The role of involuntary factors in explaining the gap between desired and realized fertility in developed countries. An analysis using a microsimulation model

Daniel Devolder

Centre d'Estudis Demogràfics - Universitat Autònoma de Barcelona (Spain)

ddevolder@ced.uab.es

Communication for Session 193:

The gap between desired and achieved fertility

XXVI IUSSP International Population Conference, Marrakech, 27 September - 2 October 2009

25 September 2009

Abstract

Desired family size in low fertility countries is generally higher than the Total Fertility Rate, even after accounting for tempo changes that bias the period fertility levels downward. We use Bongaarts' framework to analyze the role of involuntary factors in the explanation of this gap. Two kinds of factors will be studied. On one hand biological factors (sterility, low fecundability, risk of miscarriage, etc.) may explain why a proportion of women who want children will remain childless or have less children than planned. On another hand social factors associated with family formation and separation risks, may also explain why final fertility levels are lower than desired one. We use data from FFS surveys and a microsimulation model in order to estimate the role of these involuntary factors in the explanation of the gap between observed and desired fertility levels.

1. Bongaart's framework for the relationship between observed and desired fertility

Bongaarts' framework is useful for exploring the relationship between observed and desired fertility, because it categorizes the factors that explain the difference between the two as well as predicts the direction of their effect. This framework can be summarized by the following equation:

$$TFR = DFS \cdot f_u \cdot f_g \cdot f_r \cdot f_t \cdot f_i \cdot f_c$$

- f_u: effect of *unwanted* fertility (+).
- f_g: effect of *gender* preference (+).
- f_r: effect of *child replacement* (+).
- f_t: effect of *tempo* changes (+/-).
- f_i: effect of *involuntary* family limitation (-).
- f_c: effect of *competing* preferences (-).

During the demographic transition, the level of unwanted fertility (f_u) was high, so observed fertility was substantially higher than desired one, and this effect was compounded by the replacement effect (f_r) due to higher infant mortality levels in the past. In post-transitional societies, the effect of the factors that push the TFR above the desired family size (DFS) has almost vanished and observed fertility is now lower than desired one due to tempo changes (f_t), that in the last decades had a depressing effect, involuntary family limitation (f_i) and the effects of the economic and social context (f_c) that may prevent couples to fulfil their desires or change them (Bongaarts, 1998).

In this study we try to quantify the effect of the involuntary family limitation factors (f_i), related essentially to biological factors that limit fertility (permanent and acquired sterility, risks of foetal death, low fecundability) or social factors that explain why fecund women have no adequate partner (partnership formation rates by age as well as separation risks). We will do so taking data from Fertility and Family Surveys (FFS) as a starting point and exploring the effects of these two kind of factors in explaining the gap between desired and observed fertility, as measured from these surveys. We use a microsimulation model in order to quantify the role of these involuntary factors.

2. Measurement issues

There are measurement issues associated with the estimation of both observed and desired fertility levels that need to be solved in order to study the gap between the two, especially since we use surveys data to measure them. First we need to compute TFR levels that are reasonably free of tempo effects (f_r). We do it estimating period parity progression ratios from FFS countries dataset using the methodology described in Hinde (1998). Second there is the problem of estimating desired fertility, which is not an easy problem due to the different meanings it may have, depending on the type of question asked and the family and fertility situation of the persons interviewed. In order to tackle this second problem, we follow the methodology described by Rodriguez and Trussel (1981), which also provide results at the parity level. This allow us to use the question on "More children intended?", whose answers are normally less biased than those for questions on total fertility ideals or desires. This methodology was developed for Less Developed Countries, that is in the context of high observed fertility levels, that are generally also higher then desired one, due to unwanted fertility. We show in Annex 2 that this methodology gives also the correct estimates of desired fertility for low fertility countries, when we have the reverse situation: desired fertility higher than observed one. Note also that this methodology is the correct way to use the results of questions on whether a person desires more children. The FFS official publications ("Standard Country Reports") published results that are biased, because the Desired Family Size was computed by adding numbers of additional desired children to the number of children the persons already had. The result is a mix of observed and desired fertility, which typically underestimate the true level, as we can see from Table 1.

3. The gap between desired and observed fertility levels in Europe at beginning of the 1990s

Another advantage of using these methodologies is that they also allows us to take into account women parity, as seen in Table 1 and Figure 1 to Figure 3, which gives results for a group of 15 European countries, using FFS data. As observed and desired fertility total levels are obtained from the computation of period parity progression ratios, we choose to analyze them at least at two levels: total fertility for all women (***TFR***) and total fertility for women with at least one child (***TFR(1*)***), the difference between the two being explained by the parity progression ratio from 0 to 1 child, which is also the proportion of women who have at least one child ($p_{0->1}$):

$$TFR = p_{0->1} \ . \ TFR(1^*)$$

We observe that total observed fertility was effectively substantially lower than desired one in these European countries during the 1990s (Figure 1). The level of the observed TFR relative to DFS varies between 71% (for Bulgaria) and 99% (for Poland). In general terms the gap is wider for West European countries (mean difference around 20%) than for East European one (15%). This difference between these regions is largely explained by the gap at parity zero. In West European countries the distance between observed and desired fertility is higher for childless women than for women with at least one child (Figure 2). This is related to the fact that childlessness levels are quite high when the desire to have at least one child is nearly universal. On the contrary in East European countries, the gap between observed and desired fertility levels is lower for childless women than for women with at least one child (Figure 3). This can be explained by lower childlessness levels than in West European countries, because this also means that there are fewer childless women who want to have children. So the gap between desired and observed fertility in West European countries is in great part explained by what happen at the first birth, when in East European countries the gap is more related to the situation at higher birth orders.

These observations take sense in the context of differences in demographic and politic conditions between these two groups of countries during the 1980s and the 1990s. In West European countries, there was a strong fertility postponement taking place during these years, characterized by a dramatic increase in the age at first childbearing, which, we will argue later, in great part explains the high childlessness levels. In East European countries there was a demographic crisis associated with the transition from socialist to capitalist economies, which had a strong impact on total fertility, but much less on first births, at least until the second part of the 1990s.

4. Using a microsimulation model to quantify the role of involuntary factors

We use a microsimulation model that takes into account the biological dimension of fertility as well as behavioural dimensions like partnership formation, dissolution risks and contraception use. The model is quite detailed and has been used for example to explore the relationship between the fertility level by parity and the age at first partnership, if we suppose that there is no celibacy, no contraception use after the union, and women are still in their first union at age 50 (figure 3). This is useful to assess the effect of the postponement of the transition to parenthood on fertility levels: for example for a cohort of women who enter into their first partnership at a mean age of 20 years, the proportion with at least one child is 94%. This proportion falls at a level of 90% for a mean age at first partnership of 25 years and at 85% for a mean age of 30 years. If we also take into account the effects of celibacy and divorce or separation, the proportion of women with at least one child is reduced, due to the much lower fertility of women who never form a partnership and on the time lost when the partnership ends before a first birth. In our model, we also take into account those factors. For example, if we focus now on the first birth, we can compute the final childlessness level (which is the one's complement of the first parity progression ratio) for a cohort of women, when there are significant proportions who never enter into a union, or whose union end before age 50, or who use contraception while living in union, before the birth of their first child. In order to study the effects of these factors on childlessness levels, we set the global risk of divorce to a high but not uncommon level (60% of first partnerships end with a separation), but lower this level for couples with young children. The effect of divorce on final childlessness level is stronger for the case of couples that delay the start of parenthood using contraceptive means, a situation that is frequent in some European countries. For example (figure 4), for a cohort of women with a celibacy rate of 5% at age 50, and an age at first childbearing of 25 years, the childlessness level at 50 years is of 14% if the couples use no contraceptive means between the start of the first union and the first birth. If the delay between the start of the union and the start of the reproductive life is on average of 3 years, the total childlessness level for the cohort increases to 18%. The effect is even stronger for higher ages at first childbearing: a level of final childlessness of respectively 20% and 25% for a mean age of 30 years.

