Risk Sharing and On-the-Marriage Search

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PRELIMINARY AND INCOMPLETE

Abstract

Much attention has been paid to the high divorce rate, but less recognized is the frequency of remarriage. To the extent that marriage provides consumption insurance, this prompts re-examination of the gains to marriage in terms of risk sharing. This paper shows that existing models of marriage with risk sharing and limited commitment cannot explain the rate and speed at which divorcees remarry. Introducing on-the-marriage search allows simulations to match the rates seen in the data.

1 Introduction

With the ascent of individual agency and legal, socially acceptable (and unilateral) divorce, the institution of marriage has changed. Nowadays death parts only a small fraction of spouses: half of legal unions survive to the twenty year mark, and 1% of all women aged 15 and over – unconditional on being married – divorce during a given year.[1] Divorcees frequently remarry and do so quickly. By the first anniversary of a divorce, 15% of divorcees have remarried. After five years over half have remarried, and after fifteen years the rate is over 80%.[2] Of all marriages, up to 36% consist of a previously married spouse.[3] This is hardly a recent phenomenon. In fact, five year remarriage rates are even higher for every decade going back to the 1950s.[4] This paper argues that standard models of marriage cannot match the remarkably high rates of remarriage seen in the data, and that introducing on-the-marriage search to the standard framework yields a richer and more predictive model of marriage over the life cycle.

To the framework of dynamic joint household maximization with transferable utility due to Mazzocco and Yamaguchi (2009) I introduce on-the-marriage search. This allows a spouse to actively seek an outside option to the current marriage in order to negotiate a favourable division of surplus. Ligon, Thomas, and Worrall (2002) show that the efficient renegotiation of the contract requires altering the division of surplus

[1] National Health Statistics Reports, Number 49, March 22 2012.
[2] National Survey of Family Growth, 1995 cycle, Center for Disease Control.
[3] US Census Bureau, Survey of Income and Program Participation, 1996 panel, Wave 2.
[4] Note that earlier decades have smaller divorce cohorts.

as little as possible. On-the-marriage search allows for more frequent and more drastic renegotiations, potentially lowering the gains to marriage and altering consumption patterns during marriage and across marital transitions. Conversely the option to continue searching while married may increase the gains to marriage. Agents marry to pool risk from idosynchratic income shocks, as in Gallipoli and Turner (2011). I introduce limited commitment in marriage contracts, which allows for renegotiation as income shocks are realized.

I estimate this model using indirect inference. The model with on-the-marriage search predicts remarriage rates better than the standard model, which vastly underpredicts remarriage – especially in the few years following divorce. This has implications for consumption smoothing over the lifetime. Wage moments and those to do with assortative matching are predicted similarly between models.

This paper is related to literatures on dynamic joint household decision making, and assortative matching in the presence of frictions. Mazzocco and Yamaguchi (2007) show that labour supply and savings decisions of couples are codependent and therefore cannot be fully explained by individual characteristics. The authors present a joint decision making framework within which partners' individual decisions can be competetive as well as cooperative. Since married agents do not commit to paths of consumption and labour supply, an agent's weight in household decision making increases in the value of the outside option. Behaviour that improves one's outside option will increase own decision power at the expense of the spouse. The paths of consumption and labour supply over marital transitions are consistent with competetive behaviour between spouses.

Finally, Shimer and Smith (2000) and Smith (2006) study the conditions under which partners match assortatively in the presence of search frictions. Burdett and Coles (1999) show that under full commitment and without the possibility of divorce, search frictions lead to positive assortative matching within discrete castes, even when the distributions of partner quality are continuous. Burdett and Coles (2001) show that this can lead to inefficiencies in human capital investment. This paper derives results on matching assortativity when commitment is limited.

The rest of the paper is organized as follows. Section 2 presents the empirical motivation and Section 3 the theoretical framework of the model. Section 4 describes the data and measurement issues. Section 5 outlines further assumptions needed to necessitate numerical simulation and Section 6 discusses estimation issues. Results are presented in Section 7 and Section 8 concludes.

2 Empirical Motivation

The high divorce rate is widely recognized, but less attention has been paid to the phenomenon of remarriage. One-third of all marriages are remarriages for at least one spouse.[5] Within five years of divorce, over half of divorcees are remarried. These surprising facts merit reconsideration of how marriage provides consumption insurance over the life cycle.

[5]US Census Bureau, Survey of Income and Program Participation, 1996 panel, Wave 2.

Figure 1: Share of women remarried by years since divorce

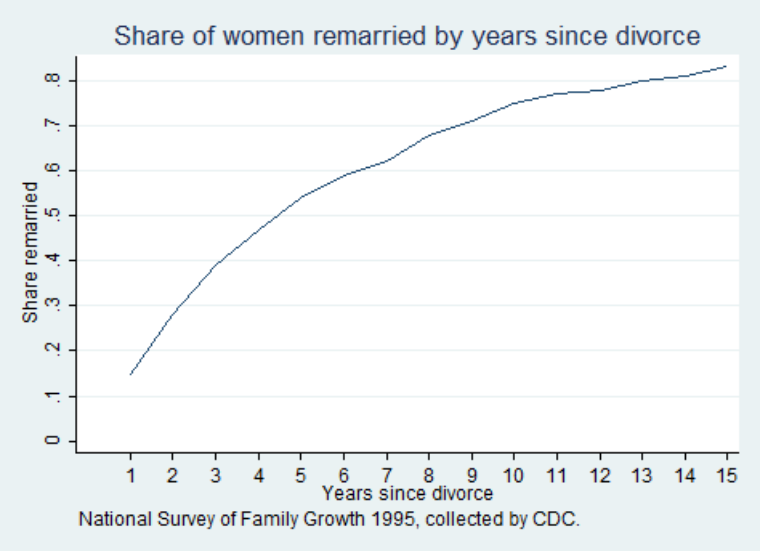


Table 1: First marriage rates of women by age group

Age group	Avg. marriage rate	Cumulative marriage rate
20-24	5.4%	27.2%
25-29	8.2%	52.5%
30-34	5.8%	64.7%
35-39	1.8%	67.9%
40-44	0.44%	68.6%

Figure 1 shows the share of women who remarry by years following a divorce according to the National Survey of Family Growth. After one year, 15% of women have already remarried (this number is over 18% in the Consumer Expenditure Survey). By the fifth year following divorce over half of all divorced women have remarried, with the share rising above 80% by the fifteenth year. Compare the one-year remarriage rate of 15% with rates of first marriage given in Table 1. The highest marriage rate for non-divorced women is 8.2% (for women in their late twenties), roughly half the one-year rate for divorcees.

