Mind the gap: a microsimulation model to quantify and explain the role of involuntary factors on observed fertility in 13 European countries

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Abstract

Desired family size in low fertility countries is generally higher than the Total Fertility Rate, even after accounting for tempo changes that bias period fertility levels downward. In this work we employ Bongaarts (2001) framework to discuss the role of the factors that explain the gap between desired and observed fertility and give a special attention to the role of involuntary factors. We consider two kinds of involuntary factors: biological factors and competing preferences. 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 the other hand, social factors associated with family formation postponement and separation risks, may also explain why eventual fertility is lower than the desired fertility, due to the fact that very few women have births while living alone (e.g. after partnership disruption) or while enrolled in schooling. This article employs data from the Family and Fertility Survey on 15 European countries to compute all the estimates of observed and desired fertility by birth order, which allows us to consider childless women and mothers separately. We then apply a microsimulation model in order to estimate the role of these two kinds of involuntary factors in explaining the gap between observed and desired fertility across multiple scenarios considering changes in age at first birth and varying separation risks.

1. Introduction

Fertility in post-transitional societies and especially in Europe is low and it has been so long enough for researchers to send out an alarm to policy makers: children are vanishing while the oldest old population is the fastest growing section of contemporary society (Myers & Agree, 1994), with serious societal and economic repercussions as baby boomers aging swells the number of the 65+ population (Giannakouris, 2010). However, it has also been noted (Bongaarts, 2001) that, if couples' desired family size levels were to be fulfilled, fertility would be much higher than current rates and very closed to replacement levels (2.1 children per woman) if not above, in some instances.

Indeed, the gap between observed and desired fertility in Europe has received much scrutiny from demographers in the last decades: observed fertility is well below desired fertility, meaning that women can seldom achieve their family size goals (Quesnel-Vallées & Morgan, 2002), and more worryingly, such chronically low fertility may 'rescale' childbearing intentions to closely fit observed fertility, leading to a low-fertility trap {Lutz:2007uw} as a consequence of the decline in desired family size (Goldstein, Lutz, & Testa, 2003).

Nevertheless, while observed fertility has decreased to under-replacement or lowest-low levels (Billari & Kohler, 2004), desired fertility remained consistently above observed fertility or very closed to replacement with strikingly similar family size ideals across cohorts (Van Peer, 2000) and in nearly all Western countries (Hagewen & Morgan, 2005; Smallwood & Jefferies, 2003). This issue is of methodological interest for demographers, as it concerns the relationship between intentions, norms and behaviors (Billari, Philipov, & Testa, 2009) and the factors that explain the divergence between desired and observed fertility (Van Peer, 2000).

In this context, Bongaarts (2001) decomposition of total fertility rate helps conceptualizing the intricate relationship between desired and observed fertility linking the two elements and conditioning on several factors, which may positively or negatively affect the total fertility rate. This theoretical organization has the advantage of giving a better understanding to the demographic and behavioral processes that lead to forgo desired family size and depress overall fertility as well as a structure to quantify the factors building up the gap between desired and observed fertility. Bongaarts (2001) total fertility rate reformulation separates between factors increasing and reducing fertility, where factors enhancing fertility are of importance in transitional populations characterized by observed fertility exceeding desired family size, while having a minor impact in post-transitional societies. On the other hand, in Europe factors negatively impacting fertility such as involuntary and societal factors, are central to reducing observed fertility and in explaining its divergence from desired family size, while enhancing factors are of marginal relevance.

In this study, after accounting for tempo effects, we explore the negative impact of involuntary factors on observed fertility and the resulting gap between desired and realized fertility, accounting for competing preferences as the residual resultant of the simulation. Biologically driven aspects (such as sterility) and societal factors (such as contraceptive use and union disruption risk), both have a negative impact on observed fertility, which has become increasingly alarming in European countries ever since the decrease in fertility started in the 70s in Western Europe and the fall of the Communist regime in Eastern Europe in 1989. Nevertheless, the mechanism behind childbearing outcomes cannot be generalized in Eastern and Western Europe, as low fertility derives from very different circumstances, which should be taken into consideration by family polices. We use FFS survey data from 11 European countries to simulate achieved fertility for all parities, for the transition to first birth and for women with at least one child, with the aim of quantifying the proportion of desired fertility foregone by women due to involuntary and societal factors. The novelty of our approach relies in the use of the FFS survey, re-estimating observed and desired fertility to create realistic country-specific scenarios by parity, and quantifying the proportion of foregone desired fertility to involuntary and societal factors.

In the first section, we discuss the methodological framework we derive from Bongaarts (2001) and our simplification of the formula used in this article to adapt its use to European countries, as well as how we construct the measurement for desired fertility starting from the FFS questionnaire.

Results show there is a clear distinction between Western and Eastern European European countries situation. Western Europe seems to greatly suffer from the effects of involuntary factors, most likely due to the postponement childbearing age, while Eastern Europe is primarily influenced by a change in preferences due to a period of economic and social instability, consequence of the fall of the Communist regime in the years preceding the survey. Our parity specific approach sheds a more insightful understanding on the magnitude of desired fertility loss. We infer that, while in Eastern Europe competing references are the main actor behind the gap between desired and observed fertility acting mostly on higher parities, in Western Europe the role of involuntary factors greatly affects fertility starting from the transition to the first birth. We believe that these findings shed new light on fertility dynamics differentials between Western and Eastern Europe and are also of particular importance to policy makers, as they imply two very different scenarios requiring adequate family policies if actual trends in low fertility are to be brought to an end.

2. Bongaarts' framework for the relationship between

The 1990s have been years of important fertility changes in Europe, which led to a sharp decrease in childbearing together with postponement of fertility toward later ages, with repercussions extending to date (Sobotka, 2004). On one hand, Western Europe has experienced a steep decline in fertility rates, reaching a minimum during the mid-1990s, well under replacement and sometimes reaching lowest-low levels (Billari & Kohler, 2004), with important variations between countries. On the other hand, the fall of the Communist regime in Eastern Europe set on unprecedented socio-economic changes following a new political and social freedom, dealing with the consequences and harsh realities of a new and developing market economy, moving away from a normative early fertility and two child family (Philipov & Kohler, 2001).

During recent years, an increasing literature has flourished focussing the attention on individual-level determinants of fertility and intentions to explain low fertility and the surging dissimilarities across European countries (Berrington, 2004; Billari et al., 2009; Rossier & Bernardi, 2009; Speder & Kapitany, 2009) as, after all, it is a couple's decision to have children (Thomson, 1997). Nevertheless, women's achieved number of children has sometimes little to do with their preferences, enduring the effect of factors that negatively impact the desired family size and disrupt fertility plans (Quesnel-Vallées & Morgan, 2002).

Indeed, current low levels of observed fertility are not representative of individual preferences as reported desired family size is higher than current levels of fertility and has kept virtually constant through time (Bracher & Santow, 1991; Hagewen & Morgan, 2005). Recent studies highlight an unmet need for fertility (Adsera, 2006) with desired number of children usually higher than observed fertility and very closed to replacement levels (Van Peer, 2000) with a few exceptions (Goldstein et al., 2003). To explain this intention-behavior inconsistency, Bongaarts (2001) remodeled the total fertility rate to connect observed to desired fertility and rewrite the association as depended on several demographic and behavioral processes, all contributing to enhance or dampen the realization of desired family size. The magnitude and the direction of such factors is highly dependent on country-specific characteristics, as well as on the stage of a country fertility transition as transitional societies usually have excess in observed fertility, while post-transitional societies experience the opposite situation (Bongaarts, 2001).

