Birth Replacement Ratios in Europe: A New Look at Period Replacement

Abstract for the Population Association of America (PAA) 2007 Annual Meeting

Topic 1: Fertility, Family Planning, and Reproductive Health
Session: 111 Low Fertility in Comparative Perspective

Authors:
José Antonio Ortega and Luis Alberto del Rey
Universidad de Salamanca

Corresponding author:
José Antonio Ortega
Dept. de Economía e Historia Económica
Edificio FES, Campus "Unamuno"
Universidad de Salamanca
37007-Salamanca, Spain
Email: jaortega@usal.es
Fax: +34 923 29 46 86
Phone: +34 923 29 45 00 (Ext. 3158)

Short Abstract

European reproduction trends are traced using a new period replacement indicator: the Birth Replacement Ratio (BRR). The BRR is a replacement ratio that compares the period number of births to the mean size of the mothers' generation at birth. In contrast with the Net Reproduction Ratio, differences between the Total Fertility Rate (TFR) and the BRR are not due only to period mortality. They also incorporate the effect of mothers' emigration and immigration. The application to a number of European countries between 1800 and 2004 (depending on data) shows interesting contrasts between the TFR and the BRR which trace the demographic history of the respective countries.
BRR makes it possible to track the impact of emigration and immigration on population replacement over the demographic transition and compare the differences between sending and receiving countries.

Extended Abstract

Motivation

Standard demographic textbooks indicate that the Total Fertility Rate is a measure of period fertility, whereas the Net Reproduction Ratio, which takes into account the mortality of the potential mothers within a synthetic cohort, is a measure of reproduction. There are several limitations to the NRR as a measure of reproduction:

(a) The synthetic cohort nature of the calculations makes more difficult its interpretation. In general there is an insistence in it being an index of potential trends, but there is no clear meaning to that,
(b) In a low mortality setting, the difference between the NRR and the TFR (or rather the female sex ratio at birth times the TFR) becomes less important, and the TFR is generally used as a replacement indicator,
(c) The NRR does not take into account migration. This is particularly undesirable in a context like the European, where the small rates of natural growth have often made migration the main component of population growth.

Remedies to some of these limitations have been proposed. For instance, Calot and Sardon (2001) propose replacement indicators that tackle migration within a synthetic cohort framework. The problem is again the difficult interpretation of the indicator, and its partial irrelevance, since they are best seen as conditional measures for alternative migration scenarios.

Methods

Our proposal, the birth replacement ratio, tackles both limitations simultaneously while providing a natural generalization of the TFR to the study of replacement. It is well known that the TFR can be interpreted as the ratio of the number of births, B, to the mean size of the mother's generation, G, where G can be seen as a weighted average of the female population using fertility rates as weights (Calot, 1994):

$$G_t = B_t / TFR_t = \sum [F_x(t) / TFR(t)] \cdot E_x(t)$$

where x refers to age, t to period, and E_x to female population exposure.

Our proposal is to estimate a related mean size of the mothers' generation at birth, BG, given by:

$$BG_t = \sum [F_x(t) / TFR(t)] \cdot B^f(t-x)$$

where $B^f(t-x)$ is the number of female births in period t-x. The BRR is therefore defined as:

$$BRR_t = B_t / BG_t$$

In contrast to the NRR, the BRR differs from the TFR due to all the components of population change, not merely mortality. The impact of mortality, fertility and migration on the BRR comes from the relation:

$$BRR_t = TFR_t \cdot \overline{\ell}_t^{Coh} \cdot (1 + k_t^{NetMig})$$

where $\overline{\ell}_t^{\,Coh}$ is the average cohort survival and k_t^{NetMig} is the net migration factor.

In particular, mortality leads to G being lower than BG in a closed population. Out-migration also leads to a reduction of G, while inmigration leads to increasing G and, therefore, increasing BRR.

Also in contrast to the NRR, it is a period indicator of replacement that tells us about the recent demographic history of the country, not about any potential growth in the future. It is not a synthetic cohort measure. This makes it easier to interpret.

