TIMING EFFECTS AND THE INTERPRETATION OF PERIOD FERTILITY

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ABSTRACT

Low fertility levels and later childbearing in many developed countries have reinvigorated the debate between period and cohort perspectives on fertility and on the meaningfulness of the period TFR. Here, fertility timing effects are defined as level changes in period fertility that do not reflect level changes in the completed fertility of cohorts. That definition leads to the Average Cohort Fertility (ACF) as a measure of period fertility adjusted for timing effects.

In an influential paper, Bongaarts and Feeney (1998) presented an alternative approach and a different measure, TFR*, to adjust for timing effects. Here, the two measures are compared. In the context of model populations, the ACF performs well, reflecting an average of the fertility of the active cohorts. The Bongaarts-Feeney TFR* is frequently unreliable, however, and can be erratic when there are shifts or cycles in period timing. When applied to 20th century U.S. experience, the ACF shows the stability associated with cohort measures. In contrast, the TFR* behaves like a period measure, and yields adjustments that are often wide of the mark.

The empirical and conceptual stability of the ACF can quantify the substantial impact that timing effects had during the “Birth Dearth” of the 1970s. The period TFR reached a low of 1.74 in 1976, but the ACF never went below 2.06 during the 1970s.

Timing Effects and the Interpretation of Period Fertility

The sustained below replacement fertility recently observed in many developed countries has renewed debate on period fertility measures and their interpretation. In particular, the increases in the mean age at childbearing seen in many very low fertility countries has focused attention on the impact of timing factors. The recent *Science* article by Lutz, O'Neill, and Scherbov (2003) is one example. Beginning with the standard measure of fertility, the Total Fertility Rate (TFR), it emphasized the importance of delayed childbearing in further depressing the already low fertility in the 15 nations of the European Union. Arguing that a late pattern of fertility would greatly increase the projected future decline in population size, the article advocated the adoption of population policies to discourage further delays in childbearing.

The Total Fertility Rate is the number of children a woman would have over her lifetime if she experienced a given set of age-specific fertility rates (ASFRs). Most commonly, as in Lutz, O'Neill, and Scherbov (2003), the ASFRs for a particular year (or period) are used, the result being a period TFR. Alternatively, rates describing a cohort (typically persons born in a given year) can be used, yielding a cohort TFR (or CTFR). The period TFR is a synthetic cohort measure. It does not describe the experience of an actual group of persons, but treats the rates of a particular year as if they characterized the lifetime experience of a birth cohort.

In the past, a number of fertility analysts, most notably Norman Ryder (1969, 1980, 1986), have championed the cohort perspective as the most appropriate way to analyze fertility. Cohorts reflect real groups of women, their common background and circumstances, their life cycle progression, and their past reproductive history. Populations may have fertility year by year, but women have children over the course of their lives. Fertility theories are typically theories of completed family size (i.e. cohort fertility) and, over time, patterns of cohort TFRs have been found to be smoother and less volatile than period TFRs. From the cohort perspective, a key shortcoming of the period TFR is its inability to distinguish a change in the timing (or tempo) of cohort fertility from a change in the level (or quantum) of cohort fertility. A decline in a given year's ASFRs may reflect a decline in the CTFR of cohorts currently childbearing, or it may only be a timing effect, a postponement of fertility to a later point in the cohort life cycle with no change in the CTFR.

The arguments for the cohort perspective have been extremely persuasive, and many demographers regard the cohort as the most appropriate way to study fertility. In recent years, however, the cohort emphasis has been strongly challenged. Ni Bhrolchain (1992) noted that a consistent cohort position implies a fixed-target model of reproductive decision making that is not supported by the evidence. Statistical investigations of fertility data have consistently shown that it is the period, not the cohort, that is the prime source of variation in fertility behavior (cf. the reviews in Hobcraft, Menken, and Preston 1982, and in Ni Bhrolchain 1992). Moreover, while distinctive age patterns of period fertility have been observed, no distinctive cohort age patterns have emerged. Instead, in different periods, all cohorts have been found to shift in a more or less similar manner. That pattern is in sharp contrast to the one observed in mortality analysis, where clear cohort regularities have been observed.

Those findings, while important, are open to interpretations that are considerably more supportive of the cohort view. The fact that cohort changes account for less variability in fertility than period changes just means that there is more variability in period fertility. The critical view simply offers a different interpretation than does the argument that advocates the cohort approach because the CTFR is a more stable measure. It is the quality, not the quantity of cohort variability that matters, and it is changes in completed family size that are often seen as most meaningful. The lack of a characteristic cohort pattern is not a real concern because the cohort perspective emphasizes the relative stability of completed family size. There are many ways for individuals to achieve their lifetime fertility goals, and it is reasonable to expect that period conditions influence behavior. Consider the analogy of a drive from one place to another. The driver proceeds at different speeds under different road conditions, while proceeding to a given destination.

The criticism that the cohort perspective implies a fixed reproductive target is more serious, because there is good evidence that no such target exists (cf. Lee 1980). Still, the fact that individuals alter their childbearing goals during their reproductive years is troublesome only if one adopts an extreme cohort view. One can readily concede that period conditions can influence both the timing and the level of cohort reproduction while still viewing completed cohort fertility as the most informative measure of fertility behavior. Moreover, early cohort goals can be important even if they later change. Returning to the driving analogy, the original destination can still be meaningful even if circumstances lead the driver to stop earlier or proceed further.

The preceding argument is to reinforce the view that the cohort perspective affords a valid approach to conceptualizing and measuring fertility. The period perspective is valid as well, and is essential for studying birth trajectories and the size and age structures of populations. An exclusively cohort view can even be misleading, as it is possible for cohort fertility to always exceed replacement level while birth cohort size steadily falls (Schoen and Jonsson 2003). Here, because the timing of fertility is the focus of interest, we need to juxtapose period and cohort behavior. The period perspective alone is not sufficient, because as Bongaarts and Feeney (1998: 278) acknowledge, “a notion of ‘deferring’ or ‘advancing’ births necessarily refers at some level to cohorts.”

THE BONGAARTS-FEENEY TIMING ADJUSTMENT

Much of the recent discussion of fertility timing was framed in an influential article by Bongaarts and Feeney (1998). Emphasizing that the period TFR is subject to distortion from changes in the timing of childbearing, they sought to separate the quantum component of the TFR from its tempo component. Their decomposition proceeded in the following manner. With f(x,t) the fertility rate of women aged x at time t (i.e. the number of births to women aged x at time t divided by the number of women aged x at time t), the year t TFR can be written

$$\mathrm{TFR}(t) = \Sigma_x f(x,t) \tag{1}$$

where index of summation x ranges over all childbearing ages. Bongaarts and Feeney (1998) defined the year t TFR for birth order o, $\mathrm{TFR}_o(t)$, as the sum of age-specific fertility rates of order o, specifically as the sum of “incidence” rates where births of order o to women aged x at time t were divided by the number of women (at all birth orders) aged x at time t. As a result,

$$\mathrm{TFR}(t) = \Sigma_o \mathrm{TFR}_o(t) \tag{2}$$

Based on a mathematical derivation given in the Appendix, Bongaarts and Feeney (1998) claimed that $\mathrm{TFR}_o(t)$ could be adjusted for tempo effects using the relationship

$$\mathrm{TFR}_o(t)^* = \mathrm{TFR}_o(t)/[1-r_o(t)] \tag{3}$$

where the asterisk denotes the adjusted $\mathrm{TFR}_o(t)$ and $r_o(t)$ represents the change, from the beginning to the end of year t, in the mean age of childbearing for birth order o. Their period TFR, adjusted to eliminate timing effects, is then given by

$$TFR(t)^* = \Sigma_o TFR_o(t)^* \quad (4)$$

Bongaarts and Feeney (1988: 286) concluded that "Tempo-adjusted total fertility rates should be added to the existing set of fertility measures used to assess fertility trends. In many if not all circumstances they will do a better job of doing what conventional total fertility rates do poorly in the presence of tempo changes: reveal the level of completed fertility implied by current childbearing behavior."

Bongaarts made use of the Bongaarts-Feeney adjustment to advance similar arguments elsewhere. Bongaarts stated that he was finding the adjusted TFR to be an accurate predictor of cohort fertility (United Nations 2000, p5). In a short article in *Science*, Bongaarts (1998:420) wrote "Once women stop deferring births, the distortion disappears and the very low fertility rates observed in the developed world should rise closer to the two children most couples want. This has already happened in the United States, where fertility rose from 1.77 to 2.08 births per women between 1975 and 1990 as birth deferment stopped. It is therefore plausible to assume that fertility in Europe will not decline further and might even turn upward soon." Bongaarts (1999) examined developing nations, arguing that trends in the total fertility of many less developed countries are likely to be distorted by timing effects. The article concluded (Bongaarts 1999:287), "In the absence of tempo effects Taiwan's TFR would have been close to the replacement level, instead of the observed level of 1.74. ... In the mid-1980s Colombia's TFR was depressed by an estimated 0.7 births per woman.." Bongaarts (2002) argued that during the 1980s and 1990s, period TFRs in many developed countries were temporarily depressed by a rise in the mean age at childbearing. "The distortion of the TFR is as great as 0.4 births per woman in Italy and Spain," (Bongaarts 2002:589).

Those assertions stimulated considerable discussion and some critical reactions. Lesthaeghe and Willems (1999) took issue with the claim made in Bongaarts (1998) that European fertility was likely to rebound substantially in coming years. From a detailed examination of fertility patterns in European Union countries, Lesthaeghe and Willems (1999:286) concluded that the Bongaarts-Feeney "model is not to be recommended ... as a prospective tool without caution: the adjusted total fertility rates do not necessarily approximate expected future levels of fertility absent further delays." The same substantive conclusion was reached by Frejka and Calot (2001). From a study of 27 low fertility countries, they found that women born during the late 1960s and 1970s are experiencing lower fertility at comparable ages than did earlier cohorts. They felt that only a fraction of the "shortfall" at the younger ages would be made up, and concluded that the completed family size of those cohorts would be lower as well.

