What Accounts for the Increase in the Number of Single Households? *

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Abstract

Between the early 1970's and the late of the 2000's the share of single females grew dramatically in the U.S. (from 21% to 32%). So did the share of single mothers (from 10% to 14%). At the same time relative wages within and between sexes underwent huge changes. In this paper we measure the contribution that changes in relative wages had in accounting for these and other demographic facts. We construct a model where agents differ in sex, take marital status and fertility decisions and invest in their children's human capital. Our findings show that changes in relative earnings potential account for: *i)* sixty percent of the observed change in the share of single women, and *ii)* nearly all the observed change in the share of single mothers. This occurs mainly through a drop in the model economy marriage rate that mimics the pattern found in the data.
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1 Introduction

Between the early 1970's and the late 2000's the share of non-married females grew dramatically in the U.S. In the 18 to 49 age group it increased from 20% to 33%. This was accompanied by a steady growth in out of wedlock child-raising that increased the share of single mothers from 10% to 14% of the total female population, while total fertility remained constant over the same period.[1] During the same time period, relative wages both within and between sexes changed significantly in the U.S.[2] The wage premia within sexes widened, while the sex wage premium shrank.

The findings of a recent body of empirical literature imply that a change in household structure as large as that observed might have important consequences on human capital accumulation.[3] Moreover, children's outcomes are shown to be affected by the type of family children live in.[4] It is important therefore to understand what has determined this shift in marital status of the population.

The purpose of this paper is to measure the contribution that changes in absolute and relative wages between and within sexes had in accounting for the observed shift in the marital status of the U.S. population. To this end, we construct a model where agents differ in age and sex, search for a mate, make marital status, fertility and investment in their children's human capital decisions. We calibrate the model to the economic and demographic characteristics of the mid seventies. Then we recompute the equilibrium of the model after adjusting wages to match their values in the 2000's and compare the two sets of steady state allocations. We decompose the pattern of wage variation into three components: a general increase, a rise in the skill premium and a decline in the gender wage. This decomposition allows us to assess the role of each single component in accounting for the observed shift in marital status of the population from the mid seventies to the late 2000's. We find that in our model

[1] In the U.S. the total fertility rate was 2.00 in 1972 and 2.06 in 2000. See *Vital and Health Statistics, NCHS, Series 21 No. 28 and No. 57.*

[2] See Katz and Murphy (1992), Krusell, Ohanian, Ríos-Rull, and Violante (2000), Gottschalk (1997).

[3] Keane and Wolpin (1997) show that factors that take place in early stages of life are crucial determinants of children's later success. Neal and Johnson (1996) find that differences in educational achievements by the time of high-school completion account for almost all the observed black-white wage gap.

[4] McLanahan and Sandefur (1994) document differences in later achievements, in particular in terms of education, between children raised in single or in two parent families.

economy changes in wages account for: *i)* almost sixty percent of the observed change in the share of single women with a shaper increase among non-college women and *ii)* nearly all the observed change in the share of single mothers. This occurs mainly through a drop in the model economy marriage rate that mimics the pattern found in the data. The drop in the male-female wage gap is the driving force. The increase in within sex wage dispersion plays a minor but still important role. Our model economy also accounts for the increase in the positive assortative matching of couples observed in the data.

The baseline model economy matches remarkably well the set of demographic and economic statistics chosen for the calibration. However, to ensure a satisfactory calibration process we also look at properties of the model that we do not impose (a form of imposing a set of overidentifying restrictions) and we confirm that the baseline model economy matches the data along many dimensions. The baseline model economy accurately predicts that high wage men were married much more often than low wage men, it matches the number of households without children and it accounts for between a fifth and a third of the intergenerational earnings correlation reported by previous empirical work.[5] The last result is particularly interesting because it is achieved without introducing any genetic or peer group effect or comparative advantage by college graduates to affect the education of their children that would reinforce the positive correlation of outcomes between parents and children. Moreover, children who grow up in single female headed households have 23% more chance of becoming a low wage type when adults.

Associated with the changes in family structure, our model finds that under the new wage structure there are other important changes such as an increase of 12% in the intergenerational earnings correlation in the model economy. This result suggests that shifts in the marital status composition of the population might have reinforced the positive intergenerational correlation of earnings that is observed in the U.S. economy. Changes in the marital status of the model population are achieved mainly through a reduction in the marriage rate as observed in the data. As an additional independent validation of the model economy, changes in the wage regime leave women's fertility unchanged which is also consistent with the data.

The model that we use has additional features that we think are interesting by themselves.

[5]The estimates oscillate between .41 and .68. See Solon (1992), Zimmerman (1992) and Knowles (1999).

First, household formation and dissolution, fertility and investment in children's education are all simultaneously determined in the context of a growth model. Second, the intra-household decision process is solved by sequencing fertility and time and resource allocation decisions in a manner that avoids the need to explicitly model strategic behavior within a couple. Third, we convexify certain decisions to guarantee continuity of the operator whose fixed point is the Bellman equation. The convexification yields two important properties that are needed to use this model: it allows us to compute the solution, and it makes the statistics of the model continuous in the parameters of the model, a necessary condition for a satisfactory calibration process.

We build on the work of Becker and Tomes (1976), Becker and Tomes (1979) and their quality-quantity trade off model of parental fertility decisions. Unlike Knowles (1999), and Aiyagari, Greenwood, and Guner (2000) our model incorporates endogenous household formation and dissolution, endogenous fertility, and inter-temporal investment in the dynasty in the form of parents' investment of time and resources in children's education.

Other attempts in the literature to answer the question of what accounts for this observed marital status shift of the U.S. population have focused on the role played by sex-ratio imbalances and by welfare programs. Wilson and Neckerman (1987) looked at the reduction in the number of marriageable men due to incarcerations, unemployment and mortality rates and do not find that this can account for the facts. Hoyne (1997) found that there is no evidence that welfare contributed to increase propensities to form female headed households for either whites or blacks and that the already weak welfare effect found in previous studies is affected by an upward bias that basically disappears when individual effects are taken into consideration in the econometric set up. The role of welfare policies is hard to assess since while the share of single female welfare recipients among low wage women increased, the share of single female non-welfare recipients actually tripled (see Table 19).

In Section 2 we report the features of the data that we are most interested in. We turn to the model in Section 3 where we also define its equilibrium. Section 4 describes how we calibrate the baseline model economy to the main features of the data in the seventies, and discusses the main margins over which agents are making decisions. In Section 5 we carry out our measurement exercises by analyzing the equilibria of economies that differ from the baseline only in terms of absolute and relative wages. Section 6 concludes. In Appendix A we describe how we constructed our measure of wages, while in Appendix B there is a brief account of the computational procedures that we use to find equilibria. Finally, Appendix C shows some additional tables of interest.

2 Main Features of the Data

Most of our data are computed from the Panel Study of Income Dynamics (PSID). We look at men's and women's marital status, number of children and wages and sort them into wage groups. It is the behavior of these wage groups that we concentrate on.

We take all PSID females and males aged 18-49 years in 1973 and in 2007. We construct a wage measure using data on wages for the 1972-1975 and 2001-2007 periods[6] (see Appendix A for details on how we construct this measure), and then we divide them by their education attainment (college and non-college).

Table 1: **Demographic and economic characteristics of rich and poor women.**

	1974	2001	Change
Wages and marital behavior of women			
Fraction of singles among all women	0.196	0.332	69%
Fraction of singles among rich women	0.214	0.276	29%
Fraction of singles among poor women	0.183	0.369	102%
Fraction of single mothers among all women	0.101	0.144	43%
Fraction of single mothers among rich women	0.	0.	%
Fraction of single mothers among poor women	0.	0.	%

Source: PSID.

Table 2 shows the key statistics that we are looking at. First, note that the fraction of women living as single increase by just over two thirds. Second, the fraction of single mothers increases by two fifths. Third, in 1973 singles were much more prevalent among college women,

[6]The larger range in the years for the second period is due to the fact that the PSID survey was only completed every other year, rather than yearly.

Table 2: **Demographic and economic characteristics of college and non-college women.**

	1973	2007	Change
education and marital behavior of women			
Fraction of singles among all women	0.196	0.332	69%
Fraction of singles among college women	0.234	0.308	32%
Fraction of singles among non-college women	0.182	0.379	108%
Fraction of single mothers among all women	0.101	0.144	43%
Fraction of single mothers among college women	0.077	0.101	31%
Fraction of single mothers among non-college women	0.107	0.209	95%

Source: PSID.

but by 2007 there were more singles among non-college than among college educated women. Fourth, most of the increase in the number of single mothers comes from non-college mothers.[7]

Table 3: **Wage changes between the sexes and between college and non-college.**

	1974	2001	Change
Men's average absolute wage increase*	19.29	21.51	12%
Wage premium between men and women	1.748	1.412	-20%
Wage premium between college and non-college women	1.564	1.601	3%
Wage premium between college and non-college men	1.383	1.659	20%

Source: PSID.

