"Why Not Settle Down Already?"
A Quantitative Analysis of the Delay in Marriage*

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Job Market Paper

Abstract

One of the most striking changes in American society in the last forty years has been the decline and delay in marriage. The fraction of young men and women who have never been married increased significantly between 1970 and 2000. Idiosyncratic labor income volatility also increased over the same period. This paper establishes a quantitatively important link between these two facts. Specifically, if marriage involves consumption commitments, then a rise in income volatility results in a delay in marriage. Marriage, however, also allows for diversification of income risk since earnings fluctuations between spouses need not be perfectly correlated. We assess our hypothesis that rising income volatility contributed to the delay in marriage vis-à-vis other explanations in the literature, using an estimated equilibrium search model of the marriage market. We find that the increase in volatility accounts for about one-third of the observed delay in marriage. Thus, we find that the effects of consumption commitments due to increased income volatility outweigh the effects of the insurance gains provided by spouses.

Keywords: delay in marriage, income volatility, gender wage gap, technological progress in the household, search models of marriage, simulated method of moments.

JEL Codes: E24, D13, J12

*November 2011. We are very grateful to Jeremy Greenwood for his advice. We would also like to thank Nezih Guner, Moshe Hazan, Greg Kaplan, Fatih Karahan, Dirk Krueger, Iourii Manovskii, Serdar Ozkan, and seminar participants at Penn, the 2011 Midwest Macro Conference, the 2011 Minerva Summer Institute at The Hebrew University, the SED Meetings Ghent, the 2011 Cologne Macro Workshop, and the 2011 Asian Meeting of the Econometric Society for their comments. The usual disclaimer applies.
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1 Introduction

One of the most striking changes in American society over the last 40 years has been the decline and delay in first-time marriage. The fraction of young men and women who have never been married increased significantly between 1970 and 2000. This trend has captured the attention of both academic researchers and the general public[1]. In the popular press, these young adults are being described as "failing to launch"[2]. The question here, in the vernacular, is: Why not settle down already? The answer we propose relies on the increased labor income volatility observed in this period. In order to quantitatively assess this hypothesis, we build and estimate a structural equilibrium search model of the marriage market.

Figure 1 shows the fraction of never-married American white males, by age, for both 1970 and 2000. This graph illustrates how the onset of marriage has been delayed. The numbers are striking. In 1970, only 26% of 25-year-old white males had never been married. By 2000, this number had more than doubled to 57%. At age 35, only 8% of white males were single in 1970, whereas this number increased to 21% in 2000. These numbers clearly illustrate the decline and delay in marriage observed in this period[3].

The economics literature has documented a rise in idiosyncratic labor income volatility over the same period[4]. Recently, Heathcote, Perri, and Violante (2010), among others, find an increase in the variance of persistent and transitory shocks to income between the late 1960s and 2000. Various effects of this changing labor market have drawn the attention of a wide body of literature[5]. However, to the best of our knowledge, no quantitative work has been done relating changes in income volatility with changing marriage decisions of young adults.

Figure 2 shows the increase in the median age of marriage for males and the increase in labor income volatility as measured by the standard deviation of persistent income shocks. It is interesting to note that both series exhibit a very similar increase between the late 1960s and 2000. In fact, the correlation between the two series is 0.96. Some empirical

[1] For an excellent review of the academic literature, see Stevenson and Wolfers (2007).

[2] *New York Times* magazine, August 18th 2010

[3] The graph for white women looks very similar. For data on cohabitation and by education groups, see appendix B. Detailed explanations about the data sources are contained in Appendix A.

[4] For example, Gottschalk and Moffitt (1994) discuss the growing instability in wages and Katz and Autor (1999) study the changes in wage structure and overall earnings inequality.

[5] For an excellent overview of this literature with a specific focus on welfare, see Heathcote, Storesletten, and Violante (2011).

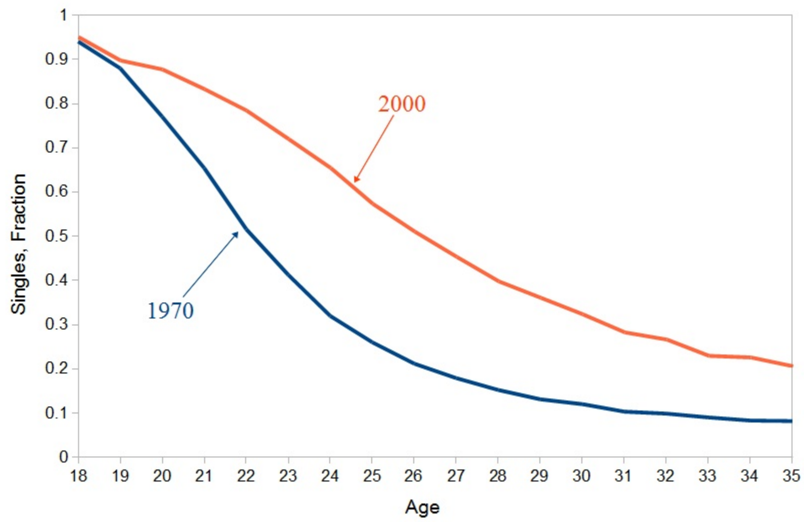


Figure 1: Fraction of White Males Never Married, by Age

papers have also provided suggestive evidence of the impact of certain aspects of labor market volatility on marriage[6].

The contribution of this paper is to establish a quantitatively important effect of rising labor income volatility on the delay in marriage. We seek to do this by exploring three channels through which income volatility can affect marriage timing. The first and novel effect that we explore in this paper arises from the presence of consumption commitments within marriage. Consumption commitments emerge when households consume goods for which adjustments are costly. These consumption commitments aggravate the effects of income fluctuations: Since a household must cover these commitments in any circumstance, following a bad income realization that household might need to cut their discretionary consumption substantially, causing a large utility loss. In this paper, we provide evidence that married individuals, compared to their single counterparts, have more consumption commitments; for example, more married couples have children or own houses. Therefore, a rise in the volatility of income results in a delay in marriage as these commitments become

[6]For example, using U.S. data, Oppenheimer, Kalmijn, and Lim (1997) argue that difficulties in starting careers in a period of higher volatility have delayed marriage. Ahn and Mira (2001) show that employment risk has caused delay in marriage in Spain. Southall and Gilbert (1996) study the impact of economic distress in 19th century United Kingdom and find that periods with more uncertainty are related with fewer marriages overall as well as higher variability in marriage rates for workers in more volatile occupations.

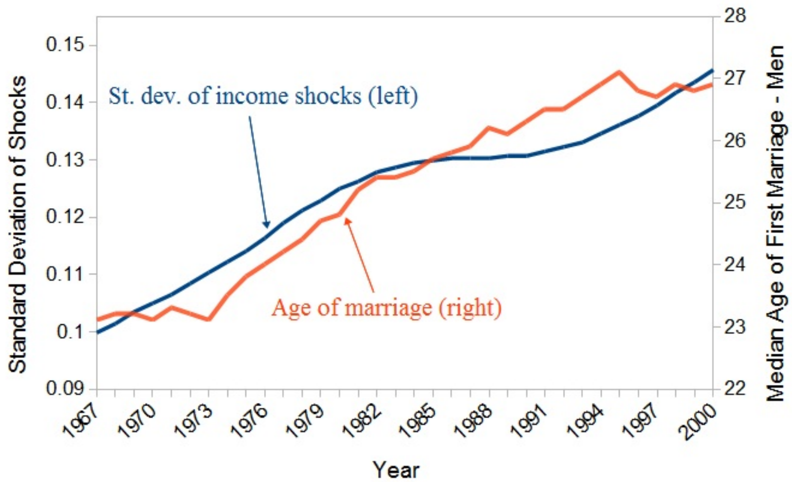


Figure 2: St. Deviation of Persistent Income Shocks and Median Age of Marriage for Males

less desirable. That is, singles might find it preferable to wait until one receives a favorable income shock, or search longer for a "better" spouse, before settling down with a family.

This paper also includes two other channels through which income volatility will affect marriage. One effect is that of spousal insurance: Marriage allows for diversification of income risk as earnings fluctuations between spouses need not be perfectly correlated. Therefore, higher income volatility may make marriage more desirable due to this insurance aspect. This mechanism is highlighted by Hess (2004). Another effect emerges if higher income volatility induces higher income inequality. With higher inequality, the marriage market will be populated by a more dispersed distribution of potential mates. Hence, the option value of searching for a spouse increases as single individuals search longer for "better" matches. Gould and Paserman (2003) find some empirical support for this channel. All three effects discussed in this and the above paragraph, consumption commitments, spousal insurance, and search incentives, are incorporated in our study. Since these channels work in opposite directions, how rising income volatility will affect the timing of marriage ultimately becomes a question about the net impact of these three effects, which is answered by our quantitative analysis.

In order to quantitatively assess the impact of increased labor income volatility on marriage decisions, we include two additional relevant changes to the U.S. labor market over this time period: the increased labor force participation of married women and the narrowing of the gender wage gap. Both changes are important determinants of the amount of insurance spouses can provide and thus in the decision to get married. Whether a wife is working or not and how high her earnings are will determine how much her income can replace her husband's if he receives a bad shock in the labor market, helping to smooth household's consumption[7]. In order to generate increased female labor force participation, we follow Greenwood, Seshadri, and Yorukoglu (2005), who make the case that less expensive household goods, such as washing machines and refrigerators, led to the increase in female labor force participation. Regalia and Rios-Rull (2001) argue that the decrease in the gender wage gap is itself important for the delay in marriage. They argue that when women become richer they can afford to be pickier with the mate they choose. Moreover, Greenwood and Guner (2009) argue that cheaper household goods made the cost of running a household lower. This caused the traditional household setup of the husband specializing in market work and the wife specializing in home production to become obsolete. The result, Greenwood and Guner argue, was a decrease in the gains from trade associated with marriage, and thus a decline in marriage. Since we include both of these channels, we can quantitatively assess their importance vis-à-vis increased income volatility.

We build an equilibrium search model of the marriage market in which the economy is populated by overlapping generations of individuals that optimally choose when to get married. Each person's labor income is risky and households can save in a riskless bond. Married couples face economies of scale in consumption but also must cover a fixed amount of consumption every period, which we call consumption commitments. Married females can choose whether or not to work in the market. The model is estimated using the Simulated Method of Moments. We target several moments regarding marriage, labor force, and consumption choices that are derived from different micro data sets.

Our results show that rising labor income volatility explains approximately one-third of the observed delay in marriage. Thus, we find that the effects of consumption commitments and changes to the option value of searching for a spouse due to rising income volatility outweigh the effects of the gains on spousal insurance. Regarding the other channels, we also find that the decrease in the price of home inputs also explains around one-third of this decline, while the effects of the narrowing of the gender wage gap are negligible. In sum, rising income volatility has substantially contributed to the delay in marriage.

[7]This extensive margin labor force participation decision by married women also accounts for the "added-worker effect", which is also an important margin for insurance. For a discussion of the added-worker effect, see, for example, Lundberg (1985).

In our model, the effect of increased labor income volatility on the timing of marriage is partially influenced by the presence of consumption commitments. Therefore, this paper contributes to the consumption commitment literature along the lines of Chetty and Szeidl (2007) and Postlewaite, Samuelson, and Silverman (2008). Chetty and Szeidl discuss how risk-averse agents can become even more risk averse in the presence of consumption commitments. Postlewaite, Samuelson, and Silverman study how risk-neutral individuals can behave as if they have preferences about risk when they face commitments. Another interesting paper by Sommer (2009) discusses the role of consumption commitments and rising income volatility. In her paper, she argues that rising volatility leads to a delay in fertility. Our papers differ in the modeling of the spousal insurance within marriage in this paper, in the equilibrium approach to the marriage market used here, and in the quantitative methodologies employed.

The remainder of this paper is organized as follows: Section 2 presents evidence on consumption commitments and risk by marital status. Section 3 presents the model, and Section 4 discusses the important channels working in the model. Section 5 discusses the estimation procedure. Section 6 discusses the results, and Section 7 concludes.