Van Imhoff and Keilman (2000), using data for the Netherlands and Norway, argued that adjusted TFRs basically followed the same pattern as unadjusted TFRs, while the pattern of actual CTFRs was quite distinct. Thus they saw no basis for the Bongaarts-Feeney claim that their adjusted TFR would reveal the level of completed fertility implied by current childbearing behavior. Moreover, they criticized Bongaarts and Feeney (1998) for using incidence rates when examining parity, noting that such rates are methodologically unsound and can lead to impossible results (e.g. the average woman having more that one first birth). Van Imhoff and Keilman (2000: 552) concluded that "although attractively simple, the Bongaarts-Feeney procedure does not solve the tempo-distortion problem."

Van Imhoff (2001) used data for 1950 and later years from Netherlands and Italy to examine the performance of the Bongaarts-Feeney adjustment. He found that in those countries period TFRs during the 1970s and 1980s were depressed by timing effects, and that the Bongaarts-Feeney approach adjusted them in the right direction. However, van Imhoff (2001) did not have a clear standard for comparison, and saw no reason why the Bongaarts-Feeney method's underlying assumptions should be satisfied. After examining a range of methods for inferring cohort fertility from period measures, van Imhoff's conclusion echoed Ryder's earlier judgment that cohort behavior cannot be accurately measured until that behavior has been completed.

Kim and Schoen (1999, 2000) attacked the methodological foundation of the Bongaarts-Feeney adjustment. Bongaarts-Feeney (1998) showed, in Scenario 2 in its Appendix, that if the schedule of age-specific fertility rates maintained a constant shape but shifted to higher (or lower) ages by a fixed amount each year, equation (3) would hold and the adjusted TFR would equal the CTFR. That was a previously unknown relationship that Kim and Schoen (1999) confirmed. In their Scenarios 3 and 4, however, Bongaarts and Feeney (1998) claimed to extend that Scenario 2 relationship to situations where the fertility schedule moves from year to year by varying amounts. Kim and Schoen (2000) showed that claim was not correct, drastically circumscribing the mathematical basis of the Bongaarts-Feeney adjustment. They also demonstrated that the Bongaarts-Feeney adjustment yielded unstable and inappropriate values when the fertility schedule moved cyclically over time.

In their Reply to criticisms from van Imhoff and Keilman(2000) and Kim and Schoen

(2000), Bongaarts and Feeney (2000) implicitly abandoned their claim that their adjusted TFR gives a demonstrably better indication of the level of completed fertility implied by current fertility than does the period TFR. Instead, Bongaarts and Feeney (2000: 560) stated that "Our goal is simply to provide a period measure of fertility that removes tempo distortions in conventionally calculated total fertility rates." They did not explain how they attain that goal, except to re-iterate that such a measure is provided by their adjustment. Yet, as Bongaarts (2002: 434) wrote, in the Bongaarts-Feeney formulation, "the terms quantum and tempo have meaning and can be calculated only on the basis of a conceptualization that introduces the [Bongaarts-Feeney] tempo-adjusted TFR". Under that conceptualization, as Zeng and Land (2002: 270) observe, the Bongaarts-Feeney adjusted period TFR "is actually the average total number of births per woman of a hypothetical cohort that has gone through the imagined extended period with changing tempo but constant quantum and invariant shape of the [fertility] schedule."

Does such a measure provide an appropriate adjustment for tempo effects? The Bongaarts-Feeney approach is based on changes in *period* timing, reflecting the difference between means of period rate schedules, not on changes in cohort childbearing. Consequently, it does not address the classic timing question of how changes in cohort tempo impact period quantum. Indeed, Bongaarts and Feeney (1998: 275) explicitly assume that there are *no cohort effects*, only age, period, parity, and duration effects. If the period mean age at childbearing rises, the Bongaarts-Feeney adjustment is always upward because women are assumed to be exposed to the given fertility rates over a longer childbearing interval. Yet, in actual populations, changes in either cohort quantum or tempo could cause the period mean age at childbearing to rise. No evidence is cited to show that childbearing ages commonly shift as assumed, and there is good reason to believe that the highest age of childbearing varies very little[1]. Especially problematic is assuming that an increase in the mean age at childbearing that is observed over a single period persists, year after year, throughout the reproductive lifespan of a hypothetical cohort. That assumption is an essential part of the Bongaarts-Feeney adjustment, but by perpetuating a timing change observed in a single period it may well magnify tempo distortions rather than remove them. In sum, the Bongaarts-Feeney adjustment lacks a clear conceptual foundation, adjusts for tempo using a procedure that re-defines the meaning of tempo, and is based on strong assumptions that rarely characterize actual populations.

Despite the criticism to which Bongaarts and Feeney (1998) was subjected, the approach continues to enjoy considerable prominence. Zeng and Land (2001) performed sensitivity analyses that showed the Bongaarts-Feeney adjusted TFR was generally robust to violations of the "constant shape" of fertility assumption. Kohler and Philipov (2001) derived a more general relationship that included the Bongaarts-Feeney adjustment as a special case. Kohler and Ortega (2002) further extended those ideas and presented tempo-adjusted period parity progression measures.[2] A U.S. National Academy of Sciences report on population projection (National Research Council 2000: Chapter 4) gave the the Bongaarts-Feeney adjustment considerable attention in its discussion of post-transition fertility. The highly visible *Science* article by Lutz, O'Neill, and Scherbov (2003) relied heavily on applications of the Bongaarts-Feeney adjustment in its interpretation of recent European fertility levels.

To recapitulate, the appearance of unprecedented and unexpected low levels of fertility has brought timing considerations to the forefront in current fertility analyses. However, the weaknesses in the Bongaarts-Feeney adjustment procedure cast doubt on a number of those studies, and suggest that a re-appraisal of fertility timing concepts and measures is appropriate.

RE-EXAMINING FERTILITY TIMING

The immediate post-World War II period saw abrupt rises in U.S. period fertility, marriage, and divorce. Cohort changes were much more modest (or nonexistent). Those sharp increases were largely produced by shifts in cohort timing, as numerous cohorts simultaneously adjusted to postwar conditions (cf. Ryder 1986, Schoen et al 1985). Such timing effects are inherently cohort phenomena, and can be exemplified by a woman delaying (or advancing) a birth, shifting fertility from one year to another without changing completed family size. As Ryder (1980: 16) emphasized, "The fundamental flaw in research based on the period mode of temporal aggregation is simply that changes in cohort tempo are manifested as changes in period quantum." Hence, in this paper, the term timing effects is used to refer to level changes in period fertility that do not reflect level changes in the completed fertility of cohorts.[3,4]

That conceptualization needs to be operationalized in order to quantify precisely what timing effects are in any given year. To do so, we can note that if a year's fertility is increased (or decreased) by timing effects, then that year should have a greater (or lesser) share of the fertility of the cohorts that are actively reproducing. It follows that we seek a measure that examines the fertility behavior of a period and assesses the extent to which that *period* has a disproportionate share of *cohort* fertility.

Such a measure of fertility timing already exists, and was independently and roughly contemporaneously derived by Butz and Ward (1979) and by Ryder (1980). The measure, called the Timing Index by Butz and Ward (1979), looks at the proportion of *cohort* fertility contributed, *in a particular period*, by the women of reproductive age during that period. Paralleling equation (1), the cohort TFR for women born in year τ can be written

$$\mathrm{CTFR}(\tau) = \Sigma_x f(x,\tau+x) \qquad (5)$$

For the cohort born in year τ, the proportion of all cohort fertility arising at age x (during year $\tau+x$) can be denoted $\beta(x,\tau+x)$ and written

$$\beta(x,\tau+x) = f(x,\tau+x) / \Sigma_a f(a,\tau+a) = f(x,\tau+x) / \mathrm{CTFR}(\tau) \qquad (6)$$

The Timing Index for year t can then be expressed as

$$\mathrm{TI}(t) = \Sigma_x \beta(x,t) \qquad (7)$$

The Timing Index measures the extent to which the *cohort* fertility of women childbearing during year t occurs in year t. When TI(t)=1, there is no timing effect, and the childbearing cohorts have fractions of their lifetime fertility during year t that are consistent with an unchanging cohort tempo. When TI(t)>1, year t contains a disproportionately large amount of the cohort fertility of the cohorts childbearing that year, indicating that cohort fertility was elevated in that year. Similarly, if TI(t)<1, year t contains a disproportionately small amount of the fertility of that year's childbearing cohorts, indicating that cohort fertility was depressed during that year. Consistent with our definition of a timing effect, the Timing Index reflects the relationship between cohort tempo and period quantum.

The Timing Index leads to a decomposition of the period TFR into quantum and tempo components. The average cohort fertility rate at time t, ACF(t), is the quantum component, and is given by

$$\mathrm{ACF}(t) = \mathrm{TFR}(t) / \mathrm{TI}(t) \qquad (8)$$

Equation (8) has the same form as equation (3), the analogous relationship in the Bongaarts-

Feeney method. Yet ACF(t) is more than an “adjusted TFR”, because it is an average of the fertility of the cohorts childbearing during year t. As Butz and Ward (1979: 666) noted, ACF(t) is a weighted arithmetic mean of those cohort TFRs, where the weight at age x is $\beta(x,t)$. Thus ACF does not reflect the fertility of any single cohort, but presents a behaviorally weighted average of the fertility of all active cohorts.

In the TI and ACF we have the desired tempo and quantum components of a period TFR. Those components are conceptually rooted, clearly interpretable measures that can easily be calculated from generally available data. Furthermore, they are strictly behavioral measures of the distribution of fertility, and carry no implication of “planning” or “intentions”. As Lee (1980) argued, a cohort’s fertility desires are likely to change over the course of its reproductive life. Such a “moving target” calls into question any interpretation of cohort timing or even completed cohort fertility that is based on fertility intentions.

The one shortcoming of the TI and ACF is that, for year t, the calculations require knowledge of the CTFR of all cohorts of reproductive age during year t. Such information is not available until 30-35 years after time t, reflecting the usual problem that confronts analyses of cohort fertility. There is no escaping the fact that if one wants to examine how cohort fertility is distributed over age, one needs information on the full age distribution of cohort reproduction.