* in 2007 $ and corrected for CPI mis-measurement.

These variations in household composition have been accompanied by large changes in absolute as well as in relative wages within and between sexes as shown in Table 3. The first column reports that women's wages have moved much closer to men's wages but are still considerably lower. Our measure of the sex premium corrects for changes in the relative education of the two sexes but not for the changes in the relative experience (see Appendix A

[7]Ellwood and Crane (1990) report that the decline in of married women was almost as large among whites as among blacks.

for details on how we constructed our measure of the sex premium). The last two rows in Table 3 show the increase in the relative wages between college and non-college. This is the well known increase in the skill premium.[8]

Table 4: **Marriage and divorce rates in the U.S.**

	1973	2007	Change
Marriage rate	0.137	0.078	-43%
Divorce rate	0.032	0.038	20%

Sources: Statistical Abstract and Vital Statistics of the U.S.

Table 4 shows marriage and divorce rates in those two years. We see that while the divorce rate has increased slightly during the period, the marriage rate has declined by 43%.[9] The main mechanism that accounts for the increase in the number of singles is, therefore, the drop in marriage rates.[10]

3 The Model

The model has overlapping generations of agents that live many periods and that differ according to various characteristics (sex, age, marital status, number of children, wage, education). Agents make decisions about the family they live in and about the investments they make in their children towards whom they have altruistic feelings. We start describing the demographics of the model in Section 3.1, then turn to the determinants of education and wages in Section 3.2. At this point we can describe the individual and the aggregate states of the economy and we do so in Section 3.3. We turn to agents' preferences in Section 3.4, while in Section 3.5 we discuss the special assumptions that we have made and we argue that they are appropriate in light of the goal of this paper. We describe the behavior of the agents in Section 3.6, which involves successive decisions on marital status, fertility and human capital investments decisions, inducing the division of each period in three subperiods. In Section 3.7

[8] See Katz and Murphy (1992), Gottschalk (1997) or Krusell, Ohanian, Ríos-Rull, and Violante (2000).

[9] Note that the notion of marriage that we use in the PSID is not exactly the same. In the data from the PSID we use permanent rather than legal partners, while divorce and marriage rates are for legal partners. Since most permanent couples are married we believed that the differences are small.

[10] The increase in divorce had already happened by 1973, it started in the mid sixties.

we describe how the population evolves over time while in Section 3.8 we define steady state equilibrium.

3.1 Demographics

Agents can be either males or females, $g \in \{m, f\}$, and one of four ages: children, young adults, old adults and old, $i \in \{1, 2, 3, 4\}$, and they age exponentially. In fact, both young and old agents may become retires, albeit at a different rate. Only adults agents make decisions. Agents start the period either single or married $q \in \{0, 1\}$. If single they live in a household without any other adult and if married they live in a household with another adult of the opposite sex. Agents choose whether they want to be married this period, which is identified by q', but the marriage only ensues if both prospective spouses want it. Changing spouse requires to stay single for at least a period. In households where a woman is present there may be children $n \in \{0, 1, 2, \cdots\}$. The women choose every period whether or not to have one more child $n' \in \{n, n+1\}$ regardless of their marital status. Therefore, during childhood, agents are attached to an adult female, their mother, who can be married or single. We further assume that the adults in the household do not know the sex distribution of their children.[11] The aging process affects all adults simultaneously and children become young adults when their parents become old. Women also keep the custody of the children upon marriage dissolution. Old agents become detached from their off-spring.

3.2 Wages and Education

Wages depend on sex, education, and age. Educational achievement depends on the investments made by the parents and we think of college attendance as the success.[12] Let $\psi(y, \ell, n)$ be the probability of college attendance. The arguments of ψ are investment in goods, y, time of the devoted to child raising by the mother ℓ, and number of children in the household n. Function ψ is increasing in its two first arguments and perhaps decreasing in the last one. It is convenient that function ψ satisfies the Inada conditions in the first two arguments to

[11] See below for details on why we make this assumption.

[12] Actually, as we will see below, we take it to mean to be in the top 40% of the wage distribution when we map it to the data. The reason is that the model does not distinguish children by gender and there were more college graduates among males than females.

ensure interior solutions to the maximization problems that we will define below. The time endowment of the mothers can be used either to invest in their children or to work in the market at the wage w. To save on notation, we use w and wage, to simultaneously refer to age and education. The evolution of w is given by transition matrix Γ_g, and hence that of w^* by Γ_{g^*}, but this matrix is characterized by only the aging probabilities.

3.3 The individual state

At the beginning of a period an adult agent is indexed, in addition to her sex that does not change, by the vector $\{w, q, n, w^*, \eta, \epsilon\}$, that we denote compactly as z, and that tells us what the agent's age/education is w, whether she is married $q = 0$ or not $q = 1$, how many children she has, n, what the age/education of the spouse or prospective spouse is w^*, and a pair of indices the quality of the match, η which is Markovian and ϵ which has continuous domain and is drawn from cdf $F_q^\epsilon(\epsilon)$. Note that we are using stars to denote prospective partner's variables, both for the age/education and the gender. An adult male with $q = 0$, and $n > 0$, means that n is the number of children of his date, since males cannot be single fathers. The two agents will only marry if both want do so. Finally, the quality of the match η from a partner that the agent just met is drawn from some γ_η distribution; if the partner is instead the spouse, then η follows a Markov process with matrix $\Gamma_\eta[\eta'|\eta]$. The Markovian part of the quality of the match η, is common to both agents, while the non-Markovian part is agent specific.[13]

3.4 Preferences

Every period, agents get utility $u_g(c, q, q', n', \eta, \epsilon)$. Agents care about consumption properly adjusted via economies of scale, which accounts for arguments, $\{c, q', n'\}$. Variables $\eta + \epsilon$ provide direct utility to the adult agents and we sometimes refer to it as love. Whether a married couple ($q' = 1$), is newly wed ($q = 1$) or not ($q = 0$) matters because the male does not like the children from a different father (this feature turns out to be important to prevent single women from improving their attractiveness for men by becoming single mothers). After one period, the male consider all children as his own. Females can place effort that reduces

[13]The non-Markovian nature of this variable guarantees that we do not have to worry about ϵ^*, the draw of the spouse.

their utility to affect the probability of getting another child. These two are the only features that make the gender of the agent affect preferences. We can write then the per period utility function as

$$u[c\,\phi(q',n')] + q'(\eta+\epsilon) - \chi(1-q)1_{n'>0}\,1_{g=m} - \xi e^2 1_{g=f} \tag{1}$$

where the first term is the standard utility function in terms of effective consumption (this is corrected by the economies of scale of family size), the second is love, the third is the possible distaste in amount χ that men have over the children of other men, and the last term is the disutility for females of placing effort in shaping their fertility.

Agents discount their own future utility at rate β. It is simpler to pose preferences of a gender g agent recursively and so we do

$$\begin{aligned} u\left(c,q,q',n',\eta,\epsilon\right) + \beta\,\pi(w)\,E\left\{V_g\left(w',q',n',w^{*'},\eta',\epsilon'\right)|w,q',n',w^*,\eta\right\} + \\ \beta\ \left[1-\pi(w)\right]\left\{\Omega^g\left(w,q',w^*,\eta\right) + b\left(n'\right)\ E\left[V\left(\bar{z}\right)|w,q',n',w^*,\eta\right]\right\} \end{aligned} \tag{2}$$

where the term inside the first expectation, V_g, is the value function that applies in the beginning of next period conditional on not aging; the last term is the utility that ensues upon getting old, with $[1-\pi(w)]$ being the probability of aging that in turn depends on the adult's age. Upon aging, agents get a direct utility that depends on their marital status, and own spouse's education which is given by function Ω and they also have altruistic feelings towards their children that show up as the expected value of function V evaluated at $\bar{z}$ times $b(n)$. We dropped the gender indicator of the value function to indicate that parents do not know the sex of their children, hence they take expected values. They weight the utility of multiple children with concave function $b(n)$.

A female can also exert effort to affect her fertility both to increase and to decrease the odds of pregnancy. Her utility function is augmented by the following term $-\xi\ e^2$ where e is the effort incurred.

3.5 Special features of the model

We have made many potentially controversial assumptions over the structure of households. In making these assumptions we have attempted to balance the commonly held notions of what is a family with our concerns. Fully specifying a model type requires solving a both a large set of equilibrium conditions and searching for a large number of parameter values capable of yielding allocations that resemble those of the data. This is a hard problem and we do not have a lot of room to spare to make assumptions that more accurately describe the institution of the family. In our model, agents naturally disagree on what they want in terms of marriage and fertility. We make many assumptions to achieve three important properties: 1) to have allocations that are continuous functions of the parameters and hence to make estimation possible; 2) to avoid thorny issues of joint decision making, so we do not have to pose either bargaining or Pareto problems within the household; 3) we want to keep the model manageable.

