College Attainment of Women

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Abstract

Up to the late 1970s, the Sex College Attainment Ratio (SCAR) or ratio of college attainment between men and women was about 1.6. Assortative mating within education groups in marriages is strong enough in the U.S. to prevent accounting for the SCAR feature based on males' higher earnings. We document the puzzling nature of the SCAR, and we explore various theories to account for it. Our main finding is that if parents' well-being is affected by the number of grandchildren, gender differences in the steepness of the negative relation between educational attainment and number of children provides the best theory to understand the SCAR.

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1 Introduction

In this paper we ask what can account for the fact that until the late seventies in the U.S. there was a big gap between the numbers of males and females college graduates, the ratio of males to females college graduates or sex college attainment ratio, henceforth, SCAR, was 1.57 in 1976.

College attainment affects earnings and also the type of family that people are likely to form. Moreover, the implications of each of these two elements are different for males and for females. We ask what differences associated with education can account for the large SCAR. We construct a simple model of families with a boy and a girl that have to decide how much to invest in the education of each. In the model, parents have standard preferences in terms of patience and risk aversion, they are altruistic towards their children and they are aware of how education is achieved and of its implications for earnings and for marriage. Moreover, there are no differences in the educational attainment opportunities between the sexes. We use some properties of the data (pertaining to the educational attainments of males and to some forms of measuring intergenerational educational persistence) that allow the model to be exactly identified, and that we use to estimate the model's parameters. We then use the estimates to ask the model about the educational implications for females and hence for the SCAR. We use additional properties of the data, properties that were not used to estimate the model, to assess the different theories (pertaining to different statistics of intergenerational educational persistence and, especially, to the cross–sectional, by education of the father, distribution of the SCAR).

We find that a simple version of the model, that we denote the baseline model economy, that takes into account earnings both directly and indirectly via the spouse that persons are likely to draw does not account for the SCAR. On the contrary, when we estimate the model to match male educational attainment, we find that the prediction of the model is that females should go more to college than males. We document this finding by decomposing the roles of the various features in shaping the answer (preferences, and various properties of the matching behavior).

We then explore a variety of alternatives to improve our understanding of the determinants of the SCAR. These alternatives are enhancements of the basic model that leave the door open to an increase in the returns to college to males relative to females. Specifically, *i)* we explore the implications of college education providing an advantage to fathers to educate their children, *ii)* we look at what happens when the share of consumption within the household depends on the share of earnings, effectively allowing the person with higher earnings to consume more, *iii)* we look at the implications of costlier education of females because of foregone home production, *iv)* we explore what happens if we account for the possibility of the parents have dissimilar concerns over the wellbeing of their two children, and, finally, *v)* we explore what occurs when we take into account the differential fertility behavior by education groups among the sexes. A summary of our findings is

1. No matter how hard we try, the baseline model cannot account for the SCAR. Even with very little risk aversion (as low as 0.4) the model cannot achieve the SCAR and, in addition, this feature induces too little intergenerational persistence.

2. When we abstract from education induced fertility differences, advantage to educated parents in educating and non income pooling within the household cannot account for the SCAR. The behavior of these two economies is very similar to the baseline.

3. That parents prefer boys is a theory that is capable of accounting for the SCAR. However, its implications for the cross–sectional distribution of the SCAR, are grossly inconsistent with the data.

4. Higher costs to educate women is a plausible theory of the SCAR, especially if we combine it with a form of parental educational advantage.

5. When we explicitly pose the educationally induced differences in fertility, we find that the model is capable of accounting for the SCAR. In addition, we get great improvements in the behavior of the variables that we use as overidentifying restrictions when we allow for parental educational advantages. We consider that this theory is better than that of females being more expensive to educate because it is based on observables (differences in

fertility rather than home production), and because it is more parsimonious (it does require less parameters).

6. Our results support that fathers' education, and no mothers', is the relevant one in determining children educational attainment.

There are several papers related to this research. Behrman, Pollak andTaubman (1986) use a model in which parents consider earnings and marriage outcomes differences between men and women to ask whether parents favor boys. Using a sample in which offspring coming from wealthier families are overrepresented they conclude that there is no evidence of gender biased parental preferences. The overall results of this paper agree in general with parents not having gender biased preferences, at least for some of the extended versions of the model that we use. Another related paper is Echevarria and Merlo (1999). They have a model of marriage and education decisions in which children are a public good inside marriage, and males transfer part of their earnings to their wives (that have lower earnings due to time devoted to children instead of the market) to avoid the dissolution of marriage. Their model implies a lower education gender gap than a model in which parents don't take into account this compensation effect. We explore this issue in this paper and our findings point to this channel not being quantitatively very important. Concerning the literature of intergenerational persistence of education, Haveman and Wolf (1995) explores the determinant of children attainment by reviewing the labor literature that comes from a different tradition than this work and points to the importance of parental education, especially that of the mother, in shaping the educational attainment of their children. However, Behrman and Rosenzweig (2001) explores the role of female education in shaping the education of their children and find a negative effect that operates through the increased labor participation associated to more education. Our findings support. an advantage to college educated parents in educating their children, and more precisely that of the father.

Since the seventies female college attainment has been increasing dramatic to the point that now their college attainment is higher than that of males. The natural question that follows this paper and that we leave for future but immediate research is what changes since the seventies have accounted for this.

The paper is organized as follows. Section 2 reports the distribution of education by gender, it estimates the returns to education in terms of earnings and describes the sorting properties of marriages. Section 3 describes the model. Section 4 describes our choices for the functional forms that we use in our model. Section 5 estimates the baseline model economy, discusses its failure in accounting for the SCAR and describes the role of the different elements that shape the investment decision. Section 6 estimates and assesses the five alternative theories described above and shows how two of them can account for the SCAR. An Appendix includes some details of the construction of earnings measures, of the formulae that yields certain transition matrices and some additional tables.

2 Data

In this Section we display some facts about college attainment, returns to education and marital sorting that are central to our discussion. All the statistics we present in this Section have been constructed from a sample of the Panel Survey of Income Dynamics of 1976: Family Public Release II. Appendix A contains the details of how we constructed the Tables of this Section, and in particular of the measure of earnings that we use.

2.1 Education distribution

In Table 1 we show the distribution of education by gender in 1976 for people between 25-35 years old. There is a clear predominance of males having attended college, while the same does not hold for high school. To see that this is not a one time effect resulting from the Vietnam War and males trying to avoid the draft, Table 2 shows the education distribution for older persons that probably excludes those that went to college to avoid the draft. This Table shows an even more drastic predominance of males. A look at both Tables indicates a secular increase in college attainment over time: Young people in the sixties and seventies were more likely to go to college than in any time before. This is not a central theme of our paper, but it is a fact that we have to be very aware of as it affects our assessment of many facets of the data.

Table 1: **Education Distribution (25-35 years old), 1976 (in %)**

	Male	Female
Four or more years of College	31.0	19.7
High School or some College	54.9	63.0
Elemental	14.1	17.3

Table 2: **Education Distribution (35-65 years old), 1976 (in %)**

	Male	Female
Four or more years of College	20.0	10.1
High School or some College	44.0	55.7
Elemental	36.0	34.2

2.2 Estimates of the returns to education

We construct some measures of the returns to education. Essentially, we measure the present value of the difference in earnings associated to a certain degree. We start looking at individual earnings and then we move to the total household earnings.

2.2.1 Individual earnings

The present value of total earnings by education groups and gender are reported in Table 3 where we normalize life-cycle earnings of college males to 100. Note that the appropriate measure of the returns to college attainment is the difference between earnings of college and high school graduates.

First note that the returns for completing four years of college is much higher for males than for females in terms of life-cycle labor earnings. Going to college gives males 32% of the earnings of a male college attendant while it gives females only 17% of those earnings.

