Fertility choice in a lifecycle model with idiosyncratic uninsurable earnings risk

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Abstract
This paper studies the determinants of fertility choice in a lifecycle model with idiosyncratic labor market risk and fertility choices. In the spirit of Becker (1960), I model children as a durable consumption good that requires ongoing maintenance. Households make sequential fertility decisions and choose how much to consume and save. I study the impact of changes in uninsurable earnings risk on completed household fertility and the timing of births. I find that young households tend to postpone (or abandon) raising children when income uncertainty is high, preferring to accumulate more precautionary savings before starting a family. Using the estimates of changes in individual earnings uncertainty from Meghir and Pistaferri (2004), the model can account very well for the evolution of total fertility rate (TFR) and mean age at birth in the United States over the last thirty years. The predictions of the model are also broadly consistent with the evolution of fertility in many other OECD countries and in countries from the Central and Eastern Europe during the economic transformation.

1 Introduction
Over the last four decades, the average total fertility rate (TFR) in OECD countries has fallen dramatically: from 2.9 in 1960s to 2.0 in 1975 and then to 1.6 in 2000. With a notable exception of the U.S., all advanced economies now have fertility rates which are well below the level necessary for population replacement (TFR 2.1). A characteristic feature of this fertility decline is that it has been accompanied by a delay in childbearing: the average age at first birth in OECD countries has increased from 24.0 in 1970 to 27.0 in 2000.1 According to Roland Pressat, a prominent French demographer, European “populations are postponing their first birth to such extent that it can be considered unlikely that any ‘recovery’ of fertility at older ages would fully compensate for the

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1For the non-availability of data on mean age at first birth, the following OECD have been excluded from the computation of the OECD average: Australia, New Zealand, Mexico, Korea and Turkey.
Figure 1: TFR and Mean Age at First Birth for EU-15, U.S., and Central and Eastern Europe (CEE)

Notes: CEE average includes the following countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, Slovak Republic and Slovenia. Source: World Bank Database (TFR); Council of Europe, Eurostats and country statistical offices (mean age at first birth).

‘loss’ of the number of children incurred at young age” (Pressat, 1991). Differently put, Pressat suggests that the most recent fertility slump is a direct result of the late start of childbearing.

The observed delay in childbearing has made economists, demographers and sociologists alike ponder about factors behind household decision to postpone fertility. Anecdotal evidence suggests that timing of fertility could be related to the perceived labor income risk. The dramatic decline in TFR (from 2.05 during the 1980s to 1.29 in 2000) – accompanied by increases in mean age at first birth (from 22.9 in the 1980s to 24.4 in 2000) – in former centrally planned economies during the transition to the market economy in the 1990s was associated with large increases in labor market uncertainty, including unemployment risk (Kreyenfeld, 2003), increasing competition and rising earnings volatility brought about by the dissolution of centralized wage-setting. Significant shifts in TFR and mean age at first birth have also been observed in Western Europe and the United States. In the western regions, TFR fell during the 1970s against the background of oil shocks, stop-go macroeconomic policies and rising unemployment (Adsera, 2005) which all contributed to higher earnings risk. The experiences of the U.S. and Europe have, however, differed since the 1990s. In the U.S., TFR increased from 1.8 to above 2.0 while in Europe, TFR remained at low levels of about 1.6. By the late 1990s, TFR in Central and Eastern Europe has also started to gradually recover, hovering between 1.2 and 1.3. In general, the changes in TFR have been accompanied by increases in the age at first birth (Figure 1).

In this paper, I explore the idea that changes in labor market risk affect timing of births and completed fertility. I build a dynamic, partial equilibrium model with idiosyncratic risk and sequential fertility choice in which household fertility decisions can be studied. Following the approach of Becker (1960), I model children as a durable good of irreversible nature which requires
ongoing maintenance. Two key predictions emerge from the model. First, I show that realistic increases in labor market risk can generate quantitatively large increases in mean age at first and second birth. For example, the model predicts that, on average, households in a country with uncertainty levels similar to those measured in the United States give the first birth approximately 4 later than households in an economy with no earnings risk, and their completed (2.3) is lower than that (2.6) in a model in which earnings uncertainty was close to absent. This is because households tend to postpone (or abandon) raising children when income uncertainty is high, preferring to accumulate more precautionary savings before starting a family. Second, the model suggests that – for medium levels of earnings uncertainty (similar to those observed in the U.S.) – the average fertility becomes insensitive to increases in labor income risk. In such an environment the households postpone the birth of the first child but do not give up on having a second or third child. Only for large levels of earnings risk, completed fertility falls below 2.0 in a steady state. This suggests that TFR in Europe could eventually recover to higher levels of about the replacement rate – a trend that has been apparent in some countries during this decade (e.g., Italy, Spain, Czech Republic, former East Germany; although the decline in unemployment rate has certainly also contributed to this outcome).

I organize this paper as follows. In sections 2, I develop a quantitatively rich lifecycle model with discrete, sequential, endogenous fertility choice and idiosyncratic labor market risk. In sections 3 and 4, I summarize the benchmark model and describe model’s calibration. In section 5, I discuss the benchmark profiles. Section 6 describes the extent to which increases in earnings risk affect household fertility decisions and reconciles the model’s predictions with demographic developments in the U.S. and the former centrally planned economies (CEE). Section 7 concludes with a discussion of possible extensions and directions of the future research.

2 The benchmark model

To qualify the impact of the labor market risk on timing of births and average fertility rate, I consider a version of the stochastic lifecycle model with uninsured idiosyncratic risk and no aggregate uncertainty.

The basic set-up of the model mirrors the following assumptions. Young households, which start their lifecycle childless and with zero asset holdings, have a limited access to credit and face idiosyncratic uninsured income shocks. While households enjoy having children, childrearing is quite expensive (as it entails both a monetary- and time cost) and the fertility decision is irreversible.