- The decision making is sequential. In each period agents take first the marriage decision, then the fertility decision and finally, the within period investment decision. There is agreement in the last one, the woman chooses fertility alone and both are required to agree to stay together.

- Utility is not transferable, hence there is no possibility for any of the prospective spouses to convince the other to stay. The decision of whether agents marry or not requires that both agree. This is handled by posing two shocks to indicate love. One, η is common and follows a Markov process with finite support and transition $\Gamma_{\eta,\eta'}$. The actual value of the shocks is not the same for both agents, what is the same is the ordinal value of this love shock. This allows for male and females to differ in what is the utility they get from marriage. The other, ϵ is individual, in the sense that each adult has its own, has continuous support and its cdf is conditional on the marital status of the agents, allowing for marriage to carry some wait, as well as on the sex of the agents.

- Every period the woman chooses unilaterally whether to have a child in addition to those she already has, and she does so before the investment decision. Note that the two parents need not agree over their desired number of children because in case of separation, it is the mother that keeps them. However, given the number of children they both agree between how much to consume and how much to invest in the children. The sequencing of decisions is what avoids the need to explicitly model bargaining.

- Children are attached to their mothers. Within the context of the model, this assumption implies that the fathers forget about their children *after* a divorce. To do otherwise would have required us to keep track of men's previous family histories, a large record keeping cost.

- Note that in our specification we do not keep track of whether the males are the biological fathers or not. That males like more there own children than those of other males is incorporated in the model by letting the marital status with which they started the period q affect current utility. If there are children from the past and if the couple was not previously married, the male has less utility that if they had been previously married. We make this assumption to prevent single women to become mothers to attract men, a feature we repeatedly encounter in previous versions of the paper.

- Investment in children has returns only if and when they age. Because of this assumption we do not need to keep track of previous investment.

- Parents do not know the sex of their children. Boys and girls are not equal (in fact their rate of return of human capital investment is different). Accordingly if parents knew the sex of their children their investment decisions would be affected. To keep track of the sex distribution of the children would increase the state space substantially.[14]

- There is no genetic transmission of characteristics. In particular, higher education or wage of the parents implies a higher education of the children only in so far the parents make higher investment.

- The costs of divorce arise from the fact that one of the components of love is drawn from a distribution that depends on marital status and no from any direct utility or resource cost of divorce.

We leave for future research the relaxation of these assumptions, to which we could add the fact that we only look at steady states.

[14] We are not interested in understanding the issue of differential investments in boys and girls. See Echevarria and Merlo (1999) and Foster and Rosenzweig (2001) for two different ways of approaching this issue.

3.6 The agents decisions

The purpose of this Section is to describe the problems that the agents face and to obtain expressions for their value functions $V_g(z)$, for $z = \{w, q, n, w^*, \eta, \epsilon\}$. We proceed backwards starting with the last subperiod that corresponds to the consumption-investment decision (Section 3.6.1), then we move to fertility decision (Section 3.6.2) and we finish with the marriage decision (Section 3.6.3).

3.6.1 The consumption-investment decision

Recall that agents devote time of the females and resources to invest in the education of the children. The outcome of such investment is higher probability of the children achieving college in case the adults age. It is easier to start by looking at the problem of a female agent that started the period with state $z = \{w, q, n, w^*, \eta, \epsilon\}$ that became (or stayed) single, $q' = 0$, and that chose to have n' children this period. We denote her value with $\widehat{G}_f(z, 0, n')$. Next, we move to the decisions of married households, as single males decide nothing at this stage.

A female that becomes single. The problem of a female with state z, that is single, $q' = 0$ and has n' children is

$$\widehat{G}_f(z,0,n') = \max_{c,y,\ell>0} u_f\left(c,0,n',0\right) + \ \pi(w)\,\beta\,E\Big\{V_f\left(w',0,n',w^{*\prime},\eta'\right)|w\Big\}+ \\ [1-\pi(w)]\,\beta\,\Big\{\Omega_f(w,0,0) + b(n^{'})E\left\{V(\bar{z}')|y,\ell,n',x\right\}\Big\} \quad (3)$$

Subject to the budget constraint:

$$c + y = (1 - \ell - \bar{h}nw)\,w. \quad (4)$$

and where the conditional probabilities are given by

$$E\Big\{V_f\left(w',0,n',w^{*\prime},\eta',\epsilon'\right)|w\Big\} = \\ \int_{W\times W^*\times H\times E} V_f\left(w',0,n',w^{*\prime},\eta',\epsilon'\right)\ \frac{x_m(dw^{*\prime},0,0,.,.)}{x_m(.,0,0,.,.)}\ \gamma_\eta[d\eta']\ \ \Gamma_w[dw'|w]\ \ F(d\epsilon'|0) \quad (5)$$

where x_m is the steady state distribution of males. Prospective dates for the period after are drawn from this distribution. The other terms just reflect the distribution of the evolution of the own wage (age/education) and love. The conditional distribution of the values for aging children is

$$E\Big\{V(\bar{z}')|y,\ell,n',x\Big\} = \frac{1}{2}\ E\Big\{\ V_f(\bar{z}')\ +\ V_m(\bar{z}')\mid y,\ell,x\Big\} = \frac{1}{2}\ \Bigg\{$$

$$\int_{\bar{Z}} V_f\left(\bar{w}',0,0,\bar{w}^{*\prime},\bar{\eta}',\bar{\epsilon}'\right)\ \frac{x_m\left(d\bar{w}^{*\prime},0,.,.,.\right)}{x_m\left(.,0,.,.,.\right)}\gamma_\eta\left[d\bar{\eta}'\right]\ \ F(d\epsilon'|0)P[d\bar{w}',\psi(y,\ell,0,n')]+$$

$$\int_{\bar{Z}} V\left(\bar{w}^{*\prime},0,0,\bar{w}',\bar{\eta}',\bar{\epsilon}'\right)\frac{x_f\left(d\bar{w}',0,d\bar{n}',.,.\right)}{x_f\left(.,0,.,.,.\right)}\gamma_\eta\left[d\bar{\eta}'\right]\ \ F(d\epsilon'|0)P[d\bar{w}^{*\prime},\psi(y,\ell,0,n')]\Bigg\} \quad (6)$$

where we see that parents do not know the sex of their children and where the conditional expectation is both over their prospective dates and hence it draws from the set of singles and , and more importantly, where $P[d\bar{w}^{*\prime},\psi(y,\ell,0,n')]$ is the probability that a child becomes of wage group $\bar{w}'$. All children become young adults and the likelihood of them becoming college graduates is increasing in the time that the mother devotes to raising the kid as well as in the resources devoted to education. We also let it depend on the marital status and on the number of children.

We denote the solutions of this problem by functions $\widehat{y}_f(z,0,n')$, $\widehat{c}_f(z,0,n')$, $\widehat{l}_f(z,0,n')$.

A male that becomes single. Single males are not attached to any children. Consequently, they simply consume what they earn working full time. His value is given by

$$\widehat{G}_m(z,0,0) = u_m\left(c,0,0,0\right)+\pi(w)\beta\ E\left\{V_m\left(w^{*\prime},0,n',w',\eta',\epsilon'\right)|w^*,x_f\right\}+(1-\pi(w))\,\beta\,\Omega_m(w^*,0,0) \quad (7)$$

where $c = w^*$, and where the conditional expectation of future values is analogous to that of single females. We now turn to discuss the investment problem of the married agents.

Investment problem of married agents. Let's write the problem of a married agent as if the female were the dictator in her family

$$\widehat{G}_f(z,1,n') = \max_{c,y,\ell>0} u_f\left(c,1,n',\eta,\epsilon\right) + \ \pi(w)\beta\ E\Big\{V_g\left(w',1,n',w^{*\prime},\eta',\epsilon'\right)|z,1,n'\Big\}+$$
$$[1-\pi(w)]\,\beta\Big\{\ \Omega_f(w,w^*,\eta)+b(n')E\left\{V(\bar{z}')|y,\ell,n',x\right\}\ \Big\} \quad (8)$$

Subject to the budget constraint:

$$c+y=\left(1-\ell-\bar{h}nw\right)w+\ w^*. \quad (9)$$

where the conditional expectations are as before. Note that the decision variables only enter as arguments of the first and last terms of equation (8), and those terms are independent of the gender of the decision maker. Henceforth both parties agree at this stage. Let's denote the solution to this problem by functions $\widehat{y}(z,1,n')$, $\widehat{c}(z,1,n')$, $\widehat{\ell}(z,1,n')$. We now turn to the fertility decision.

3.6.2 The fertility decision

Fertility is stochastic, but females can engage in costly activities in term of utility to shape the probability of having a child

$$G_f(w,q,n,w^*,\eta,q') =$$
$$\operatorname*{argmax}_{e}\left\{\widehat{G}_f(w,q,n,w^*,\eta,\epsilon,q',n)\ p(e)+\widehat{G}_f(w,q,n,w^*,\eta,\epsilon,q',n+1)\ [1-p(e)]\right\} \quad (10)$$

with solution $e^*(w,q,n,w^*,\eta,q')$. We now are in a position of defining the value for agents of each marital status. The solution of this problem can also be used to the determine the utility for the second stage for a male $G_m(z,q')$, implying that they have perfectly forecast the fertility decision of their spouses or dates. We can now turn to the marriage decision stage.