As we have stated above and as **?** has pointed out, the return from college attainment is not

Table 3: **Individual life-cycle earnings, 1976**

	Male	Female
Four years of College (a)	100.	34.
High or some college(b)	68.	17.
Elemental	49.	10.
(a)-(b)	32.	17.

Total life-cycle earnings of college males are normalized to 100.

only an increase of own life-cycle labor earnings. There is also an increase in the education of the likely spouse.

2.2.2 Marital status distribution

Table 4 describes the marital status of women by education groups where we have decomposed married women of all education groups by the education attainment of their spouses. We see that people do not marry randomly. On the contrary, 62.% of women in the 25-34 age group in 1976 that went to college are married to college graduates. This figure is about one fifth for women with only high school and almost nil for women who only have an elemental education (did not graduate from high school).

Table 4: **Females' Marital Status Distribution (25-35 years old), 1976**

	Single	Mar to Coll	Mar to High	Mar to Drop	Total
College	4.6	12.4	3.0	0.0	20.0
High	12.9	11.5	31.4	7.2	63.0
Elemental	3.9	0.2	5.5	7.4	17.0
Total	21.4	24.2	39.9	14.6	100.0

A feature that is interesting in itself even though not an issue that we address in this paper is that women marry men older than themselves. In those years the average difference was around

3 to 4 years (it has come down somewhat in the last quarter century). For this reason when looking at the marriage distribution for men, we look at a slightly older group (28 to 38). Table 5 shows the marital status of men by education groups in a similar fashion as Table 4 does for females. The fact that over three quarters of married females of the 25 to 35 age group are married to men in the 28 to 38 age group indicates that this is the right group of males to whom compare the female reference group. Table 5 shows essentially the same facts as Table 4 except for the fact that the higher education of males relative to females imply that the average spouse of males are likely to have less education than the average spouse of females.

Table 5: **Males' Marital Status Distribution (28-38 years old), 1976**

	Single	Mar to Coll	Mar to High	Mar to Drop	Total
College	5.1	11.9	13.0	0.5	30.5
High	6.8	3.2	36.4	6.3	52.7
Elemental	1.4	0.1	7.4	7.9	16.8
Total	13.3	15.2	56.8	14.7	100.0

2.2.3 Household earnings

To further investigate the role of assortative matching in marriages, we estimate total household labor earnings. To calculate this number we the use marital status distribution at each educational level.

Table 6 reports the returns to college for each education group for males and females taking into account to what groups they are likely to marry. The striking fact shown by this table is how similar they are for both men and women. Going to college means that the average household in which people are likely to live has about 50% higher earnings than just graduating from high school which in turn provides for three times the earnings of being a high school dropout.

Table 6: **Household average life-cycle earnings, 1976**

	Males	Females
Four years of College (a)	100.	97.
High or some college(b)	67.	67.
(a)-(b)	33.	30.

We normalize household earnings of college males to 100.

2.3 Education and fertility

People's education affects the number of children that they have. Typically, the pattern is that the more educated the parent, the lower the number of children. Moreover, the relation is much steeper for women, meaning that the ratio of children of college educated women relative to women that dropped out of school is lower than the same ratio for men. This is shown in Table 7 that reports the differences in the average number of children by sex and education for individuals aged 26-55 in 1968 in the PSID.

Table 7: **Fertility by Sex and Education**

	College	High School	Dropout
Females	0.72	0.86	1.00
Males	0.78	0.87	0.93

All numbers normalized to children of a dropout female. PSID Data: total number of children of those that were 26-55 in 1968.

2.4 Summary of the evidence

As we have seen in this Section, during the seventies men went to college in much higher numbers than women. The returns from their attainment are higher than those for women if we abstract from which type of household they are likely to live in. Fully accounting for the assortative matching that occurs between education classes equates the return to college attainment between men and women which raises the obvious question of why did men attend college more than women. We turn now to build a model of differential investment in education by gender where several possible explanations to this puzzle can be explored.

3 The baseline model

We start describing a basic version of the model where parents like their children equally, where college attainment is equally expensive for males and for females, and where household earnings are equally shared by the two adult members. In later sections we expand the model so that we do not make these restrictive assumptions.

The model consists of overlapping generations of agents that differ in gender $g \in \{f, m\}$. Agents may marry, and if they do, they have children. Parents invest resources in the education of their children to improve both their earnings and the odds of marrying a highly educated person.

To simplify the structure while having agents live many periods, and hence to allow us to interpret periods as years, agents age exponentially, and go through three stages: childhood, adulthood and retirement. In childhood and retirement agents do not make any decision. Adults agents age with probability ψ. While children, agents are attached to their mother. If a mother retires her children become adults. If a mother does not retire, her children may or may not grow into adulthood, an event that occurs with probability ϕ. This modelization ensures that childhood and adulthood have the appropriate lengths. Parameters ψ and ϕ are set at calibration stage.

Besides age and gender, adult agents may also differ in educational attainment, $e \in \{c, h, d\}$, or college graduate, high school graduate and high school dropout. Education is a permanent characteristic of agents, *i.e.,* agents start adulthood with an education level that remains constant throughout their remaining life. We use t to denote the type or permanent fixtures of an agent (the pair gender and education) $t = \{g, e\}$. Sex and education determine individual earnings $\varepsilon_{g,e}$.

In addition to the permanent attributes of individual agents, there are two additional characteristics that matter and that will be the agents individual state variables. They pertain to their marital status and family size. Individuals can be single or married. If married, the educational attainment of the spouse matters. Henceforth, we denote by $z \in \{0, c, h, d\}$ the marital status of an individual, where $z = 0$ denotes single. We assume that marital status evolves exogenously as a Markov process with transition matrix $\Gamma^{g,e}_{z,z'}$. This assumption is only possible under steady states. In particular, the matching probabilities have to be consistent with the distribution of available singles. We will come back later to this point. In the meantime we take $\Gamma_{z,z'}$ as a constant which is what matters from an individual point of view. Because we assume periods to be short, we assume that changing partners requires a spell of singleness. This makes $\Gamma^{g,e}_{z,z'}$ to be zero everywhere except the first column and the first row and the diagonal.

Households may have children, and if they do they have a boy and a girl. This requires the household to have an adult female member that is or was married, as children are attached to their mother and we are abstracting from out of wedlock child bearing. We denote the number of children by $n \in \{0, 2\}$. Children can grow old, in which case they emancipate, and the number of children in their mother's household reverts from 2 to 0. Upon divorce (there is no other means of separation in this model) the children remain attached to their mother who has to remain single for at least one period before a possible remarriage in which case, the groom treats the bride's children as if they were his own. We summarize the individual state by $s = \{z, n\}$. We denote with $\Gamma^{g,e}_{s,s'}$ the joint Markov process of individual states. The actual formula to get $\Gamma^{g,e}_{s,s'}$ from $\Gamma^{g,e}_{z,z'}$, and aging parameters ψ and ϕ is quite cumbersome and can be found in Appendix B.

Households choose consumption, c, and resources invested in their children, that may differ by the child's sex, y^f and y^m. In the baseline model economy, consumption is shared equally among all family members (we drop this assumption later on), and the amount of consumption enjoyed by each person equals the value of the household's total consumption expenditures adjusted by family size through standard household equivalence scales. To save on notation we make this adjustment by indexing the utility function by the household's type.

Investments in children increase the probability of educational attainment according to functions $\gamma_e(y^g)$. Note that this notation implies that we are assuming that educational attainment is not gender dependent. Conditional on their educational attainment, exogenous distribution $\mu(t, s)$, determines how the transient characteristics of the person get determined in the first period of individual adult life.