This paper argues that on-the-marriage search can explain remarkably high – and remarkably quick – marriage rates among divorcees. This mechanism has empirical backing: according to the General Social Survey, 18% of married individuals report committing infidelity against their spouse at some point during the marriage (with 2.9% claiming ingorance or refusing to answer). This should be seen as a lower bound on extramarital sexual activity, since most respondents report on the current marriage and

may be hesitant to admit infidelity.[6] Among divorced or separated individuals, 32% admit to infidelity. Although the selection bias in the latter sample is evident, it suggests infidelity as a leading cause of divorce and further demonstrates its prevalence.[7]

Note that extramarital sex is not identical to on-the-marriage search to the extent that the former may be purely recreational, and may even be allowed in certain marriage arrangments. The higher reported rate of infidelity among the divorced cohort suggests that extramarital sex ends marriages, and I will assume that recreational sex is not entirely circumscribed from partner search.

3 Model

The model introduces on-the-marriage search into the framework of Mazzocco and Yamaguchi (2007) in order to explain divorce and remarriage behaviour and consumption patterns across marital states. Single individuals expend search intensity to increase their matching rate. Married individuals increase search intensity either to find a more preferable partner or in order to increase the value of their outside option, allowing them to make a credible threat to divorce and thereby increase their decision weight in the current marriage.

Setting

Time is discrete and agents live for a known number of periods T. Agents supply labour inelastically and are subject to stochastic wage shocks. Men and women match randomly to an agent of the opposite sex in any given period and decide whether or not to marry. Marriage allows individuals to pool wage risk and so acts as insurance. Married agents can continue to search for a different marriage partner.

Participation in the marriage market requires a positive level of search intensity. In general, the cost of search effort can be in consumption or utility terms, depending on the form of the utility function.

Agents

Characterize agents by gender $g \in m, f$ and wage w, the latter being subject to i.i.d. stochastic shocks. Measures M of men and F of women inelastically supply one unit of labour each period and receive the wage, spent on regular consumption c. They also expend search intensity s at constant utility cost ψ^g, $g = m, f$.

Utility is concave and increasing. Concavity yields risk aversion which is necessary for marriage to provide insurance value. In addition to risk pooling, marriage provides economies of scale in utility.[8]

[6] Of those currently married, 13% admit to infidelity.

[7] This is consistent with the cross-cultural study of Betzig (1989) that identifies infidelity as the primary cause of divorce in 150 cultures, including the United States.

[8] The equivalence scale multiplies the utility of married agents and decreases as the marriage contract becomes more unequal. See Voena (2012) for a similar example, or Section 5 for a thourough explanation.

Single agents receive income and spend optimally on the two goods. Married agents face a two-stage optimization process. First the income of both partners is pooled and allocated by the household planner. This is a joint utility maximization with Pareto weight λ given to the man and $1-\lambda$ given to the woman. Normalize the weight on the man's utility as $\Lambda = \frac{\lambda}{1-\lambda}$. Each partner receives an 'allowance' h_t^i, where $h_t^f + h_t^m = w_t^f + w_t^m$, and proceeds to maximize the individual value function in the second step.

This two-step process is a departure from the literature, wherein the household planner solves the household allocation completely with no second individual stage. Two stages are necessary in the present setting because an increase in search intensity necessarily benefits one partner at the other's expense; the household planner would spend nothing on search intensity if it chooses the complete allocation. See the renegotiation subsection below for an elaboration.

Timing

At the beginning of period t agents match to a potential partner of the same age or fail to match with a certain probability. A matched agent observes wages from the previous period w_{t-1}^i for herself, w_{t-1}^{-i} for her partner (if the partner exists), and w_{t-1}^j for her new match, and forms expectations over current wages w_t^i, w_t^{-i}, and w_t^j that inform her marriage decision.

After marital status is determined, agents realize the stochastic wage shock.[9] Single agents spend their income on consumption, while married agents face the two-stage household maximization process described above. The conspicuous search decision made in period t determines search intensity in the following period $t+1$. After consuming, utility is realized and agents proceed to period $t+1$.

Search and Matching

Agents match randomly to another agent of the same age.[10] In a given period an agent may or may not find a match. A woman f who matches to a man m in period t proposes to him if she improves her expected lifetime utility by marrying him. If this marriage also increases expected lifetime utility for man m, the couple weds. Note that f and m may each have an existing spouse, or may be single. The decision to leave one's current spouse for a new partner is explained in more detail in the following subsection.

[9]The marital decision occurs before the stochastic wage shock so that there is an insurance value to marriage; since partners' shock are uncorrelated marriage allows agents to pool risk. Consider a married couple in period T. If agents know their wage with certainty, neither will accept a marriage contract that gives an allowance less than their own wage. Both spouses consume their own income and there is no insurance value to marriage. Anticipating this, a married agent in period $T-1$ will not accept a contract yielding personal allowance less than own income since there is no possibility future risk pooling to compensate for a current fall in income. By backward iteration it is clear that there is no insurance value to marriage in this formulation. With the marriage contract negotiated before the realization of age shocks, there is insurance value to marriage in any given period, including period T.

[10]This standard assumption simplifies the problem by giving married agents the same time horizon.

In a given period an agent has the opportunity to search with probability ϕ. This opportunity is realized stochastically at the beginning of the period and so its realization cannot inform the search intensity decision that is made in the previous period. Let the probability of having a search opportunity vary by marital status so that $\phi \in \{\pi^0, \pi^1\}$. This follows the on-the-job search literature.

Conditional on having the opportunity to search, agents match to a potential spouse with probability $p(s_{t-1}) \in [0, 1]$, a function of the previous period's search intensity. Even given the opportunity to search, an agent may not find a match in the current period.

If woman f does have the opportunity to search and does find a match, the probability that she matches to a man of type x^m is proportional to the fraction of men of that type in the population who search (of equal age to the woman). The man's type x^m is comprised of his age, wage, marital status, and wife's wage. Woman f cares only about his wage, and his willingness to propose to her (the latter of which depends on his wife's wage). Woman f is an acceptable spouse to some set of men $x \in \mathcal{J}$. Call such men viable matches for woman f. The probability of meeting a viable match is $\rho(s, x) \equiv \pi p(s) Pr[x^m \in \mathcal{J} | x^f]$. This probability is endogenously determined in equilibrium, and weakly increases in s.

