Rethinking the Relationship Between Education and Fertility. Using Simulation to Asses the Role of Unobservables

Daniel Ciganda, Angelo Lorenti.
Max Planck Institute for Demographic Research

EXTENDED ABSTRACT

Abstract

We aim to provide a new interpretation of the relationship between education and fertility by showing that a significant part of the weakening negative educational gradient of fertility across cohorts is a result of the decreasing share of unplanned births. In order to do so we combine agent-based simulation with standard statistical modeling approaches, showing how our understanding of key demographic mechanisms could change if we were able to incorporate in our modeling difficult or impossible to observe quantities. We argue that instead of interpreting recent evidence as a *reversal* of a long standing negative association, we should probably think of it as the emergence of the "true" nature of the relationship after compositional changes minimize the effect of confounding factors.

1 Introduction

Education has been considered one of the main drivers of fertility decline since the earliest versions of demographic transition theory (Notestein, 1953). By the 1970' the negative association between education and fertility seemed one of the most established regularities in the social sciences, supported by evidence from a variety of contexts and time periods (Cochrane, 1979).

This notion persisted in the following decades, supported by analysis that focused on education and contraceptive use in developing countries (Cochrane, 1983; Cleland, 1985), but also on education and postponement of parenthood in more developed contexts (Rindfuss et al., 1980; Kohler et al., 2002).

Things started to change in the late 1980's after a series of studies suggested the emergence of a positive effect of education on the transition to higher order births (Wright et al., 1988; Hoem and Hoem, 1989; Kravdal, 1992). Although follow-up studies revealed the existence of significant selection effects (Kravdal, 2001; Kreyenfeld, 2002; Kravdal and Rindfuss, 2008), the interest in negative educational gradients increased among researchers of fertility change. A number of studies supported the claim that the negative educational gradient of fertility *outcomes* was weakening (or reversing in the case of men) (De Wachter and Neels, 2011; Kravdal and Rindfuss, 2008; Caltabiano et al., 2009), but also that in a number of countries fertility *intentions* were higher among highly educated women (Testa, 2014; De Wachter and Neels, 2011).

These individual-level findings were in line with cross country analyses showing a recuperation of period fertility after countries exceeded a certain level of economic and social development (Myrskylä et al., 2009; Luci-Greulich and Thévenon, 2014), which reinforced the idea of the emergence of *reversals* of long established patterns of association. In most studies these reversals are attributed to a series of mechanisms that allow educated women in advanced societies to reconcile family and careers, like the public provision of childcare and social services, access to well paid jobs and flexible working hours and the increasing involvement of fathers in housework as gender relations become more egalitarian (Esping-Andersen, 2009).

The difficulties to disentangle the effect of education on reproductive outcomes are numerous, and most of the studies reviewed above have explicitly considered/developed strategies to overcome them. There is one element, however, that has not received the systematic treatment that we think deserves: unplanned fertility. Although studies usually interpret the negative gradient of education as resulting partly from the increased ability to control the reproductive process as education increases, to the best of our knowledge no systematic effort has been made to analyze the role of unplanned births in the evolution of the observed relationship between education and fertility.

The overwhelming majority of demographic analyses of unplanned fertility are focused on developing countries (Bongaarts, 1997, 2001, 1990) and to a lesser extent in the US, where high teenage pregnancy rates have generated interest on the issue (Henshaw, 1998). The scarcity of data from unplanned pregnancies and births in Europe is likely a combination of difficulties in measuring the unintended fraction of births and the belief that the control over the reproductive process is nearly perfect, or at least moving in that direction (Klijzing, 2000).

The few available estimates, however, contradict these assumptions. Castiglioni et al. (2001) show that approximately 25% of the births of women born around 1950 in Italy in France were unplanned. A figure that is similar to the European average provided by Singh et al. (2010) based on several independent studies conducted in the first decade of the 21st century. If we consider that these cohorts reached their peak reproductive years during the 1970's and 1980's, after the diffusion of effective contraceptive methods, it seems safe to assume that a larger fraction of births were unplanned among women from earlier cohorts.

Even if we assume a decreasing trend in the proportions of unplanned births to the extent that they do not longer represent a relevant dimension of the experience of recent cohorts, any cross-cohort comparison would likely be affected by this change in the relative fractions of planned and unplanned births that comprise total fertility. We argue that this is the case with most of the analyses that show a reversing or weakening negative educational gradient of fertility outcomes, as the relationship between education and planned fertility goes in the opposite direction than the relationship between education and unplanned fertility.

2 Objectives and Approach

Our objective is to provide a new interpretation of the relationship between education and fertility by showing that a significant part of the weakening negative educational gradient of fertility across cohorts is a result of the decreasing share of unplanned births. In order to do so we combine agent-based simulation with standard statistical modeling approaches, showing how our understanding of key demographic mechanisms can change if we were able to incorporate in our modeling difficult or impossible to observe quantities.

The simulation exercise covers the reproductive experience of the cohorts that shaped fertility trends from the second half of the 20^{th} century. In addition to the time dimension we aim to exploit cross-country variation, focusing on countries with clearly different fertility profiles: Spain, characterized by a steady decline of cohort fertility and a relatively late educational transition, and France, where fertility has been relatively high and stable and where the expansion of higher education was observed earlier than in Spain.

