TIMING EFFECTS AND THE INTERPRETATION OF PERIOD FERTILITY[1]

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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 total fertility rate (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*, however, is frequently unreliable and can be erratic when there are cycles in period timing. When applied to twentieth-century U.S. experience, the TFR* behaves like a period measure and yields adjustments that are often wide of the mark. The ACF shows the stability associated with cohort measures and quantifies 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.*

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 countries with very low fertility has focused attention on the impact of timing factors. Lutz, O'Neill, and Scherbov (2003), for example, used the standard measure of fertility, the total fertility rate (TFR), and emphasized the importance of delayed childbearing in further depressing the already-low fertility in the 15 nations of the European Union. Arguing that a pattern of late fertility would greatly increase the projected future decline in population size, these authors advocated the adoption of population policies to discourage further delays in childbearing.

The TFR is the number of children a woman would have over her lifetime if she experienced a given set of age-specific fertility rates (ASFRs). As in Lutz et al. (2003), the ASFRs for a particular year (or period) are most commonly 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 have fertility levels year by year, but women have children over the course of their lives. Theories of fertility are typically theories of completed family size (i.e., cohort fertility), and over time, patterns of CTFRs have been found to be smoother and less volatile than

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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 who are currently childbearing, or it may be only 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 the period, not the cohort, 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, although 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 the 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 and still view 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 than originally planned.

The preceding argument reinforces 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. A focus exclusively on cohorts can even be misleading because it is possible for cohort fertility always to 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 $f(x,t)$ representing 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 TFR for year t can be written

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

where the index of summation x ranges over all childbearing ages. Bongaarts and Feeney (1998) defined the TFR for year t 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,

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

On the basis of a mathematical derivation, Bongaarts and Feeney (1998: appendix) 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

$$\mathrm{TFR}(t)^* = \Sigma_o \mathrm{TFR}_o(t)^*. \tag{4}$$

Bongaarts and Feeney (1998:286) concluded that "[t]empo-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 used the Bongaarts-Feeney adjustment to advance similar arguments elsewhere. Bongaarts stated that he found the adjusted TFR to be an accurate predictor of cohort fertility (United Nations 2000:5). 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 woman 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. He stated, "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 Bongaarts's (1998) claim 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 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" (p. 286). Frejka and Calot (2001) reached the same substantive conclusion. 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. These authors believed 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, whereas 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 and noted that such rates are methodologically unsound and can lead to impossible results (e.g., the average woman having more than one first birth). Van Imhoff and Keilman concluded that "although attractively simple, the Bongaarts-Feeney procedure does not solve the tempo-distortion problem" (p. 552).

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

Kim and Schoen (1999, 2000) criticized the methodological foundation of the Bongaarts-Feeney adjustment. Bongaarts and Feeney (1998: appendix) showed, in Scenario 2, 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, Eq. (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 the relationship in Scenario 2 to situations in which the fertility schedule moves from year to year by varying amounts. Kim and Schoen (2000) showed that this 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, they stated, "Our goal is simply to provide a period measure of fertility that removes tempo distortions in conventionally calculated total fertility rates" (p. 560). They did not explain how they attained that goal, except to reiterate 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) observed, 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 affect period quantum. Indeed, Bongaarts and Feeney (1998:275) explicitly assumed 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. Bongaarts and Feeney cited no evidence that childbearing ages commonly shift as assumed, and there is good reason to believe that the highest age of childbearing varies little.[2] Especially problematic is the assumption 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 redefines the meaning of tempo, and is based on strong assumptions that rarely characterize actual populations.

Despite the criticism to which Bongaarts and Feeney's (1998) approach was subjected, it continues to enjoy considerable prominence. Zeng and Land (2001) performed sensitivity analyses that showed that the Bongaarts-Feeney adjusted TFR was generally robust to violations of the assumption of a constant shape of fertility. 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.[3] A U.S. National Academy of Sciences report on population projection (National Research Council 2000: chap. 4) gave the Bongaarts-Feeney adjustment considerable attention in its discussion of posttransition fertility. The highly visible *Science* article by Lutz et al. (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 reappraisal of fertility-timing concepts and measures is appropriate.

REEXAMINING 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 her 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*

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[2] 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."