In equilibrium the cumulative distribution functionss of men and women's types are given by M(x) and F(x) respectively, with corresponding probability density functions m(x) and f(x).

Renegotiation

Marriage is a mutually voluntary union from which either partner can divorce unilaterally. Since surplus from marriage is divided according to the marriage contract Λ, agent i may prefer to divorce given this contract but prefer to stay married given a contract $\Lambda' \neq \Lambda$. If partner i prefers to become single or to leave the current marriage for another one, this prompts a renegotiation of the marriage contract. The household planner increases the Pareto weight of the reluctant partner to the point that this partner is indifferent between remaining in the current marriage and taking the outside option.[11] The new contract is given by Λ'.[12] Now if the other partner $-i$ still prefers the current marriage under the renegotiated contract Λ' to their own outside option, the marriage contract is successfully renegotiated to Λ'. Otherwise, no contract can satisfy both partners simultaneously and the couple divorces, each taking their best outside option.

[11] Ligon, Thomas, and Worrall (2002) show that efficient renegotiation requires changing the Pareto weights as little as possible. Intuitively, risk averse agents prefer smaller variation in consumption over time.

[12] If it is the man's incentive compatability that is violated, $\Lambda' > \Lambda$, and vice versa. Note that it is possible that such a contract does not exist. Consider a man m whose relative Pareto weight is arbitrarily large, meaning the household planner allocates to him all of his own and his wife's earned income, $w^m + w^f$. This man will leave the current marriage for one that allocates him allowance $h^m > w^m + w^f$. In a case such as this there is no contract that will satisfy the reluctant partner, who initiates divorce.

Renegotiation requires that the superior outside option to be viable. Consider two couples A and B with marriage contracts Λ_A and Λ_B to which all partners prefer the current marriage to singlehood. In period t woman f^A and man m^B match, and prefer to marry each other rather than to stay in their current partnerships at the current contracts. Suppose their spouses find no match in the current period. Their match prompts a renegotiation in both marriages, so that either is indifferent between entering the new marriage and remaining in their current marriage under the new contracts $\Lambda'_A < \Lambda_A$ and $\Lambda'_B > \Lambda_B$ respectively. Four cases are now possible:

- if neither unmatched spouse m^A and f^B finds the new contract acceptable then both current marriages dissolve and the new marriage between f^A and m^B is formed;
- if m^A finds renegotiated contract Λ'_A acceptable but f^B finds contract Λ'_B unacceptable, marriage A is renegotiated successfully to Λ'_A and the tentative match between f^A and m^B disappears; therefore m^B cannot credibly threaten to leave marriage B, so the original contract Λ_B stands and the marriage continues;
- if f^B finds the renegotiated contract acceptable but Λ^A does not the outcome is analagous to the previous;
- if unmatched spouses m^A and f^B each find the new contracts acceptable then both marriages are tentatively renegotiated; this implies that the new union between f^A and m^B is not viable, meaning neither can make a credible threat to leave, and both existing marriages persist at their original contracts Λ_A and Λ_B.

From the perspective of any individual i, a match j is only significant if j cannot successfully renegotiate the current marriage. Denote such a match j as a viable match.

Value Functions

Consider a single individual i in period $t < T$ with current wage w_t^i. The wage shock is realized after matching happens, so agent i's marital status in period t is given; i does not get a chance to match to a potential partner j until period $t+1$. Having already rejected any previous spouse or potential partner met in the current period, or having failed to meet a willing partner, i maximizes value $V^{i,s}$ subject to the budget constraint $c_t^i + e_t^i = w_t^i$. Let x_t^i denote the vector of characteristics including age (equivalently the number of periods until death $T-t$), and current income, which is equal to wage w_t^i for singles, and the fraction of household income one receives from the household planner for a married individual. Let $V^{i,0}(x_t^i)$ denote the value of being single and $V^{i,1}(x_t^i, x_t^{-i}, \Lambda_t)$ the value of being married. Time preference is given by β.

The value for a single women is given by

$$V^{f,0}(x_t^f) = \max_{c_t^f, s_t^f} u^f(c_t^f) - \psi^f s_t^f + \beta\rho(s_t^f, x_t^f)\mathbb{E}[V^f(x_{t+1}^f, \hat{x}_{t+1}^m, \hat{\Lambda})]\} + \beta(1-\rho(s_t^f, x_t^f))\mathbb{E}[V^{f,0}(x_{t+1}^f)]$$

$$s.t. \quad c_t^f \leq w_t^f$$

where $V^f(x^f, x^m, \Lambda_t) = max\{V^{f,1}(x^f, x^m, \Lambda_t), V^{f,0}(x^f)\}$, indicating that upon being matched to a willing partner she chooses the maximum of the value of marrying and the value of remaining single. With probability $1-\rho(s_t^i, x_t^i)$, i does not meet a willing partner in the next period. In this case i expects to receive the value of being single with beliefs over next period's wage w_{t+1}^i (informed by current wage w_t^i and a known distribution of shocks). With probability $\rho(s_t^i, x_t^i)$ i meets a willing partner next period and decides between marrying and staying single. The expected value of the former depends on expectations over both i's wages next period and those of potential spouse j. The marriage contract of a newly wed couple is fixed at $\hat{\Lambda}$. These expectations are informed by either agent's wage in period t, as the shock to wage in period $t+1$ has not yet been realized when the marriage decision must be made at the beginning of the period. In the final period i consumes the entire wage endowment as no future match is possible.