5. Estimating fertility levels from family behaviours and DFS as observed with FFS data

We adapt this microsimulation model in order to reproduce the situation observed in each country studied with the FFS surveys (Annex 1). We use the desired fertility levels computed from the survey as an input for the model (Table 2) and suppose that the women in our simulation have children according to this desired parity progression ratios norm. We also use as inputs the partnership formation and dissolution risks deduced from the survey, as well as the observed delay between the start of first partnership and the start of reproductive life (Table 3). These inputs are combined within the model in order to derive 'observed' or simulated fertility levels we can compare with both 'true' observed and desired ones.

6. *Results from the model: measuring the role of factors explaining the gap between observed and desired fertility levels*

The results of the microsimulation model gives us a way to disentangle the effects of the involuntary factors that limit fertility (Bongaarts's f_i factor) and the effects of the changes of preferences during the reproductive life induced by the social and economic context (Bongaart's competing preferences factor f_c). What the model measure for each country is the fertility level we would have observed if the desired fertility level, which act in this case as a guide, or a behavioural norm, had remained constant during all the women reproductive life span. This means that we effectively take out the effects of the competing preferences factor which, when they are actives, explain why individuals and couples changes their fertility desires in face of changing economic constraints or the adoption of new social norms that reduce the resources and the time necessary to have children. The main result of the model is, for each country, a set of simulated parity progression ratios and a total fertility level we can compare with the observed and desired ones:

- If the simulated fertility level is the same than the observed one, this means that the gap between desired and observed fertility is explained only by involuntary factors, as we are able to recreate the observed level from constant fertility preferences (the set of a priori or desired parity progression ratios), and involuntary factors that limit fertility and are also invariables.
- On the contrary, if the simulated fertility level is equal to the desired one, this means that the gap between desired and observed levels is a consequence of factors that change fertility preferences and explain why the behaviours are not fully guided by the set of desired parity progression ratios we entered as an input of the model. In this case we can say that the answers people gave during the survey to questions on desire or plans for children were not realistic, or were not fully informed previsions of their fertility choices.
- Finally, and what is the most frequent case, simulated fertility levels can be in between the observed and desired ones. In that case both involuntary factors and competing preferences explain the gap between observed and desired levels. Taking account of the previous reasoning, we can partition this gap in the following way:
  - The difference between simulated and observed levels is explained by changes in fertility preferences.

- The difference between desired and simulated levels is explained by the involuntary factors.

The previous reasoning is based on the assumption that we have the following ordering of these fertility levels:

Desired Fertility Levels >> Simulated ones >> Observed ones

In some cases, this hierarchy of levels does not hold, and this will somehow changes the interpretation of the differences. For example, we will find several cases where simulated levels are lower than observed ones. The interpretation we will favour is that there was a recent change in fertility preferences, (one of the inputs in our model), and current preferences, just before the survey date, are lower than the ones that prevailed before and in great part explain the current observed fertility levels. Alternate interpretations, we don't discard, but will not discuss, are that either the other inputs in our model are incorrect (union formation and dissolution risks) or our model is incomplete or utterly wrong (!). The justification for privileging the hypothesis of a recent change in fertility preferences gain some support from three cases where observed fertility is actually *higher* than desired one (Poland for childless women, Figure 5, Germany and Hungary for mothers with at least one child, Figure 6). In these cases, and discarding also measuring issues, the only possible reason is that women are less inclined or have lower desires for children at time of the survey in comparison with their mood or preferences in the past 5 years (observed fertility levels used in that work are an average of the 5 years before the survey).

In order to ease the comparison between the three sets of fertility measures (desired, observed and simulated), we use as background the relative differences of observed and desired fertility levels we presented in Figures 1 to 3, using the same blue colour. Next we plot the relative level of simulated to desired fertility levels. As explained before, we assign the difference between simulated and observed levels to the effects of the competing preferences factor (using red colour) and the difference between the desired and the simulated levels to the effects of the involuntary factors (green colour). In the case when the observed level is higher than the simulated one, which we interpret as a recent change in fertility preferences, we use a mix of blue and red, and we consider it as similar to the effects of the competing preferences factor (the consequences of voluntary changes in fertility preferences).

For example, in the case of Austria, the observed TFR level is 81% of the Desired Family Size, when the simulated TFR level reaches 90%. This means that, of the 19% relative gap between TFR and DFS, 9% correspond to changes in fertility preferences and 10% to the effects of the involuntary factors (Figure 4). So both factors approximately explain half of the gap between TFR and DFS. We observe that, for other West European countries, involuntary factors outweigh the competing preferences factor in explaining this gap. On the contrary, changes in preferences are the principal factor in several East European countries (Bulgaria, the Czech Republic, Latvia, Poland and Slovenia).

If we consider now the differences at the parity level, we observe (Figure 5) that for West European countries, the huge gap between the proportion of women who have a first child and the proportion who desire at least one is almost totally explained by involuntary factors. Here the main explanation is the postponement of age at childbearing, whose level is substantially higher in West European, compared to East European countries. For these last countries, the role of involuntary factors is again important, but we observe that changes in preferences play a greater, and even a higher role, than involuntary determinants of childlessness.

For higher parities (Figure 6), it is clear that changes in preferences (people don't fulfil their desires or their fertility preferences change before having children) explain most of the gap between observed and desired fertility levels for mothers with at least one child, for most of the European countries studied here (the main exception being Belgium, and maybe Poland, but in this last country, as explained before, there is probably a recent change in fertility preferences that biases the comparison). Nonetheless the role of involuntary factors is still significant, and quite comparable across countries.

7. Conclusions

In this study, we tried to measure what part of the gap between desired and achieved fertility is explained by involuntary factors (biological determinants and partnership formation and dissolution risks). The first main conclusion is that this gap is higher in West European countries, compared with East European one. The second main conclusion is that these factors explain more than half of this gap in West European countries, principally due to the high childlessness level, when the desire for children is almost universal. For East European countries, we observe that competing preferences and changes in fertility desires just before survey time explain a greater part of the gap than involuntary factors. At the parity level, the main conclusion is that involuntary factors predominate is the explanation of the gap for childless women, when voluntary factors related to preferences explain most of the gap for families (or women with at least one child).