[3] Kohler and Philipov's (2001) results are based on a postponement function, $R(a,t)$. However, $R(a,t)$ cannot be observed and, as Kohler and Philipov (p. 4) acknowledged, it cannot be derived from observable functions. Kohler and Ortega's (2002) approach involves a good deal of investigator discretion in its implementation as well. Thus, neither approach is considered further here.

effects is used to refer to level changes in period fertility that do not reflect level changes in the completed fertility of cohorts.[4]

That conceptualization needs to be operationalized in order to quantify precisely the timing effects in any given year. 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. Thus, I 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 Ryder (1980). The measure, called the Timing Index by Butz and Ward, looks at the proportion of *cohort* fertility contributed, *in a particular period*, by the women of reproductive age during that period. Paralleling Eq. (1), the cohort TFR for women born in year τ can be written

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

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

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

The Timing Index for year t can then be expressed as

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

The Timing Index measures the extent to which the *cohort* fertility of women childbearing during year t occurs in year t. When $\mathrm{TI}(t) = 1$, 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 $\mathrm{TI}(t) > 1$, 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 $\mathrm{TI}(t) < 1$, 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, $\mathrm{ACF}(t)$, is the quantum component and is given by

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

Eq. (8) has the same form as Eq. (3), the analogous relationship in the Bongaarts-Feeney method. Yet $\mathrm{ACF}(t)$ is more than an "adjusted TFR" because it is an average of the fertility of the cohorts who are childbearing during year t. As Butz and Ward (1979:666) noted, $\mathrm{ACF}(t)$ is a weighted arithmetic mean of the TFRs of those childbearing cohorts, 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

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[4] Bongaarts (2002:428) describes timing effects in a quite similar manner: "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."

Also note that 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 et al. (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.

be easily 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 for 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 the index of fertility timing and the Bongaarts-Feeney tempo adjustment, the next step is to examine how those measures respond when different types of change occur. Model populations can be very useful in that regard because they can depict "ideal" forms of change and can be manipulated systematically.[5]

Here I focus on period change because it is the focus of most current interest and because Kim and Schoen (1999) found that period and cohort changes were qualitatively similar in effect.[6] Rather than seek complex analytical solutions, the objective is to examine the performance of TFR* and ACF under three plausible patterns of period tempo change, with period quantum always held fixed at 1. Specifically, I examine (1) increases in the mean age at childbearing to a new, constant level; (2) increases in the mean age at childbearing that continue indefinitely; and (3) 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 shift 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 two 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 1990:346), with the level of period fertility set at 1. The calculations ignore parity. To examine changes in tempo, I adjusted the age pattern of the base cohort fertility rates, keeping period quantum constant at 1. With $\phi(x)$ representing the standard rate at age x and $\phi_{adj}(x)$ representing the tempo adjusted rate, the adjusted rate is given by

$$\phi_{adj}(x) = \phi(x)\lambda^{x} \; / \; \Sigma_{a}\, \phi(a)\lambda^{a}. \tag{9}$$

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 its 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 similar to a factor in the Coale-Trussell model fertility schedules (Coale and Trussell 1974; Schoen and Kim 1996).

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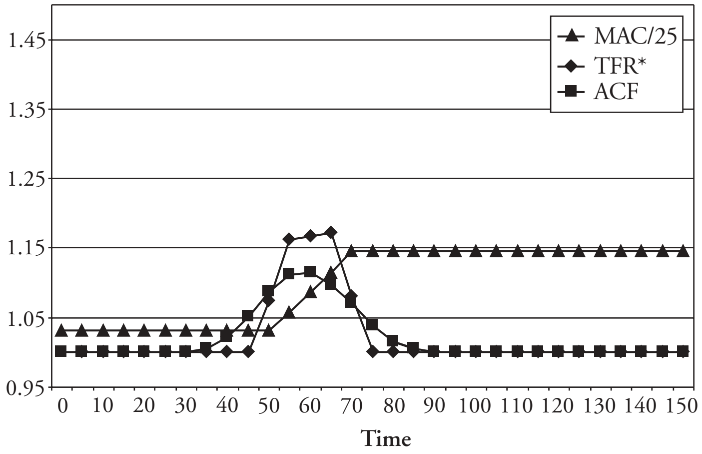
[5] Kim and Schoen (1999) used model populations to analyze continuing and cyclical period and cohort changes. They found algebraic expressions for both the TFR* and ACF, but even with constant fertility at all ages, those expressions were quite complex (and uninformative) when the changes were not both 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.