3.6.3 The marriage decision

With the $G_g(z, q')$ functions we can assess whether agents prefer to be married or to be single, by simply evaluating,

$$\max \quad \{G_f(w, q, n, w^*, \eta, 0), G_{f,m}(w, q, n, w^*, \eta, 1)\}. \tag{11}$$

$$\max \quad \{G_m(w^*, q, n, w, \eta, 0), G_m(w^*, q, n, w, \eta, 1)\}. \tag{12}$$

It takes the agreement of both parties to marry or to stay married. So the value functions are given by

$$V_g(w, q, n, w^*, \eta) \equiv \begin{cases} G_g(z, 1), & \text{if } \begin{cases} G_f(z, 1) > G_f(z, 0) \\ \text{and} \\ G_m(z, 1) > G_m(z, 0) \end{cases} \\ \\ G_g(z, 0), & \text{otherwise.} \end{cases} \tag{13}$$

In the end the decision of whether to marry amounts to finding for each gender the threshold ϵ_m and ϵ_f that makes them indifferent between getting married and remaining single.

Let $q'_g(z)$ denote the marriage outcome for a type z, gender g agent. We can use fertility decisions $n'_g(z, q')$ and marriage outcomes $q'_g(z)$ to substitute in the decision rules $\{\widehat{y}_g(z, q', n'),$ $\widehat{c}_g(z, q', n'),$ $\widehat{\ell}_g(z, q', n')\}$ and to obtain decision rules that only depend on the state variables, $\{y_g(z), c_g(z), \ell_g(z)\}$.

3.7 Population dynamics

We now describe how the population evolves over time from agents' decisions and today's distribution of the population x, a process that we write as $x' = F(x)$. In this model the population may (and does) change in size. Since we are interested in stationary equilibria, we renormalize function F to keep the population size constant. Therefore, the first thing to compute is the growth rate of the population which is

$$\lambda = \pi + \frac{1}{2}(1-\pi) \int_Z n'(z) \ dx_f. \tag{14}$$

Those that start the period married were adults last period and can be easily calculated,

$$x'_g(w', 1, n', w^{*\prime}, \eta') = \frac{\pi}{\lambda} \int_Z 1_{n'(z)} \ q'_g(z) \ \Gamma_g[w'|dw] \ \Gamma_{g^*}[w^{*\prime}|dw^*] \ \Gamma_\eta[\eta'|d\eta] \ dx_g \tag{15}$$

where $1_{n'(z)}$ denotes the indicator function: one if the statement is true and zero otherwise.

Women that start the period as single mothers ($n' > 0$) were also all adults last period because we have assumed no children's pregnancy and they are given by

$$x'_f(w', 0, n', w^{*\prime}, \eta') = \gamma_\eta[\eta'] \ \frac{x'_m(w^{*\prime}, 0, ., ., .)}{x'_m(., 0, ., ., .)} \frac{\pi}{\lambda} \int_Z \Gamma_f[w'|dw] \ 1_{n'(z)} \left[1 - q'_f(z)\right] dx_f \tag{16}$$

Single women with no children could have been children or adults last period

$$\begin{aligned} x'_f(w', 0, 0, w^{*\prime}, \eta') \ &= \gamma_\eta[\eta'] \ \frac{x'_m(w^{*\prime}, 0, ., ., .)}{x'_m(., 0, ., ., .)} \left\{ \frac{\pi}{\lambda} \int_Z \Gamma_f[w'|dw] \ 1_{n'(z)=0} \left[1 - q'_f(z)\right] dx_f + \right. \\ &\left. \frac{1-\pi}{2\lambda} \int_Z P_f[w, \widetilde{\psi}(z)] \ n'(z) \ dx_f \right\} \end{aligned} \tag{17}$$

Finally, we turn to the males. Newly aged males can be associated to children only via the women they associate with. We write the evolution of the distribution of single men as

$$\begin{aligned} x'_m(w^{*\prime}, 0, n', w', \eta') \ &= \gamma_\eta[\eta'] \ \frac{x_f(w', 0, n', , ., .)}{x_f(., ., 0, ., .)} \left\{ \frac{\pi}{\lambda} \int_Z \Gamma_m[w^{*\prime}|w^*][1 - q'_m(z)] dx_m \right. \\ &+ \left. \frac{1-\pi}{2\lambda} \int_Z P_m[w^{*\prime}, \widehat{\psi}(z)] \ n'(z) \ dx_f \right\} \end{aligned} \tag{18}$$

In the last two expressions we use some elements of tomorrow's distribution to determine tomorrow's distribution. However, those elements are marginals and are only used to determine the matching ratios, and can be readily determined from today's distribution.

3.8 Steady state

A steady state equilibrium is a set of decision rules for consumption $c_g(z)$, resources $y_g(z)$, and time $\ell_f(z)$ investment in children's education, number of children chosen by women $n'_f(z)$, marriage outcomes $q,(z)$, value functions for males and females $V_g(z)$, auxiliary functions G_g and $\widehat{G}_g$, stationary distributions of agents $x_g(z)$, and a rate of population growth λ such that:[15]

1. Functions V_g, G_g, and $\widehat{G}_g$ satisfy equations (3-13) (i.e. agents maximize).
2. Consistency between male and female actions $q'_g(z) = q'_{g^*}(z^*)$ and decisions $c_g(z) = c_{g^*}(z^*)$ and $y_g(z) = y_{g^*}(z^*)$.
3. Individual and aggregate behavior are consistent: the population is stationary, $x = F(x)$.

4 Calibration of the Baseline Economy (the Seventies)

We want to calibrate the model economy to the demographic characteristics as well as to the wage structure of the seventies. As a result of the model having a large number of parameters, we use a large set of U.S. economic and demographic statistics as calibration targets, and hence we have to solve a large system of equations and unknowns, a daunting task.

The calibration of this model economy consists in solving a non-linear system with a large number of equations and unknowns. The unknowns are the parameters of the model which turned out to be 35. Some of these parameters can be specified without having to solve for the equilibrium of the model, in our case there are 13 of these. The other 22 parameters have to be obtained by estimating the model, this is by requiring that the model economy shares some statistics with the data (or at least that the values for the statistics that we want to

[15]Note that we are indexing the consumption and investment functions by sex. This facilitates the record keeping and simplifies notation.

impose are as close as possible). This is what we mean by calibration and it is a form of GMM.

We start describing the specific functional forms that we choose and the number of parameters that we have to solve for in Section 4.1. We then describe the calibration targets in Section 4.2. To make it easier to follow, the subsection titles have the relevant number of parameters or targets. In Section 4.3 we describe the result of the calibration process that we call the baseline model economy. In Section 4.4 we discuss the performance of the baseline model economy by means of how well it matches other statistics of the data that are not explicitly targeted in the calibration. Finally, in Section 4.5 we discuss how the most important margins of the model work, the fertility decision and the gains from marriage.

4.1 Functional forms and parameters:

We divide the functional forms in five groups and describe them accordingly: demographics, wages, preferences, achievement of desired outcomes and approximation parameters. We put the total number of parameters in the section head and inside parenthesis the number of those that cannot be chosen without solving for steady states.

4.1.1 Demographics: 4 (3)

There are two population parameters that control the duration of young adulthood and the duration of total adulthood. We choose them so that young adults encompass ages 18-29 and all adults 18-49. The reason for this is to include the most important child bearing ages. We understand that a case can be made for starting at a younger age. These parameters can be set before solving for the steady state.

Females control their fertility by posing effort. There are two additional parameter that controls the probability of being fertile when posing zero effort. The functional form the the probability of not increasing the number of children, $p(e)$, is given by:

$$p_{age}(e) = \frac{\exp(e)}{\exp(e) + \kappa_{age}\exp(-e)}.$$

Therefore, the parameter κ_{age}, $age \in \{youngadult, oldadult\}$, determines this probability in the case of zero effort (i.e. $p(0) = \frac{1}{1+\kappa}$). Allowing κ to depend on the age captures the fertility risk women face upon aging. Lastly, we assume that children impose a time cost, parameterized by $\bar{h}$, on mothers.

4.1.2 Wages: 11 (4)

We want wages to reflect educational attainment as well as life-cycle characteristics. There are 4 possible wage-age levels for each sex $w \in \{w_1, w_2, w_3, w_4\}$. When mapping to data the grouping of people into wage groups we have a dilemma for the 1970's. Our choice is to group males into some college (almost 40% of American adults in the mid seventies) and high school or less (a little over 60%) and compute their average wage. For females we sort them (using an imputation of wages based on when they work (see Appendix A for details)) into the top 40% and the bottom 60%. Given these choices there is no transition between any of the wage groups beyond that implied by the aging process. Because one of the wages is a normalization, we obtain 7 parameters.