The BRR can also be seen as an improvement over the TFR as a measure of period replacement (Calot, 2001). Whereas in the TFR the elements of comparison are different (births in the denominator and number of mothers in the numerator), the BRR compares births to births (see figure 1).

Given that the TFR is currently the most widely used measure of period fertility, we define the BRR using all births. A Net Birth Replacement Ratio (NBRR) can be defined by multiplying the NBRR and the female sex ratio at birth[1].

The BRR can also be decomposed in its fertility, mortality, out-migration and immigration components. In particular, in a closed population G would be given by:

$$G_{Mort} = \sum 0.5 \cdot [\, L_x(t-x) + L_{x+1}(t-x)] \cdot B^f(t-x)$$

where $L_x(t)$ refers to the number of years lived at age *x* in the female cohort life table for women born in year *t*. By comparing G_{Mort} and G we can net out the effect of mortality on the BRR from those of net migration (k^{NetMig}).

Another useful measure is the Equivalent Total Fertility Rate (ETFR) an intermediate index between BRR and TFR

$$ETFR_t = TFR_t \cdot (1 + k_t^{NetMig})$$
$$BRR_t = ETFR_t \cdot \overline{\ell}_t$$

ETFR tells us how big the TFR ought to have been in order to produce the same number of births as had been observed, if the population had no net migration

Data

We estimate the BRR and the other index (observed whether all information is available or estimated when there is missing information regarding fertility age-schedules and average cohort mortality) for a number of European populations as far back as possible, providing also a decomposition of the effects of mortality and migration.

[1] We will not pursue that comparison here. We refer to a companion paper, Ortega (2006), where it is shown that the NBRR and the NRR are approximately the same in a closed stable population.

In the estimated index the assumption are:

- Fertility age-schedules: Use of a period-specific schedule computed from available information for other countries.
- Cohort mortality: Use of a country-specific model to combine the information available from other countries with country-specific trends

We use the following data sources:

Fertility rate by ages (age reached during the year) and **Total Fertility Rate**. Database: Population and Social Condition (EUROSTAT). International Statistics Yearbook (ISY), 2004, and National Agencies.

Births by year and **female cohort life tables**. The Human Mortality Database (HMD). University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org or www.humanmortality.de, and National Agencies.

Results

In figures 2 to 5 we can observe for Sweden, Switzerland, Italy and France the differences between BRR and TFR, and NBRR and NRR. The BRR and NBRR and the other index are take into account the migration effect and the cohort mortality while the others index do not consider the migration effect and are affected by period mortality. In the past centuries, differences between cohort and period mortality is a factor that explain the gap between TFR and BRR and specially between NRR and NBRR. But also BRR and NBRR are affected by migration.

BRR appears very sensible to net migration: in Sweden a negative migration effect between 1850 and 1950 means BRR below TFR and the opposite when there is a positive effect between 1950 and 2004. In Switzerland is even most evident the effect of migration to explain the relation between TFR and BRR. Italy and France are good examples of different trends a relation between TRF and BRR due to different effect of migration until recent years.

In figure **6** we show the trends in the TFR and the BRR in eleven European countries. Only in some countries where net migration has not been very intense the relationship between TFR and BRR is similar to that between GRR and NRR: the BRR is slightly lower due to mortality, with differences becoming less important over time. In countries that have experienced important migration flows, difference between the TFR and the BRR can be large. Spain and Italy in the 1960s are examples where the large out-migration to other European countries meant that the replacement of generations was much lower than that indicated by the TFR. Note, for instance, how Italy's generations were below replacement almost all over the period due to large emigration. In contrast, in receiving countries the number of births provide a larger replacement ratio that that indicated by the TFR. The case of Switzerland is particularly appealing: birth replacement was consistently higher than the TFR due to a constant net immigration of potential mother's. The BRR was even higher than three during the1960s. Countries

where migration flows have changed the sign over the period provide an interesting contrast. In many of those countries there is a crossover of the BRR and the TFR as immigration becomes more important. We see instances of this in many countries, like Sweden, France, the Netherlands or Denmark. It is also interesting to note that Spain or Italy, recipients of recent large migration flows, are experiencing such a crossover just around the year 2000.