2 These are equilibrium values of mean age and fertility. It should be noted that this model makes no prediction about changes in fertility rates during the transition from one steady state to another during which total fertility rates can be well below those observed in the new steady state. This is because TFR – defined as the sum of age-specific birth rates over all women alive in a given year – is a mixture of fertility decisions of different birth cohorts. In contrast, completed fertility refers to the total number of children a woman has had during her fertile life. Absent from changes in the birth-specific birth rates, the two measures coincide. However, if fertility rates are changing from cohort to cohort (such a during a transition from an early childbearing to a late childbearing), TFR can be a misleading measure of completed fertility as it provides a downward biased estimate of the actual rate of childrearing (see, for example, Bongaarts (1999) for further discussion).

3 As discussed in Bongaarts (1999), conventional theories have little to say about the level at which fertility will stabilize at the end of a demographic transition. It is often assumed or implied, however, that replacement fertility of about 2.1 births per woman will prevail in the long run. This assumption is, for example, incorporated in past projections of the United Nations and World Bank (medium variants). The model’s predictions are consistent with such long-run assumptions.
Markets which in principle would allow complete insurance do not exist; instead, there is a single risk-free saving instrument which enables households to partially self-insure by accumulating precautionary asset holdings. In the benchmark model, no borrowing is permitted. Households supply labor inelastically as they do not value leisure. Given this market structure, households with positive wealth respond to a fall in household income by temporarily dis-saving as labor supply cannot be adjusted, access to credit is not available, and the existing stock of children is irreducible.

The households go through three lifecycle stages: (i) fertile working, (ii) infertile working, and (iii) retirement. Fertile working-age households enjoy the existing stock of children and – in addition to consumption-saving choices – decide whether to have an additional child next period or not. Households with children also incur childrearing cost. The infertile working-age households continue to enjoy and maintain the existing offsprings but are unable to further extend the family size. The only decision left to the infertile working-age households is consumption-saving. In retirement, children leave home and the households – which now enjoy only their own consumption stream – stop incurring the childrearing cost. The retired households continue to decide how much to save and how much to consume. Retired households also receive pension (in a form of a certain transfer from the government) and die with certainty at period $T$.

The specifics of the model follow.

### 2.1 The demography and endowments

The model economy is inhabited by a continuum of households with identical preferences of their consumption of (i) the nondurable market good and (ii) the durable good – children. Households live $T$ periods with certainty and do not value leisure. During the first $R$ periods of life, household labor earnings are determined according to an idiosyncratic stochastic process

$$\ln y_t = \ln y_0 + h(t) + \epsilon_t + \nu_t, \quad (1)$$

where $h(t)$ govern the average age-profile of earnings, $\nu_t \sim N(0, \sigma^2_\nu)$ is a transitory shock received every period, and $\epsilon_t$ is a persistent shock, also received each period, which follows a first-order autoregression:

$$\epsilon_t = \rho \epsilon_{t-1} + \psi_t \text{ with } \psi_t \sim IID(0, \sigma^2_\epsilon) \text{ and } \epsilon_1 = 0. \quad (2)$$

After period $R$, households retire and receive a pension

$$y_t = b\overline{y}_R \text{ for } t > R, \quad (3)$$

given by a fraction $b$ of household average lifecycle earnings, $\overline{y}_R$. Thus, $b$ is a replacement rate and $\overline{y}_R$ corresponds to indexed average annual earnings.

### 2.2 Preferences

#### 2.2.1 Baseline specification

I model children as a durable good whose maintenance with ongoing maintenance. In other words, I assume that while children are rather expensive, the unitary household is compensated for the utility of consumption foregone to childrearing by deriving services (or a warm glow) from children.
The past empirical studies of the timing of birth (Hotz and Miller, 1988) as well as the standard microanalysis of fertility choices (Becker, 1960) assume that the utility or services which parents receive from existing children depend only on their number. I adopt this specification when modeling utility which households derive from their offsprings.\(^4\)

The expected discounted lifetime utility of a household that values its consumption but also derives utility from its existing stock of children can then be written as

\[
E_0 \sum_{t=1}^{T} \beta^{t-1} U(c_t, n_t),
\]

where \(c\) stands for the household consumption of the nondurable market good, and \(n\) represents the number of children the household has in a given period; \(0 < \beta < 1\) is the discount factor.

As in Becker et al. (1990), Ranjan (1999) or the literature on durable goods (Mankiw, 1985), the utility function is additively separable of the form

\[
U(c_n, n_t) = u(c_t) + w(n_t).
\]

In this model, the households are not altruistic towards their offsprings and, as such, leave no bequest to their children.

In section 4, I describe in detail the choice of the functional form for the utility function \(U(c, n)\) which I adopt when solving the household problem.

2.2.2 The fertility choice

Throughout the lifecycle, households maximize their expected discounted lifetime utility by making a continuous consumption-saving choice. Moreover, during the first \(\tau\) periods (i.e., fertile working part of the lifecycle), conditional on the existing stock of children, households decide whether to have an additional child next period or not. The binary fertility decision is represented by a variable \(K\) (kid): if a household chooses to have an additional child next period, \(K = 1\); if not, \(K = 0\). Therefore, the law of motion for the stock of children can be conveniently expressed as

\[
n_{t+1} = n_t + K_t \text{ where } K_t = \{0, 1\}.
\]

The discrete nature of the fertility decision has implications for the concavity and differentiability of the value function. While the per-period utility \(u(c, n)\) is strictly concave and differentiable in both arguments, the combination of the continuous choice (over savings) and the discrete fertility choice (to have a child or not next period) means that the expected continuation value in the dynamic program will not be necessarily concave or differentiable. The implications of the non-concave and non-differentiable value function for the solution of the household problem will be carefully discussed in Appendix B where I too describe the solution algorithm.