MODELING THE NATURE OF TIMING EFFECTS

Given our index of fertility timing and the Bongaarts-Feeney tempo adjustment, we need to examine how those measures respond when different types of change occur. Model populations can be very useful in that regard, as they can depict “ideal” forms of change and can be manipulated systematically.[5]

Here we focus on period change, as that is the focus of most current interest and Kim and Schoen (1999) found that period and cohort changes were qualitatively similar in effect. Rather than seek complex analytical solutions, the objective is to examine the performance of TFR* and ACF under 3 plausible patterns of period tempo change, with period quantum always held fixed at 1. Specifically, we examine (i) increases in the mean age at childbearing to a new, constant level; (ii) increases in the mean age at childbearing that continue indefinitely; and (iii) increases and decreases in the mean age at childbearing that cycle continuously. A one-time shift in timing is the basic type of change. That can be followed by constant timing, continuing increases, or a cyclical pattern of increases and decreases, each of which elicits a different response from the 2 measures being considered.

Five year age/time intervals are used, with change beginning at time 50. Prior to time 50, the age pattern of fertility is that observed for U.S. females in 1975 (Keyfitz and Flieger 1990, p346), with the level of period fertility set at 1. The calculations ignore parity. To examine changes in tempo, we adjust the base cohort fertility rates keeping period quantum constant at 1. With $\phi(x)$ the standard rate at age x and $\phi_{adj}(x)$ the tempo adjusted rate, the adjusted rate is given by

$$\phi_{adj}(x) = \phi(x)\,\lambda^x \;/\; \Sigma_a\;\phi(a)\,\lambda^a \qquad (9)$$

With $\lambda>1$, multiplication by λ^x increases fertility rates more at older ages than at younger ages. Dividing each $\phi(x)\lambda^x$ product by their sum over all ages insures that the $\phi_{adj}(x)$ sum to 1, but moves the fertility pattern toward the older ages. The $\phi(x)\lambda^x$ transformation is a useful analytical tool that yields a reasonable fertility pattern, has been used by a number of researchers, and is part of the structure of the Coale-Trussell Model Fertility Schedules (Coale and Trussell, 1974;

Schoen and Kim, 1996).

To incorporate change over time, we use the relationship

$$\lambda = 1 + bt \tag{10}$$

where b denotes the annual rate of increase underlying the fertility transformation. The Mean Age at Childbearing (MAC) is calculated from the rates alone, without population weights. The value of r(t) was obtained as in Bongaarts and Feeney (1998, p290), i.e. from

$$r(t) = 0.5*[\,MAC(t+1) - MAC(t-1)\,] \tag{11}$$

Fixed-Period Upward Shifts in Period Timing

Figure 1 shows the implications of a rise in the MAC from an initial value of 25.77 years to a higher level, with a constant MAC thereafter. Four different patterns of change are considered, combining shifts lasting 20 or 40 years with annual fertility transformation (b) rates of .02 and .04. In each instance, values of TFR* and ACF are shown, along with MAC (divided by 25 so a single scale can be used).

The fixed-term increase in MAC causes both TFR* and ACF to rise and then fall back to 1. However, the rise in TFR* is both steeper and greater than the rise in ACF. The rise in TFR* increases with rate b. However, TFR* is largely insensitive to the length of the period of increasing ages at childbearing, as it implicitly assumes a continuing increase. The rise in ACF is sensitive to both factors. In Year 40, 10 years before the start of the MAC increase, the ACF has risen to 1.02 because it is influenced by the higher fertility that will be experienced by cohorts active at that time. The differences between the 2 measures increase with b, but can be appreciable even for b=.02. For example, in Panel a at Year 60, the ACF is 1.11 while the TFR* is 1.17. Because TFR* focuses on the experience of a single year, it understates the average fertility of active cohorts around the beginning and the end of tempo changes, but overstates the average fertility of the active cohorts during the period of tempo change.

Continuing Increases in Period Timing

Figure 2 shows the implications of increases in the mean age at childbearing that continue indefinitely, at rates of b=.02 and b=.04. Since this approximates the pattern implicitly assumed in calculating TFR*, differences between the measures should be minimized.

The extent of those differences increases with b, and the largest ones are concentrated in the years immediately before and after the onset of the MAC increases. In Year 55, the difference (TFR*−ACF) is 0.04 when b=.02 and 0.13 when b=.04. By Year 65 (when b=.02) or Year 90 (when b=.04) the differences between TFR* and ACF have diminished to 0.01. In the long term, both measures decline to zero.

Cyclical Increases and Decreases in Period Timing

It is quite important to consider cyclical changes in timing, because from the Roaring 1920s to the Baby Boom 1960s, or from the Depression of the 1930s to the Birth Dearth of the 1970s, cycles of approximately 40 years have characterized 20th century fertility in much of the West, and especially in the United States. To model such patterns, **Figure 3** presents results for our measures for cycle lengths of 20 and 40 years and b values of .02 and .04. As previously found by Kim and Schoen (1999, 2000), the TFR* exaggerates the average fertility of active cohorts when the mean age at childbearing moves up and down. The exaggerations are greater for faster changes in MAC, but vary little with the length of the cycle. The ACF fluctuates only slightly with cycles of 20 years and b=.02, but more when b is larger or the cycle length increases. In all cases, however, ACF varies substantially less than TFR*.

TIMING EFFECTS IN THE UNITED STATES, 1917-1997

To move beyond an examination of models, we consider 20th century experience in the United States. The longstanding interest in cohort fertility among American demographers led to the National Center for Health Statistics (NCHS) volume *Fertility Tables for Birth Cohorts by Color: United States, 1917-73* (Heuser, 1976), which provided detailed tabulations of fertility rates by year, age, and parity. NCHS continues to extend the series through tabulations in Volume I (Natality) of the annual *Vital Statistics of the United States* and through the *National Vital Statistics Reports* (and its predecessor series the *Monthly Vital Statistics Report*). Data from those sources have been used to assemble an array of fertility rates by (i) single year period, from 1917 through 1997; (ii) single year of age of mother, from ages 15 through 49; and (iii) parity of mother, recognizing parities 0 through 7 and 8+.

The period TFR is readily found from the above array of fertility rates using equation (1). The rate-based mean age of childbearing (MAC) follows from the age-weighted sum of the age-specific rates. The Bongaarts-Feeney TFR* follows from equations (2) - (4) and (11), using parity specific values (women of parity zero give birth to children of order one)[6]. Cohort TFRs were found from equation (5), and the ACF was calculated using equations (6) - (8). However, for 1950 and earlier years (i.e. cohorts born before 1902), where estimates were needed for fertility in years prior to 1917, the ACF was taken from Ryder (1980)[7]. For both the CTFR and ACF, rates were imputed to complete the experience of cohorts not finished childbearing by 2001, the latest data year. For each age, the imputed rate is the average of the rates observed during the 1997-2001 period. Essentially, cohort experience was completed by assuming that recent experience would continue into the future. Such a procedure is reasonable, indeed fairly conventional, and period fertility behavior has been fairly steady since the mid-1970s (NCHS, 2002, p7). Nonetheless, imputations are not observations, and during the 1990s rates for women under age 25 declined slightly and rates for women over 30 increased somewhat. The imputations affected values for cohorts born in 1953 and later years, with those born in 1968 and later having rates under age 35 imputed. The values of the basic fertility measures are shown in **Table 1**.

Figure 4 depicts the fertility patterns, as shown by the period TFR, ACF, and TFR*. For a comparison to cohort fertility, time t also shows the CTFR of the cohort born at time t−26. The period TFR fell to a low of 2.17 in 1933, rose to a peak of 3.68 in 1957, and was below 2.00 from 1972 through 1988. Since 1989, it has been in the 2.0 to 2.1 range. The Bongaarts-Feeney TFR* followed a very similar path, though often with leads or lags of several years. Cohort fertility, whether measured by ACF or by a shifted CTFR, has followed a similar pattern, but with fluctuations of smaller magnitude. The ACF shows smaller fluctuations than does the shifted CTFR. The two cohort measures are quite distinct, as the CTFR is the experience of a single cohort while ACF is an average of the completed fertility of a number of cohorts (and averaging tends to moderate the amount of change).

Figure 4 shows that timing effects, as indicated by the difference between the ACF and PTFR curves, have frequently been sizeable. The largest differences were in the Baby Boom years 1951-64, where they reached 2/3 of a child, but sizeable differences also occurred in the 1920s, 1930s, and 1970s. The 20th century American experience demonstrates that timing effects can substantially impact period fertility.

The timing effects that occurred in the 1920-27 period have received much less attention than those of the Depression and Baby Boom. During the 1920s timing influences raised the PTFR, though both the PTFR and ACF were declining, and there was little change in the mean age at childbearing. As pointed out by Butz and Ward (1979, p669), the "acceleration" of fertility in the "Roaring 20s" cannot be attributed to conscious decision-making, but is rather a consequence of the very low fertility that occurred during the Depression years of the 1930s. It is worth repeating that timing effects, as defined here, are not necessarily planned or intended but simply indicate how cohort fertility is distributed over periods.

Figure 4 shows that the trajectory of the Bongaarts-Feeney TFR* resembles that of the PTFR much more than that of the ACF. The TFR* occasionally overadjusted for timing effects, frequently underadjusted, and during the years 1963-66 adjusted in the wrong direction. The TFR* measure showed larger cyclical swings than ACF and, consistent with Figure 3cd, TFR* showed later maxima and (in the Birth Dearth) an earlier minimum than ACF.

During the 1970s in particular, the TFR* substantially understated the impact of timing in depressing U.S. fertility and bringing about the lowest period TFRs ever recorded. In 1976, when the PTFR reached its nadir (1.745), the TFR* was 1.956, indicating a timing effect of −0.21. That year the ACF was 2.111, indicating that the true timing effect was −0.37, almost twice as large. Although the ACF for 1976 was partially influenced by imputed fertility rates, the fertility of all cohorts childbearing during that year was observed at least through age 40, giving the ACF figure of 2.11 a strong empirical basis. In the 1970s, timing effects had a substantial effect on American fertility that has been largely underappreciated by demographers. This appears to be the first time that the effect has been quantified using either the ACF or TFR*.

