Abstract

Fertility forecasting in the case of Brazil constitutes a great challenge due to the regional heterogeneity of its fertility transition, making the application of the known projection techniques difficult. Thus, the paper presents a methodology that allows to forecast the pattern and level of fertility by defining scenarios for a small geographical unit based on the fertility behavior of the total population. In this case, Brazilian Federate States (BFS) and the whole country as a unit. We use National Household Surveys, Demographic Censuses (2000 and 2010) and vital statistics where data are reliable. We assume that the trend of reproductive behavior outlined for the country as a whole is a transition process to be experienced by all BFS, differing only by the timing it occurs. From this assumption it is possible to identify –using the more recent BFS’ TFR as a first parameter– the timing of its corresponding fertility transition. Then, using interpolation procedures we replicate the national transition experienced by each ASFR. The robustness of this technique is given by the coincidence of the sum of births generated by the FBS’s ASFR and the total births generated by the ASFR defined for the whole country.

Introduction

An adequate fertility forecasting is an essential element for any reliable population forecasting. Among the well known techniques, the commonest ones are the logistic projection of fertility level, which requires a limit total fertility rate (CELADE, 1984, IBGE, 2004), and the use of the Relational Gompertz Model for estimating age fertility patterns.
(Brass, 1981; Moultrie, 2012). The technique used by United Nations is based on Bayesian probabilistic projections, which takes the pattern of a number of countries as a benchmark to establish the parameters for project the fertility of a single country (Heilig et al., 2010). For fertility forecasting, Wong (2000) used an empirical method based on exponential variations of historical series to estimate the fertility level for each of the 27 Brazilian Federal States (BFS). Kaneko (2010) draws attention to the cohort model, in which childbearing schedule is projected for individual single year cohorts of women, which is then reorganized in order to project age-specific fertility rates (p. 09) and then the period TFR. According Raftery et al. (2009) there are a number of methods for fertility projection, which can be use in different contexts and assumptions (p.08).

Fertility forecasting, in this way, requires a broad knowledge of past and present trends as well as the inclusion of its distant and proximate determinants. Relating to Brazil, the challenge is even larger since it is a huge country with enormous regional heterogeneity in the process of fast fertility transition: the current fertility levels of the five geopolitical regions are above and below replacement level. Thus, applying well-known fertility projection techniques to cover such different scenarios produce very often unsatisfactory outcomes.

Given this context, this paper deals with the difficulties of the known methods for forecasting fertility levels and pattern in each of their 27 Brazilian Federate States (BFS). We apply an alternative methodology that defines the scenarios for a small geographical unit based on the fertility behavior for the total population. This procedure is particularly valuable because in less developed settings, lack of –or unreliable– data is very often the case. Furthermore, one have the constrains of small samples size and/or unexpected variability due to scarce numbers of births, particularly at older age groups where fertility rates are near zero.

*Recent trends in fertility in Brazil*

Fertility decline in Brazil took place during late 60’s and the downward trend still prevails: the total fertility rate (TFR) change from 4.0 to 1.9 children per woman between 1980-2010. Table 1 shows the transformations on TFR, the relative contribution of women up to the age 35 and the mean age of fertility schedule. Besides the continuous decrease in the number of
children born we can see that the main contribution to fertility corresponds to women up to age 35, which reflect a young fertility pattern. The decline trend of the mean age of fertility was interrupted in 2010.

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<tbody>
<tr>
<td>TFR (per woman)</td>
<td>4,0</td>
<td>2,7</td>
<td>2,3</td>
<td>1,9</td>
</tr>
<tr>
<td>Relative contribution of fertility among women up to age 35 (per hundred)</td>
<td>79,3</td>
<td>87,7</td>
<td>91,4</td>
<td>87,1</td>
</tr>
<tr>
<td>Mean age of Fertility (in years)</td>
<td>28,9</td>
<td>26,9</td>
<td>25,6</td>
<td>26,6</td>
</tr>
</tbody>
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The age specific fertility rates (ASFR) are shown on Figure 1. It illustrates the rapid process of decline in Brazil that has one of the lowest fertility levels and youngest age pattern in Latin America. This behavior seems to reverse given the observed increase in the fertility's mean age between 2000 and 2010 and the smoothing of the peak of the curve for the last year analyzed.