2.3 Cost of children

While households enjoy their offsprings, having children is not a free lunch: childrearing entails both the monetary- and time cost of raising children. The monetary cost represents the cost of

\(^4\)A more realistic utility might depend on the children’s sex, quality and ages, and might possibly admit heterogeneity of preferences. For computational tractability, I abstract from these considerations in the model.
children’s consumption and any other monetary cost connected with childrearing. The time cost can be viewed either as a form of time-tax on household earnings or, alternatively, as a monetary value of childcare services (such as daycare, nurseries and babysitting) which households incur when parents are working.

There have been many attempts to estimate the direct childcare costs (physical care, playing, reading, etc.) and ancillary housework due to children. However, there is a significant variation in the estimates reported by various authors (see, for example, Browning (1992) for review). Given the variability of the estimates, I adopt the latter interpretation of the time cost and assume that the time spent with children represents the monetary cost of childcare services.

To model the total expenditures (including housing, food, healthcare, education and monetary value of childcare services) on children by families, I adopt the framework from Lino (1998) and assume that (i) households spend a constant fraction \( \theta \) of their income per child, (ii) households spend equal amount on each child, and that (iii) there are economies of scale to childrearing. The economies of scale are reflected by a coefficient \( e(n) \) where \( e(\cdot) \) is decreasing in the number of children, \( n \).

Under this specification, the total cost of children to a family with \( n_t \) offsprings is

\[
\theta e(n_t)n_t y_t. \tag{4}
\]

The estimates for the proportionality constant \( \theta \) as well as the estimates for the economies of scale to childrearing, \( e(n) \), come directly from Lino (1998) and I discuss them in detail in section 4. Since the children are expected to leave the household when parents retire, the cost is incurred by working-age households only.

### 2.4 Risk-free asset

There is a single risk-free instrument in the economy which enables households to partially self-insure by accumulating precautionary asset holdings. As noted previously, households start their lifecycle with zero asset holdings.

### 3 The model

Based on a previous discussion, a newly-formed unitary household maximizes

\[
\max_{\{c_t\}_{t=1}^{T}, \{K_t=\{0,1\}\}_{t=1}^{T}} \sum_{t=1}^{R} \beta^{t-1} u(c_t, n_t) + \sum_{t=R+1}^{T} \beta^{t-1} u(c_t, 0) \tag{5}
\]

s.t.

\[
A_{t+1} = \begin{cases} 
(1 + r)(A_t - c_t + (1 - \theta e(n_t)n_t)y_t) & \text{if } t \leq R; \\
(1 + r)(A_t - c_t + by_R) & \text{if } R < t \leq T, 
\end{cases} \tag{6}
\]

\[
A_{t+1} \geq 0, \tag{7}
\]

\[
n_{t+1} = n_t + K_t, \tag{8}
\]

by choosing the household consumption level \( (c) \) and whether to have a child next period \((K = 1)\) or not \((K = 0)\). \( \theta \) represents the fraction of household income spent on a child; \( e(\cdot) \) is the adjustment factor for the economies of scale to childrearing. \( \tau \) determines the last fertile period; \( R \) is the last
period spent in the labor market before the household retires. Equation 8 determines the law of motion for the stock of children and highlights the irreversible nature of the fertility decision.

The rest of the notation is standard: \((1 + r)\) is the gross rate of return on the single asset in the economy; \(y_t\) represents the household labor income. The household labor earnings are subject to uninsurable earnings shocks (where shocks are experienced at the beginning of period before the savings and fertility decisions are made), and follow the process described in section 2.1.

Only working-age households enjoy and pay for children. As discussed in section 2.1, retired households do not face any uncertainty and receive a pension proportional to the household average lifecycle earnings in the last period of the working life. In the benchmark model, no borrowing is allowed.

4 Calibration

To account for the changes in timing of first birth and the fertility rate for families with children, the calibration is constructed to reproduce two statistics from the National Longitudinal Survey of Youth 1979 (NLSY79): the average fertility rate for families with at least one child (2.27) and the mean age of households at first birth (25.09).

To match the target moments, I calibrate two parameters of consumer utility while keeping all other parameters in the model fixed. In the subsections which follow, I discuss the choice for the model economy’s functional forms and I identify the calibrated and exogenous parameters needed to compute the model. Table 1 summarizes the fixed parameters which have been measured directly in the data or come from other studies. Table 2 contains parameters which have been calibrated to statistics in the data. Table 3 contains the moments targeted in the calibration exercise and shows how the model parted with the data. Appendix A briefly describes how I construct the target moments from the data.

<table>
<thead>
<tr>
<th>Table 1: Exogenous parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous parameters</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>Risk aversion (\gamma)</td>
</tr>
<tr>
<td>Gross interest rate (R)</td>
</tr>
<tr>
<td>Discount (\beta = 1/R)</td>
</tr>
<tr>
<td>Child cost (\theta)</td>
</tr>
<tr>
<td>Persistence (\rho)</td>
</tr>
<tr>
<td>St. deviation (transitory) (\sigma_\nu)</td>
</tr>
<tr>
<td>St. deviation (permanent) (\sigma_\epsilon)</td>
</tr>
<tr>
<td>Pension proportionality (b)</td>
</tr>
</tbody>
</table>

This assumption is not central to the model as results do not essentially change if one assumes that households enjoy children even in the retirement.
### Table 2: Calibrated parameters

<table>
<thead>
<tr>
<th>Endogenous parameters (Utility of Children)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale $\psi$</td>
<td>0.36</td>
</tr>
<tr>
<td>Curvature $\kappa$</td>
<td>0.20</td>
</tr>
</tbody>
</table>

### Table 3: Calibration

<table>
<thead>
<tr>
<th>Moment</th>
<th>NLSY79</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>avg. fertility for households with children</td>
<td>2.27</td>
<td>2.27</td>
</tr>
<tr>
<td>avg. age at 1st birth</td>
<td>25.09</td>
<td>25.02</td>
</tr>
</tbody>
</table>

### 4.1 Model periods and earnings process

The model period is one year. Households are born at age 16 ($t = 1$), become infertile at age 41 ($t = 25$) and die with certainty at age 80 ($T = 65$). The retirement age is 65 ($R = 50$). The fertile horizon of the household is based on the fertility cycle of a wife and reflects the fact that most women have completed their fertility by age of 41 in the data.