References

Calot, G. (1984) "Une notion intéressante: L'effectif moyen des generations soumises au risque. I. Présentation méthodologique". *Population*, 39(6): 947-976.

Calot, G. (2001) "Pourquoi la notion de "remplacement transversal" est essentielle", *Population* 56(3): 329-331.

Calot, G and Sardon, J-P (2001) "Fécondité, reproduction et remplacement". *Population* 56(3): 337–370.

Ortega, J. A. (2006): "Birth replacement ratios: New Measures of Period Population Replacement", FUNCAS working paper / documento de trabajo 261. Available at http://www.funcas.ceca.es/Publicaciones/Documentos_Trabajo.asp

Figure 1: Reproduction index in a Lexis diagram

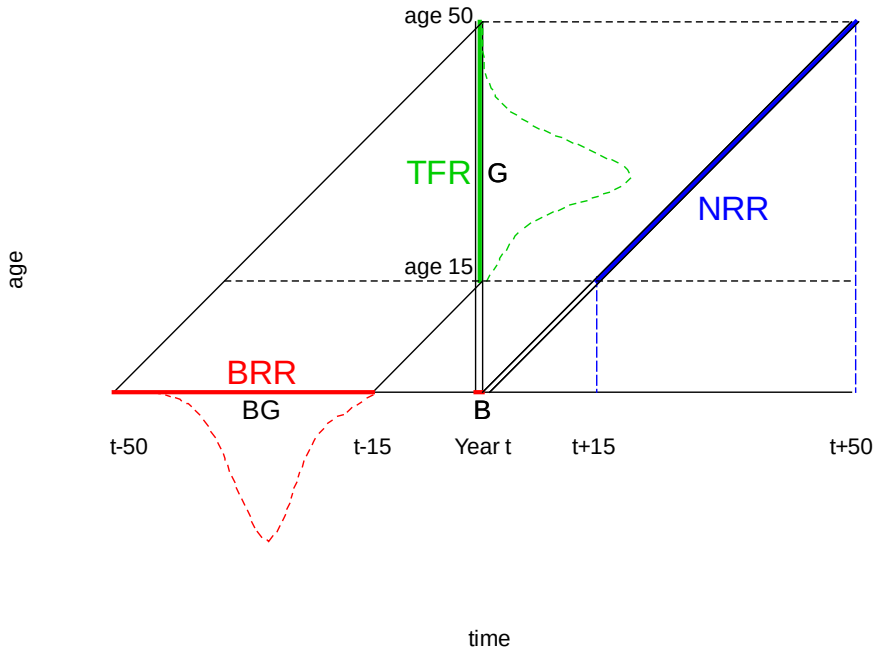

Figure 2. Sweden 1800-2004: A) BRR, TFR, ETFR (Observed and Estimated); B) NBRR and NRR (Observed and Estimated); C) KNetMig, Lcoh and Lper (Observed and Estimated)

