The proximate Determinants of Fertility: An Estimation Approach

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Abstract

The proximate determinants of fertility, originally formulated by Bongaarts (1978) with later contributions by Stover (1998) and Bongaarts (2015), remains the prevalent framework for studying fertility in developing countries. It highlights the role of contraception and abortion in the intentional reduction of fertility, and the impacts of sexual exposure and postpartum infecundability. However, the contribution of the different factors is not estimated from the data. It is imputed based on aggregate indicators for each determinant: the impact of contraception is based on overall contraceptive prevalence and an external imputation of effectiveness by method based on biomedical literature, mostly from the US in the 1970s.

We propose an alternative estimation approach to the proximate determinants where the contribution of each factor is directly measured instead of imputed. For instance, the relative protection of contraception against the risk of pregnancy is measured by comparing pregnancy rates of fecund women using and not using contraception. The role of pregnancy termination, including both induced and spontaneous terminations, is estimated by the proportion of pregnancies that do not end up in a live birth.

We estimate the role of the proximate determinants based on reproductive calendar data from Demographic and Health Surveys. We compare the decomposition obtained with the decomposition in Bongaarts (2015). The differences highlight in what contexts contraceptives are being used less effectively. While in this initial study we focus on general fertility, the approach can be applied to different population subgroups by age, union status or education in order to better target reproductive health programs.

Background

The proximate determinants of fertility framework, originally formulated by Bongaarts (1978), remains the most widely used approach to link reproductive health policies and fertility outcomes in developing countries. It connects the intentional elements in reproduction (contraception and abortion) and associated behavioural elements (sexual exposure, post-partum infecundability). The original formulation used marriage to indicate sexual exposure. Stover (1998) argued the need to include all sexually active women as exposed irrespective of marital status, a modification followed more recently by Bongaarts himself (Bongaarts 2015). As a result the modified multiplicative model is

$$TFR = C_m \times C_c \times C_i \times C_a \times TF \tag{1}$$

where C_m is the sexual exposure index, C_c the contraception index, C_i is the postpartum infecundability index and C_a the abortion index. The usefulness of the approach stems from the linking of reproductive health policies, as summarized by contraceptive prevalence, and fertility. A limitation, however, is that the fertility reduction connected to each factor is not directly measured. It is imputed based on empirical regularities documented in Bongaarts and Potter (1983) and Bongaarts (2015). In particular, these are the assumptions

- TF is the total fecundity rate. It is estimated through a regression approach (Bongaarts 2015, 558)

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- C_m the sexual exposure index is derived as $C_m = m + ex$. m: proportion of women married or in-union. ex: unmarried women who are pregnant, report sexual intercourse in the last month, use contraception, or are postpartum infecundable.
- C_c, the contraception index, is obtained as $C_c = 1 - r(u - o)e$. r: fecundity adjustment. u: contraceptive prevalence. o: overlap with postpartum infecundability. e: average effectiveness of the contraceptive mix.
- C_i the postpartum infecundability index is estimated as $C_i = \frac{20}{18.5+i}$, where i is the average duration of postpartum infecundability.
- C_a, the abortion index, is derived as $C_a = \frac{f}{f+b^*ab}$ where f is the fertility rate, ab the abortion rate. In this equation $b^* = \frac{14}{18.5+i}$ is a constant representing the number of births averted per abortion.

Since the reduction effect for each factor is imputed and not estimated, the adjustment of the model is not perfect. In particular, an imputed TFR value based on the model TFR_e, is compared to the observed TFR.

Although this approach has been widely used over the years, we have concerns about the use of imputed parameters instead of estimating them. For instance, with respect to C_c, the idea behind e is that different contraceptives are not equally effective at reducing fertility so that an average effectiveness is associated to the particular method mix prevalent in a country. For computing e, Bongaarts (2015) refers to Bongaarts and Potter (1983). The latter uses fixed values of effectiveness for each method based on estimates from the United States in the 1970s (Vaughan et al. 1977). There are a number of studies updating these estimates, the most recent being Trussell (2011). However, results are still using only United States data. Therefore, standard proximate determinants estimates assume in all countries the same effectiveness as in the United States. While this might be arguably true for methods where behaviour is not as important, such as implants, it might not be the case for other methods suchs as condom use, natural fertility methods or IUDs where behaviour matters and country differences in sex education regarding contraceptive use might be relevant.

A similar argument can be made regarding abortion modelling. Bongaarts (2015) uses for individual countries ab subregional abortion rates as estimated by Gilda Sedgh et al. (2012). An updated study recognized that these estimates tend to be consistenly higher than the observed data (G. Sedgh et al. 2016). In addition, intraregional heterogeneity in abortion risks are not being considered. Demographic and Health Surveys, however, do provide information on survey-specific reported terminations including both spontaneous and induced abortions (Sánchez-Páez and Ortega 2019). The use of the same survey to estimate fertility, contraception and terminations provides a congruent story.