SUMMARY AND CONCLUSIONS

A review of the literature on the period and cohort perspectives on fertility reinforces the value of the cohort approach and leads to defining timing effects as level changes in period fertility that do not reflect level changes in the completed fertility of cohorts. The Average Cohort Fertility measure emerges as a timing adjusted indicator of period fertility, one that contrasts sharply with the TFR*, the adjusted measure proposed by Bongaarts and Feeney (1998).

Comparing the ACF and the TFR* in the context of model populations and the experience of the United States 1917-1997 shows that the two measures behave very differently. The ACF adjusts for timing effects in a manner consistent with the definition of those effects. It provides a fertility measure that is more stable than the period TFR, and that sheds new light on the extent to which timing effects contributed to the extremely low TFRs observed in the U.S. during the 1970s. The Bongaarts-Feeney TFR* is unreliable, often yielding erratic values. It exaggerates some period behavior while failing to capture the level, and at times the direction, of changes in fertility timing effects.

The ACF has the limitation, inherent in cohort measures, of requiring knowledge of completed fertility behavior. It provides an answer to the question of what timing effects are, but for the past, not for the present. Additional research is needed to explore alternative fertility projection strategies and the likely errors associated with them, so that ACF-like measures for current fertility can be estimated with some confidence. The present analysis has largely neglected parity (except to use it in calculating TFR* for the U.S.). More work is needed to incorporate parity effects, and to examine the complex interactions that parity has with quantum and tempo that render it beyond the scope of this paper.

Timing effects can play an important role in fertility behavior. Although the approach proposed by Bongaarts and Feeney (1998) is weak conceptually and unstable empirically, demography does have a simple and meaningful definition of fertility timing and a measure that can operationalize it. Further use of the ACF and exploration of its properties can advance the measurement, analysis, and interpretation of current fertility.

ENDNOTES

1. Bongaarts and Potter (1983: 41) found from historical data that "the mean age at last birth is remarkably invariant. With few exceptions the means fall in the 39-41 year age range".

2. The Kohler and Philipov (2001) results are based on a postponement function, R(a,t). However, R(a,t) cannot be observed and, as Kohler and Philipov (2001: 4) acknowledged, it cannot be derived from observable functions. The Kohler and Ortega (2002) approach involves a good deal of investigator discretion in its implementation as well, and thus neither approach is considered further here.

3. It is noteworthy that Bongaarts (2002: 428) describes timing effects in a quite similar manner, saying "The difference between period and cohort fertility caused by changes in the timing of births is called the tempo or timing effect. Analytically, this tempo effect may be considered a distortion; it renders conventionally measured TFRs difficult to interpret."

4. Because the present focus is on the interpretation of the period TFR, timing effects are viewed narrowly. In other analyses, including some performed by Lutz, O'Neill, and Scherbov (2003), timing effects include the slower population growth and resulting age compositional changes associated with a longer length of generation. Such effects are important, but are beyond the scope of this paper.

5. In a paper presented at the Population Association of America Annual Meeting, Kim and Schoen (1999) used model population contexts to analyze continuing and cyclical period and cohort changes. They found algebraic expressions for both the TFR* and ACF, but even with constant fertility at all ages, those expressions were quite complex (and uninformative) when the changes were not both constant and continuing. Accordingly, the evaluation of the TFR* and

ACF measures begins by examining behavior under controlled conditions, rather than by recourse to formal demography.

6. The value of $r_o(t)$ in equation (3) was found from

$$r_o(t) = 0.5*[\ MAC_o(t+1) - MAC_o(t-1)\ ]$$

where $MAC_o(t)$ is the mean age of childbearing for births of order o in year t.

7. The Ryder (1980) values were given additional credibility when values calculated for the present study for years following 1950 proved to be identical to those given in that article. For the years immediately preceding 1951, those published values were very close to values produced by assuming that 1917 age-specific rates characterized earlier behavior. Ryder (1980) did not present ACF values for years after 1975.

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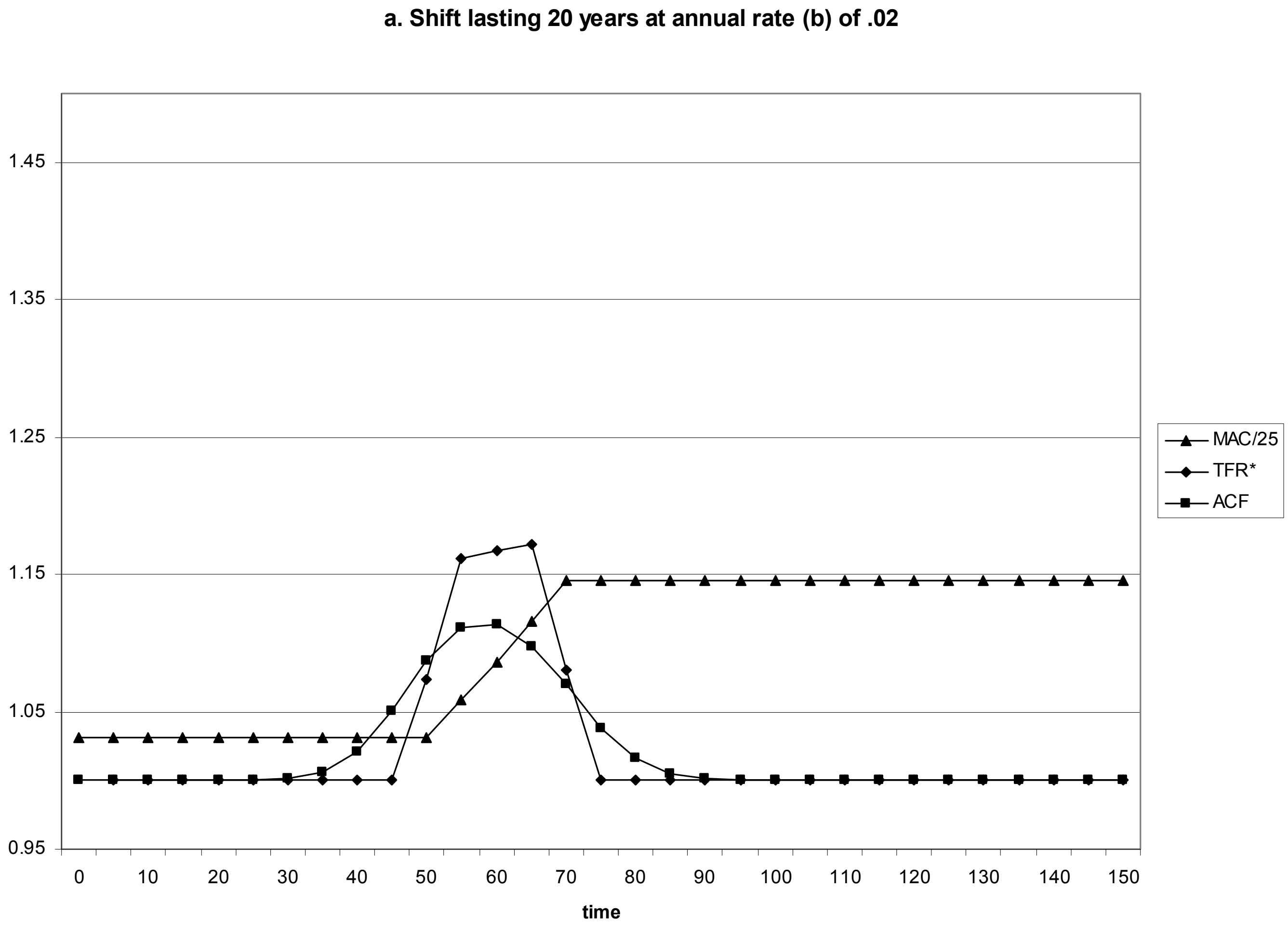
Table 1. Values for the Period Total Fertility Rate (PTFR), the Average Cohort Fertility (ACF), the Bongaarts-Feeney Adjusted Measure (TFR*), the Mean Age of Childbearing (MAC), and the Cohort Total Fertility Rate (CTFR), United States, 1917-2001

Year	PTFR	ACF	TFR*	TFR**(no parity adjustment)	MAC	CTFR (t - 26) [cohort born year (t-26)]
1917	3.0677	3.0609			28.90	
1918	3.2633	3.0155	3.1267	3.8739	28.54	
1919	3.3262	2.9824	3.2520	2.9116	28.46	
1920	3.1094	2.9202	3.0503	2.9710	28.47	
1921	3.1012	2.8706	2.9787	3.2086	28.43	
1922	3.1207	2.8254	3.0683	3.0722	28.34	
1923	3.0116	2.7789	2.9370	2.9096	28.31	
1924	2.9007	2.7303	2.8143	2.9445	28.25	
1925	2.8243	2.6858	2.8148	2.8820	28.22	
1926	2.6598	2.6425	2.6675	2.7639	28.16	
1927	2.5320	2.6023	2.5658	2.7039	28.09	
1928	2.5325	2.5649	2.5930	2.4970	28.03	2.3585
1929	2.4017	2.5290	2.3991	2.3769	28.02	2.3179
1930	2.3186	2.5005	2.3344	2.4495	28.01	2.2945
1931	2.1720	2.4762	2.2065	2.3735	28.01	2.2703
1932	2.2320	2.4577	2.2442	2.3155	27.89	2.2728
1933	2.1887	2.4415	2.2208	2.0537	27.75	2.2742
1934	2.1456	2.4295	2.1451	1.9737	27.64	2.2956
1935	2.1733	2.4241	2.1992	1.9406	27.48	2.3119
1936	2.2217	2.4217	2.3624	1.8876	27.40	2.3428
1937	2.1717	2.4275	2.2443	1.9419	27.38	2.3877
1938	2.2290	2.4371	2.2512	2.1197	27.30	2.4338
1939	2.3315	2.4514	2.5181	2.0680	27.16	2.4672
1940	2.5548	2.4688	2.7839	2.0064	27.05	2.5121
1941	2.6402	2.4949	2.8862	2.0749	27.25	2.5502
1942	2.4945	2.5233	3.1022	2.6674	27.52	2.6379
1943	2.4218	2.5465	2.6517		27.79	2.7023
1944	2.8579	2.5711	2.5272		27.35	2.7652
1945	3.1812	2.5959	2.5258		26.89	2.7940
1946	3.0262	2.6494	2.4294		26.74	2.8467
1947	3.0362	2.7104	2.6827		26.70	2.9131
1948	3.0280	2.7576	2.7563		26.72	2.9657
1949	3.1991	2.8020	2.9886		26.62	3.0065
1950	3.2865	2.8416	3.0553		26.68	3.0413
1951	3.3494	2.8865	3.0224		26.63	3.0692
1952	3.4612	2.9831	3.1280		26.60	3.1226
1953	3.4983	3.0042	3.0965		26.56	3.1565
1954	3.6047	3.0166	3.2215		26.47	3.2004
1955	3.6824	3.0176	3.3473		26.44	3.2147
1956	3.6289	3.0087	3.3011		26.42	3.2200
1957	3.6382	2.9882	3.3760		26.42	3.2067
1958	3.6057	2.9584	3.4378		26.44	3.1650
1959	3.5639	2.9182	3.4095		26.48	3.1056