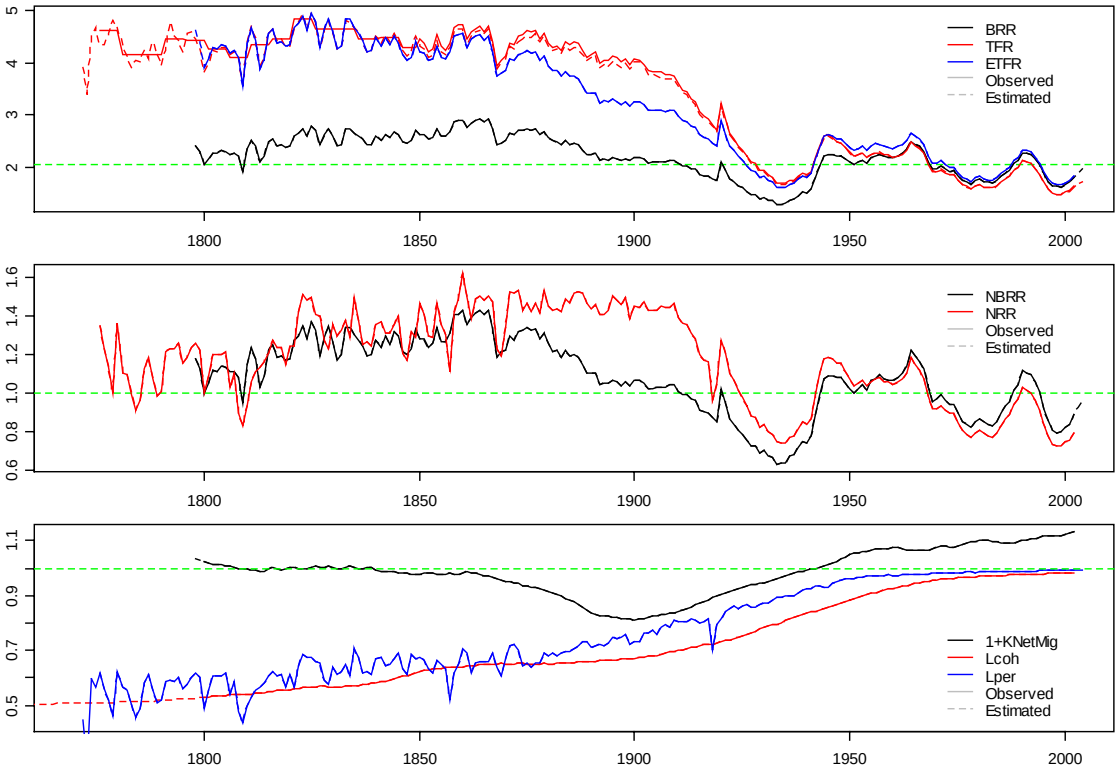

Figure 3. Switzerland 1880-2004. A) BRR, TFR, ETFR (Observed and Estimated); B) NBRR and NRR (Observed and Estimated); C) KNetMig, Lcoh and Lper (Observed and Estimated)