To parametrize the stochastic components of the idiosyncratic earnings process from section 2.1, values for three parameters are needed. Namely, to summarize the persistent shock to labor earnings, a parameter value for the serial correlation coefficient, $\rho$, and the standard deviation of the innovation term, $\sigma_\epsilon$, must be identified. To describe the transitory shock, a standard deviation of the innovation, $\sigma_\nu$, provides a sufficient statistic.

Various authors have estimated the stochastic process for logged labor earnings in section 2.1 using data from the Panel Study of Income Dynamics (PSID). Controlling for household observable characteristics (such as education or age), work by Card (1991), Hubbard et al. (1995) and Storesletten et al. (1998) indicates a $\rho$ in the range of 0.88 to 0.96, and a $\sigma_\epsilon$ in the range 0.12 to 0.25. In a related work, Meghir and Pistaferri (2004) assume the presence of a unit root and estimate that $\sigma_\epsilon$ has increased from an average value 0.15 in the 1970s to 0.21 in the 1980s. The estimates for $\sigma_\nu$ range between 0.15 and 0.24.

In this paper, I set $\rho$ and $\sigma_\nu$ equal to 0.94 and 0.17 – the values in the middle of the spectrum of the available estimates. Since I calibrate the model to match fertility moments of a cohort of agents which faced relatively high level of persistent risk, I choose $\sigma_\epsilon$ for the benchmark model equal to 0.21 – a value which lies at the upper end of the available estimates.

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6 Extending the fertile horizon of households until the age of 45 does not change the mean age of first and second birth in the model economy, and the completed fertility increases only negligibly.


8 In order to calibrate the model, I use a cohort of agents who were 14-21 years old in 1979 and, hence, made most of their fertility decisions in the 1980s and 1990s. Therefore, my choice for $\sigma_\epsilon$ lies at the upper end of the available estimates, as work by Meghir and Pistaferri (2004) suggests that households in the 1980s faced on average a higher...
To avoid numerical integration, process (1) is implemented as a discrete approximation to the otherwise continuous earnings process. For the transitory shocks, I use i.i.d. two-state Markov chain. The autoregressive process is approximated with 7-state Markov chain with innovations being i.i.d. Transition probabilities are chosen following Tauchen (1986). The process for average age-profile of earnings comes directly from the CPS data. To smooth it, I fit the estimated mean age-profile profile by a cubic polynomial in age.

For retirees, the replacement rate \( b \) is set to 40 percent of average lifecycle earnings as of the last working period, \( y_R \). Munnell and Soto (2005) report that the 1999-2002 median replacement rate for newly retired workers according to both the Health Retirement Survey and Social Security Administration data was about 42 percent of worker's average indexed earnings (higher for earnings-poor individuals and lower for earnings-rich individuals due to the progressivity of the system). On a household basis, Social Security benefits provide an average replacement rate of 44 percent; 58 percent for a couple with a non-working spouse and 41 for couples where both spouses work. Since in this paper, I model a dual-earner households with a perfectly correlated earnings I set the replacement rate, \( b \), equal to 0.4.

### 4.2 Preferences

I model household preferences as additively separable of the form

\[
U(c, n) = c^{\gamma - 1}\frac{1}{\gamma - 1} + \psi n^{1 - \kappa}\frac{1 - \kappa}{\kappa - 1}, \tag{9}
\]

where \( \gamma, \kappa \geq 0 \). Separability is a common assumption in the micro literature of fertility choice (Becker et al. (1990), Ranjan (1999)). Under separability, the curvature on the two variables can be different and changes in the household stock of the durable good – the children – do not effect household marginal utility of nondurable consumption (i.e., \( u_{cn} = 0 \)).

Household preferences for consumption are represented by a standard constant relative risk aversion utility function which is continuous, strictly increasing in consumption and concave. The risk aversion coefficient \( \gamma \) governs the saving behavior of households under uncertainty.

Modeling household utility from children requires further thought. In this paper, I assume that household utility from children increases but at a decreasing rate as the family grows. In other words, while the households abide by the saying “the more the merrier”, their marginal utility is the highest when the first child is born and gradually decreases as the family grows.

The coefficient which determines curvature of the household utility of children is \( \kappa \). For \( \kappa > 0 \), the marginal utility of the first child is the highest and the households derive relatively little additional utility from births of the subsequent children. In contrast, for \( \kappa \) equal to zero, the marginal utility of children becomes constant. In other words, as the curvature increases, the marginal utility from every additional child decreases and the households do not increase their stock of children as rapidly.

My choice of the utility function implies that, to characterize the household preferences, I must choose the values for four parameters: the three which identify the utility function; plus the time discount factor \( \beta \).

To minimize the number of calibration targets, I set the annual gross interest rate \( (1 + r) \) equal to 1.04 (as in Heathcote (2005)) and allow \( \beta = \frac{1}{1 + r} \). In order to get sensible response of household level of labor earnings uncertainty (reflected by a higher \( \sigma_e \)) than the cohort making fertility decisions in the 1970s.
saving behavior to risk, I set the relative risk aversion, $\gamma$, to an off-the-shelf value 1.5. Thus, I calibrate the model to get values for the curvature coefficient $\kappa$ and the scaling coefficient $\psi$.

