Technology and the Changing Family: a Unified Model of Marriage, Divorce Educational Attainment and Married Female Labor-Force Participation

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TECHNOLOGY AND THE CHANGING FAMILY: A UNIFIED MODEL OF MARRIAGE, DIVORCE, EDUCATIONAL ATTAINMENT AND MARRIED FEMALE LABOR-FORCE PARTICIPATION*

by

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Abstract

Marriage has declined since 1960, with the drop being bigger for non-college educated individuals versus college educated ones. Divorce has increased, more so for the non-college educated. Additionally, positive assortative mating has risen. Income inequality among households has also widened. A unified model of marriage, divorce, educational attainment and married female labor-force participation is developed and estimated to fit the postwar U.S. data. Two underlying driving forces are considered: technological progress in the household sector and shifts in the wage structure. The analysis emphasizes the joint role that educational attainment, married female labor-force participation, and assortative mating play in determining income inequality.

Keywords: Assortative mating, education, married female labor supply, household production, marriage and divorce, inequality

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1 Introduction

The character of American households has changed dramatically since World War II. First, the number of married households has plunged, both due to a rise in the number of never-married households and an increase in the rate of divorce. The change has been most notable for non-college educated households. Second, there has been a rise in assortative mating. That is, people are more likely to marry someone of the same educational level today than in the past. Third, the fraction of college educated females and males has increased substantially. This is especially true for women. Fourth, there has been a dramatic rise in labor-force participation by married females. Fifth, income inequality across households has widened significantly.[1]

The goal of this paper is to develop a unified theory capable of explaining this array of facts. The model has three key ingredients. First, marriage and divorce decisions are formalized within the context of a search-theoretic paradigm. People match randomly and only marry if both parties agree. A divorce occurs when one party in a marriage favors single life over married life. A divorcee is free to remarry if the opportunity arises. The attractiveness of a mate depends on his/her ability and educational level, as well as on the love arising from the relationship. Second, all individuals make a choice about whether to go college. They do this based on their ability and their psychic cost of going to school. Third, married households must decide whether the female should work. This depends on the wage women will earn in the market and the cost incurred by the household when she works. Labor at home is used in household production.

There are two exogenous driving forces in the analysis: Technological progress in the home and shifts in the wage structure. Technological progress in the home reduces the labor needed in household production. This makes it easier for married women to work in the market. Moreover, with better technology in the home, the economies of scale associated with married life matter less. Hence, this force promotes a decline in marriage and an increase in divorce. Two shifts in wage structure are entertained: an increase in the return to education and a decline in the gender wage gap. A rise in the return to education entices

[1] These facts are detailed in Section 2.

more men and women to go to college. Shrinkage in the gender wage gap encourages labor-force participation by married women and makes singlehood more affordable for females.

The framework developed connects the induced shifts in the structure of households to the rise in income inequality. As a thought experiment, suppose that husbands and wives work full time and that there is no gender gap. Then, random matching would reduce household income inequality. For this effect to be operational, though, married women must work. Now, an increase in positive assortative mating works to amplify income inequality. This effect will be stronger if women at the upper end of the income distribution work more than those at the lower end.

The unified framework developed here is matched with U.S. data from the 1960s using a minimum distance estimation strategy. The procedure targets a collection of stylized facts concerning educational attainment, marriage and divorce, and married female labor-force participation. The framework fits the data for 1960 well. The structural parameter values obtained also look reasonable, and are tightly estimated. The model predictions for 2005 are then compared with the corresponding U.S. data. A slight retuning of a very limited number of parameters is then undertaken before the framework is used to decompose the shift in family structure into its underlying driving forces.

Both driving forces are quantitatively important for explaining the changes in family structure outlined above. The findings suggest that technological progress in the household sector accounts for the majority of the rise in married female labor-force participation. The narrowing of the gender gap in wages plays a secondary role here, too. Technological progress in the household sector also has a conspicuous effect in explaining the fall in marriage and the rise in divorce. Changes in the structure of wages are important for the increase in assortative mating and educational attainment.

While the rise in the skill (college) premium is the root cause for widening household income inequality, shifts in family structure provide a very important amplification mechanism. An increase in the return to education entices more people in the right-hand side of the ability distribution to go to college, which makes household incomes more disperse. A rise in positive assortative mating implies that a high (low) earning woman is more likely to be matched in marriage with a high (low) earning man and this, too, heightens inequality. For this latter effect to be operational, however, married women must work in the labor force. Hence, the rise in married female labor-force participation also plays a role in generating household income inequality.

After a brief literature review in Section 1.1, the remainder of this paper is organized as follows: Section 2 describes the main facts in detail. The model is presented in Section 3. Section 4 discusses the calibration/estimation procedure for 1960 and then Section 5 considers the model results for 2005. Section 6 decomposes the effects of each of the exogenous forces at play. Section 7 discusses the implications of the developed framework for household income inequality. Some concluding remarks are offered in Section 8.

1.1 Relationship to the Literature

The framework developed here resembles, in some aspects, Greenwood and Guner (2009) who study the fall in marriage and the rise in divorce. However, their model does not have heterogeneity with respect to education and ability. By adding this in the current framework, it is possible to study implications regarding assortative mating and inequality. Another related paper is by Regalia and Ríos-Rull (2001), which was ahead of its time. While their model does feature heterogeneity in both females and males, the focus is on accounting for the rise in the number of single mothers, something left out of the current analysis. They stress market forces, such as a movement in the gender gap, as explaining this rise, but a mechanism for studying the rise in assortative mating appears to be absent.

Jacquemet and Robin (2012) estimate a search and matching model of the marriage market for the U.S. Their analysis focuses on how female and male wages affect marriage probabilities and the share of the marital surplus received by partners. Given this goal, there is no need to include endogenous divorce or educational attainment in their model, which is central to the current paper. Eckstein and Lifshitz (2011) study the effect that different mechanisms (schooling, the gender wage gap, fertility, and marriage and divorce) had on the rise in the female labor-force participation during the twentieth century. They find that up to 42% of the change is left unexplained. They attribute this residual component to improvements in household technology and changes in social norms. This is consistent with the story told in this paper.

Parts of the picture have been addressed before elsewhere. Greenwood, Seshadri and Yorukoglu (2005) analyze the importance of technological progress in the home sector for making it more feasible for married females to enter into the labor market.[2] However, they do not study the changes in household structure or inequality, as done here. The interaction between inequality and positive assortative mating has also been noted by Fernandez and Rogerson (2001) and Fernandez, Guner and Knowles (2005). Chiappori, Iyigun and Weiss (2009) discuss how positive assortative mating provides a marriage market return for female educational investment, in addition to the traditional labor market one. The same effect is at play in the model developed here and, together with the rise in married female labor-force participation, is important to explain the rise in household income inequality. Greenwood, Guner, Kocharkov and Santos (2014) document the rise in assortative mating in the U.S. between 1960 and 2005 and assess how much it contributed to the rise in inequality. They do this within a simple model-free accounting framework, while the emphasis here is on decomposing the endogenous household decisions in a structural model.

Different ways in which marriage and female labor supply decisions interact in the current framework have been pointed out in the literature. Neeman, Newman and Olivetti (2008), for example, argue that college-educated working females can afford to be more selective in the marriage market and this may lead to more stable marriages. Such outside option effect is also operational in the current framework. Gihleb and Lifshitz (2013) document that a married female who is more educated than her husband is more likely to work. They analyze how changes in assortative mating can account for shifts in married female labor supply. Here, both assortative mating and female market participation are also endogenously determined. This is done within an equilibrium framework that can be used to study income inequality.

[2] Independent empirical work by Cavalcanti and Tavares (2008) and Coen-Pirani, Leon, and Lugauer (2010) also suggests that labor-saving household products have increased married female labor supply. Adamopoulou (2010) shows that they also have contributed to the rise of cohabitation. Advances in maternal medicine and pediatric care played a similar role, as has been noted by Albanesi and Olivetti (2015).

2 Facts

The shape of the American household has changed dramatically over the last 50 years. Some salient features of this transformation are:

1. *The Decline in Marriage.* The fraction of the population that has ever been married has fallen dramatically since 1960. At that time, about 85 percent of college educated individuals and 92 percent of non-college educated ones between the ages of 25 and 54 were married (or had been married)–see Figure 1. (Data sources for this and all other figures are provided in the Appendix.) Today, only 81 (79) percent are.[3] Note that the fall in the fraction of the population that is married is greatest for non-college educated people. Part of the decline in marriage is due to a delay in the age of marriage. Part is due to a rise in divorce. In 1960 the fraction of the population that was divorced, as measured by the ratio of the currently divorced to the ever-married population, was 5 percent for the non-college educated populace and 3 percent for the college educated segment. Today, it is around 20 percent for the former and 12 percent for the latter. Again, observe that divorce has risen more for the non-college educated vis-à-vis the college educated. The fact that the decline in marriage and the rise in divorce has affected college educated and non-college educated people differentially has been noted both by sociologists, Martin (2006), and economists, Stevenson and Wolfers (2007).

2. *The Rise in Assortative Mating.* When individuals marry today, as opposed to yesterday, they are more likely to pair with an individual from the same socioeconomic class. To see this split the world into two socioeconomic classes, viz non-college educated and college educated, and compare the two contingency tables contained in Table 1.[4]

[3] Redoing Figure 1 with currently-married and currently-divorced individuals, as opposed to ever-married and ever-divorced ones, delivers very similar patterns.

[4] Greenwood, Guner, Kocharkov and Santos (2014) use five educational classes. The results there parallel the findings here for two classes.

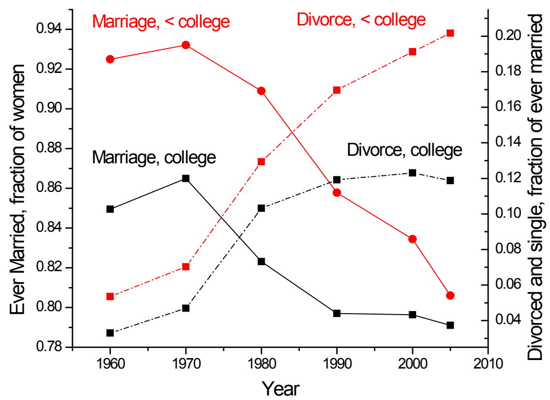

Figure 1: Marriage and Divorce by Education

TABLE 1: ASSORTATIVE MATING, AGE 25-54

1960			*2005*		
Husband	Wife		Husband	Wife	
	< College	College		< College	College
< College	0.855 (0.821)	0.023 (0.056)	< College	0.545 (0.427)	0.108 (0.226)
College	0.082 (0.115)	0.041 (0.008)	College	0.109 (0.227)	0.237 (0.120)
Statistics Measuring Assortative Mating					
$\chi^2 = 33,451$	obs $= 195,034$		$\chi^2 = 77,739$	obs $= 288,423$	
$\rho = 0.41$	$\delta = 1.08$		$\rho = 0.52$	$\delta = 1.43$	

The number in a cell shows the fraction of all matches that occur in the specified category. The figure in parenthesis provides the fraction that would occur if matching occurred randomly. First, note that there is positive assortative mating. To see this, focus on the diagonal elements in the tables. These cells show the fraction of matches where husband and wife have the same educational levels. The difference between the actual and random matches in these cells is always positive, reflecting positive assortative mating. The hypothesis of random matching is rejected by the χ^2 statistics.[5] The Pearson correlation coefficient, ρ, which measures the degree of association between the female and male educational categories, is also always positive. Second, the extent of positive assortative mating has become stronger over time. This can be seen in a number of ways. Note that between 1960 and 2005 the differences between the cells along the diagonals for the actual and random matrices increased. For each year take the ratio of the traces of the matrices for actual and random marriages. Denote this ratio by δ, which divides the actual concordant matches by the random concordant ones. The higher this number is the higher the degree of positive assortative mating. This ratio rises from 1.08 in 1960 to 1.43 in 2005. Additionally, the Pearson correlation coefficient, ρ, moves up from 0.41 to 0.52.

To further illustrate the rise in assortative mating, consider running a regression for married couples of the form

$$\begin{aligned} \text{EDUCATION}_t^w = \alpha + \beta \times \text{EDUCATION}_t^h + \sum_{y \in \mathcal{Y}} \gamma_t \times \text{EDUCATION}_t^h \times \text{DUMMY}_{y,t} \\ + \sum_{y \in \mathcal{Y}} \theta_t \times \text{DUMMY}_{y,t} + \varepsilon_t, \text{ with } \varepsilon_t \sim N(0, \sigma_t), \end{aligned} \tag{1}$$

where: $\text{EDUCATION}_t^w \in \{0,1\}$ is the observed level of the wife's education in period t and takes value of one if the woman completed college and a value of zero otherwise; $\text{EDUCATION}_t^h \in \{0,1\}$ is the husband's education; $\text{DUMMY}_{y,t}$ is a dummy variable for time such that $\text{DUMMY}_{y,t} = 1$ if $y = t$ and $\text{DUMMY}_{y,t} = 0$ if $y \neq t$; $t = 1960, 1970, 1980, 1990, 2000,$ and 2005 gives the years in the sample and $\mathcal{Y}$ is the subset of these years that omits 1960. The coefficient γ_t measures the additional impact relative to 1960 that a husband's education will have on his wife's. Note that the impact of a secular rise in female educational attainment is controlled by the presence of the time dummy variable. So, how does γ_t change over time? Figure 2 plots the

[5] The χ^2 statistics is calculated as $\sum_{i=1}^{c}\sum_{j=1}^{r}\frac{(O_{i,j}-E_{i,j})^2}{E_{i,j}}$, where $O_{i,j}$ and $E_{i,j}$ are observed and expected frequencies in cell (i,j). The degrees of freedom for the test is $(c-1)(r-1)$.

