Tempo Effects on Fertility during the Great Recession: Surprises and New Models

Extended Abstract for PAA 2014 Submission

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Abstract

The recession has reduced birth rates in many countries. Have these births been simply delayed or forever foregone? Tempo-adjustment is meant to answer such questions. Applying the Bongaarts-Feeney method, however, gives us clearly the wrong answer. Their tempo-adjusted TFR shows *increasing* birth rates with the onset of the recession. In this paper, we describe how and why the period-based approach of Bongaarts and Feeney can go wrong. We then propose alternative cohort-based approaches to tempo-adjustment that suggests that much of the fertility decline of the Recession will not be recovered. Finally, since postponement is likely to have both period and cohort components we develop a combined approach that includes both effects. Applications are made to the United States, Spain, and Greece.

1 Introduction

Birth rates have fallen significantly in a number of countries as a direct effect of the Great Recession. This would seem like a perfect opportunity for tempo-adjustment procedures like that proposed by Bongaarts and Feeney (1998) to distinguish between tempo and quantum effects. Such methods if successful will indicate what fraction of the decline in births is attributable to postponement and what fraction may never recover.

Unfortunately, the Bongaarts-Feeney (BF) adjustment gives us what is clearly the wrong answer for at least some of the countries experiencing fertility drops. Calculation of the tempo-adjusted TFR (Bongaarts and Feeney's measure of "pure quantum") in Spain, the United States, and Greece increases (rather than decreases) after 2008.

The goal of this paper is to understand what is leading the BF approach astray and to develop other methods for understanding the effect of the recession on the tempo and quantum of fertility.

Our approach is first to present the results of BF adjustment and to explain what about the BF approach could be creating the false impression that quantum is increasing. The BF approach is clearly overestimating the magnitude of postponement. Second, we show an alternative *cohort*-based approach. This approach takes account of the longer-term shifts in cohort timing, assigning any additional change to changes in period quantum. Finally, we attempt to advance the modeling of processes in which there are both period and cohort tempo effects in order in order to disentangle what is really happening as a result of the recession.

2 Illustrative Examples

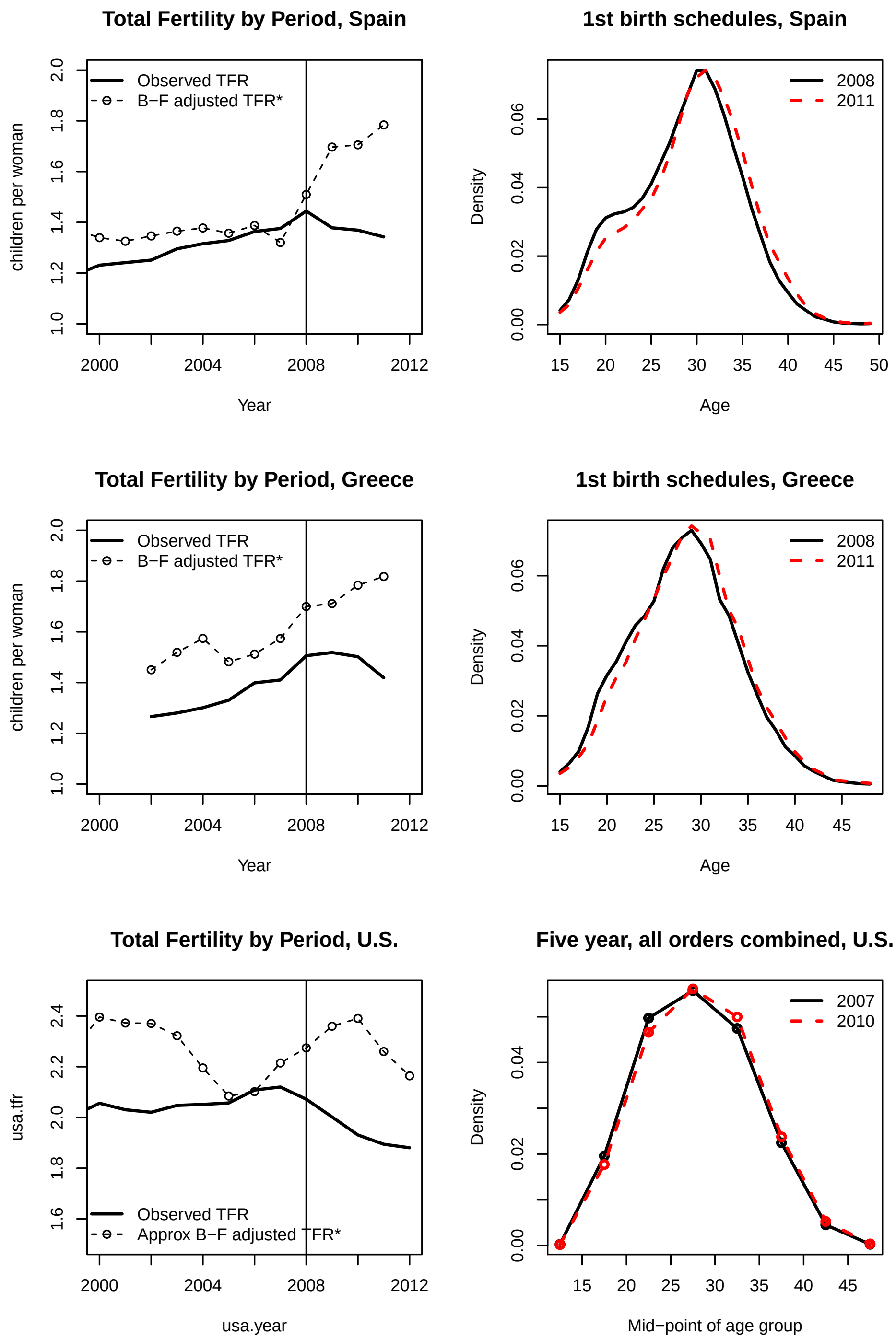
We illustrate the effect of the recession by showing period total fertility rates by parity in Spain, Greece, and the United States. In all three countries there has been a significant drop in births since the onset of the recession in 2007/2008. The literature so far (e.g., Goldstein et al. (2013)) attributes this drop to a combination of factors including increases in unemployment and declines in migration, both of which disproportionately affect younger ages.

