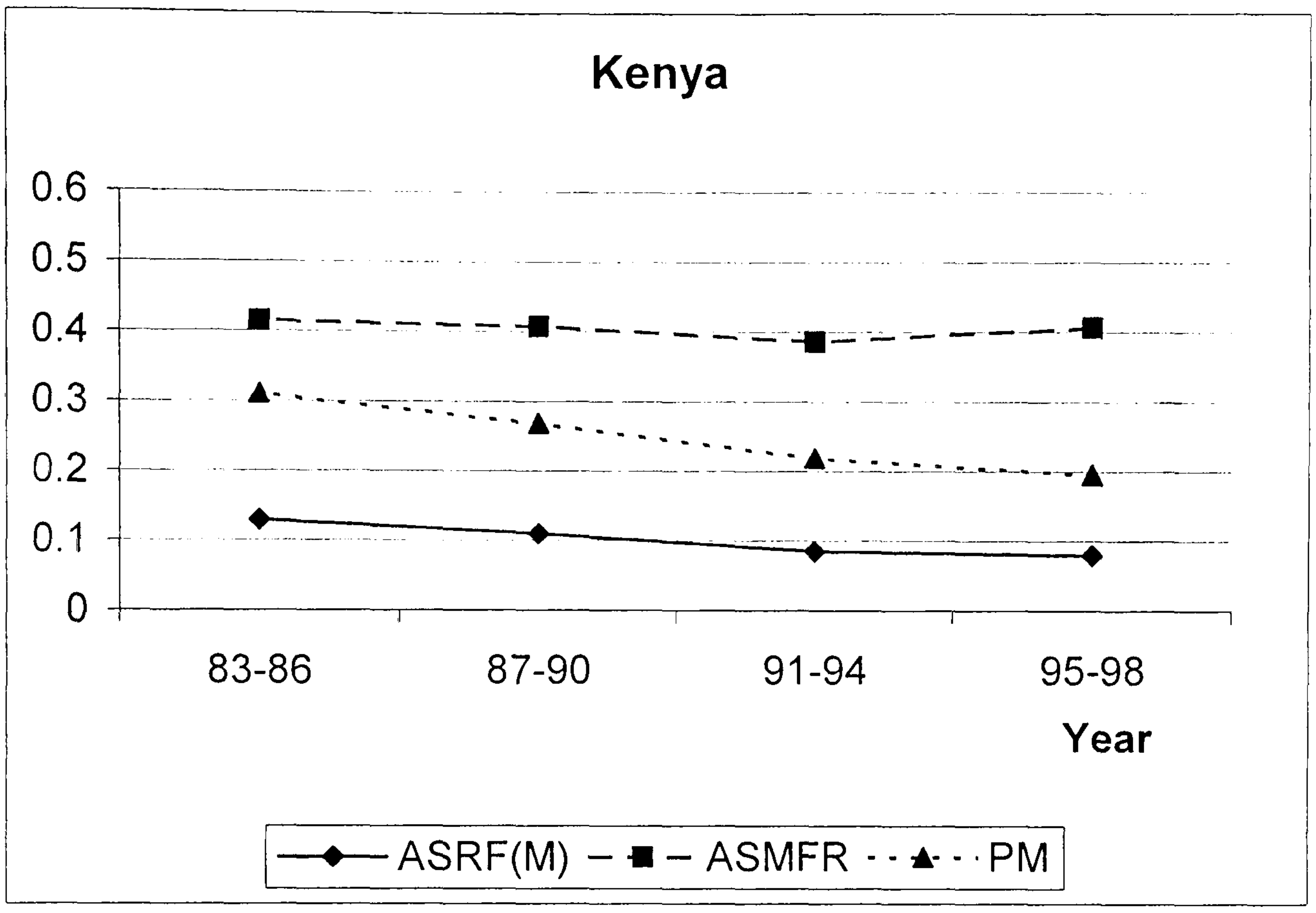


Figure 3-22. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) - Madagascar.

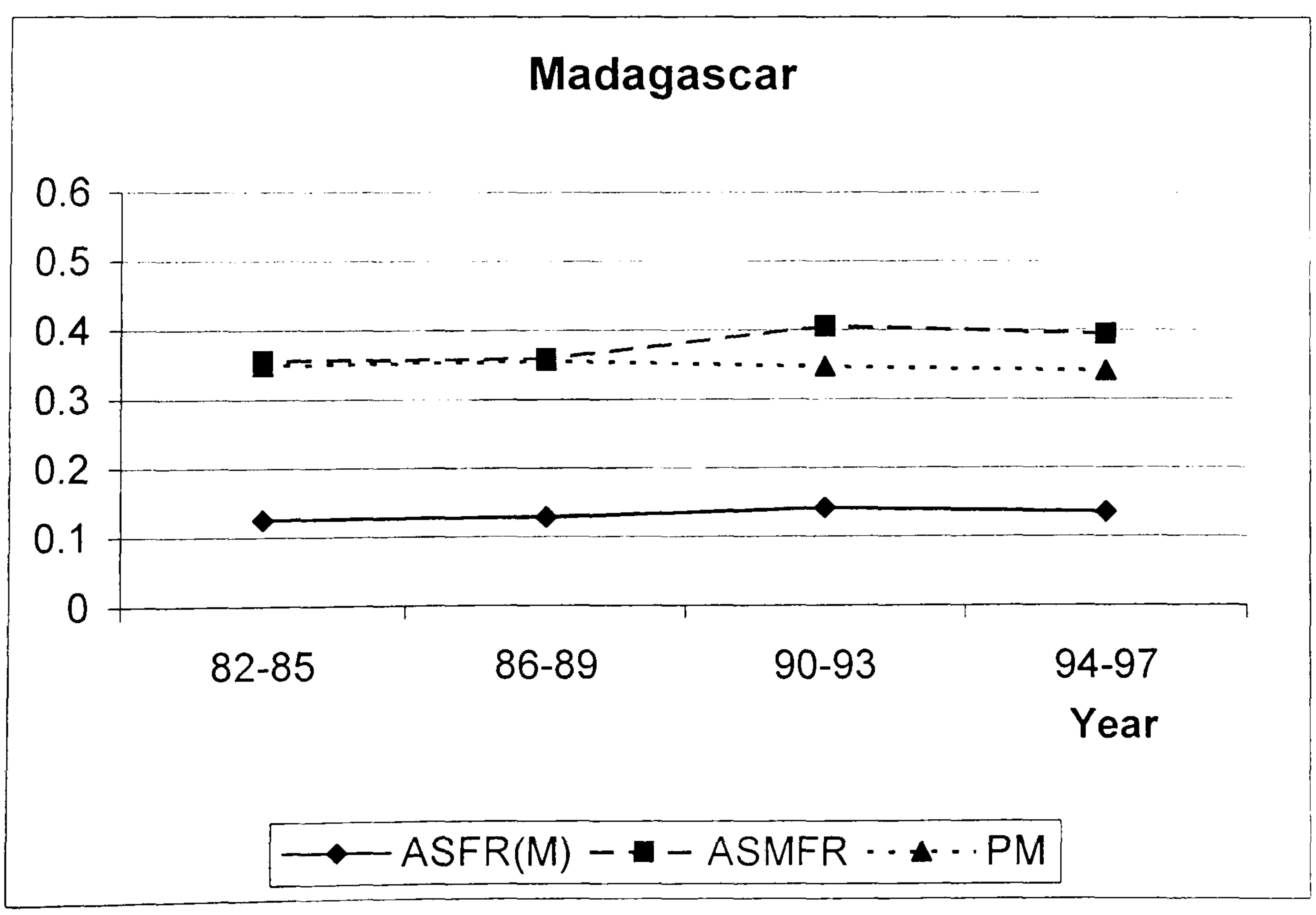


Figure 3-23. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) - Malawi.

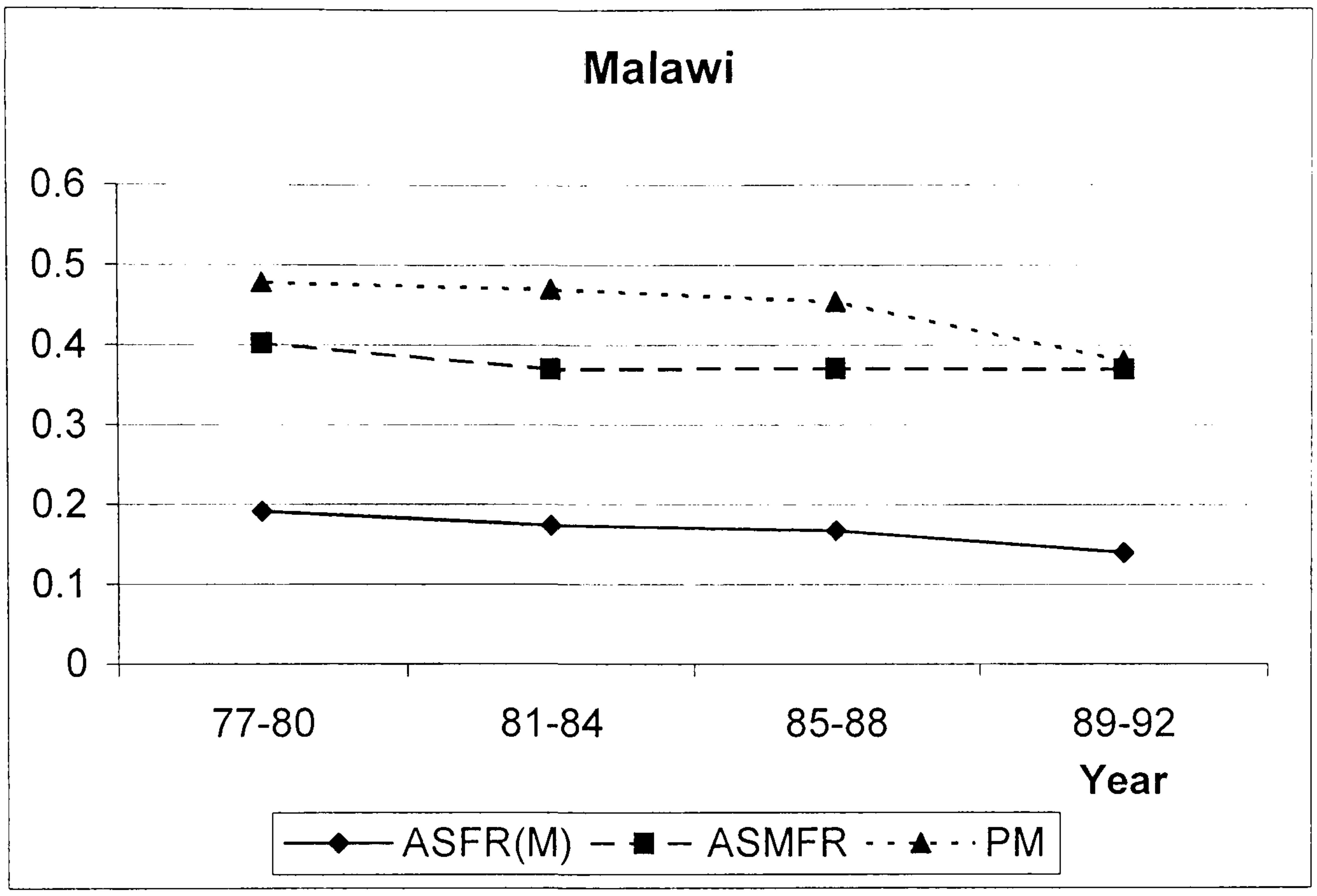


Figure 3-24. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) - Mozambique.

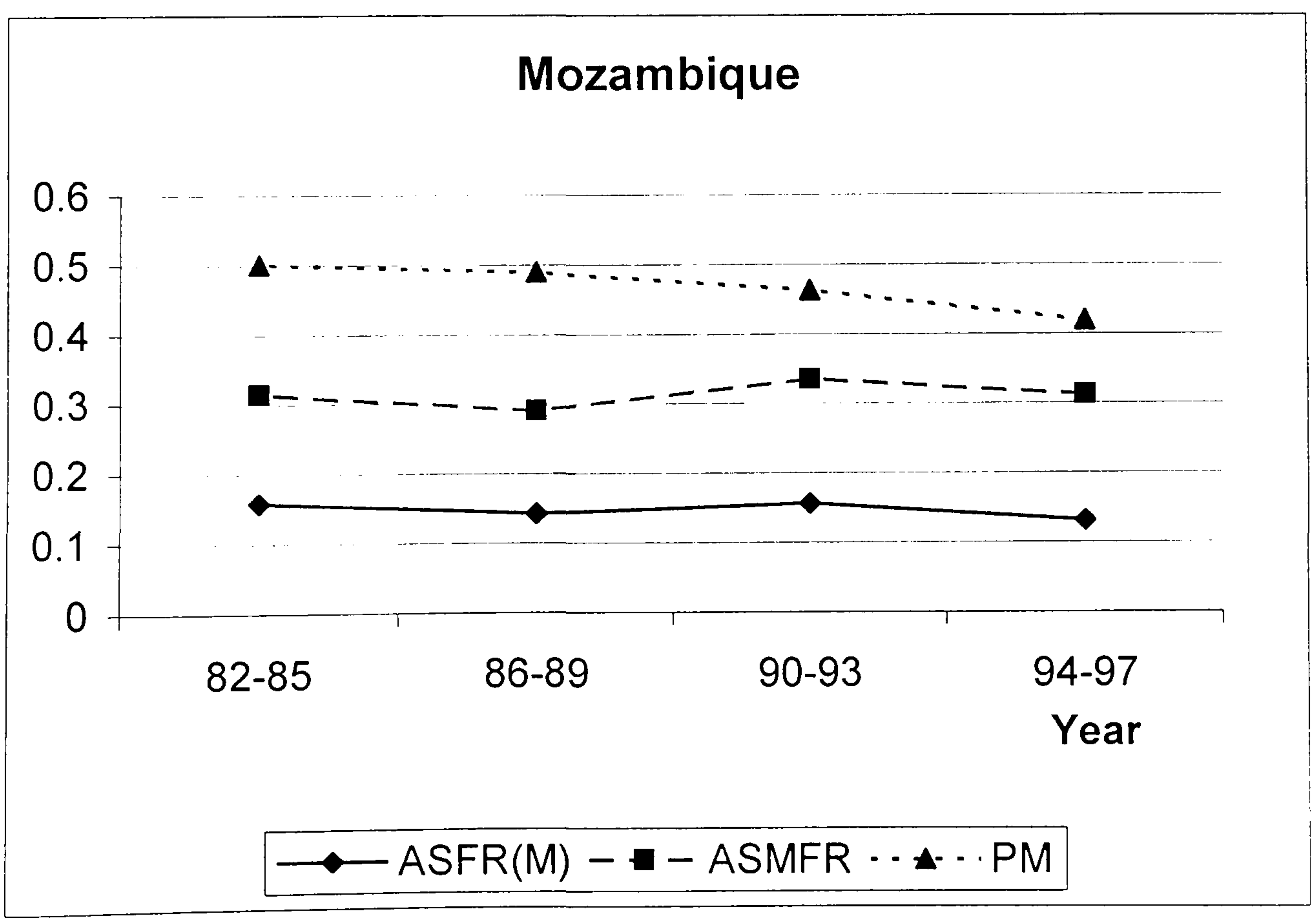


Figure 3-25. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) - Namibia.

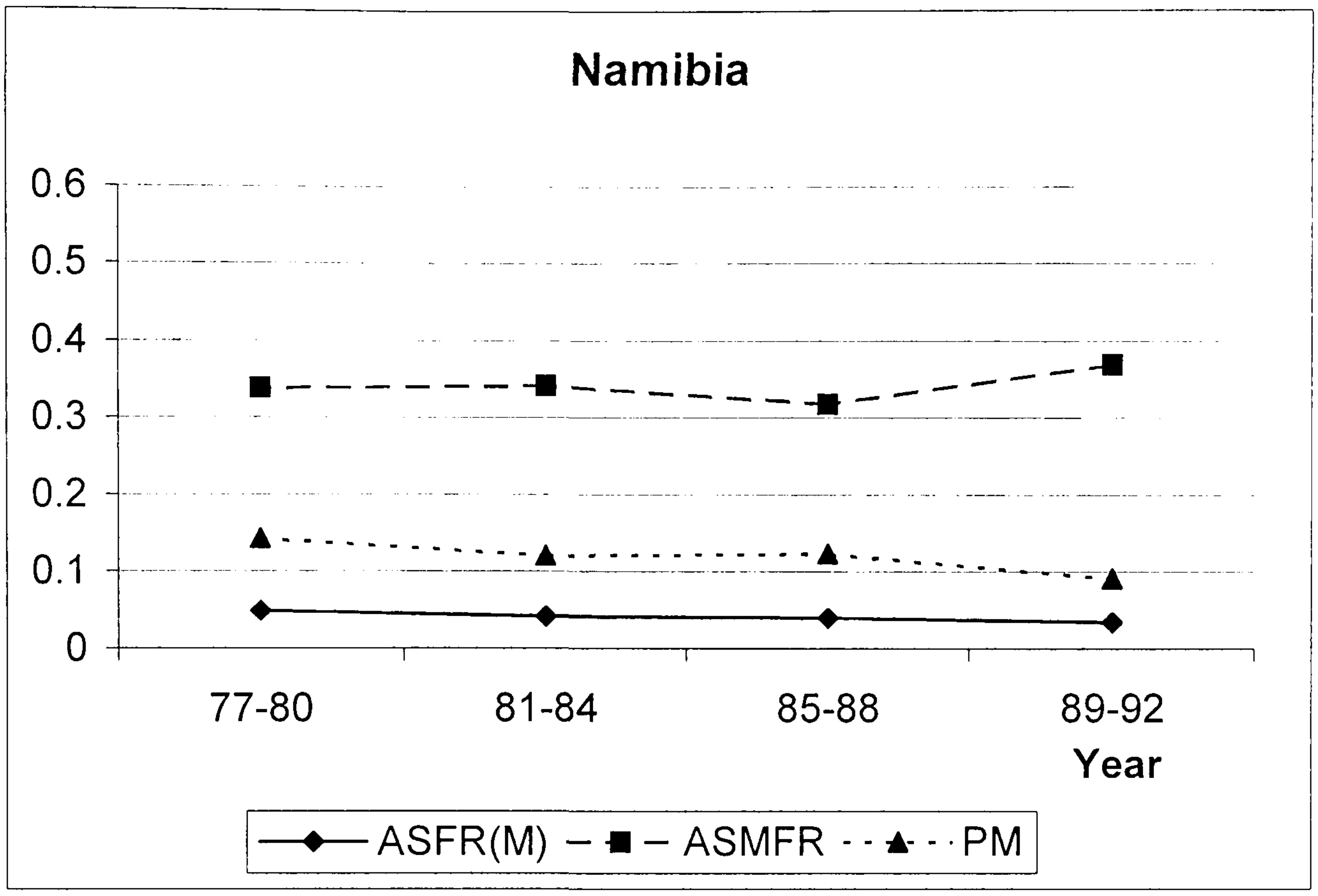


Figure 3-26. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Tanzania 1991-92.

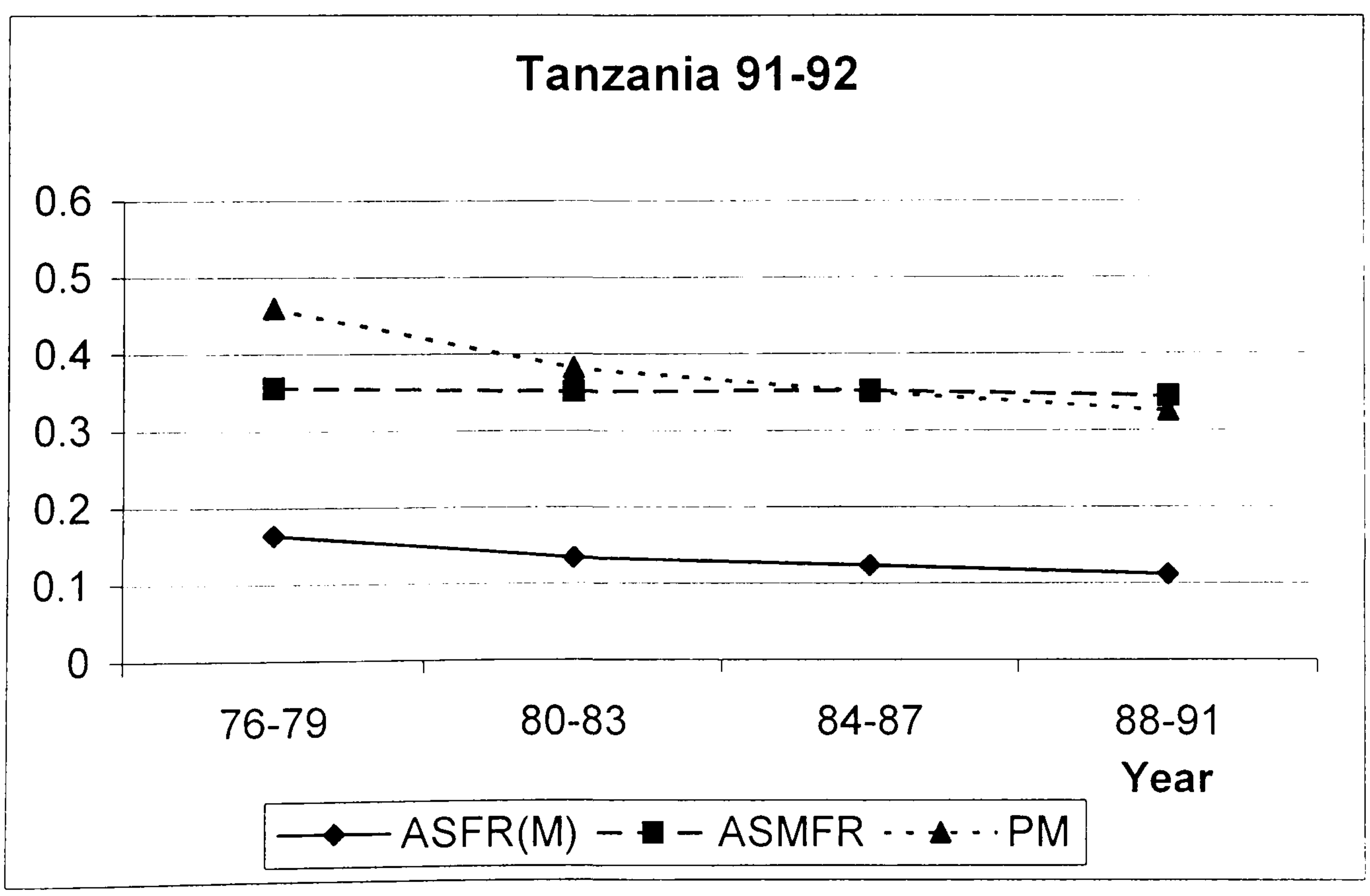


Figure 3-27. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Tanzania 1996.

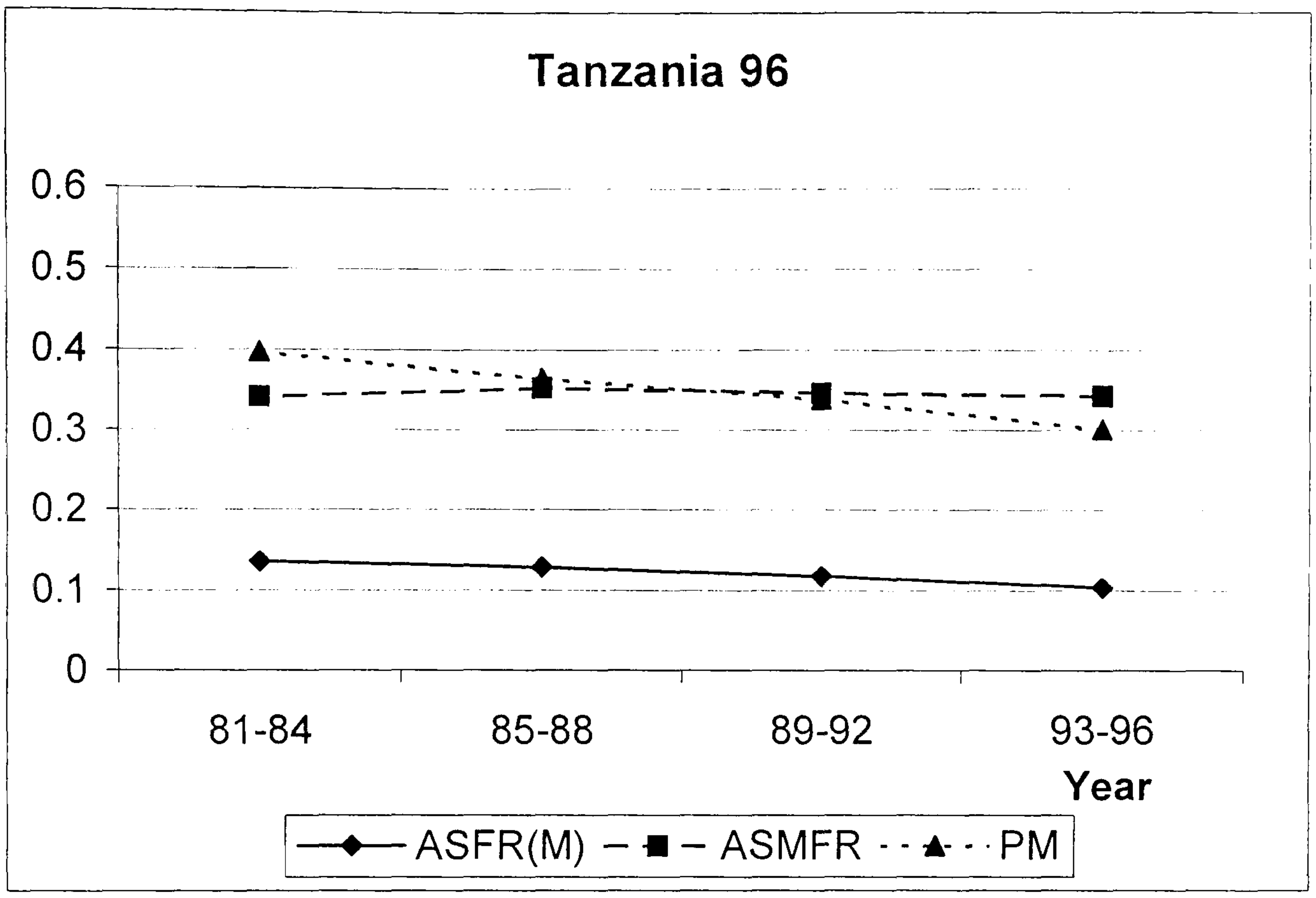


Figure 3-28. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Tanzania 1999.

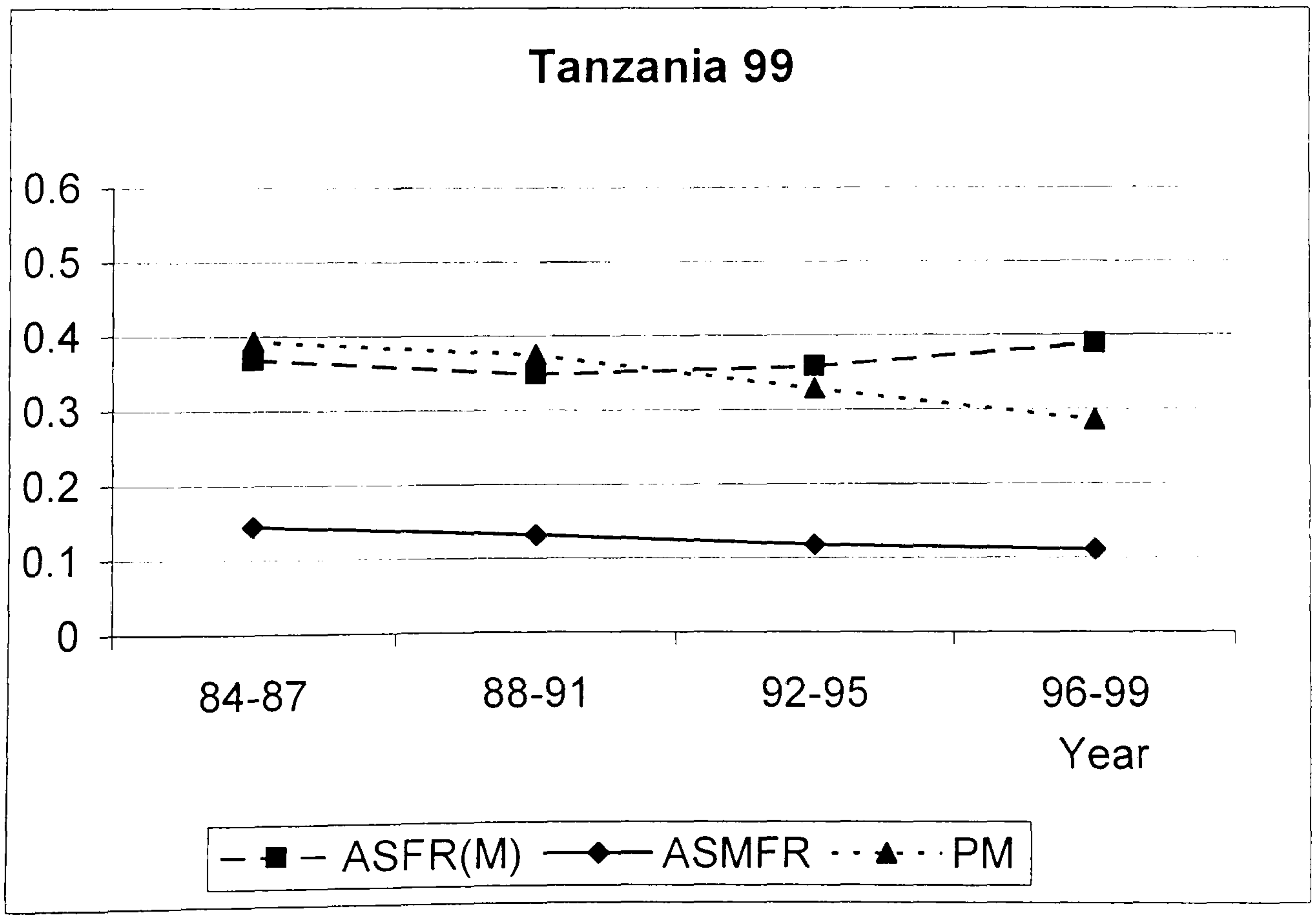


Figure 3-29. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Uganda.

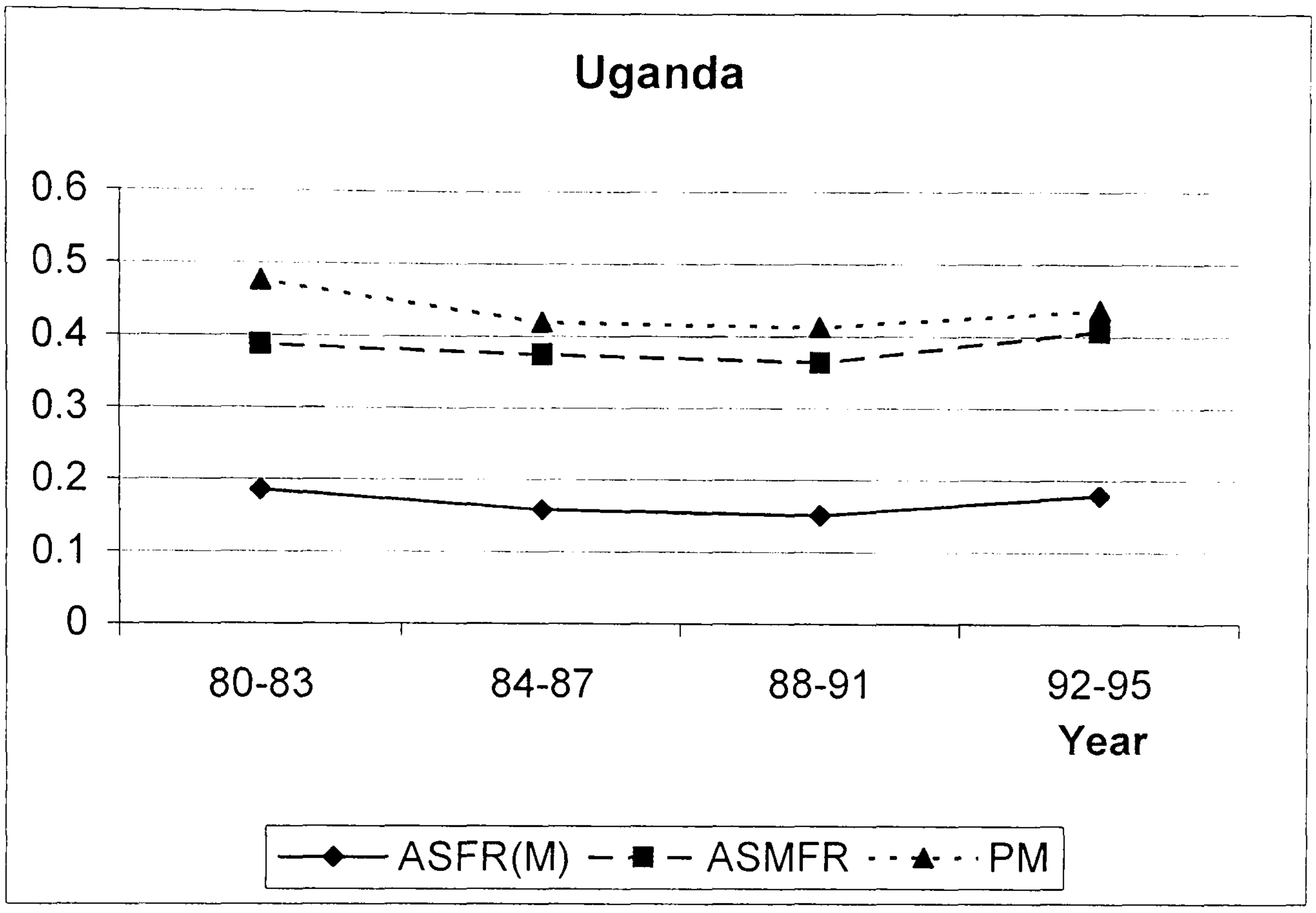


Figure 3-30. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Zambia.