In addition, we have to parameterize the function that determines the probability of children attaining a college education conditional on their parents' investment of time and money that we assume sex dependent and equal to

$$\left[\exp\left(\gamma_1 \ell^{\mu} + \gamma_2 \left(\frac{y}{n'}\right)^{\mu} + \rho_g\right)\right]^{-1} \tag{19}$$

This expression has 4 parameters. Note that we assume that for each child what matters is the total investment in time and the per capita investment in money. Note that we assume that many children matter in terms of resources not of time. This is another choice that requires more investigation. In addition, ρ_g allows the model to capture the differences in educational attainment between men and women observed in the 1970's. We will assume that $\rho_f = 0$ and $\rho_m \geq 0$.

4.1.3 Preferences: 16 (13)

Utility Function: 12 (9). We assume a current utility function that is constant relative risk aversion and takes into account family equivalence scales. Thus we rewrite equation (1) as

$$\frac{1}{1-\sigma}\left(\frac{c}{\phi(q',n')}\right)^{1-\sigma} + q'(\eta+\epsilon) - \chi(1-q)1_{n'>0}\,1_{g=m} - \xi e^2 1_{g=f} \tag{20}$$

The coefficient of risk aversion σ is hard to estimate independently and we set it to be 2.

Function ϕ transforms consumption expenditures and family composition into effective consumption. We use OECD measurements that makes $\phi(q,n) = 1 + \phi_1\, q + \phi_2\, n$, and sets $\phi_1 = 1.70$ and $\phi_2 = .50$.[16]

We pose a process for love that is quite rich to try to capture the variety of peoples family arrangements. We set 2 possible values for η_g. We assume that they are symmetric and centered around the mean $\bar{\eta}_g$, $\eta_{1,g} = -\eta_g + \bar{\eta}_g$ and $\eta_{2,g} = \eta_g + \bar{\eta}_g$, which leaves 2 values to be determined, η_g and $\bar{\eta}_g$ for each gender. This is important: we allow the persistent component of love to be quite different for males and females since we have no clear priors (except perhaps from the fact that married men live longer), and since single men cannot enjoy the utility of children which by itself may make women attractive. We do, however, assume perfect correlation between the two sexes. Which means that the ordinal values are the same for males and females and that the transition matrix is sex independent.

Markov matrix Γ requires 2 independent parameters. We further reduce the number of parameters to 1 by assuming certain forms of symmetry, $\Gamma_\eta(1|1) = \Gamma_\eta(2|2)$, and we are left with $\Gamma_\eta(1|1)$. Lastly, we have to estimate the the unconditional distribution, γ_η, from which single prospective partners draw their quality of the match indicator; we will assume that the probability of the initial draw being $\eta_{1,g}$ is given by γ_0.

In addition, we have the parameters that determine the temporary shocks to love. Recall that these have continuous support to induce continuity of allocations on parameters and hence that the model can be properly estimated. We assume that they depend on the marital

[16] This value is taken from the OECD Adult Equivalent Family Size tables.

status, allowing the model a chance for having marriage be persistent. To this end we assume the shocks ϵ to be normally distributed, and the same for men and women. Because of normalization of units, we only have to set the mean of one of the two shocks. So we have a total of three parameters for the process for this shock.

Finally, we have two more parameters, the utility cost of effort for females and the utility cost of raising other males' children for males.

Discounting: 4 (3). People discount their own future well-being at a rate $\beta = .96$ and their children's future welfare at a rate $b(n') = \beta_c \, n'^{1-\delta}$ that is increasing with n' but at a decreasing rate. Furthermore, we will assume there is a multiplicative weight, ω_c, on college children; allowing the model to separate preferences for investment in children with the preferences for additional children.

Retirement: 1. The functions $\Omega_{g,s}(w)$ $\Omega_{g,m}(w, w^*, \eta)$ that represent the expected value of being retired and single, and retired and married, are another set of preference parameters. These parameters ensure that children are attractive even when the risk aversion parameter $\sigma > 1$. We restrict function Ω_g to neither depend on marital status or on wages, sex or quality of the match variable, which leaves 1 parameter. Note that these choices give no additional value to the education of the children as a source of utility except in so far as is affects marriage probabilities.

4.2 Calibration targets

We decompose the description of the calibration targets into demographic, wages, marriage sorting and accuracy of the approximation.

4.2.1 Demographic Targets: 18

The demographic targets pertain to properties of household composition and its flows in the U.S. during the seventies. These include the distribution of women by marital status in the different education groups, the distribution of women by parental status in the different education groups, and the average size of single and two-parent households. We choose the following 18 targets (their values are in Table 5 and Table 6).

1-2. The fraction of women aged 18-49 which are single in the education groups college and non-college.

3-4. The fraction of single women aged 18-49 with children in the education groups college and non-college.

5. The fraction of women aged 18-49 without children.

6. The average age of women at 1st marriage.

7. The yearly marriage rate.

8-9. The yearly divorce rates of women within the education groups college and non-college.

10-11. The yearly divorce rates of women with and without children.

12. The difference in the remarriage probability between women with and without children.

13-14. The average number of children per mother among women in the education groups college and non-college.

15-16. The average number of children per woman conditional on the marital status of the mother.

17.-18. The birth rate of women in the age groups 18-29 and 30-49.

4.2.2 Education: 5

We target the fraction of men and women which are college educated. As well as the relative hours worked of women conditional on children, education and education of their husband.

19. The fraction of the male population with college education.
20. The fraction of the female population with college education.
21. Relative hours worked of women with children and without children.
22. Relative hours worked of college mothers and non-college mothers.
23. Relative hours worked of non-college mothers married to college men and married to non-college men.

Table 5: **Calibration targets: Demographics**

Fraction of women aged 18-49 which are single:	
College	0.2340
Non-college	0.1820
Fraction of women aged 18-49 which are single mothers:	
College	0.0767
Non-College	0.1066
Fraction of women aged 18-49 without children	0.2721
Average age of women at 1st marriage	21.10
Marriage rate	0.1373
Divorce rates	0.0328
College	0.0289
Non-College	0.0394
Without children	0.0452
With children	0.0302
Difference in remarriage probability with and without children	0.0781

4.2.3 Marriage sorting: 2

We want the baseline model economy to match the positive assortative sorting of couples that we observe in the data. Consequently among the set of calibration targets we choose:

24. The fraction of married non-college women who are married to non-college men.
25. The fraction of married college women who are married to college men.

4.3 The Baseline Model Economy

We take that the child rearing age is 18-49 years of age. In order to compute the statistics in the model economy we have to map a period into calendar time. The calibrated value of the

Table 6: **Calibration targets: Fertility**

Average # of children per mother:		
	College	2.0476
	Non-college	2.4273
Average # of children per woman:		
	Single	1.1210
	Married	1.8473
Birth rates of women:		
	Aged 18-29	0.1265
	Aged 30-49	0.0272

Table 7: **Calibration targets: Education**

Fraction of men who went to college, age 18-49		0.3761
Fraction of women who went to college, age 18-49		0.2608
Relative hours worked of women:		
	with children to women without children	0.5778
	college mothers to non-college mothers	1.2085
	non-college married to college men and to non-college men	0.7427

probability of not aging is $\pi = .898$; this implies that average adult life in the baseline is 9.81 periods, or that each period corresponds to 13 quarters. Therefore, the 30 to 44 years of age group corresponds roughly to the group of that is 4 to 8 periods of age in the model.

The task of replicating the 37 targets is daunting. We think that the baseline model economy is overall extremely successful. In any case, the reader can arrive to her own conclusions by looking at Tables 10 through **??** that describe the values of the calibration targets in the baseline model economy next to the value in the data. The parameter values that we use are in Table 18. This configuration of parameters is the best that we have been able to find in terms of matching all the targets, although, obviously, we do not match all targets exactly.[17]

[17]In fact some of them may be mutually inconsistent within a steady state structure.

Table 8: **Calibration targets: Sorting**

Fraction of college married women who are married to college men	0.7407
Fraction of non-college married women who are married to poor men	0.7766

Going through some of its statistics we see that the baseline model economy matches the demographic statistics remarkably well (Table 10). For instance, the model captures very well the negative relation between marriage and wages for women aged 30 to 44, as well as the association between motherhood and wages for the same age group. Perhaps its only shortcoming is to provide too steep a negative profile for the negative relation between average number of children and wages. Also, the average number of children in the baseline is lower than in the data, while baseline birth rates are higher than in the data. There is a reason for this result. Calibration targets are computed from mid 70s PSID data, i.e. when the transition towards women's lower total fertility was almost complete after the US baby-boom period. The high number of children among PSID families in the mid 70s was the result of the baby-boom. Birth rates were instead already affected by the transition towards lower fertility. The baseline steady state allocation is trying to match features of an economy which indeed was not in a demographic steady state in the mid 70s.[18] The baseline is also very successful in reproducing the asymmetry in the flows in and out of marriage observed in the data.