2 Consumption Commitments, Risk, and Marital Status

The focus of this paper is the relationship between the timing of marriage and income volatility. In this section, we discuss some empirical evidence on differences in labor market risk and the level of consumption commitments by marital status. We start with the latter and provide evidence on two forms of commitments: children and housing.

First we turn to children. As Figure 3 shows, a strong majority of white married men have children in their household, while the opposite is true for singles. For example, according to Panel (b) in the figure, 59% of 25-year-old married males in 2000 had at least one child in their household, whereas only 9% of their single counterparts did. Those numbers were 68% and 1% respectively in 1970; see Panel (a). What Figure 3 does not account for is the fact that some married people are newlyweds who simply haven't had time to start a family yet. Using the Panel Study of Income Dynamics (PSID), we can follow married couples to see if they have children shortly after marriage. These numbers are reported in Table 1. In this table, it is clear that most married couples have children, both in 1970 and 2000. Also, most single individuals, regardless of gender, do not have

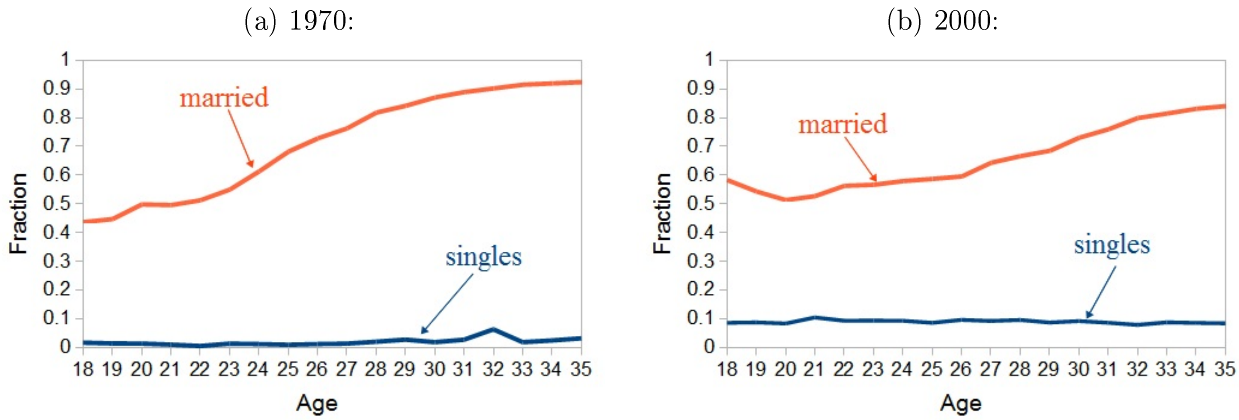


Figure 3: Presence of Children in the Household by Marital Status (White Males)

children present in the household. These data show a strong link between marriage and fertility, a notoriously expensive and persistent form of consumption commitment.

Table 1: Marriage and Fertility (Whites)

	Married with Children*	**Single Men with Children**	**Single Women with Children**
1970	88%	2%	5%
2000	85%	9%	16%

* Either had children then or would by 1972 (2002)

As further evidence of the relationship between marriage and consumption commitments, we turn to housing. Chetty and Szeidl (2007) categorize home ownership as a form of consumption commitment, while renting is not [8]. As Figure 4 shows, married males are much more likely to own their own homes than singles. At age 25, in 2000, 51% of married males were home owners whereas only 26% of singles were. The difference increases to 71% versus 38% by age 30. In 1970, the gap is even wider.

In sum, these data suggest that married households face more consumption commitments than singles. Given these differences, married individuals might behave differently in the labor market. In fact, in the model discussed below, we allow the income process

[8] Additionally, Karahan and Rhee (2011) argue that home ownership results in "lock-in" effects, which discourage geographic moves in response to changes in labor market conditions. The effects of this "lock-in" are similar to consumption commitments.

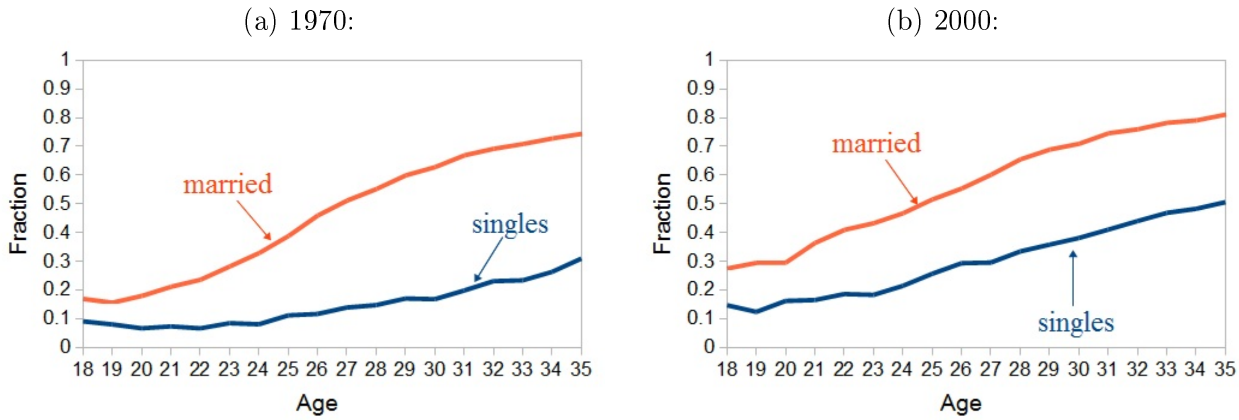


Figure 4: Home Ownership by Marital Status (White Males)

to differ by marital status and, when we discuss the estimation procedure in Section 5, we find substantial differences in these processes. As indicative evidence here, we look at what types of jobs individuals choose based on their marital status. In particular, we focus on the different occupations that men choose depending on their marital status.

We categorize how risky an occupation is by measuring the amount of residual inequality among workers in that occupation, using a procedure similar to the one employed by Bonin et al. (2007). We first run Mincerian earnings regression controlling for a cubic polynomial in age, education dummies, and a set of occupation dummies using data for white men. We then generate the residual earnings from the residuals of this regression. Then, we compute the variance of log residual earnings within each occupation and use this variance as a measure of how risky an occupation is[9]. Finally, we compute what fraction of married (or single) individuals are employed in an occupation that is considered "safe". Since there is no clearcut threshold that would determine whether an occupation is safe or not, we set this threshold at different levels, namely the 50%, 40%, or 30% occupations with lowest variances. That is, after ranking different occupations by the variances of residual earnings, we consider an occupation to be safe if its variance is below some specified threshold. The results are reported in Table 2. It is clear from the table that, whatever the threshold used, we always observe a higher fraction of married males working on safe occupations compared

[9]Even though we control for several observable variables, the residuals might contain more than just risk. For instance, if one occupation contains workers with a higher variance of fixed effects that are not affected by risk, it would still look like a "risky" occupation. Since we cannot control for fixed effects with cross-sectional data, we use this measure as a proxy for risk subject to this caveat.

to single men. In other words, married men are found in less risky occupations, potentially because of the presence of higher consumption commitments within marriage.

Table 2: Fraction of White Males in Safe Occupations

Threshold for Safe Occupation	**Married**	**Single**
50th Percentile	52.0%	39.9%
40th Percentile	37.5%	27.4%
30th Percentile	27.7%	19.6%

3 The Model

The economy is populated by overlapping generations of men and women. There is a unit measure of each gender, g, and age, a. Agents can either be single or married. Every agent is endowed with a unit of time every period.

3.1 Production

There are two goods in the economy: a market good, Y, and a home good, n. For the consumption good there is a linear production function, with labor as the only input:

$$Y = AL, \tag{1}$$

where A is a technology parameter normalized to 1, and L is aggregate market labor supply. This implies that the wage in the model is equal to the efficiency units of labor supplied.

The amount of efficiency units of labor, y, supplied by each agent follows a stochastic process around a deterministic trend:

$$y = w\phi_g f_g(a), \tag{2}$$

where w is an idiosyncratic shock and the deterministic trend is composed of ϕ_g, a gender wage gap, and $f_g(a)$, a gender specific deterministic age income profile. We will now discuss each of these terms.

The shock w consists of a persistent shock, z (with innovations η), and a transitory shock, ϵ. The shock process is specific to the agent's marital status; both the variance and the persistence of the shocks may be different between the two groups. This allows for the fact that married and single agents may behave differently, especially in the presence of consumption commitments. For example, perhaps people who are married are less likely to want to switch careers, since such moves typically involve a short run cost of lower wages during retraining. Additionally, we allow for persistent shocks to be correlated between spouses. For example, if one spouse loses a job and needs to take a new one in a different city, then the other spouse will need to find a new, potentially worse job. Since we are not modeling behavior in the labor market explicitly, we must account for differences in labor market outcomes by estimating different income processes by marital status. Thus, we assume that this process takes the following form for singles (denoted by the subscript s):

$$\begin{aligned} \ln w_s &= z_s + \epsilon_s \\ z_s &= \delta_s z_{s,-1} + \eta_s \\ \eta_s &\sim N(0, \sigma^2_{\eta,s,t}) \\ \varepsilon_s &\sim N(0, \sigma^2_{\varepsilon,s,t}). \end{aligned} \tag{3}$$

For married individuals (denoted by the subscript m), the process specifies shocks for each of the two spouses (an arrow above each shock denotes that this is a vector). The parameter ρ controls the correlation of spousal shocks. This allows us to get the appropriate level of spousal insurance in the model. This insurance is a counter mechanism to income volatility causing a delay in marriage, so getting the correct level is important. Thus, the income process for married households takes the following form:

$$\begin{aligned} \ln \vec{w}_m &= \vec{z}_m + \vec{\epsilon}_s \\ \vec{z}_m &= \delta_m \vec{z}_{m,-1} + \vec{\eta}_m \\ \vec{\eta}_m &\sim N\left(0, \begin{bmatrix} \sigma^2_{\eta,m,t} & \rho \\ \rho & \sigma^2_{\eta,m,t} \end{bmatrix}\right) \\ \vec{\varepsilon}_m &\sim N\left(0, \begin{bmatrix} \sigma^2_{\epsilon,m,t} & 0 \\ 0 & \sigma^2_{\epsilon,m,t} \end{bmatrix}\right). \end{aligned} \tag{4}$$

Note that the variances for all shocks are indexed by the time subscript $t \in \{1970, 2000\}$. An increase in volatility is measured by changing σ^2_η (σ^2_ϵ), which control the variance of the persistent (transitory) shocks.

For ease of notation, define the vector $x = (z, \epsilon)$ that contains both the persistent and transitory shocks an individual draws. Also, with a slight abuse of notation, define the function $w = w(x)$ that gives the agent's wage shock w given the persistent shock z and transitory shock ϵ.

As noted above, the amount of efficiency units available to an agent also varies with his/her age a according to the function $f_g(a)$. This is intended to capture the average life-cycle increase in earnings observed in the data.

Females supply a fraction ϕ compared to males —this accounts for the gender wage gap. Define the function ϕ_g that takes the value of 1 if $g = 1$ (males) or $\phi < 1$ if $g = 2$ (females).

We turn to the home sector now. The home good, n, is produced by a constant elasticity of substitution production function between home inputs, d, and time, h:

$$n = \left[\theta d^{\xi} + (1-\theta) h^{\xi}\right]^{1/\xi}, \tag{5}$$

where θ is the relative weight on home inputs, and ξ is the parameter that controls the elasticity of substitution between home inputs and time.

3.2 Preferences

Preferences of households are additively separable and exhibit constant relative risk aversion (CRRA) over both consumption goods and home goods. We begin with singles. Their utility function reads:

$$u^s(c, n) = \frac{c^{1-\lambda}}{1-\lambda} + \alpha \frac{n^{1-\zeta}}{1-\zeta}, \tag{6}$$

where λ is the CRRA parameter on the consumption of market goods, ζ is the CRRA parameter on home goods, and α is the relative weight of home goods.