Annex 1. Complete specification for the parameters and functions used in the microsimulation model

We simulate the reproductive live of 10.000 women, for an age interval varying between 10 and 59 years.

a. Progression of sterility with age: Pittenger (1973) model, with the coefficients from Wood (1994) adjustment:

$$S(x) = 1 - \exp\left[\frac{0.00043\left(1 - 1.14345^{x-5.67}\right)}{\ln(1.14345)}\right]$$

Where x is age in years.

b. Evolution of the risk on intrauterine death with age: model derived from data in Léridon (2004), fitted with a third degree polynomial:

$$mi(x) = 0.0509152 + 0.0093173x - 0.0004664x^2 + 0.0000086667x^3$$

Where x is age in years.

c. Determination of intrauterine death time during pregnancy: Barret (1978) formula:

$$dmi(c) = 0.11(0.55)^{c-2}, 2 \leq c \leq 8$$

Where c is the menstrual cycle.

d. Risk of late foetal mortality with age: Barret (1978) formula:

$$mn(x) = 0.24 + 0.005(x - 30)$$

Where x is age in years.

e. Duration of pregnancy: for a live birth, same value of 10 menstrual cycles (of 28 days each) for all women; 9 menstrual cycles for a stillbirth; for other foetal deaths, the duration corresponds to the value determined by Barret's formula in point **c**.

f. Heterogeneity of fecundability distributed following a normal function. Between age 20 and 35, the mean is equal to 0,23 and the standard deviation to 0,12. Each woman is assigned a relative fecundability level after a random trial on this normal function, and this relative level is held constant for all her fecund life.

g. Mean fecundability with age, same than Léridon (2004): a linear function from age 15 until 20 years, with a variation from 0 to 0.23; then a constant value up to age 35; finally the fecundability level falls linearly until the end of the fecund life (different for each woman, equal to their age at permanent sterility).

h. Distribution of the risk of temporary sterility after a childbirth (post partum amenorrhea): Lesthaeghe and Page (1980) model, with values for the model parameters so as to obtain a very short duration, with a median duration of around 4 cycles (alpha = -1.2 et beta = 1).

i. Fertility control (use of efficient contraception) implemented as a priori parity progression ratios inferior to 1. That means stopping only. Spacing is implemented only for the first interval, between first union formation and first pregnancy: refer to point **n**.

j. First partnership formation risks for women: Coale and Trussel (1974) model, with the changes implemented by Rodriguez and Trussel (1980). Standard deviation varies with mean age μ using the formula:

$$\sigma = \sqrt{\frac{45}{1 + 500\exp\left(-\frac{\mu}{2} + 5\right)}}$$

k. First partnership formation risks for men: the mean difference in age at first partnership between men and women is set at 2 years. We use again Rodriguez and Trussel (1980) model, but computing a distribution for men for each age at first partnership formation of women, in the age interval 10-59 years.

l. Higher order union formation: final proportion of separated or widowed women set to a fixed value, as indicated in the text. The distribution of duration between the time the women has no partner and the next union is the same than the one used at point **j**, but we take at age zero the age at which the proportion of women in union is superior or equal to 2 %.

m. Divorce or union dissolution risk: the distribution of risk in function of the union duration follows a generalized log-logistic model (Brüederl and Diekmann, 1995). The parameters values are the followings: alpha = 1.7, beta = 0.01 and lambda = 0.015. The final proportion of union dissolution is reached 30 years after the start of the union. The risk varies with the number of living children, following relative risks values estimated by Toulemon (1994) for French data, Andersson

(1997) and Liu (2002) for Sweden data. The values of the relative risks multipliers, the reference situation been childless, are the following (intermediate values are interpolated):

Duration since the childbirth (in menstrual cycles)	**First birth**	**Second and higher birth orders**
-11	1.0	Current value
-6	0.15	0.075
7	0.05	0.025
20	0.225	0.1125
52	0.45	0.175
65	0.5	0.1925
156	0.7	0.3
260	0.8	0.4
325	1.0	1.0

n. Distribution of waiting time between the union formation and the time when the couple no longer use contraceptive means follows a Poisson law:

$$p(m) = e^{-\lambda}\frac{\lambda^m}{m!}$$

Where *m* is the menstrual cycle when contraception is no longer used, and $m = 0$ correspond to the start of the union. The λ parameter value is a mean number of menstrual cycles, which varies, as specified in the text. When λ is superior to 5, the distribution is very similar to a normal one, with mean and standard deviation equal to λ.

o. The mortality level is fix for all countries and corresponds to "West" model life table level 25 of Coale, Demeny and Vaughan (1983).

Annex 2. The use of Rodriguez and Trussel methodology to estimate the Desired Family Size from FFS data

Rodriguez and Trussel (RT hereafter) developed a procedure to estimate Desired Family Size (DFS) from survey questions on desire for at least another child[1]. This methodology is very useful in the case of the FFS, because the main questions asked on desired fertility is precisely of this kind, the exact wording being "more children intended?" for parents or pregnant women, or "children intended?" for childless women, and then "how many additional children wanted". In order to estimate DFS with this methodology, one needs a distribution of women by parity as well as the proportion of women at each parity who want more children. But as this methodology was applied at first to Less Developed Countries surveys, the authors also took into account unwanted fertility. estimating the value of a parameter for the proportion of women who use family limitation control (contraceptive means). In order to do so, they need a question that allows to estimate the proportion of women at each parity who wanted less children than they currently have. Unfortunately there is not such question in the FFS questionnaire. So we are forced to suppose that all the women have access to contraceptive means, and that there is no unwanted fertility, which is quite reasonable in our case. The main result of this methodology is the estimation of the *unknown* intrinsic or *a priori* proportions of women at each parity who desire more children. These proportion are used to compute directly the estimated value of the mean DFS. treating them as parity progression ratios:

$$d_i = (1 - p_i).\prod_{j=0}^{i-1} p_j \qquad [1]$$

And

$$DFS = \sum_{i=0}^{N-1} i.d_i \qquad [2]$$

Where d_i are the numbers of women who want exactly i children, p_i are the *a priori* proportion of women at parity i who want more children. and $N\text{-}1$ is the highest parity.

[1] Rodriguez and Trussel (1981)

RT proposed to estimate these proportions from the numbers of women at each parity, as observed in the survey. and the corresponding number of women who want more children or who wanted fewer children that the number they currently have. Their formula is as follows:

$$p_i = \frac{m_i + \sum_{j=i+1}^{N-1} (n_j - o_j)}{\sum_{j=i}^{N-1} (n_j - o_j)} \qquad \textbf{[3]}$$

Where m_i are the observed numbers of women at parity i who want more children, n_i the observed total numbers of women at parity i and o_i the observed numbers of women at parity i who wanted less children. As we suppose that there is no unwanted fertility, the numbers o_i are equal to zero and are dropped in the following. One key supposition we have to do in order to apply this methodology is that the observed parity distribution (the n_i numbers) is wholly determined by the *a priori* (desired) parity progression ratios. But this cannot be the case, as a proportion of women at each parity who want at least another child will not have it, due to biological constraints (sterility, sub-fecundity, natural abortion, etc.) or social one (for example if they have no adequate partner). So the parity distribution observed from the survey cannot be the result of desired fertility, and the problem RT overlooked. is whether we have to adapt their methodology in order to estimate the true *a priori* (or desired) parity progression ratios. We will show now that RT's methodology is valid, even in the normal case. when the parity distribution is not generated by these *a priori* parity progression ratios. We will demonstrate it in the case of what these authors call 'full implementation', that is when there is no unwanted fertility and every women has access to efficient contraceptive means. But the result also holds for 'partial implementation', when there is a proportion of women who don't have access to contraception.

