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Young J. Kim; Robert Schoen

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# On the Quantum and Tempo of Fertility: Limits to the Bongaarts–Feeney Adjustment

YOUNG J. KIM
ROBERT SCHOEN

IN A RECENT article, Bongaarts and Feeney (1998) proposed a new method for adjusting the period total fertility rate (TFR) to eliminate the effects of the timing of fertility behavior. They claim that $TFR_{adj}$, their tempo-adjusted total fertility rate, "provides a better indication of the level of completed fertility implied by current fertility behavior, and hence a better answer to the question of how many births women will have if current childbearing behavior continues into the future" (p. 285). We take issue with that claim and show that the mathematical basis of $TFR_{adj}$ holds only under very restrictive conditions and that, with those restrictions even slightly relaxed, $TFR_{adj}$ is quite volatile in the presence of modest fertility fluctuations. We conclude that there is no reason to accept $TFR_{adj}$ as a reliable indicator of the level of fertility.

## The stringent restrictions underlying the tempo-adjusted TFR

In Scenario 2 of their Appendix, where the effects of birth order are ignored to simplify the presentation, Bongaarts and Feeney show that when the level of fertility does not change but the mean age at childbearing increases through a constant shift in the period fertility schedule, then $TFR_{adj} = TFR / (1-r)$, where $r$ is the annual increase in the mean age at childbearing. That relationship (essentially their equation (7)) is obtained by integrating the cohort fertility of the reference year using a change-of-variables approach. Although they do not say so explicitly, this approach requires the assumption that those increases of $r$ years per year have been in place long enough to have characterized the experience of all currently childbearing women. That restriction is notable because such a sustained pattern is extremely unrealistic, and a population's behavior in the short term can be very different from its behavior at long-term equilibrium.

To demonstrate this point, consider a hypothetical single-sex population in which the TFR is constant at replacement level (TFR = 1.0), with age-specific fertility rates identical at all ages of reproduction (ages 15 to 45 years). Then, beginning with year 0, an increase of 1/3 year in the mean age of period fertility occurs each year as the fixed, uniform period fertility schedule shifts upward by 1/3 year each year. While the period TFR remains constant, cohort fertility levels change as successive cohorts are differentially affected by that linear shift in fertility. In Figure 1a, we show schematically how period fertility shifts and indicate the cohorts that begin and end the transition from fixed fertility to upwardly shifting fertility. In

**FIGURE 1a Schematic diagram of a single-sex model population with linear upward shifts of 1/3 year per annum in the mean age of childbearing starting at time 0**