FIGURE 1: Distribution of fertility by age group of women (ASFR). Brazil, 1980, 1990, 2000 and 2010

The interruption of the rejuvenating age pattern

The shift to lower fertility levels was accompanied by changes in fertility behavior by age. The biggest fertility declines that occurred among older women explains the youngest distribution of fertility. This process was particularly pronounced in the North and Midwest regions: between 1980 and 1996, the mean age in these regions decreased more than three years.\(^6\)

Table 2 clearly shows that the forerunners BFS in fertility decline are also those who have first entered in the process of aging of the fertility pattern, with a steady increase in the mean age between 2001 and 2009. If this trend is followed by all BFS, we will see a postponement of childbearing and the weight of older ages in the fertility distribution will be greater (different from observed nowadays). Thus, the recovery of fertility will occur later and levels will tend to fall in the coming years and then will increase when women reach older ages.

Table 2: Average age of the fertility schedule for Rio de Janeiro, São Paulo and Santa Catarina, 2001-2009

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
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<tbody>
<tr>
<td>São Paulo</td>
<td>26.57</td>
<td>26.66</td>
<td>26.75</td>
<td>26.86</td>
<td>26.88</td>
<td>26.96</td>
<td>27.02</td>
<td>27.16</td>
<td>27.18</td>
</tr>
</tbody>
</table>

Source: SINASC, 2001 a 2009; 2000 and 2010 Demographic Census

The role of contraception in reducing fertility

Several studies identify socioeconomic determinants as education, urbanization and access to mass media (this one as a proxy of exposure to modernity ideas and consequently to adoption of values that would provide a small number of children) as the most important factors to explain the fertility transition in Brazil.\(^7\) Among the intermediate variables,

\(^6\) It is worth mentioning that the youngest standard in the North, and in this case refers only to the urban population, is found also in the Civil Registry, whose scope, although notoriously incomplete, is higher than that of sample surveys limited to the only urban conglomerates.

\(^7\) Some of these studies are: Merrick e Berquó (1983), Faria e Potter (1990), Rosero-Bixby and Casterline (1993).
contraceptive prevalence has been very important in the fertility decline, especially because of the early age at sterilization\textsuperscript{8}.

Brazil’s current reproductive age pattern is young and is related to the timing of reproduction and the contraceptives methods used. Brazil is one of the Latin-American countries with the highest contraceptive prevalence, particularly concentrated on contraceptive pills and female sterilization (BEMFAM/DHS, 1997).

On the other hand, the 2006 PNDS shows some additional changes in this pattern (Perpétuo e Wong, 2009). There was a significant reduction particularly among women from highest socioeconomic groups, and an increased use of other methods, in particular male methods, such as vasectomy and condoms. These changes resulted from increases in women’s knowledge and access to other contraceptive methods, even though this access is still quite differentiated according to social strata.

In short, the elements mentioned show the consolidation of low fertility in all Brazilian regions. Moreover, these elements provide the inputs to assess the possibilities for continuation of these trends and define what is expected for the Brazilian fertility.

**Expected levels and patterns of fertility - Methodological Procedures**

Given the brief considerations and the relatively low fertility levels achieved by Brazil as a whole, it is appropriate to adapt the use of the notion of Demographic Transition to forecast levels of fertility since most of BFS have undergone the period of sharp decline of fertility, then there are no States with significant high TFR. With the set of estimates available, we can identify trends in both time and between states, which allows us to set out a transition toward low levels of fertility identified with the Brazilian process.

The methodology used to forecast fertility levels and their corresponding age distribution as well as the results obtained, are detailed below.