At any point in time, there is a distribution of agents according to both their permanent and transient attributes, which we denote by $x(t, s)$, and we normalize to $\sum_{s,e} x(f, e, s) = 1$.

We have made the employment decision exogenous. Given that what parents are deciding is the education of their children, we believe that posing the final outcome of education in terms of earnings is a reasonable assumption. With respect to the differential fertility associated to each education level, we assume it is exogenous. To deal with the fact that in the data is not the same across education groups we do two things. First, given that preferences do not pose an explicit role for the number of descendents, in some of our specifications we normalize the number of children so that it is independent of the education level of the parents. We also follow a different procedure that involves the explicit specification of a utility function that includes a constant additive term which plays the role of the value of a person from the point of view of their parents. This utility flow is in addition of that associated to consumption. This gives an additional parameter to estimate.

3.1 The adult agents' decisions

The only decisions that households make are how much to consume, how much to invest in the boy and how much to invest in the girl. Therefore, households without children do not have any choice to make and they limit themselves to consume their income. Those with children do have decisions to make.

3.1.1 The single female decision problem

Let's start by looking at the decision of a single female of any education with children, i.e, an agent of type $\{t, s\} = \{g, e, 0, 2\}$. We denote the value function of an agent as $V(t, s)$. The problem of a single mother is given by

$$\begin{aligned} V(f, e, 0, 2) = \max_{c, y^f, y^m} \; & u\,(c, s) \\ & + \beta\,(1-\psi) \left[\phi \sum_{z'} \sum_{n'} \Gamma^{f,e}_{0,z'} \; V(f, e, z', n') + (1-\phi) \sum_{z'} \Gamma^{f,e}_{0,z'} \, V(f, e, z', 2) \right] + \\ & + \beta \; [\phi(1-\psi) + \psi] \; \sum_{g'} \sum_{e'} \sum_{s'} \; \gamma_{e'}(y^{g'}) \; \mu(g', e', s') \; V(g', e', s'). \end{aligned} \tag{1}$$

subject to:

$$c + y^f + y^m = \varepsilon_{f,e} \tag{2}$$

The terms in the first row of this expression refer to current utility and the value in case that the person does not age, which happens with probability $(1 - \psi)$. With probability ϕ the children emancipate and with probability $(1 - \phi)$ they stay at home. The terms in the second row refer to the utility achieved through the children upon their emancipation. Note that this occurs when the mother ages (probability ψ), and with probability ϕ when the mother does not age (probability $(1 - \psi)$. The utility of children is the sum of the utility of each weighted by the probability distribution that determines their type which is affected by how their education turns out to be via the child specific investments and the investment function γ_e, and via the distribution of marital status conditional on the own education μ.

We can write problem (1) more compactly as

$$V(t, s) = \max_{c, y^f, y^m} u\,(c, s) + \beta\,(1-\psi) \sum_{s'} \; \Gamma^t_{s,s'} \; V(t, s') + \beta \; [\phi(1-\psi) + \psi] \sum_{g'} E\,\{V(t', s')|y^g\} \tag{3}$$

The value for a single agent without children, be it a man or a woman is

$$V(t,s) = \quad u(\epsilon_t, s) + \beta\,(1-\psi) \sum_{s'} \; \Gamma^t_{s,s'} \; V(t,s'), \qquad\qquad s = \{0,0\}. \tag{4}$$

3.1.2 The married couple decision problem

Again, as was for single households, married households without children make no decisions. Married households with children decide how much to consume and how much to save. In our model, the two adults in the household see eye to eye with respect to the allocation of current resources. This is due to the assumption that the only way to carry resources into the future is via investment in the children (this investment only pays out if children emancipate) and to the fact that they have the same consumption and the same attitude towards children. These assumptions allow us to abstract from issues of bargaining within the household, and to solve the problem of one of the adults to obtain the households choices. The problem of a married adult is, in compact notation,

$$V(t,s) = \max_{c,y^f,y^m} u(c,s) + \beta\,(1-\psi) \sum_{s'} \; \Gamma^{t,}_{s,s'} \; V(t,s') + \beta\; [\phi(1-\psi)+\psi] \sum_{g'} E\left\{V(t',s')|y^g\right\} \tag{5}$$

subject to:

$$c + y^f + y^m = \varepsilon_{f,e} + \varepsilon_{m,z} \tag{6}$$

We denote the solutions to the agents problem as $c(t,s)$, $y^f(t,s)$ and $y^m(t,s)$.

As we can see this problem is essentially identical to that of a single mother. There are two minor differences: there are local increasing returns in household consumption (the index s is affecting the utility function) and males' earnings are in general higher than females' so typically married households have more resources at their disposal than single households do, and they can afford more investment as well as more effective consumption. Again, the value for the members of a childless couples obtained by letting consumption equal total income.

3.2 Law of motion of the adult population

The population need not be constant in this model. It depends on the rate at which childless women marry, which in turn depends indirectly on the educational decisions of the households as we will see later. The gross growth rate of the population is given by

$$\lambda = (1-\psi) \ + [\phi(1-\psi)+\psi] \sum_{z,e} x(f,e,z,2). \tag{7}$$

which is an affine function of the distribution of the population.

We can now renormalize the population each period to obtain a stationary population. Note that tomorrow's renormalized distribution of the population, x' can be obtained as a function of today population by

$$\begin{aligned} \lambda\, x'(g,e',z',n') = (1-\psi) \sum_{s} \ \Gamma^{g,e'}_{s,s'} \ x(g,e',s) \ + \\ [\phi(1-\psi)+\psi] \ \sum_{e}\sum_{z} \ \mu(g,e',z',n') \ \gamma_{e'}[y^g(t,z,2)] \ x(f,e,z,2). \end{aligned} \tag{8}$$

A stable population (one where all the groups have the same relative size) obtains when $x' = x$, and can be readily obtained as the solution of a linear system.

3.3 Competitive equilibrium

At this stage, we can readily define a stationary equilibrium since it is standard. It consists of a set of decisions rules for consumption $c(t,s)$ and expenditures in daughter and son's education $y^f(t,s)$ and $y^m(t,s)$, value functions $V(t,s)$, stationary distributions $x(t,s)$, and a rate of growth of the population λ such that: decision rules solve the maximization problem of individuals, and individual and aggregate behaviors are consistent. This requires that the stationary distribution of the population, x, which is a fixed point of equation (8), is consistent with people's beliefs about the probabilities of matching. Another way of stating this is that the distribution of males $x(m,.,.,.)$, and that of females $x(f,.,.,.)$ are consistent with each other, this is $x(f,e,n,z) = x(m,z,n,e)$ for all n and for all $z \neq 0$.

4 Restriction of the model by standard means: functional forms, demographics and earnings

We restrict the model by means of U.S. demographic and economic features such as the earnings-educational distribution and the marriage patterns across education groups. In this Section we describe the functional forms and the earnings and demographic targets for the baseline model economy.

4.1 Functional forms

There are three functional forms that we have to specify. Those that pertain to the utility function and to the probabilities of college and high school attainment given parental investments. For the temporary utility function, we choose a standard CRRA function with parameter σ, and a discount rate of β. The principal virtue of this type of function besides its popularity is the fact that it is unit independent. With respect to educational attainment, we assume that the probability of attending college given expenditure y is given by $\gamma_c(y) = 1 - \exp(-\alpha_1 \;\; y^{\alpha_2})$. We use two parameters in this function because we want to be able to match both the level and the derivative. If an individual doesn't attend college, the probability of attending high school is also increasing in parents expenditures, so $\gamma_h(y) = [1 - \gamma_c(y)][1 - \exp(-\alpha_3 \;\; y^{\alpha_2})]$. Then, we have one more parameter. To determine how expenditures in consumption translate into consumption enjoyed by each household member, we use the household equivalence scales of the OECD, where the first adult counts as 1, the second as 0.7 and each child as 0.5. Our choices of functional forms leave 5 parameters to be determined, $\{\sigma, \beta, \alpha_1, \alpha_2, \alpha_3\}$.