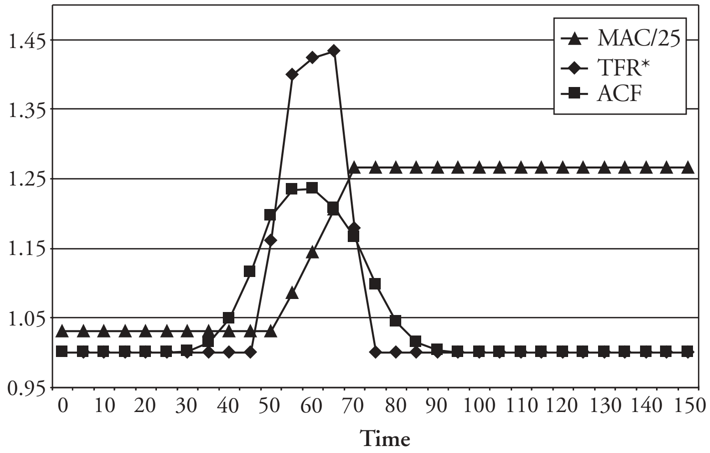
[6] In work not shown here, I explored other models that yielded similar results with respect to the behavior of the ACF and TFR*. In particular, models with constant cohort quantum but changing cohort tempo showed TI(t) = TFR(t) and ACF(t) = 1, whereas TFR*(t) exhibited considerable variability and could depart significantly from 1.

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

a. Shift lasting 20 years at annual rate (*b*) of .02



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



(continued)

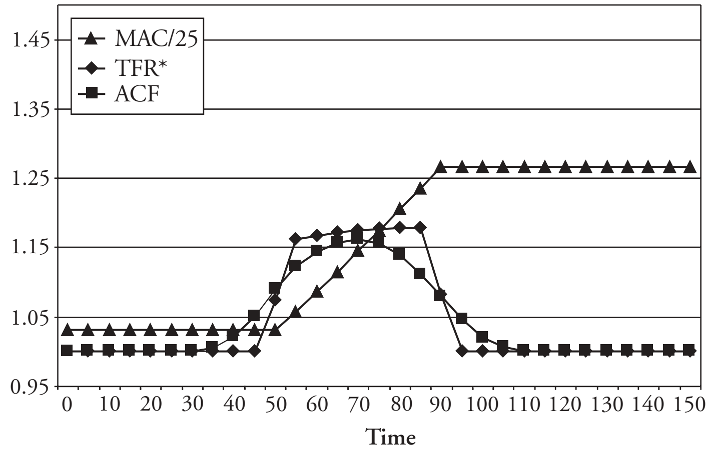
To incorporate change over time, I used the relationship

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

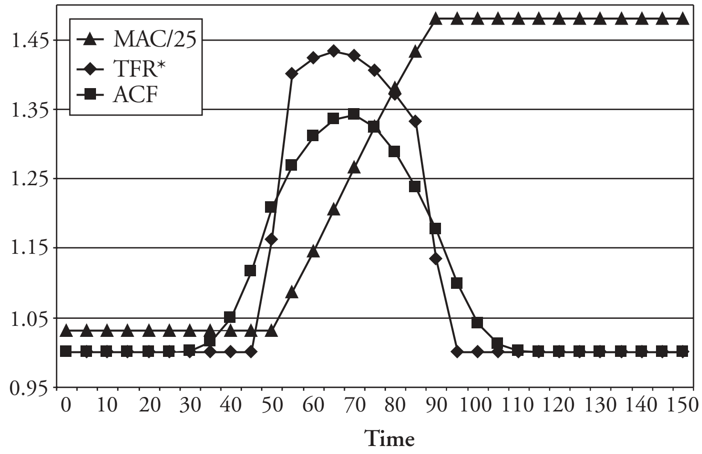
where b denotes the annual rate of increase underlying the fertility transformation. The mean age at childbearing (MAC) was calculated from the rates alone, without population weights. The value of $r(t)$ was obtained as in Bongaarts and Feeney (1998:290), that is, from

(Figure 1, continued)

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



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



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

Fixed-Interval 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. I considered four patterns of change, 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 the MAC (divided by 25 so that a single scale can be used).