For marrieds, we assume a unitary model, i.e., that spouses make decisions jointly when choosing the household's level of consumption goods c and home goods n. The fraction of the household's consumption that is enjoyed by each spouse in a married household is determined by the economies of scale in consumption —ψ is the parameter that controls these economies of scale. The utility function for each individual married agent then reads:

$$u^m(c, n) = \frac{\left(\frac{c}{1+\psi}\right)^{1-\lambda}}{1-\lambda} + \alpha \frac{\left(\frac{n}{1+\psi}\right)^{1-\zeta}}{1-\zeta}. \tag{7}$$

The agent's total utility is equal to the expected discounted value of lifetime utility:

$$U\left(\{c_{t=1}^{t=T}\},\{n_{t=1}^{t=T}\}\right)=E_{t=1}\left[\sum_{t=1}^{t=T}\mathcal{I}_{s,t}u^{s}(c_t,n_t)+(1-\mathcal{I}_{s,t})u^{m}(c_t,n_t)\right], \tag{8}$$

where $\mathcal{I}_{s,t}$ is an indicator function that the agent is single in period t.

In addition to the utility derived from the consumption of goods, when individuals first get married, they also enjoy an additive marital bliss utility denoted by γ. This is a stochastic shock drawn from the distribution $\Gamma(\gamma)$. We assume that $\gamma\sim N\left(\mu_\gamma,\sigma_\gamma^2\right)$. This utility shock is received only once at the start of married life[10]. This represents the (stochastic) lifetime discounted utility of being married that arises due to non-economic reasons.

Finally, a married household incurs a utility cost of κ_w (κ_h) if the wife moves into (out of) the labor force. This cost is a reduced form way of capturing the various costs married women encounter when changing their labor force status. It allows the model to generate movements into and out of the labor force in accordance with the data, ensuring appropriate spousal insurance. With a slight abuse of notation, define the function $\kappa(l)$ to represent the utility cost from moving into and out of the labor force such that $\kappa(0)=\kappa_w$ ($\kappa(1)=\kappa_h$) if the wife is moving into (out of) the labor force.

3.3 Budget Sets

All singles divide their time between market and home production at an exogenous rate, such that they work τ_g^s amount of their time on the market, which is allowed to depend on their gender g. Thus, their budget constraint will be given by

$$c+pd+b'=\phi_g w f_g(a)\tau_g^s+(1+r)b \tag{9}$$

where p is the price of home inputs, ϕ_g is the gender wage gap, w is the idiosyncratic productivity shock, $f_g(a)$ is an age dependent productivity level, b is the individual's current level of assets chosen in the previous period, and b' is the savings chosen today. $(1+r)$ is the gross interest rate.

[10]Since there is no divorce in the model and γ is additively separable, the assumption that the marital bliss shock is completely frontloaded at the time of marriage is without loss of generality. It also makes the computation of the model easier, given that γ will thus not be a state variable.

When married, spouses pool their resources. Furthermore, there are consumption commitments. This is modeled as a lump sum cost that married agents must pay every period, denoted by c_k. Married women have the option of whether to work in the market or work only at home —l^f is the indicator function that women choose to work in the market. Denote by w_1 and w_2 the husband's and wife's wage offers, respectively. The time spent working for the husband (wife) is τ_1^m (τ_2^m). Hence, a couple's budget constraint reads

$$c + pd + c_k + b' = w_1 f_1(a)\tau_1^m + l^f \phi w_2 f_2(a)\tau_2^m + (1+r)b. \tag{10}$$

Additionally, there is a consumption floor. If a household (either single or married) cannot afford to consume above the floor, there is assumed to be an exogenous transfer from an unmodeled government.

3.4 Timing and Marriage

The timing of a period is as follows:

- At the beginning of the period, agents observe the realization of shocks to their wage offers.
- Single agents randomly meet another single agent of the same (model) age and opposite gender and decide whether or not to get married. Marriage is an absorbing state, i.e., there is no divorce[11].
- Married agents choose whether or not the wife works[12]. All agents optimally divide their income between consumption goods, home inputs, and savings. Consumption takes place and the period ends.

3.5 Decision Making

How do households make their decisions in the model? Single agents decide how to divide their income between the consumption of market, non-market goods, and their asset hold-

[11]This is a simplifying assumption, to make modeling marriage and keeping track of singles distributions easier. Since we are trying to explain timing of first marriages only, the issue is whether or not there are a lot of young divorcés for never-married people to consider marrying. Empirically, there are not. In 2000, the percentage of young adults (under age 30) who had been divorced/separated was roughly 5% (IPUMS-Census). This figure is slightly lower for 1970. Since there are so few of these people to worry about in the data, we exclude them from the model.

[12]That is, the extensive, not intensive, margin of female labor force participation.

ings. They also have to decide whether or not to get married to a potential mate. Married agents have a similar consumption decision regarding savings and the consumption of market and home-produced goods, and must decide whether the wife should work or not. We will now describe each household's problem recursively.

Let's start with couples. The state vector for married households consists of a vector of wage shocks for the husband x, a vector of wage offer shocks for the wife x^*, the current assets level b, an indicator function l representing whether or not the wife worked last period, and their age a. Then the married value function can be written as follows:

$$\begin{aligned} V^m(x, x^*, b, l, a) &= \max_{l^f \in \{0,1\}, b' \geq 0, c \geq 0, d \geq 0} u^m(c, n) - \mathcal{I}(l^f \neq l)\kappa(l) + \beta E_{x', x^{*\prime}} V^m(x', x^{*\prime}, b', l^f, a+1) \\ &\quad \text{s.t.} \\ c + pd + c_k + b' &= w(x) f_1(a) \tau_1^m + l^f \phi w(x^*) f_2(a) \tau_2^m + (1+r)b \\ n &= \left[\theta d^\xi + (1-\theta)\left(2 - \tau_1^m - l^f \tau_2^m\right)^\xi\right]^{1/\xi}, \end{aligned} \tag{11}$$

where $\mathcal{I}(j)$ is an indicator function that takes the value of 1 if j is true and 0 otherwise. A married household chooses whether or not the wife works this period, l^f, consumption c, savings b', and home inputs d. Define the policy functions for the married problem as follows: $l^f = P_l^m(x, x^*, b, l, a)$ for the woman's labor force decision, $d = P_d^m(x, x^*, b, l, a)$ for choice of home inputs, $c = P_c^m(x, x^*, b, l, a)$ for the consumption decision, and $b' = P_b^m(x, x^*, b, l, a)$ for the savings decision. The continuation value is given by the expected value of being married during the next period, where the expectation is taken with respect to the income shocks for both spouses.

Now, we move on to singles. The value function for singles with wage shocks x, asset holdings b, gender g, and age a, after the marriage market, is as follows:

$$\begin{aligned} V^s(x, b, g, a) &= \max_{b' \geq 0, c \geq 0, d \geq 0} u^s(c, n) + \beta E_{x'} B(x', b', g, a+1) \\ &\quad \text{s.t.} \\ c + pd + b' &= w(x) f_g(a) \tau_g^s + (1+r)b \\ n &= \left[\theta d^\xi + (1-\theta)(1-\tau_g^s)^\xi\right]^{1/\xi}. \end{aligned} \tag{12}$$

Single households choose consumption c, savings b', and home inputs d. Define the following policy functions associated with the single agent's problem: $d = P_d^s(x, b, g, a)$ for choice of home inputs, $c = P_c^s(x, b, g, a)$ for the consumption decision, and $b' = P_b^s(x, b, g, a)$ for the savings decision. The continuation value for singles is the expectation of the value function $B(\cdot)$, which represents the value for a single before going through the marriage market (or the "bachelor" phase); and the expectation is taken with respect to the income shocks next period. We will elaborate on the value function $B(\cdot)$ slightly later in this section.

We can now turn our analysis to the marriage phase. In the beginning of the period, every single person randomly draws a potential partner of the opposite gender from the distribution of available singles of that particular age. Each potential couple draws a marital bliss shock γ from the distribution $\Gamma(\gamma)$. Each potential spouse will agree to marriage if and only if the continuation value in married life plus the marital bliss shock is larger than the continuation value as a single. A marriage occurs if and only if both agents agree to marriage. Formally, a marriage occurs if and only if

$$\underbrace{V^m\left(x, x^*, b+b^*, 1, a\right) + \gamma > V^s(x, b, 1, a)}_{\text{male's decision}} \text{ and } \underbrace{V^m\left(x, x^*, b+b^*, 1, a\right) + \gamma > V^s(x^*, b, 2, a)}_{\text{female's decision}}. \tag{13}$$

Let the indicator function $J(x, x^*, b, b^*, \gamma, a)$ take a value of 1 if both people agree to the match and a value of 0 otherwise. Thus,

$$J(x, x^*, b, b^*, \gamma, a) = \begin{cases} 1, & \text{if (13) holds,} \\ 0, & \text{otherwise.} \end{cases} \tag{14}$$

We can now write the value function before the marriage market (the "bachelor" phase):

$$\begin{aligned} B(x, b, g, a) \quad = \quad & \int\int \{J(x, x^*, b, b^*, \gamma, a)\left[V^m\left(x, x^*, b+b^*, 1, a\right) + \gamma\right] \\ & + \left(1 - J(x, x^*, b, b^*, \gamma, a)\right) V^s(x, b, g, a)\} d\widehat{\mathbf{S}}(x^*, b^*, g^*, a) d\Gamma(\gamma), \end{aligned} \tag{15}$$

where $\widehat{\mathbf{S}}(x^*, b^*, g^*, a)$ is the probability distribution of meeting a potential mate from the other gender (g^*) and age a. This will be elaborated on later.

3.6 Equilibrium

Before we formally define the equilibrium for this economy, we must first elaborate on the distribution of single agents, since this distribution appears in the dynamic programming problem for bachelors. Note that, because of the endogenous marriage decisions, this distribution will be an equilibrium object. The non-normalized stationary distribution for singles aged $a > 1$ is given by

$$\mathbf{S}(x', b', g, a+1) = \iiiint (1 - J(x, x^*, b, b^*, \gamma, a))\, \mathcal{I}(P_b^s(x, b, g, a) \leq b') \times$$
$$\times\, \mathbf{S}(x, b, g, a) d\mathbf{S}(x^*, b^*, g^*, a) d\mathbf{W}^s(x', x) d\Gamma(\gamma), \quad (16)$$

where g^* represents the opposite gender and $\mathbf{W}^s$ represents the wage shock process for singles defined above. Singles aged $a = 1$ are distributed over wages according to the invariant distribution of $\mathbf{W}^s$. $\widehat{\mathbf{S}}(x, b, g, a)$ denotes the normalized distribution for singles that determines the probability that single agents will meet in the marriage market, and is defined by

$$\widehat{\mathbf{S}}(x, b, g, a) = \frac{\mathbf{S}(x, b, g, a)}{\int d\mathbf{S}(x, b, g, a)}.$$

We can now formally define the equilibrium for this economy:

Definition 1 *A stationary equilibrium is a set of value functions for singles, couples, and bachelors, $V^s(x, b, g, a)$, $V^m(x, x^*, b, l, a)$, and $B(x, b, g, a)$; policy functions for single households $P_c^s(x, b, g, a)$, $P_d^s(x, b, g, a)$, and $P_b^s(x, b, g, a)$; policy functions for married households $P_c^m(x, x^*, b, l, a)$, $P_d^m(x, x^*, b, l, a)$, $P_l^m(x, x^*, b, l, a)$, and $P_b^m(x, x^*, b, l, a)$; a matching rule for singles $J(x, x^*, b, b^*, \gamma, a)$; and a stationary distribution for singles $\mathbf{S}(x, b, g, a)$ such that:*

1. *The value function $V^s(x, b, g, a)$ and the policy functions $P_c^s(x, b, g, a)$, $P_d^s(x, b, g, a)$, and $P_b^s(x, b, g, a)$ solve the single's problem (12), given the value function for bachelors $B(x, b, g, a)$ and the distribution for singles $\mathbf{S}(x, b, g, a)$.*

2. *The value function $V^m(x, x^*, b, l, a)$ and the policy functions $P_c^m(x, x^*, b, l, a)$, $P_d^m(x, x^*, b, l, a)$, $P_l^m(x, x^*, b, l, a)$, and $P_b^m(x, x^*, b, l, a)$ solve the couple's problem (11).*

3. *The value function $B(x, b, g, a)$ solves the bachelor's problem (15), given the value functions for singles and couples, $V^s(x, b, g, a)$ and $V^m(x, x^*, b, l, a)$, and the matching rule $J(x, x^*, b, b^*, \gamma, a)$.*

4. *The matching rule $J(x, x^*, b, b^*, \gamma, a)$ is determined according to (14), taking as given the value functions $V^s(x, b, g, a)$ and $V^m(x, x^*, b, l, a)$.*

5. *The stationary distribution* $\mathbf{S}(x, b, g, a)$ *solves (16), taking as given the matching rule* $J(x, x^*, b, b^*, \gamma, a)$ *and the policy function* $P_b^s(x, b, g, a)$.