After calibrating and fitting the model to empirically observed fertility trends, our analytical strategy consists of two steps: In the first one we aim to reproduce results found in the literature regarding the evolution of the link between education and fertility, applying the same statistical modeling techniques on our simulated data. In the second step we compare the results from those models with the results obtained when we include information that is usually not present in observational data but that we can produce in our simulation, namely the decomposition of fertility between planned and unplanned births and women's long term labor market attachment.

Our main hypothesis is that the relationship between education and wanted fertility among *working* women is always positive, at least after a certain threshold of years of education, and that instead of interpreting recent evidence as a *reversal* of a long standing negative association, we should probably think of it as the emergence of the "true" nature of the relationship after compositional changes minimize the confounding effect of difficult or observe quantities.

In the following sections we first describe the simulation model in detail, later we present the model fit to different fertility outcomes and the results from preliminary scenarios to assess the overall effect of education in the model. We close the paper by discussing the findings and provide some concluding remarks.

3 Model Description

Our model generates synthetic life histories structured around six main events: Leaving the education system, searching and finding a partner, getting into a cohabiting union, trying to have a child, having a/an additional child, dying.

As in other discreet event simulations time advances with the realization of each event. At each iteration the algorithm realizes the event with the shortest waiting time from a list of all possible events for the entire population of agents. After the realization of each event the system is updated and the simulation continues to the next run. By the end of a calendar year a series of aggregate indicators are computed from the life histories generated up to that moment, which are later used to asses the model fit at the macro level.

It is possible to distinguish three different dimensions of time: Process or duration time t measures the time spent in each state and the time left to the following event. Age x, which ranges between 0 and 50, and calendar time c which in the simulation exercise presented here runs from the beginning of 1925 until the end of 2016.

3.1 Desired-Achieved-Unplanned

We call our framework *Desired-Achieved-Unplanned* (DAU) because it focuses on the three quantities that are central to understanding the evolution of macro-level fertility indicators and their connection to micro-level decision-making.

In this framework *Desired* (D) refers to the total number of children individuals intend to achieve at the end of their reproductive life, in other words, the number they would give as the answer to the question "How many children do you *want* to have?". *Desired* expresses long-term intentions and is then only sensitive to long-term life course definitions. In the basic version of the DAU model the final size of the family a women wants depends only on whether or not she participates in the labor market, under the assumption that women who dedicate most of their time to housework will tend to prefer larger families and that women who have larger families will have more difficulties participating in the labor market.

It could be argued that education also plays a role in shaping desired family sizes. In fact, in our model education indirectly affects D as it is positively associated with the probability of participating in the labor market. In theory education can also have a direct and negative effect on D as it promotes opportunities for women that compete with family life. In practice however, studies have found no clear effect of education on long term fertility preferences among older cohorts (Rindfuss et al., 1980) and even a positive effect among younger cohorts in some European countries (Testa, 2014). This is a key piece of evidence, although we believe the effect of education is better operationalized through short term intentions and we will address this shortly. Going back to long term preferences, we formally define them as:

$$D_i \sim \Gamma_{a \leq D_i \leq b}({}_0D + \alpha - \beta^{A_i}, 1) \tag{1}$$

where $A_i \in \{0, 1\}$, is the labor force participation status of agent i (active vs. inactive), which is obtained from census data (see Section 4). The shape of the Gamma distribution is a function of ${}_0D$ (an initial value of D to be estimated) and parameters α & β, which define the length of distance between the distribution of family sizes of active women and the distribution of family sizes of inactive women. In cross country comparisons we could think of this distance as the expression of the difficulties people find in different countries to combine work and family, being smaller in contexts that facilitate the balance between these competing roles. Finally, a and b are the limits of the distribution.

Own computations based on Integrated Value Surveys Database (not shown) confirmed our expectation that the distribution of family size preferences has positive skew and justifies the choice of a gamma distribution.

Achieved is the micro-level equivalent of Cohort Completed Fertility and a direct result of short-term fertility intentions, which in the model are sensitive to school enrollment status, perceived economic uncertainty, labor force participation status and educational attainment. Formally, the intention to have a child ${}_BI$ is defined as:

$${}_BI_{i,x} = {}_B\rho_i \cdot \varepsilon^{E_{i,x}} \cdot R_c/K_i \cdot \upsilon_i \tag{2}$$

where ρ is the baseline intention which can be interpreted as the intention to have a child free of constraints for those agents who have the desire to have children ($D > 0$). We assume ρ to be normally distributed within a lower and an upper bound, which are estimated together with the mean and standard deviation of the distribution.

$E_i \in \{0, 1\}$ is the enrollment status of agent i and the value of ε expresses how much being enrolled affects short term fertility intentions.

R represents the perceived resources to afford a/an additional child and is given by a smoothed series of the unemployment rate, which we use to approximate the perception of agents regarding the economic situation at time c. The effect of economic uncertainty increases linearly with the number of children an agent already has K.