\textsuperscript{8} See, for example, Silva et al.;1990; Camarano, 1994; Perpétuo, 1995.
**Data**

We intend to project fertility trends for the BFS starting in 2010, the most recent year we have available data for. We use National Household Surveys, Demographic Censuses (2000 and 2010) and vital statistics where data are reliable.

*Definition of a pattern trend of behavior from Brazil as a whole: The projected levels for fertility rates by age*

The basic assumption for estimating the fertility level in Brazil is that it will continue to decrease, but at a less pronounced pace, given that the TFR is already below the population replacement level by 2010 (corresponding to a TFR of 2.1 children per woman).

Thus, for different periods in the projection spectrum, and considering the whole country, it is assumed that:

- The women between 15 and 19 years, fertility will continue to decline thus, in the next 10 years, Brazil will have the risks that today (2010) present the young girls in the more advanced BFS. This means that the fertility rate for these ages will be approximately 50 per thousand, on average, for Brazil.

- To the intermediate groups, i.e. between 20 and 30 years, since current levels are quite low it is assumed that they will maintain a downward trend in the near term, remaining stable from the next 10 years.

- For women aged 35 to 45, considering that they currently have extremely low levels, it is not expected future losses. They will keep a slight downward trend; taking account recent trend would imply in eliminating the risk of having a live birth at that age, which does not seem that it will be the Brazilian case.

- Regarding young women, from who is assumed in the immediate future a significant decrease in the risk of having a live birth, it is also expect that as they reach ages over 35 years, they will carry out the fertility postponed during earlier ages. In this sense, in the medium and long term, it is presumed that fertility will start to increase in the age group 35-40.

- Finally, for women aged over 45 years, we believe that fertility will remain at current levels
extremely low levels; i.e., with rates below at, for example, 5 births per thousand women.

Important to emphasize that the expected trend for the ASFR over time lies in the central hypotheses that current youngest cohorts will experience a *tempo* change in their risk of having a live birth.

Figure 2 summarizes the expected trend for fertility behavior for each age group, from 2010 onwards, according to the assumptions drawn above.

**Figure 2: Brazil 1960-2060: Estimated ASFR from 1960 to 2010 and forecasted from 2010.**

![Graph showing ASFR from 1960 to 2060 for different age groups.]


**Projecting the levels: the Total Fertility Rates**

The estimated rates by age as presented in Figure 2, allow us to calculate the period measure or synthetic index Total Fertility Rate.

The TFR in Brazil, given the scenario in the previous section, will decrease from 2.0 children per woman recorded in the five year period 2005-2009, to 1.7 in 2030 and, probably, to 1.6 children per woman in 2050.

Since we believe that very young women will begin to postpone the fertility, we accept the fact that they will have children at later ages. And when this happens, Brazil will register
increases in its fertility, mainly due to the “tempo” effect.

In other words, if the younger generations postpone the childbearing, the period fertility will continue to fall in the short term. By the time these women decide to have children, the period fertility may increase in the medium and long terms.

Figure 3 summarizes the results obtained for the whole country using the assumptions mentioned above, this time by plotting a period ASFR patterns:

![Figure 3 - Brazil 1980-2030: Fertility rate by age](image)

Source: For 1980-2000: census data from IBGE. 2000-2030 estimated by authors

*Preparation of estimates of fertility for each BFS*

We supposed that the tendency of the fertility outlined above is a widespread process of fertility transition to be experienced by all the BFS, but each state differs from the others in the “timing” at this process will occurs. Thereby, it is possible to identify for each BFS, by its TFR, the moment of this transition in which it is for the most recent five-year period. Once identified this time, the BFS fertility pattern will be obtained by interpolation with the corresponding pattern of the country, for the entire projection period, and the level will be
obtained by the sum of interpolated specific rates.

Table 3 shows two examples of the matching between BFS’s TFR and Brazil’s TFR to identify the timing of change in the TFR for each BFS and the corresponding ASFRs.