4 Mechanisms

Our purpose is to quantitatively explain the delay in entrance into marriage between 1970 and 2000. There are three exogenous forces that change over time in the model: income volatility, the price of home inputs (which represents technological progress in the home sector), and the gender wage gap. In this section, we discuss the effects of each of these forces in turn.

4.1 Income Volatility

This is the chief hypothesis we propose: The rise in income volatility delayed the timing of marriage. Increased income volatility, as defined by larger variances to both persistent and transitory shocks (increasing $\sigma^2_{\epsilon,m}$, $\sigma^2_{\eta,m}$, $\sigma^2_{\epsilon,s}$, and $\sigma^2_{\eta,s}$), has multiple effects. Let's first discuss the role played by the presence of consumption commitments within married households.

Consumption commitments emerge when households consume goods for which adjustments are costly. In our model, these consumption commitments are embodied in the parameter c_k. These consumption commitments aggravate the effects of income fluctuations by effectively causing an increase in risk aversion among married agents relative to single agents. Since a married household must cover c_k every period in any circumstance, following a bad income realization, that household might need to cut their discretionary consumption substantially, causing a large utility loss. In Section 2, we argued that married individuals, compared to singles, have more consumption commitments such as children, mortgages, etc. Therefore, a rise in the volatility of income results in a delay in marriage as these commitments become less desirable. That is, singles might find it preferable to wait until one receives a favorable income shock, or search longer for a "better" spouse, before settling down with a family. By delaying marriage, individuals expect to earn higher a income in the future (given the growth in wages over the life cycle) and accumulate more assets that will help them cover the consumption commitments associated with married life.

There are other channels through which income volatility will affect marriage. One effect arises if higher income volatility induces higher income inequality. If workers are subject to more volatile persistent shocks, we should expect to see a more dispersed wage distribution in the population. That means that the marriage market will also be populated by a more dispersed distribution of potential mates. Hence, the option value of searching for a spouse increases as single individuals search longer for "better" matches. Conditional on a value for the non-economic reasons for marriage (γ), if all potential mates are similar, then there is no reason to keep searching. However, if the distribution of potential mates is very dispersed, then agents may search longer for a better spouse.

Another effect comes from the availability of spousal insurance: Marriage allows for diversification of income risk since earnings fluctuations between spouses need not be perfectly correlated. For example, if a husband receives a bad income realization, the wife's income could help the household to smooth consumption. This possibility is not available for singles. Therefore, higher income volatility may make marriage more desirable due to this insurance aspect.

All three effects discussed here are incorporated in our study and, since they work in opposite directions, how rising income volatility will affect the timing of marriage ultimately becomes a question about the net impact of these three effects, which is answered by our quantitative analysis.

4.2 Price of Home Inputs

Another exogenous change present in the model are improvements in the technology of the home sector, modeled here as a decrease in the price of the inputs used in home production. Greenwood and Guner (2009) explain in detail the mechanism by which such a decrease in the price of inputs for home production (such as washing machines) would be likely to cause a decrease in marriage. The idea is simple: If marriage allows men and women to specialize according to their comparative advantages of market production and home production, respectively, then a decrease in the price of goods used as inputs for home production would tend to decrease the gains from specialization. As the prices of home inputs decrease, females have an incentive to work in the market given the substitutability of time and home inputs in the production function of home goods. If the marginal utility of home goods declines faster than that of market goods[13], married households will spend

[13]This will be the case in our quantitative analysis, since the estimation procedure yields $\lambda < \zeta$.

less on home inputs compared to less well-off single households. This will be especially true for younger and poorer individuals. Thus young single households will benefit more from improvements in the technology of home production and, as the gains from marriage decrease, agents will postpone marriage.

However, we should also note the presence of an additional channel by which the change in the price of home inputs affects the marriage decision. Marriage in our model is in some ways a normal good: There is a consumption cost to marriage (c_k) and a utility gain (γ). As the price of home inputs decreases, there will be an income effect and a substitution effect associated with this price change. Since the purchasing power of households increases due to the positive income effect, individuals might be more willing to "purchase" marriage in order to enjoy an utility gain of γ. Hence, if marriage is a normal good, then a decrease in the price of home inputs will have an income effect leading to more marriage.

4.3 Gender Wage Gap

The final mechanism explored is the narrowing of the gender wage gap. This is one of the channels explored by Regalia and Rios-Rull (2001). Again, we will highlight the various channels through which a change in the gender wage gap affects marriage decisions. With a smaller gender gap in income, women make relatively more than they did before, when compared to men. This causes two opposing effects on marriage.

The first effect appears in the changes for a female when she is single. With a lower gender wage gap, women are richer than before. They can now afford a better standard of living while they are still single and gives them a better option outside of marriage. With this more attractive outside option, women can afford to be pickier with the mate they choose and thus they search longer. This will cause a delay in marriage.

The second effect of a lower gender wage gap is related to married life. As women are richer, they are able to provide more resources to a married household. This will make them economically "more attractive" to men. *Ceteris paribus*, men will be more likely to marry in order to enjoy the extra income provided by their now-richer wives. This effect will then cause more marriages to take place.

The net effect of the gender wage gap changing over time is thus ambiguous. We quantitatively analyze these channels to determine the net effect of the gender wage gap.

5 Matching the Model to the Data

The model period is 1 year. Given the age gap of approximately 2 years between the age of marriage for a male and a female (which remained approximately constant through the period analyzed), the same model age actually corresponds to this two-year gap in the data, i.e., age 1 in the model corresponds to age 18 (16) for males (females) in the data.

5.1 Computation

In order to numerically solve the model, we use backwards induction on the value functions. The model is solved for males from ages 18 to 35 (16 to 33 for females). At this final age, we need a terminal condition. This terminal condition is determined by solving a slightly modified version of the model for an extra 30 years: After age 35 (33 for females), the marriage market is shut down, but the problems are otherwise the same as the ones described above. Agents live until age 65 (63 for females), after which they die with certainty.

We solve two steady states for the model; one that represents the world in 1970 and the other in 2000. Most parameters are kept constant for both steady states. The only parameters that change are those that govern the variance of income shocks, the gender wage gap, the price of household inputs, and the mean of the marital bliss shock distribution μ_γ. The reason for changing μ_γ across time periods will be elaborated on later. A more detailed discussion of how the parameters in the model are calibrated/estimated will now follow.

5.2 Parameters Calibrated a Priori

Some parameters are standard in the literature or have direct counterparts in the data. These parameters are listed in Table 3 and we briefly comment on them now.

Let's start with preference parameters. The time discount factor β is set to 0.97, which is the inverse of the gross interest rate and is also similar to what is used in the literature. The coefficient of relative risk aversion (CRRA) for market goods is set to 2.0, which is also standard in the macroeconomic literature. For the parameter ψ that controls the degree of economies of scale in a household, we use the OECD equivalence scale. According to this scale, a second adult in the household only needs 70% of the consumption of the first adult in order to maintain the same standard of living. So we set $\psi = 0.7$.

Table 3: Parameters Set Using a Priori Information

Parameter	**Description**	**Value**	**Source**
Preferences			
β	Time discount factor	0.97	Standard
λ	CRRA —consumption	2.0	Standard
ψ	Economies of scale	0.7	OECD equiv. scale
Technology			
θ	Weight on home inputs in production	0.206	McGrattan et al (1997)
ξ	CES home production	0.189	McGrattan et al (1997)
Income			
ρ	Correlation of spousal pers. shocks	0.25	Hyslop (2001)
τ_1^s	% of time at work (single males)	0.37	U.S. Census
τ_2^s	% of time at work (single females)	0.35	U.S.Census
τ_1^m	% of time at work (married males)	0.40	U.S.Census
τ_2^m	% of time at work (married females)	0.32	U.S.Census
$f_g(a)$	Age profile of income	–	U.S.Census
Prices			
–	Decline in the price of home inputs	6%/year	Greenwood & Guner (2009)
–	Consumption floor	$2640	Kaplan (2010)
r	Interest rate	3%	Standard

The parameters for the production function of non-market goods were estimated by McGrattan, Rogerson, and Wright (1997) using business cycle frequency data. Their numbers are used by Greenwood and Guner (2009) in a model of the marriage market. We also use their numbers in this paper.

A few parameters that control the amount of efficiency units of labor supplied by individuals can also be set here. The correlation of spousal persistent shocks ρ is set to 0.25, the number estimated by Hyslop (2001) using data from the PSID. The fraction of time spent working in the market is computed using data from the U.S. Census. We compute the number of hours worked in a week and divide by 112, the number of non-sleeping hours in a week. These numbers are allowed to vary by marital status and gender, as displayed in Table 3. The life-cycle profile $f_g(a)$ that controls the average level of efficiency units supplied at every age for each gender is computed by fitting a cubic polynomial over the mean income at each different age in the U.S. Census[14]. We choose a cubic polynomial because it provides a very good fit to the non-parametric data.

Since this is a partial equilibrium model with respect to capital and home goods markets, we have to make some assumptions about prices. We set the interest rate to $r = 0.03$, a standard value. For the decline in the price of home inputs, we use 6%, the number estimated by Greenwood and Guner (2009). This number falls in the middle of other available estimates: the Gordon (1990) quality-adjusted price index for home appliances fell at 10% a year in the postwar period; on the other hand, the price of kitchen and other household appliances from the National Income and Product Accounts (NIPA) declined at about 1.5% a year since 1950. Finally, for the consumption floor, we use data provided by Kaplan (2010). Based on his calculations, the median monthly benefit for his National Longitudinal Survey of Youth (NLSY) sample composed of young adults is \$220/month. We take this number (which amounts to \$2640/year) to be our consumption floor.

5.3 Estimation

The remaining parameters are estimated by the Simulated Method of Moments. We first need a set of data moments that will inform on the parameters of the model. For a given set of parameter values, the model will generate statistics that can be compared to the data targets. The parameter values are then chosen to minimize some weighted distance between the model statistics and the data targets. Let Ω be the vector of parameters to be estimated, and $g(\Omega)$ the difference between model moments and data moments at parameter Ω. We use a diagonal weighting matrix, W. The estimation procedure solves the following problem:

$$\min_{\Omega} g(\Omega)' W g(\Omega).$$

The vector of the standard errors for the estimator $\widehat{\Omega}$ is given by the square root of the diagonal of the following matrix:

$$V(\widehat{\Omega}) = \frac{1}{n}\left[g_1(\widehat{\Omega})' W g_1(\widehat{\Omega})\right]^{-1} g_1(\widehat{\Omega})' W \Sigma W g_1(\widehat{\Omega}) \left[g_1(\widehat{\Omega})' W g_1(\widehat{\Omega})\right]^{-1},$$

[14]The results are very similar if we use data from the PSID. We use the larger sample from the U.S. Census to get tighter estimates.

where Σ is the variance-covariance matrix of data moments, $g_1(\widehat{\Omega}) = \partial g(\widehat{\Omega})/\partial\Omega$, and n is the number of observations. The data moments derive from multiple data sets. The moments are independent across data sets. Therefore, Σ is a block diagonal matrix, with each block corresponding to a different data set. Each block is weighted by the number of observations in the block relative to the total number of observations.