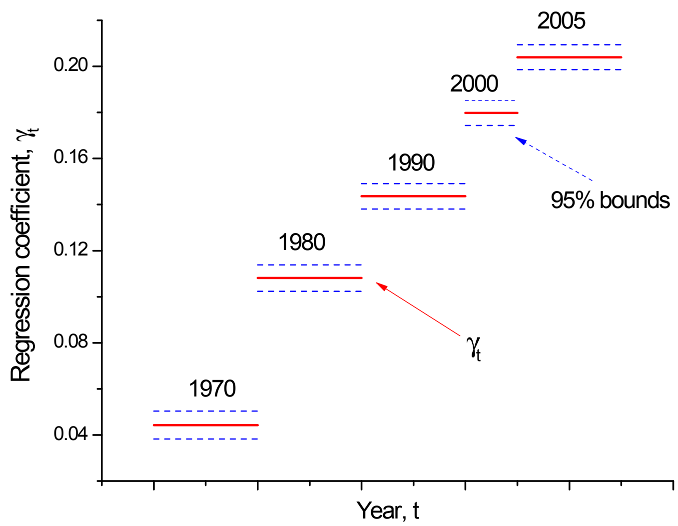

Figure 2: Rise in Assortative Mating. The solid line plots the regression coefficient, γ_t. The dashed lines show the 95 percent intervals.

rise in the γ_ts. The γ_t coefficients are significantly different from one another at the 95 percent confidence level. The same finding obtains if instead logits or probits are run. The rise in assortative mating has been noted before by sociologists Schwartz and Mare (2005).[6]

3. *The Increase in Education and Labor-Force Participation by Females.* Labor-force participation by married females has increased dramatically over the last 50 years.[7] This is true for both college educated and non-college educated women. In 1960 a minority of both classes of women worked. Now, the majority do–see Figure 3. At the same time, the number of women choosing to educate themselves has risen sharply. This may have been stimulated by a rise in the college premium, shown in Figure 4. College-educated women have always worked more than non-college educated ones. As female labor-force participation rose so did a married woman's contribution to family income–again, see Figure 3. Figure 4 also shows how the gender wage gap has

[6] Blossfeld and Timm (2003) document that the rise is not just a U.S. phenomenon but it is also observed in other developed countries.

[7] Here, as discussed in Appendix 9.1, labor-force participation is taken as the fraction of women who work (employment rate). Taking into account the unemployed women in the labor-force only changes these statistics slightly.

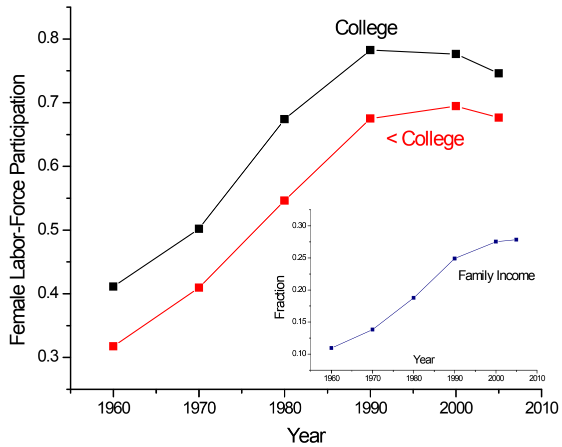

Figure 3: The Increase in Female Labor-Force Participation. The inset panel shows the contribution of married females to family income.

narrowed.

4. *The Increase in Income Inequality.* The distribution of income among households became more unequal between 1960 and 2005. The left-hand-side panel of Figure 5 shows the Lorenz curves for 1960 and 2005. Lorenz curves plot the cumulative share of income at each income percentile against the cumulative percentile of households. If income was equally distributed among households, these curves would coincide with the 45^0 line. The Lorenz curves show that the inequality increased. The Gini coefficient, which is twice the area between the Lorenz curves and the 45^0 line, increased from 0.31 to 0.43 between 1960 and 2005. Another way to see this is by plotting the household income relative to the mean household income in each percentile; this is done in the right-hand side of Figure 5. The relative income for all households below the 80th percentile declined, while there was a significant increase for households who are at the top of the income distribution.

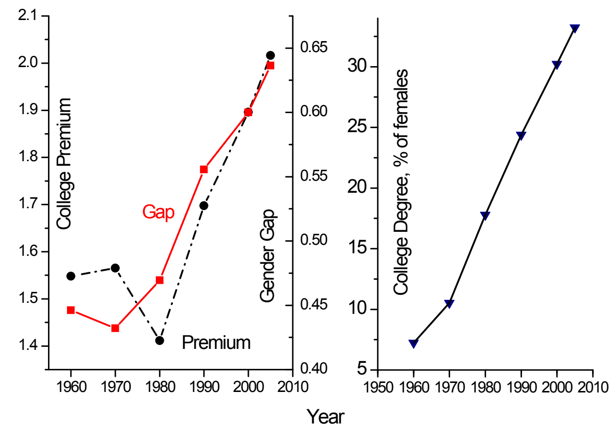

Figure 4: The Rise in Female Educational Attainment, the College Premium and the Narrowing of the Gender Gap

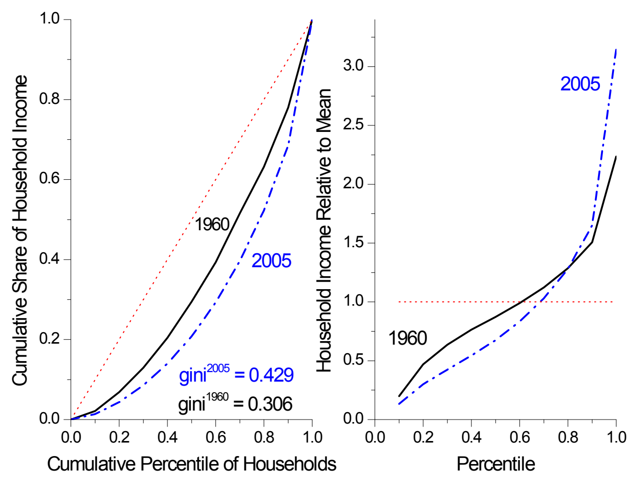

Figure 5: The Increase in Income Inequality

3 Model

What are the economic forces behind this dramatic shift in household characteristics? The idea can be described in a nutshell. People marry for both economic and noneconomic reasons: material well-being and love. On the material side of things, a woman's labor is important for both home production and market production. Over time the value of a woman's labor in home production has declined, due to technological progress in the household sector. Specifically, inputs into home production, such as dishwashers, frozen foods, microwave ovens, washing machines, and most recently the internet, have reduced the need for household labor.[8] At the same time, the value of a woman's time in the market and her incentives to obtain additional education increased as a result of a narrower gender wage gap and a higher skill premium. Therefore, love and the value of a woman's labor on the market have come to play more important roles, relative to the value of a woman's labor in home production, in the decision about whether or not to get married and whom to marry.

A rise in the skill premium heightens income inequality. If more high ability people go to college (relative to low ability ones), then the earnings differential between high and low ability individuals will widen. A higher skill premium creates a greater incentive to match assortatively. So, changes in marriage patterns can intensify inequality. But, for this mechanism to have force, married women must work in the market. Otherwise, if women never worked, household income inequality would closely follow the inequality among men.

To formalize the discussion above four things are required. First, a model of marriage and divorce is needed. Second, the framework must include a decision about whether or not married females should work. Third, the structure should incorporate an education decision. Fourth, people must be heterogenous in ability. This motivates the following setup.

[8] While the focus here is on marriages, these forces reduce the need to live in large households in general. Bethencourt and Ríos-Rull (2009) and Salcedo, Schoellman and Tertilt (2012) model the rise in single families, but in contexts not involving marriage. In a similar vein, Greenwood and Guner (2009) model the decisions of young people to leave their parent's home.

3.1 Setup

Imagine an economy that is populated by equal numbers of females, f, and males, m. Some females and males are college educated, while others are non-college educated. Some individuals of each gender will be married, the rest either divorced or never married. A person faces a constant probability of dying, π, each period. Upon death an individual is replaced by a young doppelganger who is about to begin his or her adult life. A person enters adult life with an ability level $a \in \mathcal{A}$. Initial ability is distributed across the population in line with the distribution function $A(a)$. It will be assumed that a is log normally distributed so that $\ln a \sim N(0, \sigma_a^2)$, where σ_a^2 denotes the variance of this zero-mean distribution.

The first decision that a young adult makes is whether or not to acquire an education. An uneducated male will earn the amount $w_0 a$ for each unit of labor supplied on the market, while an educated one earns $w_1 a$, where $w_1 > w_0$. A female earns the fraction $\phi \in [0, 1]$ of what a comparable male does. This reflects the gender gap in labor income. Acquiring an education has an up-front utility cost κ. For a person of gender $g \in \{f, m\}$ with ability a, κ is a random variable drawn from the distribution $C_a^g(\kappa)$. Assume that $C_a^g(\kappa)$ is a normal distribution with mean η_g/a and variance σ_κ^2. The idea here is that the cost of learning is inversely related to a person's ability, so on average higher ability individuals have lower costs of education. There is, however, mixing, since even among individuals with high ability there will be some who draw a high cost of education. Let $e \in \mathcal{E} = \{0, 1\}$ represent whether ($e = 1$) or not ($e = 0$) a person has acquired an education. After the education decision, each individual will be characterized by an ability level, a, and education level, e.[9] Denote a person's type by $(a, e) \in \mathcal{T} \equiv \mathcal{A} \times \mathcal{E}$.

Skill-biased technological progress results in skilled labor becoming more valuable relative to unskilled labor. Therefore, w_1 will grow over time relative to w_0 and the college premium moves up. As a consequence, more males will complete college. More females should finish college too. Take a single female first. The income earned when single will now have risen for a college educated woman, relative to a non-college educated one. Thus, a college educated single female can now live better than before (again, relative to an non-college educated one).

[9] It is optimal for an individual to get education in the first period. There is only a one-time utility cost and the benefits can be enjoyed for the longest possible horizon.

The extra income that a college education now provides means that a college educated single woman can afford to be choosier when selecting a husband. The same reasoning applies to being single because of a divorce.

Now, consider a married female. If she works, the return to a college education will have risen because her family will have more income (assuming that married women work). This provides an incentive to become more educated. This fact will also make a college educated woman more attractive on the marriage market. The return from finding a better partner on the marriage market, in and of itself, may provide an extra return for females (and males) to invest in college. A decline in the gender gap (a rise in ϕ) will reinforce women's incentives to acquire a college education. These forces should cause people to become pickier about their mate, causing a decline in marriage and a rise in divorce. Educated individuals are also less willing to marry uneducated agents, as with a higher skill premium, the cost of marrying an uneducated person is higher. Hence, one would expect a rise in assortative mating. This mechanism intensifies the effect of a step up in the skill premium on income inequality.

At the beginning of each period people must decide whether or not to work in the market during the period. Each person has one unit of time per period, which can be used for market or home production. Let h_f and h_m denote the hours worked by a female and a male in the market, respectively. The workweek in the market is fixed. This is reflected in the two possible values that h can take, $h \in \mathcal{H} \equiv \{0, \overline{h}\}$. Suppose single agents always work full time, allocating $\overline{h}$ to market and $1 - \overline{h}$ to household work. It is assumed that in marriage h is chosen only for the wife; the husband always works full-time.[10] Once a female decides whether or not to get educated at the start of her life, her wage rate does not change. In particular, females who choose to stay home do not experience any future wage penalty. The importance of labor market experience for the labor supply decisions of married females is emphasized, among others, by Eckstein and Wolpin (1989) and Eckstein and Lifshitz (2011). Olivetti (2006) documents an increase in the returns to experience for women and links it to the rise in their market participation. If experience matters for female wages, higher risk of divorce can encourage wives to work, as discussed by Fernandez and Wong (2014).

[10] The effect of changes in home technologies and wages on the time allocation decisions of husbands and wives has been analyzed by Bar and Leukhina (2011) and Knowles (2012).

Home goods are produced according to

$$n = \left[\theta d^{\lambda} + (1-\theta)(z - h_T)^{\lambda}\right]^{1/\lambda}, \; 0 < \lambda < 1, \tag{2}$$

where d is the amount of household durables, h_T is the total amount of time spent on market work, and $z \in \{1, 2\}$ is the household's size. The restriction that $0 < \lambda < 1$ implies that household durables, d, and time, $z - h_T$, are substitutes in household production. Household durables, d, can be purchased at the price p in terms of the market goods. The substitutability between labor and durable goods in household production implies that labor will be released from married households if the price of durables drops due to technological advance in the home sector. This promotes a rise in married female labor-force participation.

At the end of each period a single person will meet someone else of the opposite sex, with ability level a^* and education e^*. The couple will then draw two shocks. The first is a match-specific bliss shock $b \in \mathcal{B}$, taken from the distribution $F(b)$. In particular, b will be normally distributed so that $b \sim N(\bar{b}_s, \sigma^2_{b,s})$, where $\bar{b}_s$ and $\sigma^2_{b,s}$ denote the mean and variance of the bliss distribution that an unmarried couple draws from. In a marriage the bliss shock evolves according to the distribution $G(b'|b)$. Specifically, the bliss shock is assumed to follow the autoregressive process $b' = (1-\rho_{b,m})\bar{b}_m + \rho_{b,m} b + \sigma_{b,m}\sqrt{1-\rho_{b,m}}\varepsilon$, with $\varepsilon \sim N(0, 1)$. Here $\bar{b}_m$ and $\sigma^2_{b,m}$ represent the long-run mean and variance of this process, while $\rho_{b,m}$ is the coefficient of autocorrelation. A married person will decide whether or not to remain with their current partner partly on the value of this bliss shock.

The second shock, $q \in \mathcal{Q} = \{q_l, q_h\}$, measures the cost for a married woman of going to work.[11] Without loss of generality, assume that $q_l < q_h$. Some families may place a greater value on the woman staying at home; perhaps they are more likely to have children, a factor abstracted away from here. The q shock is drawn from the distribution $Q_{e,e^*}(q)$, which depends on the education levels of the husband, e, and wife, e^*. It is assumed that $Q_{e,e^*}(q)$ is uniform and a matched couple draws q_l and q_h with equal probabilities. Finally, it is assumed that $Q_{e,e^*}(q)$ depends only on the education level of the husband; i.e., there is one distribution for couples with college-educated husbands and another one for couples

[11] Guner, Kaygusuz and Ventura (2012) employ a similar strategy to model female labor-force participation.

with non-college educated husbands. This assumption is elaborated on further when the estimation strategy is discussed below. This shock is assumed to be permanent and hence does not change over time.[12] The couple then decides whether or not to marry. This decision will be based upon both economic and noneconomic considerations, as will soon become clear.