4.2 Demographics

We take the period to be a year because this simplifies the comparison between data and model statistics. We take adulthood to start at age 25. The reason for this late start is that we want to ensure that for all practical purposes, education is completed once agents are adults. We want agents to retire at age 65. The reason for this choice is not only because it nicely matches the most common retirement age of people allowing for a nice mapping between data and model, but also because we consider 40 years of age the maximum span of parenthood. These two calibration targets determine two parameters. These two choices restrict the two aging parameters ψ and ϕ.[1]

The marital status transition probabilities, $\Gamma^{g,e}_{z,z'}$ can be obtained directly from the data and this is what we do. However, consistency requires that the two transition matrices yield that the number of males of education group $\hat{e}$ married to females of education group $\tilde{e}$ is equal to the number of females of education group $\tilde{e}$ married to males of education group $\hat{e}$. Unfortunately this is not likely to be the case because of sampling error in the data, and because the distribution of education in the data is not stationary (so estimates of marriage transitions need not be consistent). To deal with this issue, we take the the educational distribution for males and females from the data as well as the transitions for females. We then adjust when required the transition of males so that the consistency requirement is satisfied.

Unless otherwise stated, when we look at the implications of various models, we take these transitions as the ones expected by the agents instead of taking those that would be consistent with each version of the model. This allows us to isolate the different effects that we are trying to understand.

[1] While the aging of adults can be fixed independently of all other parameters, that of young agents cannot. The reason is that young agents sometimes age at the same time as their parents and some time alone. This means that the age distribution of adults at first birth matters for the aging of children unless we correct it, which is what we do to ensure that all children's expected age at becoming adults is 25 years.

4.3 Earnings by education, gender and marital status

We take directly from the data the distribution of earnings by education, gender and marital status. We assume that there are no life cycle features in the earnings profiles. Therefore, we take the earnings of the different groups as being those reported in Table 3.

4.4 Fertility by education

An important feature of our model that we have to take into account is that the average number of children that a person leaves behind depends on the average fraction of time that this person has children,[2] and and this varies by sex and educational groups. This introduces a spurious reward to education, in particular when using preferences with more curvature than log where the larger the number of children, the worse off parents are. In the baseline model we normalize preferences by the expected number of children so that fertility does not affect education. We do so by multiplying the last term of equations (1) and (5) by a type specific coefficient that differs by age and sex. We calculate this coefficient in two steps by generating a large sample of I individuals of each $\{g, e\}$ over T periods and constructing an indicator function $\chi_{n>0}(i,t)$ that keeps track of each period that an individual has children. We then build a variable $a(g,e)$ that takes into account the number of periods and its distance into the future

$$a(g,e) = \sum_{i=1}^{I} \sum_{t=1}^{T} \ \chi_{n>0}(i,t) * \beta^{t-1} * (1-\phi)^{t-1} * (1-\psi)^{t-1}. \tag{9}$$

We construct our adjustment factor as the inverse of the ratio between the variable so constructed and its mean across types.

$$b(g,e) = \frac{\sum_{g=f,m} \ \sum_{e=c,h,d} \ a(g,e) \ \ \mu(g,e)}{a(g,e)}. \tag{10}$$

[2]The actual mechanism through which this happens is the age of first marriage.

Differences in fertility are still present since the number of children affects effective consumption of their parents. This mechanism just normalizes the expected utility from the progenie but not the costs.

When we do this adjustment, there is no longer agreement within the couple about investments in children relative to consumption since the two members have different effective discount rates. However, this is not very important for our purposes because there are no differences in the assessment of the son and the daughter. We deal with this issue by given the decision power to the mother.

5 The difficulties of the baseline model economy in generating attainment differences

In this Section we describe our estimates of the baseline model economy, and its failure to account for the SCAR. We start by estimating our baseline model without targeting the SCAR, and then we ask what are the predictions of the baseline model for the SCAR. In Section 5.1 we discuss our choice of targets, in Section 5.2 we explain the main finding of the baseline model and how it is affected by the various elements that conform the baseline model. In Section 5.3 we document how the problems of the baseline model economy are not solved even when attempting to estimate the model by targeting the SCAR directly.

5.1 Calibration targets

We estimate the model by targeting the main features of male college and high school attainment and a given level of educational expenditures. We do so by choosing parameter values of the educational attainment investment technology. Specifically, we have five parameters to estimate, investment technology parameters, $\{\alpha_1, \alpha_2, \alpha_3\}$, the discount rate β and the coefficient of risk aversion, σ. We estimate the technology parameters and we assume values to preference parameters that are standard in the macroeconomic literature, (σ =1.5 and $\beta = 0.95$). Table 8 reports the targets that we use for the baseline economy. They pertain to the educational attainment of males and to the size of the expenditures in education. Note that the male high school graduate

Table 8: **Targets for the Baseline Model**

Variables	Targets
Fraction of College Males	31.0
Fraction of High School Males	49.0
Education Expenditures/ Consumption (in %)	8.0

target is 49.0% instead of the 54.9% present in the data. The reason is that the distribution of males and females in the model have to be consistent with each other and this is not feasible with the numbers in the data for the reasons adduced above. The technological parameters that implement in the model economy the male educational attainment are α_1 =6.06, α_2 =0.83 and α_3 =29.84.

We now turn to look at the implications of the basic model for female college attainment and, hence, for the college attainment ratio as well as for the intergenerational persistence that it implies.

5.2 The key finding of the baseline model and its determinants

So what is the prediction of the baseline model economy for the SCAR? A whopping 38.8%, which implies a ratio of male to female college attainment of 80.0%, and hence a dramatic failure of the baseline model of accounting for the SCAR in the data.

In order to understand the role of the various factors that shape the behavior of the basic model, we report the implications for the SCAR of a set of alternative model economies that share some, but not all, of the properties of the baseline model economy. In particular, we use the same estimates for the investment technology that we obtained for the baseline economy, and we change some specific feature with respect to the baseline model economy. This procedure means that these economies will not achieve the calibration targets unless we free any additional parameter. We adjust parameter β in order to get the same college attainment for males of the data and we look at the implied sex college attainment ratio. We show the results of these experiments in Table 9. To analyze these economies we decompose them into those where education affects earnings solely and those where education affects earnings and marriage formation.

5.2.1 Education affects earnings.

We start looking at a group of economies where there is no marriage and no further descendants (no grandchildren). In other words, education only affects earnings. These economies are in the first grouping of Table 9. The first row reports the SCAR that results from optimal investment behavior of parents that try to maximize the present discounted value of their children's earnings (this is linear utility). Under this assumption the higher returns of males' education carries all the weight of the parental decision, and only the curvature of the production function limits the investment in males generating a SCAR larger than in the data. The second row introduces a little bit of curvature in the utility function, far less than what most economists are comfortable with, but enough to reduce the SCAR to a lower level than the data, even if larger than 1.

For the sake of comparison, we next use the curvature measured by Behrman, Pollak and-Taubman (1986) which is almost log ($\sigma = 0.95$). With this curvature, females go to college much more often than with the lower value used in the second row. When we use $\sigma = 1.5$, the value in the baseline, females go a lot more often to college than men, almost 80% more. The reason is that women, and in particular uneducated women, have a lot lower earnings than men, and because of the risk aversion, the extra consumption that education allows women is more valuable in utility terms than that of men from the point of view of the parents.