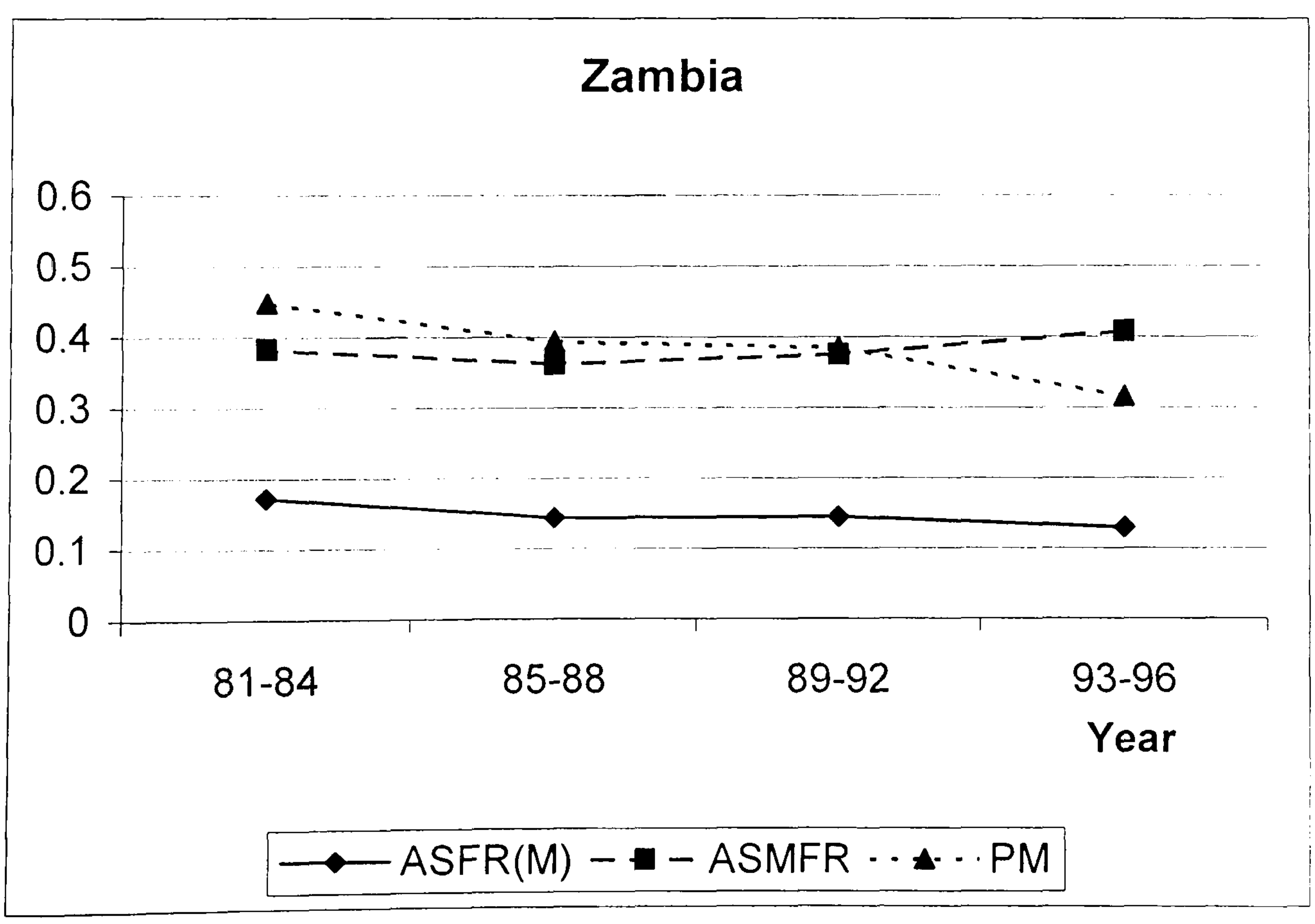
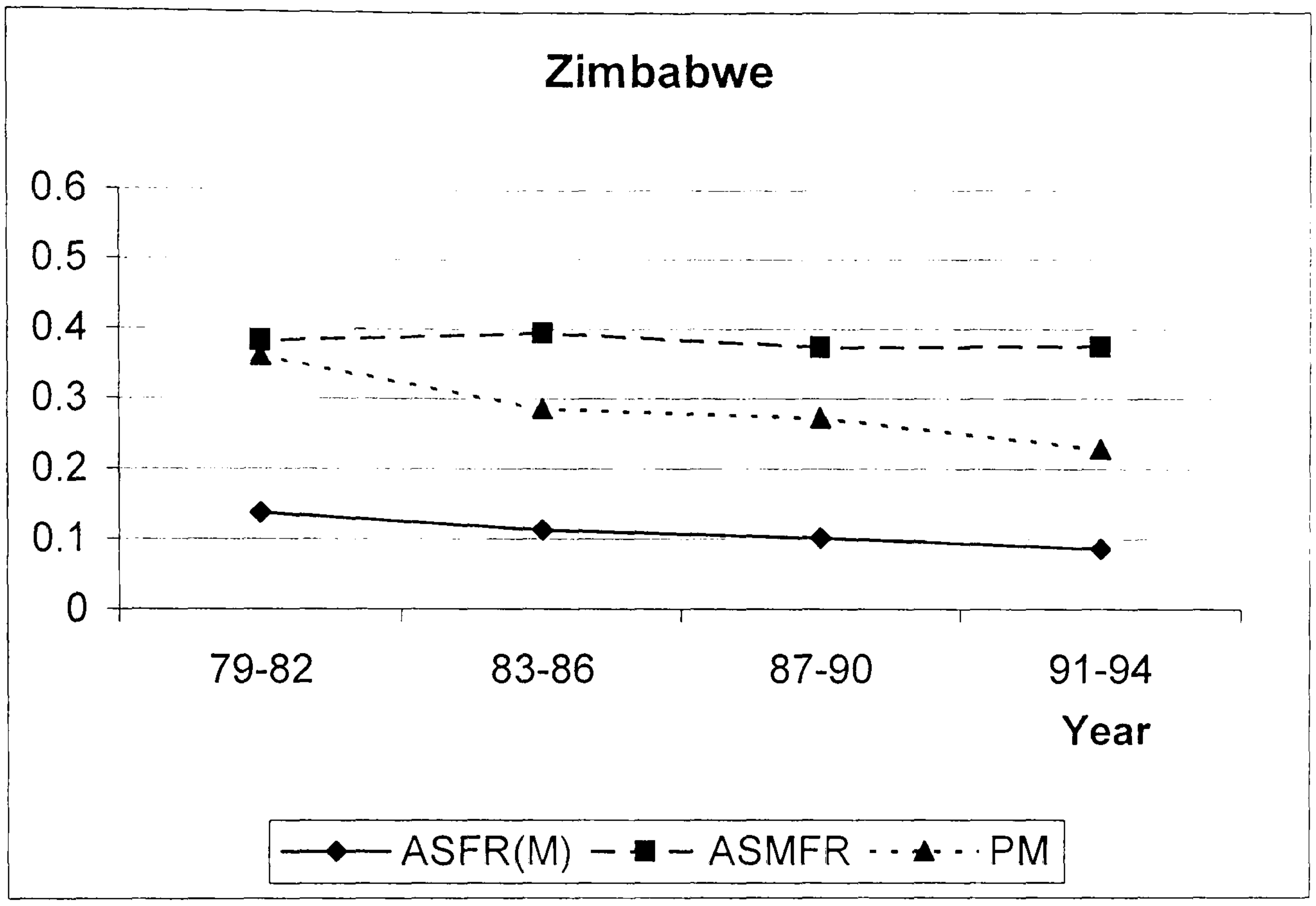


Figure 3-31. Post-marital components of the ASFRs, 15 to 19 years old (ASFR(M)) and their decompositions in the ASMFRs and the proportions ever-married (PM) – Zimbabwe.



3.6 Changes in fertility and marriage patterns

We have described the evolution of total, premarital and post-marital fertility. This section answers the question: To what extent does rising age at marriage affect fertility in southern and eastern Africa? The method used is first explained mathematically and then applied to the nine countries.

Some of the equations from Chapter 2 are first repeated and then the method is extended from age-specific to total fertility. Coale's decomposition of fertility (Coale, 1967) follows from equations (1), (2) and (3). For any period t and age-group i, we have:

$$ASFR_{ti} = PP_{ti} * ASPFR_{ti} + PM_{ti} * ASMFR_{ti}.$$

Consider two periods called T and τ, period T being the more recent and reference period. We define the standardised age-specific fertility rate of period τ compared to period T as:

$$SASFR_{(\tau/T)} = PP_T * ASPFR_\tau + PM_T * ASMFR_\tau,$$

where the subscripts i are suppressed for convenience.

$SASFR_{(\tau/T)}$ is what the fertility in period τ would have been if the proportions married had been the same as in the most recent period (T). By summing the $SASFR_{(\tau/T)}$s over all age-groups, we obtain a standardised total fertility for period τ compared to period T, $STFR_{(\tau/T)}$.

We can decompose the difference between the total fertility in period τ (TFR_τ) and in period T (TFR_T) as follows:

$$TFR_\tau - TFR_T = (TFR_\tau - STFR_{(\tau/T)}) + (STFR_{(\tau/T)} - TFR_T).$$

It is clear that the left hand-side is the change in fertility between the two periods. The first term of the right hand side represents the change in fertility explained by changes in marriage, whereas the second term represents the change in fertility explained by changes in other factors than marriage (contraception, abortion, lactational infecundability, sterility, etc.).

In this application to nine southern and eastern African countries, the fertility of women aged 15-39 years and four-year periods iare considered, as in the previous analysis. Figure 3-32 illustrates the results for Tanzania (1996 DHS). The total fertility rates, as well as the standardised total fertility rates, are plotted for four periods of four years. The dark grey area between the TFR and STFR curves represents the fertility decline explained by rising age at marriage. The light grey area between the STFR curve and the horizontal line at the level of the TFR in the most recent period, $TFR_{93\text{-}96}$, represents the part of the fertility decline explained by factors other than marriage. From the graph, it can be seen that rising age at marriage explains between 15 and 20 per cent of the Tanzanian fertility decline for women aged 15-39. This is less than the 25 per cent found in Chapter 2, which is relating to women aged 15-34. By including older women, who are not concerned by changes in age at marriage, the impact of changes in marriage on fertility is slightly reduced.

Figure 3-32. Total fertility rate and standardised total fertility rate for women aged 15 to 39 in Tanzania (from the 1996 DHS).

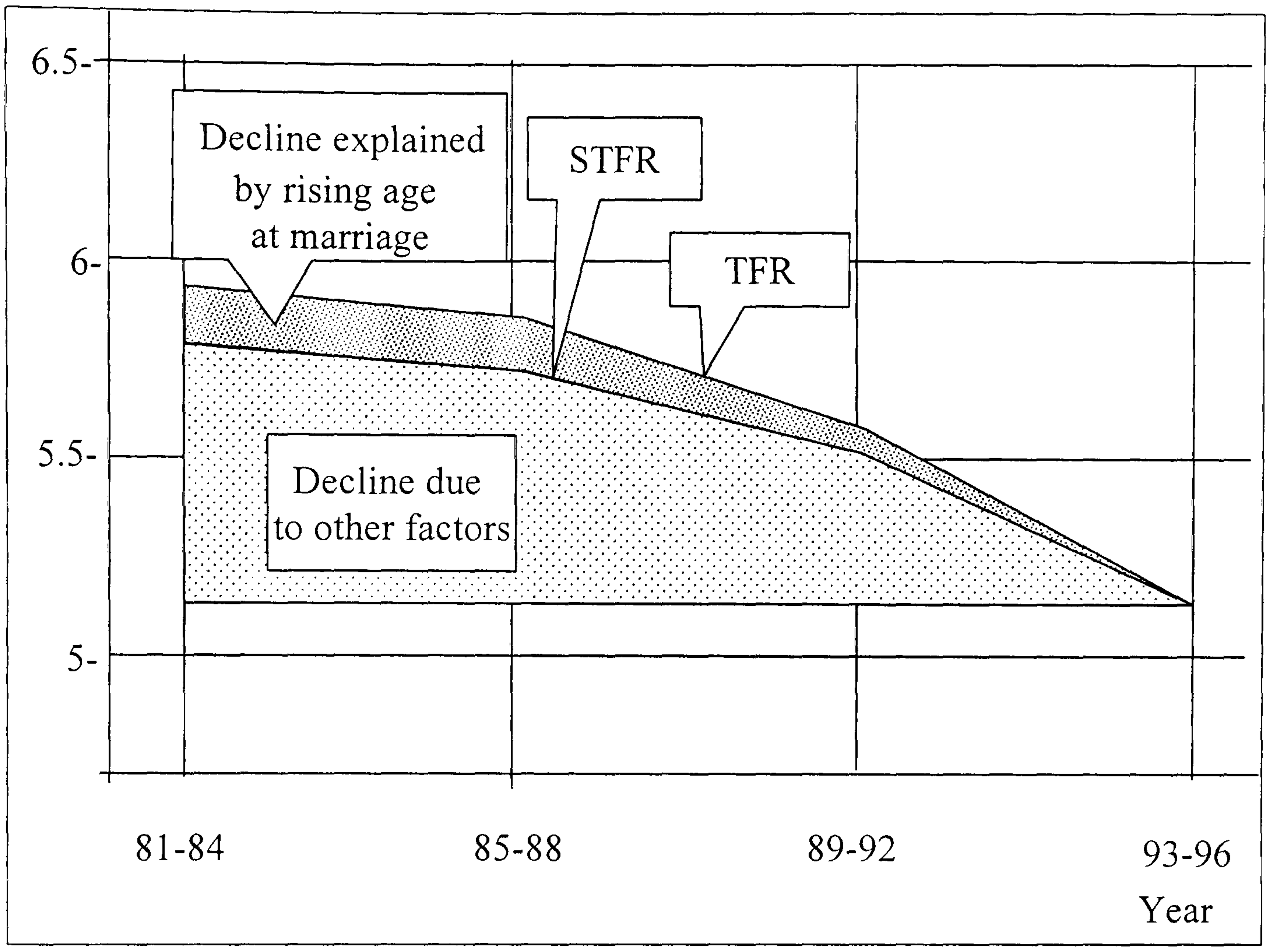
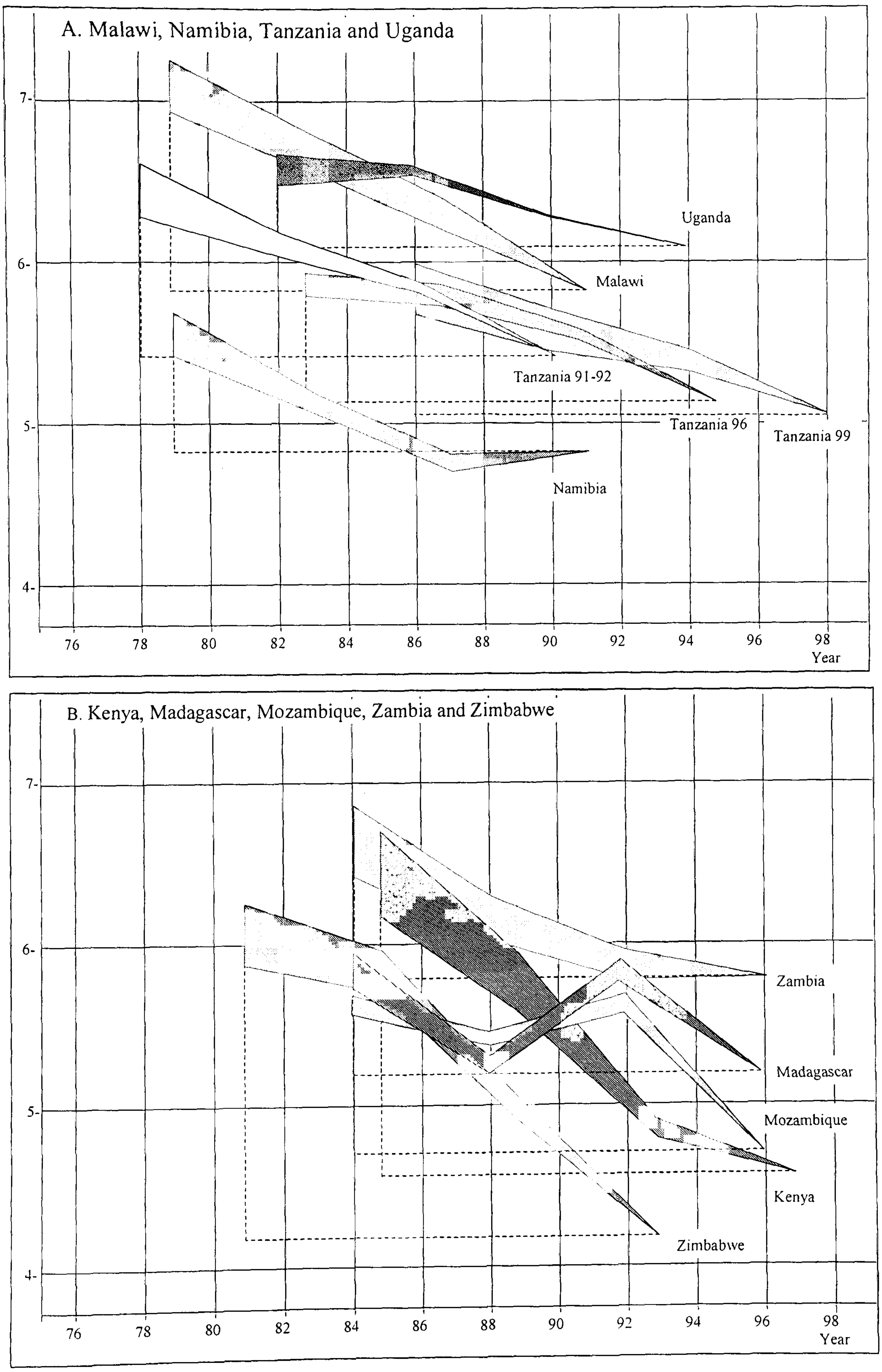


Figure 3-33 (see also Appendix E) pictures the TFRs and STFRs for all nine countries. It is expected that the STFR should lie below the TFR because age at first marriage is rising in all countries, and therefore the proportions of women who are never-married, who have lower fertility than ever-married women, is increasing.

In those countries where there has been a fertility decline, rising age at marriage explains between 17 and 38 % of the decline in the 12-year interval separating the two most distant periods: 17 % in Tanzania (1996), 20 % in Zimbabwe, 21 % in Malawi, 23 % in Kenya, 27 % in Tanzania (1991-92), 29 % in Uganda, 33 % in Tanzania (1999) and 38 % in Namibia and Zambia. The results from the three Tanzania surveys are broadly consistent. Madagascar and Mozambique do not show any clear evidence of a fertility decline over the four periods studied (as already noted, this may be due to poor data quality; a new survey would be needed to assess fertility trends). In these two countries, the other factors determining fertility are dominating the trend. If only age at marriage had changed in the 12-year interval, the fertility would have declined.

Figure 3-33. Total fertility rates and standardised total fertility rates (15-39 years old).



3.7 Conclusions

This paper confirms previous studies (e.g. Cohen, 1998) in that age at first marriage is rising through southern and eastern Africa. Rising age at first marriage is one of the factors driving the fertility declines in seven out of the nine countries studied namely Kenya, Malawi, Namibia, Tanzania, Uganda, Zambia and Zimbabwe. In these countries, around one sixth to one third of the fertility declines among women aged 15 to 39 years old is explained by rising age at marriage. The declines affect only the post-marital component of fertility, whereas the premarital component remains stable. Since childbearing before marriage is a concern in Africa, especially in terms of responsibility to support these children (Gage-Brandon and Meekers, 1993), the results found here of a stable (and not increasing) trend are encouraging.

The premarital component of adolescent fertility is stable in all but two countries studied (Madagascar and Zambia), due to an increase in the proportions of never-married adolescents and a decline in premarital fertility. The decline in adolescent premarital fertility is somewhat surprising. Bledsoe and Cohen (1993) and Meekers (1994) found a tendency towards higher premarital fertility[6], which they explain by the

[6] Bledsoe and Cohen (1993) find that the percentage of premarital births among adolescents is increasing and conclude that there is a rise in premarital adolescent fertility. However, their reasoning is misleading: a rise in the percentage of premarital births does not necessarily mean a rise in premarital fertility. In fact, since adolescents' marital fertility is declining, the percentage of premarital births will increase even if adolescents' premarital fertility is stable or declining more slowly than marital births.
Meekers (1994) concludes that premarital fertility is increasing in a number of sub-Saharan Africa countries, based on the results of his logistic regression estimating the effects of background variables on the likelihood that a woman had a premarital birth. Meekers' logistic regression can be compared to the regression found in the present thesis on p. XX in Chapter 2, but his sample is restricted to ever-married women, whereas the present thesis considers all women. The difference in the samples could explain the different results. Moreover, the regressions use a different variable to control for trends in time: Meekers uses date of first marriage as a proxy for date of first birth, whereas the present thesis uses the exact date of first birth. Meekers argues

westernisation and modernisation of African societies and the weakening of traditional family structures. However, in the present analysis, encouraging trends towards lower adolescent premarital fertility are found. Further research is needed to determine the reasons of this decline; it is expected that increased contraceptive use, the fear of the HIV/AIDS epidemic and changes in premarital sexual activity have their role to play.

The three surveys in Tanzania show similar trends for each analysis. This gives confidence in the results and conclusions drawn from them. The Tanzanian trends show similar patterns to the ones of Kenya and Zimbabwe, but less marked. Since Kenya and Zimbabwe are on the path of a fertility transition, it is hoped that Tanzania is following them.

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that the proportion of premarital births increases as the date of first marriage increases. We find that the proportion of premarital births decreases as the date of first birth increases. In a context of rising age at marriage and stable trends in age at first births, using the date of first marriage as a proxy for the date of first birth could be misleading.

Chapter 4

The impact of contraception on birth interval lengths in Tanzania

Abstract

Contraception, especially contraception to space births, is thought to have a large impact on Tanzanian fertility. The relationship between spacing and fertility is not straightforward, as discussed here. Little data on contraceptive use is available in the 1996 Tanzania Demographic and Health Survey. Therefore, we define a 'contraceptor' during a birth interval as a woman who has used contraception for the first time before or during the birth interval of interest and who has used a modern method by the survey date. The implications of using this definition are detailed. Using survival analysis, the proportions of women spacing, stopping and becoming sterile or reaching menopause after each birth are computed. Only a minority of women are found to stop childbearing, even at high parities. The median birth intervals for contraceptors and non-contraceptors are shown to be respectively around 43 and 32 months.

4.1 Introduction

As seen in the introduction to the thesis, fertility is declining in Tanzania, with total fertility rates dropping from 7.2 in 1978 to 5.6 in 1996-99. The main reasons given for the decline are a rising age at first marriage and a reduction of fertility within marriage. We have shown in chapters 2 and 3 that a rise in age at marriage is an important factor in explaining the Tanzanian fertility decline. The second factor thought to be responsible for the fertility decline, a reduction of fertility within marriage, is likely to be associated with an increased use of contraception. The effect of contraception, mainly the use of contraception to space births, on the Tanzanian fertility decline is dealt with in both this and the following chapters.

The prevalence of modern contraception among married women increased from 6.6 per cent in 1991-92 to 13.3 per cent in 1996 and 16 per cent in 1999 (Bureau of Statistics and Macro International, 1993; 1997; and Mturi and Hinde, 2001). With respect to unmarried women, 21.4 per cent of sexually active unmarried women were using a modern method of contraception in 1996 (Bureau of Statistics and Macro International, 1997).

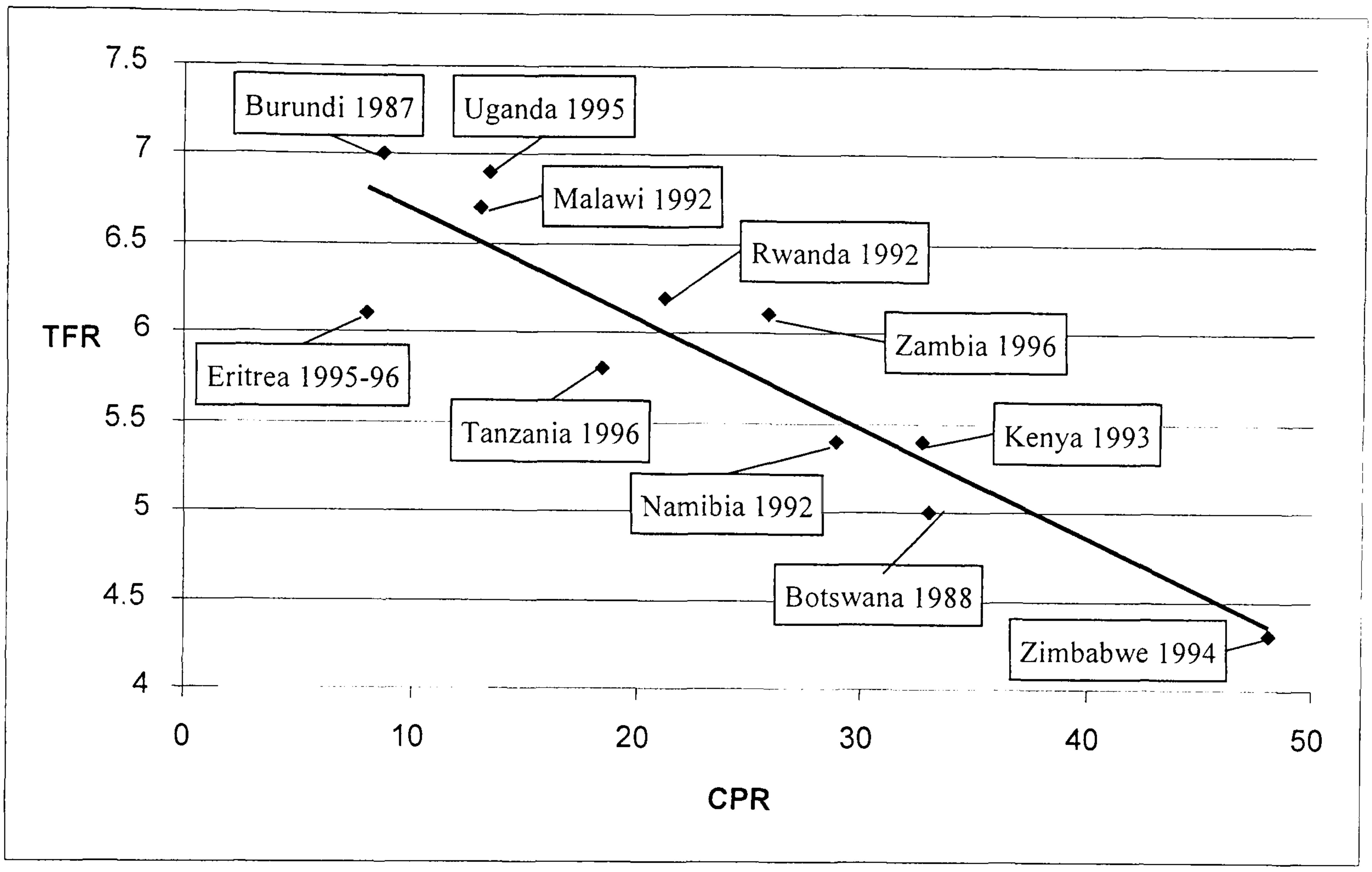
Contraception in Tanzania is used mainly to space births rather than to stop childbearing: only 1.5 per cent of all women, or 11.8 per cent of current users of modern contraception are using female sterilisation. Since most fertility transitions up to now have been led by a shortening of women's reproductive life, Tanzania is thought to show the signs of a new type of transition, led by a spacing behaviour, as pointed by Caldwell *et al.* (1992). In Asia, Latin America and most of Europe, the fertility transition was caused by a shortening of women's reproductive lives, due to later marriage and stopping childbearing at an early age. However, Szreter (1996, pp.367-439) and Garrett *et al.* (2001) show that spacing played a leading role in the English fertility transition at the turn of the twentieth century. In that case, the main methods for spacing were substantial periods of abstinence and, to a lesser extent, withdrawal. These methods for spacing births did reduce fertility due to their effectiveness and the length of time they were used for.

The English fertility transition is therefore led by the use of *traditional* methods of contraception to space births. Africa would be the first case of a fertility transition led by the use of *modern* contraception to space births. However spacing as practised in Africa may have a smaller impact on fertility than spacing or stopping as practiced in the rest of the world. Westoff and Bankole (2000, p.58) point out that contraception used to limit births has a much greater impact on fertility rates than the contraception used to space. Contraception is sometimes used during the period of post-partum infecundability. This is known as 'double protection'. Some women may not use contraception effectively (see Udjo, 1996 and Sambisa and Curtis, 1997 for the case of Zimbabwe). Bledsoe *et al.* (1998) suggest that women who are spacing their births do so to be more prepared and healthier for the next pregnancy: they use contraception to maximise the chances of survival of their children. In this context, a reduction of fertility would only be a 'side-effect' of the use of contraception to space births and not an aim in itself.

In sub-Saharan Africa where contraception is mainly used for spacing purposes, the relationship between contraceptive prevalence rates and fertility is weaker than in the rest of the world. In fact the correlation between contraceptive prevalence and fertility is considerably lower in sub-Saharan Africa (R = -0.368) than in Asia and Latin America (R = -0.807) (Westoff and Bankole, 2001). The weaker association found in sub-Saharan Africa may be due to the small impact on fertility of African women who space their births compared to women who stop in the rest of the world. Figure 4-1 shows the correlation between the total fertility rates (TFRs) of countries in southern and eastern Africa and the contraceptive prevalence rates (CPRs). Tanzania has an average TFR and CPR for the region and lies below the regression line. So the TFR is lower than what is expected from its CPR. This may be caused for example by a more effective use of contraception by Tanzanian women than their counterparts in neighbouring countries, or by other factors acting on Tanzanian fertility (e.g. higher levels of infertility or different marriage patterns in Tanzania).

It is generally assumed that a rise in contraceptive use leads to a decline in fertility without checking any further. Most research about contraception focuses on family planning programmes. A minority concentrates on the country level effect of contraceptive use on fertility stating that family planning affects fertility but without quantifying its impact. Very little is done at the individual level.

Figure 4-1. Regression of total fertility rates on the contraceptive prevalence rates in southern and eastern Africa.



Note: The contraceptive prevalence rates (CPRs) refer to the use of all methods of contraception among currently married women.
Source: Adapted from Cohen 1998.

This chapter and the next one aim at understanding the impact of spacing on the Tanzanian fertility. The present chapter focuses on preliminary analyses which give some insight on the impact of contraception on the length of the birth intervals, and the proportions of women spacing and stopping at each parity. In the next chapter, the effects of spacing and stopping on fertility are estimated using simulation models based on the information derived in this chapter.

This chapter consists of three sections. First, the terminology used is explained in the data section. Next, the rationale behind the definition of 'contraceptor' is discussed and the proportions of contraceptors by parity are analysed. Finally, a survival analysis of the length of the birth intervals is carried out. This allows us to determine the proportions of contraceptors who space and stop childbearing, as well as the impact of contraceptive use on the length of the birth intervals.

4.2 Data

This analysis is based on the second Tanzania Demographic and Health Survey (TDHS) which took place in 1996. Since Tanzania was considered as a 'low contraceptive prevalence country', the TDHS contains little information on the subject. In fact, the only relevant questions asked in the TDHS were:

- Are you currently doing something or using any method to delay or avoid pregnancy? If yes, which method are you using?
- Have you ever used anything or tried in any way to delay or avoid getting pregnant? If yes, what have you used or done?
- (For women having ever used contraception) How many living children, if any, did you have at the time you first did something or used a method to avoid getting pregnant? [7] (Bureau of Statistics and Macro International 1997)

The questions on current use of contraception cannot be used here because they refer to the last birth interval a woman has had, which is always open. So all the information is censored. It is impossible to compute the length of these intervals, and therefore to measure the difference in the length of the intervals between women using or not using contraception, and to determine the proportion of women stopping childbearing. The questions on 'ever use' and the 'number of living children at first use' can be used with caution. The first problem is that the number of living children, and not the number of children ever born was asked. As an illustration, we consider a woman who has had three children, and then the last one dies. If she says that she used contraception for the first time when she had two living children, we do not know if this was during the interval between her second and third children, or after her third child. Therefore, we

[7] A Reproductive and Child Health Survey was carried out in 1999 in Tanzania. Unfortunately, it cannot be used for the purpose of this chapter because this question about the number of living children at first use, essential for us, was not included.

will assume here that the number of children ever born was asked. This means that some women would be considered as using contraception earlier than they actually did, as shown in the above example. If this assumption has any effect, it causes us to overestimate the proportions using contraception in earlier birth intervals and to underestimate the differences between women using and not using contraception.

In order to determine if a woman is using a modern method of contraception during a birth interval, we will use the following definition. A contraceptor during a birth interval is a woman

- who has used contraception before or during the birth interval of interest;
- and who has used a modern method by the survey date.

This definition is similar to those used by Larsen (1997) and Greene (1998), except that here we restrict it to women who have ever used a modern method of contraception. The focus here is mainly on modern methods for reasons explained in the next section. Note that this analysis includes all women, and not only married women. The problems encountered when using this definition are also detailed in the next section.

The other important concept in this paper is the notion of birth interval. Only the birth intervals opened in the 15 years before the survey, i.e. for the period 1981-96, are considered to obtain recent information and to avoid problems with recalling of dates of births which happened a long time ago. Survival analysis is used so that open birth intervals (i.e. intervals where the birth closing the interval has not yet occurred or will not occur) are included. The intervals between multiple births are excluded because they do not give any insight on the difference of the length of the intervals between women using or not using contraception. Birth intervals 1-2 to 6-7 will be analysed. The samples for the higher-order intervals are too small to carry out any analysis.

4.3 Rationale behind the definition of a 'contraceptor' and proportions of contraceptors

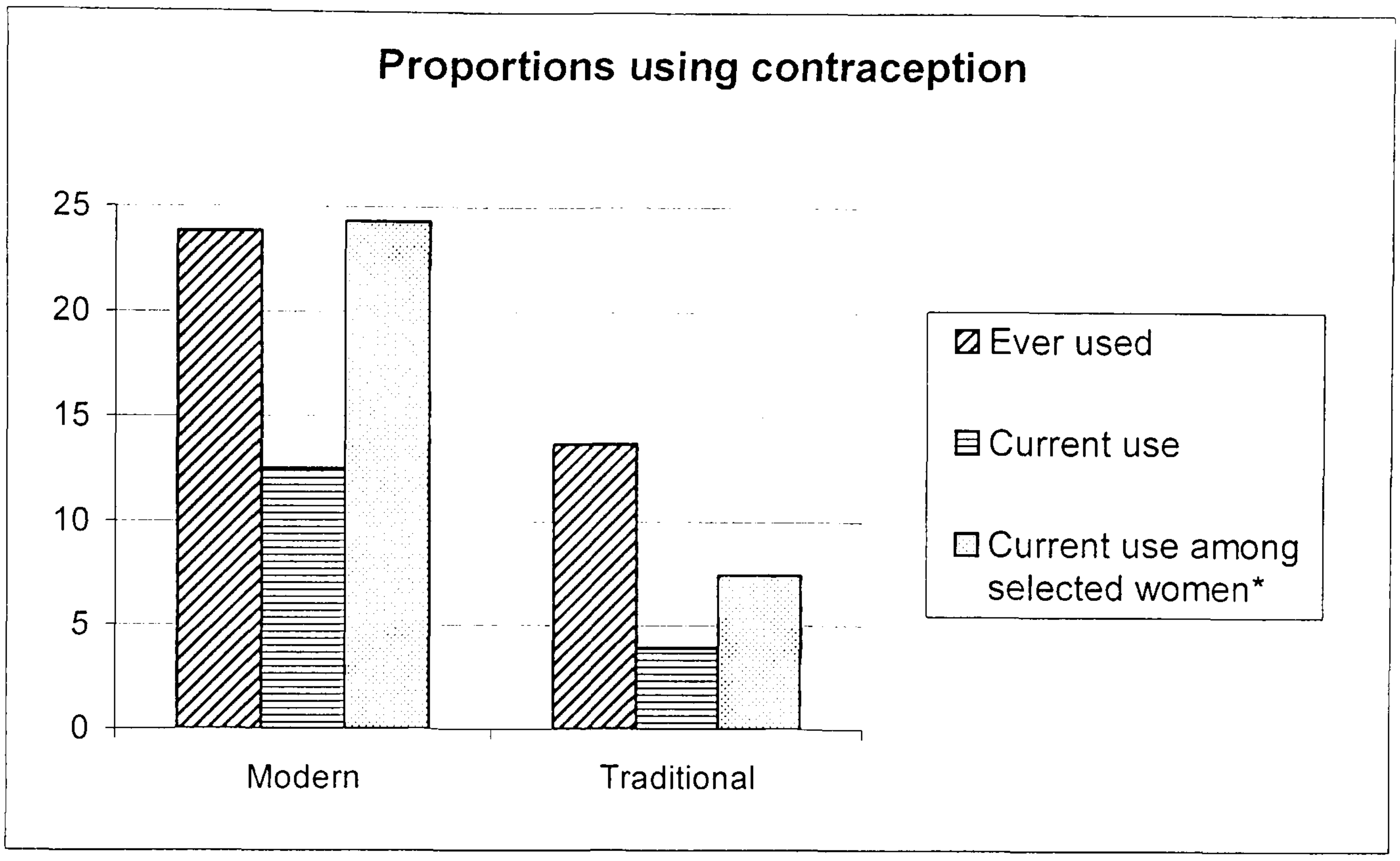
The definition of a 'contraceptor' described in the previous section is debatable. It is an approximation for women using contraception in each birth interval. However, it is the closest approximation that can be made with the available data. This section gives the rationale behind our concept of 'contraceptor' and the proportions of contraceptors in each birth interval.