We start first with the 'full implementation' steady-state case studied by RT. when there is no unwanted fertility and when desired and observed fertility are equals, an unrealistic scenario, as explained before. This means that the size of the cohorts of women in the fecund life span is equal and that desired fertility is the same for all these cohorts. Then the observed distribution of women by parity and of women who want more children that they currently have will then be proportional to the following numbers:

Parity	Number of women (n_i)		Want more children (m_i)
0	$1+(N-1).(1-p_0)$	$=N-(N-1).p_0$	p_0
1	$p_0+(N-2).p_0.(1-p_1)$	$=p_0[(N-1)-(N-2).p_1]$	$p_0 \cdot p_1$
2	$p_0 \cdot p_1+(N-2).p_0 \cdot p_1.(1-p2)$	$=p_0 \cdot p_1[(N-2)-(N-3).p_2]$	$p_0 \cdot p_1 \cdot p_2$
…	…	…	…
N-2	$p_0 \cdot p_1 \ldots p_{N-3}+p_0 \cdot p_1 \ldots p_{N-3}.(1-p_{N-2})$	$=p_0 \cdot p_1 \ldots p_{N-3}[2-p_{N-2}]$	$p_0 \cdot p_1 \ldots p_{N-2}$
N-1	$p_0 \cdot p_1 \ldots p_{N-2}$	$=p_0 \cdot p_1 \ldots p_{N-2}$	0

We present the formula for these numbers of women at each parity in details, in order to make clear that when applying [3], the sum of n_i terms leads to simple results, because most of the factors cancel out, so that:

$$\frac{m_i+\sum_{j=i+1}^{N-1} n_j}{\sum_{j=i}^{N-1} n_j}=\frac{p_0 \cdot p_1 \ldots p_i+p_0 \cdot p_1 \ldots p_i.(N-i-1)}{p_0 \cdot p_1 \ldots p_{i-1}.(N-i)}=p_i$$

Which demonstrates RT's formula [3].

If we suppose now that some women have less children than desired, due to biological or social constraints, then the *a posteriori* (observed) parity progression ratios will be inferior to the *a priori* (desired) one:

$$\overline{\overline{p_i}}=(1-\varepsilon_i).p_i$$

Where $0 \leq \varepsilon_i \leq 1$ is a coefficient whose level is a direct function of the involuntary factors that limit fertility, and $\overline{\overline{p_i}}$ is the *a posteriori* parity progression ratios which corresponds to realised fertility. In this case the corresponding formulas for the n_i and m_i numbers will be:

$$\overline{\overline{n_i}}=\overline{\overline{p_0}} \cdot \overline{\overline{p_1}} \ldots \overline{\overline{p_{i-1}}}+(N-i-1).(1-\overline{\overline{p_i}})$$

$$\overline{\overline{m_i}}=\overline{\overline{p_0}} \cdot \overline{\overline{p_1}} \ldots \overline{\overline{p_{i-1}}}.p_i+(N-i-1).\overline{\overline{p_0}} \cdot \overline{\overline{p_1}} \ldots \overline{\overline{p_{i-1}}}.(p_i-\overline{\overline{p_i}})$$

We observe that the distribution of women by parity (the $\overline{\overline{n}}_i$ numbers) is fully determined by realised parity progression ratios, which is logical, but that the numbers of women at each parity who want more children ($\overline{\overline{m}}_i$) are a mix of realised and desired parity progression ratios, so that it is not immediately obvious that RT's methodology will lead to the correct value of the *a priori* (or desired) ratios. But fortunately this is the case, as simple algebra calculation leads to:

$$\frac{\overline{\overline{m}}_i + \sum_{j=i+1}^{N-1} \overline{\overline{n}}_j}{\sum_{j=i}^{N-1} \overline{\overline{n}}_j} = \frac{\overline{\overline{p_0}}.\overline{\overline{p_1}}\ldots\overline{\overline{p_{i-1}}}.p_i + (N-i-1).\overline{\overline{p_0}}.\overline{\overline{p_1}}\ldots\overline{\overline{p_{i-1}}}.\left(p_i - \overline{\overline{p_i}}\right) + \overline{\overline{p_0}}.\overline{\overline{p_1}}\ldots\overline{\overline{p_i}}.(N-i-1)}{\overline{\overline{p_0}}.\overline{\overline{p_1}}\ldots\overline{\overline{p_{i-1}}}.(N-i)} = p_i$$

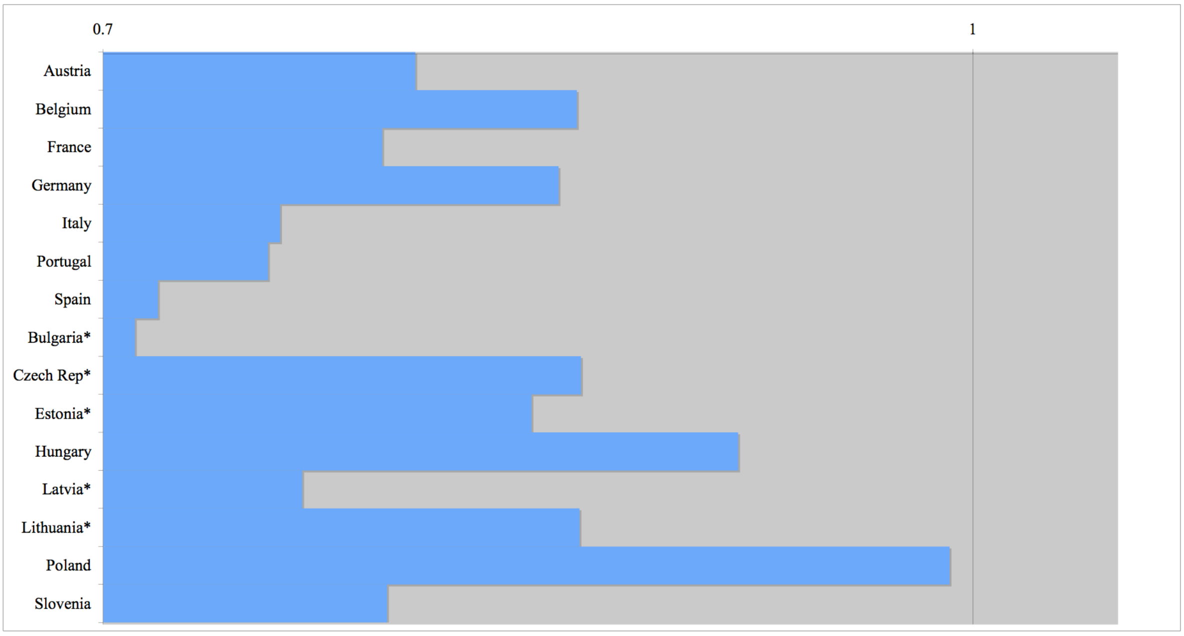
This demonstrates that RT's formula leads to a correct estimate of the *a priori* parity progression ratios, even when the observed fertility level is inferior to the desired one, and so this methodology leads to the correct estimation of the level of the DFS. This is a significant result, as desired fertility levels are not correctly estimated in the FFS country reports. and in fact are *underestimated*. This is so because, as the question on desired fertility in the FFS is on the additional numbers of wanted children, in order to estimate the DFS of each women. the standard procedure was to add this desired additional number of children to the current one. So the resulting 'DFS' is in fact a mix of observed and desired fertility levels.