Note that Rondônia’s TFR, in 2010, corresponds to the Brazilian’s TFR between 2005 and 2010. Based on this, the ASFR projected for Rondônia in 2015 are based on Brazil’s ASFRs between 2005 and 2010 (in brown); the projected ASFRs for 2020 are based on Brazil’s ASFRs between 2010 and 2015 (in blue), and so forth. Thus, we have the fertility forecasting for Rondônia over a period of 40 years.

Table 3: Identification of the timing of the start of projection for Rondônia and Santa Catarina, with reference to the Brazil’s TFR and projection of the ASFRs for this BFS from this timing

![Table 3](image)

Source: Authors’ own elaboration.

The same applies for Santa Catarina. In this case we observed that the TFR in 2010
corresponds to the Brazil's TFR between the years 2030 and 2035. The timing of Santa Catarina's fertility corresponds to Brazil's future fertility, indicating that this BFS is, nowadays, ahead of the rest of the country. Accordingly, the forecasting for Santa Catarina covers a period of 20 years from the Brazilian estimate. After reaching that period, we assume a constant level and pattern.

Re-estimation of the parameters of fertility in Brazil

By putting together the levels and patterns of fertility projected separately for each state in each period, we have then the profile for the whole country.

As the Brazilian trend was the basis for modeling the fertility forecast in each BFS, it is expected that the TFR obtained by the sum of births estimated for each BFS will be close to the TFR projected for Brazil as a whole, to each five-year projection period.

The comparison of the TFRs resulted from these two processes (Brazil as whole and Brazil by the sum of the BFS), for each period (See TAB. 4), indicates that the methodology used to project the BFS fertility reached its purpose, since the values are quite close, so that the sum of all births projected for the BFS resulted in an estimate of fertility compatible with what was projected for the country, in a given period.

| Table 4: Comparison of TFRs generated for Brazil from the projection of fertility for the country as a whole and from the sum of births projected for each BFS. 2005-2030 period |
|-------------------------------------------------|-------|-------|-------|-------|-------|-------|
|                                                 | 2,14  | 1,93  | 1,81  | 1,75  | 1,70  | 1,66  |
| TFR Brasil: Sum of BFS                          | 2,17  | 1,97  | 1,83  | 1,74  | 1,68  | 1,63  |

Source of basic data: IBGE, 2000 and 2010 Demographic Censuses; PNAD, 2001 to 2009.

The small difference observed between the estimated TFRs for Brazil (through projection and the sum of BFS) is due to the variability of the projection made individually for each state with distinct fertility behavior, relating to the others, in the beginning of the process. Moreover, the projection aggregates other factors (such as mortality and migration) that necessarily affect the final number of children born. Nonetheless, the role of these factors, if it existed, was small, given the low variation concerning to the TFR projected.
The Figure 4 shows that as the level of fertility derived from the sum of the births of BFS is close to the projected level of fertility for the total of the country, the distribution of fertility by age is also similar.

**Figure 4: Age distribution of fertility estimated for Brazil from two distinct processes - Period 2005-2030**

**a). Pattern of fertility by age projected for Brazil as a whole, by projection period.**

**b). Pattern of fertility by age obtained for Brazil from the distribution of the sum of births projected for each state, by projection period.**

Source of basic data: IBGE, 2000 and 2010 Demographic Censuses; PNAD, 2001 to 2009.

We observed that the fertility age distribution is very similar in the two methods applied, indicating that the procedure for forecasting the BFS fertility produced consistent results with what was expected for the country as a whole. Some small discrepancies are due to the same reasons applied to explain the small differences in the level: the BFS were projected
independently and have, at the beginning of the process, different patterns of distribution of fertility. So, as the BFS will differ in the timing of the projection it will reflect in the total age distribution.

Results - Some explanations on the results for the future fertility of the BFS.