### 4.3 Cost of children

As discussed in section 2.3, I model the childrearing cost as proportional to household income by a factor $\theta$ and I use an adjustment coefficient $e(n)$ to account for the economies of scale to childrearing.

Since it is not directly obvious which data moments should be targeted to identify $\theta$ and the remaining parameters for the economies of scale to childrearing, $e(n)$, I adopt their estimates from Lino (1998) which are published by the U.S. Department of Agriculture and are used in developing State child support guidelines and foster care payments.

Using the data from the Consumer Expenditure Survey (CEX) 1990-1992, Lino (1998) estimates the total expenditures on children by two-parent families with two children, an average household size in the U.S. in the 1990s. The total expenditures include all major budgetary components: housing, food, clothing, health care, childcare and education (i.e., daycare tuition, baby-sitting, elementary and high school tuition), and miscellaneous goods and services. As in my model, the author’s estimates rest on the assumption that households spend an equal amount of their income per child and do not depend on the children’s age.

Estimated expenses on children vary by household income level: on average, households in the lowest group spend 28 percent of their pre-tax income on a child, those in the middle-income group, 18 percent, and those in the highest income group, 14 percent. Given the relatively large number of discrete states needed to approximate the otherwise continuous AR(1) process for the persistent shock, I abstract from modeling the childrearing cost as stratified by income groups and assume that households spend 20 percent of their income per child (i.e., $\theta = 0.2$).

To estimate expenses for households with a single child or with more than three children, I use equivalence scales from Lino (1998) and set $e$ to 1.24 and 0.77, respectively. In other words, the economies of scale to childrearing for a two-parent family with $n$ offspring then can be written as

$$e(n_t) = \begin{cases} 
1.24 & \text{if } n_t = 1; \\
1 & \text{if } n_t = 2; \\
0.77 & \text{if } n_t \geq 3.
\end{cases} \quad (10)$$

### 5 Results

#### 5.1 The lifecycle profiles in the benchmark model

Figures (2) and (3) show the average lifecycle profiles of saving, nondurable consumption, childrearing cost and fertility for households which are formed at age 16, become infertile at age of 41, retire at 65 and die with certainty at the age of 80.

As one can see in figure (2), the average consumption increases monotonically until the age of 60 and gradually flattens out thereafter. The upward trend in the average consumption is driven by the absence of borrowing in the model. When uncertainty is present and borrowing is not allowed, the consumption tends upward as households accumulate precautionary savings early in life to insulate consumption from short-term fluctuations.\(^9\)

\(^9\)Using the data from the CEX, Fernandez-Villaverde and Krueger (2004) estimate that the age-profile of the per-
The average saving profile in figure (2) resembles closely reported by Fernandez-Villaverde and Krueger (2007). Using the data from the Survey of Consumer Finances (SCF), the authors provide evidence that the pattern of lifecycle household wealth is hump-shaped, peaks at retirement, and that wealth deteriorates only gradually for the retired households. It should be also noted that – in the model – households accumulate on average only one third of their lifetime savings by the age 40. Such saving behavior is consistent with the predictions of the “buffer-stock” savings models pioneered by Deaton (1991) or Carroll (1992). In this class of models, credit-constrained and impatient consumers engage in precautionary (“buffer-stock”) saving when young and only begin to save for retirement later in life.

adult-equivalent consumption is humped-shaped, peaking at roughly age 50. The model generates the hump-shape consumption profile if the assumption $\beta = \frac{1}{1+r}$ were relaxed by adding, for example, the conditional probability of survival and assuming absence of annuity markets.
Figure 3: Age-Specific Birth Rates for Women Aged 16-41

Figure (3a) describes the average fertility profile of households with children in the benchmark model and shows how the simulated profile parted with the cumulated birth rate profile measured in the NLSY79 data. As one can see from figure (3a), the average fertility profile matches the data surprisingly well given that the calibration targeted only two fertility moments (i.e., the average fertility rate for households with children and the mean age of households at first birth). First, the model endogenously generates the mean age at second birth (27.5) that matches well its data counterpart (27.7). Second, the benchmark model’s mean fertility profile follows the S-shaped pattern of the cumulated fertility measured in the data. The match, however, is not flawless: the benchmark model tends to understate the average completed fertility for households younger than 20, overstates completed fertility for households 20-37 year old, and understates it again at the close of the fertile horizon for households aged 37-41.

The jump in the average fertility in last fertile periods is a construct of two features of the
model: the way the childrearing cost enters the model and the finite horizon of the fertile stage of the lifecycle. Given the large number of fertile periods, keeping track of children’s ages is not computationally tractable in this model. Therefore, as discussed previously, I assume that the child cost is incurred by households with children every period between child’s birth and household retirement. Given this structure on the childrearing cost, households may find it optimal to postpone the last birth until the end of the fertile horizon. Additionally, since the last fertile period is known with certainty, some households – which otherwise would postpone the birth of an additional child a few more periods – rush and have the baby in the last fertile period of their lifecycle, thus boosting the fertility rate. This “biological-clock”-like behavior would vanish from the model if households faced uncertainty about the timing of the last fertile period.

Figure (3b) depicts variation in fertility behavior across the fertile lifecycle. All the households, which are childless and identical when formed at age 16, choose to stay “diaper-free” for the first three periods of their lifecycle. This is because households prefer to accumulate at least a minimal amount of buffer-stock savings before they assume the financial responsibility connected with the childrearing. At the age 19, the first households with strollers start to emerge. These are households which were hit by a series of good income shocks early in the life. The less fortunate households – which do not feel yet confident about their ability to partially insulate their consumption from adverse shocks – postpone fertility and stay childless. Over time, as households start to see their net worth increase, more and more households commit to having children. The reproductive behavior is the strongest for households aged 22-28, with the peak at age 24. At the age 30, the reproductive behavior of households slows down and the birth rates continue to decline until mid-30s – a point by which most households have had 2-3 children. At the age 36, households become reminded of the fertile horizon’s finite nature and – hearing the “biological-clock” ticking – households in a good financial standing decide to experience the joys of parenthood one more time. Thus, to the end of the fertile stage of the lifecycle, the household fertility increases again.