While we are aware of the overall importance that each factor plays in defining observed fertility, the effect of enhancing components, such as child replacement, gender preference and unwanted fertility, have a much smaller impact on post-transitional societies' childbearing behavior (Bongaarts, 2001). Indeed, European countries fertility is largely affected by components reducing fertility, such as postponement, involuntary factors and competing preferences, which reduce observed fertility with respect to desired family size.

Studies devoted to enhancing factors such as gender preferences, usually neglect Western countries, focusing instead on developing countries, where a strong "son preference" (Bongaarts, 2013) often generates unbalances in the population gender ratios. Research carried out on various European countries demonstrates that, while there is an overall preference for a mixed sex offspring, the transition to a third child may be affected by having two children of the same sex, especially true for less gender-egalitarian countries, when having two daughters (Andersson, Hank, Rønsen, & Vikat, 2006; Mills & Begall, 2010). Nevertheless, in European countries the effect of gender preference on fertility remains small and empirical evidence of sex-specific parental preferences is not always straightforward (Hank & Kohler, 2000). Similarly, in a context of universally accessible and available contraception, Europe exhibits much lower risks of unintended pregnancies with respect to other countries {Singh:2010iy}. Santelli et. al (2007) defines unwanted fertility as pregnancies occurring to women who want no-more or no children at all, thus differentiating between unwanted and mistimed fertility, that is to say pregnancies occurring to women who do want children but who would have preferred a different circumstance to have them, together forming the wider concept of unintended pregnancy. While women from transitional societies usually have more children than they desire (Bongaarts, 1997), leading to an excess in fertility mainly due to unwanted pregnancies (Bongaarts, 1997; 2001) and suggesting an unmet need for family planning programs {Bankole:1995ur}, unmet need for contraception in Europe is much lower, although with important variations in some Eastern European countries, namely Bulgaria, Lithuania, and Latvia, and to some extent Italy (Klijzing, 2000). Indeed, in the FFS survey there are some groups of men and women that are not using any contraceptive methods, whilst not wishing for more children. Klijzing (2000) using FFS data shows that the impact of unwanted fertility is lower than what may have been thought, with the sole exception of countries with economies in transition where, however, resorting to abortion to avoid unwanted pregnancies is a much more widespread practice with respect to Western

Europe: unmet need for or low prevalence of modern contraception does not necessarily translate into unintended or unwanted pregnancies. In Italy the low incidence of intercourse among the unmarried and the widespread and established practice of coitus interruptus keep the level of unintended pregnancies much lower than in other European countries (Castiglioni, Zuanna, & Loghi, 2001). On the other hand, in Bulgaria the widespread abortion access lowers the share of unwanted fertility (David, 1992).

Diminishing factors, such as rising age at childbearing, involuntary infertility, and competing preferences have a high impact on European fertility and are tightly connected with each other. Involuntary infertility is a composite feature, which denotes the inability to achieve reproductive objectives due to physiological or circumstantial factors such as increase in mean age at first birth, union disruption or the inability to find a suitable partner (Bongaarts, 2001).

The recent increase in mean age at childbearing has raised a lot of concern about how it would negatively influence desired fertility and interfere with couples' childbearing realization {Schmidt:2012ff}. Fertility postponement has been thoroughly investigated in demography as one of the main characteristics of the recent fertility transition (Goldstein & Cassidy, 2010; Lesthaeghe, 2001; Sobotka, 2004) and identified as a marked rise of the fertility schedule at early ages parallel to an increase at later ages (Ni Bhrolchain & Toulemon, 2005). Infertility and childbearing postponement are closely related and are progressively dependent on age (Pittenger, 1973), birth spacing, and age at first birth (Leridon, 2008), together impacting completed total fertility, especially in low fertility settings such as Italy and Spain (Billari & Borgoni, 2005). Thus the longer women delay their childbearing, the lower their completed fertility will be (Morgan & Taylor, 2006), leading to large proportion of women who will not be able to carry out their childbearing preferences in the following years (Velde, Habbema, Leridon, & Eijkemans, 2012) or will remain childless (Berrington, 2004), if they delay their childbearing past their 30s (Kneale & Joshi, 2008).

Early childbearing onset has been connected to having a better chance of closing the gap between desired and realized fertility in most Western and some Eastern European countries (Belgium, Austria, France, Italy, Sweden, Finland, Poland, Spain, and Hungary) (Van Peer, 2000). Postponing can be seen as the result of a change in women's timing preferences. The onset of the Second Demographic Transition brought on a change in fertility preferences and childbearing behavior in Europe with respect to previous decades {Lesthaeghe:1986tg}, with women favoring smaller families and larger investments per child, trading off time spent in the household with a greater participation to the labor market (Becker, 1981). Indeed, childbearing can be seen as linked to its alternatives through what the theory of planned behavior refers to as “attitudes” (Ajzen, 2005; Ajzen & Fishbein, 1975), thus activities that compete with childbearing affect childbearing behavior itself acting as a further postponing factor (Barber, 2001). Indeed, research shows how women’s entry into the labor market resulted into later births, with women’s willingness to limit their fertility to accommodate employment plans increasing with age (Stolzenberg & Waite, 2011), therefore preferences in desired number of children may suffer from the level at which women’s role as mothers and workers are competing with each other (Testa, 2007). Indeed, having children implies greater risks for women than for men especially in contexts of traditional family roles and lack of family policies (McDonald, 2006), whereas a more egalitarian family with equal division of family tasks and the presence of adequate family policies may help better reconcile childbearing and career trajectories and avoid missing out one of the two, raising the ideal family size and also reducing the gap between desired and observed fertility (Testa, 2007).

Employment highly influences having children, especially (negatively) in settings of high unemployment and economic uncertainty {Adsera:2010gv}. In general the intention to study hampers the likelihood of having a child Having a first birth is subjected to the competing effect of the intention to study, the intention to have a second child is also dependent on the intention to study (Philipov, 2009). Postponing childbearing to pursue higher educational achievements also has postponing effects on childbearing choices (Rindfuss & John, 1983) and especially on first births timing (Lappegard & Rønsen, 2005). Nevertheless, highly educated women tend to prefer larger families, as in Western Germany (3+) for all cohorts even though it has weakened over time. This finding holds broadly for most Western European countries, although the desire for larger families often does not translate into realized fertility {Heiland:2005ur}. For instance, high education has a significant impact on not realizing desired fertility in Belgium, Finland, France, Hungary, and Italy while in Sweden, Spain, Poland, and Austria, such effect disappearing after controlling for age and age at first birth (Van Peer, 2000). Early childbearing is strongly associated with lower educational attainment (Moore & Waite, 1977), as risk of early transition to motherhood has stayed persistently higher for this group, while has risen for highly educated women, with important differences throughout countries (Rendall et al., 2010). Being a student lowers family-union intensities (Hoem, 1986) and longer stays in education have been found to be associated with postponed family formation {Liefbroer:1999ci}

As the great majority of childbearing occurs to parents living together as a couple (Heuveline, Timberlake, & Furstenberg, 2003) and it is a couple's decision to have children (Thomson, 1997), the recent surge in union dissolution further complicates an already complicated picture with an additional negative effect on fertility (Cohen & Sweet, 1974)-ch.6. Indeed, childbearing decisions and union instability are strongly interrelated trajectories that together define women's achieved number of children (Thomson, 1997), consequently the longer a relationship lasts the smaller will be the gap (except in Italy) (Van Peer, 2000), while the longer women spend out of union during their childbearing years, the lower their expected number of children will be (Thomson, Winkler-Dworak, Spielauer, & Prskawetz, 2012), contributing to some of the recent decrease in overall fertility (Lillard & Waite, 1993). Separated and divorced women have an overall lower fertility (Di Giulio, Moors, & Pinnelli, 1999), but also a much higher chance to remain childless with respect to married women {Lesthaeghe:1994tn}, even when controlling for re-partnering (Beaujouan, 2010).