The last factor in 2 is one of the key pieces of the model, it expresses the effect of education and is defined as:

$$\upsilon_i = \begin{cases} 0.9/(1 + exp(\delta \cdot (Y_i - \overline{Y}_x))) + 0.1, & \text{if } A_i = 1 \\ 1, & \text{if } A_i = 0 \end{cases} \tag{3}$$

As explained earlier, our assumption here is that among *working* women education is positively related with short term fertility intentions. In other words, the amount of years spent in school progressively reduces the depressing effect of labor force participation on women's short term fertility intentions until it closes the gap between active and inactive women. The positive effect of education operates through as series of mechanisms: Increased resources, which translate into increase capacity to outsource housework and childrearing activities; a more advantaged position in the labor market, which tends to be associated with more flexible working hours and less constraints to organize the daily routine; increased bargaining power, which translates into an increased capacity to establish a more gender egalitarian arrangement with their partners, coupled with an increased probability to meet partners who are willing to assume a larger share of unpaid work. It is reasonable to believe that women in the upper part of the distribution of educational attainment are the ones that will benefit the most from the mechanisms listed above, therefore we let the mean years of education of the cohort $\overline{Y}_x$ define the inflection point after which the effect increases at a faster rate.

To keep things simple we let the intention to have a child to develop only after women enter a union. In Section 3.2 and 3.3 we provide details on how we model the transition out of the education system and the formation of partnerships.

To connect the intention to the conception of a child (or its attempt) we make I proportional to the rate of an exponential distribution and we obtain a waiting time. If the resulting waiting time is shorter than one year, then at the end of that time our simulated couple will attempt to have a child, if it is longer they will update their intention after one year and reconsider whether or not to have a child within the next twelve months. When a couple attempts to conceive, their probability to succeed decreases with the woman's age:

$$p_x = 1/1 + \exp(\theta(x - \omega)) \tag{4}$$

If they fail, they will try again in a period of one to four months (draw from a truncated normal distribution with mean 1.5), until they reach a predefined limit for failed attempts. If they succeed, a waiting time to birth is created which is equivalent to the pregnancy period and lasts 270 days. After conception, if they still have not reached D they will go back to updating their intention/evaluating whether to try and have a new child after a period of seven to fifteen months (draw from a truncated normal distribution with mean twelve months).

We arrive here at the third central element of the model: *Unplanned.* If a couple already achieved their desired family size (including $D = 0$) they still have a probability u to have an unplanned birth defined as:

$$u_{i,c} = \frac{\phi/(Y_i^{\kappa})}{1 + e^{\iota \cdot (c-(\psi - Y_i))}} \tag{5}$$

The use of a logistic function is based on the fact that demographers have for a long time thought of the adoption of contraception as a diffusion process (Rosero-Bixby and Casterline, 1993). As contraceptive methods become more effective the probability to have an unplanned birth declines. Parameters ι and ψ control the pace of the decline and its inflection point and κ the differences in the probability by year of education. In addition to calendar time, we make u dependent on an agent's educational attainment, assuming that more educated women have more knowledge, resources and incentives to control their reproductive process.

3.2 Education Completion

The time agents take to complete their education depends on the level of education they attain. We consider three levels: Primary, secondary, and tertiary. The information on educational attainment is obtained from census data as explained in Section 4.

The waiting time to education ${}_ET_i$ is obtained from the number of years Y_i agents remain in the education system, which are obtained from a truncated normal distribution:

$$Y_i \sim N_{c \leq Y_i \leq d}(\mu, 3) \tag{6}$$

Where $c = 0$ and $d = 6$ for those with *primary* education or less; $c = 6$ and $d = 12$ for those with *secondary* education; $c = 12$ and $d = 24$ for those with *tertiary* education. The mean of the distribution μ increases linearly throughout the period from 3 to 6, 8 to 12 and 16 to 22 years, for primary, secondary and tertiary education respectively.

3.3 Union Formation

The process that leads to the formation of a cohabiting union begins with the search for a partner. To define the dynamics of the search we adapt some ideas from previous efforts to model marriage markets (Grow and Van Bavel, 2015; Grow et al., 2017). Women start searching for a partner around the time they complete their education. Once the time to select a partner arrives they choose among the pool of potential partners (composed by all men in the population born ten years before and three years after their own birth year) with a probability proportional to:

$$v_{ij} = \left(\frac{S_{max} - |s_i - s_j|}{S_{max}} \right) \cdot W_j \tag{7}$$

Where s_i represents her level of education and s_j his. Besides preferring partners that have similar levels of instruction we assume that women prefer partners that work over partners that do not. Therefore we define W as:

$$W_j = \begin{cases} 1, & \text{if } A_j = 1 \\ 1/\tau, & \text{if } A_j = 0 \end{cases} \tag{8}$$

After a woman chooses a partner they start a relationship and she develops an intention to form a union which is defined as:

$$_{U}I_{i,x} = {}_{U}\rho_i \cdot \varepsilon^{E_{i,x}} \cdot R_c \cdot U_x \tag{9}$$

where U_x is a logistic function of the proportion of women in a woman's birth cohort that is married at the time of updating $_{U}I$. This mechanism generates a feedback effect that amplifies the effects of economic uncertainty and enrollment and can also be interpreted as a social norm that regulates the appropriate time to enter a cohabiting relationship. In demographic research the idea of social feedback effects, or social multiplier, has been used to understand the spread of contraceptive use (Montgomery and Casterline, 1993) but also the postponement transition (Kohler, 2001; Ciganda and Villavicencio, 2016).

As in the decision to have a child, $_{U}I$ is updated on a yearly basis until the simulated couple moves in together or one of them leaves the population.

