Social Feedback Mechanisms in the Postponement of Fertility in Spain.

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Abstract

In response to rising economic uncertainty beginning in the mid-1970s and increased opportunity costs associated with higher education, couples in Spain started postponing marrying and having children. As the reduction in the numbers of marriages and births led to a lessening of the pressure to conform to an early family formation standard, and as young men and women started imitating the behavior of their peers, the timing of family formation was pushed even further. People's beliefs about the ideal age for marriage and for becoming a mother were slower to change, but after a period of initial resistance these ideas started shifting as well, and the pace of normative change started to catch up with that of observed behavior. However, the new ideal did not increase indefinitely, and after a certain age cultural and biological limits imposed a ceiling, pushing Individuals to negotiate the opposing forces of their more immediate material conditions and the pressure to conform.

Using an agent-based model, we seek to characterize the postponement of family formation in Spain, which has led to a five-year increase in the mean age at first birth. In our model, the changes in age norms offer a bridge between the micro and macro levels, and help to explain the pace and the shape of the processes we analyze in this article.

Contents

1 Introduction

The idea that reproductive preferences represent a key element of fertility change was already present in classic demographic transition theory. Notestein (1953) recognized that the set of social norms, values, and beliefs sustaining a particular economic and demographic regime are "[..] *deeply woven into the social fabric and are slow to change*". For decades, most demographers have attributed the lag in the decline of fertility rates during the demographic transition to this slower pace of cultural change. However, the relationship between changing fertility preferences (desired family size) and fertility decline has rarely received systematic treatment.

Although social interaction became a key element of fertility decline theories after the results of the Princeton project highlighted the geographic and linguistic boundaries surrounding the onset and pace of fertility decline, analyses of the role of social interaction have too often been limited to the exchange and spread of information regarding means of fertility control.

Bongaarts and Watkins (1996) attributed this emphasis to the difficulties associated with the operationalization and measurement of other ideas which could have played a role during the demographic transition. Similarly, Lesthaeghe et al. (2001) argued that issues related to legitimacy and normative acceptability (the *willing* condition in Coale's *ready, willing and able* framework) have been underestimated in models of fertility change, as most research has assumed that social acceptance of a behavior is a natural corollary of its perception as economically advantageous.

A few more analyses of the relationships between preferences and observed fertility size appeared after data on fertility preferences were made available through programs like the World Fertility Surveys.[1] Bongaarts (2001), for example, concluded that "*A declining desired family size is indeed one of the principal forces driving fertility transitions, but in reality levels of fertility often deviate substantially from stated preferences*". He showed that in pre-transitional societies the ideal family size tends to be below the observed TFR, but that this relationship shifts in post-transitional settings.

In an analysis of the changing *timing* of fertility, Kohler et al. (2002) proposed a model that establishes a relationship of mutual dependence between individual preferences (desired age at first birth) and observed reproductive behaviors (mean age at first birth). The model implies that multiple equilibria can emerge, and allows for the formulation of hypotheses about the

[1] Cleland and Wilson (1987) provided one of these accounts, although they limit their conclusions to the contradiction of the expectations of demand theories after not finding solid evidence of a change in preferences toward smaller families prior to the fertility decline in countries of Asia and Latin America.

potential effects of exogenous pushes to the desired mean age at first birth. However, while the idea of equilibrium is theoretically elegant and mathematically tractable, there is little empirical support for the expectation of a convergence of reproductive preferences and behavior. Furthermore, working under the assumptions of Kohler's model, this kind of convergence could only be observed in a scenario in which the large set of factors which affect either fertility preferences or fertility behaviors remained stable.

Unfortunately, as data on the ideal time for the transition to parenthood are very limited, it is impossible to make comparisons of the evolution of the ideal and the observed mean ages at first birth. Data from 2006 show that by that time, the preferences and behavior were far from being in equilibrium (Testa, 2006). For example, women surveyed in Spain stated that the ideal age for becoming a mother was around 25.5, while the observed mean age at first birth for that year was 29.3.

Indeed, it would not be unreasonable to hypothesize that the evolution of the ideal mean age at first birth relative to the observed mean age will follow a pattern similar to the patterns observed for the ideal family size and the TFR. It is likely that before a certain level of control over fertility has been achieved, and while pressure to conform to an early standard is still high, the ideal mean age will be higher than the observed age, while the opposite will be the case after material conditions have pushed the observed mean age beyond a certain threshold, as appears to have been the case in most European countries in the mid-2000s (Testa, 2006).

In this paper we present a micro-macro model of the mean age at first birth in Spain in which preferences play a key role, mediating the relationship between socioeconomic incentives and the transition to parenthood. Our model also features social interaction, although not as the main driver of fertility change, as in most diffusion models, but as a mechanism of amplification of changes in material conditions (educational expansion and increasing economic uncertainty).

In other words, in our model the mean age at first birth rises as a larger share of women remain in the educational system for longer periods of time, and as unemployment becomes an increasingly regular feature of people's careers. This delay is in turn amplified by the effect of social influence, channeled through local networks of interaction. The sum of these effects (education, unemployment, and social influence) gives shape to a new ideal mean age at first birth, which also depends on the observed age at the transition to parenthood.

We explore scenarios connected with different combinations of weights of the factors considered, and we provide some hypotheses of what the co-evolution of preferences and observed behavior regarding the timing of fertility might look like.

1.1 Explanations of Fertility Postponement

The rise in the mean age at first birth in the last three to four decades has been so steep and so constant that Kohler et al. (2002) have proposed analyzing it as a *postponement transition*. This transition started in the early to mid-1970s, and has resulted in increases of three to five years in the mean age at first childbirth in European countries (Mills et al., 2011). These steep increases have been attributed to several factors. The explanation we propose has four central elements: the expansion of tertiary education, the increase in economic uncertainty, the role of social interaction as a multiplier of structural changes, and the dynamic relationship between preferences and constraints.

1.2 Educational Change

The positive association between education and the timing of fertility has long been recognized in demography (Rindfuss et al., 1980; Marini, 1984). Research on the topic has identified two different elements within the effect of education on fertility: an effect which corresponds to the effect of enrollment itself, and a post-enrollment effect. The first effect refers to the difficulties which can arise in balancing the roles of mother and student, while the second effect refers to the higher opportunity costs of childbearing for highly educated women.

Recent estimates of the contribution of increasing education to the postponement of fertility in three European countries—Britain, France, and Belgium—have reported that the joint effects of enrollment and post-education are mainly responsible for the rise in the mean age at first birth (Ní Bhrolcháin and Beaujouan (2012), Neels et al, forthcoming). However, another set of studies have reported results which point in the opposite direction (Rindfuss et al., 1996; Rendall et al., 2010). Our results support the second perspective, as they indicate that educational expansion explains only a modest fraction of the total delay in marriage/parenthood.

1.3 Unemployment

The relatively recent emergence of new evidence suggesting that there is a sign shift in the longstanding negative correlation between prosperity and fertility levels has sparked a renewed interest in explaining the relationship between economic constraints and fertility decisions. Understanding this relationship is particularly relevant to explain current and future fertility trends in southern European countries, which combine relatively weaker economic indicators with the lowest fertility levels and the highest mean ages at first birth.

Until now, the most consistent evidence of a depressing effect has been found using aggregate unemployment rates (Gutiérrez-Domènech, 2008; Adsera, 2011; Kravdal, 2002), although analyses using individual-level data have also found significant effects in the same direction. De la Rica and Iza (2005) argued, for example, that the labor market reform that introduced flexible employment contracts in 1984 is one of the main reasons why the ages at first birth in Spain are among the highest in Europe. Blossfeld et al. (2005) provided extensive macro- and micro-level evidence that economic uncertainty negatively affects the family formation process, especially among men in male-breadwinner societies with weaker welfare systems.