The specific political climate characterizing post-Communist Eastern European countries had an important impact on women's childbearing preferences. The political instability resulting from the collapse of the Communist regime in Central and Eastern European countries led to a substantial decrease in GDP and deteriorating quality of life, where the dissolution of a central state society ended up ending the state integration of society is thought to have led to anomic developments in the 1990s (Genov, 1998). As a result, during the 1990s fertility can be seen dropping throughout Eastern Europe, while mean age at childbearing rose together with births outside of wedlock (except in Catholic countries, such as Lithuania and Poland).

3. Methods Section

Of particular importance, involuntary family limitation (f_i) and competing preferences (f_c) negatively impact desired fertility, especially in societies engaged in the Second Demographic Transition (Lesthaeghe, 2001), as we will discuss later in detail. While f_i deals with the ability of couples to conceive, the latter is related to contextual factors dealing with the economic and social context that may prevent couples from fulfilling their childbearing desires. Finally, the effects of gender preference (f_g), the wish for a certain gender composition of one's progeny, are potentially important in low fertility countries: for instance, they concern approximately half of the parents with one child and a quarter of those with two children.

In this study, we employ Bongaarts (2001) framework categorization TFR directly dependent on desired family size, conditionally on several factors:

$$TFR = DFS \cdot f_u \cdot f_g \cdot f_r \cdot f_t \cdot f_i \cdot f_c \quad (1)$$

where TFR is the Total Fertility Rate, measured as the sum of women's age specific period fertility rates across their reproductive age span and DFS is the Desired Family Size estimated from the FFS survey. The equality between TFR and DFS is mediated by six factors, listed below, accompanied by the expected direction of their effect:

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

Each factor can be seen as the estimated ratio between TFR and DFS holding all the other five factors constant: if a factor has no effect, its value will be equal to 1 and vice versa, if its impact on DFS is negative, its value will be between 0 and 1. The equation (1) has been simplified in the context of the present work:

$$TFR^* = DFs \cdot f_i \cdot f_c \quad (2)$$

This means that we limited the number of factors explaining the gap between desired and observed fertility to only two out of the six factors from equation (1): involuntary factors and competing preferences, factors both having a negative impact on observed fertility.

We estimated observed fertility levels free of the effects of tempo changes, computing $TFR^* \approx TFR / f_t$; and also because the three remaining factors we didn't contemplate have in fact weak effects on observed fertility for the countries we studied.
The aim of this study is to quantify the effect of 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 cause fertility disruption (Cohen & Sweet, 1974), such as partnership formation rates by age as well as separation risks (Bongaarts, 2001). We did so taking data from Fertility and Family Surveys (FFS) as a starting point, and exploring the effects of these two kind of factors in accounting for the gap between desired and observed fertility, measured from this survey. The end result of this analysis is a decomposition of the gap between observed and desired fertility between only two groups of factors, the involuntary factors, measured by this study, and the residual ones, which Bongaarts (2001) identified as ‘competing preferences'. Competing preferences can be described as the factor that rationalizes those women who, despite not reaching their desired level of fertility, do not want anymore children, thus leading desired fertility to overestimate the real demand for children (Bongaarts 2001, p. 276). Competing preferences can also be seen as tied to contextual factors such as economic conditions, institutional structures and labor market flexibility towards women (Adsera & Adser a, 2005), even more so in the 1990s, given the increase in female labor participation and unemployment in Western Europe (Adsera, 2006).

3.1 Method

We adapt this microsimulation model in order to reproduce the characteristic of each country studied with the FFS surveys (Annex 1). We use the desired fertility, DFS, computed from the FFS 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 *simulated* fertility to compare with both *true* observed and desired ones.

3.1 Measurements Issues

In this study, we needed to address first two measurement issues regarding the estimation of the gap between observed and desired fertility: how to obtain observed fertility levels free of tempo effects and how to compute desired family size from the FFS.

For observed fertility we tried in first place to use the FFS survey data. We computed estimates of the TFR for each country, at the total level and by birth order. We found that in approximately half of the countries the TFR values obtained with the FFS differed by more than 10% from those derived through National Vital Statistics, with the greatest differences at order 1 (these problems are reported and explained in Festy and Prioux, 200x). In view of this we decided to use instead estimates provided by the Human Fertility Database (HFD). Hence in the rest of this work observed fertility for each country will be the level of the TFR corrected from tempo variation using Bongaarts and Feeney (1998) correction method, as published by the HFD, both at the total level and by birth order.

Computing a consistent estimate for women’s desired number of children is a more complicated issue, which greatly depends on the question asked in each survey. We follow here Rodriguez and Trussel (1981) methodology that gave levels higher than the one published in the FFS official publications (the "Standard Country Reports"). The latter ones in our view are downward biased, because the Desired Family Size (DFS) was computed by adding numbers of additional desired children to the number of children women already had, so that the estimates are a mix of observed and desired fertility levels, which typically underestimate the true level, as we can see by the comparison with our results in Table 1. Rodriguez and Trussel's methodology has the added benefit of allowing a parity specific approach. It is based on the use of the questions of the kind: "More children intended?” in the FFS surveys, which gives estimates of planned fertility that are admittedly better than the questions on the total ideal or desired fertility. But the path from the answers to the question on the desire for additional children to the estimation of the DFS is not direct and paved with traps, which explain why this methodology has not been used much. Rodriguez and Trussel developed it for developing countries in transitional societies, therefore in a context of unwanted fertility, when the DFS is usually lower than observed fertility (Calhoun 1991), mainly due to an unmet need for contraception (Bongaarts 1991). In Annex 2 we show that Rodriguez and Trussel's method gives also the correct estimates of desired fertility for post-transitional societies, when there is no unwanted fertility and when desired fertility is lower than observed one, which is mostly the case for countries in the FFS surveys. In our opinion this should stimulate the use of this method in future studies for estimating the DFS, and give a strong argument to keep the question on "more children intended" in the questionnaire of future fertility surveys.

3.2 The gap between desired and observed fertility in Europe

One of the main advantages of using Rodriguez and Trussel (1981) methodology is that it allows us to take into account women's parity, see Table 1 and Figure 1 to 3. This allows us to analyse the gap between observed and desired fertility in two stages: first at the total level, and then separating childless women from women at parity one and more:

$TFR^* = p^*_{0->1}.TFR^*_{(1*)}$ (3)

Where all the fertility indexes are corrected from tempo variation using Bongaarts and Feeney's correction (we use the value published by the Human Fertility Database).