Now consider an agent i married to spouse $-i$. These partners have decided at the beginning of period t to be together, either staying in an existing marriage or having just wed; each must be better off being with the other rather than being single, based on expectations over w_t^i, w_t^{-i} informed by last period's wages.[13] This means that both of the following incentive compatability constraints must hold:

$$IC_t^m : \mathbb{E}[V^{m,1}(x_t^i, x_t^{-i}, \Lambda_t)] \geq \mathbb{E}[V^{m,0}(x_t^i)] \tag{1}$$

$$IC_t^f : \mathbb{E}[V^{f,1}(x_t^{-i}, x_t^i, \Lambda_t)] \geq \mathbb{E}[V^{f,0}(x_t^{-i})] \tag{2}$$

where $V^{i,1}(.,.,.)$ is the value to a married individual, the first argument being own income, the second that of the spouse, and the third being the relative decision weight of the man. Since participation in a marriage is voluntary, define the value of having a willing partner of type w_t^{-i} as $\mathbb{E}[V^i(x_t^i, x_t^{-i}, \Lambda_t)] \equiv max\{\mathbb{E}[V^{i,1}(x_t^i, x_t^{-i}, \Lambda_t)], \mathbb{E}[V^{i,0}(x_t^i)]\}$. Violation of either incentive compatability constraint prompts renegotiation as described above.

[13] It is possible that one or the other spouse would prefer to be single once wage shocks are realized; for example, if the partner receives a negative shock. The specification of timing means that agents cannot renegotiate or divorce until period $t+1$.

Household Optimization

Joint household maximization is a multi stage process. The household planner maximizes a Pareto weighted sum of both partners' value functions by allocating the total shared income between the two of them. In the individual optimization stage each partner chooses individual consumption and search intensity so as to maximize the individual value function. Since the preference structure each individual is known to the household planner – and the contract is known to both partners – the problem can be solved by backward iteration, with the household planner anticipating each spouse's individual optimization after receiving personal income allowance h_t^i.

The household planner's problem is as follows:

$$\begin{aligned} \max_{h_t^i, h_t^{-i}} \; & V^{i,1}(x_t^i, x_t^{-i}, \Lambda_t) + \Lambda_t V^{-i,1}(x_t^{-i}, x_t^{-i}, \Lambda_t) \\ s.t. \quad & h_t^i + h_t^{-i} = w_t^i + w_t^{-i} \end{aligned} \tag{3}$$

where individual value functions are determined by:

$$\begin{aligned} V^{f,1}(x_t^f, x_t^m, \Lambda_t) = & \max_{c_t^f, s_t^f} \; u^f(\nu(\Lambda_t) c_t^f) - \psi^f s_t^f \\ & + \beta(1-\varphi\rho^f)(1-\varphi\rho^m)\mathbb{E}[V^f(x_{t+1}^f, x_{t+1}^m, \Lambda_{t+1})] \\ & + \beta\varphi\rho^f(1-\varphi\rho^m)\mathbb{E}[max\{V^f(x_{t+1}^f, x_{t+1}^m, \Lambda_{t+1}), V^f(x_{t+1}^f, \hat{x}_{t+1}^m, \Lambda_{t+1})\}] \\ & + \beta(1-\varphi\rho^f)\varphi\rho^m\mathbb{E}[V^f(x_{t+1}^f, x_{t+1}^m, \Lambda_t')] \\ & + \beta\rho^f\rho^m\left(\frac{\mathbb{E}[max\{V^f(x_{t+1}^f, x_{t+1}^m, \Lambda_{t+1}), V^f(x_{t+1}^f, \hat{x}_{t+1}^m, \Lambda_{t+1})\}]}{2} + \frac{\mathbb{E}[V^f(x_{t+1}^f, x_{t+1}^m, \Lambda_t')]}{2}\right) \\ s.t. \quad & c_t^f \leq h_t^f \end{aligned}$$

where $\nu(.)$ gives economies of scale for marriage.[14] Expected value functions for the subsequent period $t+1$ are determined as follows. If neither partner matches then next period each can expect a value corresponding to the current marriage with shocks to either partner's income. Shocks realized this period may prompt a renegotiation next period, so $\Lambda_t \neq \Lambda_{t+1}$ in general. If i matches and the partner does not, i receives the maximum of the value of the current marriage and the value of the marriage formed by accepting the match.[15] If the partner matches but i does not, then i chooses between remaining in the current marriage with a renegotiated contract Λ' and becoming single, where Λ' is a) the current contract, if the partner's incentive compatability holds; or b) if the partner's incentive compatability is violated upon meeting the match, the contract that makes the partner indifferent between staying in the current marriage and accepting the match.

[14] The function $\nu(\Lambda)$ is maximized for $\Lambda = 1$ and is globally concave. This equivalence scale is explained further in Section 5.

[15] In the event that the current marriage is renegotiated succesfully, partner i will remain in the current marriage under a new contract that yields the same value as that of accepting the match.

Table 2: Summary Statistics, CEX 1994-2011

		women			men		
	Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Single	consm.	54839	7704	9306	39251	8332	9734
	hrs. worked	36109	1698	765	30656	1842	806
	income	21939	26084	26270	17981	32415	32886
Married	consm.	76707	3979	7401	76553	3979	7393
	hrs. worked	51975	1009	575	62063	1256	603
	income	31779	17477	20936	37044	29790	33439

To simplify computation I assume that two married partners cannot match simultaneously. This means that the probability of neither matching, or one or the other matching, saturates the probability space. Note that as the length of a time period becomes short the probability of spouses matching simultaneously approaches zero; since matching probabilities are small, this assumption is not restrictive.

4 Data

I test the predictions of the model on the 1994 to 2011 cycles of the Consumer Expenditure Survey (CEX) collected by the Bureau of Labor Statistics. This survey records detailed expenditure information on American households. Households are interviewed over five consecutive quarters. Every quarter demographic and labour supply data is collected, and beginning in the second quarter households are asked to report expenditures made during the previous quarter. Thus five quarters of demographic information and four quarters of expenditure information are available. From the former I calculate marital transitions, counting new marriages when the reference person goes from widowed, divorced, separated or never married in one quarter to married in the next, and counting divorces when the reference person goes from married to divorced, separated, or never married. The latter case happens infrequently and likely results from reporting errors or annulments.

Most previous studies using CEX data make use of the NBER extracts, wherein expenditure categories are aggregated and expenditures per quarter are summed into one year. Since I use the raw extracts I can observe disaggregated expenditure categories, and make use of the short panel aspect of the survey. Summary statistics are reported in Table 1.

5 Model Assumptions

Numerical estimation requires specifying a functional form for utility and matching functions. I make the following assumptions. Utility functions are identical across genders

and take the natural logarithmic form with separable disutility in search intensity. Utility is then given by:

$$u^g(c, e) = \ln(c + e) - \psi^g s \tag{4}$$

where ψ^g is the marginal disutility to search effort for an individual of gender g. The disutility to search effort is in utility terms, as in Pissarides (2000).