In the Figure, we see the decline of Total Fertility Rates (for all birth orders combined) in Greece, Spain, and the United States. In Greece and Spain, we see that the Bongaarts-Feeney measure of tempo-adjusted fertility shoots up following the recession. In the United States, the BF measure of quantum also rises for several years. (We should note that the TFR^* values for Spain and Greece estimate postponement separately by parity and combine them using Bongaarts and Feeney's recommended approach. In the United States, we have used combined-parity data only.)

Examining the change in age-specific fertility schedules (which have been normalized to sum to one), we can see that in Greece and Spain there is a sharp drop in fertility at young ages. We have illustrated this using parity one schedules because that is the majority of births in these two countries. However the pattern is also visible if we were to combine all births. In the United States, the timing of the recession is slightly different, and it is not obvious what age-specific changes are driving the increasing mean age enough to raise tempo-adjusted fertility.

In the case of the recession, we would expect some part of the decline in TFR to be explained by declines in tempo-adjusted fertility, with the remainder being due to tempo. The surprising, and clearly implausible, result of using the BF method is that it indicates that adjusted-TFR itself increased with the onset of the recession. In other words, more than 100 percent of the decline in fertility was due to postponement; in the absence of postponement, the TFR should have actually increased (!). The BF correction over-compensates for possible tempo-effects.

More generally, the Bongaarts-Feeney approach has two major challenges. The first is how to measure the magnitude of shifts. The second is in the period-emphasis of the model itself, which allows only certain kinds of fertility


Total Fertility by Period, Spain
children per woman
Observed TFR
B−F adjusted TFR*
Year
1st birth schedules, Spain
Density
2008
2011
Age
Total Fertility by Period, Greece
children per woman
Observed TFR
B−F adjusted TFR*
Year
1st birth schedules, Greece
Density
2008
2011
Age
Total Fertility by Period, U.S.
usa.tfr
Observed TFR
Approx B−F adjusted TFR*
usa.year
Five year, all orders combined, U.S.
Density
2007
2010
Mid−point of age group

change.

When the BF model holds perfectly, changes in the mean age will perfectly estimate postponement. However, when fertility postponement is not uniform by age, small changes in birth rates at extreme ages (young or old) can leverage large changes in the mean. We show mathematically this effect in the next session. (This same point was made by Kohler and Philipov (2001), who using alternative methods try to correct for what they call "bias" in the BF formula).