3.3 Using a microsimulation model to quantify the role of involuntary factors

The model we use is a highly detailed microsimulation model of the fertility process, which takes into account both the biological dimensions of the reproductive process as well as the social dimensions (see annex 1 for the full specification of the model). We suppose here that the effects of biological factors as well as male mortality levels are the same for all the countries (list of parameters a to h and o) and that the simulated fertility levels will differ only due to variation in social and individual choices factors (parameters i to n). Our model simulates a population of 30 000 women for each country. We reconstruct the lifecycle of each woman from her birth until she reaches age 50. The simulation starts with the first union then proceeds with concurrent risks of having children, separating, of the death of the partner, of entering a second union, etc. until the woman is 50 years of age.

Our simulation starts for each country with the level of desired fertility. Desired parity progression ratios (table 2) are used in the model as *apriori* fertility levels. We then add the effect of factors that explain why the final fertility level will be lower than desired one. The parameters we enter as inputs into the model are based on FFS survey data for each country (table 3). For example, in order to reconstruct the distribution function for the process of entry in first union, we estimated two parameters from each country survey that are used as input values for the Coale and McNeill (1971) nuptiality mathematical model:

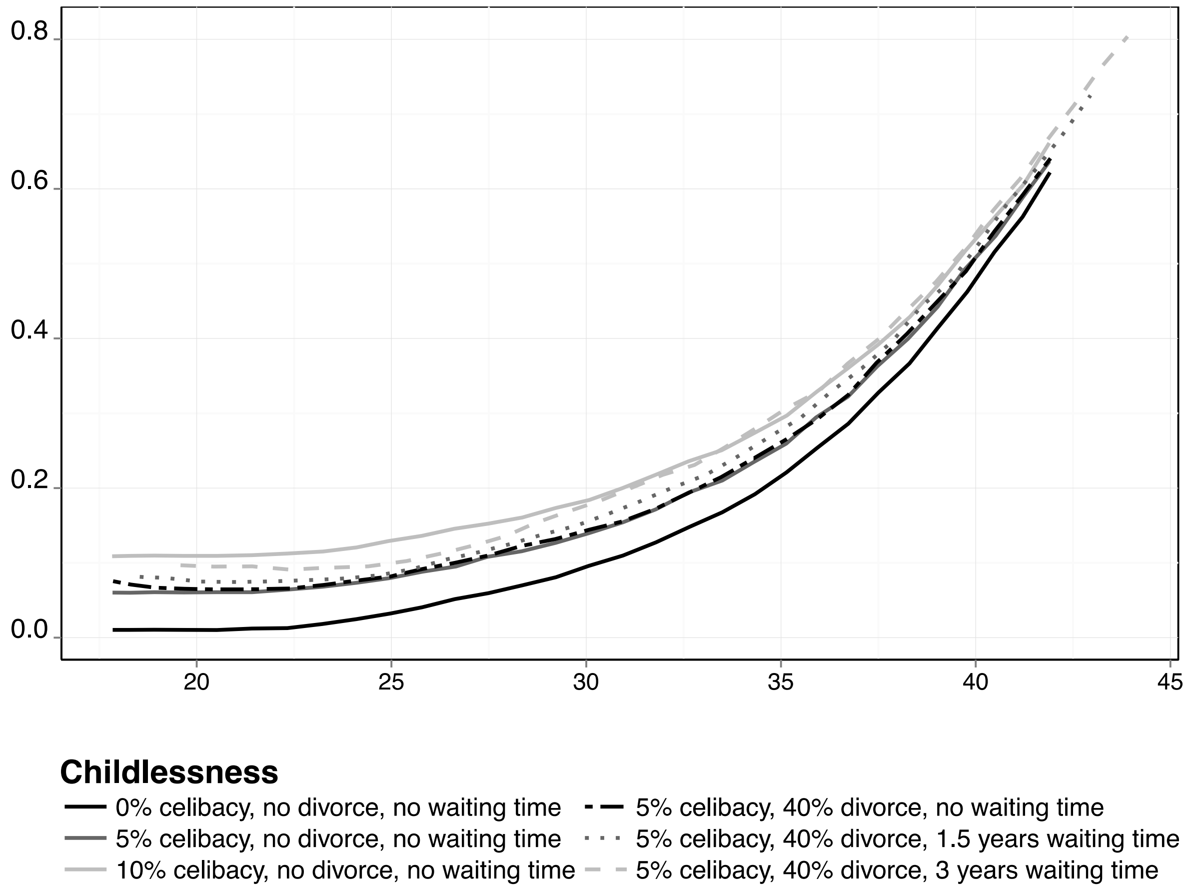
- The mean age at first union was computed from the overall Kaplan and Meier survival curve, using Hajnal (1953)'s SMAM methodology. We corrected this age and lowered its value some months in order to take into account the fact that the proportion of conceptions that occurs before the start of the union is high in some countries, especially in Eastern Europe.
- We estimated a final proportion of women who ever enter a first union from the same Kaplan and Meier curve. This value was again corrected to take into account the fact that a high proportion of women who never enter a union have children. For the correction we simply supposed that they have the same fertility behaviour than women who form unions.

In a similar way we estimated the risk of separating by duration of the union starting with the proportion of first union which separated after 15 years, as observed in the FFS. We then used this proportion as an input value for a complex model in which we take into account at the same time the distribution of the risk over time (based on Brüederl and Diekmann's model) and observed values of the relative risk of divorcing depending on whether the woman has young children.

Our simulated women are exposed to these different competing risks that serve to determine the age intervals during which the women is at risk of having children, depending on the value of the *apriori* parity progression ratios and of each woman own fecundity risk, which is determined on turn by the biological module of the model.

In order to gauge the effects of latter factors, we computed the childlessness levels we would observe in non-controlling populations as simulated by the model, each one with a differing value of the mean age at first union, varying from 15 to 45 years with a step of 1 year. Then for each age at first union we created a set of simulated populations according to various levels of the final proportion of ever entering a union, of divorce, and with a varying duration of the mean period of contraceptive use at the start of the union. The childlessness level of each one of these simulated populations is plotted in the following graph, for different combinations of these input values {according to the resultant level of the mean age at first childbearing}....

Graph 1: Childlessness levels in simulated populations, with varying age at first union, different levels of celibacy and of divorce as well as of the length of the period of contraception at the start of the union, in relation with the mean age at first childbearing



Note: proportion of women childless at age 50 in simulated populations with no fertility control, a range of 31 values for the mean age at first union, 3 differing levels of final celibacy (proportion of women who never enter a union), 2 levels of the final proportion of divorce or separation, 4 levels of the mean duration of contraceptive use at the start of the union (labelled as "waiting times". The curves are ordered according to their level at 20 years: the lowest one corresponds to 0% celibacy, the second lowest to 5% celibacy, etc.