The fixed-term increase in the MAC causes both the TFR* and the ACF to rise and then fall back to 1. However, the rise in the TFR* is both steeper and greater than the rise in the ACF. The rise in the TFR* increases with rate *b*. However, the 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 the 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 two 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 the 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 $b = .04$. Because this pattern of change approximates the pattern implicitly assumed in calculating the 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 1.

Cyclical Increases and Decreases in Period Timing

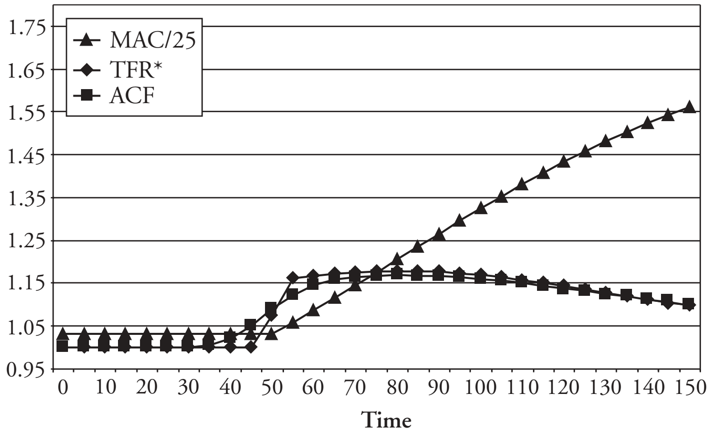
It is important to consider cyclical changes in timing because from the Roaring Twenties to the baby boom of the 1960s, or from the depression of the 1930s to the birth dearth of the 1970s, cycles of approximately 40 years have characterized twentieth-century fertility in much of the West, and especially in the United States. To model such patterns, Figure 3 presents results for the present measures for cycle lengths of 20 and 40 years and *b* values of .02 and .04. As Kim and Schoen (1999, 2000) found, the TFR* amplifies changes in fertility when the mean age at childbearing moves up and down. Those departures are greater for faster changes in the 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 the cycle length increases or *b* is larger. In all cases, however, the ACF varies substantially less than the TFR*. Panels c and d of Figure 3 show that there are times in each cycle (e.g., between Years 75 and 80 in panel d) when the TFR* adjusts period fertility in one direction from the base value of 1 while the ACF indicates that average cohort fertility lies in the opposite direction from 1.

TIMING EFFECTS IN THE UNITED STATES, 1917–1997

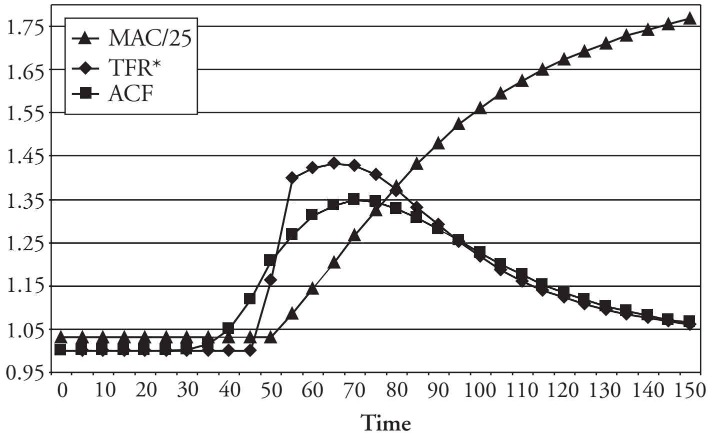
To move beyond an examination of models, I consider twentieth-century experience in the United States. The long-standing interest in cohort fertility among U.S. demographers led to the National Center for Health Statistics (NCHS) volume, *Fertility Tables for Birth Cohorts by Color: United States, 1917–73* (Heuser 1976), which provided detailed tabulations of fertility rates by year, age, and parity. The 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 (1) single-year period, from 1917 through 1997; (2) single year of age of the mother, from ages 15 through 49; and (3) parity of the mother, recognizing parities 0 through 7 and 8+.