Estimates of what is expected from fertility in each state are the most important product in this work, thus we present two graphs showing, first, the fertility level, represented here by the TFR (Figure 5). Then, as an indication of the age pattern, Figure 6 shows the evolution of the mean age of the fertility schedule. The data are grouped by Major Regions of Brazil.

Relating to the fertility level we assume that the decline trend will continue in the short and medium term. The main assumption, as stated before, is that, firstly, every BFS replicates the national trend in terms of fertility level, decline path and age pattern. The difference between states is then given by TFR they have at the beginning of the period (2010).

In the long term (2050), all of the BFS will have fertility levels below the population replacement level, within a range of approximately 1.7 to 1.3 children per woman. The pace of decline is different, depending on the TFR the BFS has in 2010. States with the highest TFR in 2010 will have a faster decline. Many of these BFS are located in the North and to a lesser extent in the Northeast. The expected difference relies on historical evidence; less developed countries that initiated the fertility transition in recent periods has shown a speed of fertility decline unseen before in industrialized contexts. In the Brazilian case, we believe that its type of integration and modernization process justify the fast pace of fertility fall that these BFS will present.

It is likely that fertility show signs of recovery, with an upward trend in the TFR before 2050. This may happen as a “tempo” effect resulted from the sharp decline that the country has experienced in the past 20 years. In other words, we believe that a significant part of the current decline in fertility is due to the postponement of childbearing instead of the decision of not having children. Thus, young women that have very low fertility rates in the decade 2010-2020 probably will have their children in the following decades; this change can

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be observed when considering the cohort behavior and is reflected in the period statistics due to the increase in births previously postponed. This trend explains, for example, increases in the TFR expected for BFS in the Southeast. It is worth to note that the tendency to a future increase in the levels of fertility is a scenario present in virtually all BFS.

The trend in the age pattern changes of the ASFR can be seen in Figure 6, which shows the mean age of this distribution. In most cases, if the hypotheses on fertility are proved to be true, the mean age of fertility is likely to increase, but this trend will change once the BFS stabilize their levels and patterns. This stability will be reached faster in contexts where fertility decline began earlier. This is the case for all states of the South and Southeast, with the only exception of Espírito Santo, whose fertility transition occurred later. To a lesser extent this is present in the Midwest States.

**Final considerations**

Due to non traditional (or unexpected) changes in a demographic context at the threshold of the first- to-second transition –if there is any at all– one needs to consider the changes in Tempo and Quantum in a fertility forecasting.

The method used here departs from the notion that in a less developed settings ASFR does not follow an uninterrupted downward trend that eventually reaches stability. Without stopping the decline in the total fertility, some ASFR can actually increase. I. e., due to the quite fast fertility decline in most LDC, a given woman can change her timing of having a baby without changes in her expected family size.

The proposed methodology is applied for estimating BFS fertility levels and patterns departing for a previous definition for the total population; Brazil in this case. The first step is to define the future fertility scenario, with the basic premise that fertility will continue to decrease, but at a slower pace, since the country is already below the replacement level. The scenario is built based on the ASFR behavior that produces the TFR.

We believe that this technique has great advantages such as simplicity of implementation and generation of consistent results for the BFSs. Furthermore, it is based on widely available data and does not require the use of modeled patterns that do not fit to the Brazilian context. The robustness of this technique is given by the coincidence of the sum of births generated by the ASFR from each FBS and the total births generated by the ASFR.
previously defined for the whole country. The methodology can be applied to developing settings that have a similar fertility transition than that observed in Brazil.
Figure 5: Federate States grouped by Major Regions (2010-2050): Total fertility rates estimated

Source of basic data: IBGE, 2000 and 2010 Demographic Censuses; PNAD, 2001 to 2009.
Figure 6: Federate States grouped by Major Regions (2010-2050): Average ages (in years) of the distributions of fertility by age.

Source of basic data: IBGE, 2000 and 2010 Demographic Censuses; PNAD, 2001 to 2009.
Selected references