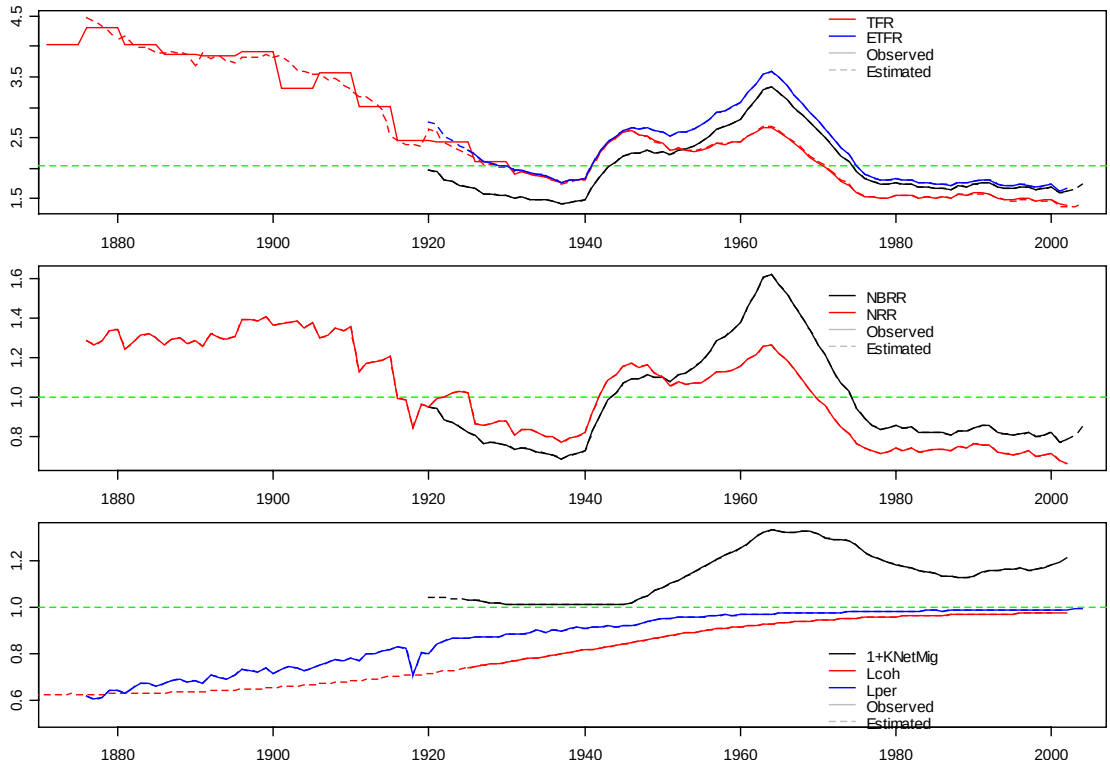

Figure 4. Italy 1920-2004: A) BRR, TFR, ETFR (Observed and Estimated); B) NBRR and NRR (Observed and Estimated); C) KNetMig, Lcoh and Lper (Observed and Estimated)