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



The period TFR is readily found from the above array of fertility rates using Eq. (1). The rate-based MAC follows from the age-weighted sum of the age-specific rates. The Bongaarts-Feeney TFR* follows from Eqs. (2) to (4) and Eq. (11), using parity-specific values (women of parity 0 give birth to children of order 1).[7] Cohort TFRs were found from Eq. (5), and the ACF was calculated using Eqs. (6) to (8). However, for 1950 and

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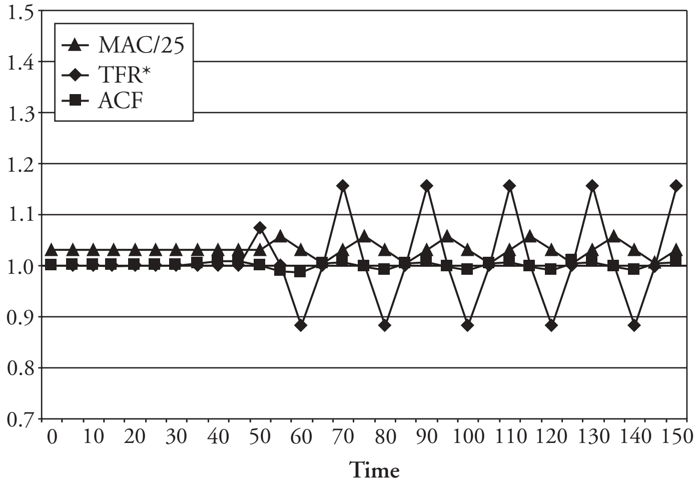
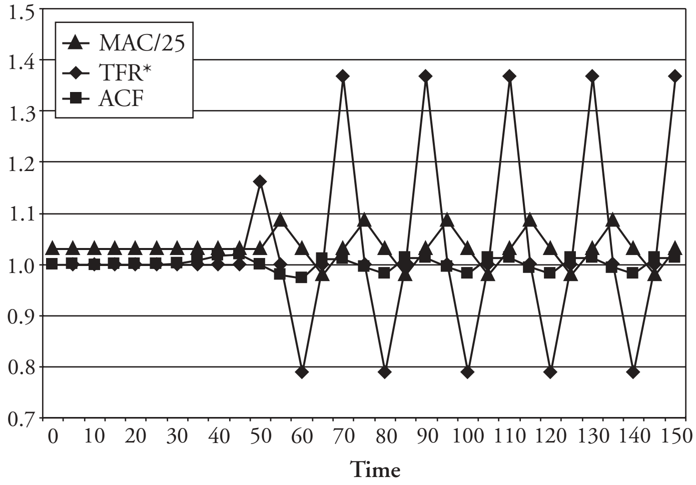
[7] The value of $r_o(t)$ in Eq. (3) was found from $r_o(t) = 0.5*[\text{ MAC}_o(t+1) - \text{MAC}_o(t-1)]$, where $\text{MAC}_o(t)$ is the mean age of childbearing for births of order o in year t.

Figure 3. **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 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



(continued)

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).[8] For both the CTFR and ACF, rates were imputed to complete the experience of cohorts not finished childbearing by