Table 9: **The SCAR in variations of the Baseline Model Economy (adjustment in β)**

	College attainment ratio
Data	1.57
1. Education Affects earnings	
Direct return to investment (linear utility)	1.98
Utility curvature $\sigma = .25$	1.41
Behrman et al. curvature, $\sigma = .95$	0.76
Our baseline curvature	0.56
2. Education affects matching behavior	
All people marry, random sorting	3.29
All people marry, data sorting	1.11
Data marital status, random sorting	1.01
Data marital status, data sorting	0.88
Data marital status, data sorting, Behrman et al. curvature	0.94
Data marital status, data sorting $\sigma = .25$	1.01
Baseline (with children)	0.80

5.2.2 Education affects matching behavior.

But males and females do not live alone, most of them marry. The next group of exercises in Table 9 looks at economies where people marry and share consumption equally with their spouses and where the risk aversion parameter has the baseline value of 1.5. In the first row of this table, we show the SCAR when parents think that their children marry with uniform probabilities immediately after they are born and they stay married forever. In this context, most of the consumption of females comes from their husbands' earnings and, consequently, there is very little incentive to spend in the education of females because it does not contribute very much to their consumption. Not surprisingly, the college attainment ratio is huge.

The second row takes into account that education of an agent affects the likelihood that its spouse is also educated while still assuming that all agents are married all their life with the same partner. This assortative sorting induces a large increase to the returns of education for women since it includes the earnings differential of the more educated husbands that educated women are likely to marry (if the assortative sorting were perfect, then there would not be any differences between males and females consumption despite the differences in their earnings). This feature dramatically reduces the college attainment ratio to almost one. The next row of Table 9 drops the assumption of all agents being always married to the same person and substitute it by the marriage and divorce probabilities of the data, but without assortative mating. There is another phenomenal drop in the college attainment ratio when we account for the fact that many women will be single large periods of time. The next row puts these two features together: accounts for marriage and divorce and marriage mating is assortative. The two effects combined lower the college attainment ratio to 0.88, a far cry from the 1.57 of the data. Note that at this stage, using utility functions with lower coefficient of risk aversion do not change the outcomes much (this is shown in the last two rows of the second group of exercises in Table 9).

The last row is just the baseline model economy where we explicitly account for the fact that there are children, and here there is a further reduction in the college attainment ratio to 0.80. This reduction is due to the fact that upon divorce children are attached to the mother, which in turn implies a lower consumption level for divorced mothers given that they have to feed their children. Poverty is now a bigger problem for females.

To summarize we see that the predictions of the model with regard to college attainment of females relative to males can be traced back to the curvature in the utility function, to the fact that people live single for long periods of their lives, to the fact that there is substantial assortative mating, and to the fact that agents have dynastic preferences. We see that both the marriage patterns of the population and the risk aversion of agents play a similar role quantitatively while caring for grandchildren may be slightly less important.

5.3 A direct route to the SCAR via the choice of risk aversion

A possible route to account for the SCAR could be by choosing directly the appropriate curvature of the utility function as discussed in Behrman, Pollak andTaubman (1986). We pursued this line by reestimating the economy adding risk aversion as a parameter and the female college attainment ratio as a target. Our best estimates are in Table 10. We see that even with values of σ as low as 0.4, the model cannot reproduce the calibration targets. Differences in consumption between single men and single women are not enough to provide an incentive to invest more in boys than in girls. In addition, this exercise is useful to illustrate that we should not treat risk aversion as a completely free parameter because it plays a crucial role in shaping the intergenerational persistence of education, the lower the risk aversion the lower the intergenerational persistence in education in the model. The persistence of education for males is almost zero. The ratio between the probability of attending college for boys with a college educated father and for boys with a high school educated father is 1.0 and the same ratio between those with a college educated father and those with a dropout father is 1.1 (1.8 and 3.3 in the data).

Table 10: **Calibrating σ**

Variables	Targets	Model
Fraction of College Males	31.0	22.0
Fraction of High School Males	49.0	46.0
Fraction of College Females	19.7	22.0
Education Expenditures/ Consumption (in %)	8.0	4.0
Parameters		
α_1		0.52
α_2		0.19
α_3		1.86
σ		0.40

We conclude from this exercise that the direct estimation of the risk aversion parameter does not yield a better understanding of the SCAR.

6 Alternative theories of the college attainment ratio

Next we explore five alternative theories as possible candidates to account for the SCAR, all these theories encompass a possible enhancement of the returns to the education of males. In Section 6.1 we explore the implications of education giving fathers an advantage in educating their own children, in Section 6.2 we look at what happens when individual earnings give an advantage in the allocation of consumption within biparental households, in Section 6.3 we explore the implications of parents preferring boys and, finally, in Section 6.4 we look at what happens when college attainment is more expensive for females, and in Section 6.5 we explore the implications of explicitly accounting for the fact that education affects the number of children in different ways for both sexes.

All these alternatives imply at least one extra parameter in the calibration process. We set as the extra target the SCAR. This means that to assess these various theories we have to look at their implications for statistics other than those we calibrate the models to. These other statistics are ratios of educational attainment among the sexes by education of the parents. In addition, and given the findings of Section 5.3, to explore these theories we estimate risk aversion directly using as an additional target the intergenerational persistence of education for males as measured by the ratio between the probabilities of college attainment for boys with a college educated father and boys with fathers that are high school graduates.

6.1 Education gives an investment advantage

We target the SCAR with a model in which college educated fathers have a comparative advantage in educating their children. There exists independent evidence that educated parents have an advantage educating their children, as is documented by Haveman and Wolf (1995). This new feature means that, a priori, there is an extra incentive to educate boys instead of girls. Technically, we implement this theory by letting parameter α_1 depend on the father's education by distinguish α_1^c for individuals with college father and α_1^{hd} for the rest of individuals.

We find that giving this advantage to college fathers doesn't increase the incentives to invest in boys versus girls. Our finding is that this feature cannot accomplish the SCAR. Even when we attempt to specify the economy by maximizing the SCAR subject to satisfying the other calibration criteria, we find it hard to obtain a SCAR above 1. Table 11 shows one of the best outcomes. We see that even though the model economy does give an advantage to college

Table 11: **Education gives an investment advantage**

Variables	Targets	Model
Fraction of College Males	31.0	40.0
Fraction of High School Males	49.0	57.0
Fraction of College Females	19.7	45.0
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.77	1.71
Education Expenditures/ Consumption (in %)	8.0	15.0
Parameters		
α_1^c		6.36
α_2		0.80
α_3		32.62
α_1^{hd}		4.00
σ		0.50

educated fathers, this is insufficient to overcome the problems that we have described above, even with a relatively low risk aversion parameter. So we conclude that advantages in fathers' education cannot account for the SCAR.

6.2 No income-pooling

We next explore the implications of allowing the consumption allocation within biparental households to depend on the relative earnings of the two spouses by letting individual consumption depend on relative earnings as suggested in Echevarria and Merlo (1999). They have a model with linear utility in which children are a public good inside marriage, and males transfer part of their earnings to their wives (that have lower earnings due to time devoted to children instead of the market) to avoid the dissolution of marriage. Their model implies a lower education gender gap than a model in which parents don't take into account this compensation effect.

In this framework biparental households maximize the weighted utilities of each member of the couple, with the weight of each spouse depending on his/her individual relative earnings through a parameter θ. The utility of the wife is weighted by

$$\gamma_f = (1-\theta)\, 0.5 + \theta \frac{\varepsilon_{f,e}}{\varepsilon_{m,e}+\varepsilon_{f,e}}, \tag{11}$$

Note that if $\theta = 0$ we are in the baseline with perfect sharing, while for $\theta \in [0, 1]$, the weight is increasing in the female's share of household earnings. This specification may or may not generate a SCAR like the data, the reason is that if now households members consumption depend on their earnings, then the rate of return of all agents goes up and this may make investments in females education more attractive than on males.