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

Rodriguez and Trussel (1981) definition of desired fertility leads to an overall higher estimation of the indicator by approximately 0.13, raising DFS consistently above 2 children per woman for all countries, with the sole exception of Eastern Germany, although closed enough (1.97). From table 1, countries with higher and lower DFS are already evident, as Scandinavia and France stand out, having a much higher desired fertility closed to or higher than 2.5 children per woman. However, a good way to appreciate the differentials in desired fertility between Eastern and Western Europe is to look at the difference between desired fertility for all women and for those at first parity (TFR1*), leading to a distinction into two groups: one having a differential closed to or higher than 0.1 (between 0.08 and 0.23), and another group with a differential value closed to 0 (between 0.02 and 0.05). This grouping interestingly translates into a rather accurate geographic division between Eastern and Western Europe with Hungary, Czech Republic, Slovenia, Latvia, East Germany, Bulgaria, and Lithuania on one side and the remaining Western European countries on the other.

The results of the microsimulation model gives us a way to single out the effect that involuntary factors (***fi***) have in each country on overall desired fertility, transition to the first child and completion of desired fertility for women with at first parity. Competing preferences (factor ***fc***) are estimated as residual factor in the simulation. The model measures for each country the fertility that we would observe if desired fertility remained constant during women's reproductive life span. This means that we effectively take out the effects of competing preferences, which accounts for individuals and couples' change 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 results display a set of simulated total fertility and parity progression ratios that we can compare with the desired level of fertility in three scenarios:

- If simulated fertility is the same as observed fertility, it 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 ratio), and involuntary factors that limit fertility and are also invariable;

- If simulated fertility is greater than observed fertility, then the difference between observed and simulated fertility can be interpreted as competing preferences;
- If simulated fertility is lower than observed fertility, the gap between desired and observed may be a consequence of factors that change fertility preferences and explain why the behaviors are not fully guided by the set of desired parity progression ratios we employ as input of the model. In this case, it may suggest 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 future fertility choices; it may also suggest that an event happened (such as economic recession or change in family policies) that may have deeply influenced or slightly shifted people's preferences in childbearing.

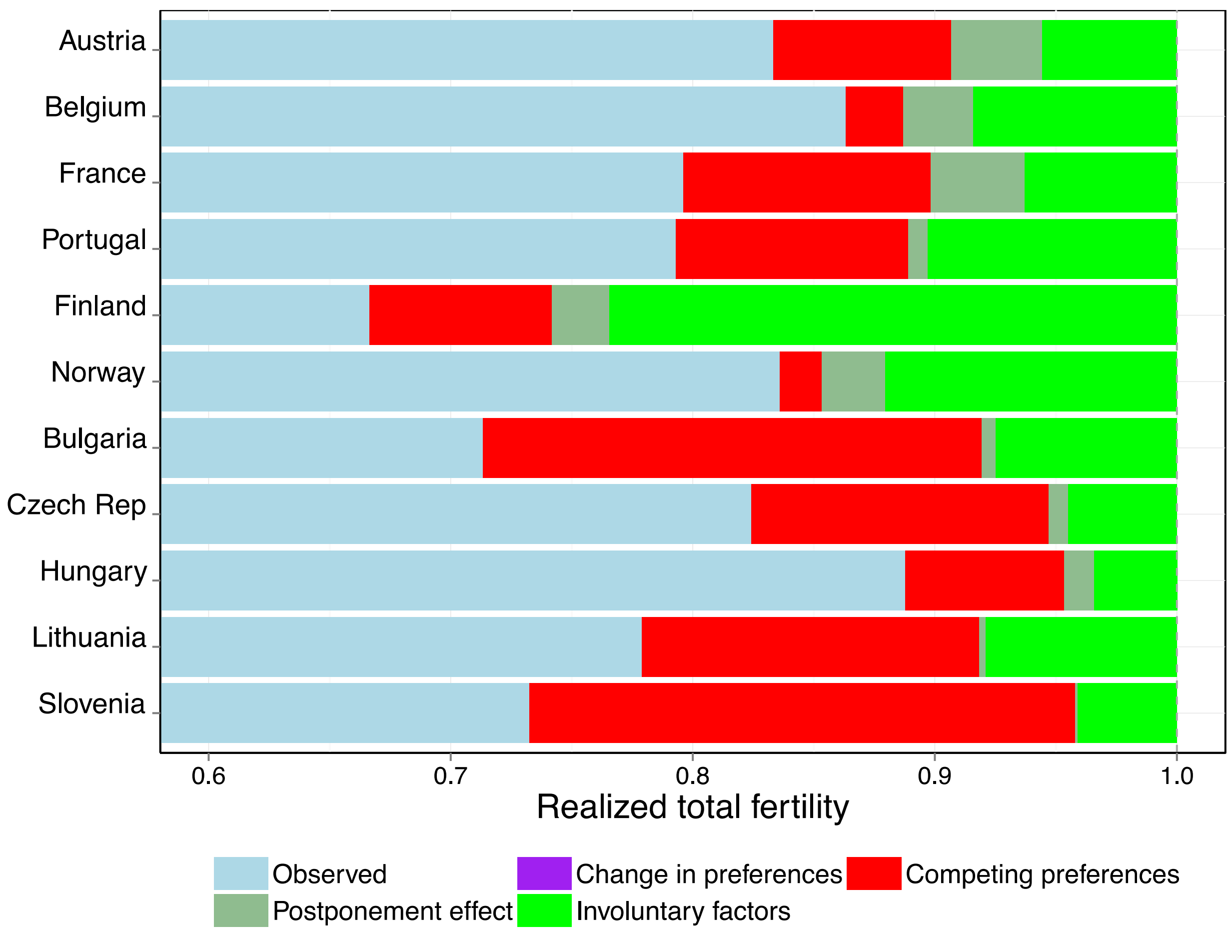
The last point is based on the assumption that we have the following ordering of these fertility levels:

$$\text{Desired Fertility} \gg \text{Simulated fertility} \gg \text{Observed fertility} \quad (4)$$

In some cases, this hierarchy does not hold true, and this will somehow change the interpretation of the differences. For instance, we will find several cases where simulated fertility is lower than observed fertility. The interpretation we favor is that there was a recent change in fertility preferences and current preferences are lower than the ones prevalent in the previous decade, therefore a sudden (positive) change in childbearing preferences would raise observed fertility. The justification for privileging the hypothesis of a recent change in fertility preferences gains some support from the case of Hungary, where observed fertility is actually higher than desired fertility. In these cases, the only possible reason is that women are less inclined or have a lower preference for children at the time of the survey in comparison with their preferences in the past 5 years, as observed fertility levels used in this work are an average of the 5 years before the survey.