3.4 Death

The waiting time to death $_{D}T_i$ is sampled using the inverse distribution function method (Willekens, 2009) where the distribution of waiting times to death is reconstructed using age-specific cohort mortality rates from the Human Mortality Database. For the ages/years where information is not available we use the latest available figures. Missing data corresponds essentially to the most recent decades, when mortality of females under 50 years of age is low.

3.5 Example Trajectory

Figure 1 presents a basic description of the operation of our model. It depicts a hypothetical life trajectory of an agent that is born during the simulation.

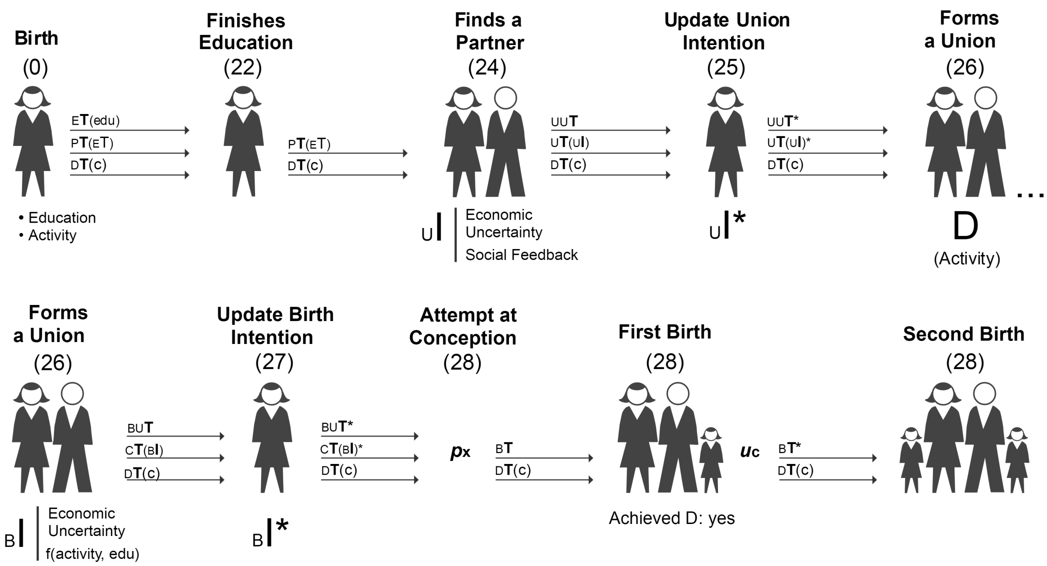


Figure 1: A Simulated Trajectory.

4 Data

Both the initialization and validation of the model depends exclusively on reliable and, for a large number of countries, readily available data from censuses and vital statistics. As mentioned in the model description, the educational attainment and labor force participation status of the agents throughout the simulation comes from census data available through the IPUMS project (Minnesota Population Center, 2018). In the case of Spain we use a pooled dataset with information from four censuses from 1981 to 2011 to obtain the proportions of men and women with primary, secondary and tertiary education and the labor force participation status (active vs. inactive) by educational level in each birth cohort from 1925 to 2016.

Figure 2 shows the evolution of educational attainment among women in Spain. We are able to observe these trends up to the cohorts born in 1980, after that we assume a continuation of the linear increase in the proportion achieving tertiary education, a linear declining trend in the share of women achieving only up to secondary education, and a stagnation in the share of women achieving primary education only (at under 10%).