A downside of the concept of 'contraceptor' is that for women who have ever used both traditional and modern methods of contraception, we do not know which type was used first. So, some women may be classified in some previous birth intervals as having used a modern method when they have not yet done so. The extent of this problem is not possible to assess with the available data.

Another issue with the definition considered is that, once a woman has used contraception in an interval, she will be classified as a contraceptor in all subsequent intervals. This means that some women who are not using contraception in a particular interval will be categorised as contraceptors. The extent of this problem can be assessed by comparing the proportions of women having ever used contraception to the proportions currently using, which would give an idea of the proportion of contraceptors who are and who are not currently using contraception.

Figure 4-2 shows that roughly half of women having ever used a modern method of contraception (23.8 per cent) are not using it at the time of the survey (12.5 per cent); this drops to about a third for traditional methods. However, the proportions currently using underestimate the use of contraception in the last, open birth interval. For example, some women have used contraception in that last, open birth interval but have stopped by the survey time in order to get pregnant; some women are pregnant and are therefore not using contraception; some women are planning to use contraception in that interval, but are still post-partum amenorrheic and therefore do not feel the need to use contraception yet. In fact, 24.3 per cent of women who are not pregnant, not post-partum amennorheic or not wanting another child soon are currently using a modern method of contraception. This proportion is in line with the 23.8 per cent of women having ever used a modern method of contraception. When analysing the Zimbabwe DHS, Greene (1998, p. 116) found that 'once a woman uses a contraceptive, she continues to contracept in subsequent intervals [...] for about 80 per cent of intervals'. She also states that users of traditional methods are less likely to use contraception consistently compared with users of modern methods (p.116-117), as found here in Figure 4-2 for the case of Tanzania. We can therefore assume that a woman who has used modern contraception in a birth interval is very likely to use it in subsequent intervals. In other words, our concept of contraceptor is fairly close to the concept of interest, i.e. women who are using contraception in each birth interval.

Figure 4-2. Proportions using contraception.



* Women who are not pregnant, not post-partum amenorrheic or not wanting another child soon.

As pointed out earlier, the focus is on modern methods of contraception. The traditional methods of contraception are withdrawal, periodic abstinence and temporary abstinence. Periodic abstinence, also called rhythm, calendar or the safe period, is abstinence from sexual intercourse during the fertile period of the woman's menstrual cycle. It is a reliable method of contraception if used correctly and should be classified as a modern method. However, in Tanzania, 62 per cent of the women having ever used periodic abstinence do not know when is the fertile period in a menstrual cycle, which makes this method likely to be very unreliable. Temporary abstinence refers to abstinence from sexual intercourse for a substantial period of time, as practised during the demographic transition in England and Wales (Szreter, 1996 pp. 367-439 and Garrett *et al.*, 2001). It is not clear whether women understand the difference between periodic abstinence and temporary abstinence; some may have said they are using periodic abstinence when they are actually abstaining for substantial periods of time.

This is supported, in the case of Tanzania, by the fact that 29 per cent of the women currently using periodic abstinence are not sexually active, i.e. had their last sexual intercourse more than a month ago or before their last birth, or do not have a regular sexual partner (Table 4-1). These women probably meant that they are using temporary abstinence rather than periodic abstinence. Moreover, only one woman states that she is currently using temporary abstinence.

Table 4-1. Percentages of current users of contraception currently breastfeeding, amenorrheic, post-partum abstaining, not sexually active and not at risk of conception.

Method	N	Breast-feeding	Amenor-rheic	Post-partum abstaining	Not sexually active *	Not at risk **
All traditional	313	52 %	26 %	3 %	26 %	43 %
Withdrawal	142	71 %	41 %	4 %	22 %	49 %
Per. abstin.	170	35 %	14 %	2 %	29 %	38 %
All modern	1018	33 %	13 %	2 %	19 %	28 %

* Last sexual intercourse more than one month ago or before the last birth; or no regular sexual partner.

** Amenorrheic, post-partum abstaining or not sexually active.

Forty three per cent of women currently using a traditional method of contraception are not at risk of conception (Table 4-1). This drops to 28 per cent for modern methods. So double protection is more prevalent among women using traditional methods than modern ones. A large proportion of women may use traditional methods of contraception for purposes other than to avoid a pregnancy. For example, 71 per cent of women currently using withdrawal are still breastfeeding. The tendency to combine withdrawal and breastfeeding, or to use withdrawal during breastfeeding may be partly in response to cultural beliefs such as the 'poisoning' of a woman's milk by sperm (Gregson, 1994 p. 671 and Håkansson, 1992 p. 63). Since it is not clear whether traditional methods of contraception are used for avoiding a pregnancy, they will not be taken into account below.

Table 4-2 shows the proportions of contraceptors by birth interval. The proportion of contraceptors, i.e. women who have used contraception before or during the interval of interest and who have used a modern method of contraception by the survey date, rises from 18 to 27 per cent from birth interval 1-2 to birth interval 3-4, and then drops to 22 per cent for the interval 6-7. This peak at the interval 3-4 is due to a selection effect among women with high parities: to reach higher parities by the survey date, they had to have relatively short birth intervals and therefore did probably not use contraception. The proportions of contraceptors are higher than the contraceptive prevalence rate (CPR) of 11.7 per cent for all women and 13.3 per cent among married women (Bureau of Statistics and Macro International, 1997): the former refers to use at any time during the birth interval whereas the latter refers to use at the exact survey time, when some women may not need contraception even if they have used it earlier in the same interval or will use it later. The CPR may not be the best indicator of contraceptive use because the exposure includes many women who are not at risk of getting pregnant (because they are already pregnant or in the period of postpartum infecundability) and who therefore have no reason to use contraception at the time of survey. On the other side, the proportions of contraceptors give some insight on the number of women who are using contraception or who have already used it and so who know how and where to get it if they wish to use it again.

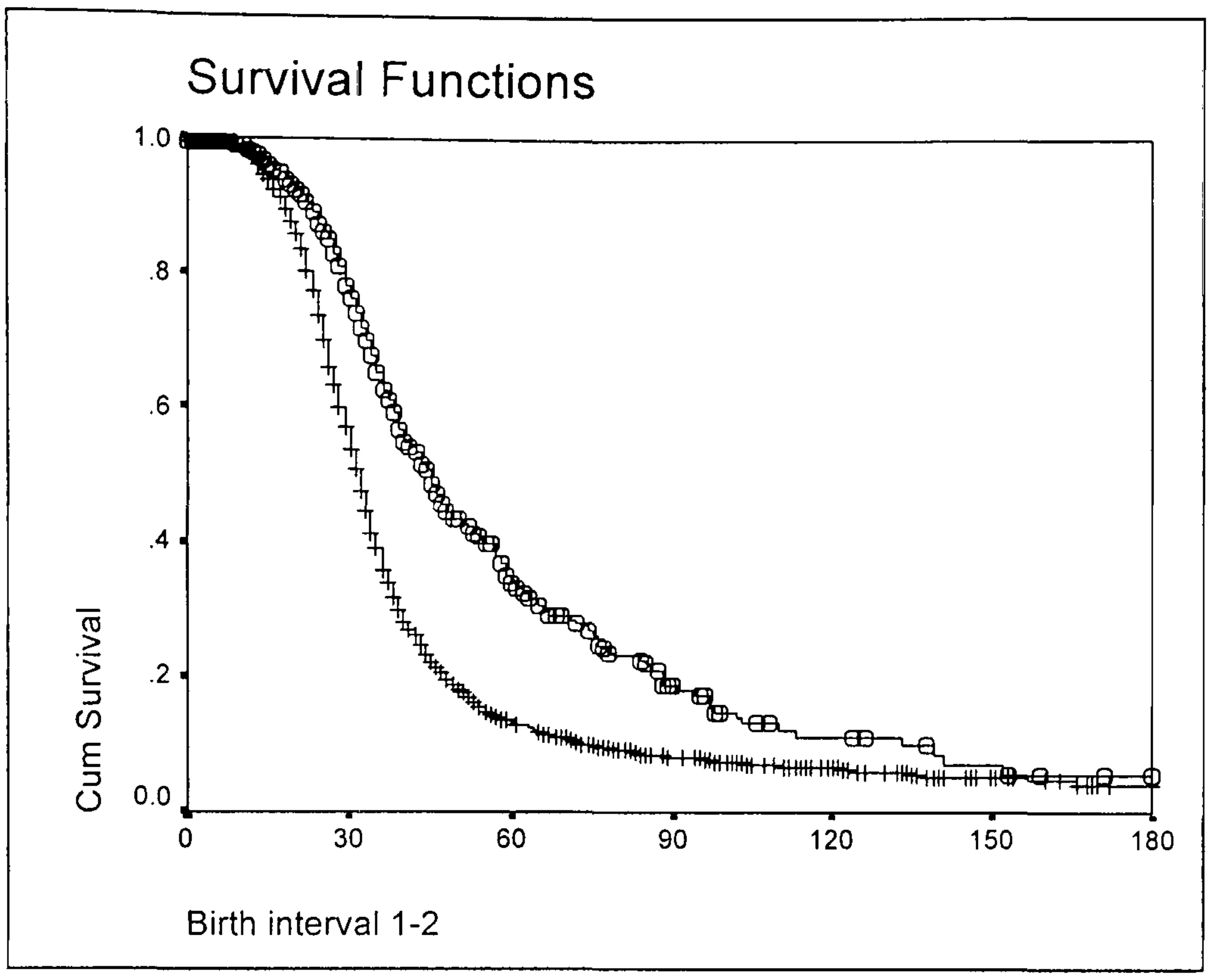
Table 4-2. Proportions of contraceptors by birth interval.

Birth interval	Proportion of contraceptors
1-2	16 %
2-3	22 %
3-4	25 %
4-5	24 %
5-6	22 %
6-7	20 %

4.4 Survival analysis of the birth intervals

Figures 4-3 to 4-8 display the survival curves of the length of the birth intervals 1-2 to 6-7 for both groups of contraceptors and non-contraceptors. For all intervals, it is clear that contraceptors lengthen their birth intervals with respect to non-contraceptors.

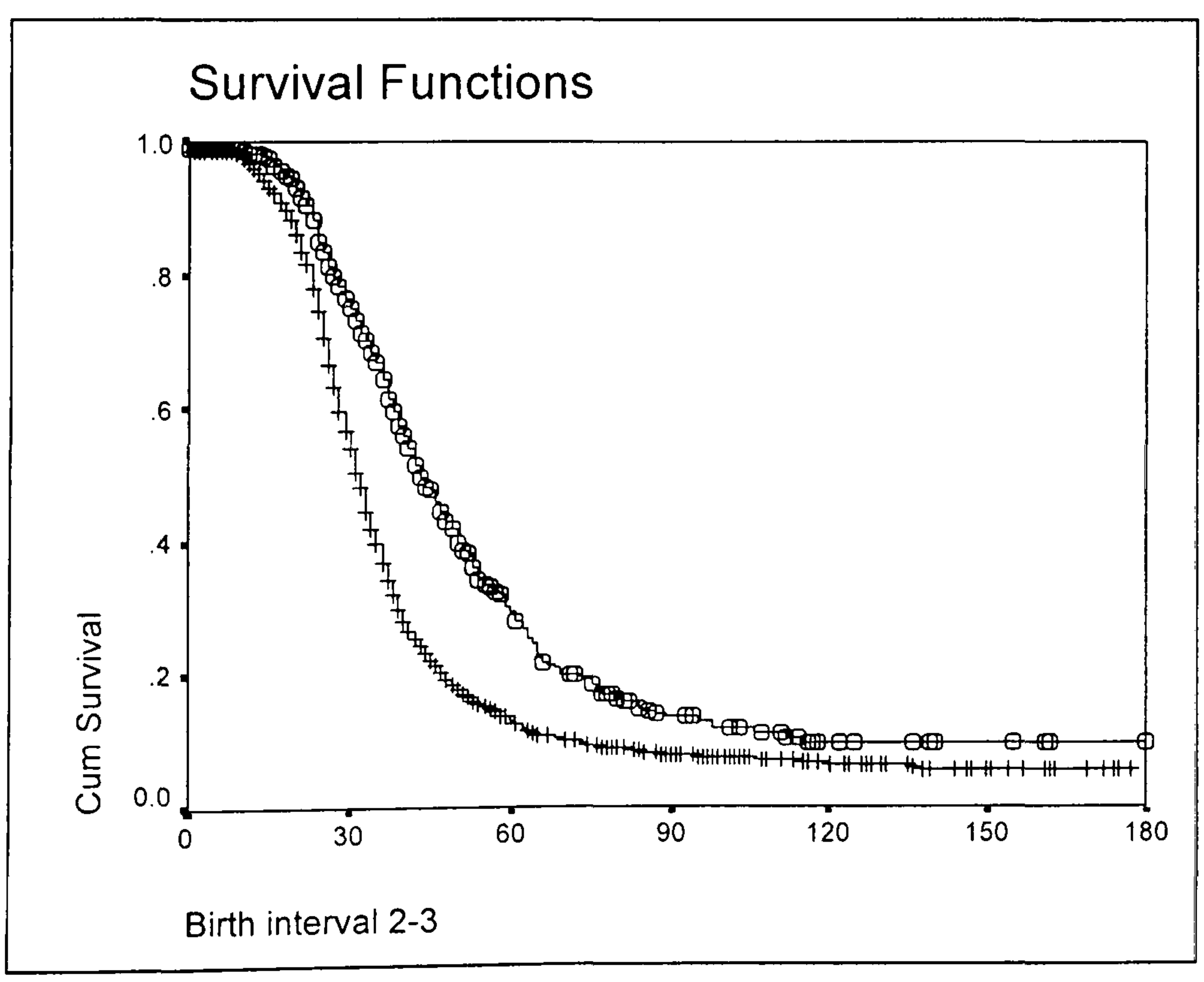
Figure 4-3. Survival curves of the length of the birth interval 1-2 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 1-2)

+ : non-contraceptors (during the birth interval 1-2)

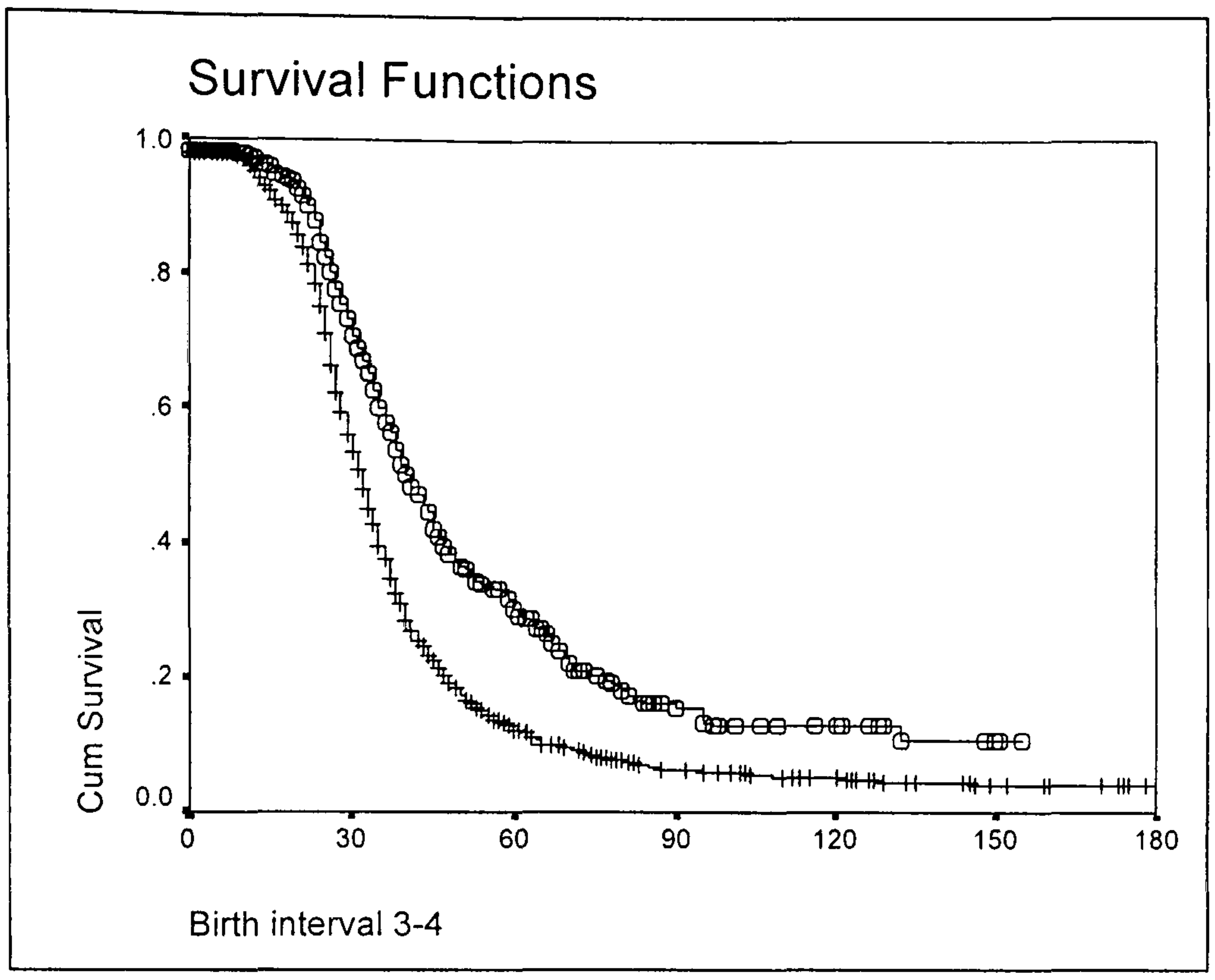
Figure 4-4. Survival curves of the length of the birth interval 2-3 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 2-3)

+ : non-contraceptors (during the birth interval 2-3)

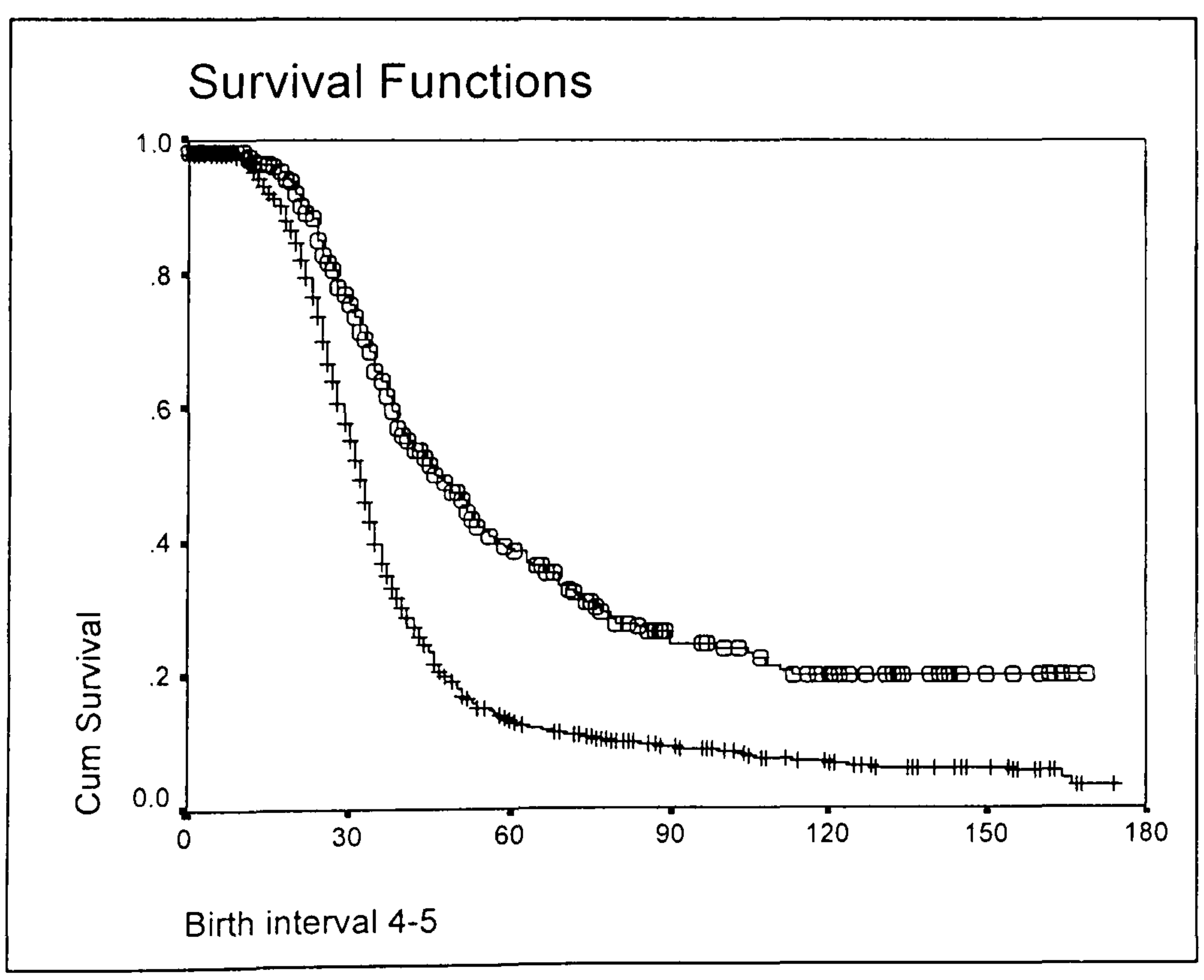
Figure 4-5. Survival curves of the length of the birth interval 3-4 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 3-4)

+ : non-contraceptors (during the birth interval 3-4)

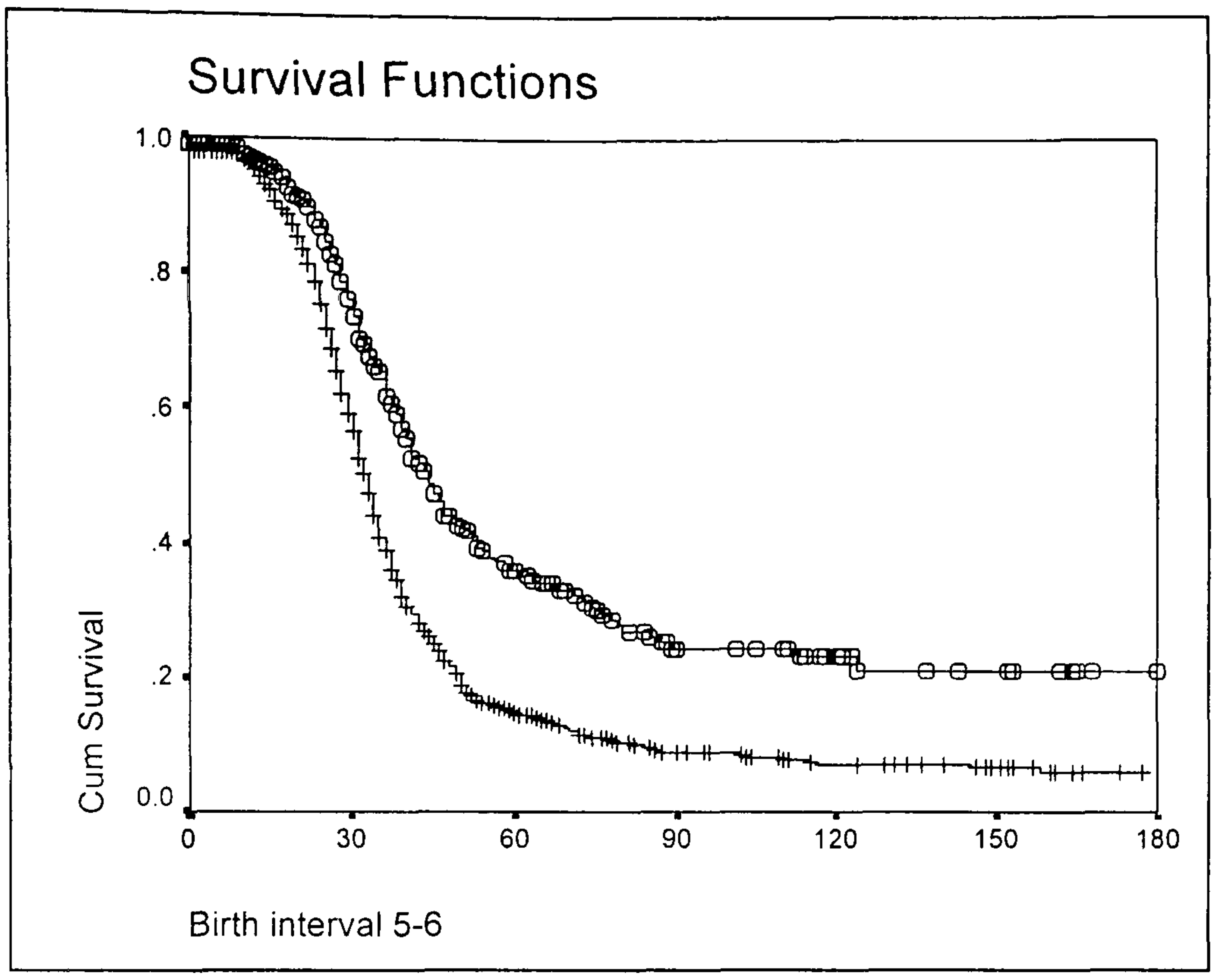
Figure 4-6. Survival curves of the length of the birth interval 4-5 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 4-5)

+ : non-contraceptors (during the birth interval 4-5)

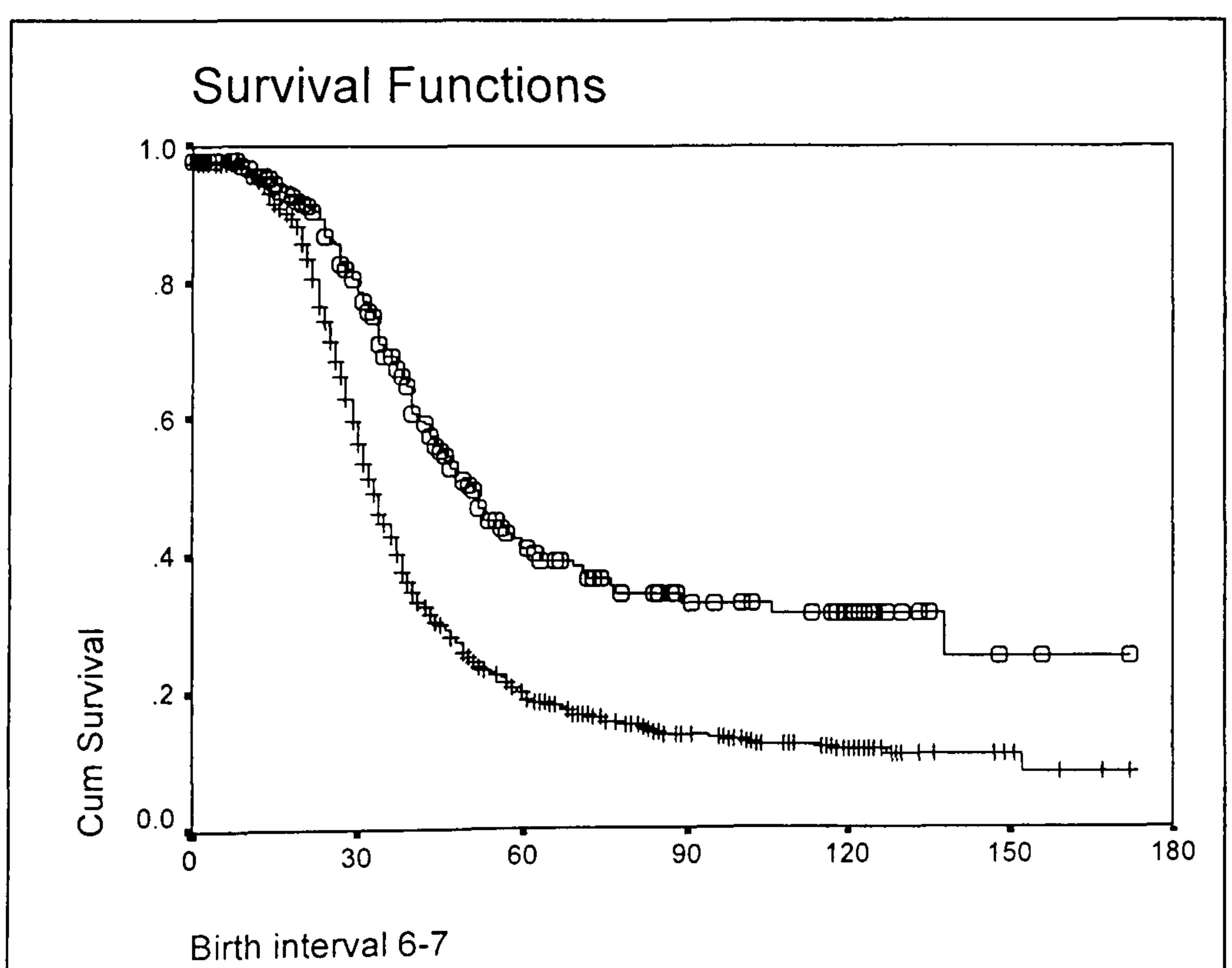
Figure 4-7. Survival curves of the length of the birth interval 5-6 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 5-6)

+ : non-contraceptors (during the birth interval 5-6)

Figure 4-8. Survival curves of the length of the birth interval 6-7 (in months) for contraceptors and non-contraceptors



o : contraceptors (during the birth interval 6-7)

+ : non-contraceptors (during the birth interval 6-7)

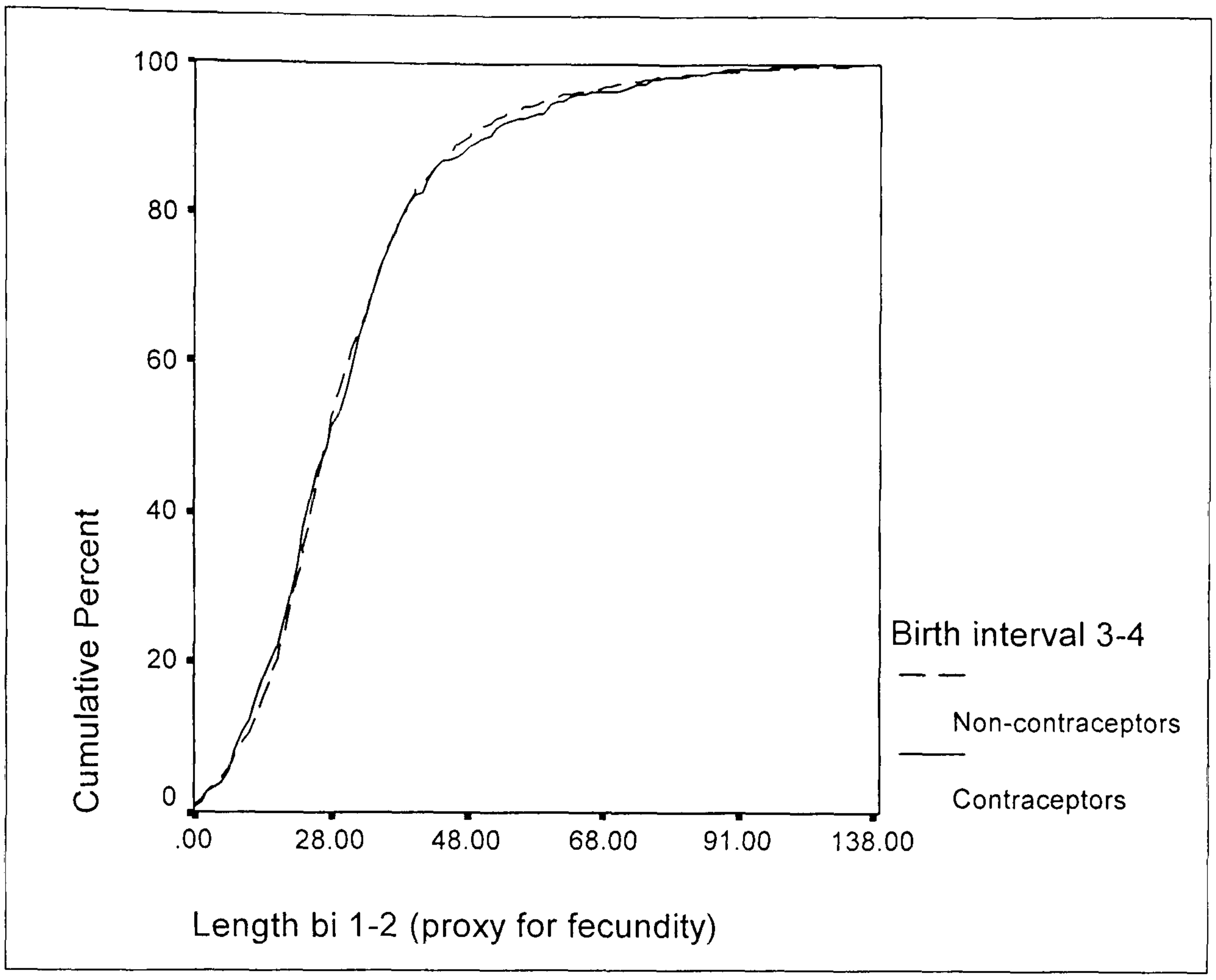
Looking at the survival curves for the intervals 1-2 and 2-3, about five per cent of women, contraceptors or not, do not go on to have another birth after ten years. The non-contracepting women who do not go on to have another birth after ten years are defined as becoming sterile in the interval. Maller and Zhou (1996) have shown that this estimator is asymptotically unbiased and consistent for the proportion of immunes (sterile women in our case) in the population.