Define the probability of a viable match of type x^j as $\varrho(e, x^i, x^j)$ for an individual characterized by x^i. This probability necessarily depends on i's type, since j must endogenously choose to marry i. Assume that the search decision is binary, that is, $s \in 0, \bar{s}$, with $\bar{s} > 1$.[16] Conditional on searching, the probability of meeting a viable partner of type x^j is proportional to that type's frequency in the population. The probability of meeting a viable match of type x^j is then given by $\varrho(s, x^i, x^j) = I(s > 0)\rho(s, x^i)g(x^j)$, where $I(.)$ is the indicator function and $g(.) = m(.), f(.)$ is the probability density functions of men's or women's types.

In order to capture complementarity in wage types I introduce an equivalence scale following Voena (2012). This acts as a multiplier on utility for married households. In a given period a married individual receives utility according to the following process:

$$u^i(c, \Lambda) = ln[c\nu(\Lambda)] - \psi^i s$$

$$\nu(\Lambda) = \nu_0[\Lambda^{\nu_1} + (1 - \Lambda)^{\nu_1}]^{\frac{1}{\nu_1}}$$

where $\nu_0 \in \mathbb{R}+$ and $\nu_1 \in [-\infty, 1]$. The bracketed component decribes inequality preferences. When $\nu_1 = 1$, spouses have no aversion to inequality and the expression is equal to one. As ν_1 approaches $-\infty$ the expression converges to the minimum of $\{\Lambda_t, 1 - \Lambda_t\}$, giving each partner an extreme aversion to an unequal contract. The parameter ν_0 normalizes the inequality multiplier compared to the utility function for singles.

A time period in the simulation is treated as one year. Wage figures and estimates, as well as all expenditures, correspond to the total income earned over a representative quarter in that year. The discount rate is set to .98.

6 Estimation

I estimate the model using indirect inference. Numerical simulation yields a distribution of marital status and expenditure, whose moments are compared to those of the CEX. The parameters listed in Table 3 vary so as to minimize a weighted sum of the squared distance between moments generated by the model and those found in the data. The moments to match are:

- wage correlation between partners,
- correlation between a partner's income share in the household and share of consumption (men and women),

[16] Since disutility is determined by ψ^g, assume $\bar{s} = 1$ without loss of generality.

- the divorce hazard rate,
- the proportion of married agents,
- the one- five-year remarriage rates,
- mean and standard deviation of earnings by men/women under/over 40,

Since the CEX records spending at the household level, I approximate consmption share by the share of clothing expenditures allocated to either partner. This requires the assumption that clothing expenditure is monotonically increasing in total expenditure. This is consistent with the positive income elasticity of clothing expenditures shown in Table 2. Figure 2 plots married men's and women's clothing expenditures across the life cycle, along with total consumption. All series follow a similar trend, peaking gently in mid life.

The correlation of wages between partners demonstrates the effect of on-the-marriage search on positive assortative matching. Comparable theoretical frameworks are Mazzocco and Yamaguchi (2007) and Burdett and Coles (2001). Correlation between a partner's income share and consumption share in the marriage will reveal the extent to which on-the-marriage search affects division of marriage surplus. The one- and five-year remarriage rates are the primary moments of interest and to my knowledge are novel statistics to estimate in this class of models. Finally, the mean and standard deviation of wages at different ages provides a basis for the risk sharing of model agents to operate to a reasonable extent given real income distributions.

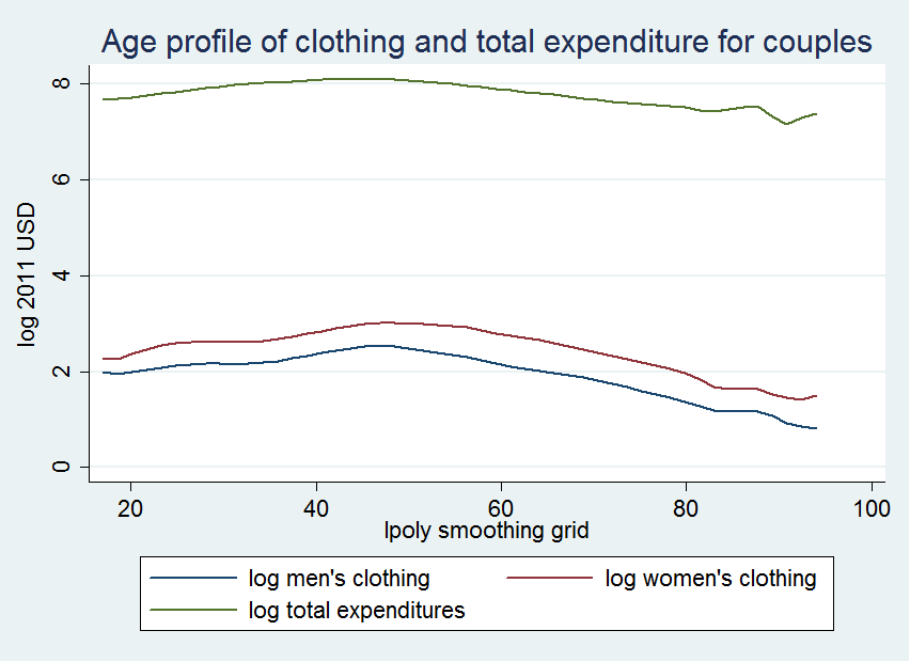
After simulation of the model economy yields a certain measure of distance from the moments of the CEX, a new set of parameters is chosen according to the Nelder-Mead method. This process continues until the moments of the simulation are sufficiently close to those of the data. This yields a final set of parameters whose plausability speak to the validity of the model.

The nature of the model economy is as follows. Unique individuals are born into the economy at age 18 and live until 100. At birth they are single, and are randomly assigned gender and wages so as to match the mean and standard deviation of the distributions of young earners found in the CEX. They proceed to choose search intensity, and which partner to marry. Once married, individuals continue to search for new potential partners with a search intensity that depends on the previous period's search decision.