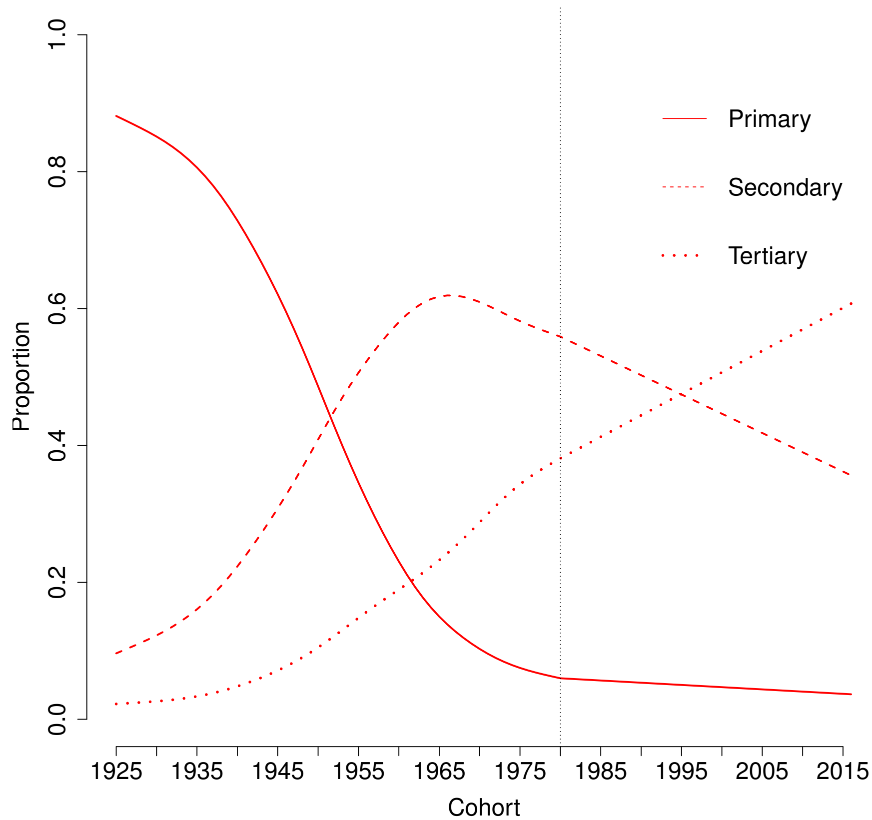


Figure 2: Observed Educational Attainment of Cohorts | Women, Spain

The expansion of education among women is usually described by the increasing proportions achieving post-secondary levels. This trend can be clearly observed in Figure 2, although even more interesting is the collapse of the proportions achieving only primary education or less. While close to 70% of women born in 1940 studied up to a maximum of six years, ten years later that proportion had dropped to under 40% and twenty years later to under 20%. As we will show later, this collapse will be fundamental to understand the profound changes in the family formation dynamics observed in Spain from the second half of the 20th century.

Figure 3 shows the proportion of active women in Spain by education and birth cohort. To obtain these figures we selected women aged 30 to 55 in the pooled census dataset, observations of women in more than one census were treated as separate observations. We use this estimates in the model as the probability of women born in the simulation to participate in the labor market, for which we have to make the simplifying assumption that this status does not change over time. In the context of our analysis this is not a problematic assumption as we are interested in representing the general level of attachment to the labor market and its influence on women's long-term fertility intentions, as described in Section 3.

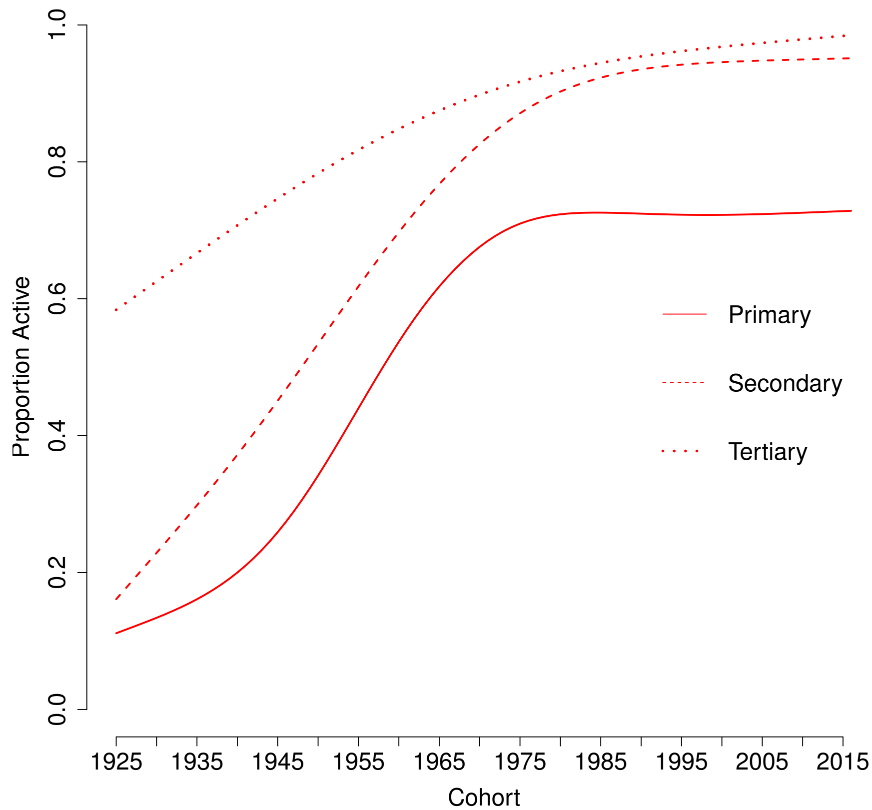


Figure 3: Labor Force Participation of Cohorts | Women, Spain

To obtain the *initial age structure* of the population we use the 1940 Spanish census. and for the *initial distribution of the population by education* we use information from the 1970 census, which is the first to present disaggregated population figures, in these two cases the data is obtained from the National Statistical Office of Spain (INE).

For the validation process we use information on several aggregate fertility indicators: Total Fertility Rates, Cohort Completed Fertility, age-specific fertility rates, mean ages at birth and at different parities and cohort childlessness. All information comes form the Human Fertility Database (2011) with the exception of the information on childlessness that was obtained from census data.