Given these concerns we propose an updated approach to the estimation of the fertility reduction effect of the proximate determinants based on:

1. Estimation, instead of imputation, of the multiplicative factors. In particular, the role of contraception can be ascertained from the comparison of fertility for sexually active women not using contraception to that of contraceptive users.
2. Use of information from the same Demographic and Health Survey to estimate:

- Total Fecundity associated to the fertility of sexually active women not using contraception.
- The reduction in fertility associated to the use of contraception by comparing fertility using and not using contraceptive methods.
- The reduction in fertility associated to pregnancy terminations, either induced or spontaneous.
- The proportion of exposed women experiencing postpartum infecundability.

In our approach a key element is the availability of contraceptive prevalence at the time of pregnancy. Such information is not always available in DHS surveys. We rely on those that include contraceptive calendar data. This makes it possible to derive estimate for many variables at the time of pregnancy, including union status, age, monthly contraceptive use, and the outcome of each pregnancy (birth or termination). Moreover, the birth record includes the length of postpartum amenhorrea and abstinence measured as the number of months after the birth. There are also questions regarding sexual activity, age at first sexual intercourse, and menopause. From this information we have all the inputs needed to estimate the effect of the proximate determinants solely based on data from the same survey. In other words, there is no need to impute specific country-case results or regional estimates to national data.

The advantage of our approach is that it can help in the formulation of more targeted reproductive health policies by identifying, for instance, populations where the impact of contraception is low given prevalence levels indicating less efficient use. The analysis can be dissagregated according to union status, age or education level, but in this initial presentation we will limit the analysis to aggregate fertility at the survey level.

Data and Methods

Data

Our preliminary sample includes 40 DHS surveys (The DHS Program 2019) from 25 countries. Our sample meet two main requirements. First, all of these surveys have contraceptive calendar data (The DHS Program 2017). Second, they include questions `v536` "Recent sexual activity", `M7` "Months of amenorrhea", and `M9` "Months of abstinence". Aggregate contraceptive prevalence is obtained from Statcompiler (ICF International 2015). We expect to include more surveys in the full paper.

For each survey, we will focus on the pregnancies that would have led to births in the 3 years prior to the interview. Based on reproductive calendar data, we measure the monthly risk of conception according to contraceptive use for sexually active women together with the conditional probabilities of pregnancy termination. We also measure the proportions of women not at risk due to postpartum infecundability.

Research is carried out in `R` (R Core Team 2019). We use `tidyverse` (Wickham 2017) functions for data manipulation and estimation. The manuscript is prepared in *Rmarkdown* format using `knitr` (Yihui 2018).

Methods

Our decomposition approach is similar in many ways to standard proximate determinants with relatively different meaning for each of the components

$$TFR = C_M \times C_C \times C_I \times C_T \times TF \tag{2}$$

While our purpose is to use separate models by age and union status, in this first estimation we only study aggregate fertility. Instead of carrying the analysis separately by age and aggregating, we get rid of the effect of population structure by reweighting the original survey weights so that all age-groups have equal weights at the survey level.

The main differences in interpretation of our estimated factors and the original imputed factors are the following:

- Sexual exposure: We use an indicator of effective sexual exposure that estimates the proportion of women that were sexually active in the year before the survey and were not infecund. Infecund women are identified by self declaration or not having gotten pregnant despite not using contraceptives in the last 3 years. In a sense, our C_M index is a combination of Bongaarts C_m and Stover index of infecundity.
- Contraception index: Instead of imputing effectiveness based on method mix we rely on the comparison of pregnancy rates for women using and not using contraceptives. The effectiveness can be examined ex-post by computing, for instance, the ratio of C_C to contraceptive prevalence. A key element in our analysis is the use of calendar data to retrieve if the pregnancy happened while the woman was using contraceptives and, therefore, experience a contraceptive failure. To avoid right-censoring, we use pregnancies beginning between 44 and 9 months before the date of interview.