One barrier for married women going to work is the presence of young children. Modeling fertility endogenously is a substantial complication. The unitary model of the household must now be abandoned, because the presence of children affects men and women differently upon a divorce. Some form of a bargaining model must now be used—see Greenwood, Guner and Knowles (2003). As a practical matter, an accounting decomposition exercise along the lines of Greenwood, Guner, Kocharkov and Santos (2014) shows that changing fertility has little impact on income inequality.[13] Part of the cost of a married woman going to work might be child care costs, so q could partially reflect these. The effect of these latter costs on married female labor supply is examined by Attanasio, Low and Sanchez-Marcos (2008).

The noneconomic factors underlying a marriage consist of the value of b, the value of q, and a measure of how compatible a couple is. For a couple with education levels e and e^*, this compatibility is represented by the function $M(e, e^*)$, where

$$M(e, e^*) = \mu_0(1 - e)(1 - e^*) + \mu_1(ee^*).$$

If neither person went to college then this function returns a value of μ_0, since $e = e^* = 0$, while if both are college educated then it gives a value of μ_1. It yields 0 for all other cases.[14] If these parameters do not change over time, then any changes in assortative mating over time will be generated endogenously by the model only in response to technological progress in the household sector and to changes in the wage structure. Changes in μ_0 and μ_1, on the other hand, can capture changes in assortative mating due to other factors, such as changing

[12] It is assumed that this cost has no bite once a marriage is dissolved. As a result, and absent an explicit fertility decision or a cost of divorce, divorced and never-married females are indistinguishable in the model economy.

[13] To be more precise, in such an accounting exercise, imposing the 1960 fertility patterns to the 2005 economy only increases the Gini coefficient from 0.430 to 0.434.

[14] It could alternatively be assumed that a fraction of agents match within their own education group while the remaining agents match randomly.

social norms in the marriage market.[15] The economic factors are based upon each person's ability and educational attainment; that is, their (a, e) pair.

Now, suppose married women stay at home when the skill premium rises. It is still possible for more women to go to college. The increased return to skill will entice more men to acquire a college education. The fact that there are more college educated men around implies that there may be a bigger incentive for women to invest in college education in order to become more desirable on the marriage market (because of compatibility considerations).

Last, let all people discount the future at the rate $\beta = \widetilde{\beta}(1-\pi)$, where $\widetilde{\beta}$ is the subjective discount factor. Suppose that for singles tastes over the consumption of market goods, c, and nonmarket ones, n, are represented by

$$T_s(c,n) = \frac{1}{1-\zeta}\left(c - \mathfrak{c}\right)^{1-\zeta} + \frac{\alpha}{1-\xi} n^{1-\xi},$$

where $\mathfrak{c}$ is a fixed cost in terms of market goods. Assume that in marriage the utility derived from consumption and love is a public good. Momentary utility for a married household is

$$T_m(c,n) = \frac{1}{1-\zeta}\left(\frac{c-\mathfrak{c}}{1+\chi}\right)^{1-\zeta} + \frac{\alpha}{1-\xi}\left(\frac{n}{1+\chi}\right)^{1-\xi},$$

where $\chi < 1$ is the adult equivalence scale. The equivalence scale reflects the fact that there are economies of scale in household consumption, so that a two-person household requires less than the twice the consumption of a one-person household in order to realize the same level of utility as the latter. The variables $\mathfrak{c}$ and χ provide an economic motive for marriage. A two-person household will be better off than single-person ones. As incomes grow over time the fixed cost, $\mathfrak{c}$, will be easier to cover. Therefore, a trend to smaller households will emerge. This will be reflected in a lower marriage rate and a higher divorce rate.

Now, suppose that $\xi > \zeta$, which implies higher diminishing marginal utility for household goods vis-à-vis market ones. In this case, single households will benefit the most from technological advance in the home sector. This is because *at the margin* they will be the most intensive users of home production, as paradoxical as this may seem. That is, while the

[15] Modeling changes in societal norms, a factor out of the purview of the current analysis, is the subject of Fernandez, Fogli and Olivetti (2004).

economically better off married couple (due to economies of scale) will consume more of all goods, relative to a single person, they will not consume twice as much home goods, because they will prefer to direct, at the margin, their larger consumption bundle toward market ones. Technological progress in the home allows for more home goods to be produced. It will improve single life the most because the marginal value for a home produced good is highest for singles. This operates to reduce household size over time.

To complete the description of the setting, the timing of events within a period is illustrated in Figure 6. At any point, the model economy will be populated by married, single-male and single-female households. Some of these married households will have husbands and wives who are college educated, while others will have two non-college educated members, and yet others will have a college educated husband and a non-college educated wife or vice versa. Similarly, single households will also differ by their educational attainments. Furthermore, not all educated agents will have the same earnings, since they have different ability levels. Finally, some married females will participate in the labor market while others won't. These differences will generate inequality among households, and the model economy provides a natural framework to study how changes in household structure affect inequality.

3.2 Singles

Consider the consumption decision facing a single. This is a purely static problem. For a single person of gender $g \in \{f, m\}$ with ability a and educational attainment $e \in \{0, 1\}$, the problem is given by

$$U_s^g(a, e) \equiv \max_{c,n,d} T_s(c, n), \tag{3}$$

subject to

$$c = \begin{cases} w_e \phi a \overline{h} - pd, & \text{if } g = f, \\ w_e a \overline{h} - pd, & \text{if } g = m, \end{cases}$$

and

$$n = \left[\theta d^\lambda + (1 - \theta)(1 - \overline{h})^\lambda\right]^{1/\lambda} .$$

Next, turn to the marriage decision. Consider a single person of gender $g \in \{f, m\}$

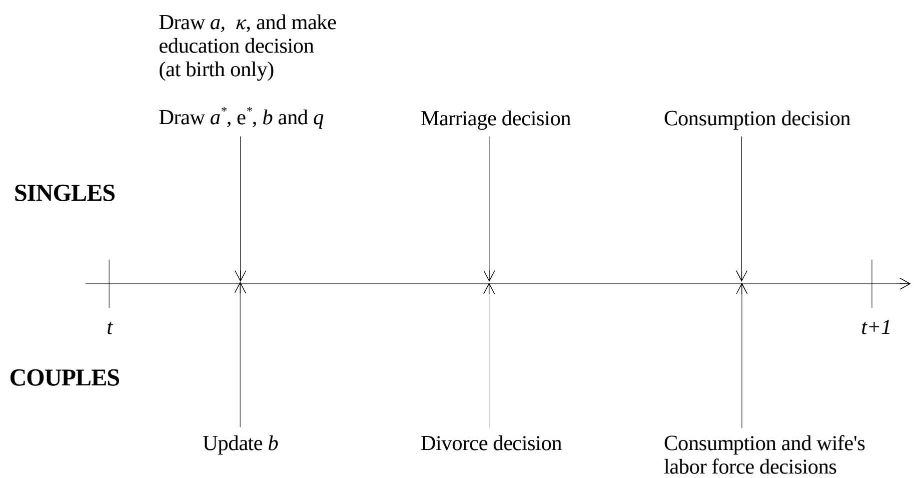

Figure 6: Timing of Decisions

with ability a and educational attainment e. Suppose that this individual meets someone of the opposite gender, g^*, who has ability a^* and education attainment e^* and the potential couple draws shocks b and q. Will they get married? To answer this question, let $V_s^g(a,e)$ and $V_s^{g^*}(a^*,e^*)$ represent the expected lifetime utilities that both parties will realize if they remain single in the current period. Likewise, denote the expected lifetime utility that is associated with a marriage in the current period by $V_m^g(a,e,a^*,e^*,b,q)$. A marriage will occur if and only if

$$V_m^g(a,e,a^*,e^*,b,q) \geq V_s^g(a,e) \textbf{ and } V_m^{g^*}(a^*,e^*,a,e,b,q) \geq V_s^{g^*}(a^*,e^*). \tag{4}$$

Observe that for a marriage to happen it must be the first choice for *both* parties. Let the indicator function $\mathbf{1}^g(a,e,a^*,e^*,b,q)$ take a value of 1 if both people in the match want it and value of zero otherwise. Thus,

$$\mathbf{1}^g(a,e,a^*,e^*,b,q) = \begin{cases} 1, & \text{if (4) holds,} \\ 0, & \text{otherwise.} \end{cases} \tag{5}$$

[Observe that $\mathbf{1}^g(a,e,a^*,e^*,b,q) = \mathbf{1}^{g^*}(a^*,e^*,a,e,b,q)$.]

The value of being single in the current period will depend on the distribution of potential future mates on the marriage market. Each mate is indexed by their (a^*,e^*) combination. Let the distribution of potential mates from the opposite gender be represented by $\widehat{\mathbf{S}}^{g^*}(a^*,e^*)$. This will be elaborated on later. The value function for a single person of gender g with ability a and educational attainment e can now be expressed as

$$\begin{aligned} V_s^g(a,e) &= U_s^g(a,e) \\ &\quad +\beta \int\limits_{\mathcal{Q}} \int\limits_{\mathcal{B}} \int\limits_{\mathcal{T}} \{\mathbf{1}^g(a,e,a^*,e^*,b,q) V_m^g(a,e,a^*,e^*,b,q) \\ &\quad +[1-\mathbf{1}^g(a,e,a^*,e^*,b,q)] V_s^g(a,e)\} d\widehat{\mathbf{S}}^{g^*}(a^*,e^*) dF(b) dQ_{e,e^*}(q), \text{ for } g=f,m. \end{aligned} \tag{6}$$

Embedded in the above dynamic programming problem is the assumption that one will draw a mate next period with an ability level less than a^* and education level e^* with probability

$\widehat{\mathbf{S}}^{g^*}(a^*, e^*)$.[16]

3.3 Couples

The static consumption problem for a married couple is

$$U_m^g(a, e, a^*, e^*, q) \equiv \max_{c,n,d,h^f \in \{0,1\}} T_m(c, n) - h^f q, \tag{7}$$

subject to

$$c = \begin{cases} w_{e^*} a^* \overline{h} + w_e \phi a \overline{h} h^f - pd, & \text{if } g = f, \\ w_e a \overline{h} + w_{e^*} \phi a^* \overline{h} h^f - pd, & \text{if } g = m, \end{cases}$$

and

$$n = \left[\theta d^\lambda + (1 - \theta)(2 - \overline{h} - \overline{h} h^f)^\lambda\right]^{1/\lambda}.$$

Recall that all utility flows are public goods within a marriage. So, the couple picks c, n, d, and h^f together. Working in the market takes away the fraction $\overline{h}$ of a person's time endowment. Recall that husbands are assumed to work full-time. The variable $h^f \in \{0, 1\}$ represents the wife's participation decision. It takes a value of 1 when the woman works and a value of 0 if she doesn't. Once again, the variable q gives the cost for a married woman of going to work. This is netted out of household utility, when the woman works. Let $H^f(a, e, a^*, e^*, q) \in \{0, 1\}$ denote the female labor force participation decision for a couple of type (a, e, a^*, e^*, q).

A divorce will occur if and only if

$$V_s^g(a, e) \geq V_m^g(a, e, a^*, e^*, b, q) \textbf{ or } V_s^{g^*}(a^*, e^*) \geq V_m^{g^*}(a^*, e^*, a, e, b, q). \tag{8}$$

Therefore, the indicator function $\mathbf{1}^g(a, e, a^*, e^*, b, q)$, specified by (5), will return a value of one if both the husband and wife want to remain married and will give a value of zero if one

[16] Other matching processes could be envisaged, such as the Gale and Shapley algorithm employed by Del Boca and Flinn (2014).

of them desires a divorce. Given this, the value function for a married person reads

$$
\begin{aligned}
V_m^g(a,e,a^*,e^*,b,q) &= U_m^g(a,e,a^*,e^*,q) + b + M(e,e^*) \\
&\quad +\beta\{\int_{\mathcal{B}} [\mathbf{1}^g(a,e,a^*,e^*,b',q) V_m^g(a,e,a^*,e^*,b',q) \\
&\quad +[1-\mathbf{1}^g(a,e,a^*,e^*,b',q)] V_s^g(a,e)] dG(b'|b)\}, \text{ for } g=f,m.
\end{aligned} \tag{9}
$$

This value function is used in equations (4), (5), (6) and (8); likewise, (6) is employed in (4), (5), (8) and (9).