Table 11 shows that the baseline model economy closely mimics the wage gender gap found in the data. For both men and women, the ratio between average wages of the top and bottom 30% is lower than in the data. At the same time the ratio between average wages of the top 30% and the 30%-70% wage group is higher than in the data. As a result the ratio between average wages of rich (top half) and poor people (bottom half) within sex in the baseline closely matches the data. This ratio is 2.146 in the model and 2.131 in the data, for women, and 2.272 in the model and 2.270 in the data, for men. The baseline model economy is largely over-estimating the wage premia between people who went to college and those who did not. This is the result of the model having all wage variation being accounted for by education. We have chosen to set the wage premium accurately.

[18]Ideally one would like to use women's total fertility rates per wage group as calibration targets, instead of the average number of children per mother. However this information is not available.

Table 9: **Performance of the baseline model economy: Demographics**

	Data	Model
Fraction of women aged 18-49 which are single:		
College	0.2340	0.2454
Non-college	0.1820	0.1701
Fraction of women aged 18-49 which are single mothers:		
College	0.0767	0.0898
Non-College	0.1066	0.0715
Fraction of women aged 18-49 without children	0.2721	.2502
Average age of women at 1st marriage	21.10	21.41
Marriage rate	0.1373	0.1838
Divorce rates	0.0328	0.0142
College	0.0289	0.0216
Non-College	0.0394	0.0118
Without children	0.0452	0.0500
With children	0.0302	0.0069
Difference in remarriage probability with and without children	0.0781	0.1140

The assortative matching (Table 12) is a little below that in the data (not surprisingly given that in the model all matching is random without any mechanism to increase the odds of matching within the same education group).

4.4 Overidentifying parameters

That the baseline model economy matches the 37 moments that we have reviewed so far is not surprising since the parameter values are designed to do so. We want to make sure that the baseline model economy is a satisfactory representation of the relation between wages and marital status during the seventies. To do so, we look at how it performs along a variety of other dimensions that were not targeted as calibration statistics.

There are four types of such statistics that we look at, and in all of them the baseline

Table 10: **Performance of the baseline model economy: Fertility**

	Data	Model
Average # of children per mother:		
College	2.0476	2.0893
Non-college	2.4273	2.4042
Average # of children per woman:		
Single	1.1210	1.4359
Married	1.8473	1.8031
Birth rates of women:		
Aged 18-29	0.1265	0.0765
Aged 30-49	0.0272	0.0386

Table 11: **Performance of the baseline model economy: Education**

	Data	Model
Fraction of men who went to college, age 18-49	0.3761	0.3836
Fraction of women who went to college, age 18-49	0.2608	0.2642
Relative hours worked of women:		
with children to women without children	0.5778	0.5619
college mothers to non-college mothers	1.2085	1.3139
non-college married to college men and to non-college men	0.7427	0.7487

model economy does very well.

1. The fraction of households with a female member that have children out of all households with a female member. It is 0.864 in the data and almost the same in the model, 0.867.

2. The joint distribution of males across wages and marital status is very different from that of women. It is the low wages men that are more likely to be single both in the model and in the data. In particular the fraction of single men in the bottom half of the wage distribution is 0.187 in the data and 0.191 in the model, while that of single men among the high wage group is 0.116 in the data and 0.097 in the model.

Table 12: **Performance of the baseline Model Economy: Sorting**

	Data	Model
Fraction of college married women who are married to college men	0.7407	0.6164
Fraction of non-college married women who are married to poor men	0.7766	0.6593

3. The autocorrelation of earnings across generations. This is a very important statistic that has generated a lot of attention. Its value in the data is between 0.41 as reported by Solon (1992) using the PSID, and a value of 0.68 estimated by Zimmerman (1992). In the baseline model economy this value is 0.137. We find this extremely reassuring. The model ignores all genetic transmission of ability and all comparative advantage of educated parents in improving the education of their children. In the baseline model economy the intergenerational correlation of earnings is a product only of explicit investments of time and money from the parents. Given that we abstract from the other channels that contribute to a positive autocorrelation, a value of 0.137 seems to us what it would be appropriate.

4. Moreover children who grow up in single female headed households have 23% more chance of becoming a low wage type when adults. This feature matches the pattern documented by McLanahan and Sandefur (1994) who find that, other things being equal, teenagers who spent part of their childhood apart from their biological father are twice as likely to drop out of high school.

4.5 The model's margins

In this section we discuss how the model's most important margins actually work. In particular, we look at fertility and marital status decisions.

4.5.1 Women's fertility decision

There are two factors that have a great influence over the fertility decision: *i)* the curvature of the utility function and *ii)* child-raising costs. The greater the curvature of the utility function, the larger the family size because parents like to smooth consumption over more children. If child-raising costs were independent from parents' earnings type, poorer parents would have fewer children, which is counterfactual. To get around this, the literature makes two assumptions, both of which are necessary: that the cost of raising a child is increasing with the parents' earnings type (typically achieved by assuming that children impose a fixed time cost to parents), and that the risk aversion parameter is below one.[19]

In our model, we also have child-raising costs increasing with parents' earnings. In fact, children consume a fixed fraction of total family consumption, which is bigger for wealthier families. Moreover, the calibration process determines a risk aversion parameter below one which is required to achieve a negative relationship between mothers' earnings and number of children, as it is empirically observed.

Not only poor mothers have more children in our model but, given relative returns of investment of parental time and of resources in children's education, high earning parents prefer to invest more resources and less time than low earning parents because the opportunity cost of time is higher for them.

4.5.2 The gains from marriage

In our model, marriage delivers five types of potential gains three of which are for both partners: *i)* prospective partners may like each other, i.e. $\eta > 0$, *ii)* there are increasing returns to consumption while living together, *iii)* there are returns to specialization, (either because the wages or the return of time investments are not equated between the spouses); one of the potential gains of marriage is solely for men, *iv)* children are non-exclusive goods, therefore a marriage gives utility to husbands; and another potential gain of marriage is only for women, *v)* marriage alleviates the decreasing returns of parents' time investment in childrearing.

Therefore, all agents want to marry somebody they like and who has a high wage, and they want to do it earlier rather than later. So the marriage decision involves assessing whether the current match is good enough or whether it is better to wait for a better one. The calibration

[19]See Becker, Murphy, and Tamura (1990) and Alvarez (1999).

process determines some specific features of this decision: it makes women less eager to accept a match by providing them often with a negative perception of their mates and it also reduces the returns to marriage by providing a negative view of it upon aging.

5 Absolute and relative wage changes

In this Section we ask to what extent the changes in wages occurred since the seventies can account for the dramatic changes that we have observed in family composition in the last few years. To answer this question, we take the baseline model economy and substitute the values for wages in the seventies for their nineties counterpart and we look at what are the implied changes in the steady state allocations. In this period, wages have changed in many dimensions, and we look at all of them both separately and together. We look at changes: in the level of all wages in Section 5.1, in the gender wage premium in Section 5.2, in the dispersion of wages both for men and for women in Section 5.3. Finally, we look at all the wage changes simultaneously in Section 5.4.

We change the wages in the model economy by changing the support of male and female wage distributions exogenously while leaving unchanged all the other parameters calibrated for the baseline economy. For example, the reduction in the wage-gender gap is achieved in the model by shifting the support of women's wage distribution upwards, while keeping men's average wage and within sex wage dispersion unchanged. As a result of these changes the model changes its steady allocations which results not only in changes in the demographics but also in changes in the wage distribution.

We care about real wages. One option would be to normalize wages using the CPI. However, because it is widely recognized that the CPI tends to overstate inflation,[20] we make a correction upwards of 0.8 percentage points in the CPI to overcome the bias.

[20]The CPI fails to fully capture improvement in goods quality or the ability of consumers to substitute away from goods which experience a sudden increase in their prices (Gottschalk (1997)). Shapiro and Wilcox (1996) review the available evidence and place the median of their subjective probability distribution for the overall bias in the CPI around 1.0 percentage point per year. They also estimate that about 80% of the mass distribution lies between 0.6 and 1.5 percentage points. The CPI Advisory Commission calculated a point estimate of 1.5 percentage points for the total bias in the CPI for the last decade, with a range extending from 1.0 to 2.7 percentage points per year.

In order to assess the individual contribution of each wage change to the shift in the marital status composition of the population we first look at the effect of *i)* increasing men's and women's average absolute wages on the steady state equilibrium allocation, keeping constant wage premia between and within sexes. Second, starting from the baseline equilibria allocation, we reduce *ii)* the sex wage premium, keeping relative wages between sexes and men's absolute average wages constant. Next, to assess the impact of the increase in within sexes wage dispersion, we change *iii)* males' and *iv)* females' wage premia keeping absolute average wages and therefore sex wage premium constant. Finally *v)* we change average absolute wages and sex, male and female wage premia together.[21]

5.1 Change in absolute average wages

We start by looking at changes in the level of all wages, while keeping relative wages between and within sexes constant. Given the way we compute wage premia between and within sexes, this means that everybody's wages increase by the same proportional amount. The main implications of the change in the level of wages are in Table 13.