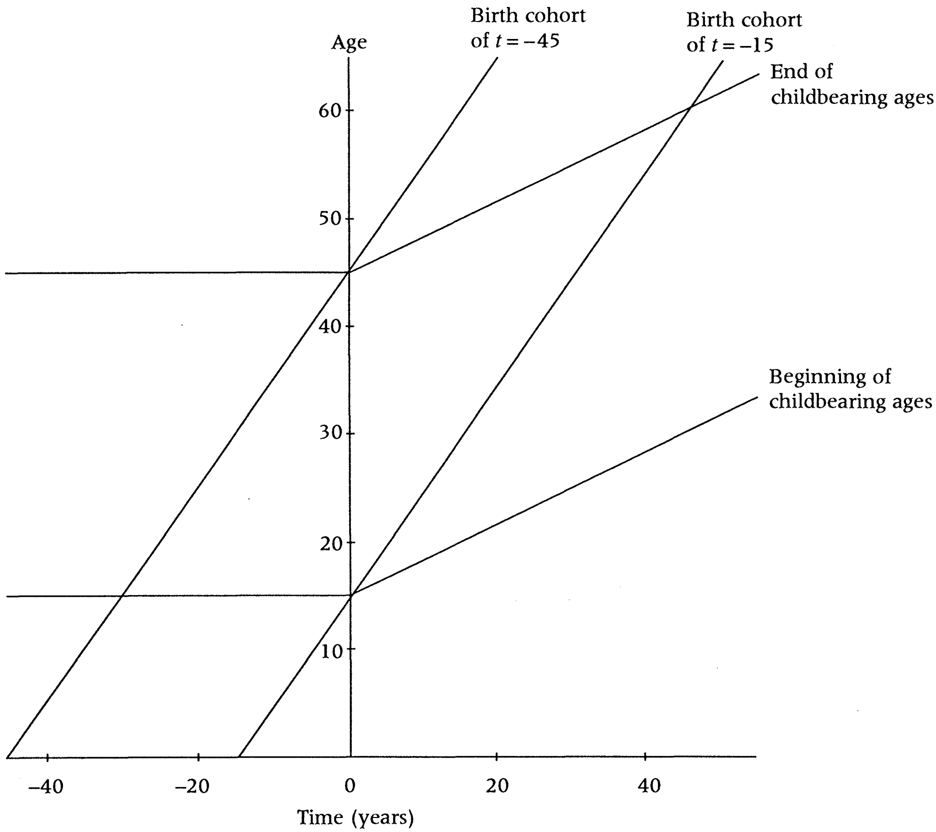
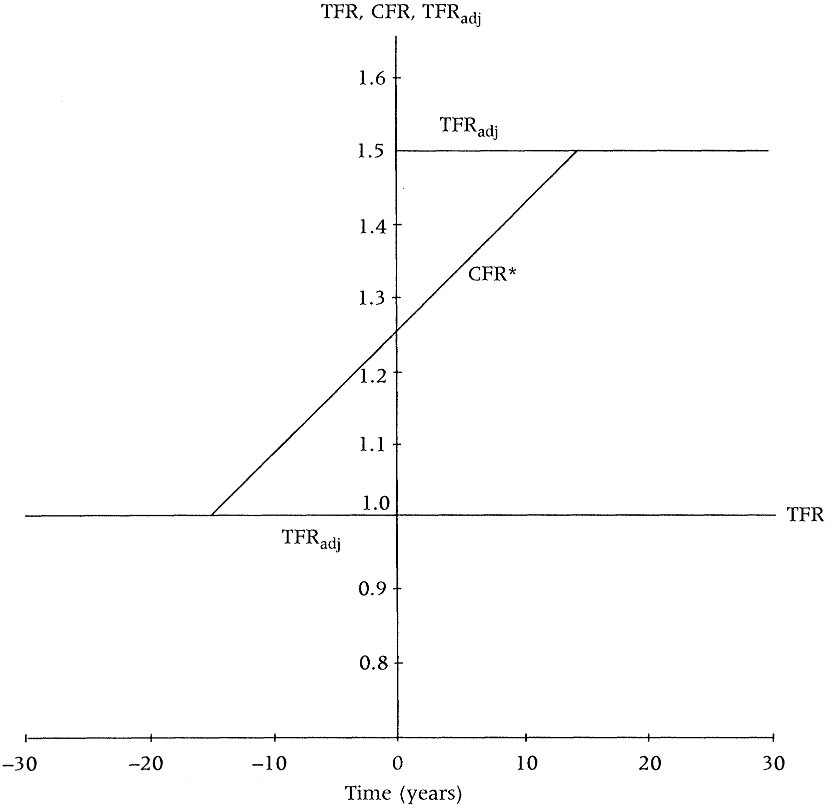


Figure 1b, we present the time trajectories of three fertility measures: the constant period total fertility rate (TFR), the cohort total fertility rate (CFR, the standard indicator of completed fertility), and the Bongaarts–Feeney adjusted $TFR_{adj}$. The CFR, taken as the completed fertility of the cohort born 30 years earlier, increases linearly from 1.0 for the cohort born in year −45 to 1.5 for the cohort born in year −15, and remains at that level thereafter. In the long term, here after year 15, the Bongaarts–Feeney measure is constant at 1.5 and equals the CFR. However, in the short term (here years −15 to 15) $TFR_{adj}$ can differ appreciably from the CFR because of the gradually lengthening reproductive age span of the transitional cohorts. The discontinuity in $TFR_{adj}$ at year 0 arises because $TFR_{adj}$ only changes when the regime of period linear shifts begins, that is, when $r$ goes from 0 to 0.33. Of course, period shifts such as the one described cannot be sustained in-

**FIGURE 1b Adjusted total fertility rates and cohort fertility rates in the above population characterized by a period total fertility rate at replacement level**