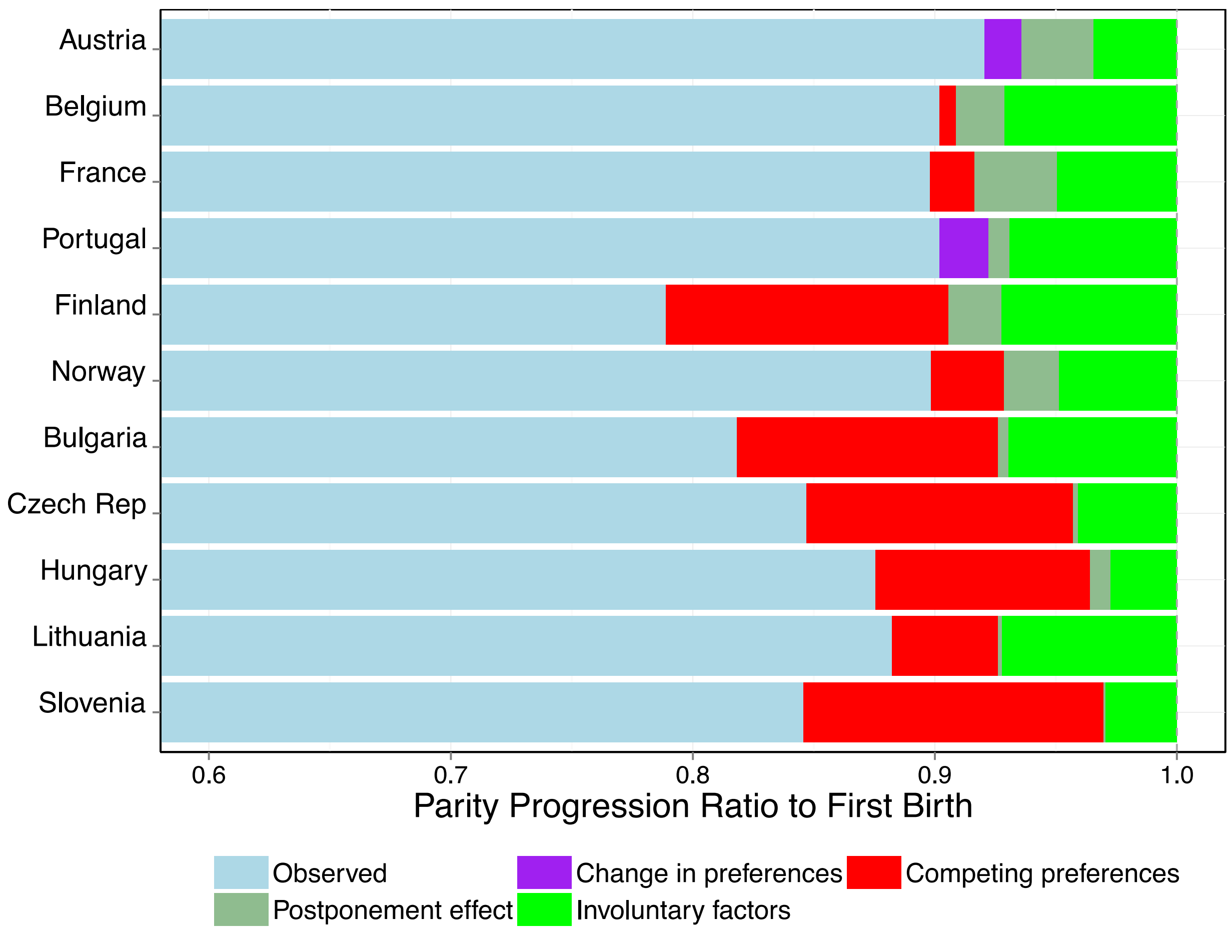
In order to ease the comparison between the three sets of fertility measures (desired, observed and simulated), we use as background the relative differences of observed and desired fertility levels we presented in Figures 2 to 4, using the blue color. Next, we plot the relative level of simulated-observed and simulated-desired fertility levels. As explained before, we assign the difference between simulated- and true-observed fertility to the effects of the competing preferences factor (in red) and the difference between the true-and simulated-desired fertility to the effect of involuntary factors (in green). In the case, when true-observed fertility is higher than the simulated-fertility, 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).

Graph 2: Simulation results showing the percentage of realized total fertility with respect to desired fertility.



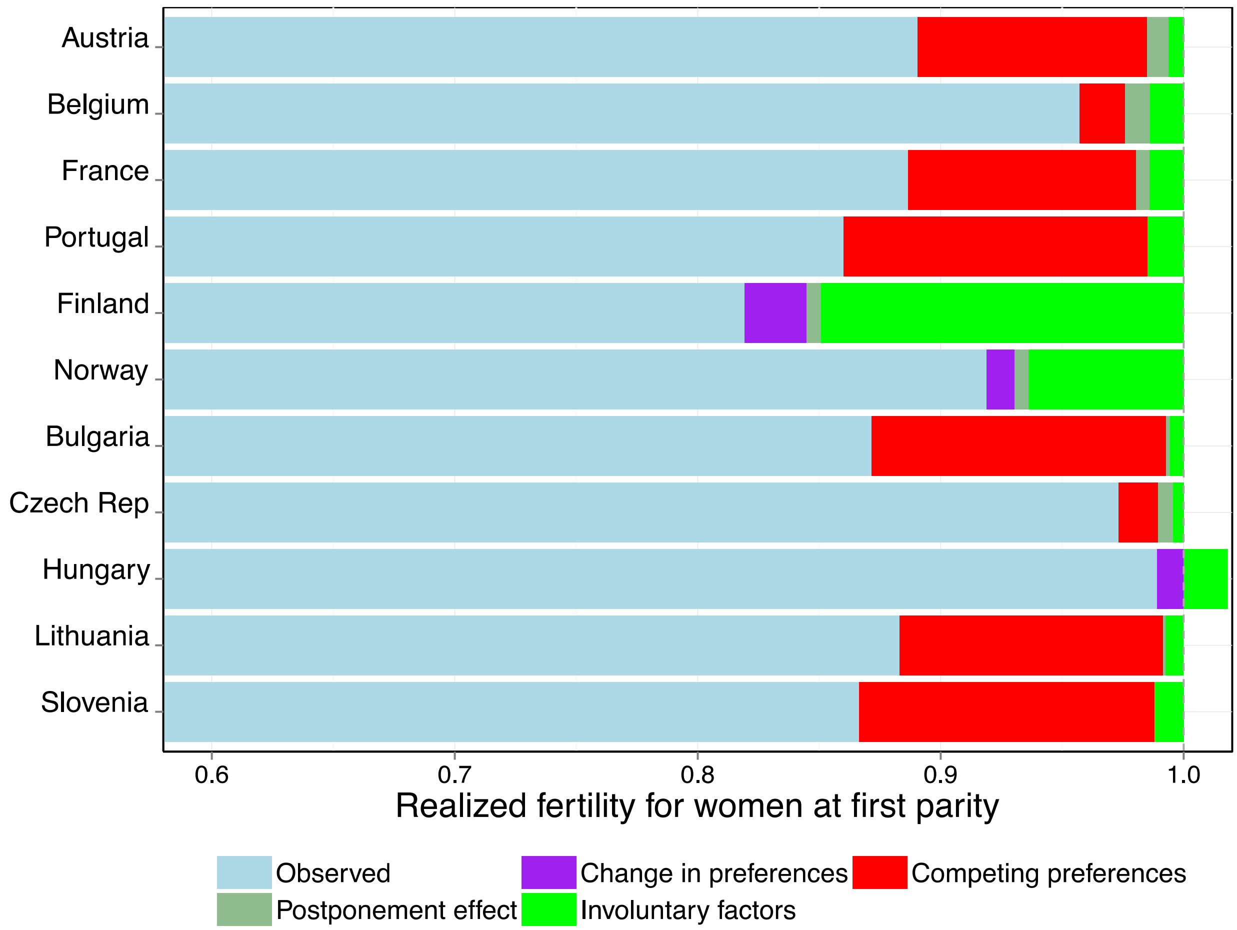
Graph 2 portrays observed fertility as a fraction of total desired fertility computed according to Rodriguez and Trussel (1981). Five countries are able to complete 80% of their desired fertility, with Hungary and Belgium reaching 85% and 86% respectively, while Finland is the only country reaching below 70% of desired fertility as suggested also by Lutz (2007). Parity progression ratio to first birth depicts a situation where five countries are closed or exceed 90% of women progressing to first birth, Eastern European countries are consistently above 80%, while Finland lags again behind, slightly below 80%. The gap between observed and desired fertility differs importantly when considering women at first parity. Women who preceded to have a child have much higher chances to fulfill their desired fertility preferences, with an increase of 10% on average (18% Finland, 16% Bulgaria, 15% Czech Republic).