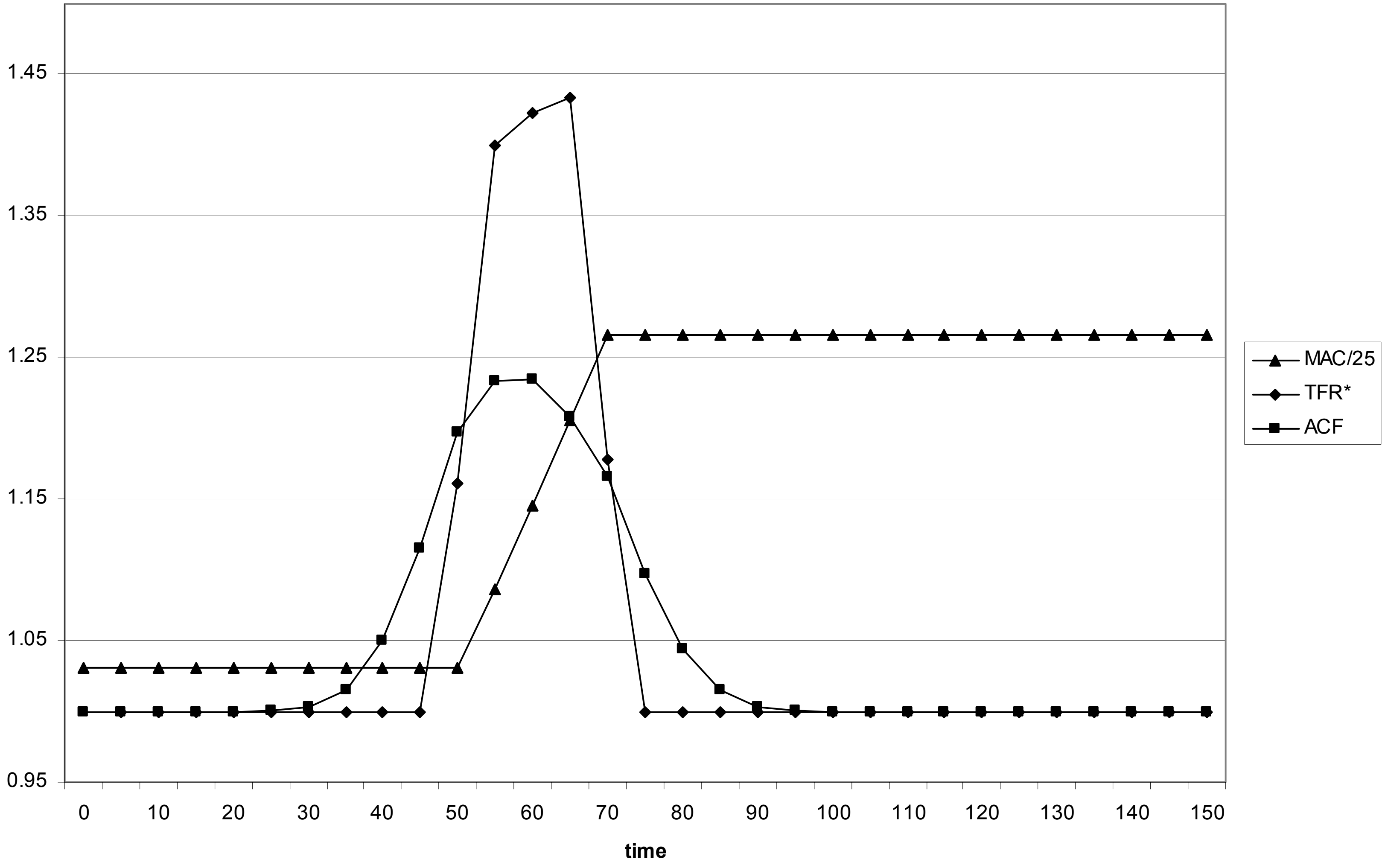
Table 1. (con't) Values for the Period Total Fertility Rate (PTFR), the Average Cohort Fertility (ACF), the Bongaarts-Feeney Adjusted Measure (TFR*), the Mean Age of Childbearing (MAC), and the Cohort Total Fertility Rate (CTFR), United States, 1917-2001

Year	PTFR	ACF	TFR*	TFR**(no parity adjustment)	MAC	CTFR (t - 26) [cohort born year (t-26)]
1960	3.4233	2.8686	3.3666		26.47	3.0346
1961	3.2978	2.8131	3.5309		26.49	2.9505
1962	3.1709	2.7549	3.5632		26.55	2.8758
1963	2.8816	2.6894	3.2285		26.55	2.7817
1964	2.6704	2.6150	2.9042		26.41	2.6761
1965	2.5255	2.5453	2.7721		26.32	2.5660
1966	2.4310	2.4777	2.5922		26.22	2.4575
1967	2.4229	2.4148	2.4521		26.15	2.3698
1968	2.4317	2.3532	2.4982		26.04	2.2893
1969	2.2454	2.2995	2.4264		25.98	2.2303
1970	1.9936	2.2503	2.2121		25.89	2.1685
1971	1.8625	2.2061	2.0579		25.80	2.1183
1972	1.8244	2.1668	2.0235		25.74	2.0738
1973	1.7722	2.1367	1.9931		25.75	2.0415
1974	1.7448	2.1117	1.9560		25.83	2.0143
1975	1.7950	2.0890	1.9794		25.86	1.9941
1976	1.7644	2.0718	1.9474		25.91	1.9829
1977	1.8167	2.0573	1.9558		25.94	1.9816
1978	1.8490	2.0464	2.0363		25.94	1.9875
1979	1.8254	2.0394	2.0220		26.04	1.9922
1980	1.8347	2.0349	2.0094		26.10	1.9952
1981	1.8053	2.0323	2.0161		26.18	1.9982
1982	1.7964	2.0317	1.9627		26.27	2.0088
1983	1.8396	2.0326	1.9636		26.32	2.0193
1984	1.8388	2.0351	1.9860		26.37	2.0261
1985	1.8699	2.0389	1.9737		26.46	2.0298
1986	1.9257	2.0440	1.9341		26.49	2.0377
1987	2.0058	2.0506	2.0268		26.47	2.0484
1988	2.0688	2.0575	2.1080		26.52	2.0608
1989	2.0651	2.0643	2.0659		26.53	2.0715
1990	2.0613	2.0729	2.1480		26.53	2.0802
1991	2.0446	2.0797	2.2483		26.59	2.0866
1992	2.0430	2.0853	2.2678		26.69	2.0947
1993	2.0415	2.0902	2.2694		26.80	2.1063
1994	2.0399	2.0952	2.2591		26.89	2.1228
1995	2.0383	2.0996	0.0000		26.99	2.1404
1996	2.0539	0.0000	0.0000		27.15	2.1550
1997	2.0699	0.0000	2.1396		27.25	2.1588
1998	2.1243				27.39	
1999	2.1088				27.52	
2000	2.0791				27.26	
2001	2.0791				27.26	

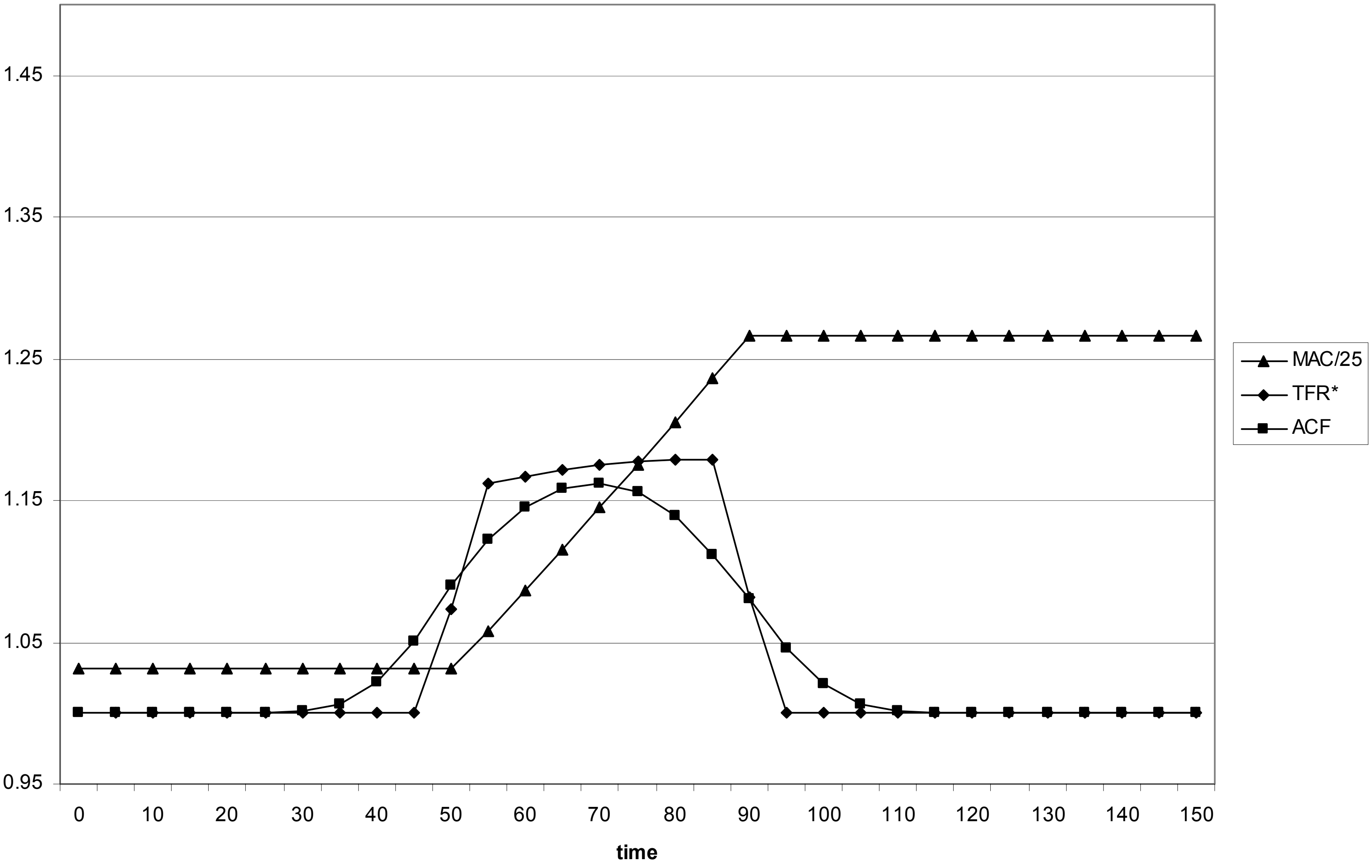
Figure 1. Values of the Mean Age at Childbearing (MAC), Bongaarts-Feeney Adjusted Fertility (*TFR), and Average Cohort Fertility (ACF) in Model Populations with a Constant Period TFR of 1 that Experience an Upward Shift in the Timing of Period Fertility Beginning at Time 50