To sort these issues we start by looking at the implications of having individual earnings play a role within the standard values for risk aversion and the technological parameters estimated in the baseline model economy, and using the discount rate to match males college attainment. We do this by looking at a variety of economies differing in θ. We find that this mechanism plays a small role. For example, for $\theta = 0.25$ the SCAR is 0.78, (versus 0.80 in the baseline economy), 'and for higher values of the parameter we get lower values of the SCAR.

We continue by jointly calibrating θ and with $\{\alpha_1^c, \alpha_1^{hd}, \alpha_2, \alpha_3\}$, adding the SCAR as a target. We use the distinction of educating technolofy between college educated fathers and the rest to get a reasonable amount of intergenerational persistence.[3] We do this exercise for various values of the risk aversion parameter. We find that only for $\sigma = 0.25$ or lower (very small curvature of the utility function), it is possible to use θ to match the sex college attainment ratio (Table 12 shows the estimates). Even though the estimate for θ is 0.92 quite different than the value of 0. implied by the baseline model economy, the properties of this economy are quite similar to those of the baseline indicating that no income–pooling is not a quantitative mechanism to induce changes in investment.

Moreover, the behavior of the overidentifying restrictions is not very supportive for this theory either. Table 13 shows the properties of model economy for the persistence and cross–section

[3] We do not report the economy where we assumed no educational advantage for college educated fathers because its implications for persistence were dramatically counterfactual.

Table 12: **No income-pooling**

Variables	Targets	Model
Fraction of College Males	31.0	31.0
Fraction of High School Males	49.0	49.0
Fraction of College Females	19.7	19.7
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.77	1.77
Education Expenditures/ Consumption (in %)	8.0	8.0
Parameters		
α_1^c		2.03
α_1^{hd}		1.13
α_2		0.45
α_3		4.64
θ		0.92

statistics. The predictions of the model in terms of intergenerational persistence of education are quite bad. Essentially, the model economy has very similar SCAR by father's education while the data has larger SCARs for the low educated. In addition the model also has very little persistence of education.

Table 13: **No income-pooling (overidentifying restrictions)**

	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	1.83	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	1.85	2.72
College Attainment Ratio | father coll	1.44	1.21
College Attainment Ratio | father high	1.67	1.50
College Attainment Ratio | father drop	1.69	2.13

6.3 Parents prefer boys

It can be always argued that specific preferences account for the outcomes: if parents care more about boys, they would invest more in their education than in the education of girls. To implement this preferential difference we pose parents as having a gender specific coefficient to discount the utility of their children. Table 14 in the appendix shows the estimates that we obtain and shows that the calibration was successful while Table 15 shows the implications of the model for the statistics that we use as overidentifying restrictions.

Table 14: **Parents prefer boys (targets and estimates)**

Variables	Targets	Model
Fraction of College Males	31.0	31.0
Fraction of High School Males	49.0	49.0
Fraction of College Females	19.7	19.7
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.77	1.77
Education Expenditures/ Consumption (in %)	8.0	8.0
Parameters		
α_1		6.36
α_2		0.98
α_3		32.52
β_f		0.21
σ		2.28

Again the properties of the overidentifying restrictions make us reject this as a good theory of the SCAR. The SCAR is essentially constant for all education groups of the father while there are important differences in the data. This model says that the education of the parents has nothing to do with the SCAR, the data shows that the the SCAR is almost twice as large among dropout fathers than among college educated fathers. The model also is a little bit off in its predictions of the intergenerational persistence of education. All this leads us to conclude that preference for boys is not a good explanation for the SCAR in the U.S. in the 1970s. This conclusion agrees with the findings of Behrman, Pollak and Taubman (1986) using US data from the mid 1980s (they use the Minnesota Twin Registry) to ask the same question.

6.4 College attainment more expensive for women

The next theory that we explore is that males and females differ in the way they acquire education. We do not assume that males are easier to educate, instead we assume that there is home production by females, but not by males, and that home production is a decreasing function of

Table 15: **Parents prefer boys (overidentifying restrictions)**

	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	2.89	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	3.06	2.72
College Attainment Ratio | father coll	1.54	1.21
College Attainment Ratio | father high	1.45	1.50
College Attainment Ratio | father drop	1.58	2.13

the expenditures on her education.[4] Our assumption can be interpreted as implying that the more resources the parents spend on their daughters' education the less time those daughters devote to home production. Specifically, we assume that young females produce consumption according to the following home production function

$$\delta_1 \ \ \exp(-y_f^{\delta_2}). \tag{12}$$

Home and market goods are perfectly additive, so that total consumption of the household is

$$c + \delta_1 \ \ \exp(-y_f^{\delta_2})$$

Note that this functional form is rich enough to have the mean and the derivative independently determined. Posing two additional parameters, δ_1 and δ_2 requires two additional targets to calibrate this version of the model. We choose in addition to targeting female college attainment to target the ratio of household production over consumption at 8%, what we deem is a reasonable estimate for the daughter's contribution alone. The estimation of this model economy presents some problems. We must fix a different target for the ratio education expenditure over consumption, 5%. Table 16 shows what is perhaps the best configuration that we managed to obtain. In it the risk aversion parameter is slightly higher than the baseline. The problems in the estimation of this economy arise because unrestricted estimates try to yield non–convex technologies ($\alpha_2 > 1$) which is inconsistent with the use of first order conditions to characterize

[4]This can be thought of as arising from a Leontieff type technology, where the input to investment requires both real resources and time of the children, and where the time of males has no alternative use.

parental behavior.

Table 16: **Female more expensive to educate (estimates targeting persistence)**

Variables	Targets	Model
Fraction of College Males	31.0	31.0
Fraction of High School Males	49.0	49.0
Fraction of College Females	19.7	19.7
Household Production / Consumption (in %)	8.0	8.0
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.77	1.77
Education Expenditures/ Consumption (in %)	5.0	5.0
Parameters		
α_1		8.28
α_2		0.95
α_3		37.97
δ_1		-1.13
δ_2		-0.22
σ		1.78

Table 17 shows the performance of this economy in terms of the non targeted statistics. First note that the persistence of education as measured by the ratio of college to dropout fathers is too low (the ratio of college to dropout mothers is actually not bad). However, the model has extraordinarily counterfactual implications for the SCAR by education of the father: the predicted SCAR for dropouts is huge, 30 times larger than the data. Essentially, this model requires poor parents to be unwilling to invest in their daughters. In this model the poverty associated with the lack of education makes very expensive to invest in daughters and hence to give up the home produced good. As a result the model generates too much of income induced differences in the SCAR.

Given the excessive SCAR for families where the father is a dropout, we also tried a different calibration strategy: to target this statistic instead of the persistence statistics that we have been using. Table 18 suggests that this strategy provides some support to this theory as the model is able to replicate some of the properties of the overidentifying restrictions. The persistence statistics, while smaller than their data counterparts, are of reasonable magnitude, and the cross–sectional behavior of the SCAR has the same features as the data, it moves inversely to

Table 17: **Females more expensive to educate: Overidentifying restrictions (targeting persistence)**

	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	2.15	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	2.64	2.72
College Attainment Ratio | father coll	1.26	1.21
College Attainment Ratio | father high	1.36	1.50
College Attainment Ratio | father drop	62.02	2.13

fathers' education[5]

Table 18: **Females more expensive to educate: Overidentifying restrictions (targeting dropout males' SCAR)**

	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.57	1.77
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	2.22	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	2.47	2.72
College Attainment Ratio | father coll	1.39	1.21
College Attainment Ratio | father high	1.63	1.50

We can use the previously described theory of educational advantage of college educated parents to improve on the performance of this model in terms of persistence. We have four different specifications of this dependence: through the mother's education, the father's, either of them, and only when both are graduates. When we do it, results are shown in Table 19, the predictions of the model in terms of persistence improve, as we expected, and the performance in terms of sex college attainment ratio across education groups remains the same.