Graph 3: Simulation results showing the percentage of realized parity progression ratio to first birth with respect to the desire of having at least one child.



In this study we explain the gap disentangling two components: involuntary factors and competing preferences. For example, in Austria, the observed TFR (1.75) reaches 83% of the Desired Family Size (2.1), while the simulated TFR (1.93) reaches 92% of the DFS. This means that, 17% of the relative gap between TFR and DFS can be divided into 9% corresponding to competing preferences effects and 8% to involuntary factors (Figure 2), so that both factors approximately explain each half of the gap between TFR and DFS.

Graph 4: Simulation results showing the percentage of realized total fertility rate for women at first parity with respect to desired fertility of women at first parity.



The results of the simulation separate the countries into two main groups: Eastern and Western Europe. The division lies in the role of involuntary factors and competing preferences in explaining the gap between observed and desired fertility. Indeed, in Western Europe involuntary factors explain the lion's share of the gap (around 10%), especially in Norway and Finland where they explain 16% and 27% of the gap respectively. Whereas, in Eastern Europe competing preferences largely outweigh involuntary factors, with the sole exception of Hungary and Austria. This result is very important as it implies the presence of two opposite mechanisms at work affecting the realization of desired fertility: on the one side biological factors and union dynamics (involuntary factors), on the other socio-economic factors (competing preferences).

Progression to first parity further proves the division between Eastern and Western Europe, with competing preferences having a much more important role in the East while involuntary factors do not differ substantially among countries. This is an important finding as in the transition to first birth in the West, biological factors such as age related fecundity, and union status dynamics (such as being single or divorced) explain almost completely cannot have the first child. On the other hand, Eastern European women's major difficulty into transitioning to first births owes to competing preferences. We can observe (Figure 3) that for Western Europe, the huge gap between the proportion of women who have one child and the proportion who desire at least one is mostly explained by involuntary factors. Finland is once again the outlier in this study, as both involuntary factors and competing preferences seem to play an important role in explaining the gap. Interestingly, a few countries register closed to zero levels of competing preferences, such as Austria, Belgium, France, Portugal, and Norway.

Women at first parity tend to achieve a much higher share of their desired fertility, partly due to a selection effect, which removes sterile women and therefore raises the chances of having more children with respect to total fertility displayed in Graph 4. Indeed, the simulation results for TFR*(1) suggests that involuntary factors have little responsibility in explaining the gap between desired and observed fertility, with the sole exception of Finland and Norway. On the other hand, the failure to reach the desired number of children for women at first parity can be almost completely attributed to competing preferences. This is a very important finding that has some considerable repercussions at family policies level. The lack of high order births in most European countries is due to factors that could be controlled through policies aimed at supporting financially families and working mothers. Nevertheless, it is important to remember that Eastern European women's DFS for women at first parity does not differ much from that of women at all parities and that it is also considerably lower than DFS of Western European women. DFS for higher parities is particularly high in Norway and Finland, two countries where involuntary factors completely explain the gap.

5. 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).

An alternate interpretation could be that we ignored factors that we assumed to be irrelevant but that in fact matter such as unwanted pregnancies, or some inputs in our model are incorrect (union formation and dissolution risks).

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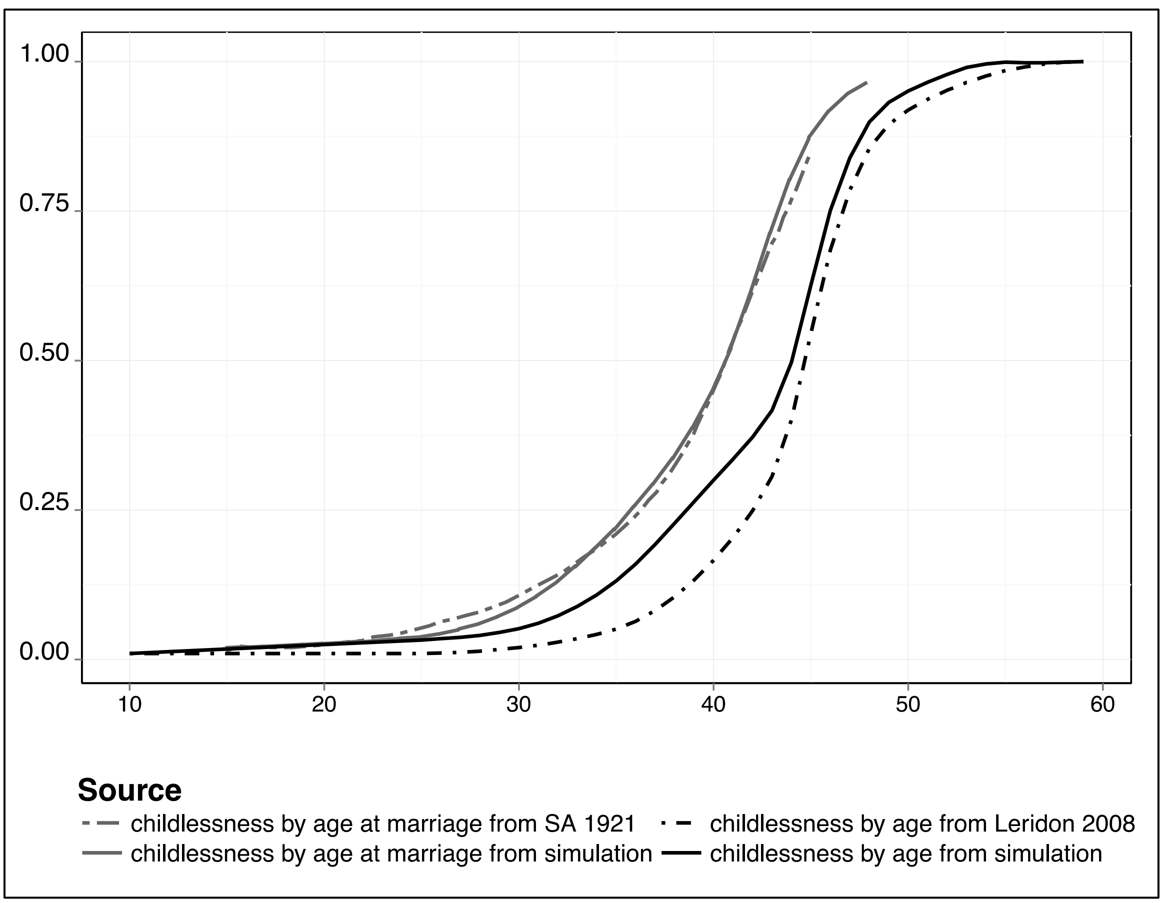
Annex 1. Complete specification for the parameters and functions used in the microsimulation model

We simulate the reproductive live of 30.000 women, from birth until 59 years. Our model is based on the following set of hypothesis, in which we take into account both the biological dimension of fertility (parameters a to h) and the one depending on social or individual choices (parameters i to n).

a. Progression of sterility with age: we followed the procedure used by Léridon (2008) and calibrated our model modifying the sterility function until our results fitted the cumulated proportions of last birth by woman's age, as collected by Louis Henry for Ancient France. Our final sterility distribution by age differs from Léridon's one, due to internal differences in the microsimulation model (right curves on the following graph). We checked our model computing childlessness levels at age 50 for women, by age of first marriage, and comparing them with observed levels for white women taken from the South African Population Census of 1921, which is one of the best dataset available for non-controlling populations (left curves).