In our case, we need to estimate 11 parameters (in addition to 12 parameters that control the processes for the income shocks) so that we have the following vector of parameters to be estimated: $\Omega = (\alpha, \zeta, \kappa_h, \kappa_w, \mu_{\gamma,1970}, \mu_{\gamma,2000}, \sigma_\gamma, p, c_k, \phi_{1970}, \phi_{2000}, \Upsilon)$, where Υ is a vector that contains the labor market parameters[15].

5.3.1 Labor Market Parameters

For the data on income processes, we use data on white men from the Panel Study of Income Dynamics (PSID)[16] for the years 1968–1997. We first run a Mincerian regression for every year in the sample, controlling for education and a cubic polynomial in age. We then obtain our measure for residual income by generating the residuals of this regression. Using this measure for residual income, we estimate the parameters from (3) and (4) using Generalized Method of Moments (GMM). Note that we separately estimate the parameters for the process for married and single individuals since individuals from the two different groups might behave differently in the labor market[17]. The results of this estimation procedure are reported in the Data column in Table 4 below. Although this procedure is popular in the literature, estimates by marital status are not common. This difference aside, the variances of the persistent shocks that we estimate are in line with the numbers reported by Heathcote, Storesletten and Violante (2010) and Meghir and Pistaferri (2004), for example. The variances of the transitory shocks are higher than their estimates[18].

To get a measure for the gender wage gap in the data, we run a Mincerian regression using log wages as a dependent variable and controlling for age, education, and a gender dummy using Census data from both 1970 and 2000. We run this regression using observed wages for individuals that both work and report positive income. The coefficient on the

[15] $\Upsilon = \left(\delta_{s,1970}, \delta_{s,2000}, \sigma^2_{\eta,s,1970}, \sigma^2_{\eta,s,2000}, \sigma^2_{\epsilon,s,1970}, \sigma^2_{\epsilon,s,2000}, \delta_{m,1970}, \delta_{m,2000}, \sigma^2_{\eta,m,1970}, \sigma^2_{\eta,m,2000}, \sigma^2_{\epsilon,m,1970}, \sigma^2_{\epsilon,m,2000}\right)$

[16] For details on sample selection and estimation procedure, see Appendix C.

[17] We also estimated the parameters for an age-specific income process in the spirit of Karahan and Ozkan (2010). Since the results were similar to the ones obtained here and we obtain tighter estimates for this simpler model, we opted for the simpler model described above.

[18] Most of the results presented in the next section are driven by the increased variance of persistent shocks, given that these are harder to insure against.

gender dummy is our data target for the gender wage gap. The value of the estimates are 0.67 for 1970 and 0.75 for 2000.

Using these estimates alone for the variances of the shocks and for the gender wage gap in the model generates sample selection problems. Specifically, for the income process, there is selection involved in who is married and who is single. If singles wait for good persistent shocks before getting married, then we would expect to truncate the top of the distribution of shocks into married people. This would make the observed shock process for singles not volatile enough. Additionally, for the gender wage gap, the estimate is obtained from a regression on observed wages. Clearly, there is selection as to which women are working and which are not. To solve these problems, we take an indirect inference approach[19]. That is, our estimation procedure will make use of the model in order to estimate the parameters that control the income processes and the gender wage gap by adopting the following steps:

1. Guess parameter values for the income process for both married and single agents, and for the gender wage gap.

2. Solve and simulate the model in order to generate artificial data from the model.

3. Run the same GMM estimator on the simulated data as on actual data.

4. Check if the GMM estimates from the model match the data estimates.

The procedure described above is followed for data from both 1970 and 2000. We must also emphasize that this estimation is performed in conjunction with the other parameters described in the next Section.

5.3.2 Other Estimated Parameters

In addition to the labor market parameters discussed in the previous section, we still need to estimate nine extra parameters. As mentioned above, however, all parameters are estimated simultaneously. In order to identify these parameters from the data, we try to choose data targets that will inform on the parameters we are estimating. Since we are jointly estimating all parameters, what follows is a heuristic argument as to how different data moments inform on model parameters.

Let us first start with parameters that influence the production and consumption of home goods: the weight of home goods in the utility function α, the CRRA for home goods

[19] For a detailed description of this technique, see Gourieroux and Monfort (1996).

ζ, and the initial level for the price of home inputs in 1970 p[20]. The data moment we use to identify the parameter p is the fraction of income spent on household operations in 2000. According to the U.S. National Income and Product Accounts (NIPA), this number is approximately 10.5%. Greenwood and Guner (2009) also include food as an example of their measure of home goods; according to NIPA, this would lead to approximately 40% of consumption share. We target an intermediate number: Household Operations, Utilities, and Personal Care. In 2000, this number was 23% of household consumption according to the Consumer Expenditure Survey (CEX). Since home goods are produced using time and, in our model, married females choose whether to work in the market or not, we use the labor force participation rate (LFPR) of married females as data targets to identify the parameters that control the utility of home goods (α and ζ). We target LFPR in both 1970 and 2000 since this can give us information on the elasticity of labor supplied by married females. According to the U.S. Census, the LFPR for married females was 0.42 in 1970 and 0.72 in 2000.

In our model, married females would be able to move into and out of the labor force freely if it were not for the parameters κ_h and κ_w. In the absence of these parameters, these costless transitions might lead to counterfactually high levels of movements into and out of the labor force, in turn leading to too much consumption insurance between husband and wife. We thus choose these two parameters so that the model generates reasonable movements. In the data, we measure these movements using PSID data. Since the PSID data is a panel data set, we can follow married females over time and observe how often they move. The data targets we use are the fractions of wives that moved into and out of the labor force in 1970. The percentage of wives that moved into the labor force in that year was 4%, the percentage that moved out was 7%.

We now turn to the parameters that govern the marital bliss shocks in 1970: $\mu_{\gamma,1970}$ and σ_γ. These parameters govern the average level and dispersion of match qualities in the economy. They control both the number and timing of marriages. Imagine that the variance of the Γ distribution was 0, for instance. In that case, a potential couple wouldn't have to worry about all the different potential relationships that are also available in the economy, as they are all the same. Then $\mu_{\gamma,1970}$ would only control the level of marriages that take place in equilibrium. With a more dispersed distribution, which is controlled by the parameter σ_γ, potential mates might prefer to wait for a better draw. In order

[20]For the price of home inputs in 2000, we decrease the price p by 6% per year, the number reported by Greenwood and Guner (2009) —see Table 3.

to identify these two parameters, we target the overall age profile of single males in 1970, which clearly informs on both the overall level of marriages and their timing.

As mentioned above, we also allow the mean of the distribution for match qualities, μ_γ, to change across steady states. This is done in order to guarantee that the model will be able to explain the entire change in the timing and level of marriages that took place between 1970 and 2000. The exogenous mechanisms discussed in Section 4 will be able to explain a considerable portion of the observed delay, but not all of it. By decreasing the mean level of match qualities, we will be able to explain the remainder of the change. That is, we can think of this change in μ_γ as explaining the residual change of the delay in marriage[21]. At first glance, it may seem unnecessary to do this: Why not simply see how much the channels in the model can account for? The problem with this is that, in order to recover the labor market parameters through indirect inference, we need to get the right levels of single and married people in the model in both time periods. We therefore need to include this residual to ensure that the model explains all the data.

In our model, married couples must cover a fixed amount of consumption c_k every period; this is supposed to represent all the consumption commitments that married agents have to incur. There is little guidance about how to identify this parameter. However, throughout the period of our analysis, most young married couples had children; most of them had more than one[22]. We then choose to target the average fraction of household expenditures attributable to children in households that have both a husband and a wife and *one* child. Considering that marriage often results in more than one child, mortgages, and other commitments, we consider this to be a be a reasonable lower bound on the consumption commitments faced by married couples. Betson et al. (2001) estimate the fraction of a household's consumption expenditure that is attributable to one child using data from the CEX. This is not a straightforward calculation since it is not immediately clear how to divide the expenditures of certain goods (like shelter or utilities, for example) between the parents and the child. That is, the focus of the problem is to determine how parents reallocate consumption within the household in order to make room for the child's consumption. The idea Betson et al. use is to determine what the child's consumption is by comparing the welfare of childless couples and couples with one child. The authors

[21] For example, this residual can be thought of as containing other explanations for the delay in marriage, like changes in social norms, improvements in contraception technology, etc. See Stevenson and Wolfers (2007) for a discussion of different explanations.

[22] For data on the relationship between marital status and consumption commitments, see Section 2.

then estimate Engel curves based on food expenditures in order to keep the standard of living constant. Following this methodology, the authors estimate the average fraction of consumption expenditures spent on one child to be 30.1%. This is the number we use as our target. Note that this fraction does vary with the income of the household. However, much of the heterogeneity that we observe in the data is not present in the model (for example, differences in education and individual fixed effects). Moreover, we are more interested in the type of risk an individual of a certain type faces throughout his or her lifetime and not specifically in the cross-sectional variation observed in the data. For this reason, we think it is reasonable to assume this constant value for c_k. In any case, in Section 6.1, we perform robustness analysis on the level of consumption commitments that married households face.

Table 4: Parameters for the Income Process

Parameter	**Description**	**Data**	**Model**	**Param.**	**SE**
Married					
$\delta_{m,1970}$	Autoregressive Coefficient	0.9959	0.9811	0.9961	0.0010
$\delta_{m,2000}$	Autoregressive Coefficient	0.9959	0.9780	0.9957	0.0002
$\sigma^2_{\eta,m,1970}$	Persistent Shock Variance	0.0063	0.0063	0.0050	0.0002
$\sigma^2_{\eta,m,2000}$	Persistent Shock Variance	0.0214	0.0241	0.0210	0.0005
$\sigma^2_{\varepsilon,m,1970}$	Transitory Shock Variance	0.0987	0.1029	0.1111	0.0009
$\sigma^2_{\varepsilon,m,2000}$	Transitory Shock Variance	0.1155	0.1122	0.1250	0.0026
Singles					
$\delta_{s,1970}$	Autoregressive Coefficient	0.9344	0.9418	0.8602	0.0156
$\delta_{s,2000}$	Autoregressive Coefficient	0.9344	0.9333	0.8950	0.0045
$\sigma^2_{\eta,s,1970}$	Persistent Shock Variance	0.0069	0.0068	0.0110	0.0018
$\sigma^2_{\eta,s,2000}$	Persistent Shock Variance	0.0233	0.0240	0.0320	0.0006
$\sigma^2_{\varepsilon,s,1970}$	Transitory Shock Variance	0.1309	0.1259	0.1402	0.0038
$\sigma^2_{\varepsilon,s,2000}$	Transitory Shock Variance	0.1532	0.1484	0.1599	0.0019

5.4 Model Fit

In this section, we discuss the fit of the model, in regard to both the moments used in the estimation and non-targeted statistics. We estimate a total of 23 parameters by targeting

Table 5: Estimated Parameters

Parameter	Description	Value	SE
α	Utility weight on home goods	0.99	0.1458
ζ	CRRA parameter on home goods	3.78	0.1623
κ_h	Cost of wife leaving the labor force	0.58	0.5471
κ_w	Cost of wife entering the labor force	1.17	0.4025
$\mu_{\gamma,1970}$	Mean marital bliss shock , 1970	195.0	21.0888
σ_γ	St. deviation of marital bliss shock	47.4	13.1627
$\mu_{\gamma,2000}$	Mean marital bliss shock , 2000	75.1	17.0736
p	Price of home inputs, 1970	28.01	8.0461
c_k	Marital consumption commitments	0.48	0.0079
ϕ_{1970}	Gender wage gap, 1970	0.623	0.0068
ϕ_{2000}	Gender wage gap, 2000	0.788	0.0160

30 data moments. The estimated parameter values are reported in Table 4 (which contains the labor market parameters) and Table 5 (which contains the remaining parameters).