All of these models overpredict persistence via the mother. Of the four specifications the one that predicts better the statistics is the one giving the advantage to the father, the others implied an even bigger persistence through the mother.

[5] Applying this strategy to the previously studied theories does not work since its implications are to increase the SCAR for all groups in a relatively uniform manner which is counterfactual.

Table 19: **Females more expensive to educate with parental educational advantage: Overidentifying restrictions (targeting male's dropout SCAR)**

	Father	Mother	Either	Both	Data
$Prob($ coll | fath coll$)$ / $Prob($ coll | fath drop$)$	2.52	2.61	2.57	2.53	3.27
$Prob($ coll | moth coll$)$ / $Prob($ coll | moth high$)$	1.70	2.03	1.74	1.89	1.17
$Prob($ coll | moth coll$)$ / $Prob($ coll | moth drop$)$	2.74	3.18	2.82	2.94	2.72
College Attainment Ratio | father coll	1.40	1.40	1.41	1.40	1.21
College Attainment Ratio | father high	1.63	1.64	1.63	1.64	1.50

6.5 Education affects fertility

So far we have abstracted from differences in the number of children by normalizing expected family size so that it is independent of education. In this section we allow explicit differences in the number of children (we don't adjust for differences in the number of periods that individuals live with their children). An important feature of the the CRRA preferences that we have been using is that the value of the risk aversion coefficient, σ, not only determines the value of risk aversion and of the intertemporal elasticity of substitution, but also determines the value of a life. In particular, less curvature than log implies that kids are a good thing and more curvature than log that they are a bad thing. This feature implies that when fertility may matter we have to use a different set of preferences to separate risk aversion from the value of the number of children. We choose to use the following utility function

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} + \overline{U},$$

where $\overline{U}$ can be thought of a term that determines the value of life. One more parameter requires one more target, and we choose the ratio of college attainment when the father is college educated over college attainment when the father is a high school graduate, that is 1.77 in the data.

Given that in the model the relation between fertility and education is partly due to the way in which we have modeled the marriage dynamics, we need to establish that the fertility differentials across education and sex groups in the model and in the data have very similar properties. Table 20 shows this. It reproduces the information in Table 7, and it reports the differences in fertility generated by the model. We see that they are very similar: both the model and the data feature a negative relation between education and fertility and, more importantly for our purposes, this negative relation is more acute for women.

Table 20: **Fertility by Sex and Education levels in the model and in the data**

	College	High School	Dropout
Data			
PSID Data: total number of children of those 26-65 in 1968			
Females	0.72	0.86	1.00
Males	0.78	0.87	0.93
Model			
Females	0.85	0.88	1.00
Males	0.77	0.80	0.76

All numbers normalized to children of a dropout female. Parental ages are 25-35

6.5.1 Calibration when fertility is taken into account

Recall that the baseline version of the economy that accounts for fertility has 4 parameters to calibrate (given that we take risk aversion and discounting as fixed). They are the three parameters for the investing technology and the absolute value of life, $\overline{U}$, and we use as targets male college and high school attainment, expenditures in education and the ratio of the probabilities of college attainment of sons of college educated fathers and of sons of fathers that are high school graduates. This exercise does not attempt to target the SCAR. We report the estimates in Table 21.[6] Again, we find that for this baseline calibration the predictions of the model in terms of college attainment of women are quite wrong. The sex college attainment ratio is 0.67, even lower than in the model without accounting for fertility differentials. On other dimensions

[6]Note that again there are problems with the convexity of the technology. To avoid these problems we rise the target for expenditures in education.

such as intergenerational persistence the model does actually quite well as Table 21 shows. We now proceed to improve the performance of the model by adding slight changes.

Table 21: **Baseline model that accounts for fertility**

Calibration		
Variables	Targets	Model
Fraction of College Males	31.0	31.0
Fraction of High School Males	49.0	49.0
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.77	1.77
Education Expenditures/ Consumption (in %)	10.0	15.0
Parameters		
α_1		6.03
α_2		0.98
α_3		34.05
$\overline{U}$		1.84
Overidentifying Restrictions		
	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	3.02	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	2.91	2.72

6.5.2 Explicitly targeting the sex college attainment ratio

We now explicitly target the SCAR in the context of this model. We do so by substituting the persistence statistic as a target and instead using the SCAR. Table 22 shows how successful this strategy proves to be since the targets are almost exactly achieved.[7] The values of the parameters change from the ones in the previous economy with a higher raw value of life, $\overline{U}$. In addition, the predictions of the model for the cross–sectional distribution (by education groups) of the SCAR are quite good. However, the persistence implied by this model economy calibration is much lower than in the data (except, obviously, for the statistic that we use for the calibration).

[7] To avoid estimates of the investment technology that yield a non convex choice set, we reduced the target for investment expenditures.

Table 22: **Targeting female college attainment in the model with fertility**

Calibration		
Variables	Targets	Model
Fraction of College Males	31.0	32.2
Fraction of High School Males	49.0	50.8
Fraction of College Females	19.7	18.4
Education Expenditures/ Consumption (in %)	5.0	5.0
Parameters		
α_1		5.70
α_2		0.99
α_3		24.00
$\overline{U}$		6.37
Overidentifying Restrictions		
	Model	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath high)	1.27	1.77
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	1.56	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	1.77	2.72
College Attainment Ratio | father coll	1.48	1.21
College Attainment Ratio | father high	1.75	1.50
College Attainment Ratio | father drop	2.20	2.13

6.5.3 Further improvements of the model by giving educated parents an advantage in educating children

Persistence can be improved in one of two ways, by increasing risk aversion and by posing an advantage for educated parents in educating their children. We pursue the latter strategy given that risk aversion already has a reasonable value (1.5).

As we did in Section 6.1, we let parameter α_1 depend on parental education. Again, we try four different specifications of this dependence: through the mother's education, the father's, either of them, and only when both are graduates. We add as a target the persistence statistic that we have used above, the ratio of the probabilities of college attainment of sons of college educated fathers and of sons of fathers that are high school graduates. Table 23 shows the performance of each of the specifications of the model in terms of the statistics that we use as overidentifying restrictions.

Table 23: **College gives an advantage educating children**

	Father	Mother	Either	Both	Data
$Prob$(coll | fath coll) / $Prob$(coll | fath drop)	2.22	2.40	2.30	2.22	3.27
$Prob$(coll | moth coll) / $Prob$(coll | moth high)	1.57	2.48	1.67	2.02	1.17
$Prob$(coll | moth coll) / $Prob$(coll | moth drop)	2.37	3.47	2.57	2.81	2.72
College Attainment Ratio | father coll	1.35	1.31	1.35	1.32	1.21
College Attainment Ratio | father high	1.65	1.68	1.65	1.68	1.50
College Attainment Ratio | father drop	2.02	2.26	2.05	2.10	2.13

All the specifications that pose an educational advantage to the college educated parents do pretty well in accounting for the data. They obviously match the advantage of college educated fathers over high school educated fathers. They all pose a large advantage of college educated fathers over dropout fathers, but less than the data. Overall then, accounting for the lower fertility of educated women seems to be an important ingredient to understand the SCAR up to the seventies. Once we do this, a model that gives an advantage to the educated father in educating his children seems to be the best one, and one that is capable of accounting for the overidentifying restrictions of persistence via the maternal line. This result supports the one obtained before. All models with parental advantage do a great job of accounting for the cross–sectional distribution of the SCAR.