Another challenge is that changes in fertility schedules have both a period and a cohort component. For example, cohorts that have postponed births at younger ages have a built-in upward pressure on births at older ages. Likewise, young cohorts encountering the recession may choose to postpone childbearing. Ideally, we would like to have a model that would allow estimation of both period and cohort postponement effects. As the reader can imagine, such a model is difficult to estimate, as the two kinds of effects are often nearly exchangeable. In the final two parts of this paper we introduce a cohort counter-part to B&F's model and then a combined model.

3 Sensitivity of the mean to age-specific fertility changes

Here we develop a simple model using perturbation analysis that is useful for understanding how violations of the proportionality assumption can have large effects on the change in mean age of fertility. (This model is remarkably like formulation by Ryder (1964) but is put to different use.)

We define a perturbed fertility schedule as

$$f(x,\epsilon) = f(x) + \epsilon f'(x,0)$$

where $f'(x,0)$ is short-hand for the derivative of f with respect to ϵ at each age x when ϵ is zero.

The total fertility rate is then

$$TFR(\epsilon) = \int f(x,\epsilon)\,dx$$

and the mean age of the fertility distribution is

$$\mu(\epsilon) = \frac{\int x f(x,\epsilon)\,dx}{\int f(x,\epsilon)\,dx}.$$

Now using the quotient rule,

$$\frac{d\mu(\epsilon)}{d\epsilon} = \frac{\int f'(x,0)x\,dx \mathrm{TFR}(\epsilon) - \int f'(x,0)\,dx \mu(\epsilon)\mathrm{TFR}(\epsilon)}{\mathrm{TFR}(\epsilon)^2}$$

$$= \frac{\int f'(x,0)\left[x - \mu(\epsilon)\right]\,dx}{\mathrm{TFR}(\epsilon)}$$

Counting age in discrete years, we can write.

$$\frac{d\mu(\epsilon)}{d\epsilon} = \frac{\sum f'(x,0)\,[x-\mu(\epsilon)]}{\text{TFR}(\epsilon)}$$

We can apply this result to the simple case in which we change fertility at a single age x^* by a total of $f'(x^*,0) = \Delta$. The effect on the mean will then be

$$\frac{d\mu(\epsilon)}{d\epsilon} = \frac{\Delta}{\text{TFR}(0)}(x^* - \mu(0)$$

The change in the mean due to a perturbation at a given age is proportional to the distance of that age from the mean.

This simple case can also be put in terms of the BF model,

$$\text{TFR}^* = \text{TFR}_{obs}/(1-\mu').$$

Substituting the change in the mean in our simple case for μ' gives

$$\text{TFR}^* = \frac{\text{TFR}_{obs}}{1-(\Delta/\text{TFR}_{obs})(x^*-\mu_{obs})},$$

or,

$$\text{TFR}^* \approx \text{TFR}_{obs}\,[1+(\Delta/\text{TFR}_{obs})(x^*-\mu_{obs})] = \text{TFR}_{obs} + \Delta(x^*-\mu_{obs}).$$

In this simple case, we then have TFR changing only by Δ but the adjusted TFR* changing a factor $(x^* - \mu_{obs})$ as great. For example, the mean age were 30 and fertility were to decline by 0.01 only at age 20, then the TFR would fall by 0.01 but the tempo-adjusted measure of quantum would be forced upwards by about 0.10.

This is roughly what appears to be happening in the case of Spain and Greece. Fertility is declining disproportionately for those in their early 20s. This age-specific decline in fertility leverages itself into a jump in the mean age, which in turn pushes tempo-adjusted fertility sharply higher. This upward adjustment outweighs the change in fertility, causing the Bongaarts-Feeney measure of period quantum to rise at the onset of the recession, when by all reasonable expectations it should be falling.

4 Cohort postponement

As an alternative to the period model, in which all ages postpone by the same amount, a cohort-based model is one way to allow differential postponement within a given period.