Overall, the parameters look reasonable and are tightly estimated. Let's start with the parameters that control the process for income shocks reported in Table 4. The parameter estimates are reported in the column called "Param." and the standard errors under "SE". The fit of the model is very good; the estimates obtained from running the GMM estimator on model data (column "Model") are very similar to the estimates obtained from actual data (column "Data"). Note that the parameter estimate and the estimates generated from model data are very similar for married households, but are not so for singles. Given our discussion in Section 5.3.1, this is to be expected. The main problem that the indirect inference procedure must overcome is the selection out of singlehood. That is, both in the model and in the data, we do not observe all the shocks faced by single individuals since they select themselves into marriage.

Table 5 reports the results for the other estimated parameters. We can observe the narrowing of the gender wage gap, represented by an increase in the relative income of women (an increase in the value of ϕ over time). The CRRA parameter for home goods ζ is estimated to be larger than the CRRA parameter on market goods. This means that the marginal utility of home-produced goods decreases faster than the marginal utility of market goods. As discussed in Section 4, this means that younger, poorer single households

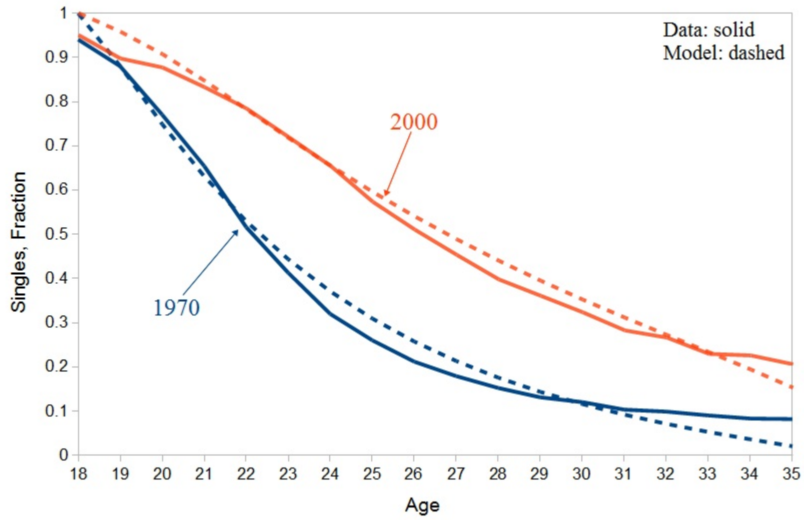


Figure 5: Model Fit —Fraction of Single Males by Age

benefit more from the decline in the price of home inputs. Finally, we can observe that the parameter that controls the average level of marital bliss shocks, μ_γ, decreases over time. This means that there is indeed a residual delay in marriage left unexplained by the forces explicitly modeled in this paper. In Section 6, we will quantify the quantitative power of each of these forces.

Figure 5 compares the fraction of single males at each age in the model and in the data. The model generates a good fit both in terms of the level of marriages that take place and also their timing.

Table 6 compares the statistics generated by the model with the other data targets. Overall, the model does a good job matching these additional moments. First, the model is able to generate an increase in the labor force participation rate of the same magnitude as the one observed in the data. This is done with a combination of the parameters that control the utility of home goods and the exogenous forces over time in both the price of home inputs and the gender wage gap. The movements of married females into and out of the labor force are also matched —this is where the utility cost parameters κ_h and κ_w are important. The observed gender wage gap, measured only on observed wages, is also matched for both years. The model also generates the same fraction of expenditures on home inputs as the fraction of expenditure of household operations observed in the data.

Table 6: Model Fit —Targeted Moments

Statistic	**Model**	**Data**
Female LFP –1970	.41	.42
Female LFP –2000	.77	.72
Observed Gender Gap –1970	.67	.67
Observed Gender Gap –2000	.75	.75
% of wives moving into LF in 1970	.04	.04
% of wives moving out of LF in 1970	.06	.07
Fraction of household expenditures on home inputs in 2000	.23	.23
Consumption commitments: % of couple's expenditures, 2000	.30	.30

Finally, the fraction of expenditures that are measured as consumption commitments is also matched.

5.4.1 Non-Targeted Statistics

The model also provides some predictions for statistics that were not targeted in the estimation procedure outlined above. The ability of the model to match these non-targeted statistics serves as a validation of the model. In this section, we study how well the model is able to match these statistics.

In the estimation, we only target the life cycle profile of single males, not females. Figure 6 plots the fraction of single females at each age both in the model and in the data. Given the symmetry across genders in the model, the model counterpart of this statistic is essentially the same as the ones for males in Figure 5, adjusted by the age gap in marriage. However, this is not necessarily true for the data. The fact that the model is able to match the fraction of single females at each age for both 1970 and 2000 guarantees that the assumption of a constant age gap in marriage is not too restrictive.

The estimation procedure targets the *average* labor force participation rates for married females. However, there is some variation of the degree of participation across the life cycle. Figure 7 plots the labor force participation rates of married females at every age for both 1970 and 2000. The model is able to qualitatively generate the same overall patterns. In 1970, the data show a decline in the participation rates when women reach their late twenties; and the model is able to generate a similar decline. In 2000, there is no such

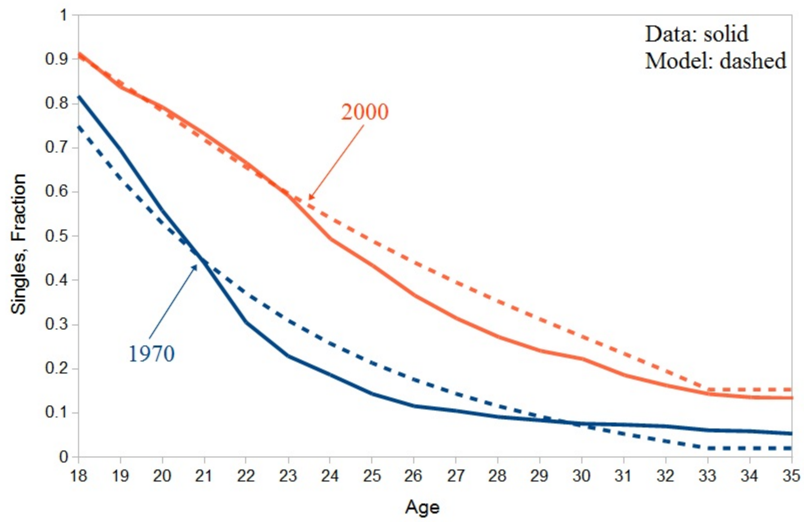


Figure 6: Fraction of Single Females by Age (Non-targeted)

decline at early ages, but we do observe a decline in participation rates at later stages in life. Again, the model is able to generate this pattern.

Finally, in this paper, we specifically allow the income processes for single and married people to differ. This is important since it allows for different choices in the labor market across marital statuses[23]. From our estimates for the processes reported above, married individuals face processes with higher persistence and lower variance, i.e., less risky processes. If we simply assumed the same process across marital statuses, we would artificially inflate the amount of risk marrieds face, and it would be actually easier for the model to generate stronger effects from increased volatility. However, there might be unwanted effects due to these variations in shock processes by marital status. For example, a male that experiences a good income realization might decide to get married with the sole purpose of "locking" himself to that good income shock, as married agents face a higher autocorrelation of shocks. In a high-volatility world, this could lead to earlier marriages as people could use this mechanism to artificially decrease the amount of volatility they face. Alternatively, when volatility is high, agents might wait longer for a better income realization and, as soon as it occurs, get married. This would cause a delay in marriage, and would also bias the selection out of singlehood. Moreover, the indirect inference approach that we use is only

[23]For example, in Section 2, we showed that married men tend to choose less risky occupations.

(a) 1970: (b) 2000:

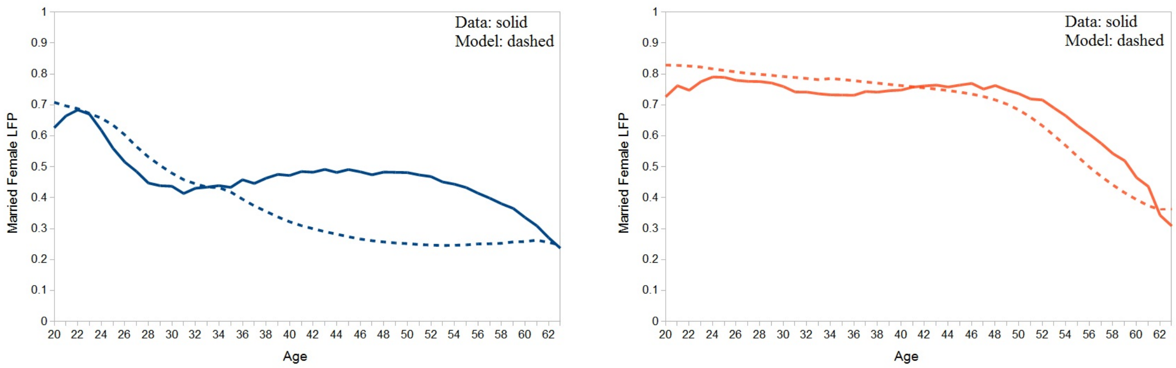


Figure 7: Labor Force Participation of Married Females

valid if the model generates the same type of selection into marriage as the one in the data. For all of these reasons, it is crucial that the model delivers the same selection-into-marriage pattern as the one we observe in the data. We now provide evidence that this is indeed the case, assuring our approach is valid.

Table 7: Income Process —All Marital Statuses (Non-targeted)

Description	**Data**	**Model**
1970		
Autoregressive Coefficient	0.992	0.986
Persistent Shock Variance	0.007	0.005
Transitory Shock Variance	0.095	0.104
2000		
Autoregressive Coefficient	0.992	0.980
Persistent Shock Variance	0.024	0.019
Transitory Shock Variance	0.112	0.109

The first check of accurate selection into marriage is related to the income process that we observe both in the model and in the data. In the estimation, we targeted the observed income process for single and married individuals separately. However, we can estimate a similar process for all individuals regardless of marital status, both in the data and in the model. If the estimates from the model do not line up with their data counterparts, this would be an indication that the selection that we obtain in the model is not consistent with the data. Table 7 presents the results of this exercise. It is clear that the model generates a very similar process to the one that is obtained from the data[24]. Given that the model generates estimates close to the data for singles only, marrieds only, and for the combined sample, the selection into marriage must also be consistent with the data.

Finally, we compare how income innovations influence the probability that an individual gets married both in the model and in the data. Again, the ability of the model to generate a similar pattern as the one observed in the data is an important indication that the selection into marriage in the model is consistent with the data. In order to test this, we run a linear probability model regression in which the dependent variable is whether or not a single male gets married, conditional on innovations in income in both the model and the data[25]. We also add a cubic polynomial in age as a control and, for actual data, add dummies for educational attainment[26]. The results are reported in Table 8. In the data, the coefficient on income differences is not significantly different from zero. The model counterpart is also very close to zero and is contained in the 95% confidence interval of the estimates in the data. Note also that the R^2 for both regressions is small, indicating that innovations in income do not explain much of the variation in the decision to get married; what seems to be important then is the amount of volatility households face and not the innovation immediately preceding marriage. Overall, the fact that the model generates very similar estimates to the ones obtained with actual data is reassuring.

Table 8: Linear Probability Model —Marriage and Innovations in Income

	Coefficient	**St. Error**	**95% CI**	R^2
Data	-0.009	0.015	[-0.040,0.021]	0.0076
Model	0.005	—	—	0.0026

Dependent Variable: Marital status dummy (married or single)

[24] As before, we estimate a process with persistent and transitory shocks. For the actual data, we combine our samples for singles and marrieds in the PSID.