Similarly, for the interval 3-4 (Figure 4-5) among non-contraceptors, about five per cent do not go on to have a fourth child after ten years. However, more contraceptors than non-contraceptors (12 against five per cent) do not go on to have another child. This can be a genuine difference, or due to a selection bias.

There could be a selection bias in both the length of the birth intervals and the proportion sterile if contraceptors were more fecund than non-contraceptors. In that case, the impact of contraception on the birth interval lengths would be underestimated as contraceptors would take less time to conceive once not using contraception any more compared with non-contraceptors. However, this has been checked in the following manner. If we only consider women having not used contraception before their second birth, the length of the second birth interval (i.e. between the first and second births) can be used as a proxy for the level of fecundity of a woman. As shown on Figure 4-9, there is no significant difference in the distribution of the length of the second birth interval between women contracepting or not in the birth interval 3-4. The results for women contracepting in the other intervals (2-3, 4-5, 5-6 and 6-7) are similar. We can therefore conclude that contraceptors are not more fecund than non-contraceptors, and therefore the level of fecundity does not bias our results.

There could also be a selection bias in both the length of the birth intervals and the proportion sterile if contraceptors were older than non-contraceptors. In that case, the impact of contraception on the birth interval lengths and the proportions sterile would be overestimated as contraceptors would take more time to conceive once not using contraception any more compared with non-contraceptors. For example, among women who have reached parity four, women who have used contraception from their first birth have on average their fourth birth 24 months later than women who have never used contraception (28.3 versus 26.3 years old). This bias has been checked by a Cox regression of the length of the birth intervals controlling first for the use or not of contraception, and then for use of contraception and age at the birth opening the

Figure 4-9. Length of the second birth interval depending on contraception status in birth interval 3-4.



interval. A Cox regression is appropriate in this case since the survival curves for contraceptors and non-contraceptors are proportional as seen on Figures 4-3 to 4-8. When comparing the survival experiences of contraceptors and non-contraceptors, age at the opening birth slightly reduces the impact of contraception on the hazard as would be expected *a priori* (see Table 4-3). There is therefore a small selection effect. However, it is small and statistically insignificant. Therefore, the fact that contraceptors are slightly older at the beginning of the interval compared with non-contraceptors does not significantly bias the results.

Table 4-3. β coefficients for the covariate 'use of contraception' in two Cox regression models, one controlling only for use of contraception and the other for use of contraception and age.

Birth interval	Only use of contraception		Contraception and age at opening birth	
	Exp (β)	95 % C.I.	Exp (β)	95 % C.I.
1-2	1.945	[1.755, 2.155]	1.935	[1.746, 2.145]
2-3	1.731	[1.574, 1.903]	1.692	[1.539, 1.861]
3-4	1.674	[1.572, 1.854]	1.623	[1.466, 1.798]
4-5	2.011	[1.788, 2.263]	1.940	[1.724, 2.183]
5-6	1.783	[1.558, 2.041]	1.705	[1.489, 1.953]
6-7	1.950	[1.641, 2.318]	1.910	[1.607, 2.270]

The difference in the proportion sterile between contraceptors and non-contraceptors in the birth interval 3-4 can therefore be explained in three different ways:

A. More contraceptors than non-contraceptors become sterile after the birth of their third child. This may be the case

- If HIV-positive women are both more likely to use contraception and more likely to become sterile. However, HIV-positive women are mainly using condoms as method of contraception and the survival curves have been re-estimated excluding condom users and the results remained the same (see below).
- If contraceptors are more likely to have extra-marital sex, which carries higher risk of STDs and therefore of becoming sterile. Among women in a stable union, five per cent of women having never used any method of contraception have had extra-marital sex in the three years before the survey, against eight per cent of women having used a modern method of contraception. These rates have to be taken with caution since women's reports of extra-marital sex are questionable. However, they show that contraceptors are more likely to have extra-marital sex, but the difference is small and only a minority of women is involved here.

B. The proportion becoming sterile among contraceptors is the same as that among non-contraceptors but some contraceptors stop childbearing after the birth of their third child. So, of the 12 per cent of contraceptors who do not go on to have a fourth birth, five per cent become sterile and seven per cent are stopping childbearing.

C. None of the contraceptors become sterile and 12 per cent of the contraceptors are stopping childbearing. This is a possible explanation since a woman who knows she is less fecund will probably not use contraception. However, only 1.3 per cent of the whole sample declared themselves as subfecund or infecund, which means that only very few women know they are sterile.

Therefore, explanation B is thought to be the most likely and we estimate that around seven per cent of contraceptors are stopping childbearing after their third birth, or 1.8 per cent of all women (7 per cent of the 25 per cent who are contraceptors in the interval). Similar reasoning can be used for the following birth intervals. The proportions of contraceptors who are stopping childbearing at different parities are presented in Table 4-4. The proportions are increasing with parity. For the interval between the sixth and the seventh births, 18 per cent of contraceptors are stopping childbearing, or 3.6 per cent of all women. Therefore a substantial proportion of

Table 4-4. Proportions of contraceptors who have decided to stop childbearing and proportions of women currently using modern contraception who do not want any more children by birth interval.

Birth interval	Proportion of contraceptors who stop	Prop. currently using who want no more
1-2	4 %	13 %
2-3	3 %	26 %
3-4	6 %	34 %
4-5	13 %	50 %
5-6	15 %	60 %
6-7	18 %	73 %

contraceptors are stopping childbearing. However this represents only a small proportion of all women.

Table 4-4 also shows the proportions of women currently using a modern method of contraception and who do not want any more children. The proportions have been computed from the fertility preference question in the 1996 TDHS. For all intervals, the proportions of women who are currently using contraception to stop childbearing are higher than the proportions of contraceptors who are stopping childbearing. The reasons are:

- Sterile women are excluded from the proportions of contraceptors who stop, but are included in the proportions currently using who want no more children. If we include sterile women with the former proportions, the proportions of contraceptors who are sterile or who stop are: 11, 10, 12, 20, 22 and 29 per cent respectively for the intervals 1-2 to 6-7. These figures are closer to the proportions currently using who want no more children. Therefore, the exclusion of sterile women on one side accounts for a part of the difference;
- Some women who want to stop childbearing may experience a contraceptive failure and so will in fact be spacing their births. In that way, our method measures 'successful' stoppers;
- Some women currently using may change their minds and decide to have another child later;
- Some of the contraceptors do not use contraception in the interval of interest. They will not stop childbearing in that interval, unless they become sterile, and are thus considered as spacing 'by default'. So they inflate the number spacing among contraceptors;
- There has been a change in fertility preferences over time: more women wanted to stop childbearing in 1996 than in the period 1981-96 since the proportion wanting to stop refers to 1996 and the proportion of contraceptors stopping refers to the period 1981-96 (this would explain the difference, if any, once the biases described above are accounted for).

Table 4-5 summarises the proportions computed so far for each birth interval up to the progression to the seventh birth. The proportions becoming sterile or reaching menopause are read from the survival curves. The proportions of women having their next child without contraception are the proportions of non-sterile non-contraceptors. The proportions of women having their next child after spacing are the proportions having another child among contraceptors. The proportions stopping are the proportions stopping among contraceptors, derived from Tables 4-2 and 4-4. These proportions are used in the next chapter as inputs for the simulation models and will be explained in more detail then.

Table 4-5. Proportions of women having their next child without using contraception; spacing; stopping; and becoming sterile or reaching menopause.

Birth interval	Having next child without contraception	Having next child after spacing	Stopping	Becoming sterile or reaching menopause
1-2	78 %	15 %	1 %	6 %
2-3	72 %	21 %	1 %	6 %
3-4	70 %	23 %	2 %	5 %
4-5	70 %	21 %	3 %	6 %
5-6	71 %	19 %	3 %	7 %
6-7	69 %	16 %	4 %	11 %

The survival analysis allows also to determine the distribution of the length of the birth intervals for contraceptors and for non-contraceptors. The focus here is on women who will go on to have another birth. So, for non-contraceptors, the median length of each birth interval is computed excluding women who do not go on to have another birth after ten years (i.e. excluding the women who become sterile during the interval). This procedure is similar to the one used to determine the median age at marriage: women who will never marry are not taken into account. Similarly, for contraceptors, the median is computed excluding women who become sterile and who stop childbearing during the interval. These non-sterile women who are using contraception and who are not stopping childbearing are spacing their births and so are called 'spacers'.

Among women who will close the birth interval, the median lengths of the intervals are around 32 months for non-contraceptors and around 43 months for spacers (Table 4-6). So, among the women who will go on to have another birth, contraceptors lengthen their intervals by nine to 18 months with respect to non-contraceptors, i.e. by 28 to 55 per cent. As already noted, the difference between contraceptors and non-contraceptors may be underestimated because of the way contraceptors are defined.

Table 4-6. Median length of the birth intervals for women who close the interval within ten years.

Birth interval	Median interval for non-sterile, non-contracepting women (in months)	Median interval for spacers (in months)
1-2	32	45
2-3	32	43
3-4	32	41
4-5	32	47
5-6	33	44
6-7	33	51

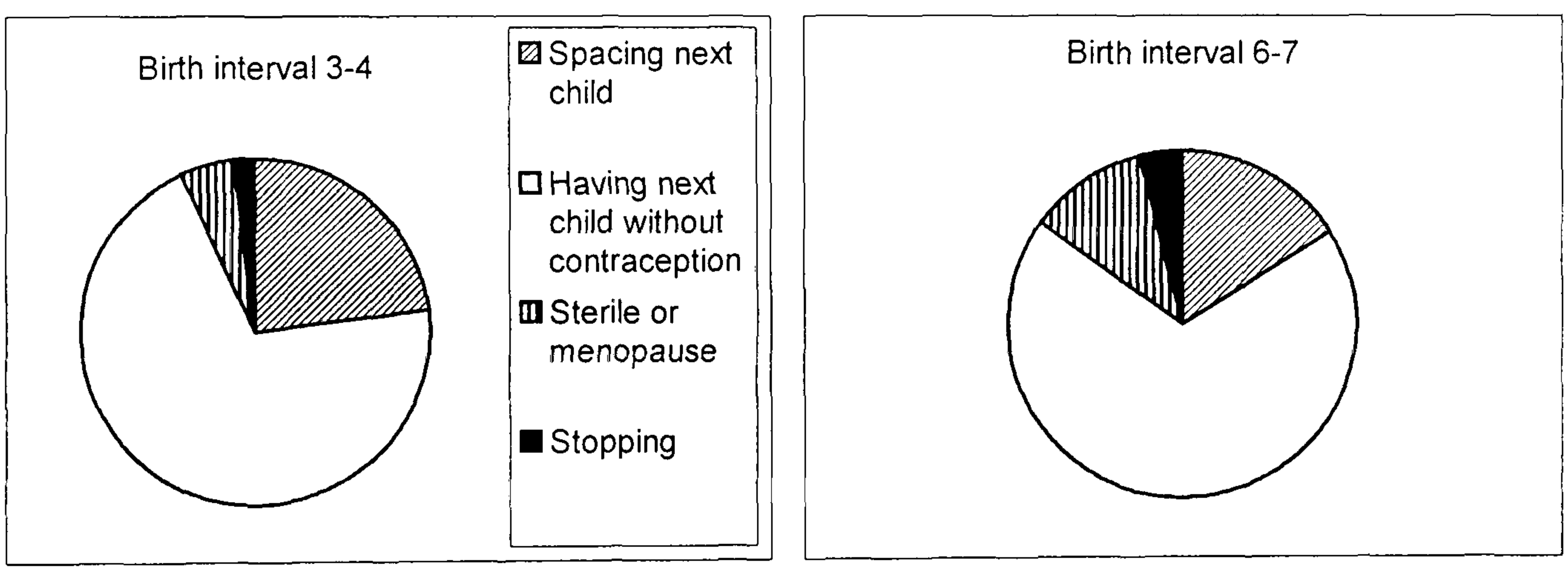
The HIV/AIDS epidemic may also have an effect on the result, because HIV-positive women may be more likely to use condoms and their fertility is lower. This would lead to an overestimate of the difference in the length of the birth intervals between contraceptors and non-contraceptors. However, the analysis has also been carried out excluding women who have ever used condoms and the results remained unchanged. The Kaplan-Meier survival curves show the same features, the lower and upper bounds of the proportions of contraceptors who stop are within 3 percentage points of the ones including condom users, and the median lengths of the birth intervals for women who will progress to the next birth are within two months of those obtained when including condom users (except for the interval 6-7, where the sample is small). Therefore, the effect of HIV/AIDS on our results is likely to be small.

4.5 Conclusions

This analysis rests on the definition of a 'contraceptor'. A contraceptor in a birth interval is a woman who has used contraception for the first time before or during the birth interval of interest and who has used a modern method by the survey date. This definition is debatable and probably leads to an underestimate of the proportion of women contracepting. However, it is the closest approximation to 'women using contraception' possible with the available data. The potential problems with this definition have been reviewed in detail earlier.

In each birth interval, the proportions of women using contraception who space and stop childbearing are computed, as summarised in Table 4-4 and pictured in Figure 4-10 for the birth intervals 3-4 and 6-7. Women who are using contraception mainly space their births. Only very small proportions are stopping childbearing, even at high parities: only four per cent of women are stopping childbearing after six births.

Figure 4-10. Proportions spacing, having the next child without using contraception, stopping and becoming sterile or reaching menopause for the intervals 3-4 and 6-7.



Women using contraception who space their births do so efficiently: they lengthen their birth intervals by around 12 months with respect to non-sterile non-contracepting women. The median length of the intervals is around 32 months for the latter and 43 months for the former. Larsen (1997) analysed the 1991-92 Tanzania Demographic and Health Survey (TDHS) and found that contraceptors took longer to conceive: the median birth interval was 21 months for women who had never used contraception, and 31 months for contraceptors. The results shown here present the same trends as Larsen's; however the length of the intervals are different because of different definitions (Larsen includes all methods of contraception and we include only modern ones) and surveys (TDHS 1991-92 for Larsen and TDHS 1996 here).

The impact of this pattern of contraceptive use on the Tanzanian fertility is examined in the next chapter. In particular, are the contraceptive prevalence rates for stopping and spacing childbearing large enough to affect significantly the country's fertility? Does a lengthening of the birth intervals of 12 months reduce significantly a woman's lifetime fertility? These are important issues addressed in the next chapter so that family planning policies can promote the most efficient pattern of contraceptive use.

Chapter 5

The impact of spacing and stopping on Tanzanian fertility

Abstract

This chapter estimates the effect of spacing and stopping on the fertility of Tanzanian women. Simulation models of women's reproductive life, focusing on contraception, are designed and calibrated using data from the 1996 Tanzania Demographic and Health Survey for the period 1986-96. The mean number of children ever born (CEB) is estimated at 5.93, which is in line with the total fertility rates given for the same period. Some projections are then run in order to estimate the impact of spacing on fertility. It is found that spacing as practiced now in Tanzania has little impact on the fertility rates whereas stopping has a large impact. This challenges the concept of a fertility transition led by spacing in Africa. The most effective way to reduce fertility in the Tanzanian population is to increase the proportion of women stopping childbearing; or alternatively an increase in both the proportions practising birth spacing and the lengths of the birth intervals among spacers will achieve a reduction.

5.1 Introduction

The impact of contraceptive use on the length of the birth intervals in Tanzania has been analysed in the previous chapter. The intervals for contraceptors, defined as a woman who has used contraception before or during the birth interval of interest and who has used a modern method by the survey date, are around 43 months, compared to 32 months for non-contraceptors. The proportion of women using contraception who space and stop childbearing; the proportion having another child without the use of contraception; and the proportion becoming sterile or reaching menopause after each parity are also computed in the previous chapter. In light of these results, an important question arises, which is addressed in this chapter: how much does the use of contraception to space births impact the fertility levels in Tanzania?

The aim of this chapter is to estimate the effect of spacing on the fertility rates in Tanzania, using simulation models. Two models of women's reproductive life with different hypotheses are designed: one assuming that spells of contraceptive use in different birth intervals are independent, the other assuming that the decision to use contraception is irreversible. The models are then explained and their limitations are discussed. The models are then calibrated using the results from the 1996 TDHS derived in Chapter 4. The TFRs resulting from the models are close to the TFR derived from the 1996 TDHS. Then, different projections are made by varying the levels of contraceptive use and the lengths of the birth intervals. Comparing the results allows the determination of the impact of a change in contraceptive use on fertility levels.

5.2 Data

This chapter is based on information drawn from the second Tanzania Demographic and Health Survey (TDHS) which took place in 1996. Since Tanzania was considered a 'low contraceptive prevalence country', the TDHS contains little information on the subject. In Chapter 4, we discussed in detail the drawbacks of the limited information to hand when working on contraception and introduce the definition of a 'contraceptor' to make best use of the data available. A contraceptor during a birth interval is a woman who has:

- used contraception before or during the birth interval of interest;
- and used a modern method by the survey date.

The limitations of this definition are explained in length in Chapter 4. The main problem is that once a woman has used contraception in an interval, she will be classified as a contraceptor in all subsequent intervals even if she is not using contraception in a particular interval. However it seems reasonable that a woman who has ever used contraception is more likely to use it subsequently than a woman who has never used it.

The most popular methods of contraception in Tanzania are pills, condoms, injections, withdrawal and periodic abstinence. Double protection is very high (43 per cent) among women using traditional methods of contraception, which means that the reasons for using traditional methods may not be for limiting fertility. So the focus will mainly be on modern methods of contraception here, and the definition of contraceptor does include the condition of having used a modern method.

The other important notion underlying this chapter is the one of birth interval. Only the birth intervals opened in the 15 years before the survey, i.e. for the period 1981-96, are considered, in order to obtain recent and reliable information.

5.3 Methodology

Barrett (1972) developed a Monte Carlo simulation of the reproductive process to determine the effect on the fertility rates of the introduction of a family planning programme (focusing on stopping childbearing) in a population. Similar discrete-event simulation models will be used here (see Banks *et al.* 1999 for a general overview of discrete-event simulation models). We will model women's reproductive life focusing on contraception. As each woman proceeds through her life, the occurrence and timing of events are determined by a random draw from an appropriate distribution imputed from the TDHS (e.g. proportions of contraceptors and women becoming sterile, lengths of the birth intervals for contraceptors and non-contraceptors). The model will then mimic the reproductive life of Tanzanian women at the time of the TDHS. By changing the distributions (e.g. increasing the proportions spacing or the length of the spacers' intervals), analytic projections are designed. Bongaarts and Greenhalgh (1985) did a similar exercise of projections to develop an alternative to the 'one-child' policy in China. The models designed here are simple; however, they show what levels of contraceptive use are needed to make an impact on the fertility rates.

The aim of the modelling is to determine the mean number of children ever born (CEB) to women under different contraceptive use assumptions. Therefore, the events of interest in a woman's reproductive life are the live births. Foetal deaths and still births are not taken into account *per se*. A foetal death or still birth that occurs between two live births leads to a lengthening of the birth interval. That lengthening of the birth interval is a natural phenomenon that we take into account since foetal deaths and still births are included in the birth intervals derived in Chapter 4. If no live birth occurs after a foetal death or a still birth, the impossibility for a woman to carry a pregnancy to term and to have a live birth can be considered as a form of sterility.

The two main advantages of simulation models in this case are as follows. First, they allow the creation of as many reproductive lives as desired. These reproductive lives are not truncated, contrary to the TDHS histories (since the survey was retrospective). The women are given characteristics like those of Tanzanian women in the ten years before the 1996 TDHS, and therefore give a snapshot of the period 1986-96, which can be better compared to the total fertility rate (TFR) calculated from the TDHS and which gives more up-to-date information. Second, simulation models allow the probability of the events to be altered (e.g. increasing the proportions spacing or lengthening the birth intervals) and projections to be made.

Two models have been designed here. The first one assumes that the use of contraception in an interval is independent of its use in another interval. This is in contradiction to our definition of a contraceptor since once a woman has been classified as a contraceptor, she remains so for the rest of her life whereas the model assumes that the use of contraception in an interval does not have any impact on the use in subsequent intervals. However, it is a simple first model. The second model assumes that the decision to use contraception to space births is irreversible, i.e. once a woman has used contraception to space her births, she will use contraception in all subsequent intervals. Since the first model assumes independence between intervals and the second predetermination, the 'reality' is somewhere between the two.

5.3.1 Model 1: Spells of contraceptive use in different intervals are independent

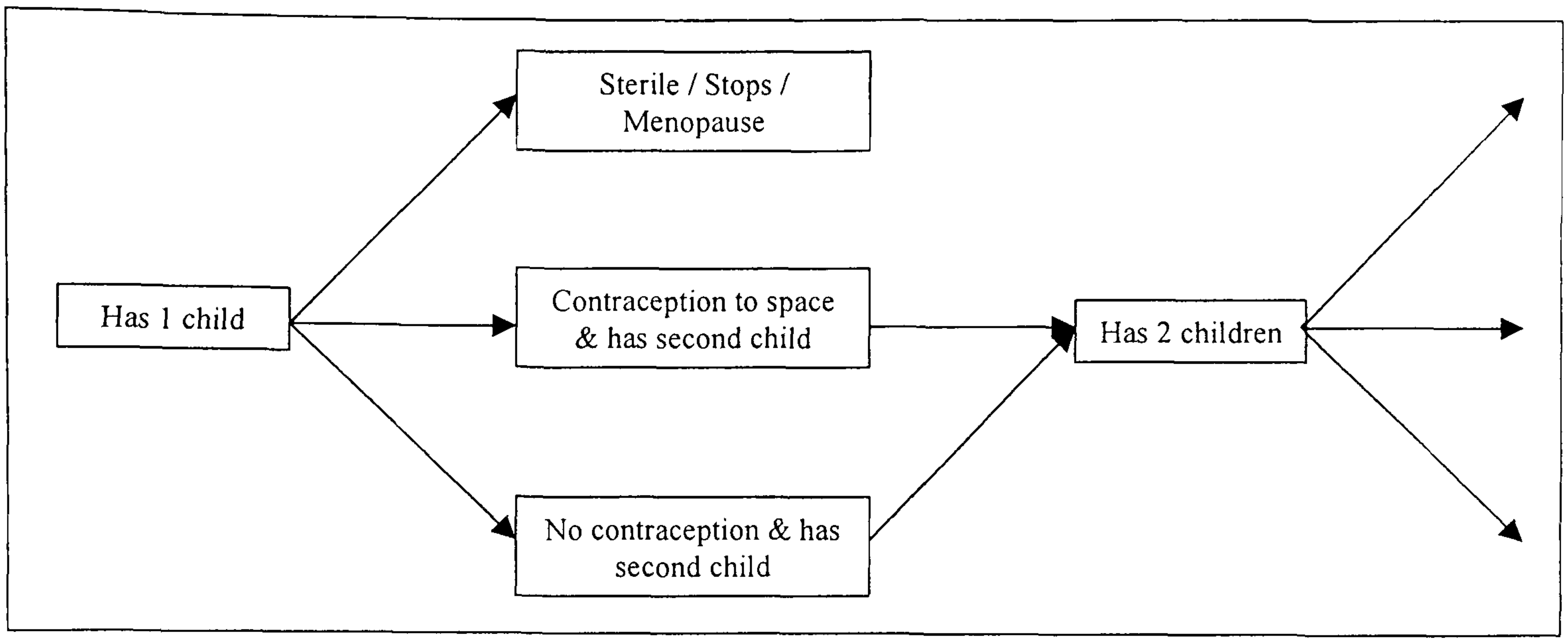
This section describes how the first model is constructed. We begin by discussing and explaining the model of the second birth interval, i.e. following the first birth. The subsequent intervals are constructed on the same model. The first interval, i.e. the interval preceding the first birth, is then explained. Next, the whole model is described. Finally the inputs and output for the model are described.

Figure 5-1 shows the second birth interval, as decomposed in this model. Once a woman has had her first child, she can follow one of three paths, each path having a different probability of happening:

- She becomes sterile, successfully uses contraception to stop childbearing (e.g. by being sterilised or starting a long course of injections), or reaches menopause. This path leads directly to the end of her reproductive life.
- She uses contraception to space her next birth. The length of the interval between her first two births is as explained below.
- She does not use any contraception and has her second child after a specific interval defined as below.

The following intervals are constructed in the same way as the second birth interval. After each birth, some women end their reproductive life. However, some will carry on having children unless we introduce an end point to their reproductive life. We therefore assume that the reproductive life, starting with a woman's first birth and ending at their last birth, lasts on average 25 years for women who do not become sterile or stop childbearing before. To allow for some variation between women, the length of a woman's reproductive life is assumed to follow a normal distribution with a mean of 25 years (300 months) and standard deviation of 75 months. Since the median age at first birth in 1996 in Tanzania was 18 years old, menopause is assumed to occur

Figure 5-1. Diagram picturing the second birth interval in Model 1

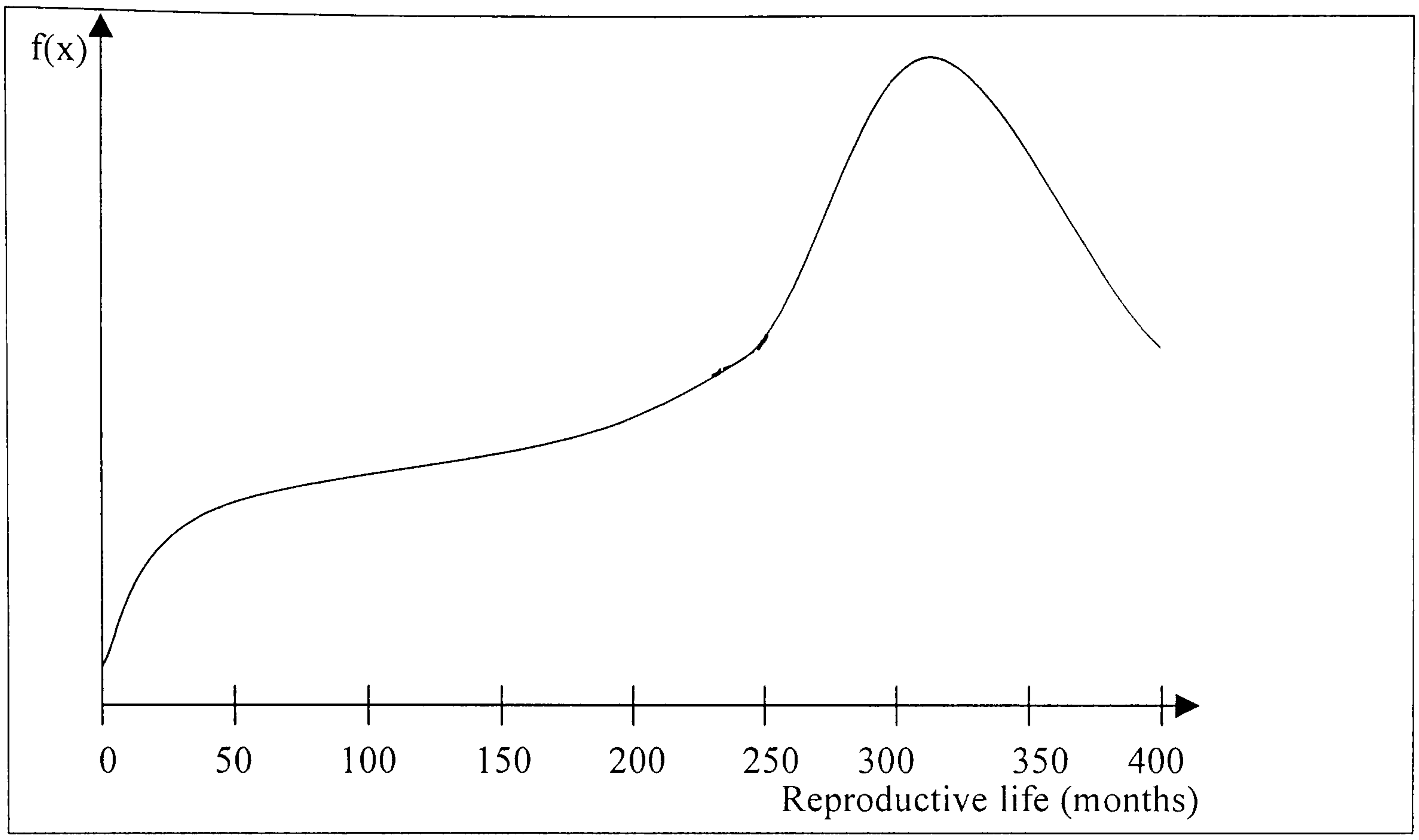


around 43 years old. It is the length of the reproductive life rather than the age at the beginning and end which is relevant here. Since the variables 'becoming sterile', 'stopping', 'using contraception' and 'not using' do not depend directly on age but rather on parity, the exact age at which events occur is not taken into account in the model. However it is important to limit the length of the reproductive life so that all women eventually stop childbearing. Figure 5-2 outlines the shape of the distribution of the length of the reproductive life, considering the levels of primary and secondary sterility found in Tanzania and the normal distribution described earlier for women who do not become sterile before menopause. For the first 20 years (240 months), secondary sterility is the main factor in ending a woman's reproductive life. Thereafter, menopause starts to have a significant impact as can be seen from the shape of the curve on Figure 5-2 at duration longer than 240 months.

Before 'creating' a woman's next child, the model checks how far in her reproductive life the woman is by adding the lengths of the birth intervals already created. If the sum of the lengths is larger than the length of reproductive life set in the model, the woman is routed to the end of her reproductive life. The model is constructed in the simulation package SIMUL8 (Version 5, Visual Thinking International, 1993-99) as shown in Appendix F.

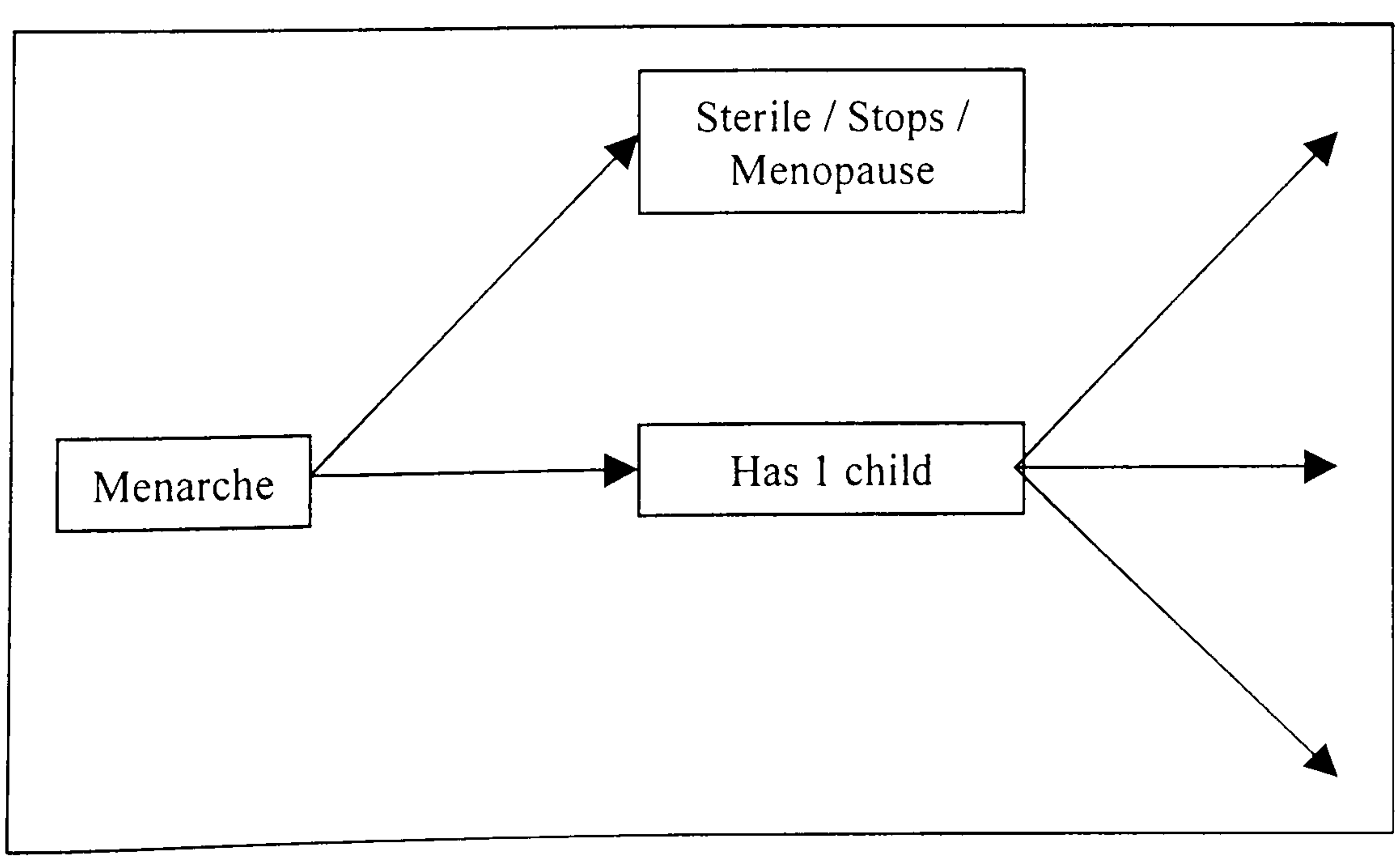
The first birth interval, i.e. the interval before the first birth, is pictured in Figure 5-3. It is very simplified in the model: the interval between menarche and first birth (or end of

Figure 5-2. Distribution of the length of the reproductive life



reproductive life for childless women) includes many variables like marriage, age at first sexual intercourse, etc. Including all these parameters would considerably complicate the model without making it necessarily more accurate for the aim of this chapter. The aim of this chapter is to estimate the effect of spacing on fertility and not the mechanisms behind the onset of childbearing. Therefore the first birth interval is included only to take into account the two per cent of childless women. We will consider here that a woman's reproductive life starts when giving birth to her first child.

Figure 5-3. Diagram picturing the first birth interval in Model 1



From Figures 5-1 and 5-3, it is straightforward to construct the whole model since the following birth intervals are built in the same way as the second one until all women reach the end of their reproductive life. Since the mean reproductive life of women who do not become prematurely sterile has been set at 25 years, in practice few women will have more than ten children: the shortest median intervals defined are around 30 months and ten intervals of 30 months amount to 300 months, or 25 years. Therefore we will repeat ten times the pattern in Figure 5-1.

The inputs for the model are as follows:

- Proportion of childless women, set at two per cent (as observed in the 1996 TDHS).
- The length of the reproductive life, normally distributed with mean 300 months and standard deviation 25 per cent of the mean (i.e. 75)[8].
- Proportions of women following each of the three paths after each birth.
- Lengths of the birth intervals for women spacing and women not using any contraception, for each interval. These will follow beta distributions with parameters defined to fit closely the empirical distributions of the length of the birth intervals estimated from the 1996 TDHS using survival analysis (see Chapter 4 for the empirical distributions).

The output will be the number of children ever born (CEB) of each woman 'created' by the model.

5.3.2 Model 2. The decision to use contraception is irreversible

In Model 2, it is assumed that once a woman has started to use contraception to space her births, she will use it in all following intervals. The first interval is modelled in the same way as for Model 1. Therefore, this section focuses on the following birth

[8] A standard deviation of 75 months for the length of the reproductive life may be considered as large. However, we also ran the models with a standard deviation of 25 months, and the results were not significantly affected by the change.

intervals. First, the intervals after the first birth are described and then the inputs and output of the model.