Ex-ante, the effects of these wage changes on the number of singles is hard to predict: an increase in the prospective spouse's wage raises women's gains from marriage, while an increase in women's wages reduces these gains, two opposing effects. It turns out that the first effect prevails over the second, but by a small margin, so that the share of single women drops by 7% and that of single mothers by 3%.[22] The mechanism through which this works more is by making low wage men more attractive partners than before, increasing their likelihood of marriage, in particular with high wage women. This explains why the share of singles decreases more among rich than among poor women and also why a reduction in the positive assortative mating ensues, as is shown in Table 13.

[21] For ease of exposition we present statistics of the population partitioned into top and bottom according to earnings. Also, we define within sex wage dispersion as the ratio between average wages of top and bottom halves of the population. The sex wage premium is the ratio between men's and women's average wages.

[22] Both effects are greater for poor women, given the curvature of the current utility of consumption.

Table 13: **Increase in average absolute wages**

	Baseline	New	Model Change	73-07 Data
Men's absolute average wage	1.332	1.485	12%	12%
Frac. of Single Women	0.1900	0.1976	4%	66%
Frac. of Singles among College	0.2454	0.2591	6%	31%
Frac. of Singles among Non-Coll	0.1700	0.1729	2%	108%
Frac. of Single Mothers	0.0764	0.0740	-3%	42%
Frac. of Single Mothers among College	0.0898	0.0914	2%	31%
Frac. of Single Mothers among Non-Coll	0.0715	0.0670	-6%	97%
Marriage rate	0.184	0.184	0%	-43%
Divorce rate	0.014	0.016	10%	19%
Assortative mating				
Col married Females married to Col Men	0.616	0.660	7%	-2%
Non-Col married Females married to Non-Col Men	0.659	0.645	-2%	-5%

5.2 Change in the gender wage premium

The implications of a reduction in the wage gender gap while men's wages as well as the wage dispersion within sexes are kept constant are in Table 14.

These changes induce two effects in opposite directions: men are more willing to marry because women's overall quality improved (their market productivity grew while their fertility was largely unaffected), while for women being single, and waiting for a better match is now more attractive. The latter effect overcomes the former. Moreover, it does in a very important manner. The drop in the gender wage gap accounts for 85% of the shift in the marital status of the population observed in the data as shown in Table 14.

Given the concavity of the current utility of consumption and the fact that rich and poor females' average wages increase by the same proportional amount to keep women's wage dispersion constant, the drop in the wage gender gap reduces the gains from marriage more

Table 14: **Reduction in the wage gender gap**

	Baseline	New	Model Change	73-07 Data
Gender wage gap	1.748	1.295	-26%	-26%
Frac. of Single Women	0.1900	0.2415	27%	66%
Frac. of Singles among College	0.2454	0.3473	42%	31%
Frac. of Singles among Non-Coll	0.1700	0.2131	25%	108%
Frac. of Single Mothers	0.0764	0.0903	18%	42%
Frac. of Single Mothers among College	0.0898	0.1303	31%	31%
Frac. of Single Mothers among Non-Coll	0.0715	0.0796	11%	97%
Marriage rate	0.184	0.155	-16%	-43%
Divorce rate	0.014	0.021	50%	19%
Assortative mating				
Col married Females married to Col Men	0.616	0.582	-6%	-2%
Non-Col married Females married to Non-Col Men	0.659	0.657	0%	-5%

for poor than for rich women. Only if these gains were on average still positive for all women would we observe a greater increase in the share of singles among poor females. Instead, rich women's gains from marrying poor men become negative. Poor women's average gains from marriage with poor men are lower than before but still positive. Additionally poor women's chances of meeting poor men increase because many more poor men remain single.

As a result the share of singles increases more among rich than poor women and positive assortative mating is strengthened. The drop in the wage gender gap accounts for more than half of the increase in the share of single females and for 72% of the increase in the share of single mothers among poor women. The share of single females among rich women increases in the model more than evidence found in the data.

5.3 The widening wage dispersion

We separate the effects of wage dispersion by gender. This is a potentially important feature because in the period under study there was a major increase in the college premium for men and women.

5.3.1 Raising males' wage dispersion

An increase in males wage dispersion induces an increase in the share of single low and high wage women, the former by 58% and the latter by 46%. Low-wage men become even poorer than before, therefore they tend to be less picky when searching for a partner. Despite this, their lower earnings make them worse prospective mates and poor women are less willing to marry them.

Table 15: **Increase in men's wage dispersion**

	Baseline	New	Model Change	73-07 Data
Males' college wage premium	1.383	1.659	20%	20%
Frac. of Single Women	0.1900	0.2269	19%	66%
Frac. of Singles among College	0.2454	0.3053	24%	31%
Frac. of Singles among Non-Coll	0.1700	0.1959	15%	108%
Frac. of Single Mothers	0.0764	0.0857	12%	42%
Frac. of Single Mothers among College	0.0898	0.1194	33%	31%
Frac. of Single Mothers among Non-Coll	0.0715	0.0724	1%	97%
Marriage rate	0.184	0.164	-11%	-43%
Divorce rate	0.014	0.019	36%	19%
Assortative mating				
Col married Females married to Col Men	0.616	0.714	16%	-2%
Non-Col married Females married to Non-Col Men	0.659	0.640	-3%	-5%

Low-wage women have a hard time to substitute poor men with rich men because the latter are now pickier than before since their wages have risen. Therefore: *i)* the share of single females increases more among poor than among rich women as shown in Table 15 and *ii)* the pattern of positive assortative mating gets reinforced.

5.3.2 Raising females' wage dispersion

An increase in females' wage dispersion increases the share of single females among high wage women by 27%, and reduces the share of low wage single women by 11%.

Table 16: **Increase in women's wage dispersion**

	Baseline	New	Model Change	73-07 Data
Females' college wage premium	1.564	1.603	3%	3%
Frac. of Single Women	0.1900	0.1888	-1%	66%
Frac. of Singles among College	0.2454	0.2506	2%	31%
Frac. of Singles among Non-Coll	0.1700	0.1665	-2%	108%
Frac. of Single Mothers	0.0764	0.0753	-1%	42%
Frac. of Single Mothers among College	0.0898	0.0908	1%	31%
Frac. of Single Mothers among Non-Coll	0.0715	0.0697	-3%	97%
Marriage rate	0.184	0.184	0%	-43%
Divorce rate	0.014	0.014	0%	19%
Assortative mating				
Col married Females married to Col Men	0.616	0.637	3%	-2%
Non-Col married Females married to Non-Col Men	0.659	0.665	1%	-5%

Low-wage women become less desirable partners than before because their income falls while their fertility remains largely unaffected. At the same time low-wage women's gains from marriage increase, everything else equal. As a result they become less picky when choosing a partner. The latter effect outweighs the former.

On the other end rich females become even richer and pickier in the search for a partner. While their earnings improve, their fertility pattern does not change significantly. [23] Therefore men are even more willing to marry them. The first effect overcomes the second and rich women are more likely to stay single and wait for high wage partners. Consequently, the positive assortative mating of couples gets reinforced.

5.4 Overall effect of wage changes (the 21st century)

We now turn to the effects of wage changes when they take place simultaneously. Table 17 reports the results.

Table 17: **Change in all wage premia and increase in absolute wages**

	Baseline	New	Model Change	73-07 Data
Females' college wage premium	1.564	1.603	3%	3%
Males' college wage premium	1.383	1.659	20%	20%
Gender wage gap	1.748	1.295	-26%	-26%
Males' absolute average wage	1.332	1.485	12%	12%
Frac. of Single Women	0.1900	0.2626	38%	66%
Frac. of Singles among College	0.2454	0.3317	35%	31%
Frac. of Singles among Non-Coll	0.1700	0.2427	42%	108%
Frac. of Single Mothers	0.0764	0.1060	39%	42%
Frac. of Single Mothers among College	0.0898	0.1319	46%	31%
Frac. of Single Mothers among Non-Coll	0.0715	0.0985	38%	97%
Marriage rate	0.184	0.142	-23%	-43%
Divorce rate	0.014	0.023	64%	19%
Assortative mating				
Col married Females married to Col Men	0.616	0.632	3%	-2%
Non-Col married Females married to Non-Col Men	0.659	0.642	-3%	-5%

[23] The average number of children of rich women goes from 2.329 in the baseline to 2.316 in the new steady state allocation; the same figure for poor women increases from 2.498 to 2.528 as their per child costs drop.

The overall effect of all wage changes depends on the relative strength of the different effects at work. The results show a dramatic increase in the number of single women and of single mothers, essentially of the same enormous size that we observe in the data.