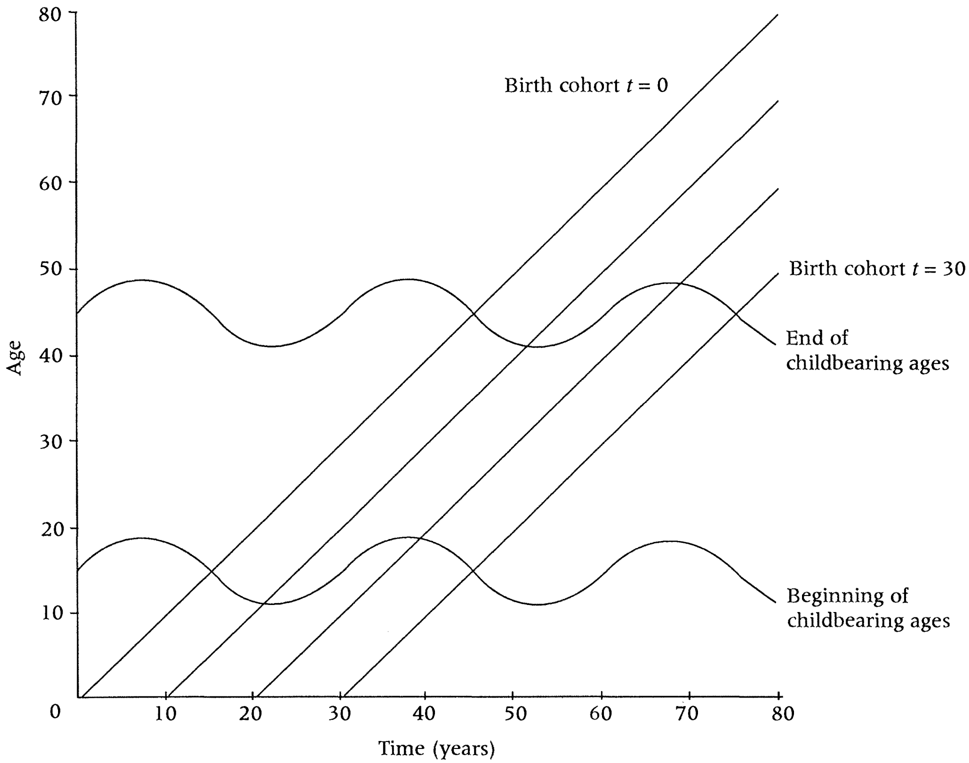

*CFR of the cohort born 30 years before the time indicated on x axis.

definitely. Here (as shown in Figure 1a) in year 45, the initial age at childbearing has already increased from age 15 to age 30.

## The volatility of the tempo-adjusted TFR

We emphasized Bongaarts and Feeney's Scenario 2 above to specify the severe restrictions that are needed for their measure to hold. Bongaarts and Feeney recognize that the change of variables they use to obtain their result in Scenario 2 does not work when the amount of change in the mean age at childbearing varies, as it does under their Scenario 3. To avoid that difficulty, they focus on a single year and in effect seek to recreate a pattern of constant change. Their derivation is flawed, however, because it does not recognize that, even in Scenario 2, their equation (8) and thus their $TFR_{adj}$ only hold in the long run, when all cohorts of reproductive age have experienced the same history of constant period shifts. Thus it is not sur-