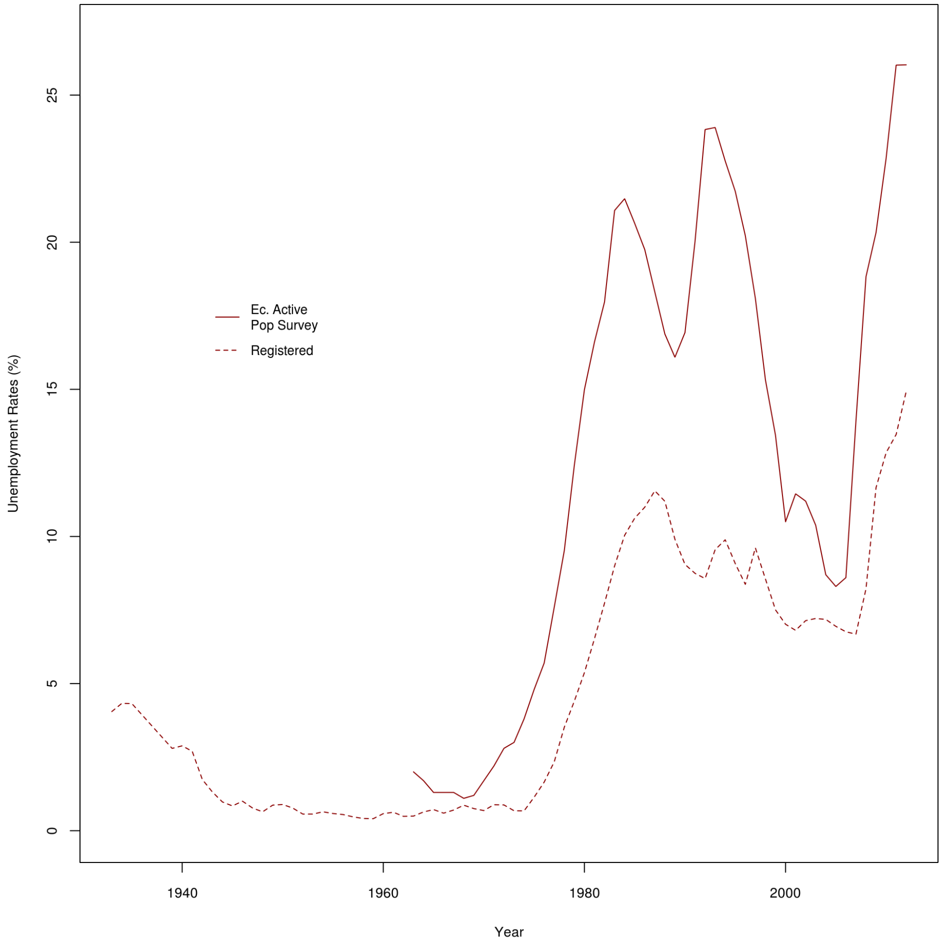
However, the considerable diversity of the institutional settings studied and the difficulties to distinguish between income and substitution effects partially explains the ambiguity of some of the results found in the literature, as well as the relative frequency of studies reporting no effects of unemployment on fertility behaviors (Kravdal, 2002; Kreyenfeld, 2010; Ozcan et al., 2010).

A potentially fruitful approach for disentangling income from substitution effects would be to establish a distinction between women in traditional male-breadwinner arrangements and women in dual-earner households. Unfortunately, the information needed to make this distinction is often missing from surveys, and only a few studies have provided results accounting for the employment status of both members of each couple. These exceptions confirm the assumption that substitution effects prevail when women are caregivers (exclusively), while unemployment tends to depress or delay fertility when both members of the household work (Vignoli et al., 2012; Baizán, 2006).

In spite of these limitations, a few studies have provided an approximate idea of the size and direction of the effect of unemployment on the transition to parenthood. Pailhé and Solaz (2012) for example, estimated that unemployment reduced the risk of having a first birth by about 25% among French men. Among French women, they found that having a fixed-term contract reduced the risk by about 20%. Using German Panel data from 1984–2004, Kreyenfeld (2005) estimated that unemployment was associated with a 60% reduction in the risk of having a first birth, but only among highly educated women. Looking at Spanish data in the period 1994–2001, Baizán (2006) found that the effect of unemployment was associated with a 40% reduction in the risk of having a first birth among unemployed women with an employed partner. We consider these estimates when defining the parameter range for unemployment in section 3.5.

Since unemployment is one of the key dimensions of our model, we concentrated our efforts on reconstructing the historical series of unemployment rates in Spain (Figure 1). The shortest series corresponds to the unemployment rates computed from the information provided by the Economically Active Population Survey, which is considered the most reliable source for labor market indicators, including unemployment rates. The second series shows the figures obtained from the official employment offices. Although it covers a longer period of time, this indicator only consider workers in the formal economy, which could lead to an underestimation of the unemployment rates. The other crucial difference between the two indicators is that the registered unemployment rate is computed over the working-age population (16–64); whereas the EAPS rate considers only the economically active population, and thus provides higher estimates. However, our goal in presenting both series is not to highlight their differences, but to show that Spain seems to have enjoyed a period of very low unemployment rates until the 1970s, when unemployment rates increased dramatically, coinciding with the increase in the MAFB presented in Figure 2.

Figure 1: Unemployment Rates, Spain 1933 -2012 | Registered and Measured by the Economically Active Population Survey.



Sources: Registered Unemployment – Statistical Yearbooks of Spain , National Statistical Institute.
Working-Age Population – Spanish Censuses 1930 to 2011.
EAPS 1960-1978 – "Estadísticas Historicas de España" (Book).
EAPS 1979 - 2013 – National Statistics Institute

1.4 Social Influence

Social interaction became a mainstream concept in demography after diffusion theories placed the spread of information and attitudes through social networks at the center of explanations of fertility decline. In “pure” diffusion models, social interaction is the main driver of fertility, with a dynamic that is independent of other structural forces; while in “blended" models, fertility change responds to changes in material conditions which are amplified by the effect of social interaction (Cleland, 2001).

Casterline (2001) has argued that the initial attempts to incorporate the notion of diffusion into fertility theories were based on an eminently practical goal: namely, the acceleration of the spread of contraceptive techniques in developing countries. This might explain why birth control has been the main focus of most of the empirical applications of diffusion models (Montgomery and Casterline, 1993; Rosero-Bixby and Casterline, 1993; Entwisle et al., 1996; Kohler, 1997; Kohler et al., 2001; Munshi and Myaux, 2006)

The most recent wave of studies on social interaction and fertility have relied on the availability of detailed datasets and new methods to empirically analyze the role of social networks in family formation decisions (Diaz et al. (2011); Balbo and Barban (2014); Mathews and Sear (2013); Balbo and Mills (2011); Lyngstad and Prskawetz (2010), among others). These studies focused less on fertility *change* and more on of the question of how family and friends influence fertility attitudes and behaviors in the transition to parenthood. They defined the mechanism by which interaction affects behavior, either as *social learning*, a self-initiated process through which agents obtain information and knowledge from others; or as *social influence*, a process through which other people and their behaviors exert pressure and control over the individual.

Beyond the specific mechanisms, social interaction has different potential implications for dynamic models of fertility change. Of those proposed by Kohler et al. (2002) two are particularly relevant in the current analysis, given how we specify these effects in our model: *social multiplier effects* or *social feedback mechanisms*, and *status quo enforcement*.

Social feedback is the process through which social interaction increases the pace or the extent of the original change in fertility behavior triggered by socioeconomic changes. In this case, imitation or the increase/release of social pressure generates an effect that can become independent of the initial change in material conditions.

Status quo enforcement refers to the resistance that social norms exert on innovative behavior. As was already mentioned, there has been little empirical analysis of this dimension (for an exception, see Munshi and Myaux (2006)). We emphasize this point because, as we will try to show in the remainder of this article, the degree to which values and norms are resistant to change could be one of the most important dimensions determining the pace and the extent of fertility change.

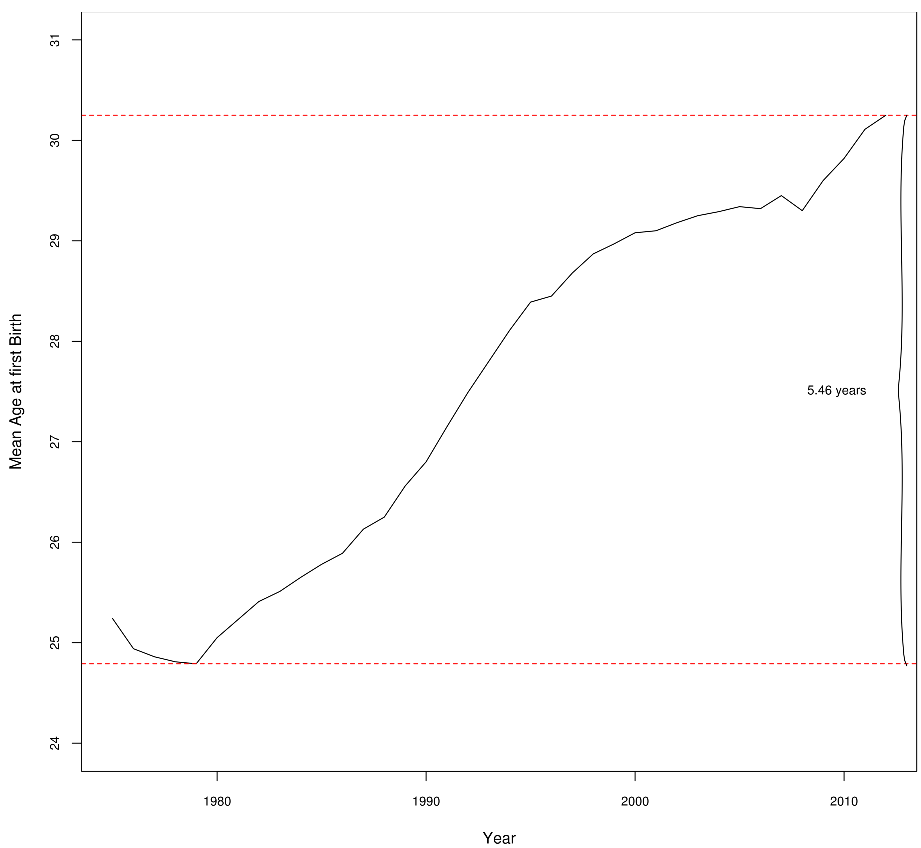
2 Model Target and Objectives

The main objective of our model is to reproduce the evolution of the mean age at first birth and the evolution of the schedule of age-specific fertility rates, which for Spain is available only from 1975 onward.