Figure 5-4 pictures the second birth interval. It is similar to Model 1, except that women who have and who have not used contraception in the interval go into different queues, since both groups of women will have different choices in the third interval, as women who have used contraception will not be able to discontinue. The third birth interval is shown in Figure 5-5: women who have not used contraception in the second birth interval are allowed to follow any of the three paths. However, women who used

Figure 5-4. Diagram picturing the second birth interval in Model 2

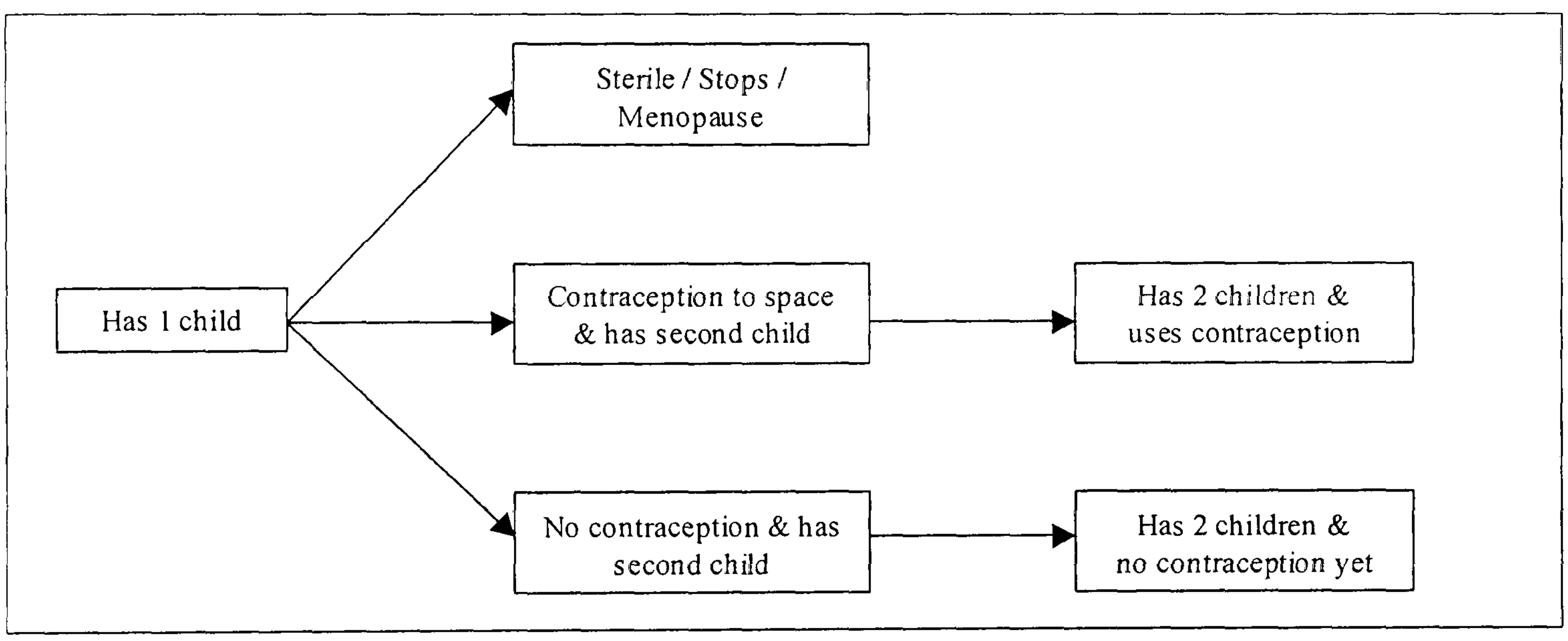
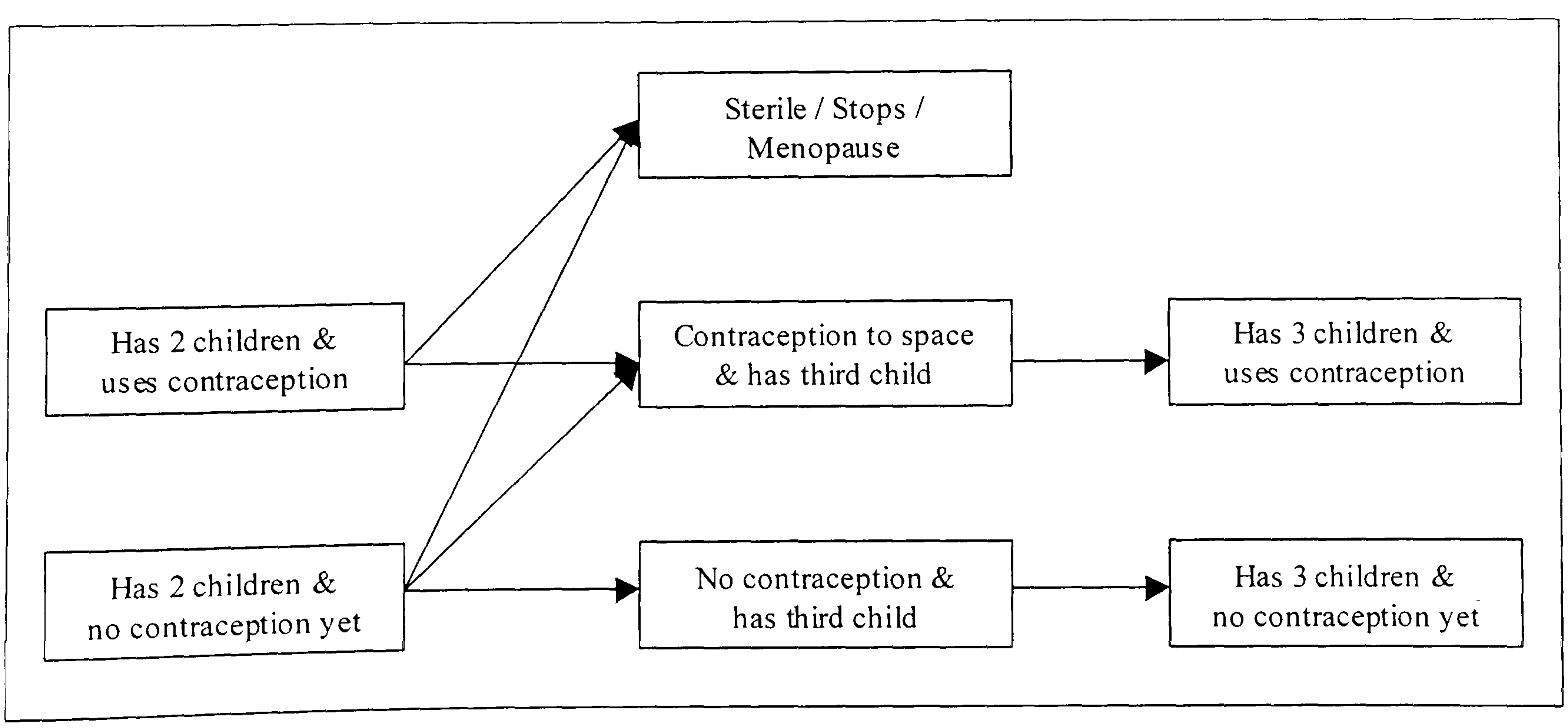


Figure 5-5. Diagram picturing the third birth interval in Model 2



contraception during their second birth interval to space their children must either continue the use of contraception to space their births, or end their reproductive life.

The whole model can be built from Figures 5-3, 5-4 and 5-5. In practice, few women have more than ten children for the same reason as in Model 1. The model as constructed in SIMUL8 is shown in Appendix G.

The inputs for the model are as follows:

- Proportion of childless women, set at two per cent.
- The length of the reproductive life, normally distributed with mean 300 months and standard deviation 25 per cent of the mean (i.e. 75).
- Proportions of women following each of the two paths after each birth for women having used contraception.
- Proportions of women following each of the three paths after each birth for women not having used contraception yet.
- Lengths of the birth intervals for women spacing and women not using any contraception, for each interval, following beta distributions as in Model 1.

The output is the number of children ever born (CEB) of each woman 'created' by the model.

5.3.3 Limitations of the models

In this section, the limitations of the two models are discussed. They concern multiple births, secondary sterility, the definition of contraceptor and the assumptions behind the models.

There is no provision for multiple births. However they represent only one to two per cent of all births, and should therefore not significantly change the results.

Secondary sterility (not including menopause) is assumed to be correlated with parity and not age: the proportions of women becoming sterile increases with the order of the birth interval and not with the woman's age. This assumption is difficult to verify because it is not possible to disentangle sterility from fecundity with the information available from demographic surveys. An in-depth medical survey would be necessary. However, it seems that a woman who has had a child is more likely to become sterile than a childless woman with the same socio-economic and sexual health characteristics (i.e. same sex risks, marital situation, etc.). This may be due to the traumas of pregnancy and childbirth and to the health risks incurred during sexual intercourse (Larsen, 1996). Glass and Grebenik (1954) when analysing the 1946 British census takes the same assumption, that "after every confinement an increasing proportion of women become physiologically sterile" (p.271). Therefore it seems likely that secondary sterility increases with parity rather than age until the age when menopause commences.

The use of 'contraceptors' instead of women using contraception has some impact on the results. Some contraceptors may actually not be using contraception in the interval of interest. Therefore the proportion of contraceptors is most probably higher than the proportions of women using contraception in each interval and the length of the birth interval for contraceptors is likely to be shorter than those for women using contraception in the interval. This has to be kept in mind when interpreting the results.

As already pointed out, we assume in Model 1 that the spells of contraceptive use in different intervals are independent. However, Model 2 will present the other extreme, i.e. the decision to use contraception is irreversible. Model 1 gives the minimum impact of spacing on fertility, whereas Model 2 gives the maximum impact. This is because spacing affects fertility by lengthening the birth intervals so that the woman reaches the end of her reproductive life not having had the time to give birth to the last 'potential' child(ren) she would have had if she had not been using contraception. Spacing is most effective at reducing fertility when it is used by a woman along all her reproductive life so that she reaches the end significantly short of time to have her last potential children. Spacing is least effective when it is used by a woman during only a few birth intervals because it does not have a sufficient impact on her reproductive life. So, spacing has its largest effect on fertility when it is used systematically along a woman's reproductive life as in Model 2; it has its smallest effect if it is randomly used in an interval 'here and there' for all women as in Model 1. Therefore the Tanzanian situation is somewhere between the two models and an average of the results for both models will be presented as well as the results for each model.

5.4 Results

In this section, both models will be run with 6,000 repetitions each, i.e. 6,000 reproductive lives 'created'. This is sufficient for the results to be stable to two decimal places. The inputs will be discussed, and then the output (number of children ever born) will be presented for each model.

5.4.1 Model 1: Spells of contraceptive use in different intervals are independent

The inputs (Table 5-1) are computed using the 1996 TDHS and based on the results from Chapter 4. Only data for the last 15 years before the survey (1981-96) are included to obtain recent information. All inputs were calculated using survival analysis. The percentage of women spacing their next birth is the proportion of contraceptors who are actually having a next child; the percentage having their next child without contraception is the proportion of non-contraceptors having a next child; and the percentage becoming sterile or stopping childbearing is the proportion of

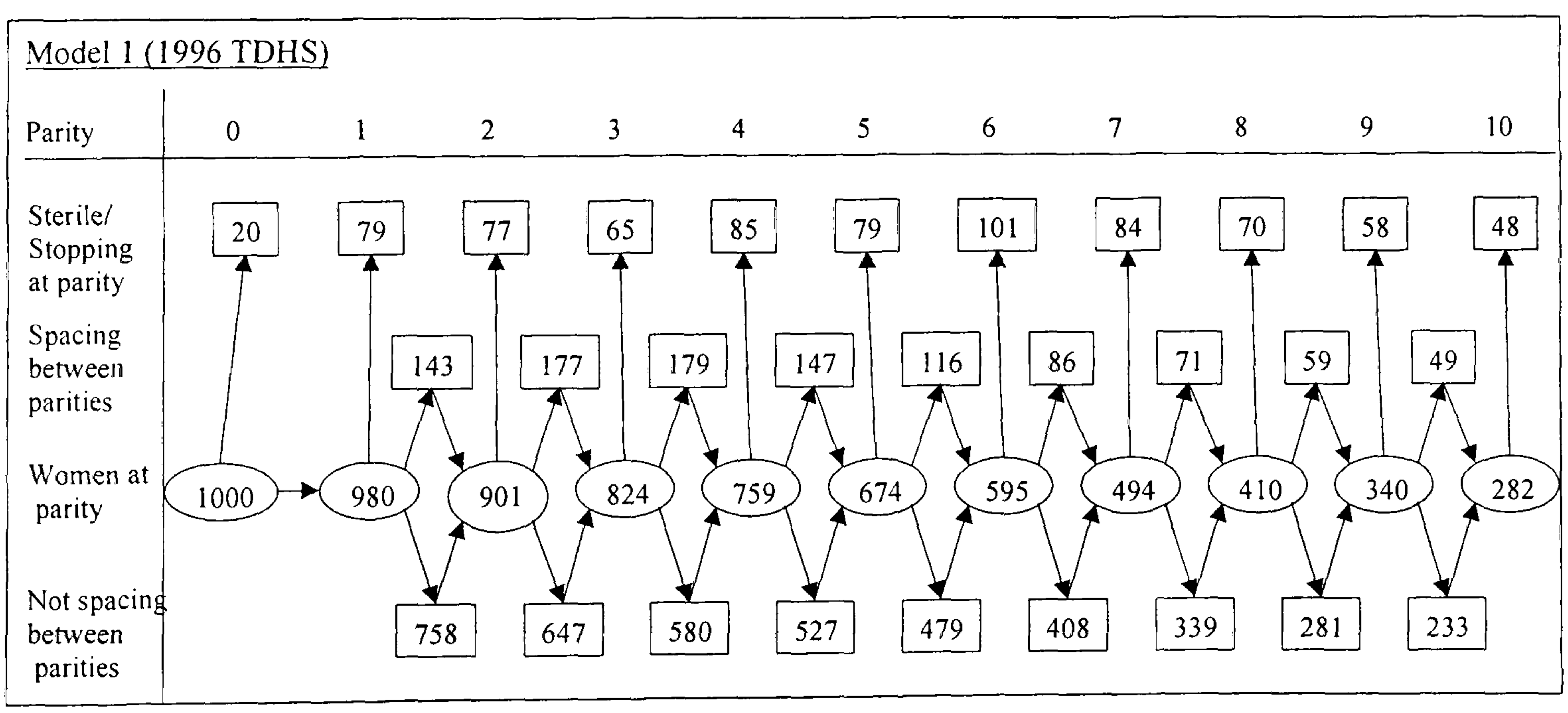
Table 5-1. Inputs for Model 1.

Birth interval	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**
Percentage becoming sterile or reaching menopause	0.06	0.06	0.05	0.06	0.07	0.11
Percentage stopping	0.02	0.02	0.03	0.05	0.05	0.06
Percentage having next child after using contraception to space	0.15	0.20	0.22	0.19	0.17	0.14
Percentage having next child without contraception	0.77	0.72	0.70	0.70	0.71	0.69
Median length of the interval for contraceptors (months)	45	43	41	47	44	51
Median length of the interval for non-contraceptors (months)	32	32	32	32	33	33

women not having a next child. There was not enough data to analyse the birth intervals beyond the seventh birth. It will therefore be assumed that the inputs for the interval 7-8, 8-9 and 9-10 are the same as for the interval 6-7. However, this assumption concerns only a small proportion of all births: in the 1996 TDHS, only five per cent of all births are of the order seven or higher.

Figure 5-6 illustrates Table 5-1 by the way of a flow chart. The proportions shown in the table are applied to a group of 1000 women. The flow chart shows the number of women in each stage at different points of their reproductive life. There is no set point in the flow chart by which all women terminate their reproductive life, as is the case in the simulation model. Therefore, women carry on having children for longer in the chart than in the model where they are stopped when reaching the end of their reproductive life. This is why the simulation models are needed. However, the flow chart gives an overview of the model.

Figure 5-6. Flow chart illustrating Model 1 using 1996 TDHS values



After having run the simulation model 6,000 times, the resulting mean number of children ever born (CEB) was 5.80.

5.4.2 Model 2. The decision to use contraception is irreversible

The inputs are computed using the same data. The length of the intervals for contraceptors and non-contraceptors are the same as in Model 1. Since Model 2 is similar to Model 1 for the second birth interval, the proportions following the three different paths are the same for this interval (see Table 5-1). The proportions following each path for the subsequent intervals are described below.

Women having already used contraception can only follow two paths: reach the end of their reproductive life or continue to use contraception to space their births. The proportions reaching the end of their reproductive life are the same as in Model 1. The proportions continuing to space their births are the complements of the proportions reaching the end of their reproductive life.

Women who have not used contraception yet can follow three paths: reach the end of their reproductive life, start using contraception to space births or continue having children without using contraception. The proportions reaching the end of their reproductive life are the same as for Model 1, shown in the first row of Table 5-1. The proportion starting to space their births in an interval should ideally be the proportion spacing in that interval (third row in Table 5-1), deducted from the proportion already spacing. This is five per cent for the interval 2-3, two per cent for the interval 3-4, and negative thereafter. The proportion is negative from the interval 4-5. The proportions of contraceptors are declining for a number of reasons. Firstly, mainly women not using contraception are able to reach high parities; however, some women may start using contraception at high parities to avoid or delay another birth. Secondly, births at high parities are from older women who are probably less likely to use contraception compared with births at low parities from younger women. Thirdly, there is a truncation bias because the TDHS is a retrospective survey. Among women of a certain age, there are more births with short intervals than with long intervals that have happened by the survey date for higher parities. Typically, short intervals are from women not contracepting and long intervals from women spacing. As a consequence, spacers are underrepresented at higher parities compared with non-contraceptors. If the full birth histories were available, the percentage spacing would be higher and the percentage not spacing lower. Therefore the proportions starting contraception to space births will be imputed at five per cent in all intervals. The proportions continuing having children without using contraception are the complements of the sums of the proportions reaching the end of their reproductive life and the proportions starting to use contraception.

Figure 5-7 gives an overview of Model 2 by the way of a flow chart; and Figure 5-8 illustrates with more detail the transitions from parity 0 to 4.

Figure 5-7. Flow chart illustrating Model 2 using 1996 TDHS values

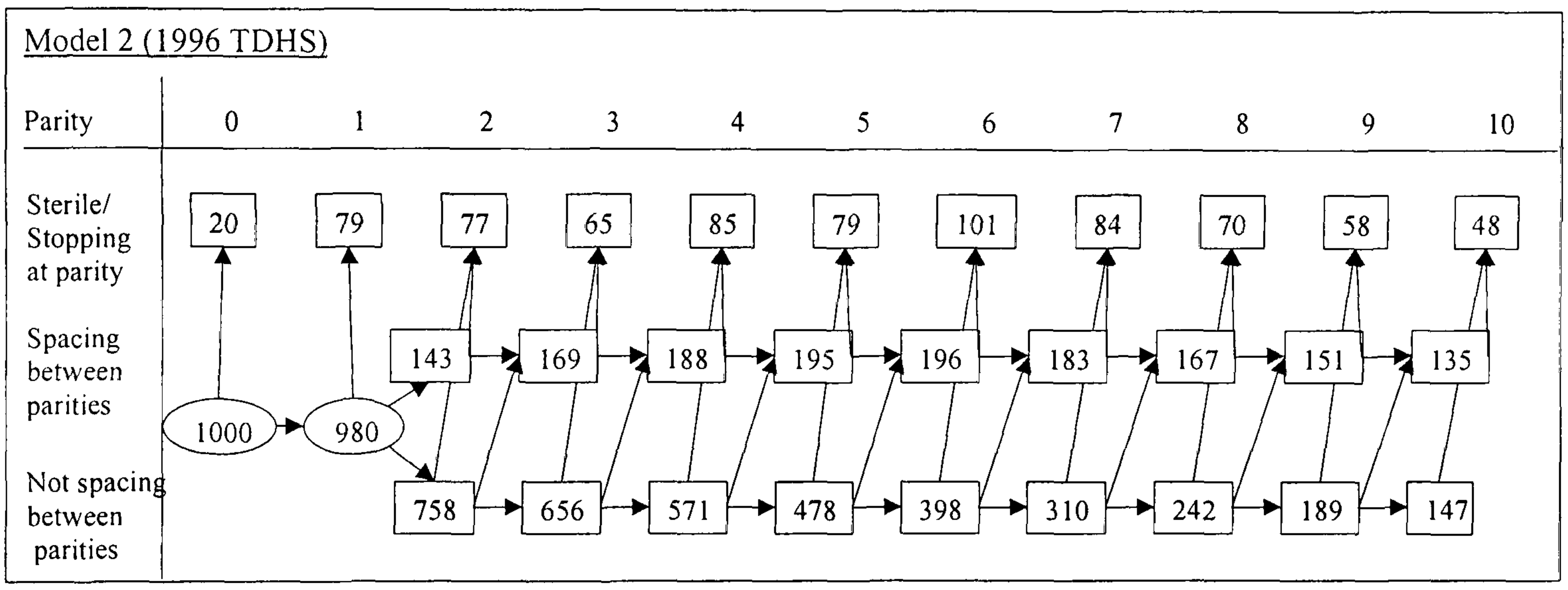
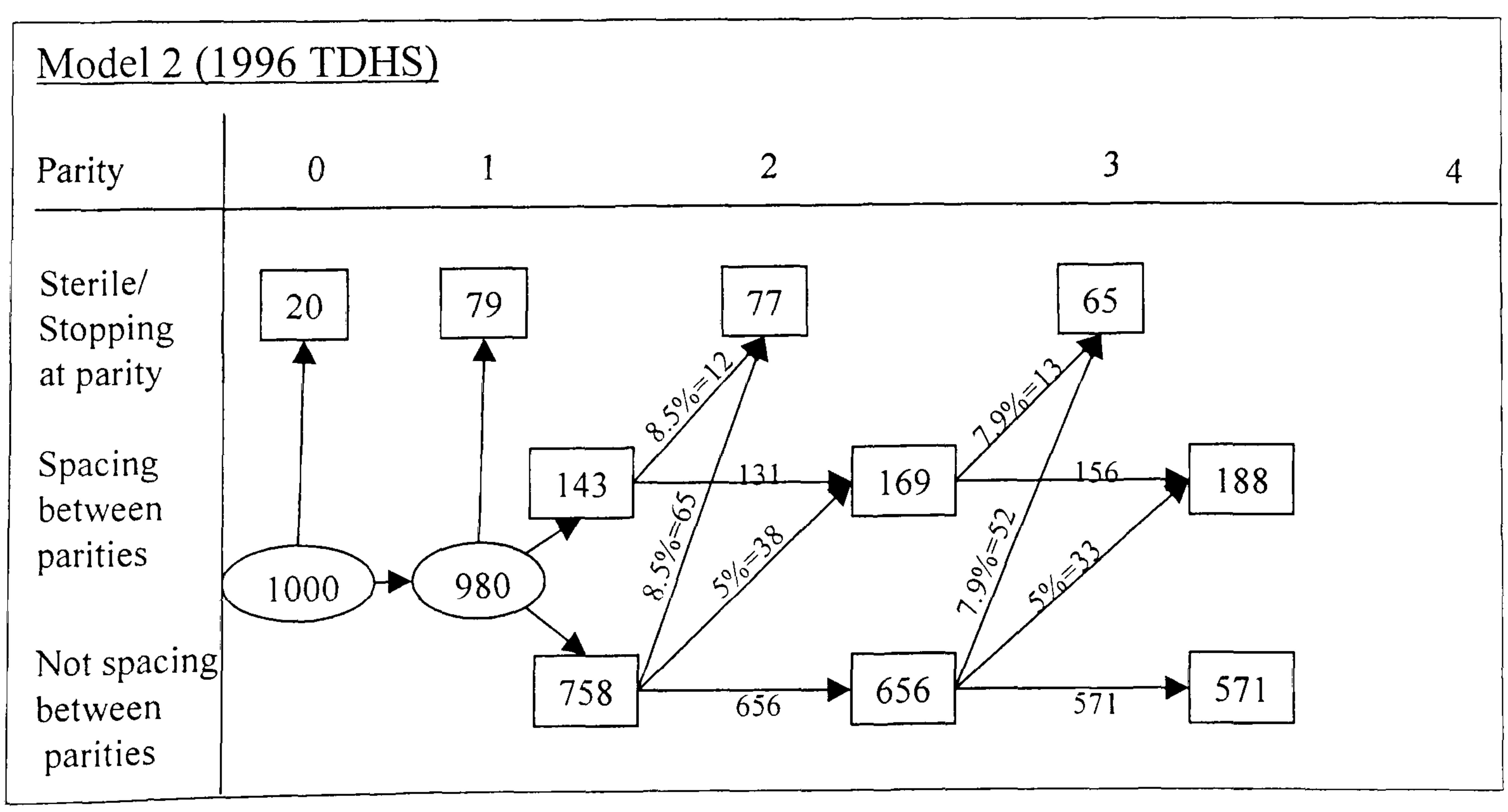


Figure 5-8. Flow chart illustrating Model 2 using 1996 TDHS values – explanation of the transitions between parities 0 and 4



After having run this model 6,000 times, a mean number of children ever born (CEB) of 5.62 was found.

5.4.3 *Comparison of the results with the total fertility rates*

The results for the two models can be compared to the total fertility rates found in Tanzania in the period 1986-96:

- 6.5 in 1988 (Mturi and Hinde 1994)
- 6.3 in 1989-91 (Bureau of Statistics and Macro International 1993)
- 5.8 in 1994-96 (Hinde and Mturi 2000)
- 5.6 in 1996-99 (Mturi and Hinde 2001).

In Model 1 (spells of contraceptive use in different intervals are independent), the mean CEB is 5.80. In Model 2 (decision to space births is irreversible), the mean CEB is 5.62. This gives an average CEB of 5.71 over both models. So these results are of the same order and in line with the TFRs found in the same period in Tanzania. This gives credibility to the models and shows they are a reasonable baseline to make some projections.

5.5 Projections

By changing the input values in both models, it is possible to do some projections of the number of children ever born under some new circumstances, e.g. higher rates of contraceptive use or longer spacing of births.

Table 5-2 presents the projections run. All projections have been run 6,000 times. 6,000 repetitions were sufficient: the mean number of children born was not changing at the second decimal place when adding more repetitions. The last column in Table 5-2 entitled 'average' is the half-way point between the projections from both models. Table 5-3 gives the differences between the values obtained from the 1996 TDHS and the projections, both in units and percentages.

Table 5-2. Projections

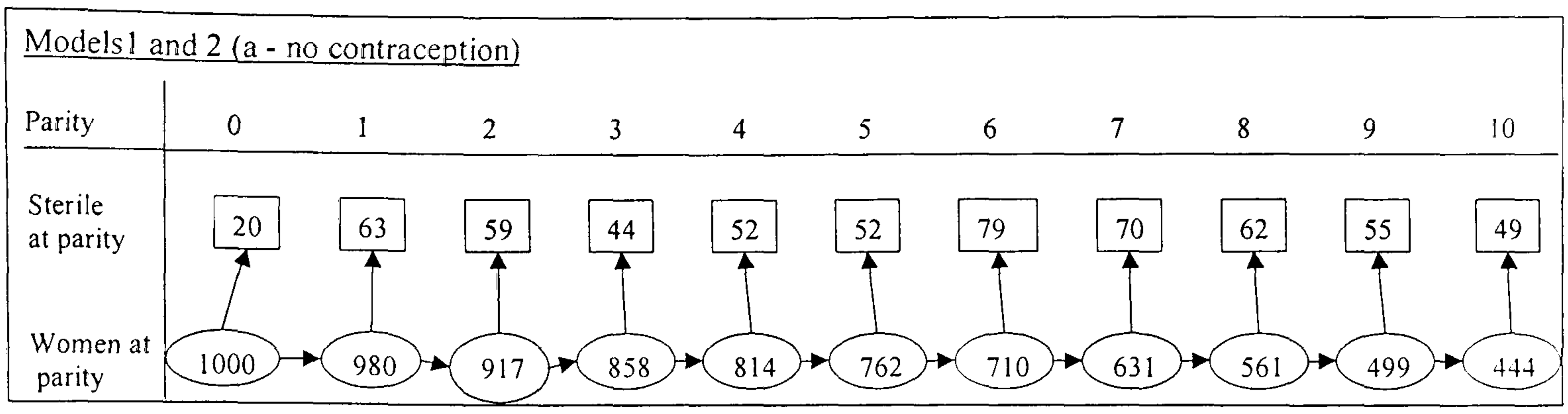
	Model 1	Model 2	Average
Values from the 1996 TDHS	5.80	5.62	5.71
(a) no contraception	6.95	6.95	6.95
(b) contraception only to stop	5.87	5.87	5.87
(c) 20 % more spacing	5.64	5.41	5.53
(d) 20 months longer spacing	5.57	5.47	5.52
(e) 40 months longer spacing	5.35	5.15	5.25
(f) 20 % more and 20 months longer spacing	5.16	4.69	4.93
(g) 20 % more stopping	3.12	3.41	3.27
(h) 10 % more stopping after the third birth	4.73	4.92	4.83

Table 5-3. Differences between the 1996 TDHS values and the projections

	Model 1	Model 2	Average
(a) no contraception	-1.15 (-17 %)	-1.33 (-19 %)	-1.24 (-18 %)
(b) contraception only to stop	-0.07 (1 %)	-0.25 (-4 %)	-0.16 (-3 %)
(c) 20 % more spacing	0.16 (3 %)	0.21 (4 %)	0.18 (3 %)
(d) 20 months longer spacing	0.23 (4 %)	0.15 (3 %)	0.19 (3 %)
(e) 40 months longer spacing	0.45 (8 %)	0.47 (8 %)	0.46 (8 %)
(f) 20 % more and 20 months longer spacing	0.64 (11 %)	0.93 (17 %)	0.78 (14 %)
(g) 20 % more stopping	2.68 (46 %)	2.21 (39 %)	2.45 (43 %)
(h) 10 % more stopping after the third birth	1.07 (18 %)	0.70 (12 %)	0.88 (15 %)

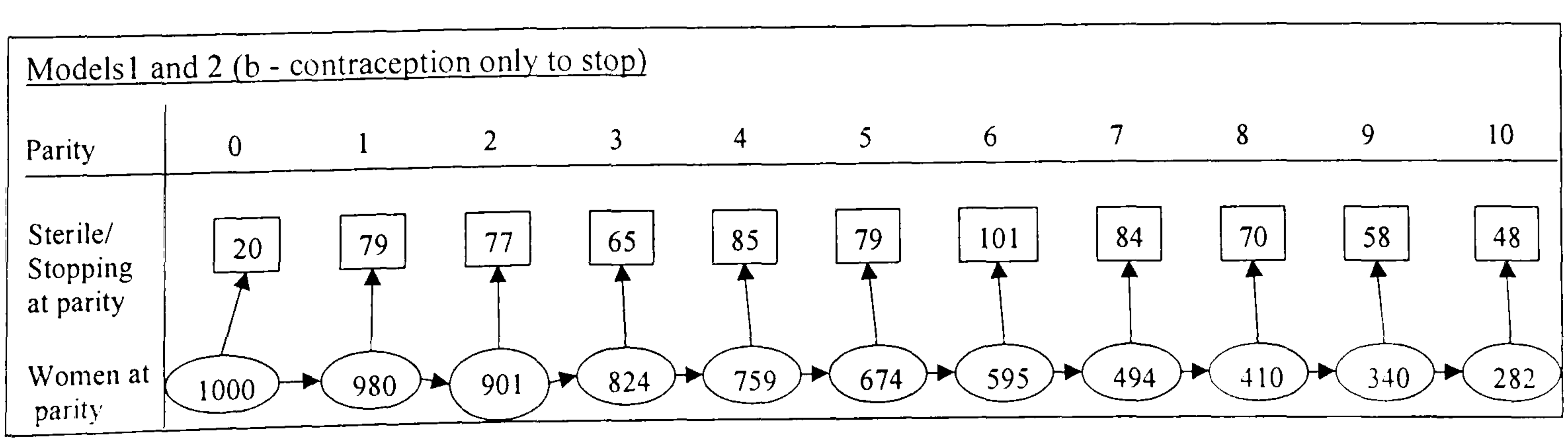
In both models, projection (a) consists in setting up the contraception levels at zero, i.e. no woman is using contraception. The flow chart in Figure 5-9 illustrates this projection. In this case, both models give the same results, a mean CEB of 6.95, around 1.24 births or 18 per cent higher than the mean CEB obtained from the TDHS when averaging both models. A mean CEB of 6.95 is close to the maximum fertility of 7.2 births achieved in Tanzania around 1978 (Hinde and Mturi, 2000). This means that fertility would be 18 per cent higher in Tanzania if contraception was not present. For comparison, we estimate Bongaarts' index of contraception C_C at 0.88, which implies that about 12 per cent of the maximum potential fertility has been suppressed by the use of family planning methods. This is in line with our results.

Figure 5-9. Flow chart illustrating Projection (a) in both models



In projection (b), it is assumed that only contraception to stop childbearing is available, i.e. the women spacing their births in the TDHS are not using any contraception here. This projection is illustrated in Figure 5-10. Again, both models give the same results, a mean CEB of 5.87. When averaging both models, the mean CEB under the 'contraception only to stop' hypothesis is 0.16 birth or three per cent higher than that in the TDHS. Comparing projections (a) and (b), little of the effect of contraception on fertility is due to the use of contraception to space: when averaging both models, 17 per cent (6 per cent in Model 1 and 21 per cent in Model 2) of the births avoided by the use of contraception are through spacing, versus 83 per cent through stopping. On the other side, the prevalence rate of using contraception to space is far higher than that to stop: between three and 18 per cent of contraceptors, depending on the birth interval, are stopping childbearing; the remainder are spacing. In other words, the three to 18 per cent of women using contraception to stop are responsible for 83 per cent of the births avoided by the use of contraception, whereas the 82 to 97 per cent of women using contraception to space are responsible for 17 per cent of the births avoided. This shows how ineffective the use of contraception to space births as practised in Tanzania in reducing fertility is compared with its use for stopping.

Figure 5-10. Flow chart illustrating Projection (b) in both models



The next step is to determine what levels of contraceptive use would be needed to reduce fertility in Tanzania. In Model 1, projection (c) involves adding, for all intervals, 20 per cent to the proportions spacing (i.e. roughly doubling the proportions spacing) and taking it off the proportions having another child without contraception. The resultant changes are illustrated in Figure 5-11. In Model 2, it involves adding, for all intervals, 20 per cent to the proportions starting to use contraception to space in the interval, and taking it off the proportions having another child without contraception (Figure 5-12). The mean CEBs are 5.64 and 5.41 respectively for Models 1 and 2, i.e. three to four per cent less than the mean CEBs using the values from the TDHS. It is a very small decline in fertility for a large increase in contraceptive use. Therefore increasing the proportion of women spacing without any other measures will not have any significant effect in reducing fertility in Tanzania.