An individual is fully characterized in period t by:

- $age_t \in \{18, ..., 100\}$,
- wage $w_t \in \{w^1, w^2, ..., w^W\}$,
- partner's wage $w'_t \in \{0, w^1, w^2, ..., w^W\}$,
- search intensity $s_{t-1} \in \{0, 1\}$,
- partner's search intensity $s'_{t-1} \in \{0, s^1, s^2, ..., s^S\}$ (with $s^1 \geq 0$ and $s^S < 1$),

Figure 2: Age profiles of clothing and total expenditure for couples



- and the marriage contract $\Lambda_t \in \{0, \Lambda^1, \Lambda^2, ..., \Lambda^N\}$ (with $\Lambda^1 > 0$ and $\Lambda^N < 1$). [17]

I make the standard assumption that married couples share the same age.[18] Grid sizes are set as $W = 12$, $S = 2$, and $N = 21$, with $w_t \in \{3400,5000,10500,14132,18108,23250,29375,38000,53639,72$ (corresponding to centiles in the CEX), $e \in \{0, 1\}$, and $\Lambda \in \{.01, .05, .1, ..., .95, .99\}$, following Mazzocco and Yamaguchi (2007).

Computational details of the model economy are as follows. First, conditional value functions are calculated for arbitrary agents. These are defined over the entire space of $\{age_t, w_t, w'_t, s_t, s'_t, \Lambda_t\}$. Conditional value functions return the value to an individual with given characteristics as a function of own search intensity s_t and partner's s'_t, which are choice variables in period t. These affect discounted future value through the matching process.[19]

Now income allocations are determined for arbitrary agents. Single agents receive their own wage income. For couples, the current marriage contract Λ_t has been determined in the previous period. The household planner takes pooled income $w_t + w'_t$ and allocates a fraction Λ_t to the man, with fraction $1 - Lambda_t$ given to the woman. This is consistent with the household planner's problem given by equation (4).

[17] For single individuals $w'_t = e'_{t-1} = \Lambda_t = 0$.

[18] See Mazzocco and Yamaguchi (2007).

[19] Note the omission of previous period's search intensity s_{t-1} and s'_{t-1}; these have been chosen optimally in the previous period given $\{age_{t-1}, w_{t-1}, w'_{t-1}, \Lambda_{t-1}\}$ and are uniquely determined by these variables.

At this point search intensity decision rules are determined. Hypothetical agents maximize the individual value function by choosing search intensity s. This is computed by evaluating the conditional value functions for each of $\{0, s^1, s^2, ..., s^S\}$ and picking the search intensity s that yields the maximum value.[20] Expected future value depends on the probability of meeting a willing match of a particular type, which is taken as given. The value function in period t is now realized, being composed of the utility derived from consumption and the expectation of next period's value function. The latter depends on the expected distribution of matched partners, which is a function of e.

Next, marriage, divorce, and renegotiation decision rules are calculated for arbitrary agents. Given a match with a partner with any wage, and given the wage of the current spouse (or lack of a current spouse), an agent chooses the maximum value of being single, staying married to the current spouse (which may require a renegotiation), and wedding the newly realized match.

Now that decision rules have been defined, the simulated individuals execute these decisions based on their randomly assigned characteristics. Potential marriage partners are randomly matched based on the endogenous distribution of searching individuals and marital decisions executed, determining the distribution of partners for the next iteration. New wages are assigned according to the following process.

Wages

Wages take one of the discrete values $w_t \in \{w^1, w^2, ..., w^W\}$. Each period wages update according to the process:

$$ln(w_{t+1}) = ln(w_t) + ln(\varepsilon_t)$$

where

$$\varepsilon \sim N(\mu, \sigma^2)$$

and

$$\mu = b_0 + b_1 age + b_2 age^2 + b_{man}.$$

The wage process is identical across genders except for the constant trend b_{man}. At age 66 individuals retire and cease to experience wage shocks. They continue to receive 70% of their retirement-age income until death at age 100.

Marriage and divorce

Individuals make a marriage decision before realizing their own or their partner's wage in the current period. This allows married partners to pool risk derived from wage uncertainty. The sequence of events described as follows is a specific implementation of the process described in Section 2. First, married individuals evaluate the current marriage, treating singlehood as the outside option. Three situations are possible:

[20] Since the decisions over $\{s_t, s_t'\}$ are made simultaneously there is the possibility of multiple equilibria. So far simulation has not yielded such a case; the rule when this occurs is to implement the planner's solution of no search intensity.

Table 3: Parameters

Parameter	Description
ψ^f	search cost for women
ψ^m	search cost for men
δ	rate of exogenous marriage death
ϕ	scaling parameter on match frequency
φ	probability a married agent can search
b_0	constant in AR(1) wage process
b_1	coef. on age in AR(1) wage process
b_2	coef. on age^2 in AR(1) wage process
b_{man}	male dummy in AR(1) wage process
σ	standard deviation of wage shock
ν_1	degree of aversion to unequal contracts
ν_0	multiplier on utility for married couples

- If both partners prefer to remain married rather than to become single, the current marriage persists under the current contract.
- If both partners prefer to divorce, there is no contract that can satisfy both. The marriage dissolves and both partners become single.
- If one partner prefers to divorce and the other does not, then the renegotiation process begins with singlehood as the outside option for either agent. Either the contract is successfully renegotiated and the marriage persists under the new contract, or renegotiation is unsuccessful and the partners divorce.

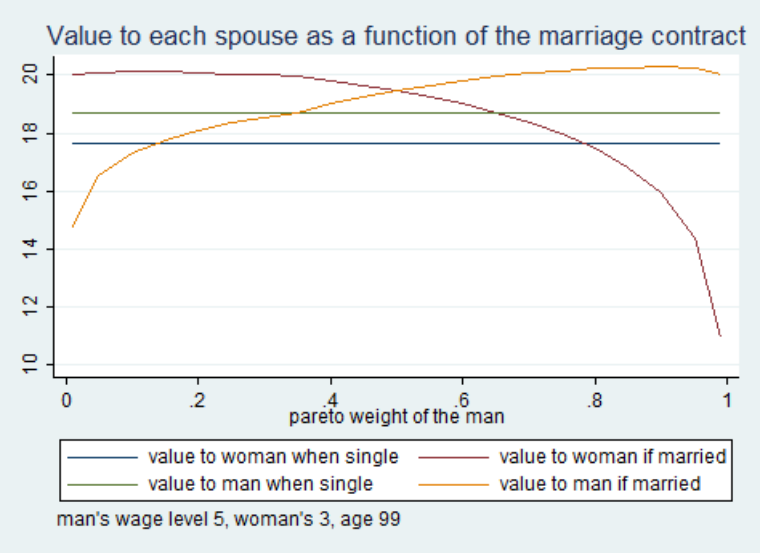
Now all agents are either married in a mutually acceptable union, or are single.