[25] We also ran a similar regression with the level of income (and not differences) as the explanatory variable. However, we must note that, by running the regression in levels in the data, we are not filtering out any fixed effects (which are controlled for in the differences specification). The model nonetheless generates very similar estimates to the ones obtained with actual data.

[26] For the actual data, we use a sample of white men from the PSID, since we need a panel data set for this exercise given that we must follow an individual over multiple periods of time to determine income innovations and whether he will get married.

Overall, the model is able to match several important features of the data, both some that were targeted in the estimation procedure and some that were not. Crucially, the model generates the same pattern of selection out of singlehood and into marriage that is observed in the data. Given this very reasonable model fit, we can now use the model to understand the contributions of several channels to the observed delay in marriage.

6 Results

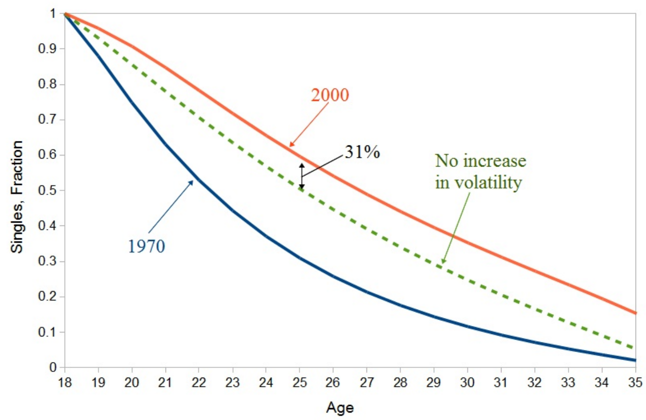
In this section we decompose the effects of various mechanisms on the delay in marriage. To do this, we perform a series of counterfactuals that aim to isolate the effect of each particular channel. Each counterfactual works as follows: From the 1970 steady state, we change all parameters to the 2000 values, *except for the parameter of interest.* For example, when we study income volatility, we change the gender wage gap, the price of home inputs, and the residual component (μ_γ), and see how much is left to be explained by volatility. The counterfactual question is "What would have happened to the timing of marriage had income volatility not increased?" We then look at how much each mechanism affects the change from the model benchmark in 1970 to the model benchmark in 2000.

The results for all counterfactuals are plotted in the different panels of Figure 8. Each figure plots the fraction of single males at each age for the benchmark years of 1970 and 2000, as well as the fraction that is computed under the counterfactual assumptions.

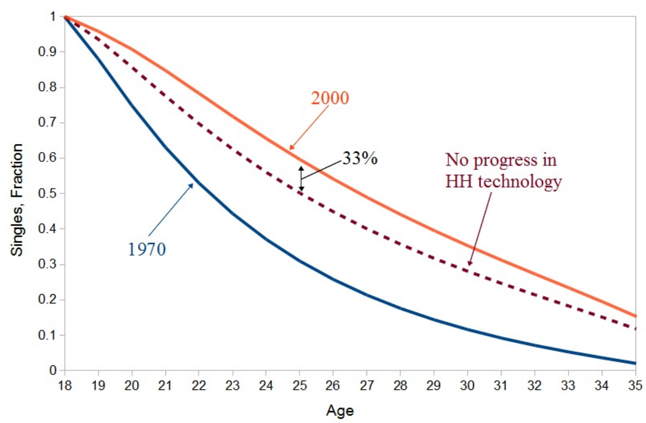
The effect of rising income volatility on marriage can be inspected in panel (a). It is clear that shutting down any increase in income volatility causes more marriages to take place since we observe a lower fraction of singles in the counterfactual. As a way of quantifying the effect of increased income volatility, we choose age 25 as a reference point to examine how much of the overall decline in marriage between 1970 and 2000 is left to be explained once income volatility is kept at the 1970 level. As is highlighted in the graph, 31% of the observed delay in marriage at age 25 would not have taken place were it not for the increase in income volatility. This shows that the effects of consumption commitments and added gains to search due to rising income volatility dramatically outweigh the effects of the gains to spousal insurance.

Panels (b) and (c) plot the effects of the counterfactuals for the technological progress in the home sector and the narrowing of the gender wage gap respectively. Again, we focus on the changes at age 25. The results show that declining prices for home inputs are also an important factor: they account for 33% of the decline in marriage. On the other hand, the

(a) No Change in Income Volatility:



(b) No Change in HH Technology:



(c) No Change in Gender Wage Gap:

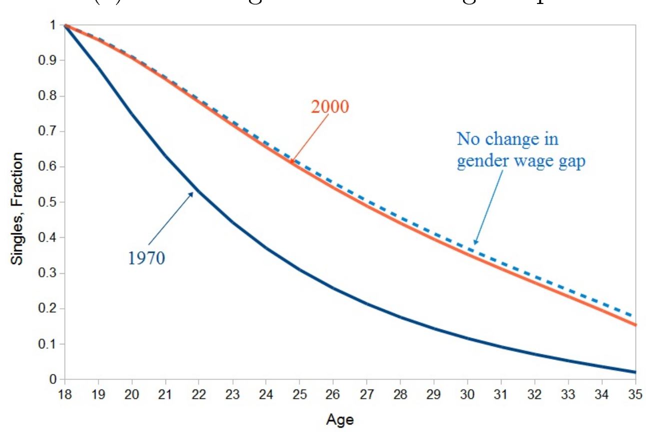


Figure 8: Fraction of Single Males by Age —Effects of Different Channels on Marriage

narrowing of the gender wage gap actually leads to slightly more marriage in the economy. However, as a result of the two opposing forces mentioned in Section 4.3, the overall effect is weak. On one hand, when women earn more money, they find it easier to remain single; on the other hand, they become more attractive to men. Quantitatively, it turns out that these effects mostly cancel out the effect of the narrowing wage gap.

In sum, results show that two channels (increasing income volatility and declining home input prices) have strong quantitative effects that lead to delays in marriage, while a third channel (the narrowing gender wage gap) does not. The effect of declining home inputs is significant, but going forward we will focus on the income volatility channel, as this paper seeks to establish a quantitative relationship between that channel and marriage delay. Almost one-third of the observed change between 1970 and 2000 can be attributed to higher income volatility. As previously shown, one of the factors of such a result is the role that consumption commitments play within marriage. In the next section, we show that income risk is still important for marriage decisions even if the amount of consumption commitments is substantially lower.

6.1 Robustness —Lower Level of Consumption Commitments

As seen in the previous sub-section, rising income volatility is an important determinant of the timing of first marriages. The effect of rising volatility also depends on how large the consumption commitments faced by married households are; this is what we explore now. In this section, we perform robustness analysis regarding the level of these consumption commitments faced by married households. In order to do this, we recalibrate the model by targeting a lower level for the variable c_k that represents these commitments. We set the new target at 15% of the average married household income, i.e., half the value that was used in the benchmark case. This is equivalent, in dollar terms, to the amount spent on one child by the poorest decile in the Consumer Expenditure Survey (CEX). In other words, we set the consumption commitments for all households equal to what is spent by the least well-off families in the data. We then perform the same counterfactual as above; that is, we change all parameters to the 2000 values, except for the variance of income shocks. We then look at how much this mechanism affects the change from the model benchmark in 1970 to the model benchmark in 2000. The result of the counterfactual with the lower level of consumption commitments is plotted in Figure 9.

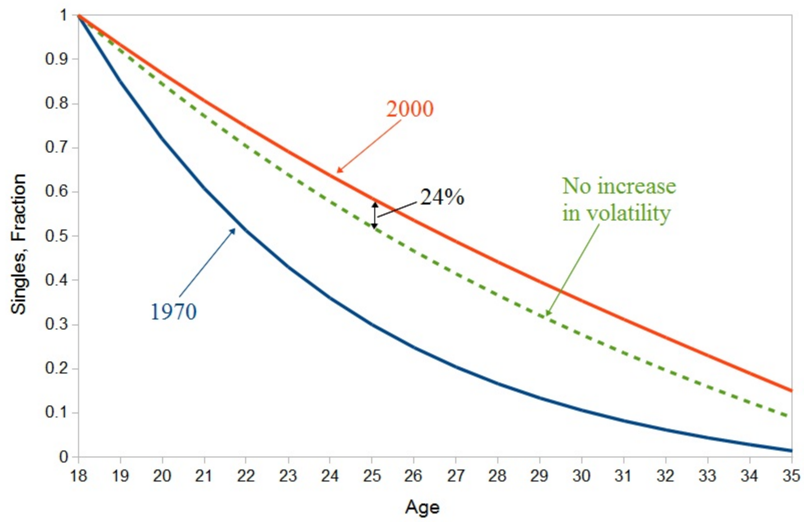


Figure 9: Fraction of Single Males by Age —Robustness

As can be seen from the figure, even with the lower level of consumption commitments, higher volatility is still an important determinant of the timing of marriage. Not surprisingly, the effect is weaker when marriage involves less commitments: Increased income volatility is now responsible for 24% of the observed delay in marriage at age 25, as opposed to 31% found with the model benchmark. This lower effect is due to the fact that, with lower commitments within marriage, the adjustments to the household's discretionary consumption that are caused by fluctuations in income do not have to be as pronounced as before. Nevertheless, risk is still an important determinant of the timing of marriage, and young adults do delay marriage in response to higher income volatility.

6.2 Policy Experiment —An Abstract Illustration

As discussed above, the rise in income volatility observed between 1970 and 2000 explains a significant fraction of the delay in marriage observed in the same period. We must note that the amount of volatility individuals face in the labor market is also subject to the effects of government policies. In this section, we perform a simple exercise in order to illustrate this impact of government labor market policies on household formation. This exercise is of interest because failure to take changes in household formation into account might potentially bias the welfare analysis of a given policy.

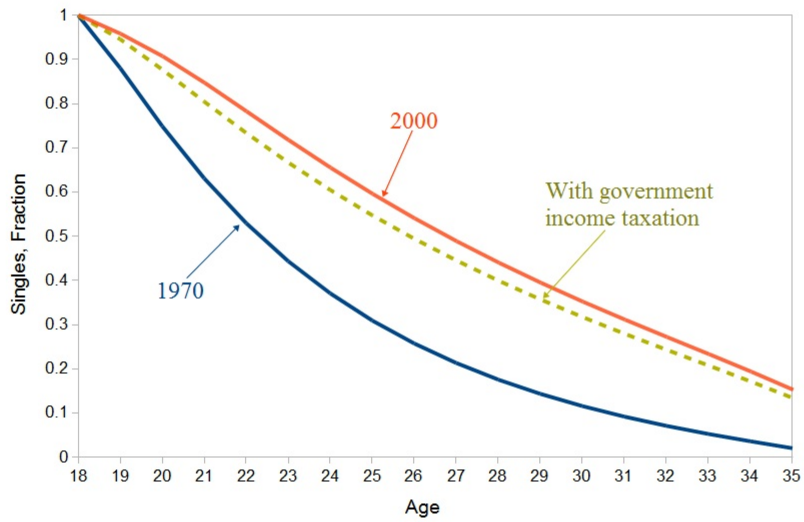


Figure 10: Fraction of Single Males by Age —Policy Experiment

The policy experiment here is very simple. Suppose the government taxes income at a 10% rate and rebates the proceeds as lump sum transfers to all households. By doing so, the government is implicitly providing insurance to people against income fluctuations.

The results of this policy on the timing of marriage are plotted in Figure 10. We can see that this policy significantly affects household formation. The implicit insurance and consequent decrease in volatility caused by the policy would be responsible for closing 16% of the delay in marriage observed between 1970 and 2000.

We also compute the welfare impact of this policy. We measure welfare using the equivalent variation of income; that is, the maximum amount of income households are willing to pay in order to live in a world with such a policy. We compute the welfare from the point of view of 18-year-old males. Essentially, the equivalent variation is how much an 18-year-old is willing to pay to start his life in a world with the policy. The result is given in the first entry of Table 9. Eighteen-year-olds would be willing to relinquish up to 11.2% of their lifetime income in order to live in a world with this policy. This number is very high because there is very little distortion caused by the policy and young agents would be one of the greatest beneficiaries of such a policy. The most interesting message from this welfare analysis is not the number itself, however, but the differences that we would find if changes in household formation are *not* considered.