b. Shift lasting 20 years at annual rate (b) of .04



c. Shift lasting 40 years at annual rate (b) of .02



d. Shift lasting 40 years at annual rate (b) of .04

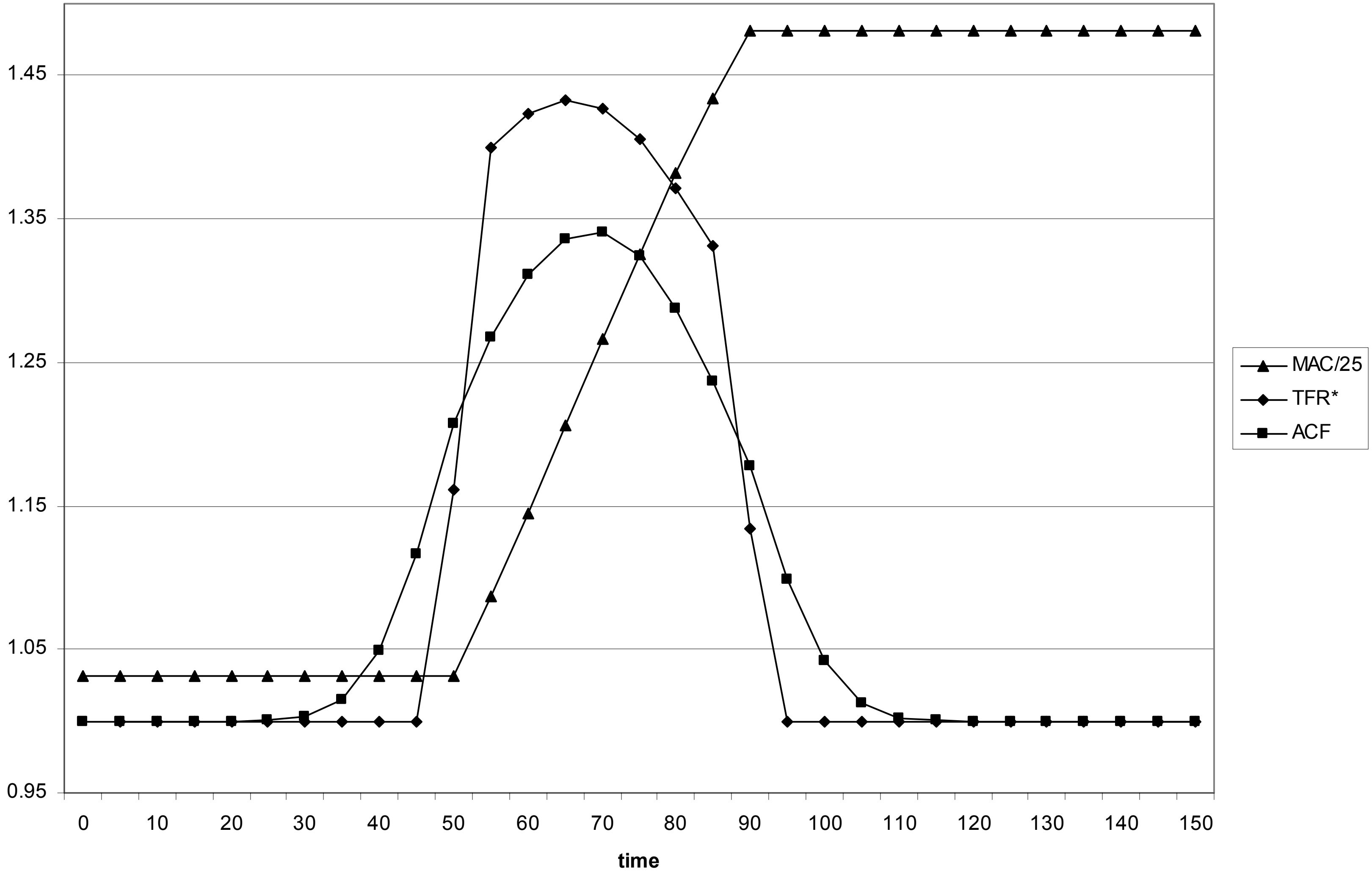
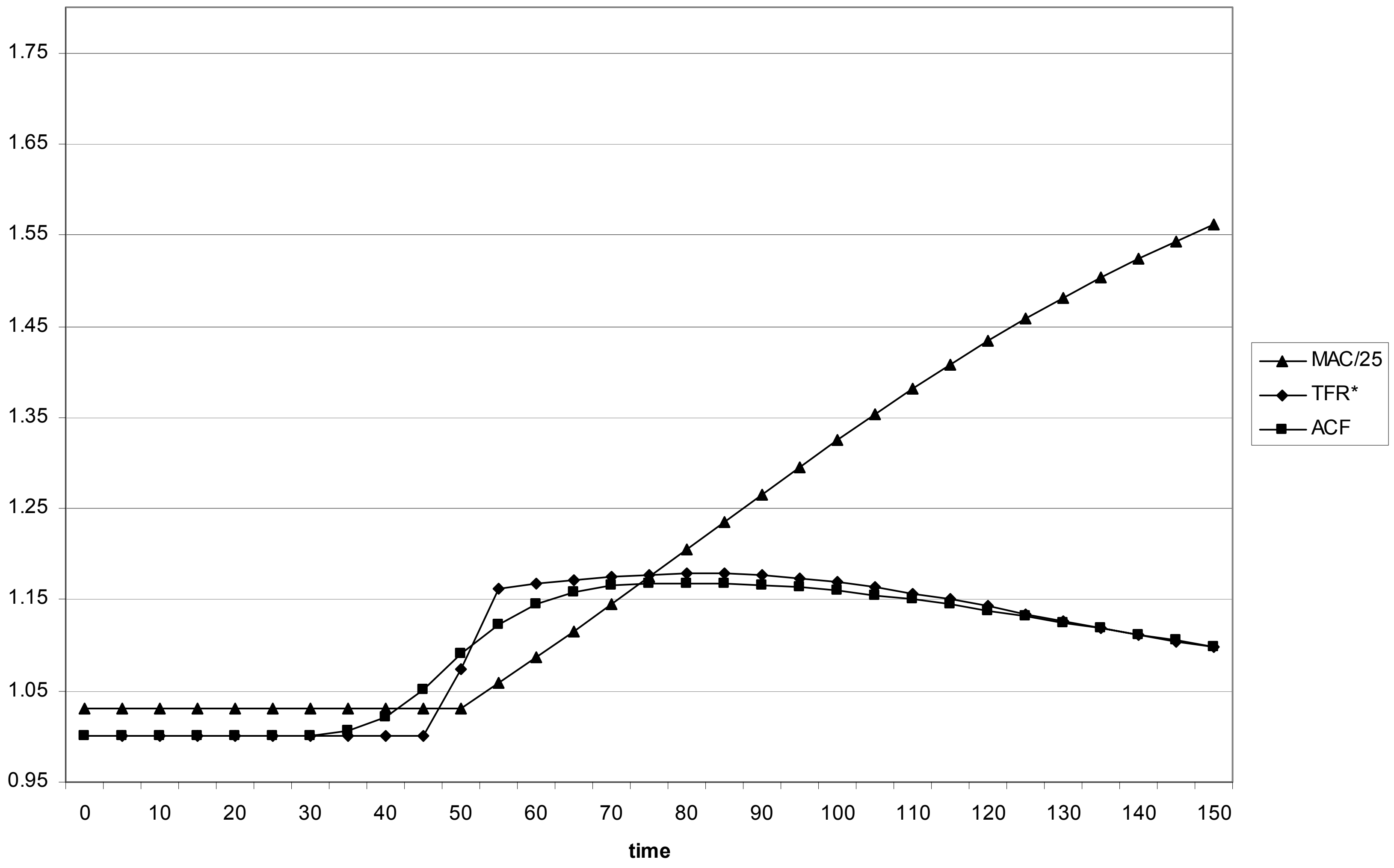