3.4 Educational Choice

People choose their education level at the beginning of adult life after they observe κ, the utility cost of education. The problem they face is

$$
\max_{e \in \{0,1\}} \{V_s^g(a,e) - e\kappa\}, \tag{10}
$$

where V_s^g is defined by (6). The decision rule stemming from this problem will be represented by a simple threshold rule, since $V_s^g(a,1) > V_s^g(a,0)$,

$$
E_a^g(\kappa) = \begin{cases} 1 \text{ if } \kappa \leq \widetilde{\kappa}_a^g, \\ 0 \text{ if } \kappa > \widetilde{\kappa}_a^g. \end{cases} \tag{11}
$$

The total number of agents of gender g with ability a who choose to get a college degree is then given by

$$
\int_{-\infty}^{\infty} E_a^g(\kappa) dC_a^g(\kappa),
$$

and the total number of gender g agents with college education is

$$
\int_0^{\infty} \int_{-\infty}^{\infty} E_a^g(\kappa) dC_a^g(\kappa) dA(a).
$$

3.5 Steady-State Equilibrium

The dynamic programming problem for a single person, or (6), depends upon knowing the solution to the problem for a married person, as given by (9), and vice versa. Furthermore, to solve the single's problem requires knowing the steady-state distribution of potential mates in the marriage market, $\mathbf{S}^g(a)$. The non-normalized steady-state distribution for singles is

$$\begin{aligned}\mathbf{S}^g(a',e') &= (1-\delta)\int_{\mathcal{Q}}\int_{\mathcal{B}}\int_{\mathcal{T}}^{a',e'}\int_{\mathcal{T}}[1-\mathbf{1}^g(a,e,a^*,e^*,b,q)]d\mathbf{S}^g(a,e)d\widehat{\mathbf{S}}^{g^*}(a^*,e^*)dF(b)dQ_{e,e^*}(q)\\ &+(1-\delta)\int_{\mathcal{Q}}\int_{\mathcal{B}}\int_{\mathcal{B}}\int_{\mathcal{T}}^{a',e'}\int_{\mathcal{T}}[1-\mathbf{1}^g(a,e,a^*,e^*,b,q)]d\mathbf{M}^g(a,e,a^*,e^*,b_{-1},q)dG(b|b_{-1})\\ &+\delta e'\left[\int_{-\infty}^{\infty}E^g_{a'}(\kappa)dC^g_{a'}(\kappa)dA(a')\right]+\delta(1-e')\left[1-\int_{-\infty}^{\infty}E^g_{a'}(\kappa)dC^g_{a'}(\kappa)dA(a')\right]\text{ for } g=f,m.\end{aligned} \tag{12}$$

In the above recursion, $\mathbf{M}^g(a,e,a^*,e^*,b_{-1},q)$ represents the steady-state distribution over married people and $\widehat{\mathbf{S}}^{g^*}(a^*,e^*)$ denotes the normalized distribution for singles of the opposite gender and is defined by

$$\widehat{\mathbf{S}}^{g^*}(a^*,e^*)\equiv\frac{\mathbf{S}^{g^*}(a^*,e^*)}{\int_{\mathcal{T}}d\mathbf{S}^{g^*}(a^*,e^*)}. \tag{13}$$

The first term in (12) counts those singles who failed to match in the current period. The second term enumerates the flow into the pool of singles from failed marriages. The last two terms represent the arrival of new adults (the doppelgangers).

In similar fashion, the distribution of married men and women is defined by

$$\begin{aligned}\mathbf{M}^g(a',e',a^{*\prime},e^{*\prime},b',q') &= (1-\delta)\int_{\mathcal{Q}}^{q'}\int_{\mathcal{B}}^{b'}\int_{\mathcal{T}}^{a',e'}\int_{\mathcal{T}}^{a^{*\prime},e^{*\prime}}\mathbf{1}^g(a,e,a^*,e^*,b,q)\\ &\times d\widehat{\mathbf{S}}^{g^*}(a^*,e^*)d\mathbf{S}^g(a,e)dF(b)dQ_{e,e^*}(q)\\ &+(1-\delta)\int_{\mathcal{Q}}^{q'}\int_{\mathcal{B}}^{b'}\int_{\mathcal{B}}\int_{\mathcal{T}}^{a',e'}\int_{\mathcal{T}}^{a^{*\prime},e^{*\prime}}\mathbf{1}^g(a,e,a^*,e^*,b,q)\\ &\times d\mathbf{M}^g(a,e,a^*,e^*,b_{-1},q)dG(b|b_{-1}),\text{ for } g=f,m.\end{aligned} \tag{14}$$

The first term on the right-hand side measures the flow into marriage from single life. Only $1-\delta$ of these matches will last into the next period. The second term counts the number of marriages that will survive from the current period into the next one. To compute a steady-state solution for the model amounts to solving a fixed-point problem, as the following definition of equilibrium should make clear. [Note that $\mathbf{M}^{g}(a, e, a^{*}, e^{*}, b_{-1}, q) = \mathbf{M}^{g^{*}}(a^{*}, e^{*}, a, e, b_{-1}, q)$.]

Definition 1 *A stationary matching equilibrium is a set of value functions for singles and marrieds, $V_{s}^{g}(a, e)$ and $V_{m}^{g}(a, e, a^{*}, e^{*}, b, q)$, an education decision rule for singles, $E_{a}^{g}(\kappa)$, a matching rule for singles and married couples, $\mathbf{1}^{g}(a, e, a^{*}, e^{*}, b, q)$, and stationary distributions for singles and married couples, $\mathbf{S}^{g}(a, e)$ and $\mathbf{M}^{g}(a, e, a^{*}, e^{*}, b_{-1}, q)$, all for $g = f, m$, such that:*

1. *The value function $V_{s}^{g}(a, e)$ solves the single's recursion (6), taking as given her/his indirect utility function, $U_{s}^{g}(a, e)$, from problem (3), the value function for a married person, $V_{m}^{g}(a, e, a^{*}, e^{*}, b, q)$, the matching rule for singles, $\mathbf{1}^{g}(a, e, a^{*}, e^{*}, b, q)$, and the normalized distribution for singles, $\widehat{\mathbf{S}}^{g}(a, e)$, defined by (13).*

2. *The value function $V_{m}^{g}(a, e, a^{*}, e^{*}, b, q)$ solves a married person's recursion (9), taking as given her/his indirect utility function, $U_{m}^{g}(a, e, a^{*}, e^{*}, q)$, from problem (7), the matching rule for a married couple, $\mathbf{1}^{g}(a, e, a^{*}, e^{*}, b', q)$, and the value function for a single, $V_{s}^{g}(a, e)$.*

3. *The decision rule $E_{a}^{g}(\kappa)$ solves a single's education problem (10), taking as given $V_{s}^{g}(a, e)$ from (6).*

4. *The matching rule $\mathbf{1}^{g}(a, e, a^{*}, e^{*}, b, q)$ is determined in line with (5), taking as given the value functions $V_{s}^{g}(a, e)$ and $V_{m}^{g}(a, e, a^{*}, e^{*}, b, q)$.*

5. *The stationary distributions $\mathbf{S}^{g}(a, e)$ and $\mathbf{M}^{g}(a, e, a^{*}, e^{*}, b_{-1}, q)$ solve (12) and (14), taking as given the decision rule for an education, $E_{a}^{g}(\kappa)$, and the matching rule $\mathbf{1}^{g}(a, e, a^{*}, e^{*}, b, q)$.*

4 Fitting the Model to the U.S. in 1960

The model developed will now be fit to the U.S. data for 1960. There are many parameters. A few of them are easy to choose and can be assigned on the basis of a priori information. Most of the parameters will be fitted using a minimum distance estimation procedure, however. The estimation procedure will focus on the 1960 U.S. economy. In the next section the model will be simulated using 2005 wages and durable goods prices and the resulting fit examined. It will be assumed that the model is in a steady state for each of these years.

4.1 A Priori Information

The easy ones are done first. The length of period is one year. Let $\widetilde{\beta}$ (the subjective discount factor) be 0.96, a standard value in macroeconomic studies, such as in Prescott (1986). All the targets for the estimation are calculated for individuals between ages 25 and 54, which corresponds to an operational lifespan of 30 years. Set $\pi = 1/30 = 0.033$ so that individuals in the model also live 30 years on average. This would dictate a value for the discount factor of $\beta = 0.960 \times (1 - 0.033)$. Assigning a value for the work week, $\overline{h}$, is straightforward. Assume a 40 hour work week. Since there are 112 non-sleeping hours in a week, let $\overline{h} = 40/112 = 0.36$.[17] Last, the household production parameters, θ and λ, have been estimated by McGrattan, Rogerson and Wright (1997). Their numbers, $\theta = 0.21$ and $\lambda = 0.19$, are used here.[18] Finally, in line with the OECD equivalence scale, set $\chi = 0.70$. To summarize, the parameter values picked on the basis of a priori information are displayed in Table 2.

[17] An alternative would be to set $\overline{h}$ to actual hours worked per week. The value of $\overline{h}$ would then be 0.37, 0.35, and 0.39 in 1960 for single males, single females, and married males, respectively, and 0.38, 0.36, and 0.40 in 2005. Simulating the model economy for 1960 and 2005 with these values, instead of $\overline{h} = 0.36$, produces almost identical results.

[18] The parameter λ determines the elasticity of substitution between durable goods and household time, $1/(1-\lambda)$. McGrattan, Rogerson and Wright (1997) identify this parameter using time series variation. Since targets from a single year (specifically, 1960) are used to estimate the parameters here, λ is not included among them. Table B1 in Appendix B shows the 1960 model statistics when λ is increased or decreased by 20%, while all other parameters are kept at their benchmark values. Changes in λ do not have any major effect on 1960 targets.

Table 2: Parameters – A Priori information

Category	*Parameter Values*	*Criteria*
Preferences	$\widetilde{\beta} = 0.96$	Prescott (1986)
	$\chi = 0.70$	OECD Scale
Household Technology	$\theta = 0.21, \lambda = 0.19$	McGrattan et al (1997)
Death Probability	$\pi = 1/30$	A 30 year lifespan
Hours	$\overline{h} = 0.36$	Data

4.2 Minimum Distance Estimation

This leaves 23 parameters to be assigned. There are 6 preference parameters, $\{\zeta, \mathfrak{c}, \alpha, \xi, \mu_0, \mu_1\}$, 5 parameters for the marital bliss shocks, $\{\overline{b}_s, \sigma_{b,s}, \overline{b}_m, \sigma_{b,m}, \rho_{b,m}\}$, 3 wage parameters $\{w_{0,1960}, w_{1,1960}, \phi_{1960}\}$, 1 parameter for durable goods prices, p_{1960}, 3 parameters for the cost of education, $\{\eta_f, \eta_m, \sigma_\kappa\}$, and 1 parameter for the ability distribution, σ_a. It is assumed that q_h and q_l differ by the education level of the husband. Let q_h^1 and q_l^1 denote the cost of joint work for couples with a college educated husband, and q_h^0 and q_l^0 be the corresponding values for households with a non-college educated husband. This adds 4 more parameters. For both types of husbands, it is assumed that there is an equal chance of drawing a high or a low cost. Normalize the wage rate for a non-college educated male in 1960 to be one, so that $w_{0,1960} = 1$. The remaining 22 parameters are estimated so that the model matches, as closely as is possible, a set of 25 data moments for 1960.[19]

The data targets are:

1. *Educational Attainment.* The fraction of females and males that went to college.

2. *Vital Statistics.* The fraction of the population that has ever-been married by educational level, and that is currently divorced (out of the ever-married populace) by education level.[20]

[19] In the data used, observations come from a mixture of different cohorts. In the model, there is essentially an infinite horizon cohort, with some of its members dying each period and being replaced with doppelgangers. One way to get the data to be close to the steady state approximation is to use averages of a sub-period rather than just a single year. The decennial census that is used to compute the moments contains data for 1960 only. Computing the same data targets using the Current Population Survey (CPS) for several years in the 1960s (1962-1965) yields remarkably similar statistics.

[20] In the model economy individuals form households to enjoy economies of scale in household production

3. *Assortative Mating.* A contingency table for marriage that contains the fractions of marriages for each possible combination of educational levels for both the husband and wife.

4. *Married Female Labor-Force Participation.* The fraction of married females, classified by the education levels of husbands and wives, that work, and the share of household income provided by wives.

5. *Skill premium and gender earnings gap:* The earnings ratio between college educated and non-college educated males (the skill premium), and the earnings ratio between females and males (the gender gap).

6. *Inequality:* The Gini coefficient for earnings inequality among households; the 90-to-10 and 90-to-50 percentile ratios; income inequality across married households by the educational attainments of husbands and wives; and the ratio of single female to married household income.

Before the parameter estimates and the model fit are presented, a comment on the skill premium and gender wage gap as targets is in order. Take the skill premium first. Wages are needed for non-college and college educated males in 1960; viz, $w_{0,1960}$ and $w_{1,1960}$. Recall that $w_{0,1960} = 1$. The college premium in 1960 for the model is the average ratio of earnings for a college educated male to a non-college educated one, as given by

$$\frac{w_{1,1960}\left[\int_0^\infty \int_{-\infty}^\infty aE_a^m(\kappa)dC_a^m(\kappa)dA(a)\right] / \left[\int_0^\infty \int_{-\infty}^\infty E_a^m(\kappa)dC_a^m(\kappa)dA(a)\right]}{\left[\int_0^\infty \int_{-\infty}^\infty a(1-E_a^m(\kappa))dC_a^m(\kappa)dA(a)\right] / \left[\int_0^\infty \int_{-\infty}^\infty (1-E_a^m(\kappa))dC_a^m(\kappa)dA(a)\right]}.$$

This is an endogenous variable, because young single males decide whether or not to go to

and consumption. Hence, it is a model of couples living together rather than being legally married. While it is possible to combine the married and cohabiting population to arrive at a stock of people who live together, it is more problematic to calculate a separation rate for cohabiting people. In the U.S. Census the divorced category only covers those who had been married in the past. See Gemici and Laufer (2014) for a study of cohabitation and marriage. These authors calculate dissolution rates for married and cohabiting couples from the Panel Study of Income Dynamics. The calculation of such rates, however, is only possible after 1978.

school. The strategy here is to pin down $w_{1,1960}$, along with other parameters, such that this statistic is as close as possible to its data counterpart, about 1.55 in 1960.

A similar strategy is followed to determine the gender wage gap parameter ϕ_{1960}. Recall that $\mathbf{M}^f(a, e, a^*, e^*, b, q)$ and $\mathbf{S}^f(a, e)$ are non-normalized distributions of married and single females, respectively. As in the data, average earnings for females are calculated for those who work; i.e., all singles and married ones who participate in the labor market. This is given by

$$\begin{aligned}
&\phi_{1960} w_{1,1960} \int \ldots \int aeH^f(a, e, a^*, e^*, q) d\mathbf{M}^f(a, e, a^*, e^*, b, q) \\
&+\phi_{1960} \int \ldots \int a(1-e) H^f(a, e, a^*, e^*, q) d\mathbf{M}^f(a, e, a^*, e^*, b, q) \\
&+\phi_{1960} w_{1,1960} \int \int aed\mathbf{S}^f(a, e) + \phi_{1960} \int \int a(1-e) d\mathbf{S}^f(a, e).
\end{aligned}$$

(Again, $w_{0,1960} = 1$.) The first and second terms in this equation give the average earnings for married skilled and unskilled women who decide to work. The last two terms calculate the same statistic for single women. On the other hand, since all males, single or married, work, the average earnings for them read

$$\left[w_{1,1960} \int_0^{\infty} \int_{-\infty}^{\infty} aE_a^m(\kappa) dC_a^m(\kappa) dA(a) + \int_0^{\infty} \int_{-\infty}^{\infty} a(1 - E_a^m(\kappa)) dC_a^m(\kappa) dA(a) \right].$$

The gender earnings gap in the model is the ratio of these two averages. The parameter ϕ_{1960} is estimated, again along with other parameters, to generate a gender earnings gap in the model that is as close as possible to the observed gender earnings gap in the data, about 0.45 in 1960.