5.2 The impact of children on household saving and consumption

At this point, one can ask how much consumption does an average household forego in order to have children? To answer this question, I compare the consumption, savings and mean wealth-earnings profiles generated by the benchmark model in which households get warm glow from children with a model in which households derive utility from having them (i.e., ψ = 0).

As one can see in figure (2d), for an average household having offsprings and large savings or high consumption levels does not necessarily go hand in hand. When households commit to having children, their ability to accumulate large amounts of savings is inhibited compared to childless households. According to the model, the net worth of a household with children represents only one half of wealth accumulated by a childless household (figure 2d) and the mean wealth to earnings ratio for households with children is below that of childless households (figure 4). The only exception are the early periods of the lifecycle (i.e., up to age 28) when households which have (or plan on having) children save a larger portion of their income than households which stay childless. Similarly, consumption of an average 50-year old household with two children is only about 60 percent of consumption level attained by a childless household. This is because – all else equal – financial resources of a household with children which can be divided between parental

\[10\]

\[13\]
Figure 4: Mean Wealth-Earnings Profile for Households with Utility from Children (Benchmark) and without
consumption and savings are lower than those of a childless household which does not incur the
childrearing cost.

The increased saving propensity of young households with offsprings is given by the children’s
durable nature: since childrearing is expensive and the existing stock of children cannot be reduced
when an adverse shock hits, consumption of households with children is bound to fluctuate more so
than consumption of their childless counterparts. Therefore, young households tend to accumulate
larger savings deposits early in life to better insolate consumption from earnings fluctuations once
their family size starts to expand.

6 Idiosyncratic risk and fertility

6.1 Predictions of the benchmark model

In this section, I ask how changes in idiosyncratic earnings risk affect household fertility in the
benchmark model. Figure (5) captures the impact of changes in standard deviation of earnings, $\sigma_\epsilon$,
on household fertility and the timing of childbearing.$^{11}$ As can be seen from figure (5), increases in
earnings uncertainty can have a quantitatively large impact on timing of birth while, interestingly,
the relationship between earnings uncertainty and fertility is nonlinear. If the standard deviation
of earnings increases from a small level (e.g., $\sigma_\epsilon$ from 0.01 to 0.12), the mean age at first birth
increases significantly from 17 to 21.3. At the same time, the fertility rate declines from 2.6 to 2.3.
For medium level of risk (e.g., $\sigma_\epsilon$ between 0.12 and 0.25), the mean age at first birth continues
to rise but the fertility rate stops falling. This result can be understood using the following logic:
when there is no labor market risk, households – which in principle are “children-friendly” – do
not need to hedge earnings risk early in life and only save for the retirement later. Therefore,
such households are able to commit to the financial obligations connected with large family sizes.

When earnings risk rises and the need to accumulate precautionary savings early in life becomes
imminent, households both delay the childbearing and decrease their family sizes. However, since
households in the model – as in the real life$^{12}$ – like to have at least two children, for medium levels
of uncertainty (similar to those observed in the U.S. data), the fertility rate stays approximately
constant while the mean age at first birth keeps rising. In the case of very large earnings uncertainty,
however, the precautionary savings motive dominates the desire to have children and fertility rate
falls below 2.0 (see again figure 5a) while the average birth of the first child is pushed back even
further (figure 5b).

6.2 Empirical evidence: United States

Since the model is calibrated to the U.S. economy in the 1990s, it is interesting to ask how the
model’s predictions fit the data prior to this period. In the U.S., the mean age at first birth has

$^{11}$It should be stressed that households in the model have no way to insure the highly persistent shock whose
variance I am increasing. This assumption is certainly not completely unrealistic as the available evidence (Attanasio
and Davis, 1996) suggests that most persistent shocks are reflected into consumption.

$^{12}$While the TFR has started to drop significantly below replacement level in most Western European countries
and the U.S. during the 1970s and the 1980s, value studies, opinion polls and even large scale surveys (such as the
Eurostat or NLSY79) have found that the number of children considered ideal for society or for one’s own family
has remained above two children per woman (Goldstein et al. (2003) and own calculations from NLSY79). Only in
German-speaking parts of Europe the average ideal family size has fallen below the replacement (to about 1.7.) in
the recent years.
Figure 5: Impact of Increasing Risk on Household Fertility
increased by 3.5 between 1970 and 2000 (with the steepest increase from 1975 to 1985) while TFR has declined from 2.5 in 1970 to 1.8 in 1985 and then risen again to 2.0 in 2000 (Table 4). The fact that the rise in mean age at birth has been widespread, occurring for each birth order, race and Hispanic origin group, and all States, supports the idea that there has been a real change in reproductive behavior of women in United States (Mathews et al., 2002). While there are several factors which may help to explain evolution of TFR and the mean age at first birth in the 1970s for which I do not control in this model (such as rising education attainment, increasing female labor participation and contraceptive use, legalization of abortion in the late 1960s, or long-run demographic cycles related to the baby-boomer generation), it is interesting to see whether some of the changes in the fertility and timing of births could be attributed to changes in the earnings risk.