Although most European countries registered significant postponements in the MAFB in the last decades of the 20^{th}century, in Spain the increase was particularly intense. As we can see in Figure 2, the median age increased by about five years over the observed period.

An initial exploration of the curve suggests the presence of unemployment as a relevant factor in the shaping of this trend: a similarly steep increase until the mid 90s, a deceleration thereafter and up to the end of the first decade of the 21^{st} century, and another peak coinciding with the most recent economic crisis.

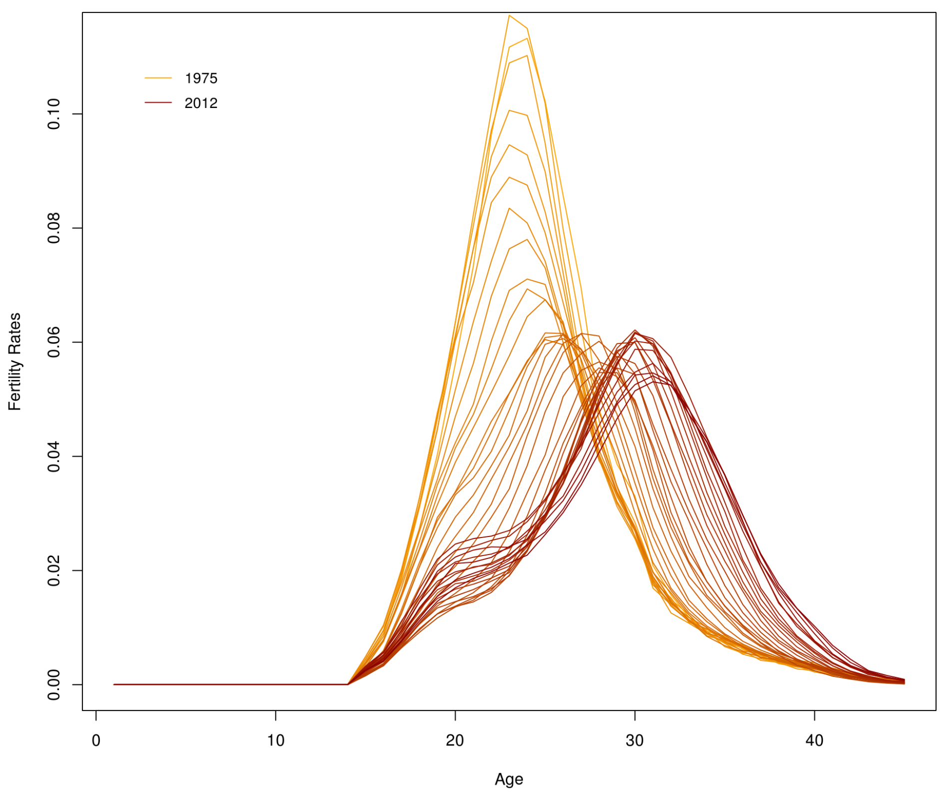
Figure 2: Mean Age at First Birth Spain, 1975-2103



Source: National Statistics Institute of Spain

Figure 3 provides more information about the nature of this change. The evolution of the age-specific fertility rates shows that the increase in the mean age shown in Figure 2 has been the result of a reduction in fertility rates at younger ages, but also of the increase in births at older ages. From 1975 to 2012 the peak of the distribution has shifted from around age 23 to age 30. It is also interesting to note the resistance to change of adolescent fertility rates, which prevented the mean age at the transition to motherhood by the end of the period from being even higher.

Figure 3: Age Specific Fertility Rates | Spain, 1975-2012



Source: National Statistics Institute

We also intend to provide an estimation of the contribution of each of the factors included in the model (expansion of education, unemployment, and social influence) to the rise in the mean age at first birth.

In addition, we would like to contribute to the analysis of the dynamics of the relationship between preferences and observed demographic behaviors, which is one of the most powerful explanatory forces in our model.

3 Model Layout

In response to rising economic uncertainty and increased opportunity costs associated with higher education, couples in Spain start postponing marrying and having children. As the reduction in the numbers of marriages and births due to these rapid socioeconomic changes leads to a lessening of the pressure to conform to an early family formation standard, and as young men and women start imitating the behavior of their peers, the timing of family formation is pushed even further. People's beliefs about the ideal age for marriage and for becoming a mother are slower to change, but after a period of initial resistance these ideas start shifting as well, and the pace of normative change catches up with that of observed behavior. However, the new ideal does not increase indefinitely, after a certain age cultural and biological limits impose a ceiling, pushing individuals to negotiate the opposing forces of their more immediate material conditions and the pressure to conform.

In other words, using an agent-based model, we show that the change in the mean age at first birth in Spain resulted from compositional changes in the population with respect to education, the increase in unemployment, and the multiplier effect of social interaction. These two last effects directly affect the age- and education-specific probabilities of each agent of marrying and of having a first child. The joint effect of the changes in socioeconomic incentives and social interaction alters social ideals regarding the timing of childbearing, and that movement in turn feeds back to the individual level, acting as a baseline over which the new effects of economic uncertainty and education operate.

Our simulation runs for 70 years, from 1943 until 2013, and we base our simulations on Spanish data (more details about the data are provided in Sec. 4). The ages of the initial population are randomly assigned according to the female population structure of Spain from the 1940 census. Starting the simulation in 1943 ensures that all of the women of reproductive ages (15+) will be out of their reproductive period when our analysis of the MAFB begins (see Section 3.2).

The model contains five procedures for agents which are carried out at each time step: aging, partnership formation, reproduction, entry into/exit from the labor market, and the building of a network. Each time step (or iteration) corresponds to one year. At every new iteration the agents age, and they may die off according to the corresponding age- and year-specific mortality rates. As they enter the simulation, the agents are assigned the final educational level they will achieve: primary, secondary, or tertiary. At age 15, an individual becomes an adult who can find a partner (marriage or cohabitation), who might reproduce, and who builds her own social network by choosing a number of ν contacts from a larger pool of potential friends based on their social distance with respect to education. At age 16 the agents join the labor market. The agents do not remain in the simulation beyond age 45.

Although the population is exclusively composed of females agents, we also model the key attributes of their partners and potential partners. To that end, the attributes of the partners are treated as additional attributes of the female agents, as shown in Table 1. Table 2 summarizes the global variables used in the simulation.

Table 1: Agents' Caracteristics

Agent Variables	Variable Name	Values
Identity number	*id*	1, 2, ...
Age	*x*	0–45
Age partner	*xp*	15–60
Age at first birth	*xb*	15–45
Education level	*edu*	1: "primary" 2: "secondary" 3: "tertiary"
Marital status	*ms*	0: "single" 1: "married/cohabitation"
Employment status	*es*	0: "agent employed" 1: "agent unemployed"
Employment status partner	*esp*	0: "partner employed" 1: "partner unemployed"
Network	*net*	1, 2, ...

Table 2: Global Variables

Global Parameters	Parameter Name	Value
Starting year	*iniYear*	1943
Final year	*finYear*	2012
Sex ratio at birth	*SRB*	0.515
Minimum age at birth	*minAge*	15
Maximum age at birth	*maxAge*	45
Unemployment prevalence	σ	0–0.99
Average network size	ν	15–25
Fertility rate for parity 1+	*f2*	0–0.99

3.1 Union and Fertility Rates

We estimate the original union and fertility rates using the multistate model presented in Figure 4. The model resembles the classic illness-death model without recovery used in medical research. All of the individuals start at stage 0-*Single Without Children*, and have the potential to stay in this state or to move to either state 1-*Union*, or to the absorbing state 2-*First Child*. After reaching state 1, individuals can either stay or leave the state to enter state 2. Each of these transitions is governed by a cause-specific hazard *h(t)* from which we obtain the Nelson-Aalen estimators of the cumulative hazard for each event.