Figure 2. Values of the Mean Age at Childbearing (MAC), Bongaarts-Feeney Adjusted Fertility (TFR*), and Average Cohort Fertility (ACF) in Model Populations with a Constant Period TFR of 1 that Experience a Continuing Rise in the Timing of Period Fertility Beginning at Time 50

a. Timing increase at annual rate (b) of .02



b. Timing increase at annual rate (b) of .04

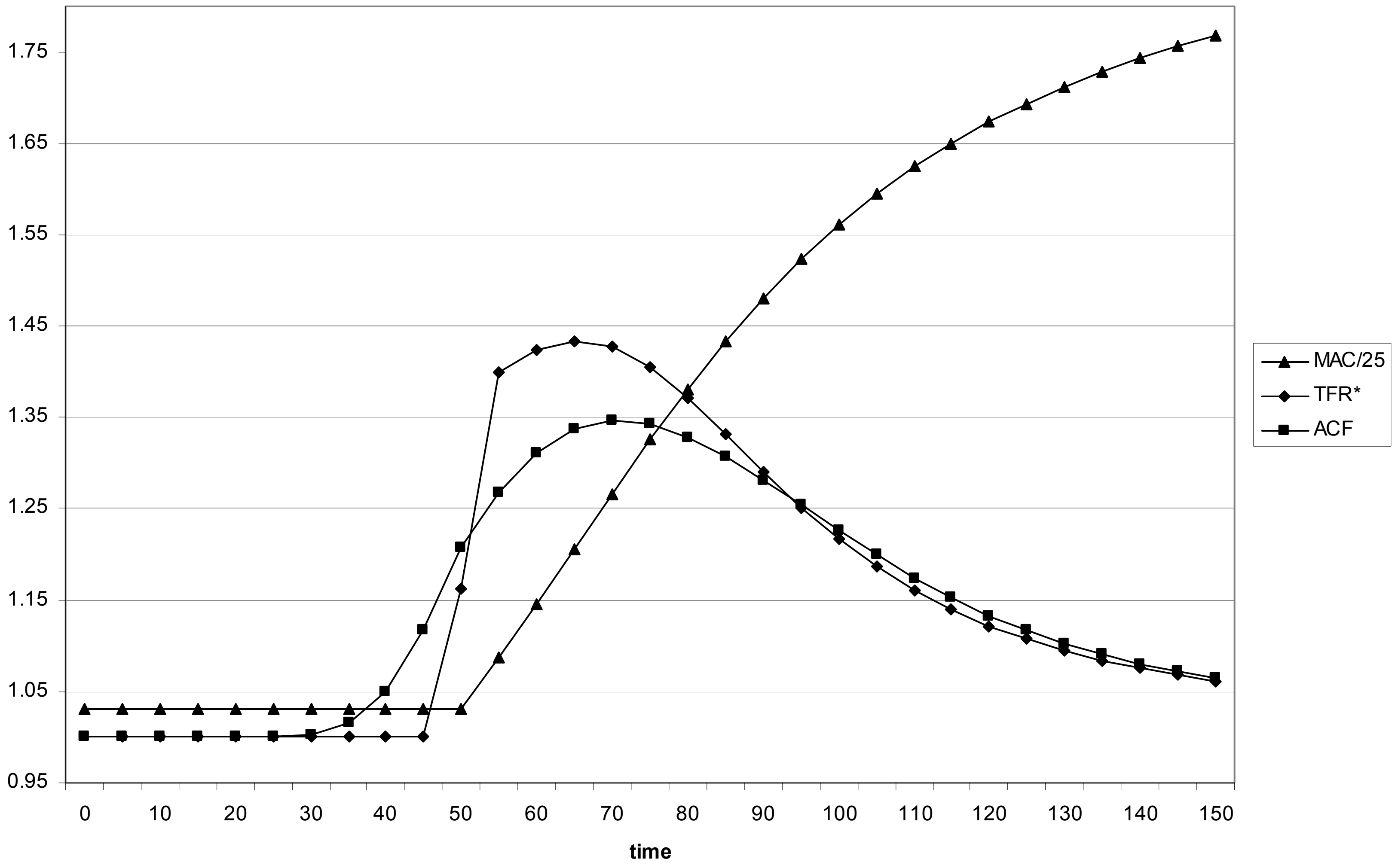
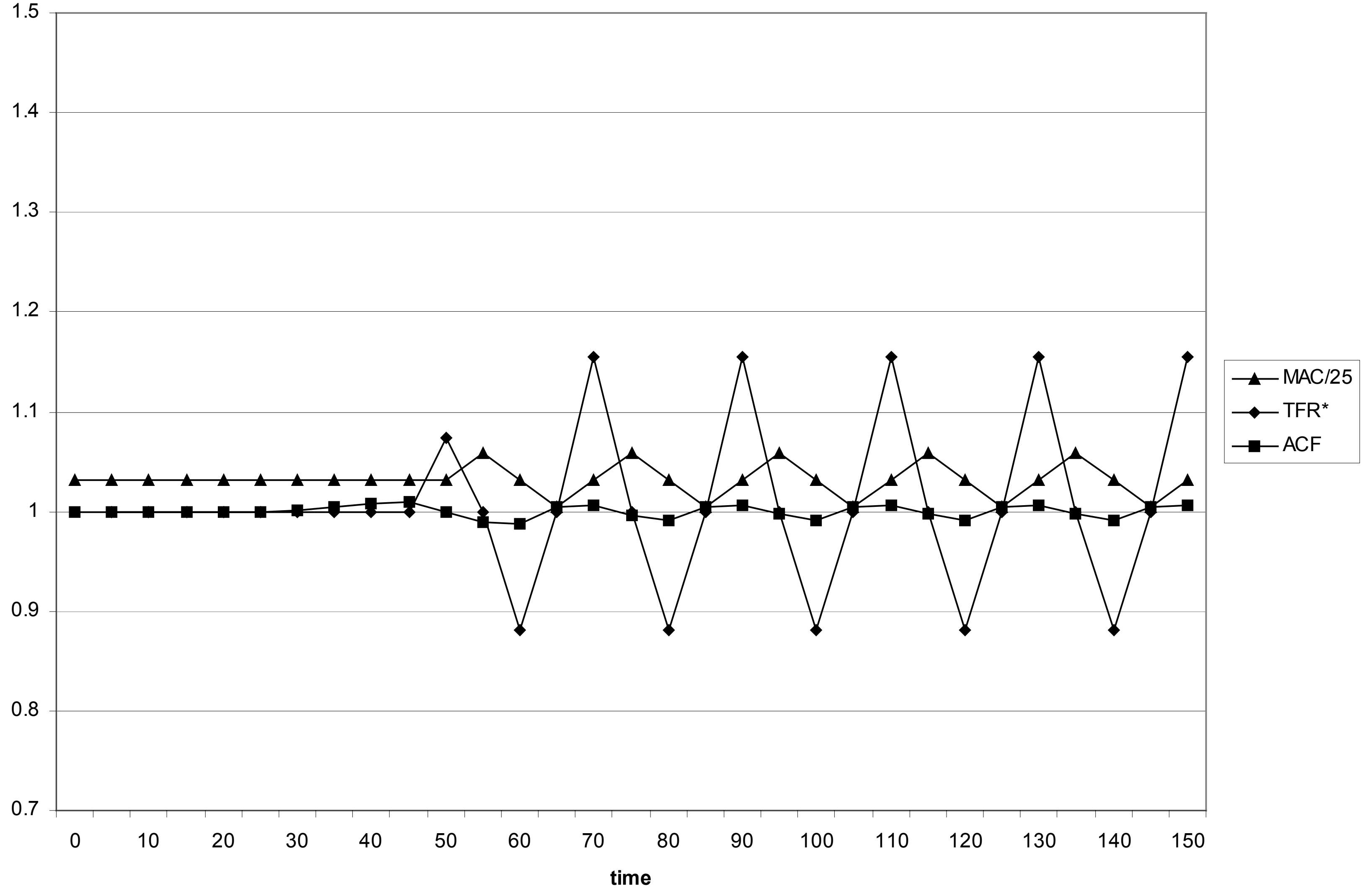
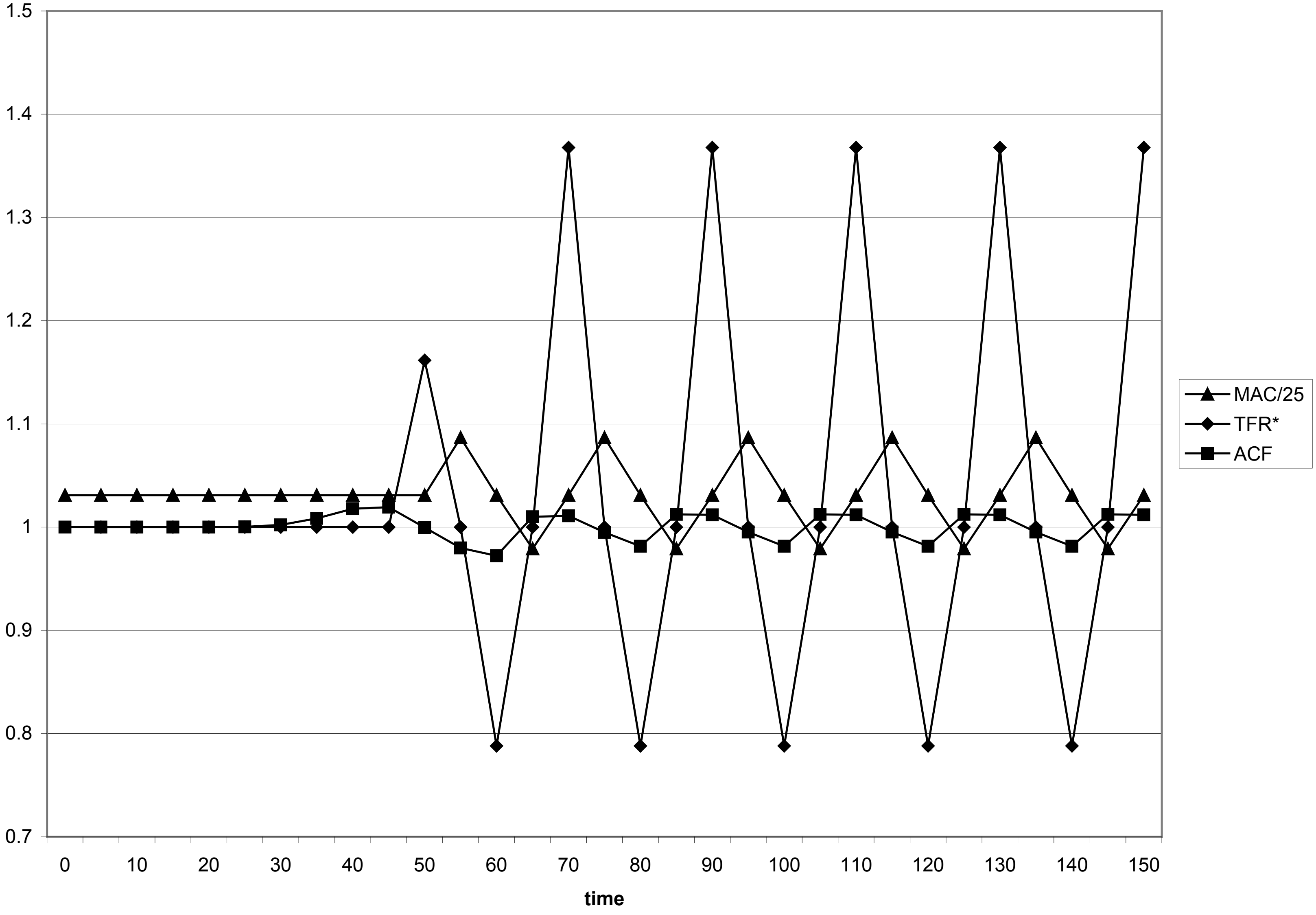