Next, matches are realized. In a given period an individual may or may not find a match. A match is defined as a willing partner of the same age; if individual i finds a match to be acceptable, then the two marry. Make the simplifying assumption that only one partner has a matching opportunity in a given period. This opportunity is assigned with equal probability to either partner, and its allocation is unknown when decisions are made. To make the matching process of singles consistent with couples, single agents have a one-half probability of matching in any period.

Parameters

Table 3 shows the paremeters estimated by the model. Couples endogenously choose to divorce, but to the extent that the model underpredicts divorce rates, the exogenous rate of marriage death δ will pick up the slack. The parameter ϕ scales the frequency of matching to vary the gains from search. This takes into account the probability that an individual has the opportunity to search, which is stochastically determined after search intensity has been decided. Married agents have an additional friction: the parameter φ

Figure 3: Value functions of a 99 year-old couple for different Pareto weights



scales the probability that married agents have the opportunity to search. In principle this can be higher or lower than one, depending on whether married agents are able to search more or less frequently; the parameter is always estimated at less than one. The parameters ψ^i, $i = m, f$ denote the marginal cost of search in terms of utility. The parameters b determine the wage process, and the equivalence scale is determined by the parameters ν_0 and ν_1.

7 Results

First I illustrate the marriage and search decisions. Figure 3 shows value functions for a hypothetical 99 year-old couple as functions of the marriage contract. The flat lines plot values to either spouse when single and so do not depend on the contract. Neither will accept a marriage contract that yields a value less than the value of being single; this determines the space of mutually acceptable contracts, in this case given by the interval $\lambda \in [.3, .6]$. Figures 4 and 5 show similar value functions plotted for couples of ages 50 and 25, respectively. Note that at younger ages, individuals face greater lifetime uncertainty and so a wider range of contracts are feasible.

Table 4 compares moments found in the data to those generated by the model. The targets are taken from the CEX, while model moments are calculated from a random sample of 3000 individuals from the simulated panel. These simulated moments result from parameter values given in Table 5, which generate output with the least weighted difference from data moments.

The main parameters of interest are the one- and five-year remarriage rates. The model estimates these accurately (particularly compared to an identical model without

Figure 4: Value functions of a 55 year-old couple for different Pareto weights

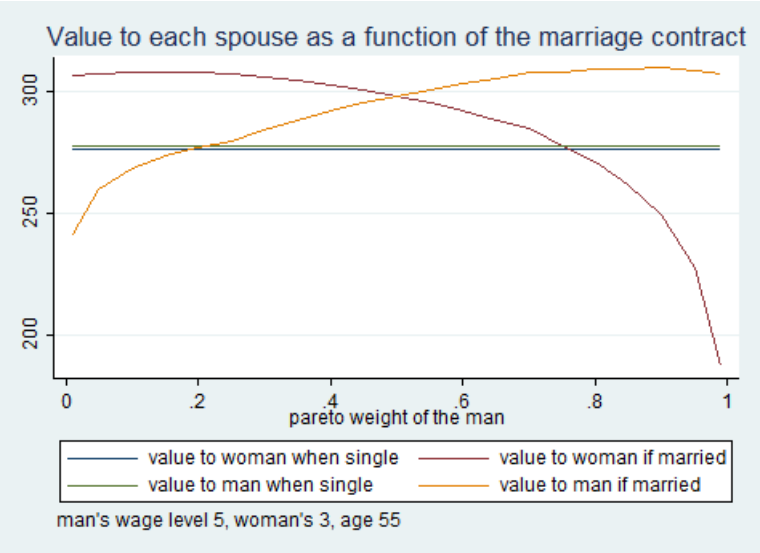
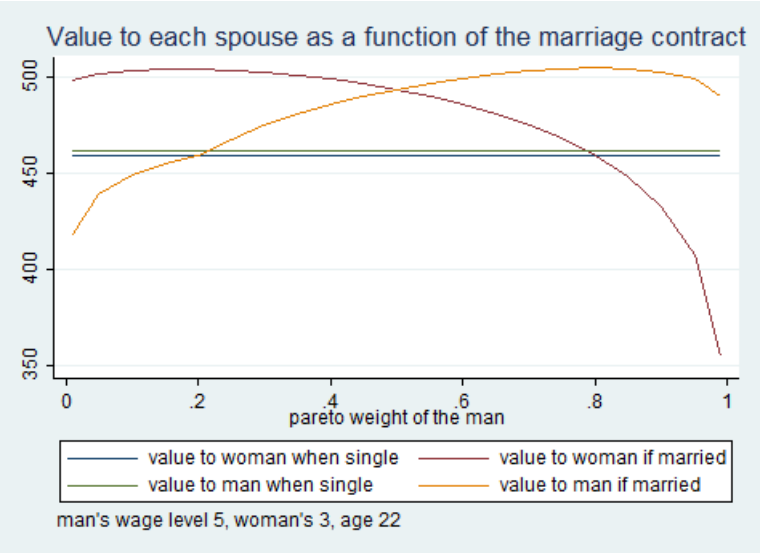


Figure 5: Value functions of a 22 year-old couple for different Pareto weights



on-the-marriage search, whose estimates are given in Table 6). The one-year unconditional marriage rate (not a targetted moment) is estimated at .067, around the same as in the NSFG data discussed in Section 2. The estimate of the one-year remarriage rate – the same statistic, with the sample restricted to recent divorcees – is four times greater. This is primarily because individuals who have succeeded in on-the-marriage search choose endogenously to divorce their current partner; i.e. they self select into the divorcee population.

The model overpredicts the divorce rate. Half of this overprediction is due to the exogenous marriage death rate δ. The proportion of married agents is slightly overpredicted. Adding a cost to divorce procedures would work to correct both this and the more significantly overpredicted divorce rate.

The model matches well the correlation of wages between partners due to the aversion to inequality represented by $\nu_1 < 1$. Without aversion to unequal partnerships ($\nu_1 = 1$), a married couple with significantly different wage levels can preserve their marriage by renegotiating to a very unequal contract. When $\nu_1 < 1$ this is less sustainable and wages of either partner become complements in generating the surplus to marriage. Besides the equivalence scale, the gains to marriage are also determined by risk sharing, which becomes more valuable the higher the degree of uncertainty over future wages. The estimated income shock parameters are relatively high, generating a surplus to any marriage, even unequal ones.