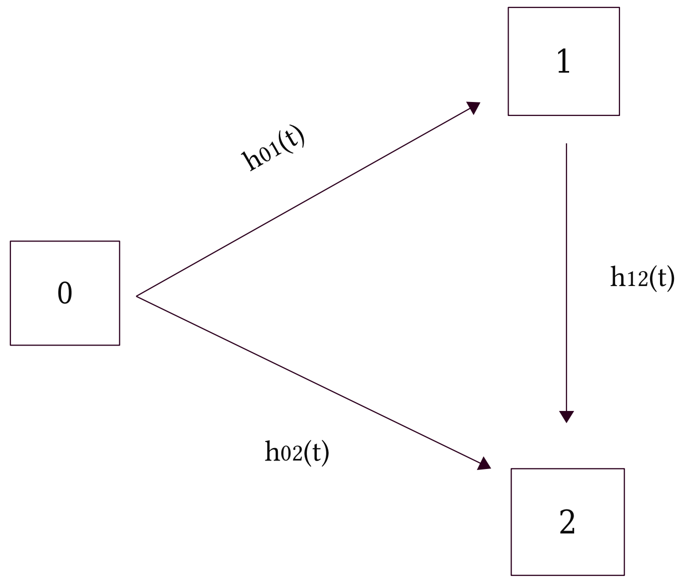
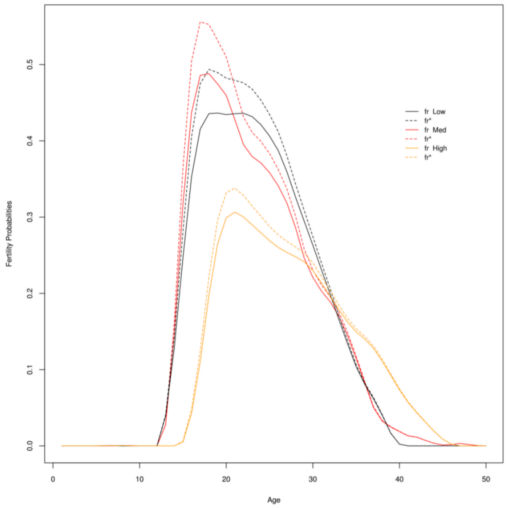


Figure 4: Multistate Model | Single without Children (0), Union (1), First Child (2) .

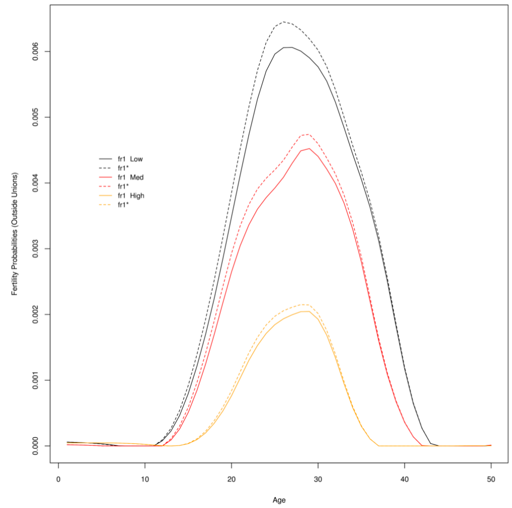
From the estimators of the cumulative hazard, we derive the sets of age- and education-specific fertility probabilities for a first birth $f(x, edu)$, fertility probabilities for a first birth outside of a union $f1(x, edu)$, and union probabilities $u(x, edu)$. These sets of probabilities represent both the observed and the intended fertility behaviors at the beginning of our period of interest, as, for the sake of simplicity, we assume that behaviors and intentions are in equilibrium at that time. They act as the baseline over which the effects of unemployment and local social influence operate. For parity one or higher, the fertility rate is $f2$ for all individuals.[2]

[2]As we model the effect of labor market exits exogenously, we need a set of initial probabilities that is net of the effect of unemployment to avoid an overestimation of this effect. Unfortunately, as the dataset we use for the estimation of the original probabilities does not contain information on the employment histories of the interviewees, we have to provide a rough estimate of the effect of unemployment. As we will show in Section 2.4, Spain did not register high levels of unemployment until the mid 1980s, which means that the effect of unemployment on our cohorts born in 1940–1960 would have been relatively mild. We assume a decreasing effect by age: the final probabilities are about 15% higher than the original at age 15, only about 5% at age 30, and about the same by the end of the reproductive period at age 45; as shown in Figure 5.

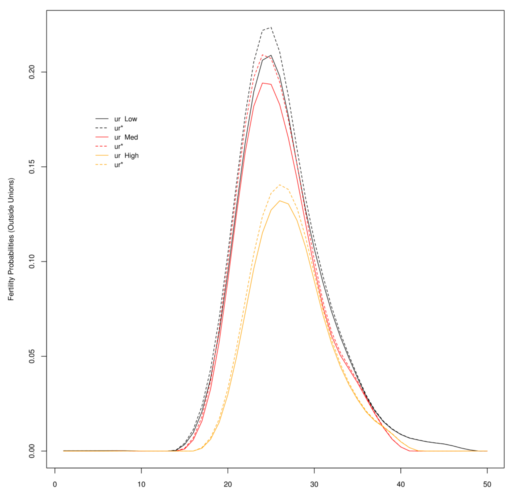
Figure 5: Age and Education-Specific Probabilities from Multistate Model | Cohorts 1940-1960, Spain



(a) Fertility Probabilities



(b) Fert Probs Outside Unions



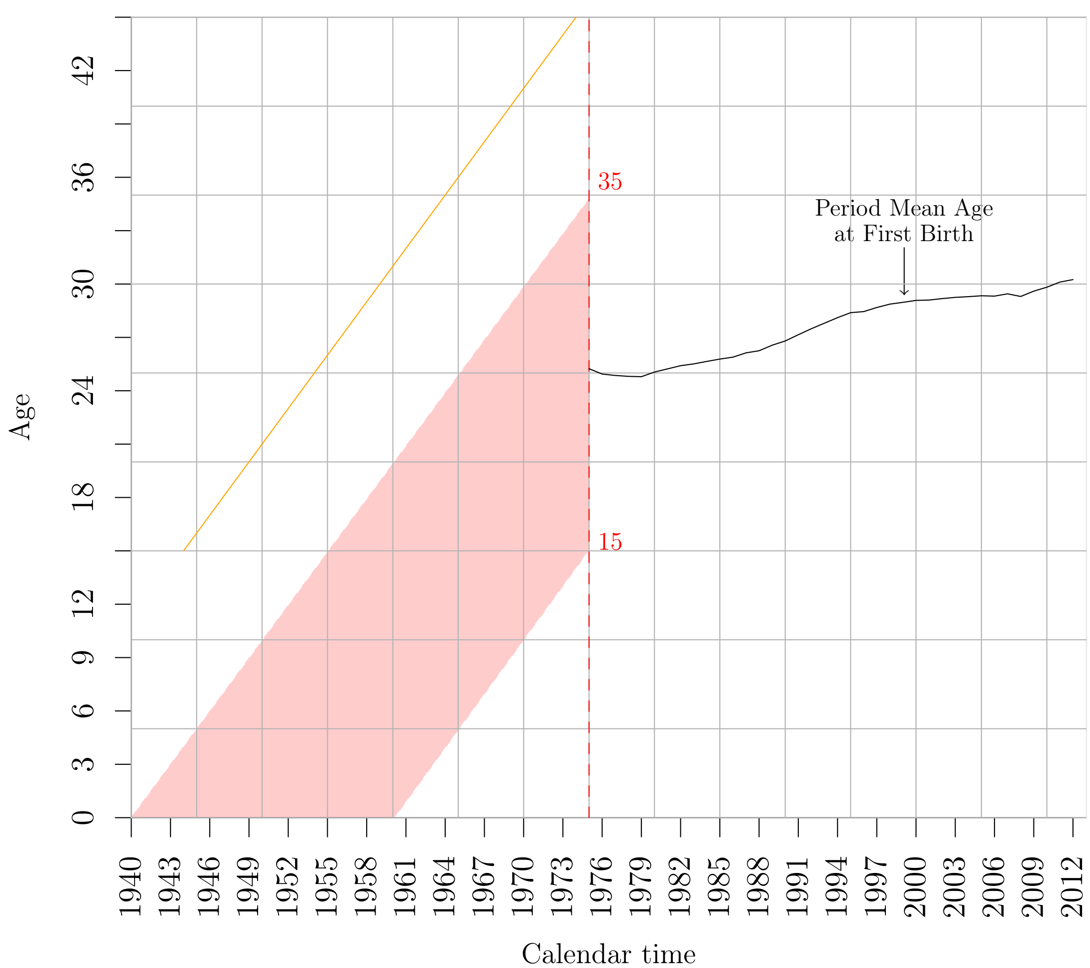
(c) Union Probabilities

3.2 Modelling Period Measures From Cohort Data

These observed fertility and union rates correspond to the cohorts of females born between 1940 and 1960. We restrict our sample to this period for two reasons. First, we want to avoid mixing a large number of cohorts with different labor market and educational experiences. Second, because the fertility schedules of these cohorts shaped the period mean ages at first birth in the mid-1970s, before the beginning of the increase we are trying to model. Figure 6 shows these dynamics.