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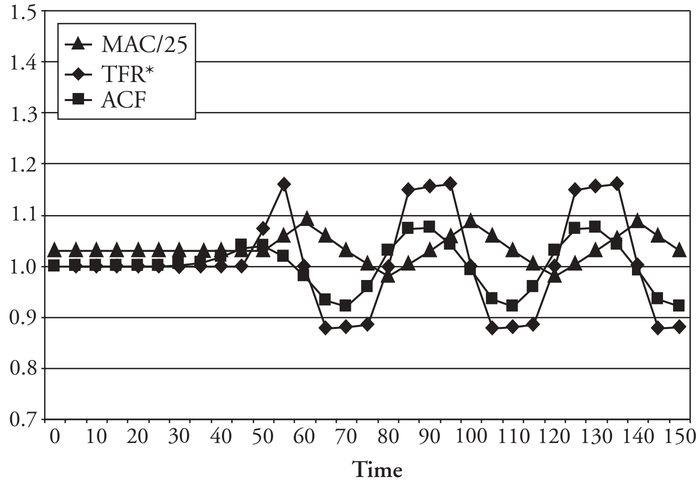
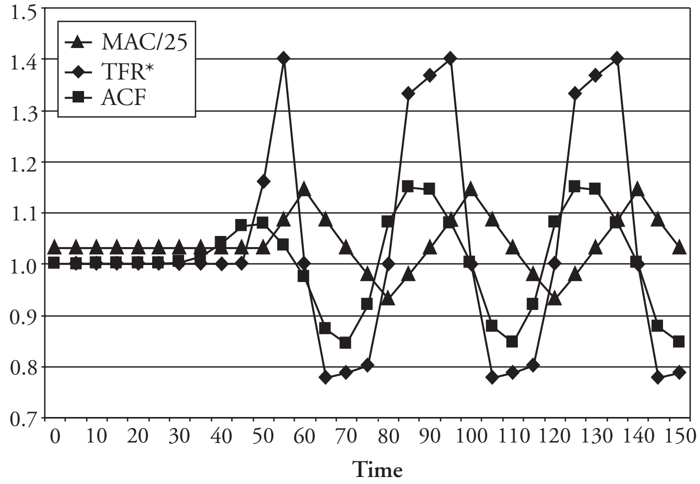
[8] Ryder's (1980) values were given additional credibility when I calculated identical values for the present study for years following 1950. For the years immediately preceding 1951, Ryder's values were close to values

(Figure 3, continued)

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



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



2001, the latest year for which data are available. 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 2002:7). Nonetheless, imputations are not observations, and during the 1990s, rates for women under age 25 declined slightly

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I produced by assuming that 1917 age-specific rates characterized earlier behavior. Ryder did not present ACF values for years after 1975.

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. Also shown are values of TFR**, the adjusted fertility measure, analogous to the TFR*, that combines all parities.

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 course, but with fluctuations of smaller magnitude. The ACF shows smaller fluctuations than does the shifted CTFR. The two cohort measures are quite distinct because the CTFR is the experience of a single cohort, whereas the ACF is an average of the completed fertility of a number of cohorts (and such averaging generally moderates 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 1951–1964, where they reached two thirds of a child, but sizable differences also occurred in the 1920s, 1930s, and 1970s. The twentieth-century American experience demonstrates that timing effects can substantially affect period fertility.

The timing effects that occurred in the 1920–1927 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 Butz and Ward (1979: 669) pointed out, the “acceleration” of fertility in the Roaring Twenties 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 1963–1966, adjusted in the wrong direction. The TFR* measure showed larger cyclical swings than the ACF and, consistent with Panels c and d in Figure 3, TFR* showed later maxima and (in the birth dearth) an earlier minimum than the 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 (1.74), the TFR* indicated a timing effect of –0.21. That year, the ACF was 2.11, indicating that the true timing effect was –0.37, almost twice as large as indicated by the TFR*. 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 a strong empirical basis. In the 1970s, timing effects had a substantial effect on U.S. 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*, so that its actual magnitude can be appreciated. As Table 1 indicates, through 1997, the United States never had average cohort fertility below 2.03.