Figure 5-11. Flow chart illustrating Projection (c) in Model 1

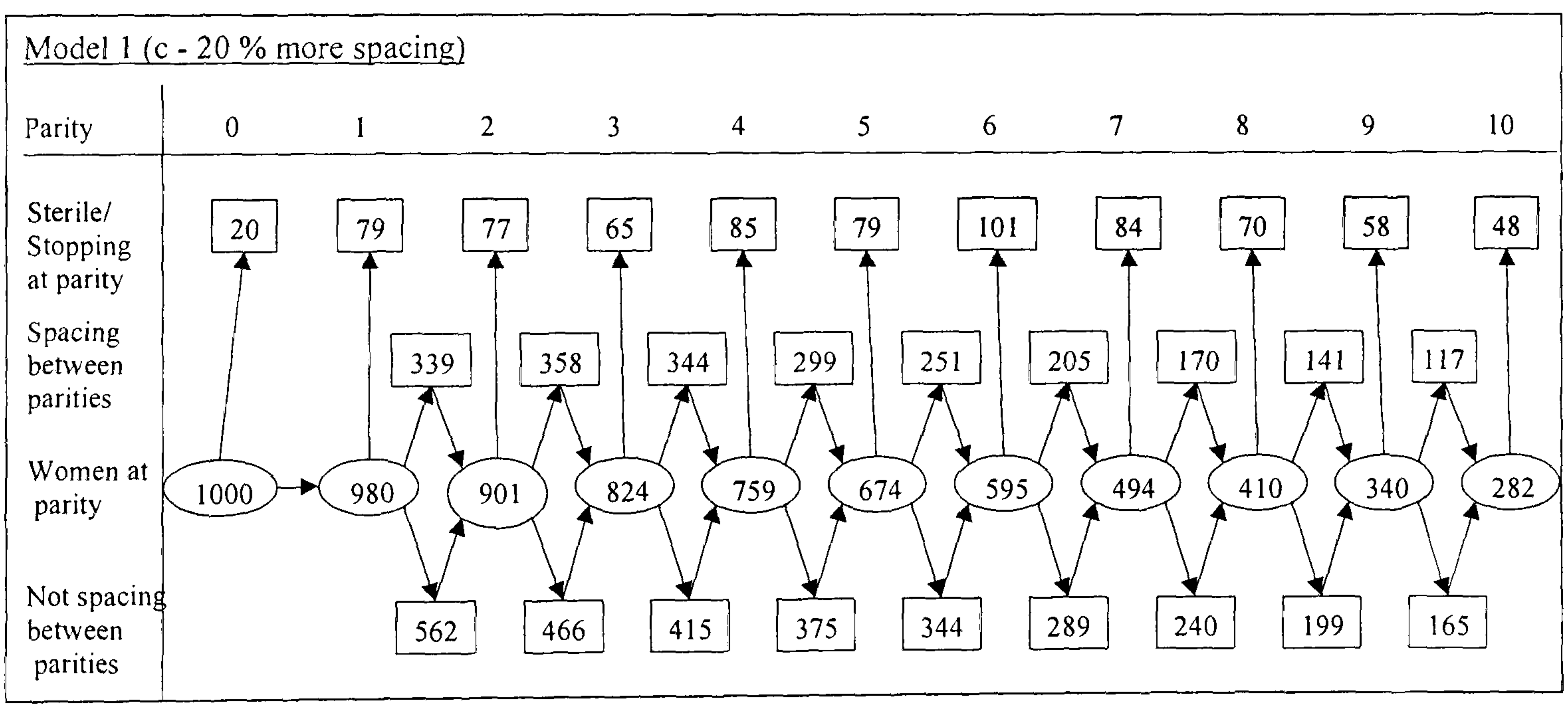
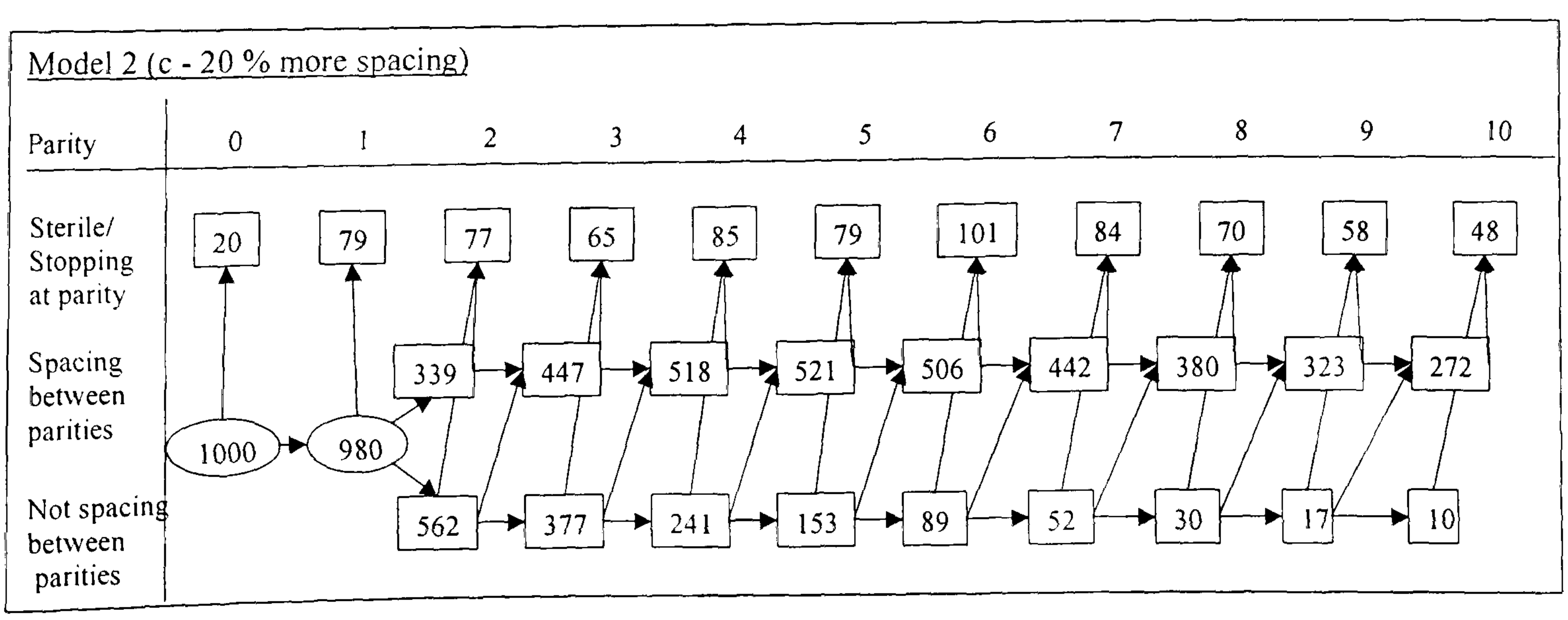


Figure 5-12. Flow chart illustrating Projection (c) in Model 2



Projection (d) consists in lengthening the mean of all birth intervals for contraceptors by 20 months. The flow charts are the same as for the 1996 TDHS values (Figures 5-6 and 5-7) since the proportions at each stage of the reproductive life do not change; however, since the birth intervals for contraceptors are lengthened, some women will reach the end of their reproductive life with less children. This leads to a mean CEB of 5.57 and 5.47 respectively for Models 1 and 2, i.e. three to four per cent less than the mean CEB using the values from the TDHS. It is a very small decline in fertility. However, lengthening the intervals by a further 20 months is considerable: in the TDHS, the intervals for contraceptors are around 13 months longer than for non-contraceptors. So lengthening the intervals by another 20 months is more than doubling the present difference between contraceptors and non-contraceptors, to reach intervals of 60 to 70 months. However, it is realisable as proven by younger women in South Africa whose birth intervals are in excess of 60 months (Moultrie and Timæus, 2002). Also, by lengthening the birth intervals, the timing of fertility will be affected and the gap between generations increased, leading to a lower rate of population growth.

Projection (e) consists in lengthening the mean of all intervals for contraceptors by 40 months. This is effectively doubling the 20 months lengthening of projection (d) and consequently the impact on fertility is roughly doubled as well. As in Projection (d), the flow charts are the same as the ones with the 1996 TDHS values. The mean CEB is reduced by nearly half a birth, or eight per cent. It is a significant decline in fertility, however the intervals for contraceptors would need to be doubled.

Projection (f) combines (c) and (d): 20 per cent more and 20 months longer spacing. The flow charts are the same as in Projection (c). This gives a mean CEB of 5.16 and 4.69 respectively for Model 1 and 2, i.e. 0.64 and 0.93 birth or 11 and 17 per cent less than the mean CEB using the TDHS. Averaging both models, the mean CEB is reduced by 0.78 birth or 14 per cent. This is a significant decline in fertility of three quarter of a birth. This strategy of 'more and longer spacing' could be applied through a strong family planning programme.

Projections (g) and (h) concern stopping rather than spacing. In projection (g), 20 per cent is added to the proportions becoming sterile in each interval, and 20 per cent is taken off the proportions not using contraception in the case of Model 1 (Figure 5-13). For Model 2, 20 per cent is shifted from the proportions having never used contraception to the proportions becoming sterile whilst the proportions for women contracepting remain the same (Figure 5-14). For both models, the mean CEB drops dramatically. The drop is less marked in Model 2 because the proportions of women stopping in each interval is increased only for women having never used contraception, i.e. the increase is only applied to a part of the population in each interval. However, these results give a good idea of the impact of stopping on the fertility levels.

Figure 5-13. Flow chart illustrating Projection (g) in Model 1

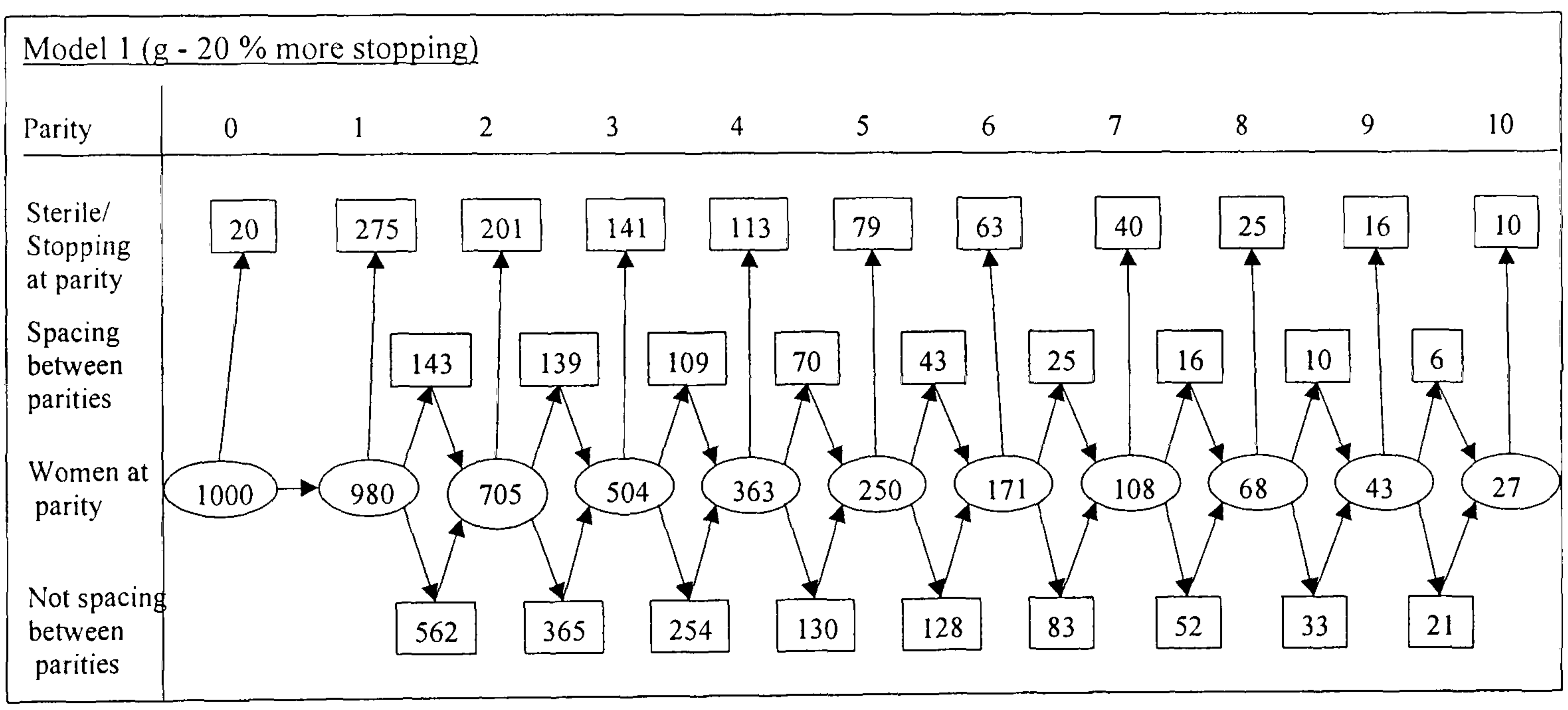
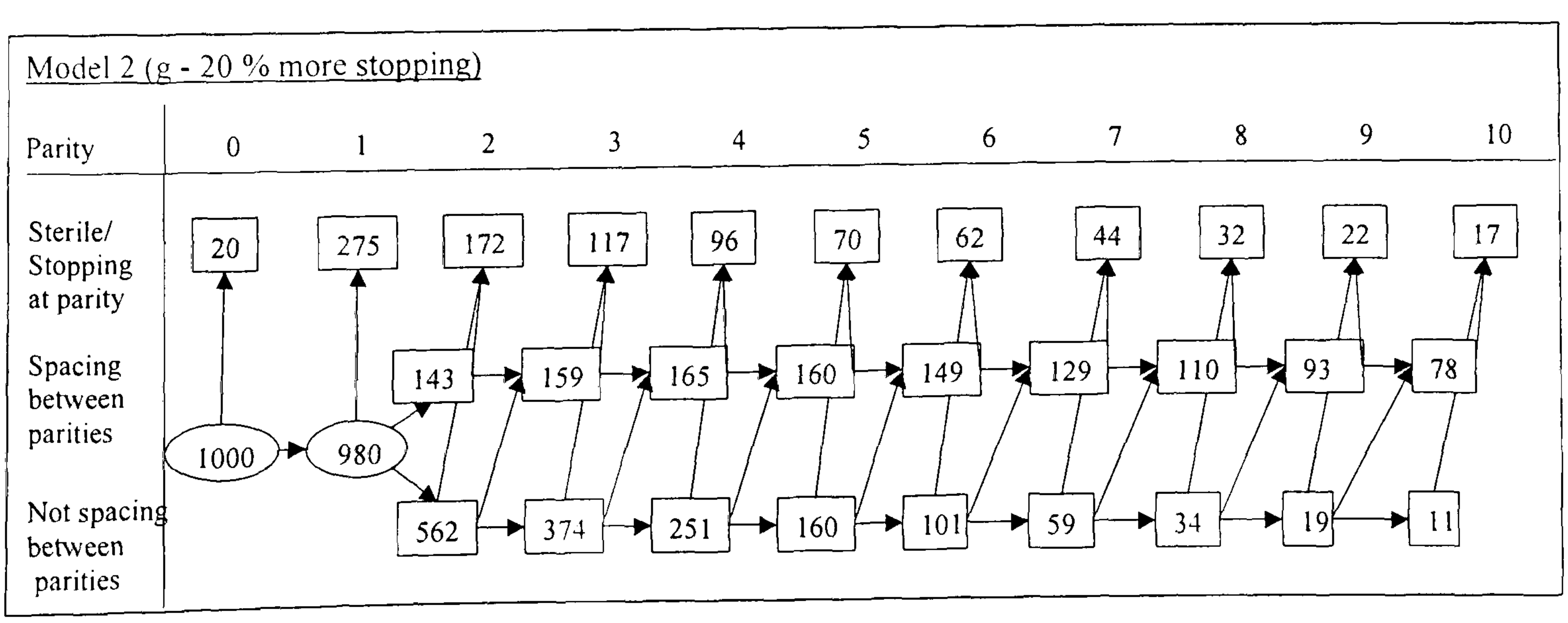


Figure 5-14. Flow chart illustrating Projection (g) in Model 2



Since it is unrealistic to think that 20 per cent of women would want to stop childbearing after one or two birth(s), a more sensible figure is given by projection (h) where the proportions stopping increase by ten per cent from the birth interval 3-4 onwards (Figures 5-15 and 5-16). In this case, the mean CEB is 1.07 births or 18 per cent less than for the 1996 TDHS in Model 1, and 0.70 birth or 12 per cent less in Model 2. For the same reason as projection (g), the drop is less marked in Model 2. Averaging both models, the mean CEB is 4.83, i.e. 0.88 birth or 15 per cent less than for the 1996 TDHS. Putting aside projection (g), strategies (f) and (h) are the most efficient in reducing significantly fertility in Tanzania.

Figure 5-15. Flow chart illustrating Projection (h) in Model 1

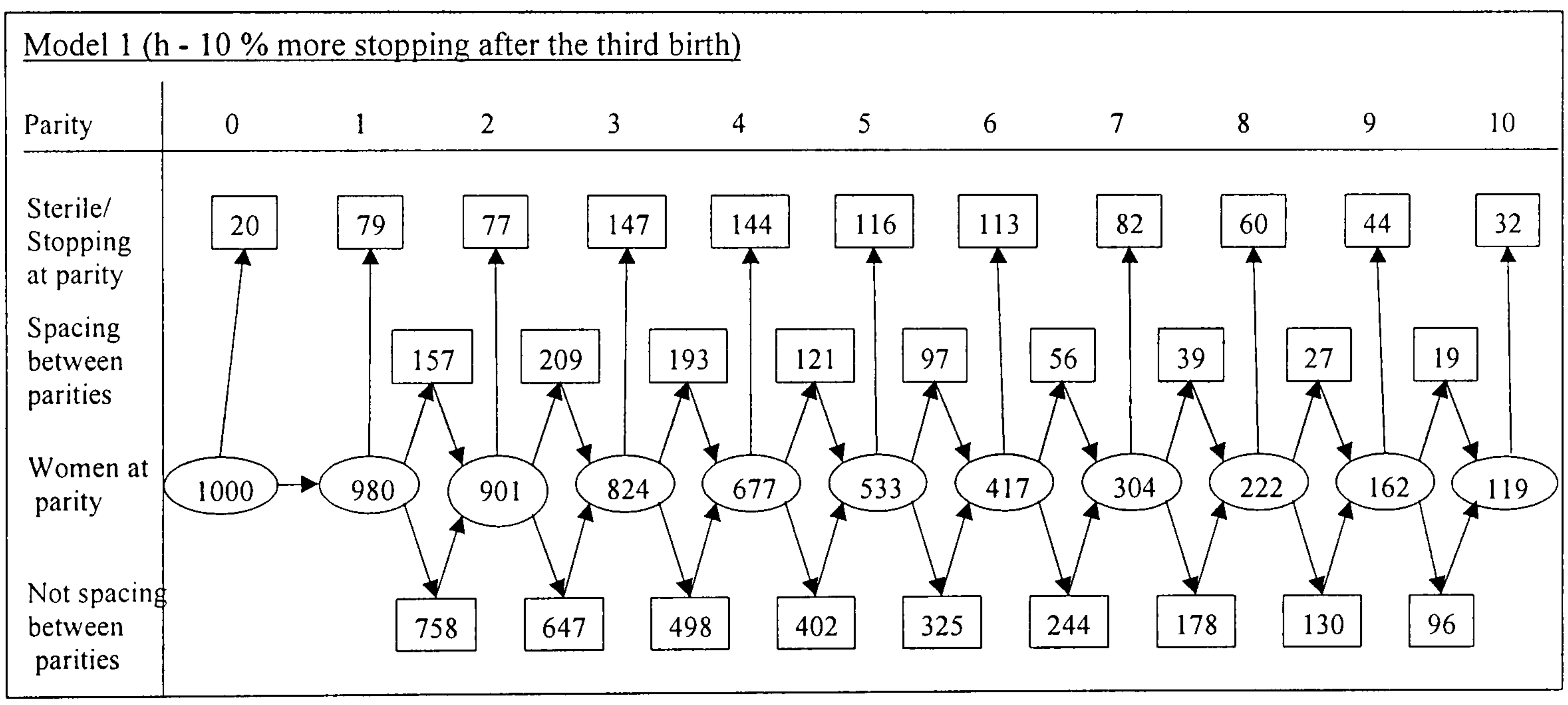
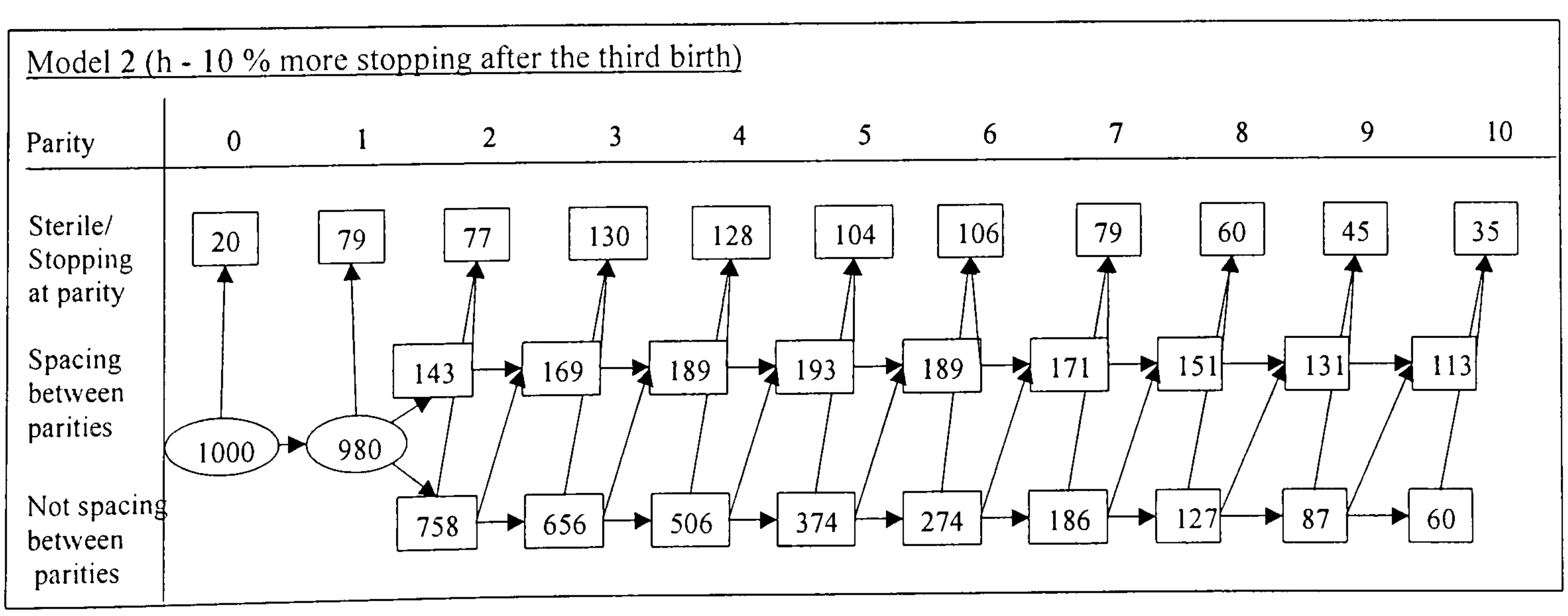


Figure 5-16. Flow chart illustrating Projection (h) in Model 2



5.6 Conclusions

The aim of this chapter was to evaluate the impact of spacing births on the fertility levels in Tanzania and to determine some family planning strategies which might effectively reduce fertility. Two simulation models have been designed to represent women's reproductive life focusing on the use of contraception in each birth interval. Model 1 assumes that the spells of contraceptive use to space births in different intervals are independent. Model 2 assumes that the decision to use contraception to space births is irreversible. The 'reality' lies in between the two: some women who have started to use contraception to space births will do so until the end of their reproductive life, and some will use it during only one or some intervals. When using values derived from the 1996 TDHS as inputs, Models 1 and 2 give respectively a mean CEB of 5.80 and 5.62 or an average of 5.71 for the period 1986-96, which are in line with TFRs of 6.3 and 5.8 found from the 1991-92 and 1996 TDHS (Bureau of Statistics and Macro International 1993; Hinde and Mturi 2000).

By varying the proportions of women using contraception to space, it is possible to determine the impact of spacing on the fertility of Tanzania. Looking at the half-way point between the two models, the mean CEB would be 5.87 in the absence of contraception to space births, an increase of three per cent compared to the 1996 TDHS. On the other side, if spacing was twice as prevalent as what it is in the 1996 TDHS, the mean CEB would be 5.53, a three per cent decline, which is a very small impact. However, putting a large effort in family planning by increasing the proportion spacing by 20 per cent and lengthening the intervals by a further 20 months leads to a significant decline in fertility of 0.78 birth or 14 per cent.

The impact of spacing as practiced now in Tanzania on fertility is small because of the way spacing operates. Instinctively, the logic behind spacing is that women who are spacing their births should have fewer children because, having longer intervals between births, they will reach menopause with fewer children. However, this is true only:

- if women lengthen their birth intervals significantly, and the 13 months – around a year - that Tanzanian women add to their birth intervals when spacing may not be enough;
- and, most importantly, if women are fecund until menopause, i.e. their reproductive life is as long as possible so that spacing has its largest impact. This happens if they do not become sterile or decide to stop childbearing before. This is questionable in Africa where the levels of secondary sterility are still high.

Spacing is less effective when secondary sterility is high (i.e. when reproductive lives are short). So it is in sub-Saharan Africa, where the levels of secondary sterility are the highest, that spacing is the least effective. On the other side, spacing has been effective at reducing fertility in historical England and Wales (Szreter, 1996), where the levels of secondary sterility were low and women were spacing for long periods and until menopause.

Comparative to spacing as practiced now in Tanzania, stopping is very efficient in limiting fertility. The mean CEB is reduced by 16 per cent, averaging both models, when comparing projections (a) and (b), i.e. no contraception and contraception only to stop. Hence, in Tanzania, the part of the fertility decline explained by contraceptive use is mainly due to women stopping childbearing even if they are only a small minority of contraceptors. Women spacing their births have only a secondary role to play in the fertility decline. This is not to say that spacing is not beneficial (e.g. for the well-being and health of mothers and babies) and it should therefore not be discarded from family planning programmes because of its small impact on fertility.

When looking at the projections, a strategy of more and longer spacing, or a strategy of more stopping would lead to a significant decline in fertility of around three quarter of a birth or 15 per cent. Ten per cent more women stopping childbearing from the interval 3-4 would have an impact similar to 20 per cent more and 20 months longer spacing.

In the light of this study, the fertility decline in Tanzania is not a new type of fertility transition as suggested by Caldwell *et al* (1992). Spacing as practiced now in Tanzania is not sufficient to affect significantly the fertility rates; stopping, even if far less prevalent, has a larger impact on fertility. This suggests that the fertility transition in Tanzania is following Asia and Latin America where women's reproductive life was shortened by later marriage and stopping childbearing at an early age. In Tanzania, new patterns of marriage are associated with lower fertility (Harwood-Lejeune, 2000) and, as demonstrated here, the fertility is reduced by about a birth due to stopping. However, if women were to space more and for longer, spacing would have a significant impact on fertility, but this is not the case yet as shown by the 1996 TDHS results.

The most efficient patterns of contraceptive use in Tanzania, in the light of our projections, would be an increase in both the proportions and the length of the birth intervals for women spacing births; or an increase in contraceptive use for stopping childbearing among higher order births. An increase in only the proportions or the length of the intervals for women spacing births is not enough to affect significantly the fertility.

Chapter 6

Discussion and conclusions

The aims of this thesis are to understand and estimate the impact of marriage and contraception on the fertility transition in Tanzania. This chapter draws together the results of the four previous chapters to give some insights into the fertility transition in Tanzania. The main findings of each chapter are first recalled. Then, the fertility transition in Tanzania is discussed. A summary of the main conclusions is then given. Finally, areas for further research are proposed.

6.1 Findings of the four chapters

6.1.1 Chapter 2: The impact of rising age at marriage on the Tanzanian fertility decline

Both the pre- and post-marital fertility rates are declining at all ages in Tanzania. However, because the proportions unmarried are increasing as the premarital fertility is declining, the premarital component of total fertility is stable over time among younger women aged 15-29. A decline in premarital fertility is encouraging since premarital births pose concerns about the responsibility for supporting these children.

As the age at marriage increases, women experience the age-specific premarital fertility rates (ASPFRs) for longer. These ASPFRs are declining and lower than the age-specific post-marital fertility rates (ASMFRs). Therefore, rising age at marriage has a positive impact on the fertility decline. Considering women aged 15-34, rising age at marriage is estimated to explain around 25 per cent of the Tanzanian fertility decline when analysing the 1996 TDHS, and between 40 and 50 per cent when analysing the 1999 TCRHS.

6.1.2 Chapter 3: The impact of rising age at marriage on fertility in southern and eastern Africa

The fertility is declining in all the countries studied, with the exception of Madagascar and Mozambique. The largest declines are in Kenya, Zimbabwe and Namibia to some extent, followed by Malawi, Tanzania and Zambia; Uganda being slightly behind. This classification matches well the ones by Kirk and Pillet (1998) and Cohen (1998). These declines affect only the post-marital component of fertility, the premarital component remaining stable. We have shown that the proportion of the decline in fertility among women aged 15 to 39 explained by rising age at marriage varies from one sixth to one third. Westoff (1992) also recognises that a proportion of the decline in fertility in Kenya and Zimbabwe was due to a rise in age at marriage.

6.1.3 Chapter 4: The impact of contraception on birth interval lengths in Tanzania

This chapter aimed to develop some insights and background information which is used in Chapter 5 to model the impact of contraception on the lengths of the birth interval and the proportions of women progressing to the next birth.

Women using contraception[9] who space their births lengthen their birth intervals by about 13 months with respect to women not using contraception who go on to have another birth. The intervals are around 32 months for non-contraceptors and 45 months for contraceptors. Women in Tanzania using contraception space their births rather than stop childbearing.

[9] 'Using contraception' has to be taken in the same way as the definition of a contraceptor. Women 'using contraception' in a birth interval are women who have started to use contraception in or before the interval of interest and who have used a modern method by the survey date.

6.1.4 Chapter 5: The impact of spacing and stopping on Tanzanian fertility

The use of simulation models shows that spacing as practiced now in Tanzania has little effect on reducing fertility. Two reasons are given to explain this. First, the relatively high level of secondary sterility present in Tanzania jeopardises the full impact that spacing could have on fertility. In fact, secondary sterility strikes women before they reach menopause and so the full impact of spacing cannot be reached. Second, women do not space their births for long enough durations: an increase in interval lengths of 13 months for contraceptors compared with non-contraceptors is not sufficient. However, increasing both the amount and the length of spacing, i.e. a strategy of more and longer spacing, would have a significant impact on the fertility levels. This increase in spacing is not impossible to achieve as has been shown in South Africa where younger women now have birth intervals substantially longer than 60 months (Moultrie and Timæus, 2002).

The models also indicate that the few women who are stopping childbearing in Tanzania (between two and six per cent of women, depending on the parity reached) are actually lowering fertility significantly more than the many who are spacing (between 14 and 22 per cent of women, depending on the parity reached). Without contraception, fertility would be 18 per cent higher in Tanzania, with stopping reducing fertility by 15 per cent and spacing by only three per cent.

6.2 The fertility transition in Tanzania

As developed in the introduction, the two factors which lead the fertility transition in the developing world are a rise in age at marriage in the early stages of the transition, and an increase in contraceptive use. We have seen here that both elements are key factors explaining the Tanzanian fertility transition. However, it is argued that the sub-Saharan Africa fertility transition is a new type of transition led by longer spacing between births (Caldwell *et al.*, 1992; Locoh and Makdessi, 1995). It was also pointed out in Chapter 1 that spacing as practised in sub-Saharan Africa is used to achieve the long birth intervals embedded in the African culture, and not to limit family size. We discuss below whether the Tanzanian fertility transition follows the traditional path or the path advanced by Caldwell *et al.*

The rise in age at marriage operates on the fertility transition in Tanzania as it did in the rest of the developing world (Chapter 2). Of course, the impact in Tanzania is less evident than in Asia where there is virtually no premarital fertility; however, premarital fertility was also common in Latin America and in some parts of Europe during their fertility transitions. On these grounds, we cannot say that the Tanzanian fertility transition is a new type of transition with regards to the impact of marriage.

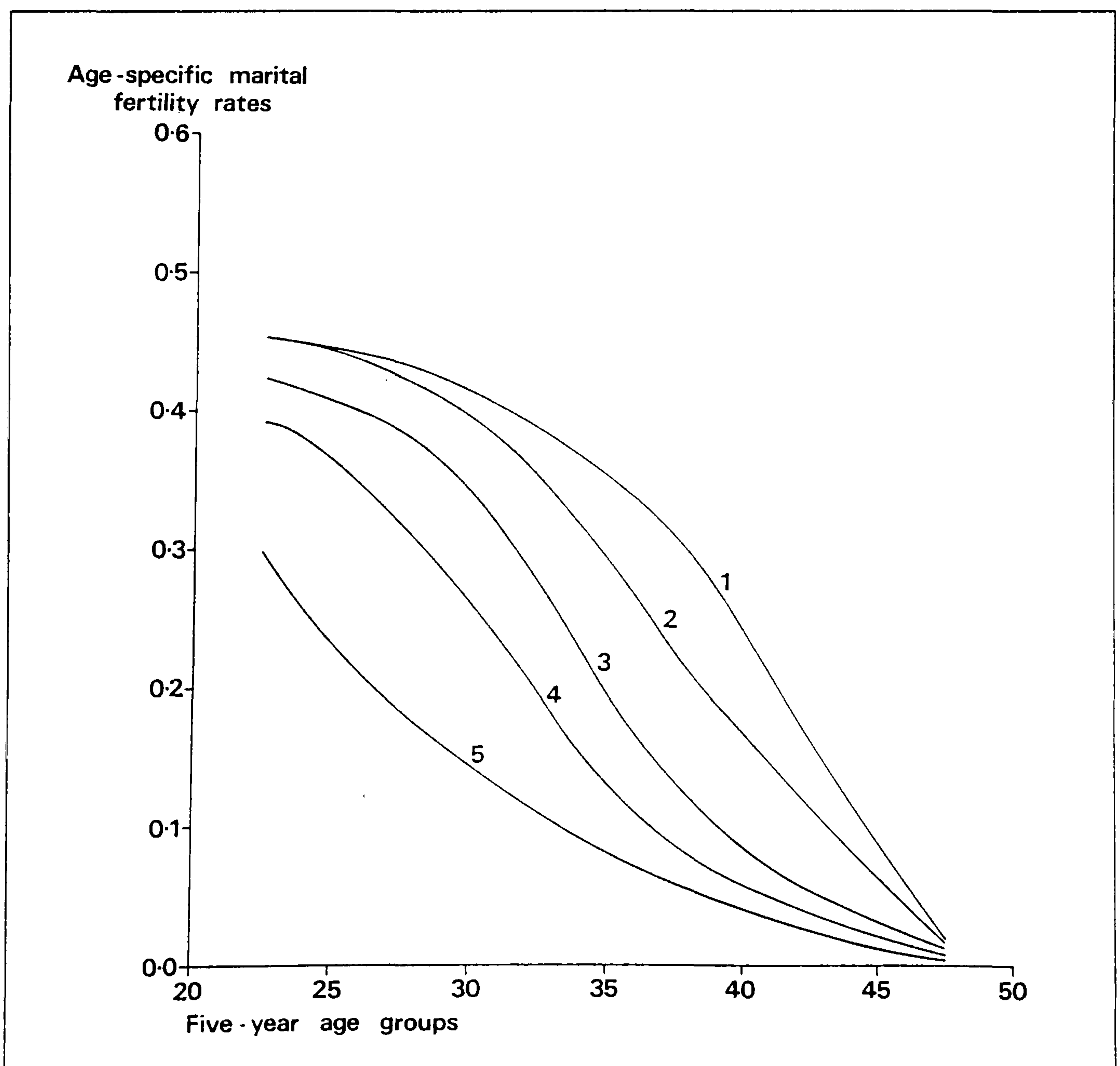
With regards to the impact of contraception, it is usually hypothesised that sub-Saharan Africa is following a new type of transition where contraception is used to space births to achieve long birth intervals rather than to limit family size (Caldwell *et al.*, 1992; Locoh and Makdessi, 1995). We have seen in Chapter 5 that contraception is effectively used mainly for spacing births. However, spacing as practised now in Tanzania has little effect in reducing fertility. It may have other benefits in terms of the health of mother and baby, but not a direct impact on the completed parity distribution. However, if spacing was to become more prevalent (i.e. more women spacing for longer), it would have an impact on the fertility rates. On the other side, the few women stopping childbearing do have a large impact in terms of reducing the fertility rates. Under these circumstances, the Tanzanian fertility transition may be more similar to the transitions in the rest of the developing world than previously thought: the fertility rates are declining through the use of contraception to stop childbearing. Women are spacing their births, but it is happening in parallel, without a significant impact on the fertility decline.