Changes in the microeconomic uncertainty in the U.S. over the past thirty years are well documented (see, for example, Gottschalk (1997) or Levy and Murnane (1992) for review). For example, Heathcote and Violante (2004) estimate that the variance of logged annual household earnings has increased from by 20 percentage points from 1967-1996, with most of the increase taking place in the 1980s and the early 1990s. The observed increases in earnings risk have been – by far and large – attributed to increases in the persistent component of household earnings which, in turn, is standardly assumed to represent the uninsurable idiosyncratic earnings risk (Meghir and Pistaferri, 2004). Using a sample of households from PSID for the period 1968-1993, Meghir and Pistaferri (2004) provide yearly estimates of the standard deviation of the persistent shock to labor earnings for the period 1969-1991 (comparable data for later periods are not readily available). According to the authors’ estimates, the standard deviation of the persistent shock increases throughout the 1970s and in the early 1980s (reaching whopping 0.25 in 1984) and declines after 1984 with a slight tendency to increase at the end of the survey period.

Figure 5 shows that as $\sigma_e$ increases from 0.15 (e.g., an arithmetic average for 1969-1979 in Meghir and Pistaferri (2004)) to a benchmark value of 0.21 (e.g., an average for 1980-1991), the mean age at first birth increases from 21.5 to 25.09 while the mean age at second birth rises from 23.8 to 27.5. This is very similar to the actual increases in the data between 1970 and 1995: 3.1 years and 3.4 years, respectively. At the same time, the model predicts that the changes in labor market risk of this magnitude shall have no effect on the completed fertility of households with at least one child, which should stay fixed at approximately 2.3 (a value which implies TFR of about 1.9-2.0). While the actual data do not fit this prediction exactly (TFR fell between 1970 and 1975 and kept at 1.8 during the next decade), the all times-low TFR in the 1970s and 1980s can be ascribed to the rising mean age at birth (Bongaarts, 1999). Indeed, correcting for “tempo” effects (due to rising mean age at birth), Bongaarts and Feeney (1998) estimate that the “adjusted” TFR kept at a constant level of about 2.0 throughout the 1970s and 1980s – a result consistent with the model’s predictions.  

13This is because TFR gives a misleading estimate of the actual rate of childbearing when the age at childbearing is changing: women in populations where the mean age at birth rises actually bear more children than is indicated by the TFR. This distortion in TFR continues as long as the age at birth rises, but – once the deferment ends – the distortion is removed and TFR rises. Bongaarts (1999) argues that this is exactly the pattern observed in the United States in the late 1980s: the TFR was well below replacement rate (at about 1.8) for most of the 1970s and 1980s, but rose quickly to about 2.0 in the late 1980s. This rise coincided with the end (or a significant slow-down) of the rise in the mean age at first birth.

14Bongaarts and Feeney (1998) find that TFR-depressing tempo effects existed during the 1970s and 1980s in the U.S. data, creating a wedge between the actual (“adjusted”) and reported (“unadjusted”) TFR of about 0.2. The tempo effects disappeared around 1990 when unadjusted TFR has returned to levels of about 2.0.
Table 4: Mean age of a mother at 1st birth

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<tr>
<td>2005</td>
<td>2.05</td>
<td>25.2</td>
<td>–</td>
</tr>
</tbody>
</table>

Absolute change 1970 - 2000: 0.44 3.5 3.6


6.3 Empirical evidence: Central and Eastern Europe (CEE)

The model also generates some interesting predictions for the former centrally planned economies where labor market risk changed dramatically during a short period of time. Prior to the economic transformation in the late 1980s, Eastern and Central Europeans gave on average the first birth 3-4 years sooner than the households in the West. In addition, total fertility rates in the centrally planned economies were by approximately 0.4 larger than those measured in the West.

At the dawn of economic transformation, households started to postpone childbearing. This delay led to a drop in the annual birth rates. In the early 2000s, in spite of the originally gloomy forecast of a demographic “crisis”, fertility rates in the emerging economies started to gradually recover again but the mean age at first birth has settled at levels observable in the West. For example, TFR in the East Germany has decreased from 1.7 in 1988 to 0.8 in 1992 and then risen to 1.3 by 2005. Meanwhile, the mean age at first birth in East Germany has increased from 24.6 in 1990s to West Germany’s 28 by 2000 (Max-Planck, 2004).

The demographic developments in the Eastern and Central Europe following the economic transformation gave a rise to a “convergence” hypothesis (Kreyenfeld, 2003). The “convergence” hypothesis suggests that fertility behavior in transforming economies converges to the Western fertility trends, which in turn are dictated by institutional and economic conditions in the market economies (such as rising labor market risk, increasing earnings inequality or higher returns to education). The demographic behavior postulated by the “convergence” hypothesis is consistent with the steady state prediction of this model: after the economy has achieves a new, higher earnings dispersion equilibrium, both TFR and the mean age at first birth adjust to the new economic conditions. In other words, the mean age at birth rises but TFR declines only slightly (unless the labor earnings uncertainty remains very high).

Since birth statistics are based on the characteristics of parents and, thus, the decision to postpone children is not reflected in a statistics until the parents have actually given birth to a “postponed” child. Therefore, if a relatively large number of households decide to postpone starting a family, TFR falls rapidly while the average age at birth may stay constant (or may even initially drop). Once postponers start having children, the increase in mean age at first birth is then often rapid and steep.
7 Conclusions

This paper studies household fertility decisions in presence of idiosyncratic labor market risk. It is shown that higher earnings uncertainty increases the mean age at first and second birth. The calibrated model matches well the changes in timing of births in the U.S. between the 1970s and 1990s, and can help to explain the evolution of TFR during that period. The model can also account for demographic developments in Central and Eastern Europe, following the transition from a centrally planned to a market economy.

Several other factors may account for the upward trend in mean age at births. Education, career, and increasing contraceptive use have been reported as important factors in household fertility decisions. Already Silver (1965) suggests that increased willingness to plan family size, among other things, means increased attention to economic variables, implying that fertility decisions of households respond to fluctuations in labor income and employment.

In my future research, I plan to study the evolution of fertility and mean age at birth during adjustments between low-risk and high-risk steady states. It is likely that the current fertility rates in the OECD world – as low as 1.2 – are well below their equilibrium values and only reflect temporary declines combined with a downward bias in TFR as household fertility adjusts to the higher earnings risk environment and the mean age at birth rises.