The model over predicts the effects of the wage changes among high earning women and underpredicts the effects among low wage women. Moreover, the changes in the marital status of the population are achieved in the model mainly through a reduction in the marriage rate, the same mechanism that does the job in the data, although its drop in the model economy is twice as big as in the data. The model economy is also successful in accounting for the rising trend in the positive assortative mating of couples which is observed in the data.

Together with the changes in family structure, our model finds that under the new wage structure there are other important changes such as an increase in the inter-generational earnings correlation by 12% in the model economy. Additionally, being born in a single female headed household increases the likelihood of becoming a low-earning type adult by a third. This result suggests that shifts in the marital status composition of the population might have reinforced the positive inter-generational correlation of earnings that is observed in the U.S. economy. After the change in the wage regime the inter-generational earnings correlation is 0.153. The model economy of the nineties accounts for 25%-40% of the inter-generational earnings correlation found in empirical studies without considering any peer group or genetic effect which might strengthen the correlation between parents' and children's outcomes.

As an additional independent validation of the model economy, changes in the wage regime leave women's fertility virtually unchanged.[24] This is consistent with the stability in US women's total fertility rates observed since the mid 70s.

6 Conclusion

In this paper we have constructed a general equilibrium model where agents choose to form families, have children and invest in their human capital. We calibrated the model to the distribution of families and wages of the seventies. We used the model to measure the role played

[24]The average number of children per mother goes from 2.497 to 2.498 among poor women and from 2.329 to 2.282 among rich women.

by changes in wages in accounting for the enormous changes observed in family structure in the last few years. According to our model, the observed changes in wages (they have gone up, the college premium has increased and the gender premium has decreased) have played a fundamental role in generating the increase in the number of people living as singles that is observed in the data.

In doing this project, we have, not only created a novel model susceptible of calibration, with agents differing in age, gender, family status and education levels, but we also have made a few technical developments to get around certain technical problems that arise in models with discrete choice and lack of transferable utility.

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Appendices

A The wage indicator

The wage indicator is a measure of earnings potential computed both for people in and out of the labor force. We take all PSID females aged 30-44 years and males aged 35-49 years in 1974 and in 1989 and follow their wage history for years 1973 to 1976 and 1988 to 1991 respectively. We divide the sample of observations of PSID individuals into twenty four groups according to gender, age, work experience, completed education and race. If individuals work for at least two of the four years taken into consideration we average individual yearly hourly wages over those years to get a measure of wage potential unaffected by short term fluctuations. When wages are not observed they are imputed, i.e. each individual is assigned a wage that is a function of the average wage of the education, gender, race, work experience group she/he belongs to.

Agents whose wages are imputed are more likely to be associated with unobservable characteristics that select them out of the labor market. Because of this selection bias our measure of potential wages is most likely an upper bound of agents' actual earnings potential. The wage indicator turns out to be age independent. When we sort women according to their wages, poor (bottom half of the wage distribution) and rich (top half) females on average have the same age 36.9 and 37.1 years respectively in 1974, 36.4 and 36.8 years in 1989.

A.1 The wage gender gap

When we compare our measure of wage gender gap with that previously found in the gender pay gap literature, it might at first seem too high both at the beginning and at the end of the period. O'Neill and Polachek (1993) use annual earnings of full-time year-round workers to compute the male-female pay gap. They report a value of 1.67 in 1979 and 1.51 in 1988. Since full-time male employees work about 8%-10% hours more than full-time female employees the wage gender gap that they report is likely to overestimate that obtainable using yearly hourly earnings. In fact Blau and Kahn (1997) using yearly hourly earnings of full-time non agricultural, non self-employed workers aged 18-65 years report a male-female pay gap of 1.60 in 1979 and 1.38 in 1988. Like us they use the PSID data. For this reason we compare our statistics with what they obtain. The male-female pay gap that we compute from the PSID is 1.90 in 1974 and 1.59 in 1991. The difference in the starting year between the periods that we and Blau and Kahn consider should not be relevant because changes in the wage gender gap started towards the end of the seventies. Our measure of the wage gender gap differs from theirs for the following two reasons.

First, we use both observed and imputed wages. It is more likely that we impute wages for women than for men because women are notoriously less attached to the labor force. Secondly, women with long spells out of the labour force are more likely to be low productivity women, with less education and less accumulated work experience. Including these observations in our sample drags down women's average yearly hourly earnings across occupations. In fact if we used only observed wages, our measure of the wage gender gap would drop to 1.72 in 1974 and 1.54 in 1991. Notice that the drop is relatively higher for the gender pay gap computed at the beginning of the period of interest. The share of women over the total female sample who are out of the labour force and for whom we impute earnings is indeed higher in the mid seventies than at the beginning of the nineties.

Secondly, our age cohorts (30-44 for women and 35-49 for men) differ from those usually considered in the literature. Blau and Kahn (1997) include male and female workers aged 18-65 years. If we use the same age brackets and only observable wages our measure of the male-female pay gap would be 1.60 in 1974 and 1.46 in 1991. These figures are comparable with those computed by Blau and Kahn (1997)). An approximate 6% discrepancy between our figures and theirs for the end of the eighties might be due to the fact that they exclude part-time workers and self-employed. It is nevertheless impossible to verify this conjecture because they do not specify the criteria used to distinguish part-time from full-time workers.

Since our model does not account for the gender difference in educational achievements found in the data, when we compute relative wages within and between sexes we do control for this difference. This means that we compute women's average wage and women's wage dispersion assuming that the educational composition of the female population is equal to that of the male population in the two periods taken into consideration. Under this hypothesis the wage gender gap obtained is 1.86 in 1974 and 1.56 in 1991.

B Computational Procedures

There are various parts to the computational procedure. The calibration process is like solving a large system of equations and unknowns. We proceed by minimizing the weighted sum of the square of the residuals of the 37 equations described in Section 4 by choosing the 37 parameters described there using standard of the shelf routines.

To evaluate the sum of weighted residuals for a given parameterization we have to solve the steady state of the model economy for that parameterization, compute the relevant statistics and compare them with data.

Computing the steady state involves finding the stationary measure and the decision rules associated to it. To do so given that the state space is finite, we proceed as follows:

(i) Start with initial guesses for the measure of males x_m^0 and x_f^0 females and for the value functions V_m^0 and V_f^0

(ii) Given x_m^0 and x_f^0 solve the households' problem by iterating on the Bellman type equation defined in Section **??**. At each step of the iteration we proceed backward solving all stages by means of first order conditions

  (ii.1) Solve the single female and the married females' investment problem.

  (ii.2) Solve females' effort decision to determine the number of children.

  (ii.3) Solve females' and males' effort decision to determine marital status.

(iii) Using the resulting decision rules, update the initial guesses of the measures x_m^0 and x_f^0; if at the first iteration on the the $x's$ the difference between their old and new is less than some tolerance value then we reached the stationary distribution. Otherwise, iterate on the $x's$ until convergence is reached, and then update the initial guesses x_m^0 and x_f^0, and go back to step (ii).

The mapping T is not monotonic which implies that iterations need not converge. We get around this problem by slow updating.

Computing the relevant statistics amounts to evaluate simple integrals that is done with standard methods. Comparing the model statistics with their data counterparts is trivial.

C Other Tables of Interest

Table 18 shows the parameter values of the baseline model economy while Table 19 shows some statistics regarding welfare coverage in the period under study.

Table 18: **Calibrated parameter values for the baseline model economy**

Demographics		Wages		Preferences		Preferences	
Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
π	0.9688	w_1	0.6579	σ	0.4311	$\mu_{q=0}$	0.0000
κ	0.1304	w_2	0.9464	ϕ_1	1.7000	$\sigma_{q=0}$	3.1453
$\Gamma_w(w_1\|w_1)$	0.9462	w_3	0.7283	ϕ_2	0.5000	$\mu_{q=1}$	3.9069
		w_4	1.2325	$\eta_{1,m}$	-5.9882	$\sigma_{q=1}$	0.7365
		w_1^*	1.0000	$\eta_{2,m}$	1.2376	ξ	0.0261
		w_2^*	1.1849	$\bar{\eta}_m$	3.4751	χ	1.5268
		w_3^*	1.2968	$\eta_{1,f}$	-2.5112	β	0.9570
		w_4^*	1.9504	$\eta_{2,f}$	-1.2130	β_c	0.1064
		μ_1	0.1000	$\bar{\eta}_f$	-0.7530	δ	0.5626
		μ_2	0.3457	$\Gamma_\eta(\eta_1\|\eta_1)$	0.9999	Ω_s	26.5228
		γ_1	0.3833	$\Gamma_\eta(\eta_2\|\eta_2)$	0.0076	Ω_m	12.7760
		γ_2	1.5909				

Table 19: **Fraction of welfare and non-welfare recipients among poor single women**

	1974 PSID	1991 PSID
Welfare recipient	0.064	0.076
Non welfare recipient	0.075	0.212
Total	0.139	0.288