Let DATA represent a vector of 25 moments that are calculated from the U.S. data for 1960. A vector of the analogous 25 moments can be obtained from the steady state of the model for 1960. The results for the model will be a function of the parameters to be estimated, of course. Therefore, represent this vector of moments by $\mathcal{M}(\omega)$ where ω denotes the vector of 22 parameters to be estimated. Define the vector of deviations between the data and the model by $G(\omega) \equiv \text{DATA} - \mathcal{M}(\omega)$.

Minimum distance estimation picks the parameter vector, ω, to minimize a weighted sum of the squared deviations between the data and the model. Specifically,

$$\widehat{\omega} = \arg\min G(\omega)' W G(\omega),$$

where W is some positive semi-definite matrix. The estimation assumes that the model is a true description of the world, for some value of the parameter vector, ω. The number of targets is larger than the number of parameters. The estimator, $\widehat{\omega}$, is consistent for any weighting matrix, W. Let $\text{se}(\widehat{\omega})$ represent the vector of standard errors for the estimator, $\widehat{\omega}$. It is given by

$$\text{se}(\widehat{\omega}) = \text{diag}\{\frac{[J(\widehat{\omega})' W J(\widehat{\omega})]^{-1} J(\widehat{\omega})' W \Sigma W J(\widehat{\omega}) [J(\widehat{\omega})' W J(\widehat{\omega})]^{-1\prime}}{n}\},$$

where $J(\widehat{\omega}) \equiv \partial \mathcal{M}(\widehat{\omega}) / \partial \widehat{\omega}$, Σ is the variance-covariance matrix for the data moments, and n is the total number of observations.[21] The data moments are calculated from the 1960 U.S. Census. Each element in Σ is weighted by the number of observations for a particular moment relative to the total number of observations. Set $W = I$, where I is the identity matrix.

Table 3 reports the parameter estimates and their associated standard errors. The set of moments and the corresponding results for the benchmark model for 1960 are displayed in Table 4. The fitted parameter values look reasonable and are tightly estimated, for the most part.

[21] Each diagonal element of Σ corresponds to the variance of a particular moment in the data. Since most moments are calculated with different sample restrictions, off-diagonal terms are set to zero.

TABLE 3: PARAMETERS – ESTIMATED (MINIMUM DISTANCE)

Category	*Parameter Values*	*Standard Error*	*95% Conf. Interval*
Preferences	$\alpha = 1.198$	0.029	[1.141, 1.255]
	$\xi = 3.114$	0.021	[3.073, 3.155]
	$\zeta = 1.782$	0.010	[1.762, 1.803]
	$\mathfrak{c}= 0.068$	0.0004	[0.067, 0.069]
	$\mu_0= 0.400$	0.170	[0.067, 0.733]
	$\mu_1= 1.308$	0.094	[1.124, 1.492]
Ability Shocks	$\sigma_a= 0.310$	0.003	[0.304, 0.315]
Matching Shocks	$\bar{b}_s= -1.497$	0.111	[-1.715, -1.279]
	$\sigma_{b,s}= 0.599$	0.075	[0.451, 0.746]
	$\bar{b}_m= -0.403$	0.029	[-0.459, -0.347]
	$\sigma_{b,m}= 0.338$	0.028	[0.284, 0.393]
	$\rho_{b,m}= 0.959$	0.004	[0.951, 0.967]
Home Shocks	$q_l^0= 0.175$	0.066	[0.046, 0.305]
	$q_h^0= 0.303$	0.127	[0.053, 0.552]
	$q_l^1= -0.226$	0.066	[-0.354, -0.097]
	$q_h^1= -0.126$	0.123	[-0.367, 0.115]
Prices	$p_{1960}= 54.703$	8.219	[38.594, 70.812]
	$w_0 = 1$ (normalization)	–	–
	$w_1 = 1.040$	0.015	[1.011, 1.068]
	$\phi = 0.400$	0.002	[0.396, 0.404]
Cost of Education	$\omega_m= 69.861$	5.525	[59.031, 80.690]
	$\omega_f= 134.970$	8.770	[117.781, 152.159]
	$\sigma_e= 54.134$	4.871	[44.587, 63.681]

The estimate of the degree of curvature in the utility function for market goods ($\zeta = 1.78$) is in line with the macroeconomics literature, which typically uses a coefficient of relative aversion of either 1 or 2. Note that nonmarket goods have a weight of $\alpha = 1.20$ in utility. This can be thought of as corresponding to a weight assigned to consumption in a typical macro model of 0.45, with the remaining weight of 0.55 being applied to leisure; i.e., $0.55/0.45 = 1.20$. Nonmarket goods play a role similar to leisure here. Thus, this coefficient does not seem unreasonable. The utility function for nonmarket goods is more concave ($\xi = 3.114$) than the one for market goods. As was mentioned in Section 3, this implies that a household will tilt its allocation towards market goods as it gets wealthier, and, as a result, this parameter affects the differences in marriage and divorce rates for educated and non-educated individuals.

A household spends about 19 percent of its market consumption on covering the fixed costs of a home (when $\mathfrak{c} = 0.068$). This fixed cost provides an economic motive for marriage since married agents can pool resources to cover $\mathfrak{c}$. It also gives an incentive for married women to participate in the market. If $\mathfrak{c}$ were set to zero, with all other parameters kept at their benchmark values, the fraction of single individuals would be 20 percent (instead of 15 percent). Furthermore, married women are less likely to participate in the labor market. Married female labor-force participation would be only 3.5 percent. The parameters of the marital bliss shocks determine marriage and divorce rates in the model. Note that the distribution for singles has a lower mean (-1.497 versus -0.403), but a higher variance (0.599 versus 0.338), than the one for married couples. This creates an incentive for singles to wait for a match with high b. Once a marriage is formed, marital bliss is quite persistent ($\rho_{b,m} = 0.959$).[22] An educated person realizes 1.308 utils (μ_1) from marrying a similarly educated person. The extra utility for a marriage between two non-educated individuals is lower, 0.4. These are higher than the mean level of bliss in a marriage of -0.403 and influence the level of marital sorting. Setting μ_0 and μ_1 to zero in the 1960 economy would generate a correlation between husbands and wives education that is close to zero.

The estimation requires that joint work is costly for households in which the husband is non-college educated ($q_l^0 = 0.175$ and $q_h^0 = 0.303$), but there is a benefit of joint work for households in which the husband is educated ($q_l^1 = -0.226$ and $q_h^1 = -0.126$). Given husband's educational attainment, these parameters determine how the labor-force participation of a married female changes with her own education. This allows the benchmark economy to produce the observed response of female labor-force participation with respect to female educational attainment. Finally, the variance of the ability distribution, together with the parameters that determine the cost of education, weigh on both the fraction of individuals who choose to get a college education and the overall level of inequality.

[22] In the simulations, $N(\bar{b}_s, \sigma_{b,s}^2)$ and $b' = (1-\rho_{b,m})\bar{b}_m + \rho_{b,m} b + \sigma_{b,m}\sqrt{1-\rho_{b,m}}\varepsilon$ are approximated on a discrete grid of size 15 using Tauchen's (1986) procedure. Similarly, $N(0, \sigma_a^2)$ is approximated on a grid of size 40.

As Table 4 illustrates, the model has no problem matching most of the targets. Single females relative to married couples are poorer in the model than they are in the data. The model misses the relative income of households that are composed of a college-educated wife and a non-college educated husbands. Note, however, that there is a very small number of such households (only 2.8 percent of all marriages). The model yields a slightly higher level of divorce in 1960; 3.3 percent in the data versus 4 percent in the model for college educated people and 5.3 percent in the data versus 4.4 percent in the model for non-college educated ones. As a result, the proportion of singles in the model is also higher than the data in 1960. The model has some difficulty mimicking the very high rate of marriage for the non-college educated in 1960.

Table 4: Data and Benchmark Model, 1960

	Data		Model	
Education	Fem	Males	Fem	Males
	0.072	0.125	0.074	0.129
Marriage				
Fraction	Sing	Marr	Sing	Marr
	0.130	0.870	0.151	0.849
Rates	<Coll	Coll	<Coll	Coll
–Marriage	0.925	0.849	0.888	0.882
–Divorce	0.053	0.033	0.044	0.040
Sorting	Wife		Wife	
Husband				
< Coll	0.855	0.023	0.843	0.028
Coll	0.082	0.040	0.085	0.045
Corr, educ	0.414		0.403	
Work, Marr Fem				
Husband	Wife		Wife	
	< Coll	Coll	< Coll	Coll
< Coll	0.328	0.528	0.318	0.586
Coll	0.213	0.347	0.207	0.294
Participation, all	0.324		0.315	
Income, frac	0.110		0.122	
Inequality				
Gini	0.306		0.307	
Ratio 90/10	4.829		4.536	
Ratio 90/50	1.817		2.043	
Income, Sf/M	0.543		0.393	
Income, Marr				
Husband	Wife		Wife	
	< Coll	Coll	< Coll	Coll
< Coll	0.932	1.335	0.943	0.700
Coll	1.369	1.501	1.400	1.501
Skill Premium	1.548		1.566	
Gender Gap	0.446		0.419	

5 Moving Forward to 2005

The model economy is now ready to be simulated for 2005. This is done using the 2005 prices for durable goods and 2005 wages. As will be seen, in order the match the U.S. data as best as possible a *very limited* number of parameters need to be tweaked for 2005. These parameters involve the utility cost of education and compatibility between individuals of different education levels. There are two key goals of the analysis. The first is to assess the importance of the two driving forces for (i) the rise in assortative mating, (ii) the decline in marriage and the increase in divorce, which has impacted on non-college educated individuals more than college educated ones, (iii) the rise in educational attainments and married female labor-force participation, and (iv) increase in income inequality among households. This assessment is undertaken in Section 6. Before doing this, it is important for the model to match the U.S. data for 2005. The second goal is to understand the role that the change in family structure plays in generating income inequality. This is done is Section 7. Again, a good fit is desirable before pursuing this goal.

5.1 U.S. Stylized Facts and Benchmark Model Results

In order to simulate the model economy for 2005, first set $w_{0,2005}$, the wage rate for unskilled individuals, to 1.17, as the earnings of non-college educated males grew by 17 percent between 1960 and 2005. Next, $w_{1,2005}$ (the wage rate for an efficiency unit of skilled labor) and ϕ_{2005} (the gender wage gap) are chosen such that the skill premium and the gender earnings gap in the model economy are as close to their data counterparts as possible. The skill premium increased from 1.55 to 2.02 between 1960 and 2005. At the same time, women's earnings relative to men's increased from 0.45 to 0.64. Matching these two targets in 2005 implies $w_{1,2005} = 1.81$ (vs. $w_{1,1960} = 1.04$) and $\phi_{2005} = 0.59$ (vs. $\phi_{1960} = 0.40$).

Durable goods were also cheaper in 2005 than they were in 1960. Gordon (1990) reports that the quality-adjusted price of consumer durables declined between 6 percent and 13 percent a year for different durables between 1950 and 1985. A price index for eight durables (refrigerators, air conditioners, washing machines, clothes dryers, TV sets, dishwashers, microwaves and VCRs) fell at 10 percent a year. In the National Income and Product Accounts, the price index for "furnishings and durable household equipment" relative to the price index for "personal consumption expenditures" dropped by about 60 percent between 1960 and 2005 (close to 2 percent a year).[23] In the simulation it will be assumed that the price of durables falls by 5 percent a year, a value between these two estimates. Consumer durable goods prices in 2005 are then given by $p_{2005} = p_{1960} \times e^{-0.05(2005-1960)}$.[24]

Finally, η_f and η_m are allowed to take different values in 2005. (Recall that given a, an individual of gender g draws κ, the utility cost of an education, from a normal distribution with mean η_g/a and variance σ_κ^2). The 2005 values for these parameters are selected such that the model economy generates exactly the increase in educational attainment that is observed in the data. If these parameters are not allowed to change between 1960 and 2005, the model still generates an increase in the educational attainment, but the increase is smaller, especially so for females.[25] Matching the observed skill premium and the gender earnings gap in 2005 economy is possible, only if the model also delivers the correct levels of educational attainments men and women. In order to match the rise in educational attainment, η_f and η_m had to be decreased from 134.97 to 69.6 and from 69.86 to 58.55 between the 1960 and 2005 steady states, respectively. The model requires a larger decline in the cost of education for females.[26] All other parameters are kept in their 1960 values.[27]

[23] Source: National Income and Product Accounts (NIPA), Table 2.3.4, Price Indexes for Personal Consumption Expenditures by Major Type of Product, version October 30, 2014.

[24] The results for 2005 model economy with lower (2.5%) and higher (7.5%) price declines are reported in Table B2 in Appendix B. The decline in marriages and the rise in female labor-force participation are weaker (stronger) with a lower (higher) price decline.

[25] Table B3 in Appendix B shows the 2005 model economy results when η_f and η_m are kept in their 1960 levels. The fraction of males and females who choose a college education would be 20.4 percent and 10.3 percent, respectively. For males, this is about 40 percent of the increase in educational attainment between 1960 and 2005. For females, however, the increase is much smaller. The educational attainment of females would only increase from 7.4 percent to 10.3 percent between 1960 and 2005, which is just 11 percent of observed rise.