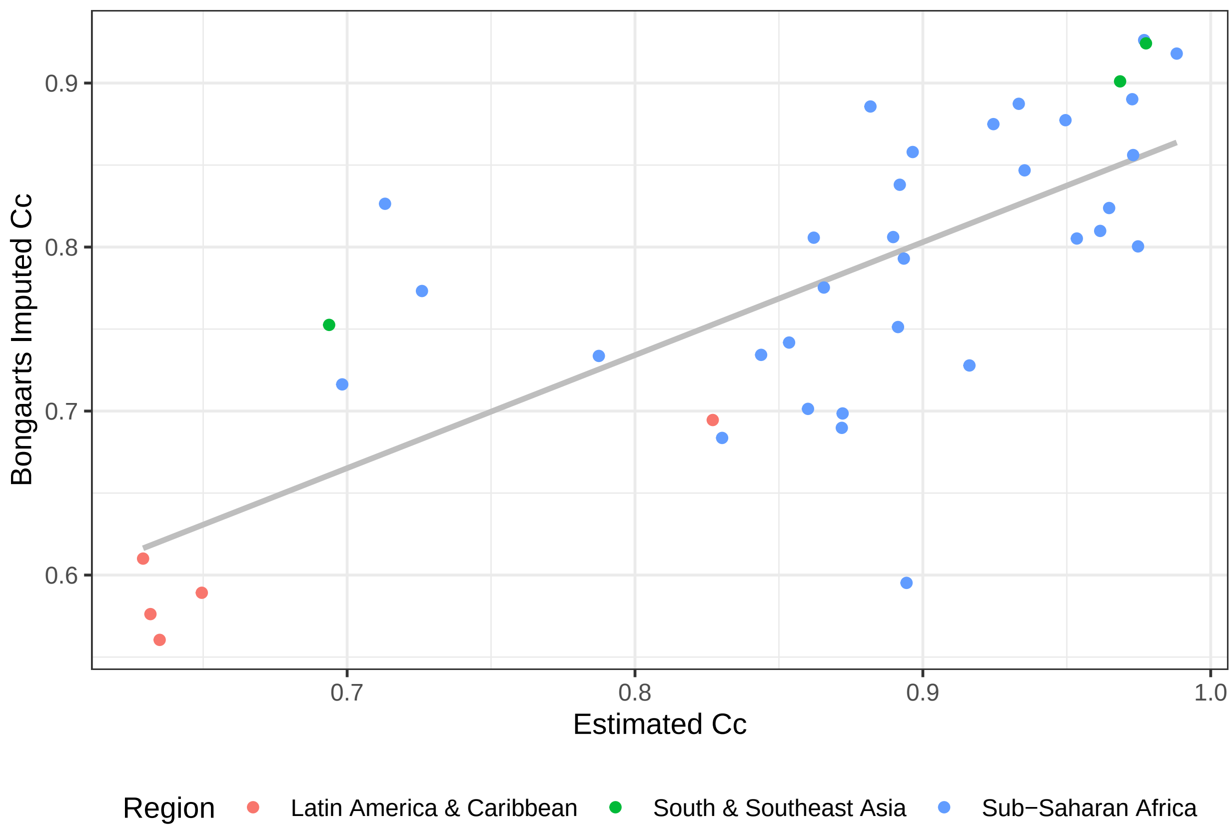

Figure 1: Contraception index according to both methods

- Postpartum infecundability: Instead of imputing the proportion infecund based on average length of lactation, we use the information provided by DHS on the duration of lactational amenhorrea (lam) and sexual abstinence (sab) for every birth. We assign the highest period between the two of them to the corresponding birth. The reduction in fertility due to this factor comes from the proportion of initially computed exposure that is spent in postpartum infecundability.
- The pregnancy termination index: We track the outcome of all pregnancies that would have led to a birth in the 3 years prior to the interview. The pregnancy termination index is the proportion of pregnancies ending up in a live birth. In most DHS surveys there is no information regarding the type of termination (Sánchez-Páez and Ortega 2019). That is why we do not attempt to separate spontaneous and induced terminations.
- Total fecundity: We estimate total fecundity based on the total fertility of women that had not used contraception over their reproductive years.

Preliminary results

While our calculations are at a preliminary stage, in Figure 1 we show the comparison of the contraceptive index as calculated with the Bongaarts approach based on imputation, and our contraceptive index based on the observed reduction in fertility. Differences among them will serve to identify surveys where the reduction of fertility is lower than expected given contraceptive mix indicating possible misuse of pregnancy methods. We see that there is a linear association between both indicators but also important differences at the survey level.

Discussion

We will address some of the limitations of both methods. In particular, there are some problems connected to our approach of using as a benchmark the comparison of fertility of contraceptors and non-contraceptors.

- One issue discussed by Bongaarts (2015) is that the knowledge a woman has about her own fecundity influences her decision to use contraception. As a result, contraceptors are on average more fecund than non-contraceptors. We will evaluate the possible impact this has on our estimated C_C levels.
- It is known that contraceptive prevalence based on reproductive calendar data is, for some surveys, lower than contraceptive prevalence measured at the moment of interview Bradley, Croft, and Rutstein (2011). This can be due to missreporting of changes in monthly contraceptive use. We will discuss the possible impact this has on our estimates.
- The estimated probabilities of pregnancy termination based on reported terminations in DHS surveys are often lower than estimates from other sources, particularly in the case of countries where induced abortion is not legal. In addition, Sánchez-Páez and Ortega (2019) document that in many countries, particularly in sub-Saharan Africa, probabilities of termination indicate undereporting of spontaneous terminations as well. We will discuss how possible underreporting of terminations impact our estimates. Basically, the probabilities of conception will be underestimated as well leading to low levels of estimated TF.

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