Figure 3. Values of the Mean Age at Childbearing (MAC), Bongaarts-Feeney Adjusted Fertility (TFR*), and Average Cohort Fertility and Average Cohort Fertility (ACF) in Model Populations with a Constant Period TFRs of 1 that Experience Cyclical Changes in the Timing of Period Fertility Beginning at Time 50

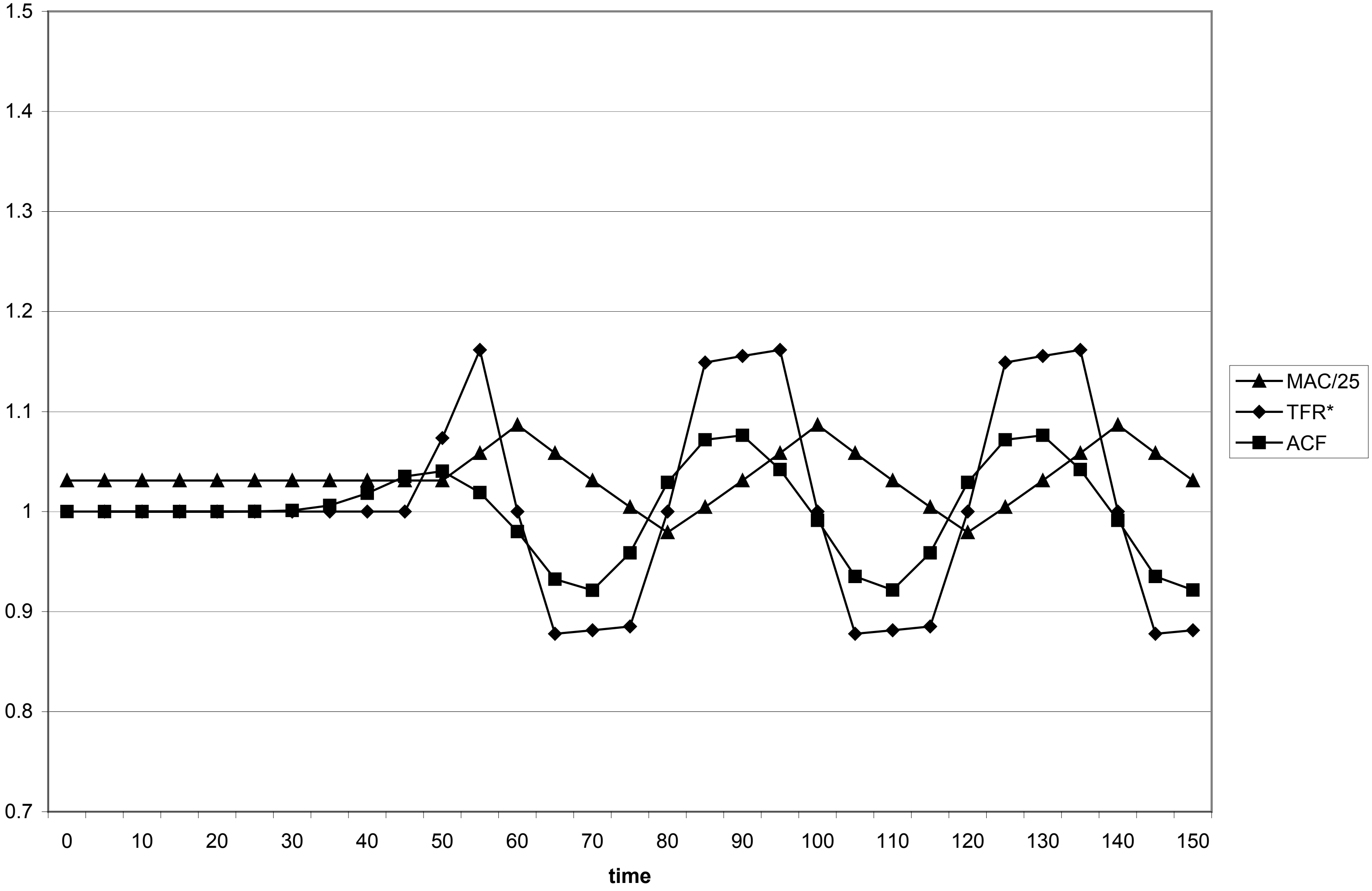
a. 20 year cycles at annual rate (b) of .02

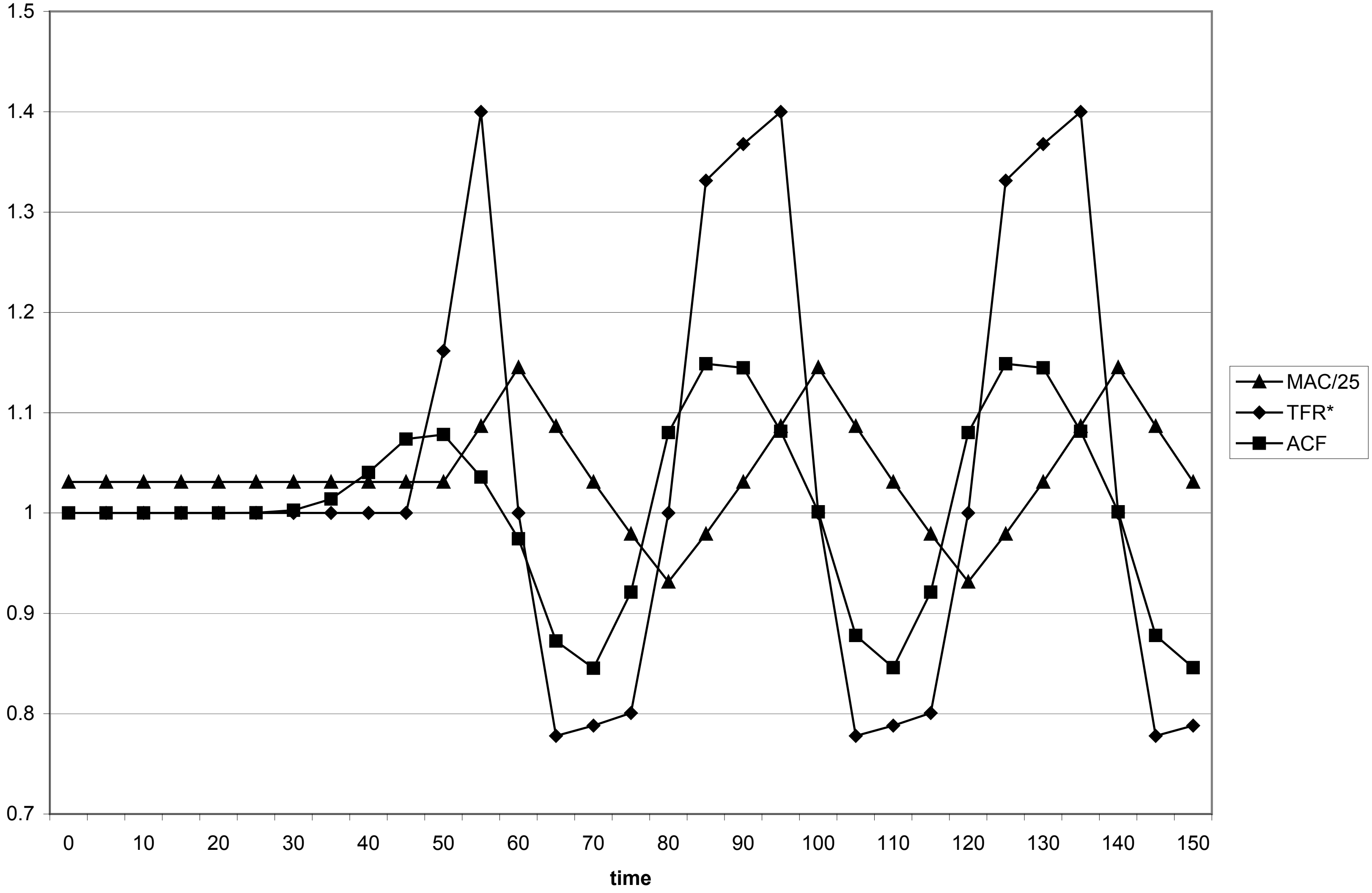


b. 20 year cycles at annual rate (b) of .04



c. 40 year cycles at annual rate (b) of .02





d. 40 year cycles at annual rate (b) of .04

Figure 4. Values of the Period Total Fertility Rate (PTFR), the Average Cohort Fertility (ACF), the Cohort Total Fertility Rate (CTFR) for the Cohort Born in Year t-26, and the Bongaarts-Feeney Adjusted Measure (TFR*)