Table 1. Desired and observed fertility level for women in the fecund life span living in 15 European countries during the 1990s, from FFS data

Country	DFS (FFS Standard country report)	Desired Fertility			Observed Fertility		
		TFR	$p_{0->1}$	TFR(1*)	TFR	$p_{0->1}$	TFR(1*)
Austria	2	2.10	0.940	2.24	1.70	0.842	2.02
Belgium	2.01	2.16	0.905	2.39	1.87	0.816	2.29
France	2.27	2.49	0.952	2.61	1.98	0.855	2.31
Germany	-	2.00	0.933	2.14	1.71	0.755	2.23
Italy	2.07	2.17	0.966	2.25	1.65	0.809	2.04
Portugal	2.1	2.16	0.957	2.26	1.64	0.800	2.04
Spain	2.2	2.41	0.964	2.50	1.73	0.836	2.07
Bulgaria	1.9	2.01	0.975	2.06	1.43	0.877	1.66
Czech Rep.	2	2.21	0.988	2.23	1.91	0.924	2.06
Estonia	2.39	2.49	0.963	2.59	2.11	0.914	2.31
Hungary	2.1	2.20	0.990	2.22	2.02	0.906	2.23
Latvia	2.1	2.25	0.988	2.28	1.73	0.942	1.84
Lithuania	2.1	2.14	0.961	2.23	1.85	0.928	2.00
Poland	2.2	2.33	0.933	2.49	2.31	0.950	2.43
Slovenia	2.23	2.35	0.991	2.37	1.87	0.956	1.96

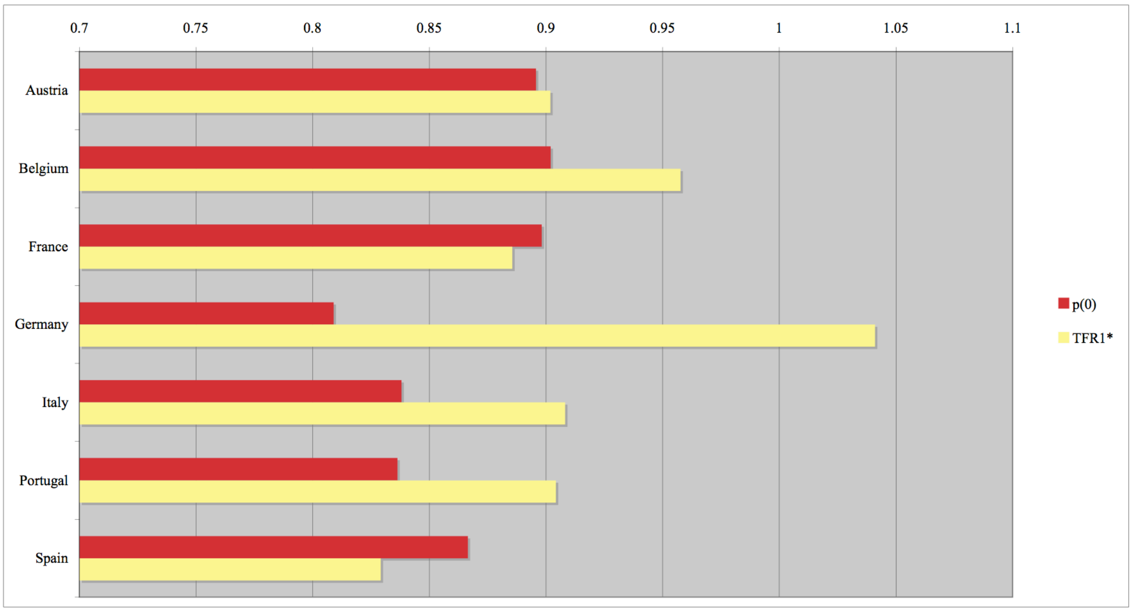
Source: Fertility and Family Surveys (FFS), female sample. The value for the TFR is derived from estimates of the first four period parity progression ratios (p_{0-1}, $p_{1->2}$, $p_{2->3}$, $p_{3+->4+}$). TFR(1*) is the fertility level of women with at least one child, computed by TFR / $p_{0->1}$. The values are means of the last five complete calendar years before the survey. Desired fertility is estimated based on the results of the question on "More children intended?", using the methodology introduced by Rodriguez and Trussel (1981), with the supposition that there is no unwanted fertility (see Annex 2). Belgium data are for Dutch speaking persons only. Germany data are for the entire sample, pooling East and West Germany datasets.

Figure 1. Observed total fertility levels (TFR) relative to desired one (DFS) for European countries during the 1990s, from FFS data



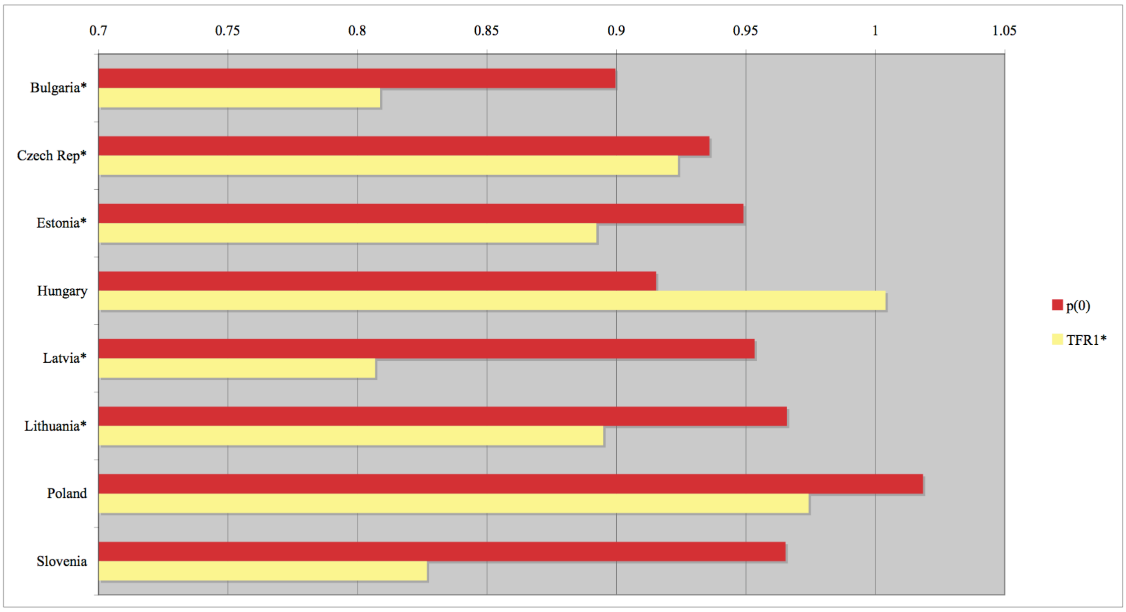
Source: based on data in table 1. Countries marked with an * experimented a rapid drop in fertility just before the survey.