[26] Several changes that are not modeled here might be behind these exogenous shifts in education costs. For example: the federal government began guaranteeing student loans in 1965, which increased accessibility to colleges. Moreover, Title IX of the Education Amendments, passed in 1972, banned discrimination against women in education. Another factor might be changes in social norms, that are not explicitly modeled within the current framework.

[27] It is assumed that the survival probability, π, takes the same value in 1960 and 2005. Life expectancy at birth increased by 7.7 years between 1960 and 2005 (The 2012 Statistical Abstracts of the US, Table 104. Expectation of Life at Birth, 1960 to 2008, and Projections, 2010 to 2020, available at http://www.census.gov/compendia/statab/cats/births_deaths_marriages_divorces/life_expectancy.html). Individuals enter the model economy, however, at age 25 and leave the model at age 55. As a result, the effect of changes in life-expectancy for the model economy will be very small. Nevertheless, a counterfactual

Table 5 shows the results.

Overall the model does a good job matching the set of stylized facts presented for 2005. First, marriage became less important over this period. Specifically, the fraction of the population that is single more than doubled in the data (from 13.0 to 33.9 percent). The model is able to generate about 40 percent of this increase (15.1 to 23.9 percent). The rise in the number of singles and the fall in the fraction of marrieds is due to both a decline in the rate of marriage and an increase in the rate of divorce. This feature of the data is also matched. The model does deliver a more pronounced decrease in the marriage rates between 1960 and 2005 for non-college educated people compared with the college-educated. However, marriage rates for less educated people decline by 6 percentage points in the model (compared to 12 in the data), whereas the decline for college-educated individuals is 5.2 percentage points (and 5.8 in the data). In the data the increase in the divorce rate is greater for non-college educated individuals (5.3 percent to 20.2) vis-à-vis college educated ones (3.3 percent to 11.9). The model also generates the differential increase in divorce, but the differential increase is less pronounced in the model than it is in the data. The fraction of divorced people increases by 4.9 percentage points for non-college educated people (versus 14.9 in the data) and only by 2.0 for college educated ones (compared with the 8.6 that was observed).

Second, the model does a great job replicating the increase in labor-force participation by married females (from 32.4 to 70.1 percent in the data and 31.5 to 71.6 percent in the model). The model also explains well the upward movement in the share of family income that working wives provide (11.0 to 27.8 percent in the data versus 12.2 to 32.3 percent for the model).

Third, there is more income inequality among households in 2005, both in the data and the model. The Gini coefficient increases from 0.306 to 0.429 between 1960 and 2005 in the data. The model is able to generate about 45 percent of this increase (from 0.307 to 0.362).

Finally, the framework has no trouble generating a rise in assortative mating. In fact, the mechanism in the model is too strong. The correlation between a husband's and wife's

that adds 7.7 years to the average life expectancy was conducted and the results are similar to the benchmark.

education increases to 0.892 in the 2005 model economy, while it is 0.512 in the 2005 data. As it was highlighted in Section 2, the rise in assortative mating can also be captured by the following regression

$$\text{EDUCATION}_t^w = \alpha + \beta \times \text{EDUCATION}_t^h + \gamma \times \text{EDUCATION}_t^h \times \text{DUMMY}_{2005,t} + \theta \times \text{DUMMY}_{2005,t}, \tag{15}$$

where $t \in \{1960, 2005\}$. Now, it is shown in Appendix 9.2, that it is possible to estimate the parameters of this regression from the information contained in the 2×2 contingency tables. The estimated value of γ, which captures the increase in assortative mating between 1960 and 2005 in the data, is 0.297. In contrast, estimated value for the model economy is almost twice as high, 0.580.[28] Basically, the model has difficulty generating mixed marriages between skilled and unskilled individuals. In particular, there has been a rise in the data for marriages between skilled females and unskilled males, from 2.8 percent of all marriages in 1960 to 10.8 percent of all marriages in 2005.[29] The model economy is not able to generate this increase. The lack of mixed marriages in 2005 also affects how the model economy performs with respect to the labor-force participation of females. In particular, skilled females who are married to skilled males work too little in the model economy compared with what they do in the data, while unskilled females married to unskilled males work too much.

Can the model economy deliver a lower level of sorting in 2005? Consider the following thought experiment: Imagine that the extra utility of a match between two skilled individuals, μ_1, takes a lower value in 2005. In particular, lower μ_1 such that the coefficient γ in (15) is as close as possible to its data counterpart. This requires μ_1 to be reduced by a factor of 3 (from 1.308 to 0.436). One interpretation for this exogenous change is that people are less class conscious today versus yesteryear. The *rise* in positive assortative mating obtained in the model therefore comes *solely* from powerful economic forces. The results of this experiment are shown in Table 6.[30] Note that, now, the γ coefficients obtained from

[28] The estimated values for the other coefficients in the regression, α, β, and θ, are 0.026, 0.302 and 0.139 in the data, and 0.032, 0.312 and 0.085 in the simulations.

[29] Coles and Francesconi (2011) study the emergence of these "toyboy" marriages within a model where individuals value both the wage as well as fitness of their partners.

[30] For the results in Table 6, the calibrated values for skilled wages and the gender gap in 2005 are $w_{1,2005} = 1.885$ and $\phi_{1960} = 0.592$. The cost of education is also slightly altered in this economy to match the observed education rates for males and females. The cost parameters are set to $\omega_m = 52.00$ and

running regression (15) both in the data and in the model are much closer (0.297 and 0.315 respectively). Most of the remaining outcomes in Table 6 are very similar to those in Table 5. The 2005 model economy in Table 6 is, however, able to generate a larger decline in the fraction of married population than the one in Table 5 (from 0.85 to 0.74, instead of from 0.85 to 0.76). The 2005 model economy in Table 6 also does a much better job capturing how married female labor-force participation changes as a function of their own and their husbands' education levels. There is, however, one drawback. The model economy in 2005 is not able to generate the differential in divorce rates between skilled and unskilled individuals. Indeed, skilled individuals have a slightly higher divorce rate than unskilled ones in the 2005 model economy (0.11 vs. 0.10). All in all the fit in Table 6 is very good. Take this as the benchmark economy for the subsequent analysis.

$\omega_f = 54.00$.

Table 5: Moving Forward to 2005 (A Prelude)

	1960				*2005*			
	Data		*Model*		*Data*		*Model*	
Education	Fem	Males	Fem	Males	Fem	Males	Fem	Males
	0.072	0.125	0.074	0.129	0.332	0.318	0.331	0.318
Marriage								
Fraction	Sing	Marr	Sing	Marr	Sing	Marr	Sing	Marr
	0.130	0.870	0.151	0.849	0.339	0.661	0.239	0.761
Rates	<Coll	Coll	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.925	0.849	0.888	0.882	0.806	0.791	0.828	0.830
–Divorce	0.053	0.033	0.044	0.040	0.202	0.119	0.093	0.060
Sorting	Wife		Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.855	0.023	0.843	0.028	0.545	0.108	0.644	0.024
Coll	0.082	0.040	0.085	0.045	0.082	0.265	0.024	0.308
Corr educ; γ	0.414; –		0.403; –		0.519; 0.297		0.892; 0.580	
Work, Marr Fem								
Husband	Wife		Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.328	0.528	0.318	0.586	0.685	0.823	0.745	0.440
Coll	0.213	0.347	0.207	0.294	0.632	0.711	0.793	0.671
Participation, all	0.324		0.315		0.701		0.716	
Income, frac	0.110		0.122		0.278		0.323	
Inequality								
Gini	0.306		0.307		0.429		0.362	
Ratio 90/10	4.829		4.536		8.219		6.341	
Ratio 90/50	1.817		2.043		2.500		2.359	
Income, Sf/M	0.543		0.393		0.433		0.391	
Income, Marr								
Husband	Wife		Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.932	1.335	0.943	0.700	0.724	1.047	0.737	0.843
Coll	1.369	1.501	1.400	1.501	1.167	1.534	1.198	1.546
Skill Premium	1.548		1.566		2.016		2.014	
Gender Gap	0.446		0.419		0.636		0.634	

Table 6: Data and Benchmark Model, 1960 and 2005

	1960				2005			
	Data		*Model*		*Data*		*Model*	
Education	Fem	Males	Fem	Males	Fem	Males	Fem	Males
	0.072	0.125	0.074	0.129	0.332	0.318	0.334	0.315
Marriage								
Fraction	Sing	Marr	Sing	Marr	Sing	Marr	Sing	Marr
	0.130	0.870	0.151	0.849	0.339	0.661	0.263	0.737
Rates	<Coll	Coll	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.925	0.849	0.888	0.882	0.806	0.791	0.827	0.813
–Divorce	0.053	0.033	0.044	0.040	0.202	0.119	0.100	0.112
Sorting	Wife		Wife		Wife		Wife	
Husband					< Coll	Coll	< Coll	Coll
< Coll	0.855	0.023	0.843	0.028	0.545	0.108	0.601	0.080
Coll	0.082	0.040	0.085	0.045	0.082	0.265	0.081	0.238
Corr educ; γ	0.414; –		0.403; –		0.519; 0.297		0.628; 0.315	
Work, Marr Fem								
Husband	Wife		Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.328	0.528	0.318	0.586	0.685	0.823	0.726	0.810
Coll	0.213	0.347	0.207	0.294	0.632	0.711	0.580	0.731
Participation, all	0.324		0.315		0.701		0.722	
Income, frac	0.110		0.122		0.278		0.322	
Inequality								
Gini	0.306		0.307		0.429		0.364	
Ratio 90/10	4.829		4.536		8.219		6.303	
Ratio 90/50	1.817		2.043		2.500		2.394	
Income, Sf/M	0.543		0.393		0.433		0.422	
Income, Marr								
Husband	Wife		Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.932	1.335	0.943	0.700	0.724	1.047	0.737	0.871
Coll	1.369	1.501	1.400	1.501	1.167	1.534	1.270	1.617
Skill Premium	1.548		1.566		2.016		2.022	
Gender Gap	0.446		0.419		0.636		0.636	

6 Under the Hood

The forces underlying the decline in marriage, the increase in assortative mating, the upswing in married female labor-force participation, the rise in educational attainment, and higher income inequality will now be inspected. These forces are labor-saving technological progress in the home, a rise in the general level of wages, a widening in the college premium, and a narrowing of the gender wage gap. Two experiments are considered here. First, technological advance in the household sector will be shut down. Hence, only the structure of wages changes in this experiment. Second, shifts in the wage structure are turned off. Now, there is only technological progress in the home. The analysis takes the results in Table 6 as the benchmark for the two experiments.

6.1 No Technological Progress in the Home (Change in Wage Structure Only)

To begin with, consider shutting down technological progress in the home. Thus, only changes in the wage structure (the skill premium and the gender wage gap) are operational. Specifically, fix the 2005 price of household inputs, p, at the 1960 level. All other parameters are set at the values used to produce the 2005 benchmark model economy presented in Table 6. Think about this experiment as representing a comparative statics exercise, one done numerically as opposed to the more traditional qualitative analysis that uses pencil and paper techniques. The results of this experiment are shown in Table 7. As can be seen from the table, technological progress in the household sector is vital for promoting married female labor-force participation. Without it very few married women, about 27 percent, would work in 2005. In fact, a lower fraction of educated females would work in 2005 than in 1960. This is because households are richer in 2005 than in 1960, due to a rise in wages.[31]

Producing home goods is labor intensive. Married households are better disposed to un-

[31] The absence of technological progress in the home leads to a large drop in married female labor supply. One might think that the equilibrium level of wages will rise in response. This could operate to dampen the withdrawal of labor effort by women. The structure employed here assumes that production is linear in male and female work effort, so such an effect is precluded. This assumption is relaxed in Appendix B (see Table B4); the results are similar.

dertake household production relative to single ones, because they have a larger endowment of time. Hence, the lack of technological progress in the home makes marriage more attractive. In the benchmark economy, the number of married individuals declines from 85 percent to 74 percent between 1960 and 2005, an 11 percentage point decline. The decline is smaller without technological progress in the home. The number of married individuals is now about 78 percent in 2005, a decline of about 7 percentage points. This decline is due to higher wages and a lower gender wage gap, which make singlehood more affordable. A higher skill premium makes skilled individuals choosier in the marriage market and consequently boosts the degree of assortative mating. The rise in assortative mating is, however, smaller than the benchmark economy: the correlation between a husband's and wife's education increases from 0.40 to 0.52. A similar conclusion can be drawn by comparing the corresponding γ coefficients from the regression in (15): γ decreases from 0.315 in the 2005 benchmark to 0.155 in this counterfactual. When females do not work, the upward movement in the skill premium has a smaller effect on marital sorting since, in this case, their wage is not important. Finally, income inequality in 2005 remains roughly constant when technological progress in the home is shut down.

Table 7: No Technological Progress in the Home (Change in Wage Structure Only)

	1960		2005			
	Benchmark		*Experiment*		*Benchmark*	
Education	Fem	Males	Fem	Males	Fem	Males
	0.074	0.129	0.272	0.340	0.334	0.315
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.151	0.849	0.219	0.781	0.263	0.737
Rates	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.888	0.882	0.830	0.850	0.827	0.813
–Divorce	0.044	0.040	0.066	0.068	0.100	0.112
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.843	0.028	0.581	0.053	0.601	0.080
Coll	0.085	0.045	0.164	0.202	0.081	0.238
Corr educ; γ	0.403; –		0.516; 0.155		0.628; 0.315	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.318	0.586	0.212	0.376	0.726	0.810
Coll	0.207	0.294	0.207	0.465	0.580	0.731
Participation, all	0.315		0.271		0.722	
Income, frac	0.122		0.134		0.322	
Inequality						
Gini	0.307		0.363		0.364	
Ratio 90/10	4.536		5.778		6.303	
Ratio 90/50	2.043		2.488		2.394	
Income, Sf/M	0.393		0.504		0.422	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.943	0.700	0.728	0.932	0.737	0.871
Coll	1.400	1.501	1.293	1.562	1.270	1.617
Skill Premium	1.548		1.877		2.022	
Gender Gap	0.446		0.721		0.636	

6.2 No Change in Wage Structure (Technological Progress in the Home Only)

Now consider the situation where there is only technological progress in the home; i.e., shut down changes in wages. In particular, set wages for both females and males at the levels they had in 1960; i.e., $w_{0,2005} = w_{0,1960}$, $w_{1,2005} = w_{1,1960}$, and $\phi_{2005} = \phi_{1960}$.[32] The results of this comparative statics experiment are shown in Table 8. Observe first that the fraction of married women that work in 2005 is now 63.2 percent. This is only 7 percentage points less than the number of married women that work in the 2005 benchmark economy (72 percent). Therefore, growth in wages is not the key driver of the rise in married female labor-force participation. Technological progress in the household sector is.