For the computation of the MAFB, we need all of the agents considered to be exposed to the entire set of intensities presented in Figure 5. Hence, starting the simulation in 1943 ensures that all of the women of reproductive ages (orange line in fig 6) are older than 45 years before we start the computation of the simulated MAFB in 1975. Moreover, this initialization procedure (1943–1974) prevents us from assigning an initial parity to the agents and an age at first birth to those with parity one or higher, as doing so could affect the resulting MAFB.

Figure 6



3.3 Age of Partners

When an agent enters a union, a random age and the corresponding age-specific unemployment rate are assigned to her partner. The age is obtained from a normal truncated distribution, using the age of the agent plus two years as the mean value:

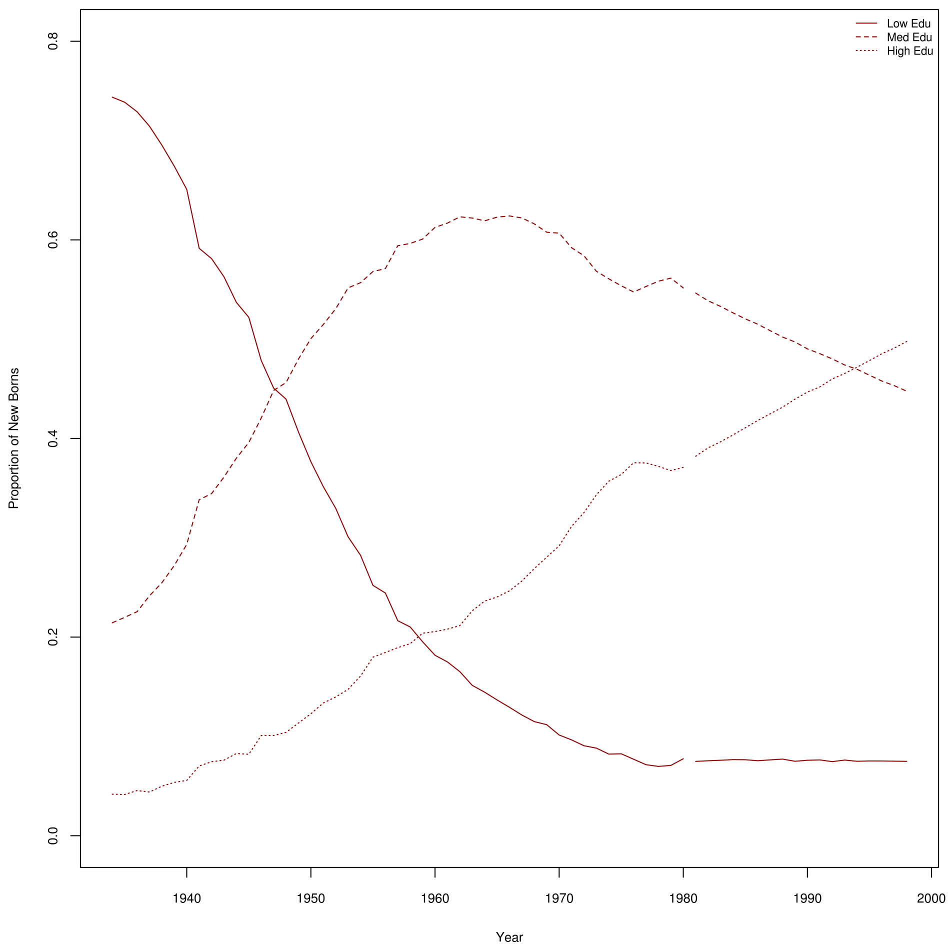
$$xp_i \sim N_{a \leq xp_i \leq b}(x_i + 2, 1) \quad (1)$$

where $a = x_i - 4$ and $b = x_i + 8$.

3.4 Evolution of Educational Attainment

The expansion of tertiary education among women is one the most impressive social changes which occurred in Spain in the 20th century: the share of women who completed tertiary education rose from 5% of those born in the late 1930s, to one-third of those born in the 1970s, to around 45% of the more recent cohorts (Castro-Martín & Martín-García, 2014).

Figure 7: Observed and Predicted Proportion of New Borns by Achieved Education level | Females, Spain.



Source: 2011 Spanish Census, National Statistics Institute

As shown in Figure 7,since the late 1930s the proportion of female newborns who will achieve tertiary education has been increasing almost linearly. The 2011 census provides reliable figures for the generations born up to 1980; after that point 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%).

In our model, education is defined according to the three levels mentioned above, which correspond to the number of years of formal schooling: fewer than six (*primary*), from six to 13 (*secondary*), and more than 13 (*tertiary*). Each year we assign the newborns in our model a level of education matching the proportions that each of these levels represent in the total female population, as shown in Figure 7.

3.5 Unemployment Effects

Starting from the observed unemployment rates, we obtain the proportion of the population who were unemployed in each year of our simulation, by age group and sex. From these series we then model the exits from and entries into the labor market, while assuming that a proportion σ of those who were unemployed in the previous year will stay in that state.

We assume that unemployment affects an individual's decisions about whether and when to enter into a union and to have a first child, both within and outside a union. The strength of this effect depends on the employment status ec_i of the couple, with three different scenarios: 1) the agent is unemployed, $es_i = 1, esp_i = 0$; 2) her partner is unemployed, $es_1 = 0, esp_i = 1$; and 3) both members of the couple are outside the labor market, $es_i = esp_i = 1$. In practice, that means that the original fertility and union rates of each agent i are modified by an unemployment multiplier um_i defined as

$$um_i = \frac{1}{1 + \exp(-0.1(x_i - \alpha_{ec_i}))} \tag{2}$$

where x_i is the age of the agent, and the α parameter (which depends on the employment status of the couple, ec_i) determines the strength of the effect. Figure 8 shows the unemployment multiplier over the union rates $u_t(x, edu)$ for the different combinations of the employment status of both members of the couple. These sets of α values are the ones we used in our final model in section 5.1, which provides a good fit for our target.

In the three cases the effect is more pronounced at younger ages. For instance, for those couples in which only the female partner is unemployed the probability of getting into a cohabiting union or having a first child (after being in a union) is about 80% of the original probability if the female partner is 25 years old, about 65% if the male partner is unemployed, and about 30% if both partners are out of the labor market.

The function of the multiplier for the fertility probabilities is the same, although we assume that the effects to be slightly smaller than the multiplier for the union probabilities. We understand that the decision to form a new household is easier to postpone in response to economic uncertainty than the decision to have children once the union is formed.

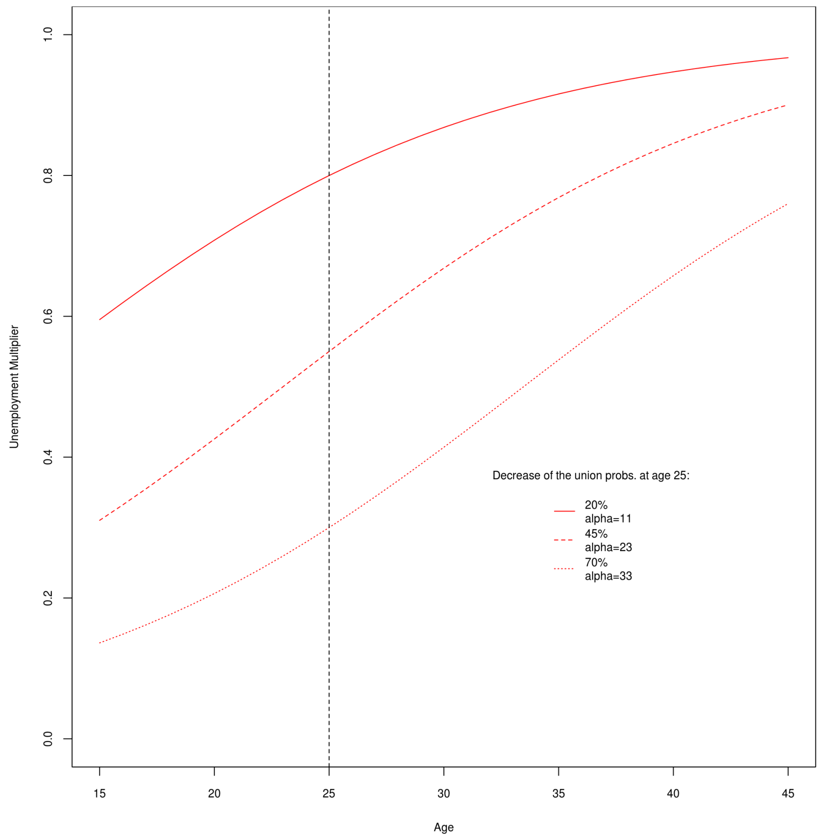


Figure 8: Effects of Unemployment by Age on the Original Fertility and Union Rates

3.6 Local Social Influence Effects

In the model, the agents do not base their decisions about the timing of marriage/cohabitation and the transition to parenthood exclusively on their immediate material conditions (unemployment) and their perceived opportunities (education); they are also influenced by their network of peers. As the decisions of the members of a given agent's network are themselves determined by the labor market conditions and their education, the strength and the direction of the influence the network exerts will be shaped by its members' material conditions and their perceived future opportunities. In other words, a social feedback mechanism is triggered by a change in these conditions, which in turn reinforces and amplifies the original effect.