Now imagine that we compute the welfare effects in a model that does not take any changes in household formation into account. That is, we compute the equivalent variation of the policy in a world where people decide whether or not to marry as if the policy was not implemented. The result is given in the second entry of Table 9. The policy is again welfare-improving, but the truly interesting fact is how different the numbers for the equivalent variations are: 11.2% for the policy that accounts for household formation versus a much-lower 6.0% for the policy that does not.. This result suggests that household formation is an important margin to consider when assessing the effects of government labor market policies.

Table 9: Welfare Effects of Government Policy

Experiment	**Equivalent Variation**
Benchmark with policy	11.2% of income
Policy without changes in HH formation	6.0% of income

7 Conclusions

There have been drastic changes in American society over the last 40 years. Young adults have been delaying marriage in a manner that is frequently described as "failing to launch." We contribute toward answering the most natural question: Why?

We propose a new hypothesis: increasing income volatility has led to a delay in marriage. The idea behind this hypothesis is simple. If marriage involves consumption commitments, such as children or home mortgages, then an increase in income volatility makes marriage less desirable. Young singles will thus delay marriage until a later point when they will ostensibly have greater incomes or accrued assets to offset these commitments. Despite the implicit insurance between spouses, this channel is quantitatively important.

We quantitatively assess this new hypothesis vis-à-vis others in the literature. In this paper, we estimate a structural search model of the marriage market with increasing income volatility, a narrowing gender wage gap, and decreasing prices of home inputs. We find that rising income volatility explains about one-third of the decline in marriage. The decrease in the price of home inputs also explains about one-third of this decline. The narrowing of the gender wage gap has a small effect. In sum, we find that our hypothesis is correct, and that rising income volatility has a substantial impact on the delay in marriage.

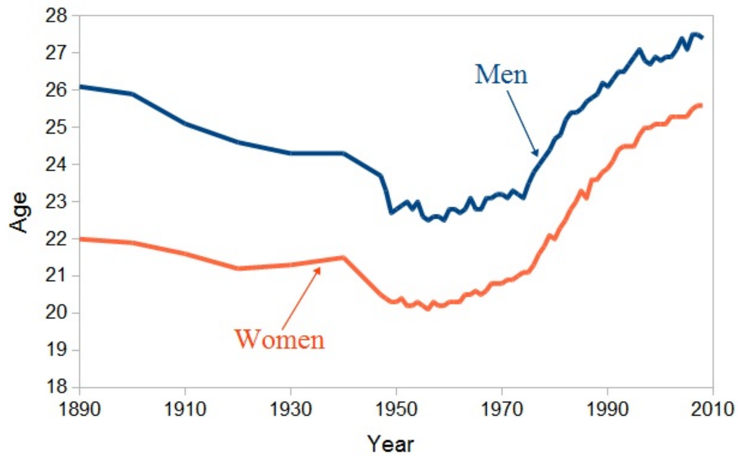


Figure 11: Median Age at First Marriage

Note that the median age of individuals at their first marriage over the twentieth century was U-shaped, as Figure 11 shows. Data limitations hurt our ability to evaluate key statistics for the earlier part of the century, leaving our hypothesis untestable for that period of time; however, it is possible that the labor market was volatile during the beginning of the century, causing delayed marriage. With a more complete data set, perhaps increasing income volatility could explain the full time series. This possibility can be explored in future studies.

The framework developed here could also be used to address different questions. For example, in the presence of consumption commitments, individuals may sort into jobs or occupations with greater or lesser risk based on their marital status. Another possibility is an analysis of the impact on household formation of different government policies that affect the labor market, as hinted in Section 6.2. We leave these possibilities for future research.

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A Data Sources

This appendix describes the sources of the data for selected tables and figures in the paper that contain actual data.

Figure 1: The data for never-married white males comes from the Integrated Public Use Microdata Series (IPUMS) Census for both 1970 and 2000.

Figure 2: The data for the median age of individuals at their first marriage comes from the U.S. Census Bureau (Table MS-2). The standard deviation of persistent shocks are the values estimated by Heathcote, Storesletten, and Violante (2010). Their series for the variances is smoothed using the HP-filter. The non-filtered data is very noisy but is also positively correlated with the series for age at first marriage (0.40). The values for the variances reported in their paper are very similar to the ones obtained here in Section 5.

Figure 3: The fraction of households with children is computed using data on families headed by a white male from the IPUMS-Census data for both 1970 and 2000.

Figure 4: The fraction of homeowners by marital status is computed using IPUMS-Census data for both 1970 and 2000 based on the response to the variable OWNERSHP.

Figures 12 and 13: The data for never-married white males comes from the IPUMS-Census for 1970 and 2000. A male is college-educated if he has at least 16 years of education.

Figure 14: The data for white males comes from the IPUMS-Census for both 1970 and 2000. The lines labeled "1970" and "2000" are the same as in Figure 1. Singles that are not cohabitating are represented in the line "2000 - no cohabitation". Note that, for 2000, we do not consider individuals that are not married but *cohabitate and have* children as singles. This explains the small difference between the lines "2000" and "2000 - legal".

Table 1: The fraction of households with children is computed from the PSID. For married households, we follow them until their next interview after two years in order to determine whether they eventually had children. Since our focus is on young adults, we restrict the age range of included individuals to between 18 and 40.

Table 2: We use data for white males from the IPUMS-Census for 2000. We restrict the age range between 20 and 60. Earnings are measured using the wage income (INCWAGE). Individuals whose usual hours worked were less than 10h/week (520h/year) were excluded, as were those with an hourly wage of less than half the prevailing minimum wage. As discussed in the text, in the Mincerian regression, we control for a cubic polynomial in age, education dummies (less than high school, high school, some college, college or more), and a dummy for each occupation.

B Other Data on the Delay in Marriage

In this section, we present data on the delay in marriage for different groups of the population for both 1970 and 2000. Figures 12 and 13 plot the fraction of white males that are single conditional on their educational attainment, i.e., whether they have a college degree or not. It is clear that marriage has been delayed by individuals of both education groups.

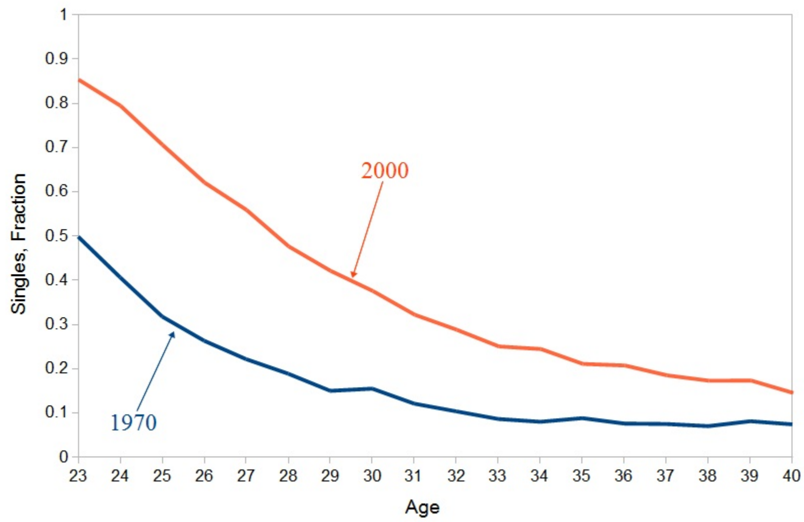

Figure 12: Percentage of College-Educated White Males Never Married, by Age

One form of living arrangement that we abstract from in this paper is cohabitation. Young adults could have been opting to cohabitate instead of getting married in 2000. Figure 14 shows that this is not the case. Even though there is a fraction of the population that currently cohabitates, an increase in the fraction of singles among young adults is clearly visible in the figure. Note that our definition of married individual differs a little from the legal definition reported in the Census. In particular, we treat individuals that *cohabitate and have children* as effectively being married. This causes the small adjustment observed in Figure 14.

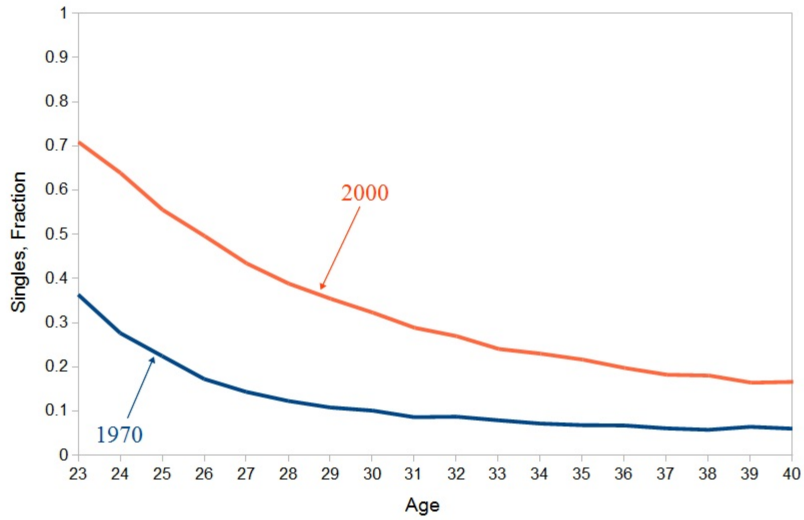

Figure 13: Percentage of Non-College-Educated White Males Never Married, by Age

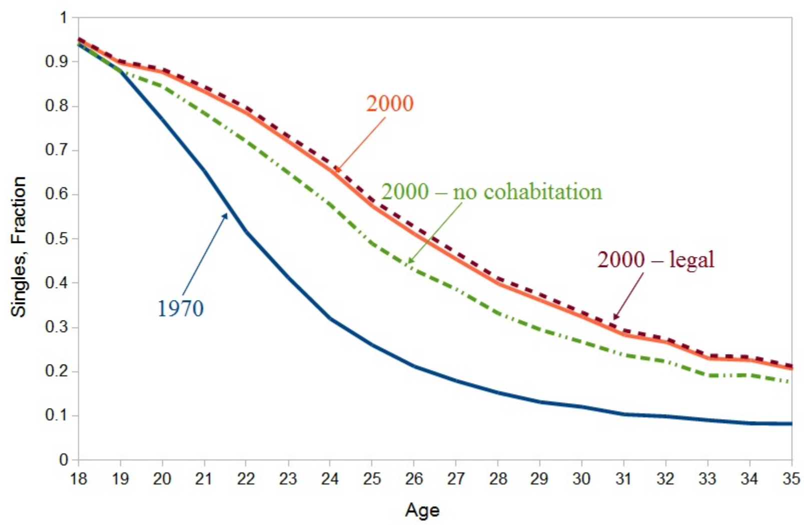

Figure 14: Living Arrangements of Young Adults

C Estimation of Income Processes

We use data from the PSID for all waves between 1968 and 1997. As described in the text, we separately estimate the processes described in Section 3.1 for married and single individuals. We use data for male respondents that satisfies the following criteria for at least three years (which need not be consecutive): (i) the individual reported positive earnings and hours; (ii) his age is between 18 and 64; (iii) he worked between 520 and 5100 hours during the year; and (iv) he had an hourly wage above half of the prevailing minimum wage at the time.

First, in order to generate the residual earnings, we run a cross section Mincerian regression for each year, controlling for education and a polynomial in age. Residuals generated from these regressions are used in the estimation procedure. We estimate a slightly modified version of the processes described in Section 3.1 in order to include individual fixed effects (which are not present in the model). We estimate time-varying variances for each shock for each year and HP-filter these time series for the variances. These HP-filtered variances for the shocks are reported in Table 4. The standard errors are computed using a bootstrap procedure. For a formal proof of identification of the parameters, see Karahan and Ozkan (2010).