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

$m(d) = 0.0509152 + 0.0093173d - 0.0004664d^2 + 0.0000086667d^3$

Where d is the duration in menstrual cycles.

c. Risk of intrauterine mortality during pregnancy: Barret (1978) formula:

$mi(d) = 0.11(0.55)^{d-2} \; with \; 2 \leq d \leq 8$

Where d is the duration in menstrual cycles.

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

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

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, based on desired fertility levels (table 2). That means stopping only. Spacing is implemented only for the first interval, between first union formation and first pregnancy: see point **n**.

j. First partnership formation risks for women: Coale and McNeil (1972) model, using the reparametrization by Rodriguez and Trussel (1980). Standard deviation varies with mean age $\boldsymbol{\mu}$ using the formula:

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

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 separates and the next union is the same than for the process of entry in first union, but using as starting point the age at which the proportion of women in union is superior or equal to 2 % in the previous distribution.

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):

Table A1: Relative risks multipliers of separation associated with the presence of children under 25 years of age.

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

The microsimulation model is iterated until the resultant proportion of separation is the same than the one entered as input.

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

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

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

o. The mortality level is the same for all countries and corresponds to the "West" model life table level 25 of Coale, Demeny and Vaughan (1983). Mortality here is for male only, for computing the risk of widowing.

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

Rodriguez and Trussel (hereafter RT) developed a procedure to estimate Desired Family Size (DFS) from questions on plan for at least another child and applied it to the World Fertility Surveys (WFS)[1]. This methodology is also useful in the case of the FFS, because one of the questions asked is precisely of this kind, the exact wording being "do you want to have a(nother) child sometime?". As they applied this methodology to high fertility countries, they also took into account unwanted fertility using another question in the WFS surveys on whether the last birth was wanted. Since unwanted fertility was not considered as an important topic in the FFS surveys, only pregnant women were asked whether the current pregnancy was wanted. Unfortunately the answers are not directly interpretable in term of unwanted fertility, as we don't know whether women will have an abortion afterward. This leads us to apply RT's methodology supposing that there is no unwanted fertility, which actually is quite reasonable for most of the FFS countries. In that case, RT propose to estimate DFS from a set of desired parity progression ratios p_i computed as:

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

Where m_i are the numbers of women at parity i who want more children, n_i the total numbers of women at parity i and $N-1$ is the highest parity.

One key supposition RT implicitly made is that the observed parity distribution (the n_i numbers) is completely determined by the desired parity progression ratios. But generally this is not the case, due precisely to the existence of a gap between observed and desired fertility. So the numbers n_i observed from the survey cannot be the result of desired fertility levels, and the problem RT overlooked, is whether we have to adapt their methodology in order to estimate desired parity progression ratios. In the following we show that RT's formula gives the correct result, even when observed and desired fertility differ.

The demonstration will be limited to the case of what RT call the 'full implementation model', that is when there is no unwanted fertility and every woman has access to efficient contraceptive means. Using the same reasoning than RT, we study a simplified steady-state situation in which women have the same age fertility schedule and age and parity are confounded. In that situation,

[1] Rodriguez and Trussel (1981)

all the women with *n* births will have them at the same age, one each year, in a total of *n* years. If we start first with RT's original hypothesis of equality between observed and desired fertility levels, the observed distributions of women by parity and of women who want more children will only be function of the desired parity progression ratios and thus proportional to the following numbers for cohorts of the same size (here this size is set to one):

Table A2: Desired parity progression ratios.

Parity	Number of women (n_i)	Want more children (m_i)
0	$N - p_0.(N-1)$	p_0
1	$p_0.(N-1) - p_0.p_1.(N-2)$	$p_0.p_1$
2	$p_0.p_1.(N-2) - p_0.p_1.p_2.(N-3)$	$p_0.p_1.p_2$
...	...	...
N-2	$p_0...p_{N-3}.(2) - p_0...p_{N-2}$	$p_0...p_{N-2}$
N-1	$p_0...p_{N-2}$	0
Total	*N*	*DFS*

When we apply formula [1], most of the factors cancel each other out when we sum the n_i numbers, as can been inferred from the first column of the previous table, and it simplifies to:

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

Which demonstrates RT's formula in the simplest case. If we suppose now that observed and desired fertility are not equals, in the context of this steady state case, this means that the observed numbers of women by parity are generated by a set of parity progression ratios than differ (and that will be in fact lower for FFS fertility countries) from desired ones:

$$\bar{\bar{p}}_i \neq p_i$$

The preceding values of the distributions of terms n_i and m_i will then change to:

$$\bar{\bar{n}}_i = \bar{\bar{p}}_0 \ldots \bar{\bar{p}}_{i-1} + (N-i-1).\bar{\bar{p}}_0 \ldots \bar{\bar{p}}_{i-1}.(1-\bar{\bar{p}}_i)$$

$$\bar{\bar{m}}_i = \bar{\bar{p}}_0 \ldots \bar{\bar{p}}_{i-1}.p_i + (N-i-1).\bar{\bar{p}}_0 \ldots \bar{\bar{p}}_{i-1}.(p_i - \bar{\bar{p}}_i)$$

We observe that the numbers of women by parity (the terms n_i) are completely determined by the observed parity progression ratios, but that the numbers of women at each parity who want more children (the m_i) are a mix of observed and desired parity progression ratios, so that it is not immediately obvious that RT's methodology will lead to the correct value of the desired ratios. But fortunately this is the case, as simple algebra calculation leads to:

$$\frac{\bar{\bar{m}}_i+\sum_{j=i+1}^{N-1}\bar{\bar{n}}_j}{\sum_{j=i}^{N-1}\bar{\bar{n}}_j}=\frac{\bar{\bar{p}}_0\ldots\bar{\bar{p}}_{i-1}.p_i+(N-i-1).\bar{\bar{p}}_0\ldots\bar{\bar{p}}_{i-1}.(p_i-\bar{\bar{p}}_i)+(N-i-1).\bar{\bar{p}}_0\ldots\bar{\bar{p}}_i}{p_0\ldots p_{i-1}.(N-i)}=p_i$$

This demonstrates that, when there is no unwanted fertility, RT's formula gives a correct estimate of the desired ratios and of the DFS, even when observed fertility levels are not equal to desired ones. This is a significant result, as this also demonstrates that desired levels estimated by this formula are independents of observed fertility levels, which is not the case with the 'official' DFS levels, as published by the FFS team: the procedure they used was to add a desired additional number of children to the number women already had. So those resulting 'DFS' are in fact a complex mean of observed and desired fertility levels with lower values than the one obtained using RT's methodology (as seen in Table 1).