Marriage still declines significantly, from 85 percent to 76 percent. This 9 percentage point decline is about three-quarters of the total 11 percentage point decline between 1960 and 2005. Hence, while both advancement in wages and home technologies affect marriage and divorce decisions, the effect of home technologies is relatively more important. In contrast, without changes in wages, the degree of assortative mating remains more or less constant, as can be seen from the changes in γ (it decreases substantially from 0.315 in the benchmark to 0.138 in this experiment). Hence, wages are key for shifts in assortative mating. Furthermore, without the growth in wages, the hike in inequality is smaller.

[32] The results when only the gender wage gap is kept at its 1960 value are shown in Appendix B in Table B5. The importance of the narrowing gender gap for changes in married female labor force participation is stressed by Jones, Manuelli and McGrattan (2003).

Table 8: No Change in Wage Structure
(Technological Progress in the Home Only)

	1960		*2005*			
	Benchmark		*Experiment*		*Benchmark*	
Education	Fem	Males	Fem	Males	Fem	Males
	0.074	0.129	0.200	0.188	0.334	0.315
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.151	0.849	0.236	0.764	0.263	0.737
Rates	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.888	0.882	0.848	0.817	0.827	0.813
–Divorce	0.044	0.040	0.089	0.108	0.100	0.112
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.843	0.028	0.730	0.090	0.601	0.080
Coll	0.085	0.045	0.079	0.101	0.081	0.238
Corr educ; γ	0.403; –		0.440; 0.138		0.628; 0.315	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.318	0.586	0.621	0.791	0.726	0.810
Coll	0.207	0.294	0.619	0.581	0.580	0.731
Participation, all	0.315		0.632		0.722	
Income, frac	0.122		0.258		0.322	
Inequality						
Gini	0.307		0.328		0.364	
Ratio 90/10	4.536		6.290		6.303	
Ratio 90/50	2.043		1.869		2.394	
Income, Sf/M	0.393		0.284		0.422	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.943	0.700	0.925	0.941	0.737	0.871
Coll	1.400	1.501	1.251	1.396	1.270	1.617
Skill Premium	1.548		1.443		2.022	
Gender Gap	0.446		0.439		0.636	

7 Households and Inequality

Income inequality among households increased between 1960 to 2005. How much of this upturn is driven by changes in wages? And, how much of it is due to the propagation mechanisms stressed here: the decisions of households regarding education, marriage, and married female labor supply? In order to address this question, take the 1960 economy and change wages (the skill premium and the gender wage gap) and durable goods prices to their 2005 values.[33] Though prices are changing, consider keeping the decisions regarding education, marriage and married female labor supply constant at their 1960 values. With these modified prices and artificially fixed decisions, a new counterfactual steady state can be computed. Calculate the Gini coefficient for this hypothetical scenario. In this experiment, if an individual was not going to college in the 1960 economy, he/she still chooses not to go to college, despite a higher skill premium. If a female decided to get married, she still does so, even though household technology and the gender gap have improved. Note that since all decisions are fixed in their 1960 levels, the lower price of durables has no affect other than allowing individuals to enjoy a higher utility, due to the positive income effect. As a result, the outcome of this experiment shows how much shifts in wages, per se, contribute to the hike in inequality.

The results are shown in column (2) in Table 9. Column (1) simply reports the Gini coefficient for the 1960 economy. The Gini coefficient increases from 0.307 to 0.331. This constitutes 42.1 percent of the total increase in the Gini, from 0.307 to 0.364. So, shifts in wages are clearly an important driver of the hike in income inequality. Still, the model's propagation mechanism is very important, accounting for the remaining 57.9 percent. This propagation mechanism will be examined now. In order to do this, redo the above experiment, but now allow households to adjust the labor-force participation decisions for married females. Education and marriage decisions are still kept at their 1960 values. Married female labor-force participation rises from 31.5 in the 1960 benchmark to 61.2 percent in this counterfactual economy due to cheaper consumer durables. The Gini coefficient, however, does not change–column (3). Changes in female labor-force participation alone do not affect

[33] The wage structure, education costs and compatibility parameters μ_0 and μ_1 imposed here are all taken from the 2005 economy described in Table 6.

inequality. Next, keep married female labor-force participation decisions at their 1960 values and let marriage decisions change. The results are shown in column (4). When marriage decisions are allowed to react, the number of married individuals declines from 0.85 to 0.69 percent and the degree of positive assortative mating slightly increases from 0.40 to 0.41.[34] These changes result in higher inequality. Marriage decisions account for about 17.5 percent (59.6 percent minus 42.1 percent) of the rise in income inequality.

In column (5) both marriage and labor-force participation decisions are allowed to adjust. Education decisions are still kept in their 1960 values. The level of inequality moves up even further. Observe the nonlinear interaction effect. Allowing only female labor-force participation to adjust had no effect on inequality. Likewise, permitting just the marriage decisions to respond accounted for 17.5 percent of the changes in inequality. But, allowing female labor-force participation and marriage decisions to react *together* accounts for 33.3 percent (75.4 minus 42.1 percent) of the total climb. The effect of changes in marriage patterns (who is married, who is single, and who marries with whom) is magnified when married females are allowed to adjust their labor supply behavior. A rise in the skill premium and a reduction in the gender gap boost the tendency toward positive assortative mating. For this effect to be fully operational, married females must work. A skilled male is indifferent on economic grounds between a skilled and unskilled female if neither of them works, assuming that skill doesn't affect a woman's production value at home. When both work, however, the skilled female becomes the more attractive partner, at least from an economic point of view.

Finally, the gap between columns (5) and (6) shows the contribution of endogenous education, and the subsequent induced changes in marriage and married female labor supply decisions, on income inequality. Not surprisingly, allowing education decisions to respond hikes income inequality. When the skill premium rises more high ability people will go to school. This amplifies the spread between what high and low ability people earn.

[34] Remember that here the extra utility derived when two skilled individuals marry μ_1 is set to a much lower value relative to the 1960 benchmark. Thus, the modest increase in this correlation somewhat conceals the powerful forces behind the rise in positive assortative mating.

Table 9: Deconstructing the Increase in Income Inequality

	1960	*Experiments*				*2005*
	(1)	(2)	(3)	(4)	(5)	(6)
Decisions held Fixed		Edu., Mar., LFP	Edu., Mar.	Edu., LFP	Edu.	
Gini	**0.307**	**0.331**	**0.331**	**0.341**	**0.350**	**0.364**
Change in Gini	0.000	0.024	0.024	0.034	0.043	0.057
Cumulative Change	**0.0%**	**42.1%**	**42.1%**	**59.6%**	**75.4%**	**100.0%**

8 Conclusions

People today are more likely to marry someone of the same socioeconomic class than in the past. At the same time the prevalence of marriage has fallen and the occurrence of divorce has risen, especially for people without a college education. Women are much more likely to go to college now. Married ones work more. Household income inequality amplified. This has led to a dramatic transformation of the American household.

To address these facts a model of marriage and divorce is developed. In the constructed framework, individuals marry for both economic and noneconomic reasons. The noneconomic reasons are companionship and love. The economic ones are the values of a spouses's labor at home and in the market. Technological progress in the household sector erodes the value of labor at home. This reduces the importance for a marriage of the labor used in household production. As a result married women enter the labor market. Love becomes a more important determinant in marriage. An individual can now afford to delay marriage and wait to find a mate that makes him or her happy. This leads to a decline in marriage and a rise in divorce. Increases in the college premium provide an incentive for both young men and women to go to college. A college educated person earns more in both married and single life. The fact that men now desire women that make a good income provides a extra incentive for a young woman to go to college, or vice versa. An additional motivation may be that people like to marry others with the same educational background. In equilibrium, this leads to a rise in assortative mating, which in conjunction with increased married female labor-force participation, contributes to the growth in income inequality.

The structural model developed is fitted to U.S. data using a minimum distance estimation procedure. A collection of data moments summarizing educational attainment, the patterns of marriage and divorce, married female labor-force participation, and income inequality in 1960 is targeted. The estimated structural model matches the stylized facts well, yielding parameter values that are both reasonable and tightly estimated. The model predictions for 2005 are also broadly in line with the data. Like almost everything in life there is still room for improvement. In particular, the model generates too steep an increase in assortative mating. In order to decompose the effects of technological progress in the home and changes in the wage structure on the variables of interest, a small set of parameters are tuned to generate a reasonable 2005 benchmark.

The decomposition exercises show that technological progress in the home is an important factor for explaining the rise in married female labor-force participation. The narrowing of the gender gap plays an ancillary role here. Technological progress in the home is also a significant driver of the decline in marriage and rise in divorce. The structure of wages in the U.S. has a powerful influence on assortative mating and educational attainment. As the skill premium climbs, income inequality widens. This increase is intensified by the endogenous forces at work: higher levels of educational attainment, stronger positive assortative mating, and the hike in married female labor-force participation magnify the rise in household income inequality.

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9 Appendix A

9.1 Data

Unless stated otherwise, all data is obtained from IPUMS-USA. For the years 1960, 1970, 1980, 1990 and 2000 the data derives from federal censuses, while for 2005 it comes from the American Community Survey (ACS). The ACS has a sample size comparable to the one percent census samples that IPUMS provides for the other years. The age group for which the analysis is done is 25-54. Only singles and married couples are considered. Widows, widowers and married individuals whose spouses are absent are excluded from the analysis. The wage variable is restricted to be non-negative. Furthermore, all single female and male households in which the household head does not work or has zero wages are excluded. All married households in which the male earner does not work or have zero wages are excluded too. These restrictions are motivated by the economic environment used in the paper. This allows the computation of the exact data counterparts to the model moments used in the estimation of the model. A college educated individual refers to someone with 4 years of college or more, otherwise the person is labelled as being non-college educated. This applies to both males and females.

Figure 1. The fraction of the population that is ever married is one minus the fraction of the population that is never married. The fraction of the population that is currently divorced is calculated by taking the stock of currently divorced and then dividing it by the stock of ever-married people.

Figure 2. The value of γ_t is plotted from the regression equation (1). This equation is estimated for married couples using the data mentioned above. The regression coefficient measures the incremental likelihood (relative to 1960) that an educated male is married to an educated female in the year t, for $t = 1970$, $1980, 1990, 2000$, and 2005.

Figure 3. Female labor-force participation is calculated from the variable EMPSTAT in IPUMS. This variable takes one of three values: working, not working and not in the labor force. It is assumed to be in the labor force if EMPSTAT=1, i.e. if she is working. This calculation is done for both college and non-college educated women. A wife's contribution to family income is calculated by computing the ratio of her labor income to total family labor income. This ratio is averaged across all married women.

Figure 4. A woman is labelled as having a college degree if she has 4 years of college or more. The college premium is calculated by dividing the average labor income for college educated men by the average labor income for non-college educated ones. The gender wage gap is calculated as the ratio of the average wages for working women to the average wage for working men.

Figure 5. Single and married households are sorted in an increasing order by their total household labor income. The Lorenz curves and the Gini coefficients are computed based on this ordering.

9.2 Fitting a Linear Regression Model to the Contingency Tables

On the one hand, consider running the following regression for the years 1960 and 2005:

$$\text{EDUCATION}_t^w = \alpha + \beta \times \text{EDUCATION}_t^h + \gamma \times \text{EDUCATION}_t^h \times \text{DUMMY}_t^{05} \\ + \theta \times \text{DUMMY}_t^{05},$$

where $\text{EDUCATION}_t^w \in \{0, 1\}$ is the observed level of the wife's education in period $t = 1960, 2005$ and takes a value of one if the woman completed college and a value of zero otherwise, $\text{EDUCATION}_t^h \in \{0, 1\}$ is the husband's education, DUMMY_t^{05} is a dummy variable for time such that $\text{DUMMY}_t^{05} = 1$ if $t = 2005$ and $\text{DUMMY}_t^{05} = 0$ if $t = 1960$. The coefficient γ measures the additional impact relative to 1960 that a husband's education will have on his wife's in 2005. On the other hand, denote the contingency tables for 1960 and 2005 by

$$\begin{bmatrix} p_{<c,<c}^{60} & p_{<c,c}^{60} \\ p_{c,<c}^{60} & p_{c,c}^{60} \end{bmatrix} \text{ and } \begin{bmatrix} p_{<c,<c}^{05} & p_{<c,c}^{05} \\ p_{c,<c}^{05} & p_{c,c}^{05} \end{bmatrix}.$$

The rows give the husband's education levels, the columns the wife's. The elements in the contingency table give the population moments for each of the four types of marriages for the two years in question.