Our cohort shift model of fertility blends cohort based tempo effects with period quantum change. Cohort tempo can be represented as the outcome of shifts that describe how much each cohort may have advanced or delayed its fertility schedule. Different generations will have different plans for the timing of childbearing that play out over the course of their lives. These underlying schedules of intended fertility then encounter period driven events or shocks that may ultimately reduce or increase the cohort's total fertility. This model, a mixture of cohort and period influences, captures both the lifetime implications of cohort fertility intentions and the immediate responses to unanticipated period events. It is the interplay of cohort plans and period events that produces the variety in the observed fertility surface.

Denote the fertility rate at age a and time t by $f(a,t)$, with the fertility rate at age a of the cohort born at time c given by $f(a, c+a)$. Let $f_0(a)$ denote a normalized, standard baseline fertility schedule that sums to one.

The cohort shift model of fertility:

$$f(a,t) = f_0(a - S(t-a))q(t). \tag{1}$$

Here, the $q(t)$ term is the period intensity of fertility, which would be equal to the TFR if there were no shifts. The shifts S are indexed by the cohort born in year $t-a$.

For the cohort-shift model of equation (1), $q(t)$ can be recovered from observed rates by defining the shift-adjusted period total fertility rate as

$$\mathrm{TFR}^{\dagger}(t) := \int_0^{\omega} f(a,t)(1 + S'(t-a))da, \tag{2}$$

where $S'(t-a)$ is the derivative of $S(c)$ evaluated at $t-a$, the incremental shift relevant for the cohort aged a at time t.

5 Combining cohort and period shifts

Cohort and period shifts are not incompatible ideas. Both types of postponement can be encompassed in one model.

The combined model of shifted fertility:

$$f(a,t) = f_0(a - S(t-a) - R(t))(1 - R'(t))q(t) \tag{3}$$

This combined model includes as special cases both the cohort-based model explored at depth in this paper (setting $R = 0$), and the period-based model used by Bongaarts and Feeney (setting $S = 0$). For the combined model of period and cohort shifts given in equation (3), the adjustment factor needed to recover $q(t)$ is given by

$$\frac{1 + S'(t-a)}{1 - R'(t)}.$$

With this adjustment factor we can define shift-adjusted period total fertility as

$$TFR^{\dagger+*}(t) := \int f(a,t) \frac{1 + S'(t-a)}{1 - R'(t)}\, da.$$

Fitting this combined model to data poses challenges regarding identification of distinct period and cohort effects. One approach that we are developing uses numerical optimization to try to separate these. However, a promising new approach fits the period and cohort effects sequentially.

6 Preliminary Conclusions

While our formal analysis of fertility change during the recession is still in its early stages, it is clear that the existing Bongaarts-Feeney approach cannot explain the patterns we are seeing today.

In short, the recession is hitting younger people especially hard, and for this and other reasons we are seeing disproportional declines in fertility at younger ages. Under these conditions the BF model overcompensates, estimating such a large tempo effect that it produces implausible increases in the quantum of fertility. Using perturbation analysis, we see why small changes in births at young ages can produce this result.

As an alternative to the purely period approach of BF, we plan to apply the cohort model we introduced earlier (Goldstein and Cassidy, 2010) to the current recession and the years preceding it. This model allows the younger cohorts to postpone at faster rates than the older cohorts.

The cohort-model, however, we believe is also incomplete. In order to address this, we will introduce the combined period and cohort postponement model. Our future work will develop estimation methods for this model and use it to try to analyze the recession.

As a final note, we emphasize that no model will be able to answer with certainty how many of the missing babies of the recession will be born in the coming years. Still, it is clear that the B&F model is not by itself able to provide useful information. Our hope is the introduction of alternative models will at a minimum highlight the potential unreliability of the BF model, and at best, provide a useful alternative.

References

J. Bongaarts and G. Feeney. On the quantum and tempo of fertility. *Population and Development Review*, pages 271–291, 1998.

J. Goldstein, M. Kreyenfeld, A. Jasilioniene, and D. D. K. Örsal. Fertility reactions to the "great recession" in Europe. *Demographic Research*, 29(4): 85–104, 2013.

J. R. Goldstein and T. Cassidy. Cohort postponement and period measures. MPIDR Working Papers WP-2010-015, Max Planck Institute for Demographic Research, Rostock, Germany, Feb. 2010.

H.-P. Kohler and D. Philipov. Variance effects in the bongaarts-feeney formula. *Demography*, 38(1):1–16, 2001.

N. B. Ryder. The process of demographic translation. *Demography*, 1(1):74–82, 1964.