Figure 2. Observed fertility levels relative to desired one for West European countries during the 1990s, taking into account women parity, from FFS data



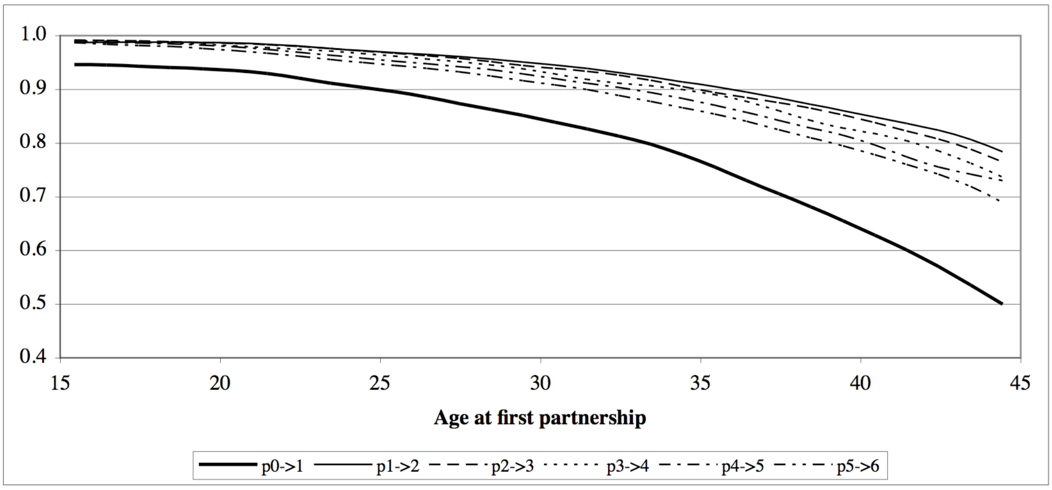
Source: based on data in table 1.

Figure 3. Observed fertility levels relative to desired one for East European countries during the 1990s, taking into account women parity, from FFS data



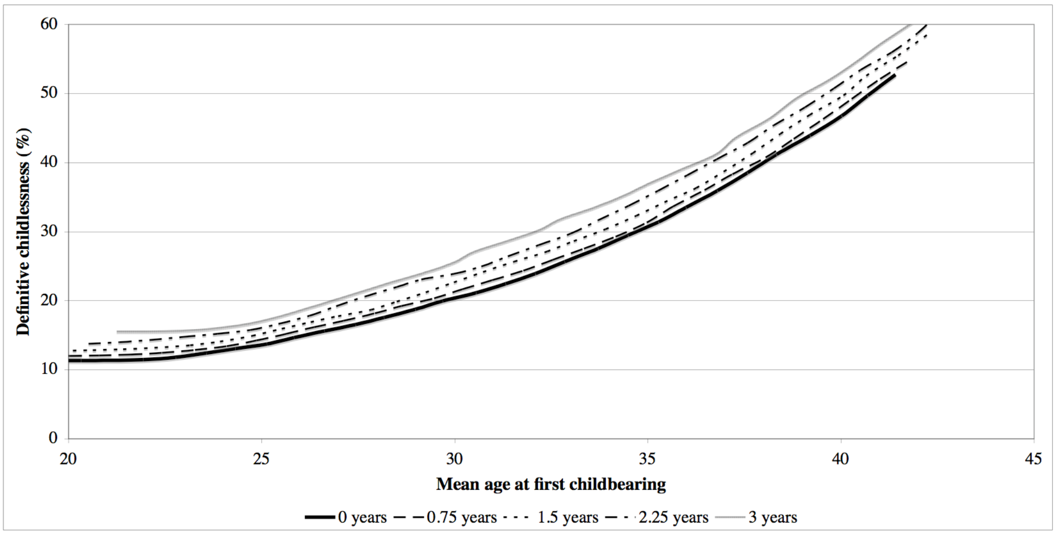
Source: based on data in table 1. Countries marked with an * experimented a rapid drop in fertility just before the survey.

Figure 3. Level of parity progression ratios at age 50 according to the age at first partnership (100% of women still in their first union at age 50, no contraception): results from microsimulation



Source: Devolder (2005).

Figure 4. Effect of union separation on involuntary childlessness according to the mean length of the period of contraceptive use after partnership formation: results from microsimulation



Notes: Each curve gives the final childlessness level associated with a specific mean duration of the period of contraception use after the start of the first union. The final proportion of union separation is of 60%, with a lower risk for couple with young children. The proportion of separated entering another union is of 70% for women and 80% for men, the final proportion of women who never entered a union at age 50 is of 5%.

Table 2. Level of a priori (desired) parity progression ratios for 15 countries, from FFS data

	$p_{0\text{->}1}$	$p_{1\text{->}2}$	$p_{2\text{->}3}$	$p_{3\text{->}4}$	$p_{4\text{->}5}$	$p_{5\text{->}6}$	$p_{6\text{->}7}$	$p_{7\text{->}8}$
Austria	0.940	0.817	0.354	0.339	0.310	0.091		
Belgium	0.905	0.841	0.428	0.338	0.235	0.615	0.500	0.667
France	0.952	0.840	0.527	0.396	0.500	0.541	0.389	0.083
Germany	0.933	0.789	0.353	0.241	0.076	0.500		
Italy	0.966	0.828	0.348	0.286	0.301	0.367	0.636	0.667
Portugal	0.957	0.795	0.333	0.375	0.483	0.475	0.600	0.619
Spain	0.964	0.883	0.422	0.422	0.382	0.321	0.250	
Bulgaria	0.975	0.771	0.269	0.324	0.167			
Czech Rep.	0.988	0.884	0.317	0.172	0.350	0.286		
Estonia	0.963	0.847	0.486	0.397	0.472	0.444	0.733	0.500
Hungary	0.990	0.859	0.301	0.270	0.265	0.400	0.286	
Latvia	0.988	0.809	0.385	0.298	0.455	0.409	0.111	
Lithuania	0.961	0.852	0.332	0.245	0.316	0.182		
Poland	0.933	0.862	0.466	0.338	0.407	0.358	0.444	0.571
Slovenia	0.991	0.902	0.365	0.256	0.344	0.375	0.667	0.005

Source: Fertility and Family Surveys (FFS), female sample. Desired parity progression ratios estimated from the results of the question on "More children intended?", using the methodology introduced by Rodriguez and Trussel (1981), with the supposition that there is no unwanted fertility (see Annex 2). In the microsimulation model, we suppose that the value of desired parity progression ratios for higher parities are equal to the last one in this table. For example $p_{8\text{->}9}$ for France is 0.083, and $p_{6\text{->}7}$ for Lithuania is 0.182, and the level is constant afterward.