A Data and the calibration targets

The data used are taken from the National Longitudinal Survey of Youth (NLSY), a nationally representative sample of 12,686 young men and women ages 14 to 22 when they were first interviewed in 1979. These individuals were interviewed annually through 1994 and are currently interviewed on a biennial basis.

The first three NLSY surveys (1979, 1980 and 1981) have a very short fertility history. In 1982 the fertility data collection was greatly expanded, a full retrospective information about the respondent’s fertility history was collected, and many of the inputs to the fertility variables used in this study were revised in order to maximize internal consistency across the years. In general, when a respondent was interviewed each year from 1979 to 1982, the revised 1980 variables give an accurate picture of the respondent’s fertility history as of 1982.

This study uses the data from 1982 through 2004. To be included in the subsample used in the article, households from the NLSY had to meet the following criteria: (i) the head of the household has had at least one child between the years 1982 and 2004, (ii) the head of the household must have been more than 20 years old at birth of the first child, and (iii) households still participated in the survey in 2004 (by which time’s the fertility cycle of the absolute majority of households was completed). Sampling weights were employed to create a nationally representative sample of households (as the NLSY oversamples Hispanics, blacks, and economically disadvantaged whites). Respondents with the missing data for variables used in the calibration were dropped from the analysis.

B Numerical solution and algorithm

In this model, households have a finite horizon and so the model is solved numerically by backward recursion from the terminal period. At each state, I solve the value function and optimal policy
rule, given the current state variables and the solution to the value function in the next period. Hence, in the fertile stage of the lifecycle \((t = [1, \tau])\), a household with a state vector \((a, n, \epsilon, \nu, t)\) solves the following recursive problem

\[
v(a_t, n_t, \epsilon_t, \nu_t, t) = \max_{\nu_{t+1}} \left\{ \begin{array}{ll}
\max_{u_{t+1}} u(c_t, n_t) + \beta E[v(a_{t+1}, n_{t+1}, \epsilon_{t+1}, \nu_{t+1}, t+1) | \epsilon_t], & K = 0 \\
\max_{u_{t+1}} u(c_t, n_t) + \beta E[v(a_{t+1}, n_{t+1}, 1, \epsilon_{t+1}, \nu_{t+1}, t+1) | \epsilon_t], & K = 1,
\end{array} \right.
\]

subject to the budget constraint (6) and the credit constraint (7). After period \(\tau\), when a household loses its capacity to bear children, the decision problem for the household with a state vector \((a, n, \epsilon, \nu, t)\) simplifies to

\[
v(a_t, n_t, \epsilon_t, \nu_t, t) = \max_{n_{t+1}} u(c_t, n_t) + \beta E[v(a_{t+1}, n_{t+1}, \epsilon_{t+1}, \nu_{t+1}, t+1) | \epsilon_t],
\]

which is again subject to the constraints (6) and (7).

As discussed in section 2.2.2, the complication in the model arises from the combination of a discrete choice (have a child next period or not) and a continuous choice (over saving). This combination means that the value function will not be necessarily concave or differentiable. Solving backwards, one can safely assume that the value function is concave and differentiable in the infertile stage of a lifecycle when, conditional on the existing number of children \(n_t\), households only make a continuous choice with respect to savings. However, the guarantee of the value function’s concavity and differentiability vanishes at the period \(\tau\) when households are free to choose whether to have an additional child or not. This problem repeats itself in any other period of the lifecycle when the households are fertile and free to make a discrete fertility decision. Hence, while the value functions are increasing in assets \(A_t\), the concavity and differentiability of the value function is not guaranteed in at any period prior to period \(\tau\). Hence, I employ the finite dynamic programming methods and only approximate the solution to the household problem.

In the model, there are three continuous state variables to be discretized: the asset stock, and the transitory and permanent components of household earnings. Without their discretization, the state space for the household problem would be of the size \((\mathbb{R}^+ \times \tau \times \mathbb{R}^+ \times \mathbb{R}^+ \times T)\).

To ensure that the dynamic program is computationally tractable, I approximate the otherwise continuous-valued stochastic components of the earnings process by a discrete-valued process with 7 states for the persistent and 2 states for the transitory component. To discretize the wealth, I employ a nonlinear grid with 101 gridpoints and an upper bound on savings of 100, highly concentrated around the zero. A sensitivity analysis has been conducted with respect to the upper bound on savings. Hence, for \(\tau = 25\), the discrete approximation to the households’ state space is now of the size \((101 \times 25 \times 7 \times 2 \times 50)\).

The algorithm used to solve the households problem is as follows. First, I guess values for values for the calibrated parameters \(\kappa\) and \(\psi\). Employing these guesses and the remaining parameters summarized in Table 1, I use finite dynamic program to solve for optimal decision rules for savings \(a(a, n, \epsilon, \nu, t)\) and demand for children \(n(a, n, \epsilon, \nu, t)\). Next, I simulate the shock histories for 10,000 households. Using the simulated histories and the optimal decision rules \(a(a, n, \epsilon, \nu, t)\) and \(n(a, n, \epsilon, \nu, t)\), I calculate the targeted moments for the model economy. In next step, I use the method of simulated moments to pin down the parameter values for coefficients \(\kappa\) and \(\psi\) which produce moments summarized in table (2). Since the differentiability of the objective function for the method of simulated moments is not guaranteed, I use a minimization procedure that does not rely on the existence of the gradient – Downhill Simplex. Once the preference parameters \(\kappa\) and \(\psi\) are located, I resolve the household problem and save the optimal decision rules.
### TFR and Mean Age at Birth: EU-15 and CEE

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Source: Council of Europe, Eurostats and various country statistics
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