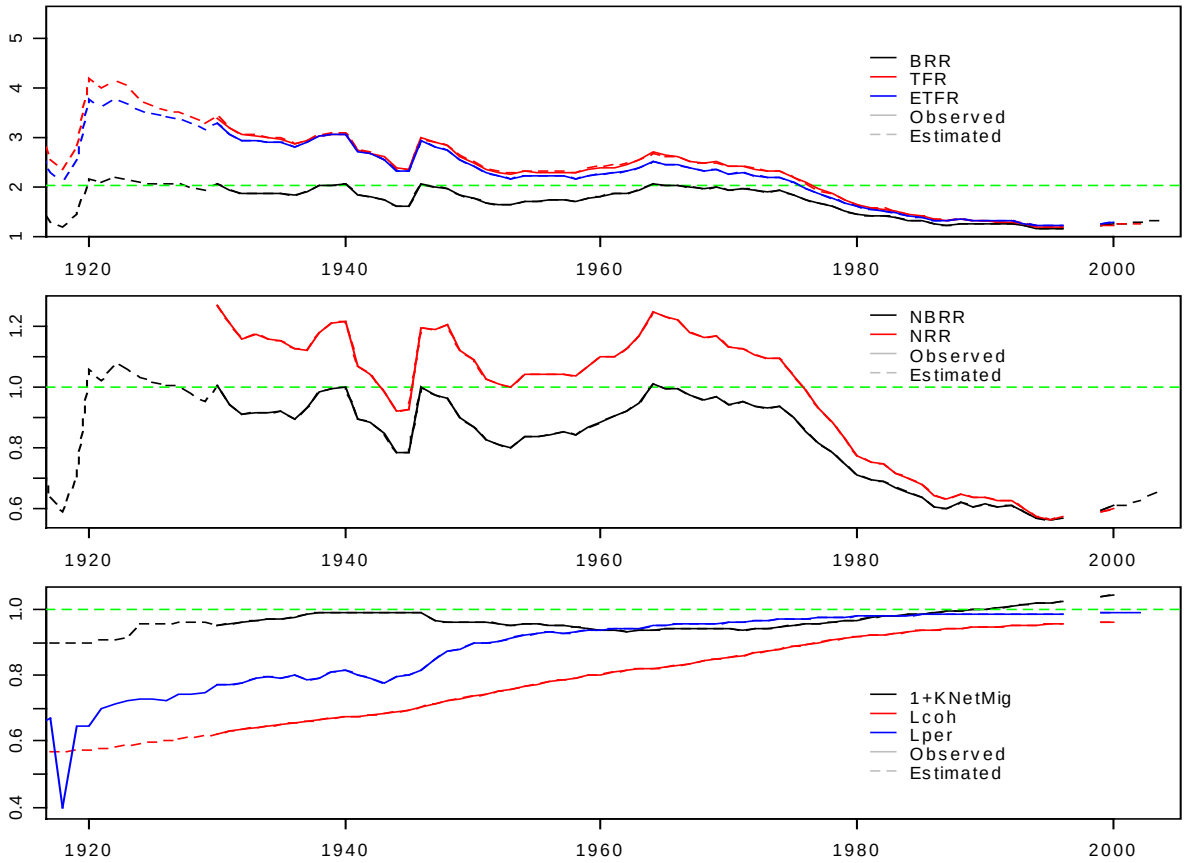

Figure 5. France 1920-2004: A) BRR, TFR, ETFR (Observed and Estimated); B) NBRR and NRR (Observed and Estimated); C) KNetMig, Lcoh and Lper (Observed and Estimated)

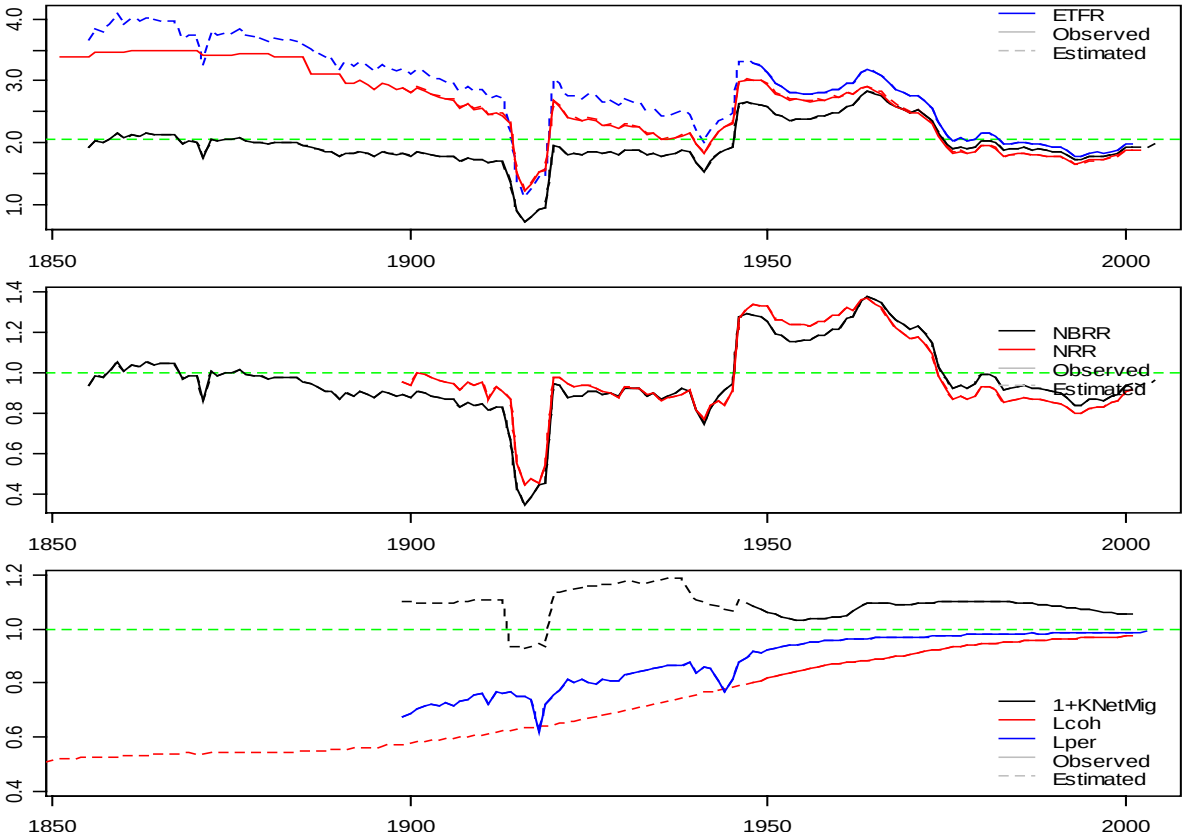

Figure 6. **TFR**, **BRR** and K^{NetMig} in twelve European countries 1950-2004