To map the contingency tables into the regression, pick the four parameters α, β, γ, and θ to solve the following least squares minimization problem, which minimizes the prediction error for the regression across the four types of marriage in each of the two years:

$$\min_{\alpha,\beta,\theta,\gamma} \{p_{<c,<c}^{60}(-\alpha)^2 + p_{<c,c}^{60}(1-\alpha)^2 + p_{c,<c}^{60}(-\alpha-\beta)^2 + p_{c,c}^{60}(1-\alpha-\beta)^2 \\ + p_{<c,<c}^{05}(-\alpha-\theta)^2 + p_{<c,c}^{05}(1-\alpha-\theta)^2 \\ + p_{c,<c}^{05}(-\alpha-\beta-\gamma-\theta)^2 + p_{c,c}^{05}(1-\alpha-\beta-\gamma-\theta)^2\}.$$

To understand why, focus on the first term which represents a type-($< c, < c$) marriage in 1960. This occurs with odds $p_{<c,<c}^{60}$. Plug the education level for the husband, or $\text{EDUCATION}_{1960}^h = 0$, into the regression equation. The regression equation predicts an answer of

α. But, $\textsc{education}_t^w = 0$ when the wife has a less than college education. So, the term $(0-\alpha)^2 = (-\alpha)^2$ is the square of the prediction error for a type-($< c, < c$) marriage in 1960. The first-order conditions associated with this problem are represented by a system of 4 linear equations:

$$\begin{aligned} &p^{60}_{<c,<c}\alpha - p^{60}_{<c,c}(1-\alpha) - p^{60}_{c,<c}(-\alpha-\beta) - p^{60}_{c,c}(1-\alpha-\beta) \\ &- p^{05}_{<c,<c}(-\alpha-\theta) - p^{05}_{<c,c}(1-\alpha-\theta) - p^{05}_{c,<c}(-\alpha-\beta-\gamma-\theta) - p^{05}_{c,c}(1-\alpha-\beta-\gamma-\theta) = 0, \end{aligned}$$

$$-p^{60}_{c,<c}(-\alpha-\beta) - p^{60}_{c,c}(1-\alpha-\beta) - p^{05}_{c,<c}(-\alpha-\beta-\gamma-\theta) - p^{05}_{c,c}(1-\alpha-\beta-\gamma-\theta) = 0,$$

$$-p^{05}_{<c,<c}(-\alpha-\theta) - p^{05}_{<c,c}(1-\alpha-\theta) - p^{05}_{c,<c}(-\alpha-\beta-\gamma-\theta) - p^{05}_{c,c}(1-\alpha-\beta-\gamma-\theta) = 0,$$

and

$$-p^{05}_{c,<c}(-\alpha-\beta-\gamma-\theta) - p^{05}_{c,c}(1-\alpha-\beta-\gamma-\theta) = 0.$$

The solution to this system of linear equations is

$$\alpha = \frac{p^{60}_{<c,c}}{p^{60}_{<c,<c} + p^{60}_{<c,c}}, \beta = \frac{p^{60}_{c,c}}{p^{60}_{c,<c} + p^{60}_{c,c}} - \alpha, \theta = \frac{p^{05}_{<c,c}}{p^{05}_{<c,<c} + p^{05}_{<c,c}} - \alpha, \gamma = \frac{p^{05}_{c,c}}{p^{05}_{c,<c} + p^{05}_{c,c}} - \alpha - \beta - \theta.$$

10 Appendix B (Material for Online Appendix)

10.1 Varying the Elasticity of Substitution between Household Durables and Time in Home Production

Here the quantitative importance of the parameter λ for the 1960 economy is assessed. This parameter determines the elasticity of substituion between houshold durables and household time in home production. Its value is set to 0.19 in the benchmark economy. Suppose this value is increased (decreased) by 20 percent, while keeping all the other parameters of this economy intact. The results of this experiment are shown in Table B1 below. The intuition here is that as the value of λ increases (decreases), the inputs in home production become more (less) substitutable. As a consequence, married households can adjust the amount of purchased durables and the time spent in home production. This would imply that married female labor force participation rate may change. Furthermore, as the economic value of marriage is altered, marriage and divorce decisions can change too. The results below show that these shifts are not dramatic. For instance, when λ is set to a 20 percent lower value (from 0.19 to 0.15), the fraction of working wives is reduced by around 1 percentage point (from 40 percent to 39 percent). The reduction in the fraction of single people is also small (from 15 percent to 14 percent). Thus, the overall fit of the 1960 model economy is not changed dramatically when varying the value of the parameter λ.

Table B1: Varying the Elasticity of Substitution between Durables and Time in Home Production

	1960					
	$\lambda = 0.15$		$\lambda = 0.19$ (Bench)		$\lambda = 0.23$	
Education	Fem	Males	Fem	Males	Fem	Males
	0.075	0.130	0.074	0.129	0.075	0.127
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.144	0.856	0.151	0.849	0.158	0.842
Rates	<Coll	Coll	<Coll	Coll	< Coll	Coll
–Marriage	0.890	0.885	0.888	0.882	0.885	0.876
–Divorce	0.037	0.038	0.044	0.040	0.049	0.044
Sorting	Wife		Wife		Wife	
Husband					< Coll	Coll
< Coll	0.840	0.030	0.843	0.028	0.846	0.026
Coll	0.086	0.044	0.085	0.045	0.081	0.047
Corr, educ	0.389		0.403		0.434	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.283	0.611	0.318	0.586	0.351	0.576
Coll	0.222	0.312	0.207	0.294	0.209	0.280
Participation, all	0.289		0.315		0.342	
Income, frac	0.111		0.122		0.133	
Inequality						
Gini	0.311		0.307		0.305	
Ratio 90/10	4.556		4.536		4.366	
Ratio 50/10	2.219		2.043		2.222	
Income, Sf/M	0.405		0.393		0.384	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.941	0.687	0.943	0.700	0.945	0.710
Coll	1.414	1.530	1.400	1.501	1.391	1.486
Skill Premium	1.557		1.566		1.573	
Gender Gap	0.427		0.419		0.414	

10.2 Varying the Decline of the Prices of Household Durables

The 2005 benchmark economy is simulated with an annual price decline of household durables of 5 percent. Here, the economy is simulated for a lower (2.5 percent) and higher (7.5 percent) price decline. The results are shown in Table B2 below. First, the decline of marriage and the rise of divorce are stronger when the price decline is higher, that is, when the technology of home production improves faster. As a consequence, the fraction of single people rises from 0.21 to 0.29 when the annual decline of the price rises from 2.5 percent to 7.5 percent. Second, married female labor-force participation is strongly influenced by the rate of price decline of home durables. For instance, if the decline is 2.5 percent, only 55 percent of married women work in 2005 (in the model). If the price decline is raised to 7.5 percent, 84 percent of all married women work.

Table B2: Varying the price of durables

	2005					
	$\gamma = 0.025$		$\gamma = 0.05$ (Bench)		$\gamma = 0.075$	
Education	Fem	Males	Fem	Males	Fem	Males
	0.326	0.323	0.331	0.318	0.342	0.307
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.210	0.790	0.239	0.761	0.287	0.713
Rates	< Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.844	0.848	0.828	0.830	0.795	0.803
–Divorce	0.075	0.044	0.093	0.060	0.120	0.078
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.638	0.026	0.644	0.024	0.638	0.032
Coll	0.032	0.304	0.024	0.308	0.017	0.313
Corr, educ	0.868		0.892		0.891	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.597	0.121	0.745	0.440	0.853	0.836
Coll	0.744	0.481	0.793	0.671	0.632	0.813
Participation, all	0.554		0.716		0.841	
Income, frac	0.257		0.323		0.372	
Inequality						
Gini	0.353		0.362		0.375	
Ratio 90/10	5.855		6.341		6.785	
Ratio 50/10	2.529		2.688		2.762	
Income, Sf/M	0.431		0.391		0.358	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.742	0.940	0.737	0.843	0.736	0.722
Coll	1.112	1.535	1.198	1.546	1.164	1.558
Skill Premium	1.987		2.014		2.035	
Gender Gap	0.644		0.634		0.621	

10.3 Education Costs are Set to 1960 Level

The education cost parameters are kept to their 1960 level in this modified version of the 2005 economy. The results are shown in Table B3 below. If the cost of education is not modified, the model does not generate a large increase in the education rates of females. The fraction of educated females goes from 0.07 to 0.10. The fraction of educated males rises from 0.13 to 0.20 but this is less than the increase observed in the data.

TABLE B3: EDUCATION COSTS TO 1960 LEVEL

	1960		*2005*			
	Benchmark		*Experiment*		*Benchmark*	
Education	Fem	Males	Fem	Males	Fem	Males
	0.074	0.129	0.103	0.204	0.331	0.318
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.151	0.849	0.255	0.745	0.239	0.761
Rates	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.888	0.882	0.833	0.801	0.828	0.830
–Divorce	0.044	0.040	0.103	0.086	0.093	0.060
Sorting	Wife		Wife		Wife	
Husband			< Coll	Coll	< Coll	Coll
< Coll	0.843	0.028	0.807	0.003	0.644	0.024
Coll	0.085	0.045	0.081	0.109	0.024	0.308
Corr, educ	0.403		0.707		0.892	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.318	0.586	0.747	0.268	0.745	0.440
Coll	0.207	0.294	0.542	0.675	0.793	0.671
Participation, all	0.315		0.721		0.716	
Income, frac	0.122		0.324		0.323	
Inequality						
Gini	0.307		0.360		0.362	
Ratio 90/10	4.536		6.046		6.341	
Ratio 50/10	2.220		2.729		2.688	
Income, Sf/M	0.393		0.378		0.391	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.943	0.700	0.814	1.107	0.737	0.843
Coll	1.400	1.501	1.479	2.022	1.198	1.546
Skill Premium	1.566		2.233		2.014	
Gender Gap	0.419		0.594		0.634	

10.4 No Technological Progress in the Home - General Equilibrium Effects

The structure employed in the analysis assumes that production is linear in male and female work effort. Consider relaxing this, somewhat. In particular, imagine an aggregate production function of the form

$$\mathbf{o} = \mathbf{z}\mathbf{k}^{\kappa}\mathbf{h}^{1-\kappa},$$

where $\mathbf{o}$ is aggregate output, $\mathbf{z}$ is total factor productivity, $\mathbf{k}$ is the capital stock, $\mathbf{h}$ is the total stock of labor measured in efficiency units, and $\mathbf{z}$ is total factor productivity. Let $\mathbf{k} = 1$ and set $\kappa = 1/3$. The problem with using this production function is the introduction of capital. In particular, are people able to buy or trade capital? To keep things simple, this needs to be ruled out. Suppose that there is a government in the economy. It owns this capital stock. It rents it out at the rental rate r. The proceeds from this rental income are used to finance government spending, g. This government spending could be entered into the utility function in a separable way. This assumption implies that there is no need to think about capital income. Workers will only earn their wages, as before. The wage rate for a unit of raw unskilled labor, w_0, is given by

$$w_0 = (1 - \kappa)\mathbf{z}\mathbf{h}^{-\kappa}.$$

Note that $\mathbf{h}$ is simply the sum of labor effort across all individuals, where each type of labor is weighted by their 2005 efficiency level in production; i.e., a college educated woman of ability level a is weighted by $\phi_{2005}(w_{1,2005}/w_{0,2005})a$. Total factor productivity, $\mathbf{z}$, is picked so that the model matches the unskilled wage rate for 2005. This implies that $\mathbf{z} = 1.61$.

The results are shown in Table B4 below. Somewhat surprisingly, married female labor-force participation drops even further. Why? It is true that the general level of wages does rise when married female labor-force participation drops. But, when there is no technological progress in the household sector, female labor is greatly valued at home. The rise in the general level of wages makes households better off, ceteris paribus, because males now earn more. The positive income effect associated with the increase in husbands' incomes induces more wives to stay at home.

Table B4: Married Female Labor-Force Participation

	Experiment/G.E. Effects	*Experiment/No G.E. Effects*	*Benchmark*
Participation	0.245	0.271	0.722

10.5 No Change in Gender Gap

Take the 2005 economy adjusted to match the observed marital sorting level in 2005. Then, shut down the decline in the gender gap; i.e., set $\phi_{2005} = \phi_{1960}$. The results for this counterfactual are shown in Table B5. First, there is a sizable change in the education rates for females relative to the 2005 benchmark economy. The fraction of educated women increases by more than 10 percentage points (from 0.33 to 0.45). The larger gender gap leads to a negative income effect for single women. This increases the relative value of marriage for these women. Getting into a marriage is easier if the female is educated, therefore the rate of education rises. Second, assortative mating declines somewhat. The correlation between educational types drops from 0.63 in the benchmark equilibrium to 0.56. Perhaps a single female can no longer choose to be as picky about her mate. Third, there is a drop in married women's labor-force participation from 0.72 to 0.57. So, the majority of the rise in married female labor-force participation between 1960 and 2005 (in the model) can be attributed to technological progress in the home; recall that when technological advance in the home is shut down, married female labor force participation drops from 0.72 to 0.27.

Taking stock of the results from the comparative statics exercises suggests that technological progress in the household sector plays an important role in stimulating labor-force participation by married females. The narrowing of the gender plays a significant, but secondary, role here.

TABLE B5: NO CHANGE IN GENDER GAP

	1960		*2005*			
	Benchmark		*Experiment*		*Benchmark*	
Education	Fem	Males	Fem	Males	Fem	Males
	0.074	0.129	0.446	0.316	0.334	0.315
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.151	0.849	0.252	0.748	0.263	0.737
Rates	<Coll	Coll	< Coll	Coll	< Coll	Coll
–Marriage	0.888	0.882	0.839	0.823	0.827	0.813
–Divorce	0.044	0.040	0.095	0.111	0.100	0.112
Sorting	Wife		Wife		Wife	
Husband			< Coll	Coll	< Coll	Coll
< Coll	0.843	0.028	0.521	0.158	0.601	0.080
Coll	0.085	0.045	0.054	0.266	0.081	0.238
Corr, educ	0.403		0.564		0.628	
Work, Marr Fem						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.318	0.586	0.574	0.758	0.726	0.810
Coll	0.207	0.294	0.393	0.497	0.580	0.731
Participation, all	0.315		0.573		0.722	
Income, frac	0.122		0.236		0.322	
Inequality						
Gini	0.307		0.365		0.364	
Ratio 90/10	4.536		6.530		6.303	
Ratio 50/10	2.220		2.874		2.633	
Income, Sf/M	0.393		0.330		0.422	
Income, Marr						
Husband	Wife		Wife		Wife	
	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.943	0.700	0.774	0.747	0.737	0.871
Coll	1.400	1.501	1.351	1.520	1.270	1.617
Skill Premium	1.566		2.034		2.022	
Gender Gap	0.419		0.453		0.636	