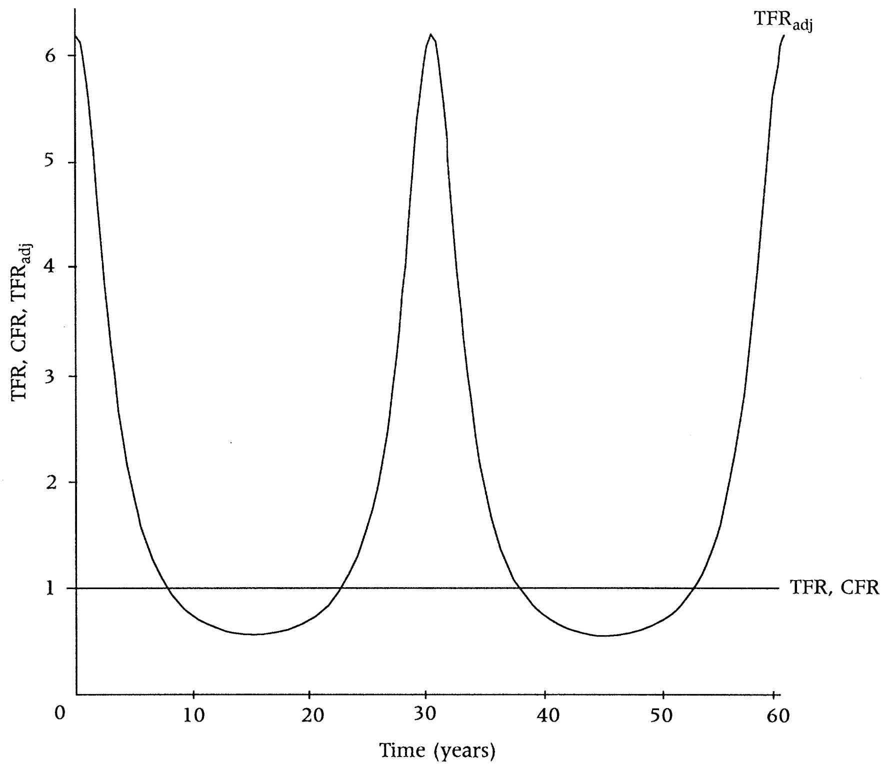
**FIGURE 2a Schematic diagram of a single-sex model population with constant period and cohort fertility and with period sinusoidal shifts over time in the ages at which childbearing begins and ends**



prising that when the change in the mean age at childbearing varies over time, their adjusted TFR becomes unstable.

To see that this is so, consider a "Scenario 3–type" model where fertility is at replacement level and does not vary over time or over age within the reproductive age range, but where the period reproductive age range shifts sinusoidally over time. In particular, let the timing of period fertility cycle so that the reproductive age range in year $t$ goes from $15 + 4\sin(2\pi t/30)$ to $45 + 4\sin(2\pi t/30)$. Here, because both the cycle length of the sinusoidal fluctuation and the length of the period reproductive age span are fixed at 30 years, every *cohort* in the model also has a reproductive age span of 30 years. As shown in Figure 2a, each cohort ends its reproductive years at the same point in the sinusoidal cycle at which it started. In Figure 2b, we show the population's time trajectories of TFR, CFR, and $TFR_{adj}$. Since fertility is the same at every reproductive age, and since every period and every cohort have reproductive age spans of 30 years, TFR = CFR = 1.0.

**FIGURE 2b Adjusted total fertility rates in a population characterized by constant period fertility and constant cohort fertility, both at replacement level, and by shifts in the beginning and ending ages of childbearing as shown above**



However, because the period reproductive ages shift, $TFR_{adj}$ is not constant, but varies from a low of 0.54 to a high of 6.16. Thus, in a population with constant period and cohort fertility and modest swings in the ages of reproduction, the Bongaarts–Feeney measure fluctuates dramatically. In fact, even with the amplitude of the sinusoidal fluctuations remaining within demographically reasonable bounds, $TFR_{adj}$ can become infinite.

We have further explored the behavior of $TFR_{adj}$ under the more realistic assumption that fertility follows a normal distribution with a mean of 30 years and a standard deviation of 4.5 years. In such models, we have considered both period and cohort sinusoidal shifts in the reproductive age span. We obtain qualitatively similar results in those cases as well, with $TFR_{adj}$ fluctuating markedly and showing pronounced peaks well above the CFR.

## Conclusions

We find that the Bongaarts–Feeney measure performs as claimed only under the assumption of a constant linear shift affecting every cohort of reproductive age. In other cases, the measure performs poorly. It mischaracterizes the course of completed fertility in the short term, even when period timing shifts are linear. When timing shifts sinusoidally, the Bongaarts–Feeney measure is unstable. In a model with constant period and cohort fertility levels of 1.0, a relatively modest fluctuation in timing leads to $TFR_{adj}$ values exceeding 6.1.

Fundamentally, the Bongaarts–Feeney measure, which is based on behavior in a single year, does not incorporate enough information to disentangle effects of fertility timing and level without imposing stringent and unrealistic restrictions. When those restrictions are not met, the measure can be unstable and can grossly mischaracterize fertility levels and trends.

## Note

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