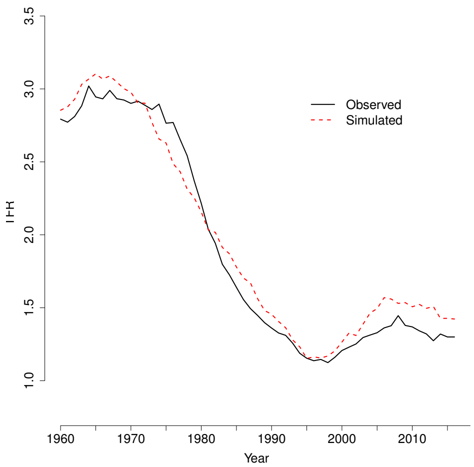
5 Results

5.1 Model Fit

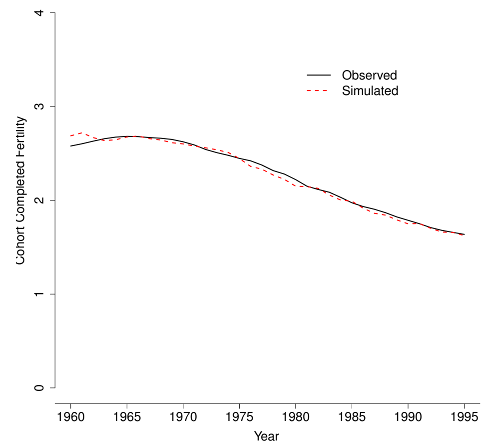
Figure 4 presents model fit results to Spanish fertility data. We use various different aggregate outcomes to make sure the underlaying trajectories simulated by the model resemble real trajectories as close as possible. Our model provides a relatively good fit to period fertility rates (Panel (a)), although it is unable to pick up the strong period effects of the most recent economic recession and slightly overestimates the recovery of period rates in recent years. That mismatch is partially the result of timing effects, as it can be seen in Panel (d), the simulated mean age at birth remains stable while the observed one shows a sudden increase that is likely the expression of increasing economic uncertainty since 2008. Nevertheless, considering the need for parsimony and the length of the period covered we believe this is a solid foundation for our scenarios analysis, in particular if we focus on cohort indicators, which the models seems to be able to reproduce very precisely (Panel (b)) [1]. The fit with respect to the observed proportion of childless women in the first half of the observed period is less satisfactory due probably to complex marriage market dynamics as a result of the Spanish civil war at the end of the thirties that the model is unable to pick up. In any case the discrepancy is still relatively small and the fit improves significantly in more recent years.

[1] Cohort fertility is presented here with a 30 year lag to associate each cohort quantum to their peak reproductive years.

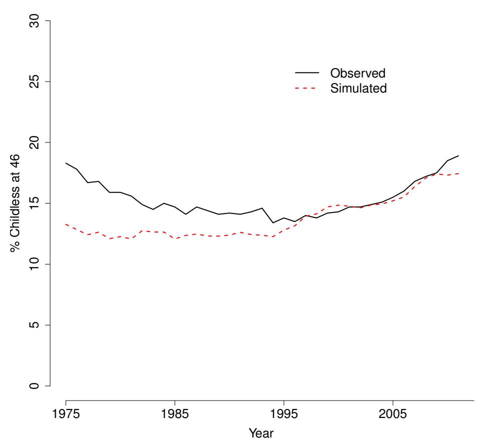
Figure 4: Observed vs Simulated Fertility Outcomes | Spain.



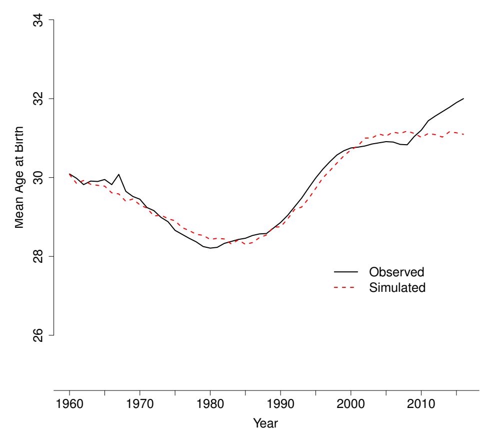
(a) TFR



(b) Cohort Completed Fertility



(c) Childless



(d) Mean Age at Birth

Figure 5 presents the decomposition of the TFR in Spain for the simulation period. Our assumption here is that the unplanned fraction decreases significantly after the second half of the 1970's, contributing to the general decline of period fertility rates in that period. In the original model we assume that the fraction of unplanned births is negligible after the 90's. These assumption is in line with the few estimates provided for European countries although we are currently looking for alternative data sources that allow us to validate this trend. Considering the scarcity of data and the reliability of estimates, however, we also intend to generate different scenarios in order to asses how our results are affected by different assumed paths.

Figure 5: Observed vs Simulated (Planned / Unplanned) Total Fertility Rates | Spain, 1960 - 2016