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

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**[a]	MAC	CTFR (*t* – 26) [Cohort Born Year (*t* – 26)]
1917	3.3333	3.0609			28.61	
1918	3.3122	3.0155	3.4886	3.8739	28.65	
1919	3.0677	2.9824	3.0856	2.9116	28.90	
1920	3.2633	2.9202	3.1267	2.6710	28.54	
1921	3.3262	2.8706	3.2520	3.2086	28.46	
1922	3.1094	2.8254	3.0503	3.0722	28.47	
1923	3.1012	2.7789	2.9787	2.9096	28.43	
1924	3.1207	2.7303	3.0683	2.9445	28.34	
1925	3.0116	2.6858	2.9370	2.8820	28.31	
1926	2.9007	2.6425	2.8143	2.7639	28.25	
1927	2.8243	2.6023	2.8148	2.7039	28.22	
1928	2.6598	2.5649	2.6675	2.4970	28.16	2.4419
1929	2.5320	2.5290	2.5658	2.3769	28.09	2.4050
1930	2.5325	2.5005	2.5930	2.4495	28.03	2.3585
1931	2.4017	2.4762	2.3991	2.3735	28.02	2.3179
1932	2.3186	2.4577	2.3344	2.3155	28.01	2.2945
1933	2.1720	2.4415	2.2065	2.0537	28.01	2.2703
1934	2.2320	2.4295	2.2442	1.9737	27.89	2.2728
1935	2.1887	2.4241	2.2208	1.9406	27.75	2.2742
1936	2.1456	2.4217	2.1451	1.8876	27.64	2.2956
1937	2.1733	2.4275	2.1992	1.9419	27.48	2.3119
1938	2.2217	2.4371	2.3624	2.1197	27.40	2.3428
1939	2.1717	2.4514	2.2443	2.0680	27.38	2.3877
1940	2.2290	2.4688	2.2512	2.0064	27.30	2.4338
1941	2.3315	2.4949	2.5181	2.0749	27.16	2.4672
1942	2.5548	2.5233	2.7839	2.6674	27.05	2.5121
1943	2.6402	2.5465	2.8862	3.4509	27.25	2.5502
1944	2.4945	2.5711	3.1022	3.4316	27.52	2.6379
1945	2.4218	2.5959	2.6517	2.2346	27.79	2.7023
1946	2.8579	2.6494	2.5272	1.9713[a]	27.35	2.7652
1947	3.1812	2.7104	2.5258	2.4391	26.89	2.7940
1948	3.0262	2.7576	2.4294	2.7585	26.74	2.8467
1949	3.0362	2.8020	2.6827	2.9978	26.70	2.9131
1950	3.0280	2.8416	2.7563	2.9118	26.72	2.9657
1951	3.1991	2.8865	2.9886	3.1336	26.62	3.0065
1952	3.2865	2.9214	3.0553	3.2998	26.68	3.0413
1953	3.3494	2.9557	3.0224	3.2316	26.63	3.0692
1954	3.4612	2.9831	3.1280	3.3563	26.60	3.1226
1955	3.4983	3.0042	3.0965	3.2781	26.56	3.1565
1956	3.6047	3.0166	3.2215	3.3927	26.47	3.2004
1957	3.6824	3.0176	3.3473	3.5948	26.44	3.2147
1958	3.6289	3.0087	3.3011	3.6016	26.42	3.2200

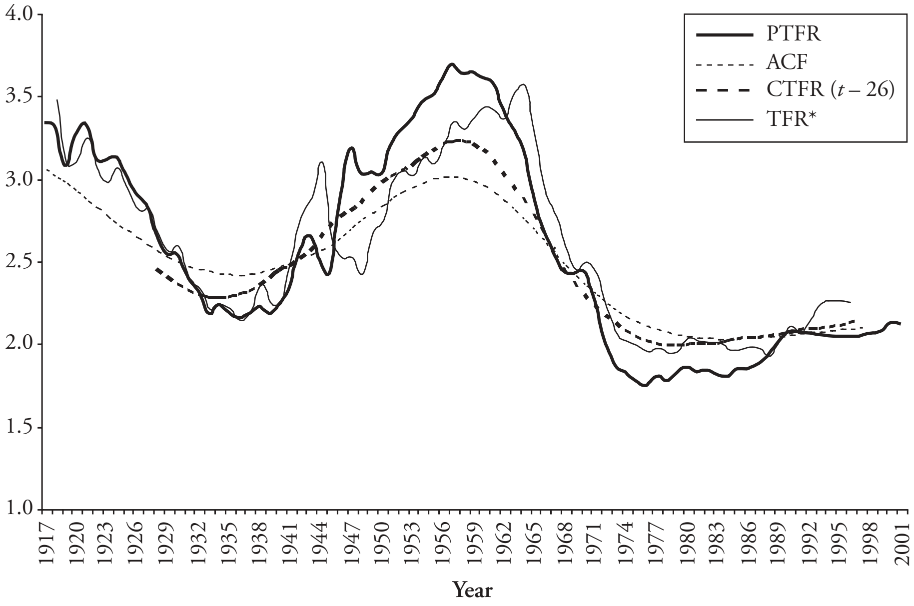
(continued)