If we go back to the definition of the fertility transition as being 'a sustained and usually irreversible decline in fertility driven by the increasing use of contraception, sterilisation and abortion to limit family size' (Onuoha and Timæus, 1995), it applies well to the situation in Tanzania. The use of contraception (including sterilisation) to stop childbearing, i.e. to limit family size, is impacting fertility whereas the use of contraception for other reasons (like achieving longer birth intervals) is not. From this evidence, Tanzania is following the path of a traditional fertility transition driven by the decision to limit family size rather than the new path advanced by Caldwell *et al.*

(1992). If spacing was to become more prevalent, the Tanzanian fertility transition would become closer to the path advanced by Caldwell than to the traditional transition. However, it is not the case for now. Which of spacing, stopping or both is likely to become more prevalent in the future is discussed at the end of this section.

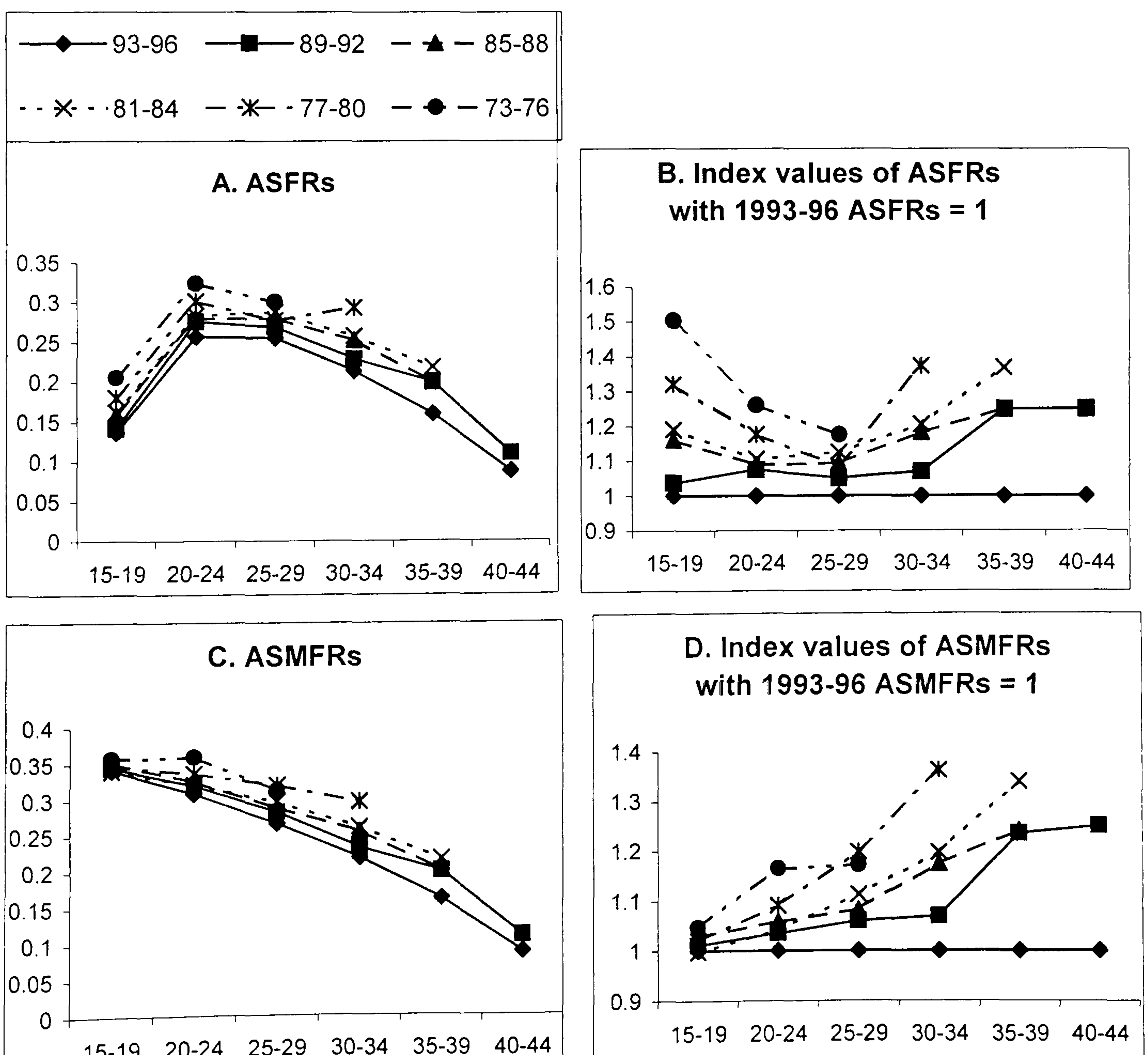
Caldwell *et al.* (1992) argued also that the African fertility transition is different because a similarity in fertility decline is found at all ages, both inside and outside marriage. They compare this pattern of fertility decline with the European and Asian fertility transition where the decline (in marital fertility as specified by Knodel (1977)) was getting larger as age was increasing as shown in Figure 6-1. In fact, a straightforward analysis of the age-specific fertility rates (ASFRs) show that the Tanzanian age-specific fertility pattern may not show a similar decline at all ages, but may be closer to the pattern described for Europe and Asia.

Figure 6-1. Knodel's pattern of a fertility decline (1 being the oldest period and 5 the most recent)



Panel A of Figure 6-2 shows how the ASFRs have declined in Tanzania over time. At first glance, the decline seems to be generalised to all age-groups. However, a more careful analysis of the ASFRs shows it is not the case. Panel B shows the ASFRs in the different periods as a ratio of the 1993-96 rates. So, if the ASFRs were 1 for all age-groups in 1993-96, then the 1981-84 rates would have been 1.19, 1.11, 1.13, 1.21 and 1.37 respectively for the age-groups 15-19 to 35-39. We can clearly see that the decline is more pronounced at younger and older ages with the smallest declines between ages 20 and 30. The decline in fertility at younger ages is certainly due to a rise in age at marriage, whereas the decline at older ages is probably due to an increase in contraception to stop childbearing. This pattern of age-specific fertility is far from

Figure 6-2. ASFRs, ASMFRs and index values.



Source: 1996 TDHS

the one advanced by Caldwell *et al.* (1992). It does not match their description of the European and Asian decline either. However, if marriage had an impact on fertility at the onset of the transition (as explained by Casterline, 1994), then it should be impacting the ASFRs as shown in Figure 6-2.

When looking at the age-specific marital fertility rates (ASMFRs) in panels C and D of Figure 6-2, the decline in marital fertility is practically non-existent at younger ages and larger at older ages. This is exactly the pattern specified by Knodel and Caldwell *et al.* during the European and Asian fertility transition. When looking at the age-specific premarital fertility rates, ASPFRs (results not shown), the decline is not universal among all age-groups either: it is larger among women aged 20-24 but the trends are unclear due to the small sample of never-married women available at older ages. So, we have shown that the Tanzanian ASFRs and ASMFRs follow the same patterns as the European and Asian ones during their fertility transition. From this evidence, for now, Tanzania is following the path of a traditional fertility transition, similar to the rest of the world.

It is clear that for now, Tanzania follows the model of a traditional fertility transition. However, it is uncertain whether Tanzania will remain on that path or diverge to follow the path advanced by Caldwell. If stopping becomes more prevalent, then Tanzania will clearly remain on the path of a traditional fertility transition. However, if spacing becomes more prevalent, Tanzania will follow Caldwell's path. The results of Brown (1996), as shown in Chapter 1, allow us to speculate on the path that Tanzania is likely to follow.

Brown (1996) shows that as sub-Saharan Africa countries move towards more advanced stages of their fertility transition, the correlation between CPR and TFR becomes stronger and in line with the correlations found world-wide. He forecasts a convergence of the sub-Saharan Africa and global associations between CPR and TFR, and therefore challenges the model of a new type of fertility transition in sub-Saharan Africa. The correlation between CPR and TFR may become stronger as contraception to stop childbearing becomes more prevalent. In fact, by using a measure of contraceptive use to limit family size rather than the CPR, the correlation between contraception and TFR might be similar in all parts of the world.

It is therefore more likely that Tanzania will remain on the path of a traditional fertility transition rather than diverge to the path advanced by Caldwell. There is however a country in southern Africa where spacing is likely to have a positive impact on the fertility decline, namely South Africa. Moultrie and Timæus (2002) suggest that the doubling of the birth interval lengths in 30 years has a large impact on the South African transition. The authors note as well that South Africa is the only country with such large birth intervals (more than 60 months for younger women) in the region and can therefore be considered as an exception. However, such a long period of spacing is likely to be caused by other reasons than to achieve the long birth intervals embedded in the African culture as is the case in the rest of the region.

6.3 Summary of the main conclusions

Rising age at marriage is an important factor in explaining the fertility transition in Tanzania. It is estimated to explain between 25 and 45 per cent of the decline in fertility in the last 20 years.

Another important factor in explaining the fertility transition in Tanzania is contraceptive use. Contraception in Tanzania is mainly used to space births; however this has a relatively small impact on the fertility rates. The use of contraception to stop childbearing is far less prevalent but has a much larger impact on the fertility decline even if it is less prevalent.

The fertility transition in Tanzania is driven by a rising age at marriage and contraceptive use to limit family size as in the rest of the world. There is no evidence showing that the Tanzanian fertility transition is following a new path where spacing has a large role to play.

6.4 Areas for further research

When estimating the impact of contraception on fertility, we use the definition of a 'contraceptor'. This definition, even if it has been used by others (Larsen, 1997 for example), is debatable as explained in Chapters 4 and 5; however it is the only means to further the analysis of contraception with the data available. It would therefore be interesting to do the same analysis on a data set where the 'real' proportions of contraceptors is available, for example when the next TDHS will be available (it should contain the relevant information), or using a different country (e.g. Kenya where more information on contraception was gathered because the contraceptive prevalence rates are higher).

It is likely that the fertility transition in some parts of eastern and southern Africa is following the same path as Tanzania. This can be checked by repeating the analyses carried out here on other countries of the regions where the data is available and verifying if our conclusions hold.

The proximate determinants which lead the fertility transitions are mainly rising age at marriage and contraception. These were the focus of this thesis. However, other proximate determinants may also play a role in the Tanzanian fertility decline. As discussed in chapter 1, the AIDS epidemic has a direct impact on foetal loss, amenorrhoea and coital frequency (Gregson *et al.*, 2002). These determinants are assumed not to impact the fertility transition in the rest of the world. This is probably not the case in sub-Saharan Africa. Another proximate determinant of importance is abortion. It may have an impact on fertility, which is difficult to estimate since abortion is illegal in Tanzania as seen in chapter 1. A thorough analysis of the impact of these determinants on fertility would therefore be of interest.

A relevant extension of this thesis would also be to examine the factors behind the proximate determinants. The AIDS epidemic and the adverse economic conditions found now in most of sub-Saharan Africa are thought to impact fertility. However, their impact still needs to be evaluated.

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Appendices

Appendix A. 1999 Tanzania Child and Reproductive Health Survey results

Appendix B. Computation of the ASFRs, ASPFRs and ASMFRs

Appendix C. SPSS Syntax for computing the total and post-marital exposures and number of births

Appendix D. Median age at first marriage and at first birth, and proportions of premarital births by residence, education and religion

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Appendix F. Model 1 in SIMUL8

Appendix G. Model 2 in SIMUL8

Appendix A. 1999 Tanzania Child and Reproductive Health Survey results

Table A-1. Median ages at first marriage and first birth, and percentage of premarital first births (1999 TCRHS).

	Median age at first marriage	Median age at first birth	Difference between median age at first birth and marriage	Percentage of first births which were premarital
All	**18.3**	**19.3**	**1.0**	**17.9**
Birth cohort				
15-19	19.5	19.8	0.3	30.2
20-24	19.0	19.8	0.8	21.7
25-29	18.5	19.6	1.1	17.7
30-34	18.3	19.1	0.8	19.4
35-39	17.5	18.8	1.3	15.4
40-44	16.7	17.8	1.1	12.6
45-49	16.7	18.1	1.4	10.5
Residence				
Urban	19.3	19.9	0.6	21.1
Rural	18.0	19.0	1.0	16.3
Educational level				
No education	16.6	18.2	1.6	8.8
Primary	18.6	19.2	0.6	23.4
Secondary	21.7	22.2	0.5	12.9
Religion				
Catholic	19.1	19.6	0.5	23.2
Protestant	18.9	19.3	0.4	24.0
Moslem	18.1	19.2	1.1	13.5
None	17.3	18.6	1.3	15.0

Note: Median ages at first marriage and first birth are estimated using a life table (to avoid problem of censoring).

Table A-2. ASFRs and TFRs with their pre- and post-marital components (1999 TCRHS).

Age-grp	96-99	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.139= 0.028+0.111	0.141= 0.023+0.118	0.154= 0.023+0.131	0.169= 0.024+0.145	0.184= 0.030+0.154	0.213= 0.019+0.194	0.247= 0.021+0.226	0.229= 0.011+0.218
20-24	0.258= 0.019+0.239	0.284= 0.015+0.269	0.299= 0.021+0.278	0.313= 0.014+0.299	0.298= (0.015)+0.283	0.318= (0.020)+0.298	0.326= (0.014)+0.312	(0.332)= 0.015+0.317
25-29	0.241= (0.009)+0.232	0.267= (0.006)+0.261	0.276= (0.004)+0.272	0.279= (0.008)+0.271	0.279= (0.008)+0.271	0.304= (0.006)+0.298	(0.360)= 0.028+0.332	
30-34	0.218= (0.002)+0.216	0.229= (0.002)+0.227	0.236= (0.005)+0.231	0.275= (0.005)+0.270	0.226= (0.004)+0.222			
35-39	0.154= (0.001)+0.153	0.173= (0.002)+0.171	0.180= (0.002)+0.178	0.162= (0.007)+0.155				
40-44	0.079= (0.001)+0.078	0.101= (0)+0.101	(0.131)= 0+0.131					
TFR	**5.45= 0.30+5.15**	**5.98= 0.24+5.74**	**6.38= 0.28+6.10**					

Note: ASFRs are in brackets when less than 250 years of exposure. Cell entries are in the form ASFR = ASFR(P) + ASFR(M).

Table A-3. ASPFRs (1999 TCRHS).

Age-group	96-99	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.040	0.034	0.037	0.040	0.055	0.038	0.049	0.026
20-24	0.073	0.075	0.113	0.090	(0.102)	(0.161)	(0.122)	(0.131)
25-29	(0.097)	(0.101)	(0.079)	(0.150)	(0.180)	(0.110)	(0.862)	
30-34	(0.048)	(0.094)	(0.161)	(0.135)	(0.105)			
35-39	(0.034)	(0.072)	(0.077)	(0.235)				
40-44	(0.044)	(0)	(0)					

Note. ASPFRs are in brackets when less than 250 years of exposure.

Table A-4. Cumulative ASPFRs and ASFR(P)s from age 15 to 29 (1999 TCRHS).

	96-99	92-95	88-91	84-87	80-83
Cumulative ASPFR	1.05	1.05	1.15	1.40	(1.69)
Cumulative ASFR(P)	0.28	0.22	0.24	0.23	(0.27)

Table A-5. ASMFRs and TMFRs (1999 TCRHS).

Age-group	96-99	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.389	0.358	0.349	0.369	0.349	0.385	0.397	0.384
20-24	0.324	0.336	0.341	0.355	0.333	0.340	0.352	(0.359)
25-29	0.255	0.278	0.288	0.286	0.284	0.315	(0.344)	
30-34	0.224	0.233	0.238	0.280	0.232			
35-39	0.156	0.175	0.182	0.160				
40-44	0.080	0.102	(0.132)					
TMFR	**7.14**	**7.41**	**7.65**					

Note. ASMFRs are in brackets when less than 250 years of exposure.

Table A-6. Cumulative ASMFRs and ASFR(M)s from age 15 to 29 (1999 TCRHS).

	96-99	92-95	88-91	84-87	80-83
Cumulative ASMFR	4.84	4.86	4.89	5.05	4.83
Cumulative ASFR(M)	2.91	3.24	3.41	3.58	3.54

Table A-7. SASFRs, CF, CFM, CFM/CF (1999 TCRHS).

A. Standardised age-specific fertility rates (SASFRs).

Age-group	96-99	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.139	0.127	0.126	0.134	0.139	0.137	0.149	0.128
20-24	0.258	0.268	0.281	0.285	0.272	0.293	0.292	
25-29	0.241	0.262	0.269	0.274	0.275	0.297		
30-34	0.218	0.228	0.235	0.275	0.227			
35-39	0.154	0.173	0.180	0.161				
40-44	0.079	0.100	0.129					

B. Change in fertility, CF.

Age-group	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.001	0.014	0.030	0.045	0.073	0.108	0.090
20-24	0.026	0.041	0.055	0.040	0.060	0.068	
25-29	0.026	0.036	0.038	0.039	0.064	0.120	
30-34	0.012	0.018	0.057	0.009			
35-39	0.019	0.025	0.008				
40-44	0.022	0.052					

C. Change in fertility due to marriage, CFM.

Age-group	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	0.014	0.028	0.035	0.046	0.076	0.098	0.101
20-24	0.016	0.018	0.028	0.026	0.025	0.035	
25-29	0.005	0.007	0.005	0.004	0.008	0.360	
30-34	0.001	0.000	0.000	-0.001			
35-39	-0.001	-0.001	0.001				
40-44	0.001	0.002					

D. CFM/CF.

Age-group	92-95	88-91	84-87	80-83	76-79	72-75	68-71
15-19	13.516	1.921	1.185	1.018	1.036	0.915	1.127
20-24	0.631	0.437	0.506	0.653	0.419	0.509	
25-29	0.195	0.200	0.127	0.112	0.119	3.013	
30-34	0.123	0.020	-0.003	-0.086			
35-39	-0.031	-0.031	0.111				
40-44	0.055	0.045					

Table A-8. Estimated proportion of the decline due to nuptiality for women aged 15-34 years (1999 TCRHS).

Period	TFRs			Estimated proportion of the decline due to nuptiality
	1996-99	Summed from SASFRs	Observed in period	
1980-83	4.28	4.57	4.94	0.56
1984-87	4.28	4.84	5.18	0.38
1988-91	4.28	4.56	4.83	0.49
1992-95	4.28	4.43	4.61	0.55

Appendix B. Computation of the ASFRs, ASPFRs and ASMFRs

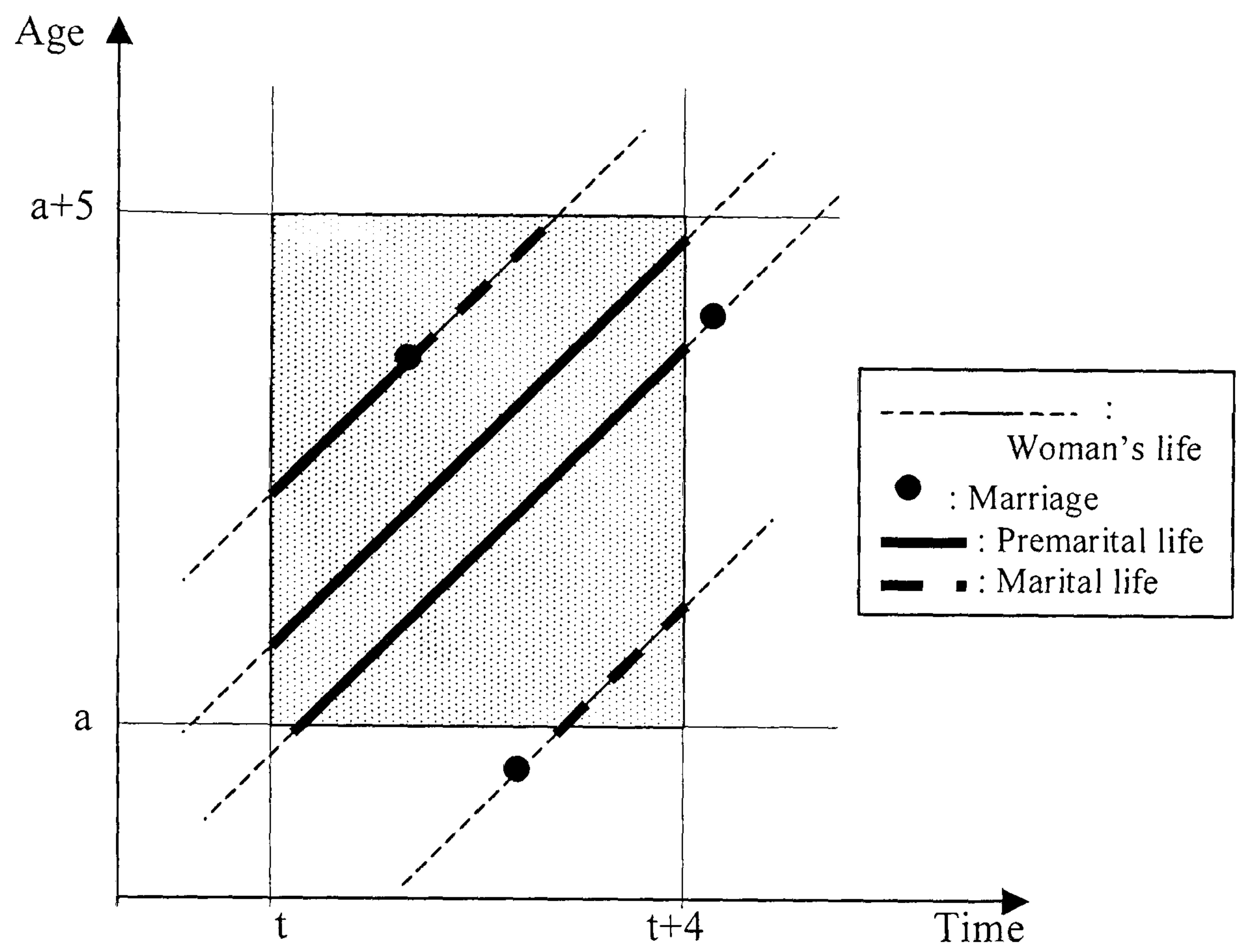
The age-specific fertility rate (ASFR) for an age-group A and a period T is the ratio of the number of births from women aged A during period T by the number of years of exposure of women aged A during period T.

The age-groups used in this paper are the usual five-year age-group 15-19, 20-24, ..., 45-49, noted [a, a+5[. The periods are four years long, noted [t, t+4[. Four rather than five-year periods are considered to circumvent problems with the displacement of births from the fifth to the sixth year preceding the survey to avoid the longer questionnaire designed for births in the five years before the survey. Four-year periods are suitable because they are long enough to allow a large number of years of exposure for the denominator of the ASFRs.

The ASFRs here are calculated using exact exposure and births for the age-group and period considered, i.e. the events on the numerator match exactly the exposure on the denominator of the ASFR. The Lexis chart in Figure B-1 illustrates this. Each diagonal line represents a woman's life. To compute the ASFR for age-group [a, a+5[and period [t, t+4[, we need to include all the years or parts of year (months) of a woman's life covered by the dotted rectangle for the denominator, and all the births which happened in the rectangle for the numerator. So all the births and months of exposure shown by a bold line (dotted and plain) in the rectangle are taken into account.

The age-specific premarital fertility rate (ASPFR) for an age-group A and a period T is the ratio of the number of premarital births from women aged A during period T by the number of years of premarital exposure of women aged A during period T. In this case, the births and months of exposure taken into account are shown by a plain bold line in Figure B-1.

Figure B-1. Lexis chart illustrating exact premarital and marital exposure.



The age-specific post-marital fertility rate (ASMFR) for an age-group A and a period T is the ratio of the number of post-marital births from women aged A during period T by the number of years of post-marital exposure of women aged A during period T. In this case, the births and months of exposure taken into account are shown by a dotted bold line in Figure A2-1.

Appendix C displays the SPSS Syntax used to compute total and post-marital exposures, and the number of total and post-marital births for each period and age-group. The premarital exposures are found by subtracting the post-marital exposure from the total exposure. Similarly, the number of premarital births is found by subtracting the number of post-marital births from the total number of births. With these exposures and number of births, we compute the ASFRs with their pre- and post-marital components, the ASPFRs and the ASMFRs as explained in Chapter 2.

Appendix C. SPSS Syntax for computing the total and post-marital exposures and number of births

C.1 Total exposure for women in a specific age-group (45-49 here) during a period j

```
* To be set up: write the variable name instead of '', or delete the command.
* Age = First year of the age-group.
Compute AGE = 45.
Compute DOB = 'Date of birth (CM)'.
Compute YRINT = 'Year of the interview'.
*Note: write the year as 88, 96, etc, and consider the last year if the interview
spread on 2 years.
Compute INTDATE = 'Date of interview (CM)'.

*Here are the years each period starts:.
*period1=YRINT-3.
*period2=YRINT-11.
*period3=YRINT-19.
*period4=YRINT23.
*period5=YRINT27.
*period6=YRINT-31.
*period7=YRINT-35.
*period8=YRINT-39.

Compute DECINT = 12*(YRINT+1).
Variable label DECINT 'December of the year of interview'.

Compute STPER8 = DECINT+1-32*12.
Variable label StPer8 'Start of period 8'.

Compute START = STPER8-AGE*12.
```

```
If dob+60 le start exp8 = 0.
If (dob+60 > start and dob+60 le start+48) exp8 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp8 = 4.
If (dob+1 > start and dob+1 le start+48) exp8 = (start+48-dob-1)/12.
If dob+1 > start+48 exp8 = 0.

Compute START = start+48.
If dob+60 le start exp7 = 0.
If (dob+60 > start and dob+60 le start+48) exp7 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp7 = 4.
If (dob+1 > start and dob+1 le start+48) exp7 = (start+48-dob-1)/12.
If dob+1 > start+48 exp7 = 0.

Compute START = start+48.
If dob+60 le start exp6 = 0.
If (dob+60 > start and dob+60 le start+48) exp6 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp6 = 4.
If (dob+1 > start and dob+1 le start+48) exp6 = (start+48-dob-1)/12.
If dob+1 > start+48 exp6 = 0.

Compute START = start+48.
If dob+60 le start exp5 = 0.
If (dob+60 > start and dob+60 le start+48) exp5 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp5 = 4.
If (dob+1 > start and dob+1 le start+48) exp5 = (start+48-dob-1)/12.
If dob+1 > start+48 exp5 = 0.

Compute START = start+48.
If dob+60 le start exp4 = 0.
If (dob+60 > start and dob+60 le start+48) exp4 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp4 = 4.
If (dob+1 > start and dob+1 le start+48) exp4 = (start+48-dob-1)/12.
If dob+1 > start+48 exp4 = 0.
```

```
Compute START = start+48.
If dob+60 le start exp3 = 0.
If (dob+60 > start and dob+60 le start+48) exp3 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp3 = 4.
If (dob+1 > start and dob+1 le start+48) exp3 = (start+48-dob-1)/12.
If dob+1 > start+48 exp3 = 0.

Compute START = start+48.
If dob+60 le start exp2 = 0.
If (dob+60 > start and dob+60 le start+48) exp2 = (dob+60-start)/12.
If (dob+60 > start+48 and dob+1 le start) exp2 = 4.
If (dob+1 > start and dob+1 le start+48) exp2 = (start+48-dob-1)/12.
If dob+1 > start+48 exp2 = 0.

Compute START = start+48.
If dob+60 le start exp1 = 0.
Do if (dob+60 > start and dob+60 le start+48).
   Compute exp1 = (dob+60-start)/12.
   If dob+(age+5)*12 > intdate exp1 = exp1 - (dob+(age+5)*12-intdate)/12.
End if.
If (dob+60 > start+48 and dob+1 le start) exp1 = 4 - (decint - intdate)/12.
If (dob+1 > start and dob+1+age*12 le intdate) exp1 = (intdate-
(dob+1+age*12))/12.
If dob+1+age*12 > intdate exp1 = 0.

Execute.
```

C.2 Marital exposure for women in a specific age-group (45-49 here) during a period j

*Note that Premarital exposure = Total exposure - Marital exposure.

*To be set up in addition to the syntax for the total exposure:.
Compute DOM = 'Date of first marriage'.

* To be set up: write the variable name instead of '', or delete the command.
Compute AGE = 45.

Compute DECINT = 12*(YRINT+1).
Variable label DECINT 'December of the year of interview'.

Compute StPer8 = DECINT+1-32*12.
Variable label StPer8 'Start of period 8'.