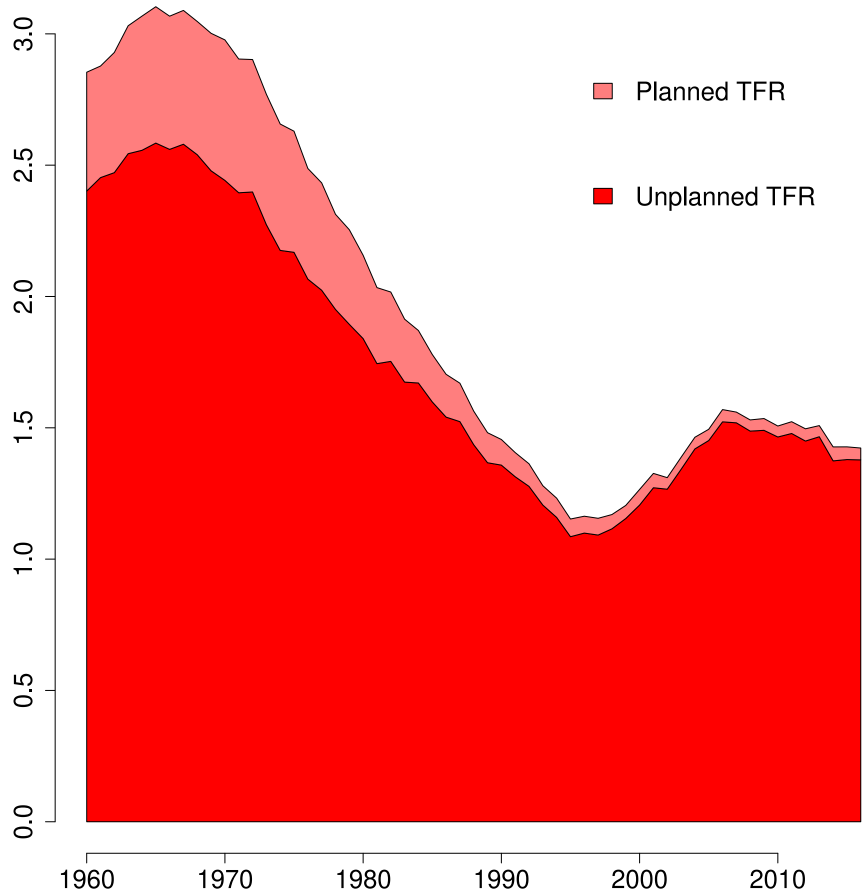
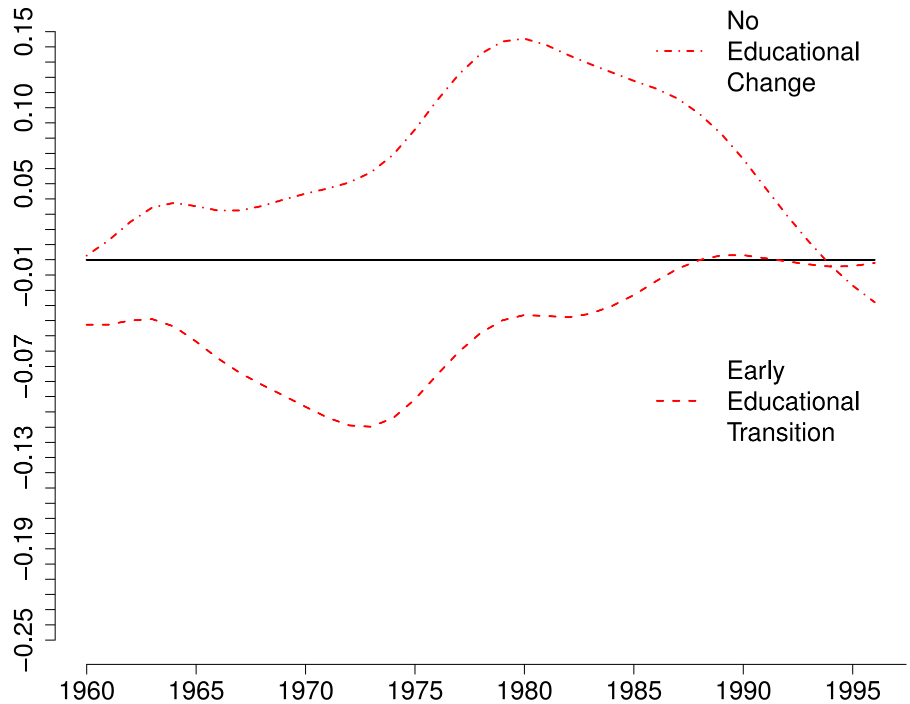


Figure 6 present the difference in completed cohort fertility between the baseline model (black horizontal line) and our preliminary scenarios. For our first scenario we fix educational attainment to the levels observed at the year of start of our simulation ("No educational Change"). We find the results from this scenario particularly interesting. Although the simulated level of fertility increases for the cohorts that were in their peak fertility years until 1980, it starts a sustained decline after that moment and it sits below the observed level (black line) for more recent cohorts. Although it might seem counter-intuitive at first, it is reasonable if we think that this counterfactual presents a world in which women still massively enter the labor market without benefiting from the increase resources/flexibility/bargaining power associated with higher education. Although these mechanisms are not modeled explicitly in our framework, they are behind our decision to assume an overall positive link between education and short-term fertility intentions, which is the key piece to understand the trends produced in this scenario.

Figure 6: Differences In Completed Cohort Fertility in Scenarios with Respect to the Original Model. Spain, Year of Peak Fertility of Cohorts.



The second scenario corresponds to an early educational transition, more precisely what we do here is to run the same model on the Spanish data, but with the observed evolution of educational attainment of France. What we find is that if Spain had experienced an earlier educational expansion fertility would have been lower than observed until the end of the 1980's after which it would have followed a similar trajectory than the one depicted by the observed data. It is interesting how, in this scenario, fertility does not continue increasing for the recent cohorts. This is partly explained by the higher mean ages at birth reached in this counterfactual, the higher intention associated with a higher share of highly educated women is counterbalanced by reduced exposure, at least in an *all else equal* scenario.

6 Discussion and Next Steps

Our preliminary analyses show that the proposed relationship between educational attainment and fertility generates interesting and plausible scenarios. A world with no educational expansion would have produced higher fertility rates (at least in a country like Spain), but only before women had completed the transition into the labor market.

This is in line with recent evidence from statistical models that show a positive correlation of education and fertility intentions and outcomes.

Similarly, an earlier educational expansion would have resulted in lower fertility rates until the share of highly educated women had been large enough to compensate for the negative effect of higher labor market participation rates. In this case however, fertility would not have surpassed the observed rates as a result of the reduction of exposure associated with a larger fraction of women starting their reproductive trajectories later in life.