As was previously mentioned, at age 15 each agent forms a network composed of a maximum of ν members the same age as the agent of reference. The agents choose these contacts from a pool of potential friends based on their similarity with respect to education. Thus, the social distance between two agents i and k is defined as

$$sd_{ik} = \exp(-\theta(edu_i - edu_k + 1)^2) \tag{3}$$

where edu_i and edu_k are the respective educational levels, and θ a parameter that controls the level of educational homophily in the agent's network.

The social influence si that an agent i of age x receives from her network is based on the distance between the proportion of members in her network who are already mothers ρ_i, and the average proportion of mothers of age $x = x_i$ in all of the networks in the absence of unemployment and educational change ρ^*_x.

$$si_i = \begin{cases} \dfrac{0.7}{1 + \exp(-0.7(x_i - \frac{\gamma}{1+\rho_i-\rho^*_x}))} + 1, & \text{if } \rho_i - \rho^*_x > 0.05 \\ 1, & \text{if } |\rho_i - \rho^*_x| \leq 0.05 \\ \dfrac{1}{1 + \exp(-0.05(x_i - \frac{\gamma}{1+\rho_i-\rho^*_x}))}, & \text{if } \rho_i - \rho^*_x < -0.05 \end{cases} \tag{4}$$

For the transition to marriage/cohabitation, the social influence function works in a similar way, although instead of considering the proportion of mothers in the network we use the proportion of members of the network who were already married/cohabiting π_i, and the proportion of agents of age $x = x_i$ who were already married/cohabiting in all of the networks in the absence of unemployment and educational change π^*_x. In both cases the strength of the effect is given by γ.

ρ^*_x and π^*_x are obtained after allowing agents to experience the hypothetical transition (marriage and childbirth) using baseline probabilities *before* the application of the effects of unemployment and social influence. The effect of education is also removed by assigning agents the distribution of educational attainment of the previous generation (10 years before). From these transitions we compute the hypothetical proportions of females who were married/cohabiting by age (π^*_x), and the hypothetical proportion of mothers by age (ρ^*_x) who would have existed in the agents' networks if the original fertility and partnership schedules had not been disturbed by changes in the labor market and the composition of the population by education.

When the difference between ρ^*_x and ρ_i or π^*_x and π_i exceeds the 5% threshold, the social influence multiplier either augments ($\rho^*_x < \rho_i$, $\pi^*_x < \pi_i$) or reduces ($\rho^*_x > \rho_i$, $\pi^*_x > \pi_i$) the original rates

$u_t(x, edu)$ and $f_t(x, edu)$. If the absolute difference is less than 5%, the social influence has no effect. Figure 9 illustrates the effect for a set of γ values that offer a good model fit (see Section 5.1).

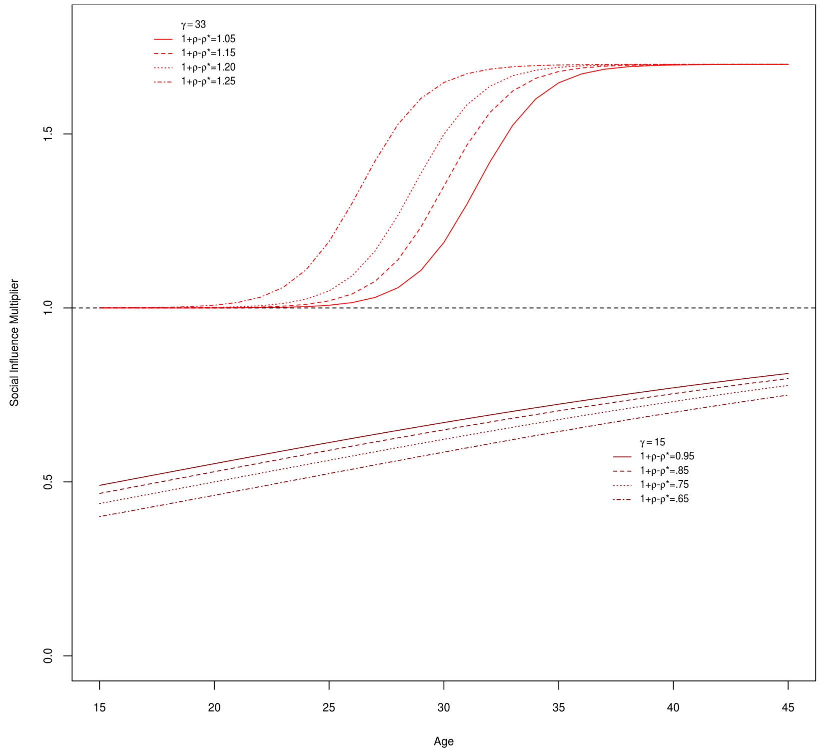


Figure 9: Social Influence by Age

We understand the decision regarding the timing of family formation as the product of a series of influences, from the closer social network, to biology, to the prevalent ideas among the larger social collective about the "appropriate" time to process such events. We assume that an agent's decisions become progressively independent of the behavior of her peers as she approaches the upper limit of the family formation period, and other influences become stronger. Hence, we model a decreasing negative effect of social interaction with increasing age. Conversely, we assume that the positive effect will increase with age as it joins other influences (proximity to the biological limit, family influences) in pushing forward the transition to parenthood.

The functions of the positive and negative effects over the probability of marrying or having children are, however, markedly different. The model offers a better fit when the negative influences are more homogeneous by age than the positive influences, which does not occur until after age 25, and reaches its peak 10 years later; as seen in Figure 9.

The parametrization of this effects is not an easy task given the lack of previous empirical references. The values we present here were obtained after several exercises with the calibration of the model. To illustrate, we show that with these parameters the probability of marriage/childbearing for an agent who is 30 years old is 70% of the original if one marriage/mother in her network (assuming the networks have an average size of 20) is lost due to the effect of unemployment and increasing education. To illustrate the positive influence, we show that adding one marriage/mother to the network implies an increase of about 20% of the original rates, also at age 30.

In our model, we interpret this form of local social influence as being a *social multiplier* because, based on the previous definition, it is strictly linked to the changes produced at the level of material conditions.

3.7 Micro-Macro Link

The unemployment and the social influence effects are captured by the individual multipliers um_i and si_i to obtain for each agent i the individual probabilities of union formation u_i^* and of having the first child within marriage f_i^*:

$$u_i^* = u_t(x_i, edu_i) \cdot um_i \cdot si_i \tag{5}$$

and

$$f_i^* = f_t(x_i, edu_i) \cdot um_i \cdot si_i \tag{6}$$

The fertility probabilities of women who have children outside of marriage or cohabitation $f1(x, edu)$ are not affected by unemployment and the local social influence, as given the cultural framework in Spain we assume that this type of event is frequently unplanned, and is therefore less conditioned by labor market or peer behavior considerations.

The effects of unemployment and social influence at the micro level result in a set of modified probabilities of marrying and giving birth at the macro level. The baseline probabilities at $t+1$ are defined as:

$$u_{t+1}(x, edu) = \begin{cases} \dfrac{\overline{u^*}(x, edu)}{\max(\frac{\overline{u^*}(x,edu)}{u_t(x,edu)}, \theta)}, & \text{if } \frac{\overline{u^*}(x,edu)}{u_t(x,edu)} < 1 \\ \\ \overline{u^*}(x, edu), & \text{otherwise} \end{cases} \tag{7}$$

where $\overline{u^*}(x, edu)$ is an *average* by age and educational level of the union probabilities defined in (5). $f_{t+1}(x, edu)$ is computed analogously. These updated probabilities recover the average effects of unemployment and social influence by age and education of the previous year, and they are used to obtain the new baseline for the next time step. As this baseline represents the *desired timing of childbearing*, its value depends on the prevailing mean age at first birth in the population. The dynamics between the *observed* mean age and the *desired* mean age are governed by θ. When the desired mean age is far from the maximum age to which individuals in the population would like to postpone family formation, then θ is closer to one, and all of the effects of um and si are recovered in the new baseline. This means that the desired and the observed mean ages grow at a similar speed. As the desired mean age nears the ceiling imposed by people's preferences, then θ gets closer to zero, and the new baseline does not consider a portion or all of last year's effects as people resist further increases in the ages at marriage and childbirth.