(Table 1, continued)

Year	PTFR	ACF	TFR*	TFR**[a]	MAC	CTFR (t – 26) [Cohort Born Year (t – 26)]
1959	3.6382	2.9882	3.3760	3.6722	26.42	3.2067
1960	3.6057	2.9584	3.4378	3.7093	26.44	3.1650
1961	3.5639	2.9182	3.4095	3.6139	26.48	3.1056
1962	3.4233	2.8686	3.3666	3.4373	26.47	3.0346
1963	3.2978	2.8131	3.5309	3.4418	26.49	2.9505
1964	3.1709	2.7549	3.5632	3.2720	26.55	2.8758
1965	2.8816	2.6894	3.2285	2.6976	26.55	2.7817
1966	2.6704	2.6150	2.9042	2.3977	26.41	2.6761
1967	2.5255	2.5453	2.7721	2.3074	26.32	2.5660
1968	2.4310	2.4777	2.5922	2.2368	26.22	2.4575
1969	2.4229	2.4148	2.4521	2.2187	26.15	2.3698
1970	2.4317	2.3532	2.4982	2.2443	26.04	2.2893
1971	2.2454	2.2995	2.4264	2.0846	25.98	2.2303
1972	1.9936	2.2503	2.2121	1.8284	25.89	2.1685
1973	1.8625	2.2061	2.0579	1.7332	25.80	2.1183
1974	1.8244	2.1668	2.0235	1.7816	25.74	2.0738
1975	1.7722	2.1367	1.9931	1.8578	25.75	2.0415
1976	1.7448	2.1117	1.9560	1.8397	25.83	2.0143
1977	1.7950	2.0890	1.9794	1.8701	25.86	1.9941
1978	1.7644	2.0718	1.9474	1.8393	25.91	1.9829
1979	1.8167	2.0573	1.9558	1.8476	25.94	1.9816
1980	1.8490	2.0464	2.0363	1.9482	25.94	1.9875
1981	1.8254	2.0394	2.0220	1.9829	26.04	1.9922
1982	1.8347	2.0349	2.0094	1.9714	26.10	1.9952
1983	1.8053	2.0323	2.0161	1.9721	26.18	1.9982
1984	1.7964	2.0317	1.9627	1.9295	26.27	2.0088
1985	1.8396	2.0326	1.9636	1.9387	26.32	2.0193
1986	1.8388	2.0351	1.9860	1.9759	26.37	2.0261
1987	1.8699	2.0389	1.9737	1.9826	26.46	2.0298
1988	1.9257	2.0440	1.9341	1.9425	26.49	2.0377
1989	2.0058	2.0506	2.0268	2.0347	26.47	2.0484
1990	2.0688	2.0575	2.1080	2.1326	26.52	2.0608
1991	2.0651	2.0643	2.0659	2.0753	26.53	2.0715
1992	2.0613	2.0729	2.1480	2.1183	26.53	2.0802
1993	2.0446	2.0797	2.2483	2.2289	26.59	2.0866
1994	2.0430	2.0853	2.2678	2.2866	26.69	2.0947
1995	2.0415	2.0902	2.2694	2.2729	26.80	2.1063
1996	2.0399	2.0952	2.2591	2.2515	26.89	2.1228
1997	2.0383	2.0996	2.1396	2.3429	26.99	2.1404
1998	2.0539				27.15	
1999	2.0699				27.25	
2000	2.1243				27.39	
2001	2.1088				27.52	

[a] TFR** is the adjusted fertility measure analogous to TFR* that combines all parities.

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



period fertility that do not reflect level changes in the completed fertility of cohorts. The ACF 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 in 1917–1997 shows that the two measures behave 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 (or cohort) TFR and that reveals the extent to which timing effects produced the extremely low TFRs observed in the United States during the 1970s. The Bongaarts-Feeney TFR* is not reliable and often yields erratic values. It amplifies 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 can be used to determine what timing effects are for the past, but 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 the TFR* for the United States). More work is needed to incorporate parity effects and to examine the complex interactions that parity has with quantum and tempo, which 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.

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