For our next steps we plan to: First, reproduce previous studies reporting a weakening negative effect of education on fertility outcomes by fitting statistical models to our simulated data, and second, to introduce in this models some key quantities that are usually not available in observational data but can be key to our understanding of the mechanisms linking education and fertility.

References

Bongaarts, J. (1990). The measurement of wanted fertility. *Population and development review*, 487–506.

Bongaarts, J. (1997). Trends in unwanted childbearing in the developing world. *Studies in Family planning*, 267–277.

Bongaarts, J. (2001). Fertility and reproductive preferences in post-transitional societies. *Population and Development Review 27*, 260–281.

Caltabiano, M., M. Castiglioni, A. Rosina, et al. (2009). Lowest-low fertility: Signs of a recovery in Italy. *Demographic research 21*(23), 681–718.

Castiglioni, M., G. Dalla Zuanna, and M. Loghi (2001). Planned and unplanned births and conceptions in italy, 1970–1995. *European Journal of Population/Revue européenne de Démographie 17*(3), 207–233.

Ciganda, D. and F. Villavicencio (2016). Feedback mechanisms in the postponement of fertility in Spain. In *Agent-Based Modelling in Population Studies*, pp. 405–435. Springer.

Cleland, J. (1985). Marital fertility decline in developing countries: theories and the evidence.

Cochrane, S. H. (1979). Fertility and education: What do we really know?

Cochrane, S. H. (1983). Effects of education and urbanization on fertility.

De Wachter, D. and K. Neels (2011). Educational differentials in fertility intentions and outcomes: family formation in flanders in the early 1990s. *Vienna Yearbook of Population Research*, 227–258.

Esping-Andersen, G. (2009). *Incomplete revolution: Adapting welfare states to women's new roles*. Polity.

Grow, A., C. Schnor, and J. Van Bavel (2017). The reversal of the gender gap in education and relative divorce risks: A matter of alternatives in partner choice? *Population studies 71*(sup1), 15–34.

Grow, A. and J. Van Bavel (2015). Assortative mating and the reversal of gender inequality in education in Europe: An agent-based model. *PloS one 10*(6), e0127806.

Henshaw, S. K. (1998). Unintended pregnancy in the united states. *Family planning perspectives*, 24–46.

Hoem, B. and J. M. Hoem (1989). The impact of women's employment on second and third births in modern sweden. *Population Studies 43*(1), 47–67.

Human Fertility Database, . (2011). Human fertility database.

Klijzing, E. (2000). Are there unmet family planning needs in europe? *Family planning perspectives*, 74–88.

Kohler, H.-P. (2001). *Fertility and social interaction: An economic perspective*. Oxford University Press.

Kohler, H.-P., F. C. Billari, and J. A. Ortega (2002). The emergence of lowest-low fertility in Europe during the 1990s. *Population and Development Review 28*(4), 641–680.

Kravdal, Ø. (1992). The emergence of a positive relation between education and third birth rates in norway with supportive evidence from the united states. *Population studies 46*(3), 459–475.

Kravdal, Ø. (2001). The high fertility of college educated women in norway: An artefact of the separate modelling of each parity transition. *Demographic research 5*, 187–216.

Kravdal, Ø. and R. R. Rindfuss (2008). Changing relationships between education and fertility: A study of women and men born 1940 to 1964. *American Sociological Review 73*(5), 854–873.

Kreyenfeld, M. (2002). Time-squeeze, partner effect or self-selection? an investigation into the positive effect of women's education on second birth risks in west germany. *Demographic research 7*, 15–48.

Luci-Greulich, A. and O. Thévenon (2014). Does economic advancement 'Cause'a re-increase in fertility? An empirical analysis for OECD countries (1960–2007). *European Journal of Population 30*(2), 187–221.

Minnesota Population Center, . (2018). Integrated public use microdata series, international: Version 7.0.

Montgomery, M. R. and J. B. Casterline (1993). The diffusion of fertility control in Taiwan: Evidence from pooled cross-section time-series models. *Population Studies 47*(3), 457–479.

Myrskylä, M., H.-P. Kohler, and F. C. Billari (2009). Advances in development reverse fertility declines. *Nature 460*(7256), 741–743.

Notestein, F. W. (1953). *Economic problems of population change.* London: Oxford University Press.

Rindfuss, R. R., L. Bumpass, and C. St. John (1980). Education and fertility: Implications for the roles women occupy. *American Sociological Review 45*(3), 431–447.

Rosero-Bixby, L. and J. B. Casterline (1993). Modelling diffusion effects in fertility transition. *Population Studies 47*(1), 147–167.

Singh, S., G. Sedgh, and R. Hussain (2010). Unintended pregnancy: worldwide levels, trends, and outcomes. *Studies in family planning 41*(4), 241–250.

Testa, M. R. (2014). On the positive correlation between education and fertility intentions in europe: Individual-and country-level evidence. *Advances in life course research 21*, 28–42.

Willekens, F. (2009). Continuous-time microsimulation in longitudinal analysis. *New frontiers in microsimulation modelling*, 353–376.

Wright, R. E., J. F. Ermisch, P. A. Hinde, and H. E. Joshi (1988). The third birth in great britain. *Journal of Biosocial Science 20*(4), 489–496.