In section 5.2 we show different potential scenarios regarding the dynamics between the observed and the desired timing of family transitions.

4 Data and Tools

Our model could be described as a semi-artificial population model, which is a particular type of agent-based model (ABM). According to Bijak et al. (2013), this kind of model results from the introduction of ABM techniques into a predominantly empirical discipline like demography, and is characterized, precisely, by the combination of empirical and simulated data.

For the computation of the original union and fertility rates, we use the 1991 Sociodemographic Survey. It provides a large representative sample of the Spanish population (age>10), with 159,154 observations.

To obtain the initial age structure of the population we use the 1940 census. 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. Both censuses are from the National Statistical Office of Spain (INE).

The age- and sex-specific mortality rates from 1943 to 2013 were obtained from the Human Mortality Database.

For the reconstruction of the long unemployment series, we made use of various sources. The numbers of people who were registered as unemployed came from the Statistical Yearbooks of Spain published by the National Statistical Institute. We also used an interpolation of the censuses from 1930 to 2011 to obtain the number of working-age individuals. The EAPS series 1960-1978 came from the book "Estadísticas Historicas de España". Finally, the series for the period 1979-2013 came from the National Statistics Institute of Spain.

Simulations were run in Netlogo and R using the RNetlogo extension (Thiele et al., 2012). To obtain the estimates from the multistate model we used the `survival` (Therneau, 1999) and the `mvna` (Allignol et al., 2008) packages.

5 Results

We begin this section by introducing the non-linear model described before, calibrated to fit the evolution of the mean age at childbirth and the distribution of age-specific fertility rates. In a second step, we provide some examples from linear specifications to illustrate the role of the threshold and the ceiling defined in our original model. Finally, we try to assess the individual role of each of the components of the model by presenting simulation results in which we alternately remove each of the effects considered.

5.1 Non-linear Model

Figure 10 shows the observed and the simulated MAFB. The parameters for the unemployment and social influence multiplier correspond to the values shown in Figures 8 and 9. This specification closely reproduces the observed trend, especially the steep increase until the mid-1990s.

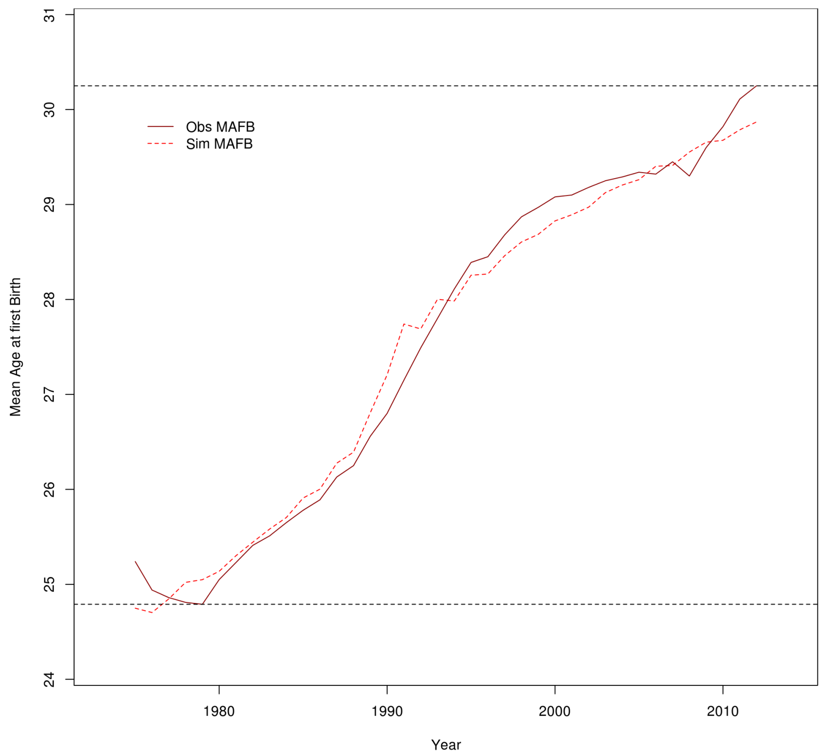


Figure 10: Simulated vs Observed MAFB Spain | Model 1: Educational Change

Although the previous figure gives us an idea of how well the model approximates the data, the real challenge lies in the matching of the evolution of the distribution of ASFRs. As shown in Figure 11, the model also reproduces this trend relatively well, especially the resulting distribution and the shift in the peak to around age 30.

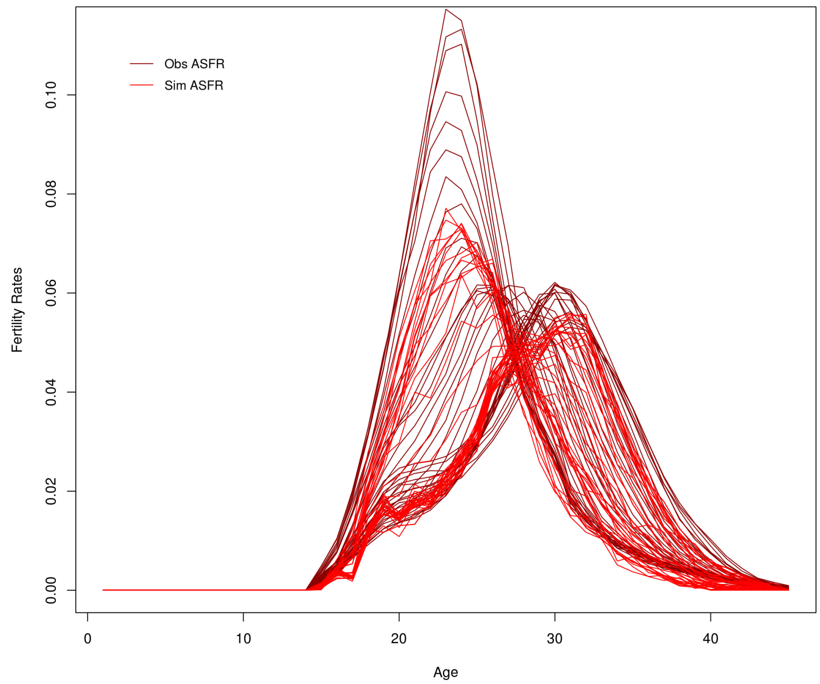


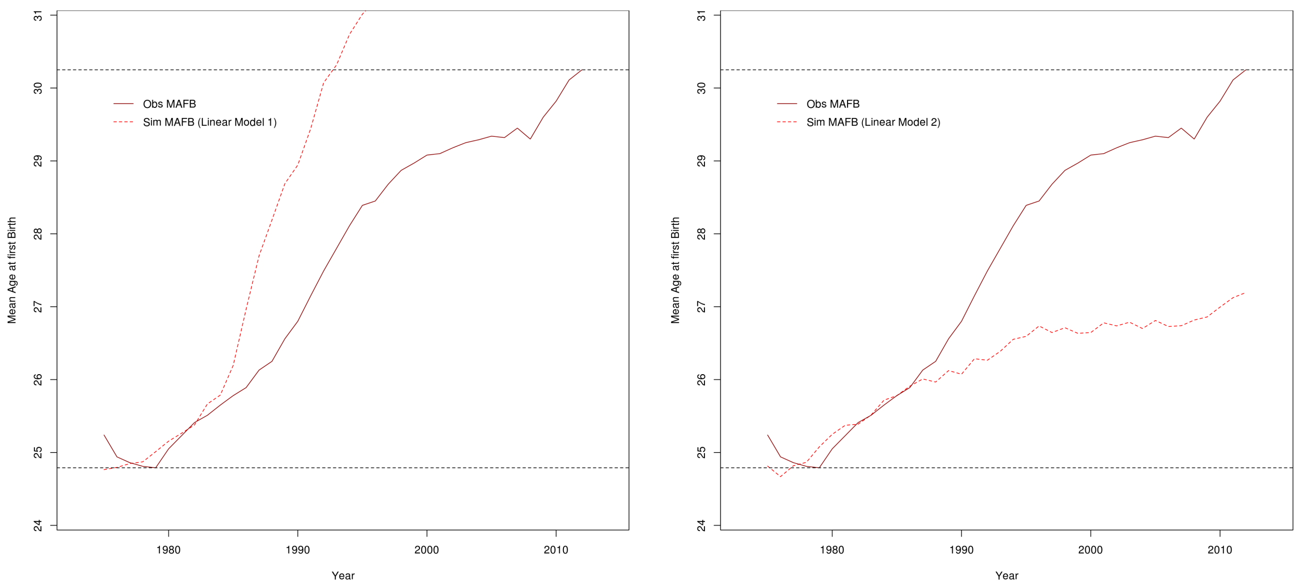
Figure 11: Simulated vs Observed MAFB Spain | Model 1: Educational Change

5.2 Linear Models

In this section we compare our original model with two other linear specifications. As described in Section 3.7, the bridge between the individual and the aggregate level in our model is provided by the influence that age norms regarding marriage and childbearing exert on the agents. Hence, the pace and the shape of fertility change will depend greatly on how these social norms shift in response to changes in behavior. Figure 12 show two different possibilities. In Figure 12a age norms evolve at the same speed as behaviors, as each year individuals adjust their expectations, while taking into account the totality of the information generated in the previous year regarding the material incentives and obstacles to marrying and reproducing, as well as the behavior of their peers ($\theta = 1$). Figure 12b, on the other hand, presents a scenario in which norms are highly resistant to change, and individual preferences defy the most immediate changes in the socioeconomic incentives for marriage and childbearing.