Table 3. Value of the parameters used in the microsimulation for union formation, dissolution, and contraception use, for women in the fecund life span (FFS data).

Countries	Mean age at first union formation (in years)	Proportion not in union at age 50 (%)	Proportion of mothers who never enter a co-resident union (%)	Time of contraception use in union before first pregnancy (in years)	Proportion of first unions that end by a separation, after 15 years of union (%)	Proportion entering another union, after 10 years of separation (%)
Austria	22.8	4.8	3.2	1	40	54
Belgium	23.3	4	0.3	0.875	21	65
France	23	5	3.6	0.875	41	47
Germany	23.8	15	7.7	0.875	42	61
Italy	26.9	9	1.6	0.25	14	35
Portugal	25	6	0.3	0.25	20	47
Spain	25.2	5	0.5	0.375	20	47
Bulgaria	21	3	0.6	0.25	30	68
Czech Rep.	20.9	1	0.4	0.25	33	77
Estonia	22.8	5	3.4	0	47	60
Hungary	21	3	0.6	0.25	30	68
Latvia	22.1	4	1.5	0.125	47	60
Lithuania	23.2	5	1.9	0.125	26	57
Poland	24	8	5.4	0	9	38
Slovenia	21.5	2	1.9	0.125	15	71

Note: *Mean age at first union*: from Kaplan and Meier table of first partnership on all the sample; we subtract a value different for each country, between 3 and 12 months, to take account of conceptions before the first partnership. *Proportion not in union at age 50 years*: from the same Kaplan and Meier table than the previous variable (with extrapolation to 50 years in some cases). *Proportion of mothers who never enter a co-resident union*: estimated from FFS surveys by computing the proportion of mothers aged 35 years and more who never formed a union (defined in the survey as co-resident union). *Mean time of use of contraception in union before first birth*: based on Devolder and Galizia (2008), table 2. *Proportion of first unions that end by a separation, after 15 years of union*: Andersson and Philipov (2002), table 26. *Proportion entering another union, after 10 years of separation*: Andersson and Philipov (2002), table 43, with some extrapolation. This last table is computed for children, not for separated women, so the actual level may be slightly different. Andersson and Philipov didn't compute their tables for Portugal, Bulgaria and Estonia. We set the values of the parameters equal to those of, respectively, Spain, Hungary and Latvia. Also the tables for Germany in this publication are computed for East and West Germany separated. We simply take an average, taking population size in 1990 as a weighting factor.

Figure 4. Role of involuntary factors and competing preferences in the explanation of the gap between observed and desired fertility in 15 European countries, from FFS data and microsimulation results: Total Fertility Rate

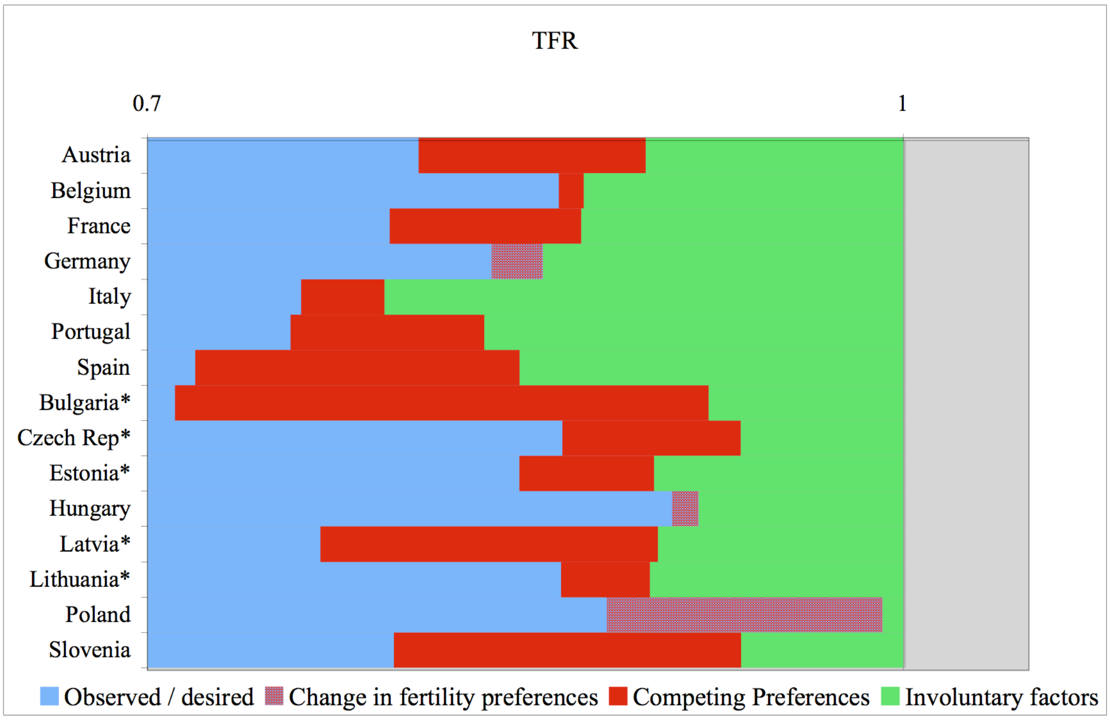


Figure 5. Role of involuntary factors and competing preferences in the explanation of the gap between observed and desired fertility in 15 European countries, from FFS data and microsimulation results: proportion of women with at least one child (first parity progression ratio)