Compute START = STPER8-AGE*12.
If dob+60 le start exp8 = 0.
Do if dom le start+ age*12.
  If (dob+60 > start and dob+60 le start+48) exp8 = (dob+60-start)/12.
  If (dob+60 > start+48 and dob+1 le start) exp8 = 4.
  If (dob+1 > start and dob+1 le start+48) exp8 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
  If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom) exp8 = 0.
  If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom) exp8 = (dob+(age+5)*12-dom)/12.
  If (dob+60 > start+48 and dob+1 le start) exp8 = (start+age*12+48-dom)/12.
  If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp8 = (start+age*12+48-dom)/12.

```
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp8 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp8 = 0.
If dob+1 > start+48 exp8 = 0.

Compute START = start+48.
If dob+60 le start exp7 = 0.
Do if dom le start+ age*12.
    If (dob+60 > start and dob+60 le start+48) exp7 = (dob+60-start)/12.
    If (dob+60 > start+48 and dob+1 le start) exp7 = 4.
    If (dob+1 > start and dob+1 le start+48) exp7 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp7 = 0.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp7 = (dob+(age+5)*12-dom)/12.
    If (dob+60 > start+48 and dob+1 le start) exp7 = (start+age*12+48-
dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp7 =
(start+age*12+48-dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp7 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp7 = 0.
If dob+1 > start+48 exp7 = 0.

Compute START = start+48.
If dob+60 le start exp6 = 0.
Do if dom le start+ age*12.
    If (dob+60 > start and dob+60 le start+48) exp6 = (dob+60-start)/12.
    If (dob+60 > start+48 and dob+1 le start) exp6 = 4.
    If (dob+1 > start and dob+1 le start+48) exp6 = (start+48-dob-1)/12.
```

```
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp6 = 0.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp6 = (dob+(age+5)*12-dom)/12.
    If (dob+60 > start+48 and dob+1 le start) exp6 = (start+age*12+48-
dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp6 =
(start+age*12+48-dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp6 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp6 = 0.
If dob+1 > start+48 exp6 = 0.

Compute START = start+48.
If dob+60 le start exp5 = 0.
Do if dom le start+ age*12.
    If (dob+60 > start and dob+60 le start+48) exp5 = (dob+60-start)/12.
    If (dob+60 > start+48 and dob+1 le start) exp5 = 4.
    If (dob+1 > start and dob+1 le start+48) exp5 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp5 = 0.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp5 = (dob+(age+5)*12-dom)/12.
    If (dob+60 > start+48 and dob+1 le start) exp5 = (start+age*12+48-
dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp5 =
(start+age*12+48-dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp5 =
(start+48-dob-1)/12.
```

```
End if.
If dom > start+age*12+48 exp5 = 0.
If dob+1 > start+48 exp5 = 0.

Compute START = start+48.
If dob+60 le start exp4 = 0.
Do if dom le start+ age*12.
    If (dob+60 > start and dob+60 le start+48) exp4 = (dob+60-start)/12.
    If (dob+60 > start+48 and dob+1 le start) exp4 = 4.
    If (dob+1 > start and dob+1 le start+48) exp4 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp4 = 0.
    If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp4 = (dob+(age+5)*12-dom)/12.
    If (dob+60 > start+48 and dob+1 le start) exp4 = (start+age*12+48-
dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp4 =
(start+age*12+48-dom)/12.
    If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp4 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp4 = 0.
If dob+1 > start+48 exp4 = 0.

Compute START = start+48.
If dob+60 le start exp3 = 0.
Do if dom le start+ age*12.
    If (dob+60 > start and dob+60 le start+48) exp3 = (dob+60-start)/12.
    If (dob+60 > start+48 and dob+1 le start) exp3 = 4.
    If (dob+1 > start and dob+1 le start+48) exp3 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
```

```
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp3 = 0.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp3 = (dob+(age+5)*12-dom)/12.
   If (dob+60 > start+48 and dob+1 le start) exp3 = (start+age*12+48-
dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp3 =
(start+age*12+48-dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp3 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp3 = 0.
If dob+1 > start+48 exp3 = 0.

Compute START = start+48.
If dob+60 le start exp2 = 0.
Do if dom le start+ age*12.
   If (dob+60 > start and dob+60 le start+48) exp2 = (dob+60-start)/12.
   If (dob+60 > start+48 and dob+1 le start) exp2 = 4.
   If (dob+1 > start and dob+1 le start+48) exp2 = (start+48-dob-1)/12.
End if.
Do if dom > start+age*12 and dom le start+age*12+48.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp2 = 0.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom)
exp2 = (dob+(age+5)*12-dom)/12.
   If (dob+60 > start+48 and dob+1 le start) exp2 = (start+age*12+48-
dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp2 =
(start+age*12+48-dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp2 =
(start+48-dob-1)/12.
End if.
If dom > start+age*12+48 exp2 = 0.
```

```
If dob+1 > start+48 exp2 = 0.

Compute START = start+48.
If dob+60 le start exp1 = 0.
Do if dom le start+ age*12.
   If (dob+60 > start and dob+(age+5)*12 le intdate) exp1 = (dob+(age+5)*12-
start-age*12)/12.
   If (dob+(age+5)*12 > intdate and dob+1 le start) exp1 = (intdate-start-
age*12)/12.
   If (dob+1 > start and dob+1+age*12 le intdate) exp1 = (intdate-dob-1-
age*12)/12.
End if.
Do if dom > start+age*12 and dom le intdate.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 le dom)
exp1 = 0.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > dom and
dob+(age+5)*12 le intdate)
        exp1 = (dob+(age+5)*12-dom)/12.
   If (dob+60 > start and dob+60 le start+48 and dob+(age+5)*12 > intdate)
exp1 = (intdate-dom)/12.
   If (dob+60 > start+48 and dob+1 le start) exp1 = (intdate-dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 le dom) exp1 =
(intdate-dom)/12.
   If (dob+1 > start and dob+1 le start+48 and dob+age*12 > dom) exp1 = 0.
End if.
If dom > intdate exp1 = 0.
If dob+1+age*12 > intdate exp1 = 0.

Execute.
```

C.3 Total number of births in age-group i during period j

```
* To be set up: write the variable name instead of '', or delete the command.
Compute child1 = '1st child born'.
Compute child2 = '2nd child born'.
Compute child3 = '3rd child born'.
Compute child4 = '4th child born'.
Compute child5 = '5th child born'.
Compute child6 = '6th child born'.
Compute child7 = '7th child born'.
Compute child8 = '8th child born'.
Compute child9 = '9th child born'.
Compute child10 = '10th child born'.
Compute child11 = '11th child born'.
Compute child12 = '12th child born'.
Compute child13 = '13th child born'.
Compute child14 = '14th child born'.
Compute child15 = '15th child born'.
Compute child16 = '16th child born'.

Compute DECINT = 12*(YRINT+1).
Variable label DECINT 'December of the year of interview'.

Compute B15_1 = 0.
Compute B15_2 = 0.
Compute B15_3 = 0.
Compute B15_4 = 0.
Compute B15_5 = 0.
Compute B15_6 = 0.
Compute B15_7 = 0.
Compute B15_8 = 0.
Compute B20_1 = 0.
Compute B20_2 = 0.
```

Compute B20_3 = 0.
Compute B20_4 = 0.
Compute B20_5 = 0.
Compute B20_6 = 0.
Compute B20_7 = 0.
Compute B20_8 = 0.
Compute B25_1 = 0.
Compute B25_2 = 0.
Compute B25_3 = 0.
Compute B25_4 = 0.
Compute B25_5 = 0.
Compute B25_6 = 0.
Compute B25_7 = 0.
Compute B25_8 = 0.
Compute B30_1 = 0.
Compute B30_2 = 0.
Compute B30_3 = 0.
Compute B30_4 = 0.
Compute B30_5 = 0.
Compute B30_6 = 0.
Compute B30_7 = 0.
Compute B30_8 = 0.
Compute B35_1 = 0.
Compute B35_2 = 0.
Compute B35_3 = 0.
Compute B35_4 = 0.
Compute B35_5 = 0.
Compute B35_6 = 0.
Compute B35_7 = 0.
Compute B35_8 = 0.
Compute B40_1 = 0.
Compute B40_2 = 0.
Compute B40_3 = 0.
Compute B40_4 = 0.

```
Compute B40_5 = 0.
Compute B40_6 = 0.
Compute B40_7 = 0.
Compute B40_8 = 0.
Compute B45_1 = 0.
Compute B45_2 = 0.
Compute B45_3 = 0.
Compute B45_4 = 0.
Compute B45_5 = 0.
Compute B45_6 = 0.
Compute B45_7 = 0.
Compute B45_8 = 0.


Do repeat birth = child1 to child16.
   Do if birth ge (DECINT+1-32*12) and birth le (DECINT-28*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_8 = b15_8+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_8 = b20_8+1.
      If (birth - dob ge 301 and birth - dob le 360) b25_8 = b25_8+1.
      If (birth - dob ge 361 and birth - dob le 420) b30_8 = b30_8+1.
      If (birth - dob ge 421 and birth - dob le 480) b35_8 = b35_8+1.
      If (birth - dob ge 481 and birth - dob le 540) b40_8 = b40_8+1.
      If (birth - dob ge 541 and birth - dob le 600) b45_8 = b45_8+1.
   End if.
   Do if birth ge (DECINT+1-28*12) and birth le (DECINT-24*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_7 = b15_7+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_7 = b20_7+1.
      If (birth - dob ge 301 and birth - dob le 360) b25_7 = b25_7+1.
      If (birth - dob ge 361 and birth - dob le 420) b30_7 = b30_7+1.
      If (birth - dob ge 421 and birth - dob le 480) b35_7 = b35_7+1.
      If (birth - dob ge 481 and birth - dob le 540) b40_7 = b40_7+1.
      If (birth - dob ge 541 and birth - dob le 600) b45_7 = b45_7+1.
   End if.
   Do if birth ge (DECINT+1-24*12) and birth le (DECINT-20*12).
```

```
    If (birth - dob ge 181 and birth - dob le 240) b15_6 = b15_6+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_6 = b20_6+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_6 = b25_6+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_6 = b30_6+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_6 = b35_6+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_6 = b40_6+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_6 = b45_6+1.
End if.
Do if birth ge (DECINT+1-20*12) and birth le (DECINT-16*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_5 = b15_5+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_5 = b20_5+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_5 = b25_5+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_5 = b30_5+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_5 = b35_5+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_5 = b40_5+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_5 = b45_5+1.
End if.
Do if birth ge (DECINT+1-16*12) and birth le (DECINT-12*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_4 = b15_4+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_4 = b20_4+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_4 = b25_4+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_4 = b30_4+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_4 = b35_4+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_4 = b40_4+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_4 = b45_4+1.
End if.
Do if birth ge (DECINT+1-12*12) and birth le (DECINT-8*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_3 = b15_3+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_3 = b20_3+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_3 = b25_3+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_3 = b30_3+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_3 = b35_3+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_3 = b40_3+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_3 = b45_3+1.
```

```
  End if.
  Do if birth ge (DECINT+1-8*12) and birth le (DECINT-4*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_2 = b15_2+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_2 = b20_2+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_2 = b25_2+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_2 = b30_2+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_2 = b35_2+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_2 = b40_2+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_2 = b45_2+1.
  End if.
  Do if birth ge (DECINT+1-4*12) and birth le (DECINT).
    If (birth - dob ge 181 and birth - dob le 240) b15_1 = b15_1+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_1 = b20_1+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_1 = b25_1+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_1 = b30_1+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_1 = b35_1+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_1 = b40_1+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_1 = b45_1+1.
  End if.
End repeat.
Execute.
```

C.4 Number of post-marital births in age-group i during period j

*Note: Premarital births = Total births – Post-marital births.

*To be set up in addition to the total population:.
Compute DOM = 'Date of first marriage'.

Compute DECINT = 12*(YRINT+1).
Variable label DECINT 'December of the year of interview'.

Compute B15_1 = 0.
Compute B15_2 = 0.
Compute B15_3 = 0.
Compute B15_4 = 0.
Compute B15_5 = 0.
Compute B15_6 = 0.
Compute B15_7 = 0.
Compute B15_8 = 0.
Compute B20_1 = 0.
Compute B20_2 = 0.
Compute B20_3 = 0.
Compute B20_4 = 0.
Compute B20_5 = 0.
Compute B20_6 = 0.
Compute B20_7 = 0.
Compute B20_8 = 0.
Compute B25_1 = 0.
Compute B25_2 = 0.
Compute B25_3 = 0.
Compute B25_4 = 0.
Compute B25_5 = 0.
Compute B25_6 = 0.
Compute B25_7 = 0.

Compute B25_8 = 0.
Compute B30_1 = 0.
Compute B30_2 = 0.
Compute B30_3 = 0.
Compute B30_4 = 0.
Compute B30_5 = 0.
Compute B30_6 = 0.
Compute B30_7 = 0.
Compute B30_8 = 0.
Compute B35_1 = 0.
Compute B35_2 = 0.
Compute B35_3 = 0.
Compute B35_4 = 0.
Compute B35_5 = 0.
Compute B35_6 = 0.
Compute B35_7 = 0.
Compute B35_8 = 0.
Compute B40_1 = 0.
Compute B40_2 = 0.
Compute B40_3 = 0.
Compute B40_4 = 0.
Compute B40_5 = 0.
Compute B40_6 = 0.
Compute B40_7 = 0.
Compute B40_8 = 0.
Compute B45_1 = 0.
Compute B45_2 = 0.
Compute B45_3 = 0.
Compute B45_4 = 0.
Compute B45_5 = 0.
Compute B45_6 = 0.
Compute B45_7 = 0.
Compute B45_8 = 0.

```
Do repeat birth = child1 to child16.
 Do if birth ge DOM.
   Do if birth ge (DECINT+1-32*12) and birth le (DECINT-28*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_8 = b15_8+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_8 = b20_8+1.
      If (birth - dob ge 301 and birth - dob le 360) b25_8 = b25_8+1.
      If (birth - dob ge 361 and birth - dob le 420) b30_8 = b30_8+1.
      If (birth - dob ge 421 and birth - dob le 480) b35_8 = b35_8+1.
      If (birth - dob ge 481 and birth - dob le 540) b40_8 = b40_8+1.
      If (birth - dob ge 541 and birth - dob le 600) b45_8 = b45_8+1.
   End if.
   Do if birth ge (DECINT+1-28*12) and birth le (DECINT-24*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_7 = b15_7+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_7 = b20_7+1.
      If (birth - dob ge 301 and birth - dob le 360) b25_7 = b25_7+1.
      If (birth - dob ge 361 and birth - dob le 420) b30_7 = b30_7+1.
      If (birth - dob ge 421 and birth - dob le 480) b35_7 = b35_7+1.
      If (birth - dob ge 481 and birth - dob le 540) b40_7 = b40_7+1.
      If (birth - dob ge 541 and birth - dob le 600) b45_7 = b45_7+1.
   End if.
   Do if birth ge (DECINT+1-24*12) and birth le (DECINT-20*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_6 = b15_6+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_6 = b20_6+1.
      If (birth - dob ge 301 and birth - dob le 360) b25_6 = b25_6+1.

      If (birth - dob ge 361 and birth - dob le 420) b30_6 = b30_6+1.
      If (birth - dob ge 421 and birth - dob le 480) b35_6 = b35_6+1.
      If (birth - dob ge 481 and birth - dob le 540) b40_6 = b40_6+1.
      If (birth - dob ge 541 and birth - dob le 600) b45_6 = b45_6+1.
   End if.
   Do if birth ge (DECINT+1-20*12) and birth le (DECINT-16*12).
      If (birth - dob ge 181 and birth - dob le 240) b15_5 = b15_5+1.
      If (birth - dob ge 241 and birth - dob le 300) b20_5 = b20_5+1.
```

```
    If (birth - dob ge 301 and birth - dob le 360) b25_5 = b25_5+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_5 = b30_5+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_5 = b35_5+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_5 = b40_5+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_5 = b45_5+1.
End if.
Do if birth ge (DECINT+1-16*12) and birth le (DECINT-12*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_4 = b15_4+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_4 = b20_4+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_4 = b25_4+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_4 = b30_4+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_4 = b35_4+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_4 = b40_4+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_4 = b45_4+1.
End if.
Do if birth ge (DECINT+1-12*12) and birth le (DECINT-8*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_3 = b15_3+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_3 = b20_3+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_3 = b25_3+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_3 = b30_3+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_3 = b35_3+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_3 = b40_3+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_3 = b45_3+1.
End if.
Do if birth ge (DECINT+1-8*12) and birth le (DECINT-4*12).
    If (birth - dob ge 181 and birth - dob le 240) b15_2 = b15_2+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_2 = b20_2+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_2 = b25_2+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_2 = b30_2+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_2 = b35_2+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_2 = b40_2+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_2 = b45_2+1.
End if.
Do if birth ge (DECINT+1-4*12) and birth le (DECINT).
```

```
    If (birth - dob ge 181 and birth - dob le 240) b15_1 = b15_1+1.
    If (birth - dob ge 241 and birth - dob le 300) b20_1 = b20_1+1.
    If (birth - dob ge 301 and birth - dob le 360) b25_1 = b25_1+1.
    If (birth - dob ge 361 and birth - dob le 420) b30_1 = b30_1+1.
    If (birth - dob ge 421 and birth - dob le 480) b35_1 = b35_1+1.
    If (birth - dob ge 481 and birth - dob le 540) b40_1 = b40_1+1.
    If (birth - dob ge 541 and birth - dob le 600) b45_1 = b45_1+1.
  End if.
 End if.
End repeat.
Execute.
```

Appendix D. Median age at first marriage and at first birth, and proportions of premarital births by residence, education and religion

Table D-1. Median age at first marriage by residence, education and religion.

	Residence		Education			Religion		
	Urban	Rural	None	Primary	Secondary	Catholic	Protestant	Moslem
Kenya	20.92	19.42	16.92	19.00	21.92	19.83	19.83	18.58
Madagascar	21.08	18.00	16.33	18.17	21.25	19.42	19.75	(18.00)*
Malawi	18.33	17.67	17.17	17.92	21.83	n.a.+	n.a.	n.a.
Mozambique	19.00	17.17	16.83	18.00	22.58	17.58	18.33	16.25
Namibia	25.92	24.00	21.50	24.00	26.50	22.42	25.50	n.a.
Tanzan. (91-92)	19.00	18.00	16.58	18.75	22.25	18.67	18.67	17.83
Tanzania (96)	19.17	18.42	16.92	18.83	22.50	19.00	19.25	18.00
Tanzania (99)	19.25	18.00	16.58	18.58	21.67	19.08	18.92	18.08
Uganda	18.83	17.33	16.58	17.42	20.67	17.67	17.92	17.42
Zambia	18.92	17.75	16.92	17.58	20.50	18.08	18.08	n.a.
Zimbabwe	20.33	19.00	17.33	18.58	20.92	n.a.	n.a.	n.a.

Table D-2. Median age at first birth by residence, education and religion.

	Residence		Education			Religion		
	Urban	Rural	None	Primary	Secondary	Catholic	Protestant	Moslem
Kenya	20.92	19.50	18.42	19.08	21.58	19.58	19.75	19.75
Madagascar	21.67	18.75	18.17	18.75	21.58	20.00	20.25	(18.92)*
Malawi	19.25	18.92	18.67	18.92	22.08	n.a.+	n.a.	n.a.
Mozambique	19.33	19.08	19.17	19.00	21.75	19.25	19.25	18.75
Namibia	20.50	20.92	20.00	20.08	22.00	20.08	21.00	n.a.
Tanzan. (91-92)	19.25	18.92	18.17	19.17	22.42	19.17	19.33	18.17
Tanzania (96)	19.67	19.25	18.42	19.50	22.83	19.58	19.58	19.08
Tanzania (99)	19.92	19.00	18.17	19.17	22.17	19.58	19.33	19.17
Uganda	19.50	18.50	18.08	18.50	20.67	18.75	19.00	18.25
Zambia	19.17	18.58	18.33	18.33	20.00	18.83	18.75	n.a.
Zimbabwe	20.25	19.50	18.75	19.00	21.00	n.a.	n.a.	n.a.

Table D-3. Percentage of first births which are premarital by residence, education and religion.

	Residence		Education			Religion		
	Urban	Rural	None	Primary	Secondary	Catholic	Protestant	Moslem
Kenya	31	33	17	35	37	35	34	17
Madagascar	20	24	17	25	24	23	23	(22)*
Malawi	17	11	11	12	28	n.a.+	n.a.	n.a.
Mozambique	31	15	13	22	40	17	26	13
Namibia	67	50	43	57	64	49	60	n.a.
Tanzan. (91-92)	25	20	13	28	19	25	24	19
Tanzania (96)	24	21	15	24	23	25	24	18
Tanzania (99)	21	16	9	23	13	23	24	14
Uganda	26	17	12	20	34	19	19	23
Zambia	25	20	12	19	38	20	22	n.a.
Zimbabwe	27	23	14	24	30	n.a.	n.a.	n.a.

* Less than 100 women in the category.

\+ n.a.: not available.

Appendix E. Total fertility rates and standardised total fertility rates

Table E-1. TFRs and *STFRs (in Italics)* from 15 to 39 years old.

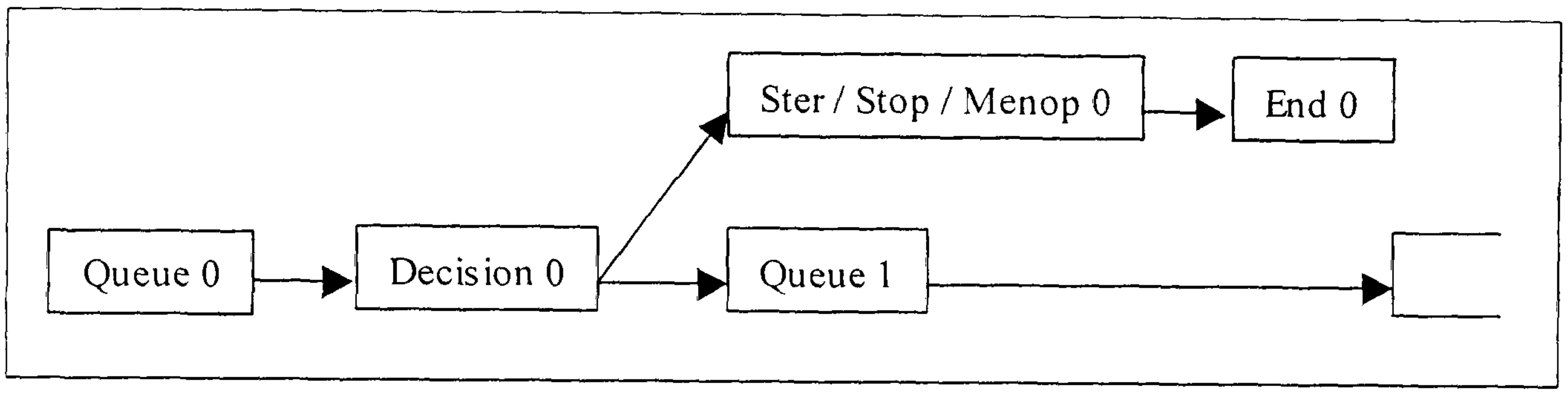
<table>
<tr><th></th><th>76</th><th>77</th><th>78</th><th>79</th><th>80</th><th>81</th><th>82</th><th>83</th><th>84</th><th>85</th><th>86</th><th>87</th><th>88</th><th>89</th><th>90</th><th>91</th><th>92</th><th>93</th><th>94</th><th>95</th><th>96</th><th>97</th><th>98</th><th>99</th></tr>
<tr><td>Kenya</td><td colspan="7"></td><td colspan="4">6.69</td><td colspan="4">5.91</td><td colspan="4">4.92</td><td colspan="4">4.55</td><td></td></tr>
<tr><td>*S Kenya*</td><td colspan="7"></td><td colspan="4">*6.19*</td><td colspan="4">*5.59*</td><td colspan="4">*4.77*</td><td colspan="4">*4.55*</td><td></td></tr>
<tr><td>Madagascar</td><td colspan="6"></td><td colspan="4">5.91</td><td colspan="4">5.32</td><td colspan="4">5.88</td><td colspan="4">5.16</td><td colspan="2"></td></tr>
<tr><td>*S Madagascar*</td><td colspan="6"></td><td colspan="4">*5.74*</td><td colspan="4">*5.21*</td><td colspan="4">*5.77*</td><td colspan="4">*5.16*</td><td colspan="2"></td></tr>
<tr><td>Malawi</td><td></td><td colspan="4">7.25</td><td colspan="4">6.79</td><td colspan="4">6.37</td><td colspan="4">5.81</td><td colspan="7"></td></tr>
<tr><td>*S Malawi*</td><td></td><td colspan="4">*6.95*</td><td colspan="4">*6.57*</td><td colspan="4">*6.14*</td><td colspan="4">*5.81*</td><td colspan="7"></td></tr>
<tr><td>Mozambique</td><td colspan="6"></td><td colspan="4">5.68</td><td colspan="4">5.48</td><td colspan="4">5.68</td><td colspan="4">4.69</td><td colspan="2"></td></tr>
<tr><td>*S Mozambique*</td><td colspan="6"></td><td colspan="4">*5.57*</td><td colspan="4">*5.37*</td><td colspan="4">*5.59*</td><td colspan="4">*4.69*</td><td colspan="2"></td></tr>
<tr><td>Namibia</td><td></td><td colspan="4">5.66</td><td colspan="4">5.18</td><td colspan="4">4.79</td><td colspan="4">4.81</td><td colspan="7"></td></tr>
<tr><td>*S Namibia*</td><td></td><td colspan="4">*5.34*</td><td colspan="4">*5.07*</td><td colspan="4">*4.71*</td><td colspan="4">*4.81*</td><td colspan="7"></td></tr>
<tr><td>Tanzania 91-92</td><td colspan="4">6.61</td><td colspan="4">6.18</td><td colspan="4">5.88</td><td colspan="4">5.40</td><td colspan="8"></td></tr>
<tr><td>*S Tanzania91-92*</td><td colspan="4">*6.28*</td><td colspan="4">*6.05*</td><td colspan="4">*5.84*</td><td colspan="4">*5.40*</td><td colspan="8"></td></tr>
<tr><td>Tanzania 96</td><td colspan="5"></td><td colspan="4">5.90</td><td colspan="4">5.86</td><td colspan="4">5.58</td><td colspan="4">5.12</td><td colspan="3"></td></tr>
<tr><td>*S Tanzania 96*</td><td colspan="5"></td><td colspan="4">*5.77*</td><td colspan="4">*5.73*</td><td colspan="4">*5.51*</td><td colspan="4">*5.12*</td><td colspan="3"></td></tr>
<tr><td>Tanzania99</td><td colspan="8"></td><td colspan="4">5.99</td><td colspan="4">5.73</td><td colspan="4">5.47</td><td colspan="4">5.05</td></tr>
<tr><td>*S Tanzania 99*</td><td colspan="8"></td><td colspan="4">*5.68*</td><td colspan="4">*5.46*</td><td colspan="4">*5.29*</td><td colspan="4">*5.05*</td></tr>
<tr><td>Uganda</td><td colspan="4"></td><td colspan="4">6.64</td><td colspan="4">6.59</td><td colspan="4">6.26</td><td colspan="4">6.08</td><td colspan="4"></td></tr>
<tr><td>*S Uganda*</td><td colspan="4"></td><td colspan="4">*6.48*</td><td colspan="4">*6.54*</td><td colspan="4">*6.26*</td><td colspan="4">*6.08*</td><td colspan="4"></td></tr>
<tr><td>Zambia</td><td colspan="5"></td><td colspan="4">6.86</td><td colspan="4">6.27</td><td colspan="4">5.97</td><td colspan="4">5.78</td><td colspan="3"></td></tr>
<tr><td>*S Zambia*</td><td colspan="5"></td><td colspan="4">*6.45*</td><td colspan="4">*6.03*</td><td colspan="4">*5.77*</td><td colspan="4">*5.78*</td><td colspan="3"></td></tr>
<tr><td>Zimbabwe</td><td colspan="3"></td><td colspan="4">6.25</td><td colspan="4">5.97</td><td colspan="4">5.02</td><td colspan="4">4.20</td><td colspan="5"></td></tr>
<tr><td>*S Zimbabwe*</td><td colspan="3"></td><td colspan="4">*5.83*</td><td colspan="4">*5.70*</td><td colspan="4">*4.84*</td><td colspan="4">*4.20*</td><td colspan="5"></td></tr>
</table>

Appendix F. Model 1 in SIMUL8

The first and second birth intervals for Model 1 are explained in detail. The subsequent intervals can easily be deducted from the second interval. The input values are taken from Table 5-1, i.e. the results from the 1996 TDHS.

Figure F-1 shows the first birth interval as modelled in Simul8.

Figure F-1. First birth interval for Model 1 in Simul8



Each woman entered the model through <u>Queue 0</u>, where three labels are attached and set:

- *CEB*, the number of children ever born to the woman, set to 0;
- *Reproductive life*, the time in months between the woman's first and most recent births, set to 0;
- *Menopause*, a dummy variable set to 1 and which remains 1 until a woman has reached menopause, at which time it takes the value 2.
- *End of reproductive life* randomly drawn from a N(300,75) distribution.

In <u>Decision 0</u>, a woman is randomly routed out following one of two paths:

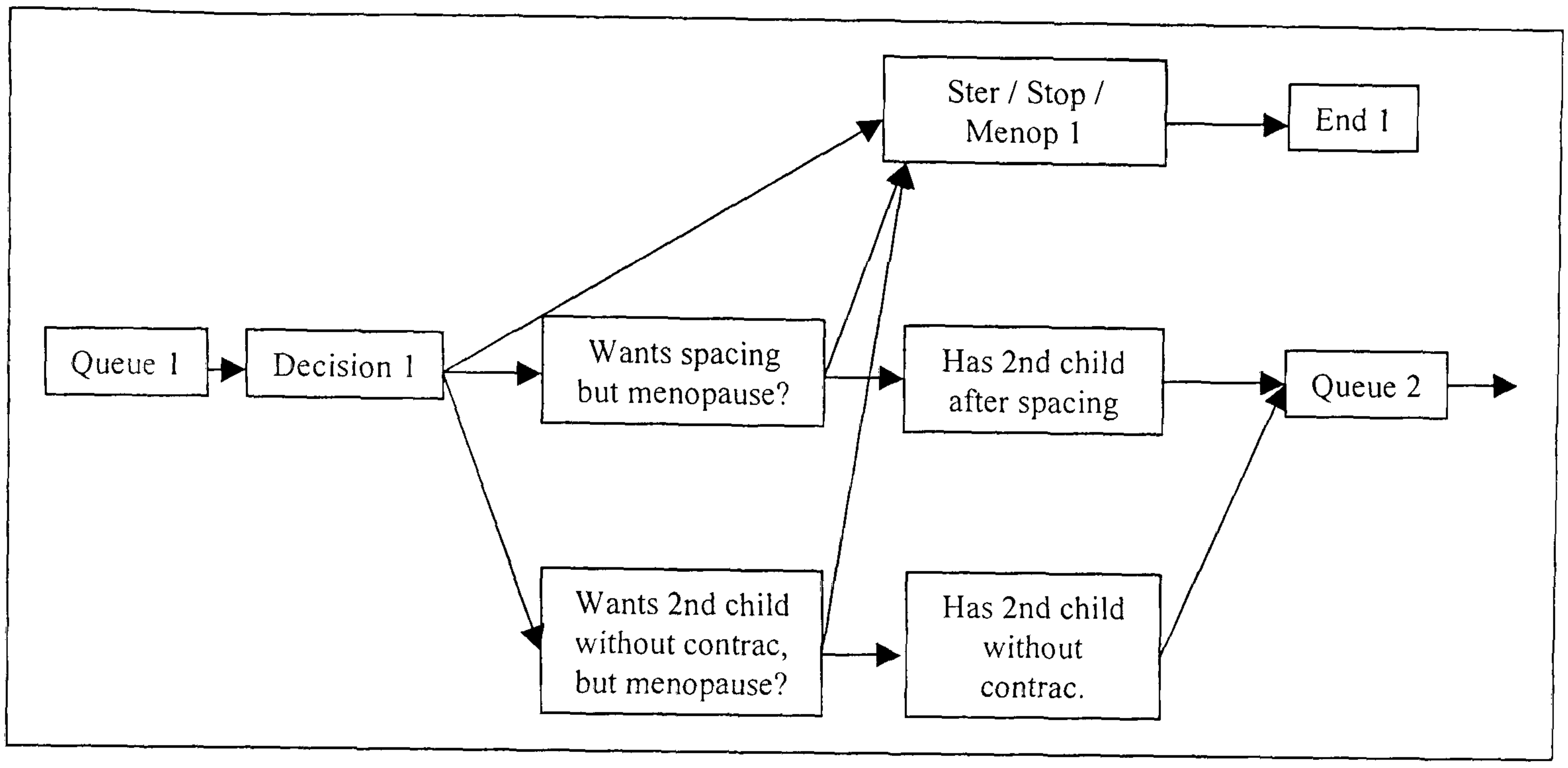
- 2 % are or become sterile, decide not to have any children or reach menopause;
- 98 % join <u>Queue 1</u> and will have a first child.

<u>Ster / Stop / Menop 0</u> is a transition to <u>End 0</u>, i.e. the end of reproductive life for women who do not have any children.

<u>Queue 1</u> joins the first and second birth intervals.

Figure F-2 shows the second birth interval as modelled in Simul8.

Figure F-2. Second birth interval for Model 1 in Simul8



In <u>Decision 1</u>, the label *CEB* is incremented by 1, i.e. the woman has her first child. There are three randomly assigned routes out:

- 8.1 % become sterile, decide not to have any children or reach menopause;
- 14.6 % want to space their second birth;
- 77.3 % want a second child without using contraception.

<u>Ster / Stop / Menop 1</u> and <u>End 1</u> are similar to <u>Ster / Stop / Menop 0</u> and <u>End 0</u>.

In <u>Wants spacing but menopause?</u>, we check if the woman would not reach menopause before the end of the interval and should therefore be routed to <u>Ster / Stop / Menop 1</u>. The following label action is defined:

If *Reproductive life* + (value drawn from a beta distribution of mean 45 months) > *End of reproductive life*,

Set *Menopause* = 2.

In other words, if a woman reaches the end of her reproductive life during this interval, then the label *Menopause* becomes 2. The <u>routing</u> out here is:

- to <u>Ster / Stop / Menop 1</u> if *Menopause* is 2;
- to <u>Has second child after spacing</u> if *Menopause* is 1.

Wants second child without contraception but menopause? is similar to Wants spacing but menopause?, except that the interval is drawn from a beta distribution of mean 32 instead of 45 months, and the routing out is to Ster / Stop / Menop 1 and Has second child without contraception.

In Has second child after spacing the label *Reproductive life* is increased by the value from the beta distribution of mean 45 months drawn in the previous step.

Similarly, in Has second child without contraception the label *Reproductive life* is increased by the value from the beta distribution of mean 32 months drawn in the previous step.

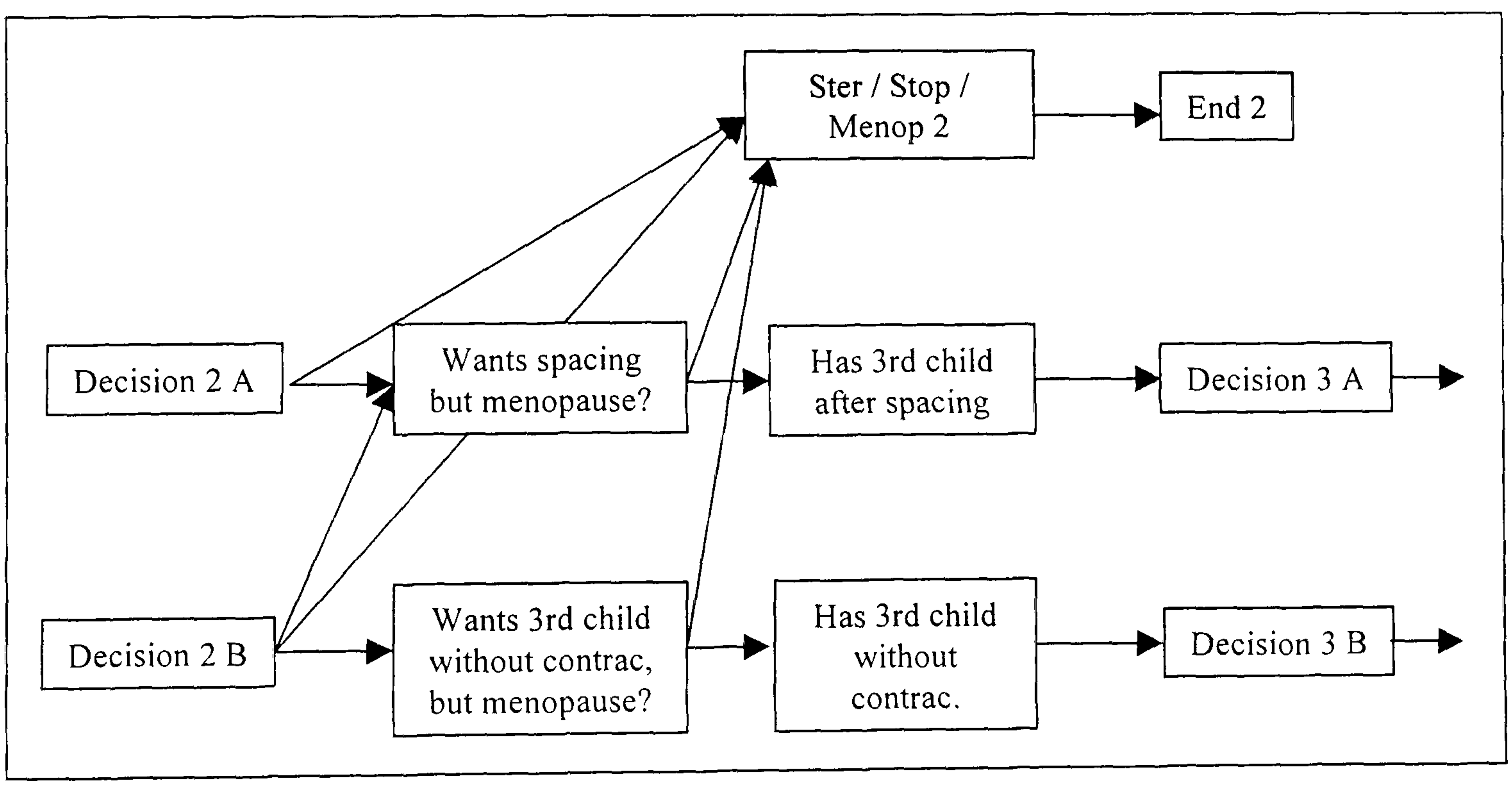
Queue 2 joins the second and third birth intervals.

Appendix G. Model 2 in SIMUL8

The first birth interval in Model 2 is constructed in exactly the same way as in Model 1. From Figure 5-4, it is straightforward to adjust Model 1 for the second birth interval. So the third interval will be explained here. The subsequent intervals can easily be deduced from the third interval. The input values are taken from Tables 5-1 and 5-2, i.e. the results from the 1996 TDHS.

Figure G-1 shows the third birth interval as modelled in Simul8. Compared to Model 1, Queue 1, Queue 2, etc. are not needed any more. They were needed in Model 1 to 'gather' the women coming from different paths. The activities with the same names as in Model 1 operate in the same way. Therefore the only two activities to describe are Decision 2 A and Decision 2 B.

Figure G-1. Third birth interval for Model 3 in Simul8.



In Decision 2 A, the label *CEB* is incremented by 1, i.e. the woman has her second child. There are two randomly assigned routes out:

- 8.5 % become sterile, decide not to have any children or reach menopause;
- 91.5 % want to space their third birth;

In Decision 2 B, the label *CEB* is incremented by 1, i.e. the woman has her second child. There are three randomly assigned routes out:

- 8.5 % become sterile, decide not to have any children or reach menopause;
- 5 % want to space their third birth;
- 86.5 % want a third child without using contraception.

As shown in Figure G-1, the main difference between the two models is the arrow from Decision 2 B to Wants spacing but menopause?. It irreversibly moves women from not using contraception to using contraception for the rest of their reproductive life.