These scenarios result in gross overestimations and underestimations, respectively, of the effects considered. In our original model, we assume that people's preferences are initially resistant to change. This resistance is attributable to both the inertia of cultural norms and the time it takes for information regarding new material incentives to reach and be processed by individual agents. After the change in socioeconomic incentives picks up speed and individuals adapt their expectations, the age norms start to catch up with behaviors, but only until they reach a ceiling imposed by people's beliefs about the upper limit of the ideal age range for marrying or having children.

Figure 12: Observed vs Fitted MAFB, Results from Linear Models | Spain, 1975-2012



(a) Norms = Behavior

(b) Norms < Behavior

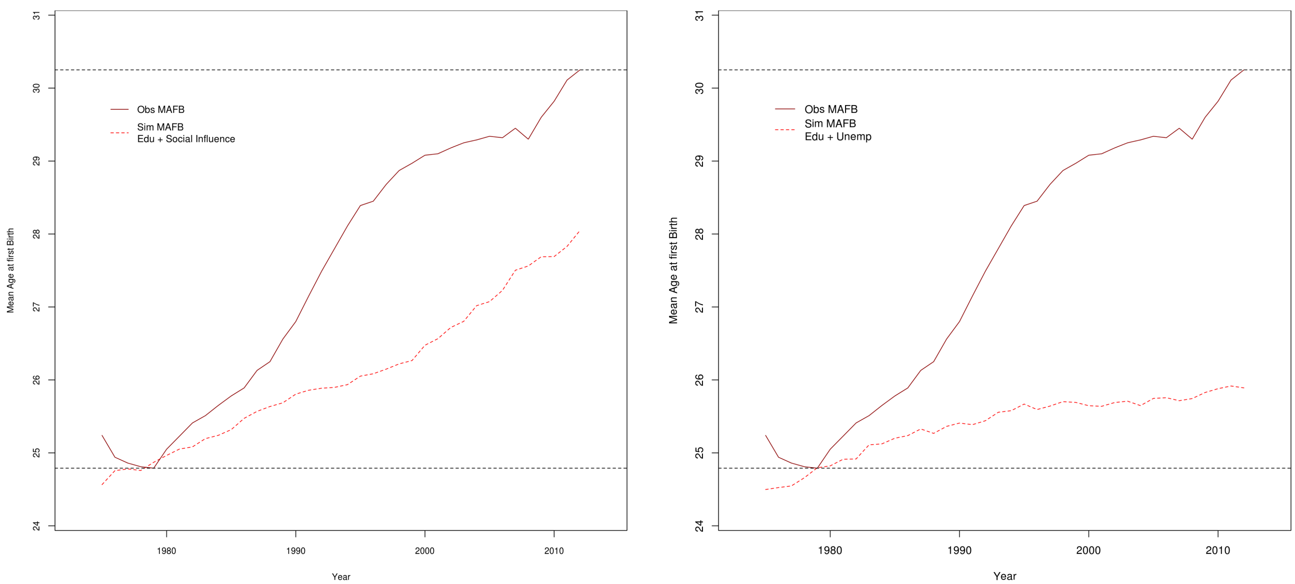
5.3 Net Effects

In this section we present the results of a series of exercises in which we try to isolate the different effects considered in our model. More than providing us with definite answers, we hope that these results will contribute to the discussion about the limitations of this approach when the models include non-linearities, as well as to the discussion about the potential and the limitations of ABMs.

Figure 13 shows the effects of two specifications of the original model: one in which the effect of unemployment is omitted (Figure 13b), and one in which the effects of social influence are omitted (Figure 13a). The first point worth noting is that even though in this case the amplifying effect of social interaction is connected only to the effects of education, its contribution is still quite large. Thus, its *total* contribution to the model (when the effect of unemployment is included) is bigger than we had originally expected. The difference is attributable in part to the fact that while unemployment affects the agent directly and exclusively (20% to 25% of the population in years of high unemployment), the effect of social influence spreads through the networks, reaching most, if not all agents in the population.

The other interesting element is that the difference between the two is amplified by the fact that the model with social influence reaches the threshold, while the model without social influence stays below it. This helps us illustrate the relative futility of trying to isolate effects, and the idea that the pace of the process cannot be explained solely by the measure of the strength of each of its components.

Figure 13: Observed vs Fitted MAFB, Results from Non Linear Models with Omitted Effects | Spain, 1975-2012



(a) Model Without Unemployment

(b) Model Without Local Social Influence

6 Conclusions

We set out to build a model of the postponement of family formation in Spain, and learned a few things in the process. First, we were able to confirm our initial assumption that fertility change cannot be properly described without considering the effect of social interaction. Although the role of social interaction was acknowledged in previous approaches, the novelty of ours is that we considered the influence of both the local level of interaction, or the network; as well as another level which provides the bridge between the collective and the individual through the formation of and reaction to social norms.

As we tried to show, determining the pace at and the extent to which norms change—in this case, age norms related to the timing of family formation transitions—is essential to understanding the pace and the extent of fertility change. However, people's attitudes and values do not change spontaneously; in general, people react to changes in the structure of material opportunities and risks. The formation of people's expectations and preferences is grounded in a series of elements that determine their present and future opportunities. Although we did not directly touch on these elements, we do not intend to treat norms as black boxes. The strength with which people resist further increases in the timing of family formation depends on their expectations about the present and future conditions for childbearing. These conditions include, for example, very concrete elements, like the availability of affordable childbearing and support systems for balancing family and work; as well as on people's perceptions of the present and future dynamics of the labor market.

The inclusion of non-linearities in our model, like thresholds and ceilings, was fundamental to gaining an understanding of the process we set out to explore. One of the most important conclusions we derived from our results was already present in the models which pioneered agent-based techniques: i.e., that most complex social phenomena cannot be understood by the aggregation of each of their individual components (Schelling, 1971).

Another lesson we learned in this process was that local level of social interaction can be more relevant than we had originally expected. The ability of networks to amplify and spread a particular effect was particularly visible in our model when we compared the influence of networks to other factors which affect individuals directly. In other words, the amplifying effect of social feedback mechanisms can easily surpass the original effect that triggered it.

Nevertheless, we also believe that for most of the questions we explored here, we are still at the stage of analyzing dynamics and mechanisms, and less ready to provide exact magnitudes. We found, for example, that the pressure to marry/have children does not emerge until after a certain age, and that this pressure is more concentrated than the one exerted by the factors which might encourage the postponement of these transitions.

Researchers who specialize in a particular dimension of our model may find some of our choices too simplistic. Although we were tempted to keep incorporating heterogeneity and complexity into our model, we believe we are currently hitting the limit of *required complexity*, and that each additional layer could easily take us beyond that critical point where more becomes less.

Nonetheless, there are a few elements which may be interesting to explore in the future using this or a similar model.

Instead of having a stable effect, it is likely that the role of economic uncertainty changed over time as the composition of dual-earner households significantly increased in the period analyzed. We think that modeling the changing role of women with regard to paid and unpaid work could shed additional light on our conclusions.

In addition, it could be relevant to explore a more sophisticated version of the effects of economic uncertainty, including for example, the role of precarious forms of employment or the indirect effects of aggregate dynamics on individual decisions. The indirect effects that economic crises or high unemployment levels may have on the expectations of agents who are not directly affected could be easily incorporated using ABMs.

The classic schema of the innovators versus the followers of demographic change could also be tested by modeling different thresholds and ceilings (resistance and limits of normative change) for different subgroups of the population.

Finally, as we consider the future, we believe that the forces which have been pushing the timing of family formation will continue moving in the same direction, at least in the medium term. There is room for further educational expansion in Spain, and a high degree of economic uncertainty is likely to be a feature of people's lives in the near future. Thus, how fertility trends develop depends on whether people's preferences are strong enough to offset to these forces. But then again, these preferences do not represent an abstract, independent force. The direction the elements that shape these preferences take in the future will certainly shape the ongoing development of the timing of family formation in Spain.

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