6.6 Summary from this section

Of the five theories that we have examined, two cannot match the SCAR and three can. College giving an educational advantage to the father is not capable of yielding the SCAR. Non-income pooling within the household is able to yield the SCAR, but only through very low values of the risk aversion parameter. Overall, these two specifications turned out to be behave very similarly to the baseline model economy.

The theory that states that parents care more for boys is capable of generating the SCAR for suitably chosen parameters. However, its implications for its cross–sectional distribution are counterfactual. In the data the education specific SCAR is lower for highly educated people, while in this model is flat.

The theory that states that females are more expensive to educate is more effective. It requires that the estimation targets the SCAR for families with a father that is a dropout. When this is the case, the model can achieve the SCAR in the data while generating a persistence that is slightly lower than the data. The cross–sectional distribution of the SCAR is a little bit off but it is like the data. The performance of the model further improved by adding an educational advantage to college fathers that increases the overall persistence.

The specification that takes into account the educationally induced differences in fertility can also account for the SCAR. Its performance is especially good when we allow the college educated father to have an an educational advantage. We consider this theory slightly better than that of females being more expensive to educate because it is based on observables (differences in fertility rather than home production), and because it is more parsimonious (it does require less parameters).

7 Conclusions

In this paper we have looked at the question of what accounts for the SCAR value of 1.6 of the 1970's. We documented this feature of the data as well as related ones. We showed that simple models based on returns to investment and curvature in the utility function predict that if parents are equally altruistic towards their children, then females should have attended college more than males. We also showed how taking into account family formation is very important. We then explored various alternative theories that can rise the returns to college for men relative to women. We found that two alternative theories can account for the data: one that imputes a higher cost of education for females and one that takes into account that college education induces a sharper decline of fertility for females relative to males. Both these theories are improved when giving a college educated parent, particularly the father, an advantage to educate their children.

The next step in this research is to account for the dramatic reduction in the SCAR of recent years, taking into account the evolution of the relation of education with earnings, marital status and fertility.

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Appendix

A The measure of life-cycle earnings

A.1 Individual life-cycle earnings

We obtain a measure of life-cycle earnings by sex, education and marital status. We use data from the Panel Survey of Income Dynamics 1976, in which information of wages and hours worked refers to the previous year. The measure of potential life-cycle earnings we built is computed considering people in and out of the labor market. For people out of the labor market we estimate a wage per hour according to their characteristics. To impute wages we use the wage equation below. This equation includes as regressors, age, experience, educational level and Mills Ratio. **?** shows that the inclusion of this last regressor lets estimate the rest of the coefficients in the wage equation consistently, avoiding the problems related to sample selection typical in estimation of wage equations. For each sex we estimate the following regression:

$$\ln w_j = \beta_0 + \sum_{i=1}^{7} \beta_i \, x_{i,j} + \varepsilon_j$$

where $x_{1,j}$ is a dummy variable that takes the value 1 if the individual has 4 or more years of college and zero otherwise, $x_{2,j}$ is a dummy variable for having finished high school but not graduated from college, $x_{3,j}$ is age, $x_{4,j}$ is age square, $x_{5,j}$ is labor experience, $x_{6,j}$ is labor experience squared and $x_{7,j}$ is the Mills ratio, obtained through the estimation of a Probit model on the employment decision.

After imputing wages to people that are out of labor market we obtain average wage per hour, $\overline{w}$, and average annual hours worked, $\overline{h}$, for seven groups of age $\{25-29, 30-34, \cdots, 60-64\}$. We build a measure of life-cycle labor earnings at the beginning of the adult life by sex, $g = \{f, m\}$, education, $e = \{c, h, e\}$, and marital status, $d = \{\text{single, married}\}$, that result from the discounted sum of labor earnings along the life-cycle. We use an interest rate of $r = 4\%$ to discount earnings:

$$\varepsilon_{g,e,d} = \sum_{t=1}^{7} \overline{w}_{g,e,d}(t)\overline{h}_{g,e,d}(t) \left(\frac{1}{1+r}\right)^{(t-1)*5} \left(\frac{1-\left(\frac{1}{1+r}\right)^4}{1-\left(\frac{1}{1+r}\right)}\right),$$

We are assuming that there are no cohort effects.

In Table 6 we report $\sum_d \mu(d)\, \varepsilon_{g,e,d}$, where $\mu(d)$ is the distribution of the population across d.

A.2 Household life-cycle earnings

In building this measure we assume that married individuals equally share their earnings with their spouses. Let $z \in \{0, c, h, d\}$ be the marital status of the individual: single, married with a college spouse, married with a high school graduated spouse or married with a high school dropout. Given the distribution of the population by marital status in age group 25-65, $\mu(z)$, we can build a measure of the expected earnings of an individual of sex g and education e, $\hat{\varepsilon}_{g,e}$. Then,

$$\hat{\varepsilon}_{g,e} = \sum_{z} \mu(z) \left[\left(\frac{\varepsilon_{g,e,z} + \varepsilon_{\bar{g},z,e}}{2} \right) I_{z>0} + \varepsilon_{g,e,z} I_{z=0} \right]$$

B Expressions for model objects: The transition for the individual states

The actual formula to get $\Gamma^{g,e}_{s,s'}$ from $\Gamma^{g,e}_{z,z'}$, and aging parameters ψ and ϕ is given by

$$\Gamma^{g,e}_{s,s'} = \Gamma^{g,e}_{(z,n),(z',n')} = \left\{ \begin{array}{cc} \Gamma^{g,e}_{(z,0),(z',0)} & \Gamma^{g,e}_{(z,0),(z',1)} \\ \Gamma^{g,e}_{(z,1),(z',0)} & \Gamma^{g,e}_{(z,1),(z',1)} \end{array} \right\} =$$

$$\left[\begin{array}{cc} \begin{pmatrix} \Gamma^{g,e}_{0,0} & 0 & 0 & 0 \\ \Gamma^{g,e}_{c,0} & \Gamma_{c,h} & 0 & 0 \\ \Gamma^{g,e}_{h,0} & 0 & \Gamma_{h,h} & 0 \\ \Gamma^{g,e}_{d,0} & 0 & 0 & \Gamma^{g,e}_{d,d} \end{pmatrix} & \begin{pmatrix} 0 & \Gamma^{g,e}_{0,c} & \Gamma^{g,e}_{0,h} & \Gamma^{g,e}_{0,d} \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \\ \phi_1 \begin{pmatrix} \Gamma^{g,e}_{0,0} & 0 & 0 & 0 \\ \Gamma^{g,e}_{c,0} & \Gamma^{g,e}_{c,c} & 0 & 0 \\ \Gamma^{g,e}_{h,0} & 0 & \Gamma^{g,e}_{h,h} & 0 \\ \Gamma^{g,e}_{d,0} & 0 & 0 & \Gamma^{g,e}_{d,d} \end{pmatrix} & \begin{pmatrix} \phi_2 \Gamma^{g,e}_{0,0} & \Gamma^{g,e}_{0,c} & \Gamma^{g,e}_{0,h} & \Gamma_{0,d} \\ \phi_2 \Gamma^{g,e}_{c,0} & \phi_2 \Gamma^{g,e}_{c,c} & 0 & 0 \\ \phi_2 \Gamma^{g,e}_{h,0} & 0 & \phi_2 \Gamma^{g,e}_{h,h} & 0 \\ \phi_2 \Gamma^{g,e}_{d,0} & 0 & 0 & \phi_2 \Gamma^{g,e}_{d,d} \end{pmatrix} \end{array} \right] \quad (13)$$

where $\phi_1 = (1 - \psi)\phi + \psi$ and $\phi_2 = 1 - \phi_1$.