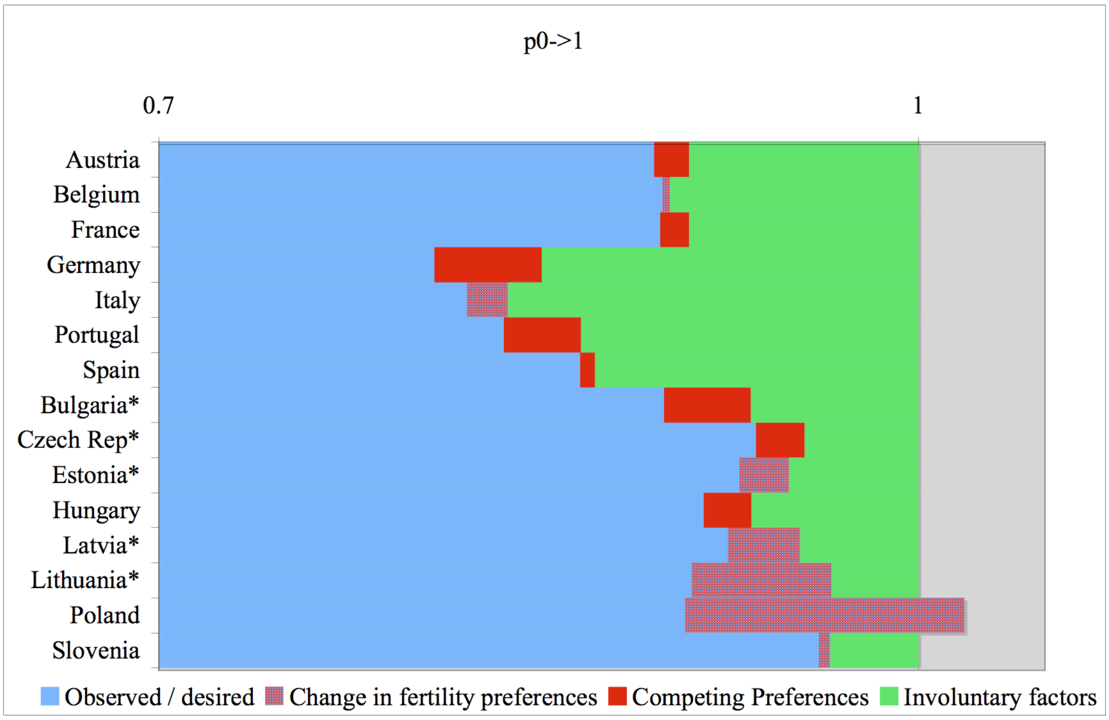
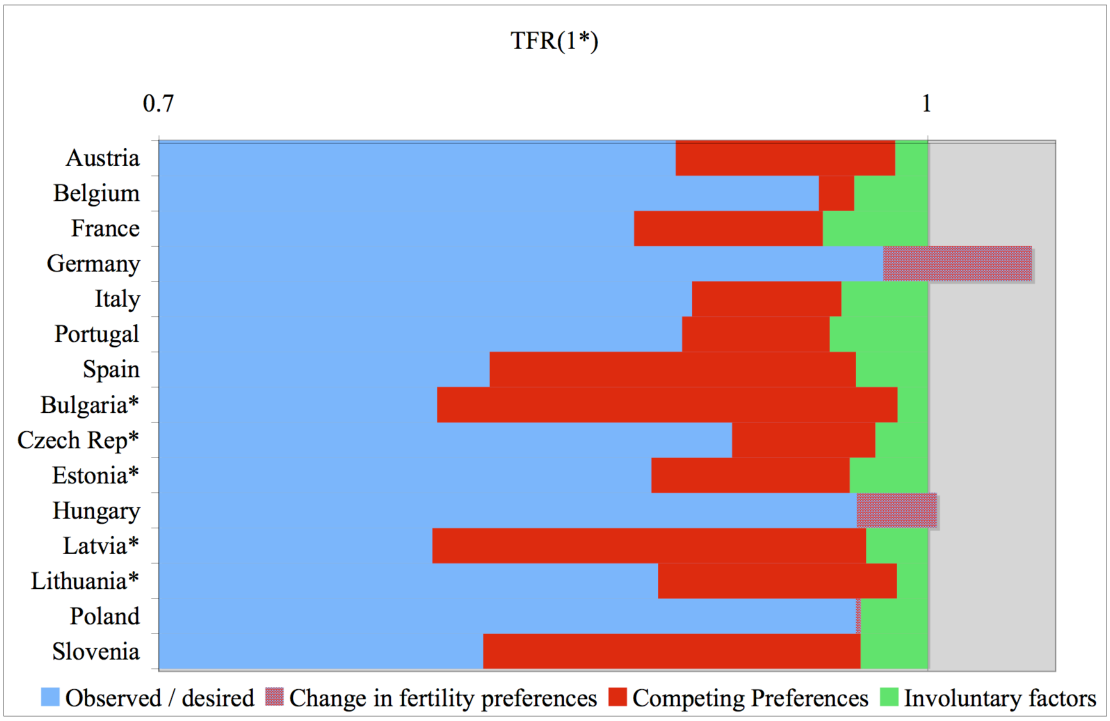


Figure 6. Role of involuntary factors and competing preferences in the explanation of the gap between observed and desired fertility in 15 European countries, from FFS data and microsimulation results: Total Fertility Rate for women with at least one child



Andersson, G. (1997). "The Impact of Children on Divorce Risks of Sweden Women." Population Journal of Population **13**: 109-145.

Andersson, G. and D. Philipov (2002). "Life table representations of family dynamics in Sweden, Hungary, and 14 others countries: A project of descriptions of demographic behavior." Demographic Research **7**: 67-144.

Barrett, J. C. (1978). "Effects of Various Factors on Selection for Family Planning Status and Natural Fecundability: a Simulation Study." Demography **15**(1): 87-98.

Bongaarts. J. (1998). Fertility and Reproductive Preferences in Post-Transitional Societies. PRD Working Paper. New York. Population Council.

Brüederl, J. and A. Diekmann (1995). "The Log-Logistic Rate Model. Two Generalizations With an Application to Demographic Data." Sociological Methods & Research **24**(2): 158-186.

Coale, A. and J. Trussel (1974). "Model fertility schedules: variations in the age structure of childbearing in human populations." Population Index **40**(2): 185-258.

Coale, A., P. Demeny, et al. (1983). Regional Model Life Tables and Stable Populations. New York, Academic Press.

Devolder, D. Ed. (2005). L'infécondité volontaire en Europe. ses causes et conséquences prévisibles: une étude comparative. Bruxelles. Commission Européenne. (http://www.ced.uab.es/devolder/cedchildlessness.zip).

Devolder, D. and Galizia, F. (2008). "To form a union without having a child. The lengthening of the initial period of life in union before parenthood. A study based on European FFS data", European Population Conference, Barcelona.

Hinde. A. (1998). Demographic methods. London. Arnold.

Léridon, H. (2004). "Can assisted reproduction technology compensate for the natural decline in fertility with age? A model assessment." Human Reproduction **19**(7): 1548-1553.

Lesthaeghe, R. J. and H. J. Page (1980). "The Post-Partum Non-Susceptible Period: Development and Application of Model Schedules." Population Studies **34**(1): 143-169.

Liu, G. (2002). Divorce risks of Swedish women in first marriages: two cohorts born in 1950 and 1960. MPIDR Working Paper. Rostock.

Majumdar, H. and M. C. Sheps (1970). "Estimators of a Type I Geometric Distribution from Observations on Conception Times." Demography **7**(3): 349-360.

Pittenger, D. B. (1973). "An Exponential Model of Female Sterility." Demography **43**(185-201).

Rodriguez, G. and J. Trussel (1980). Maximum Likelihood Estimation of the Parameters of Coale's Model Nuptiality Schedule from Survey Data. Word Fertility Survey, Technical Bulletins, Nº 7.

Rodriguez. G. and J. Trussel (1981). "A note on synthetic cohort estimates of average desired family size." Population Studies **35**(2): 321-328.

Toulemon, L. (1994). "La place des enfants dans l'histoire des couples." Population **49**: 1321-1346.

Wood, J. W. (1994). Dynamics of Human Reproduction. Biology, Biometry, Demography. New York, Aldine de Gruyter.