Correlation between income and consumption shares are overestimated by the model. Note that between men and women, the correlation differs in the data. In the model the zero-sum nature of income allocation – without the ability to save – yields identical correlations between genders. If married agents are able to hold separate savings accounts then these correlations need not be identical across genders.

Finally, wage levels are significantly underpredicted for earners younger than 40, and slightly overpredicted for those older, with estimates of the standards deviations following accordingly. Since the current formulation assumes inelastic supply of labour, wages will be underestimated to the extent that the absent market contribution of unemployed and out-of-labour force partners pushes down the average. This model shortcoming likely interacts with the gains to marriage indirectly through its effect on wage shocks. Alternatively, a richer wage process that allows stochastic shocks to vary by age and gender may yield more accurate wage predictions.

To demonstrate the contribution of this model, I run a simulation identical to the first except for the exclusion of on-the-marriage search (Model B), and compare this to the results of my preferred model with on-the-marriage search (Model A). Table 6 compares Model B's predictions compared to the data, and Table 7 gives the parameters generated by the simulated method of moments.

Non-marital moments are estimated at similar levels to those of Model A. Parameter estimates are nearly identical. The similarity shows that the model is working in a predictable way and validates the theoretical framework.

Model B significantly underpredicts remarriage rates. Whereas Model A generates remarriage rates slightly higher than those of the data, Model B's one-year and five

Table 4: Moment Targets and Estimates

Description	Target	Estimate
corr. partners' human wages	0.182	0.182
corr. inc. share to consm. share, women	0.075	0.322
corr. inc. share to consm. share, men	0.049	0.322
divorce hazard rate	0.008	0.0174
proportion of married agents	0.607	0.759
1 year remarriage rate	0.185	0.242
5 year remarriage rate	0.475	0.467
mean income below 40,women	\$12752	\$15623
stdev. of income below 40,women	\$15356	\$12851
mean income above 40,women	\$17542	\$22673
stdev. of income above 40,women	\$22565	\$19894
mean income below 40,men	\$17308	\$16034
stdev. of income below 40,men	\$19282	\$13288
mean income above 40,men	\$22349	\$25946
stdev. of income above 40,men	\$26912	\$22067

Table 5: Parameter Estimates

Estimate	Parameter	Description
0.012	ψ^f	search cost for women
0.0040	ψ^m	search cost for men
0.0046	δ	rate of exogenous marriage death
0.42	ϕ	scaling parameter on match frequency
0.21	φ	probability a married agent can search
1.0	b_0	constant in AR(1) wage process
0.0030	b_1	coef. on age in AR(1) wage process
-0.000026	b_2	coef. on age^2 in AR(1) wage process
0.020	b_{man}	male dummy in AR(1) wage process
.49	σ	standard deviation of wage shock
0.52	ν_1	degree of aversion to unequal contracts
0.91	ν_0	multiplier on utility for married couples

Table 6: Moment Targets and Estimates without On-the-marriage search

Description	Target	Estimate
corr. partners' human wages	0.182	0.178
corr. inc. share to consm. share, women	0.075	0.629
corr. inc. share to consm. share, men	0.049	0.629
divorce hazard rate	0.008	0.0464
proportion of married agents	0.607	0.483
1 year remarriage rate	0.185	0.0606
5 year remarriage rate	0.475	0.247
mean income below 40,women	\$12752	\$15294
stdev. of income below 40,women	\$15356	\$12620
mean income above 40,women	\$17542	\$21528
stdev. of income above 40,women	\$22565	\$19099
mean income below 40,men	\$17308	\$15553
stdev. of income below 40,men	\$19282	\$12923
mean income above 40,men	\$22349	\$22563
stdev. of income above 40,men	\$26912	\$19964

year remarriage rates are one-third and one-half, respectively, of those found in the data. Particularly striking is the fact that the one-year remarriage rate is more severely underestimated than the five-year. In Model B, the sample of newly divorced individuals is quite different from that of Model A, wherein individuals who have already found a new partner divorce their current spouse in favour of the new. In Model B new divorcees do not have this head-start, and may include disproportionately individuals who have received negative wage shocks.

To a first order the gains from marriage are lower to an individual who cannot continue to search, so it is natural that Model B should underpredict the share of married households.[21] Counterintuitively, the divorce rate is overpredicted by a factor of nearly six (whereas Model A overpredicted this statistic by a factor of two). The direct effect of introducing on-the-marriage search should make divorce more likely, since better outside options than singlehood can be readily found. On the other hand, a married individual in Model B who wants to search must first divorce in order to do so. It seems that the latter effect dominates. The fact that Model A predicts all marriage statistics better – including those that do not directly relate to remarriage – demonstrates that the introduction of on-the-marriage search improves the standard model's predictions of marriage dynamics.

Finally, I estimate the mean and standard deviation of lifetime consumption in either model. Table 8 shows that on-the-marriage search allows for better consumption insurance. This is related to the higher divorce rate in Model B, caused by the requirement

[21] Note that estimates of the parameters of the equivalance scale, ν_0 and ν_1, are similar across models. Their small divergence does not explain the difference in gains to marriage.

Table 7: Parameter Estimates without On-the-marriage search

Estimate	Parameter	Description
0.011	ψ^f	search cost for women
0.0030	ψ^m	search cost for men
0.0045	δ	rate of exogenous marriage death
0.45	ϕ	scaling parameter on match frequency
-	φ	probability a married agent can search
0.97	b_0	constant in AR(1) wage process
0.0049	b_1	coef. on age in AR(1) wage process
-0.000055	b_2	coef. on age^2 in AR(1) wage process
0.011	b_{man}	male dummy in AR(1) wage process
.45	σ	standard deviation of wage shock
0.74	ν_1	degree of aversion to unequal contracts
0.92	ν_0	multiplier on utility for married couples

Table 8: Comparison of Consumption

	mean	stdev.
Model A (with on-the-marriage search)	17851.62	12998.33
Model B (without on-the-marriage search)	15561.65	17044.36

that spouses separate in order to gain the option to search. Although Model A yields more frequent renegotiation, on-the-marriage search allows for less divorce and lower variation in consumption over the lifetime.

8 Conclusion

I have introduced search intensity and on-the-marriage search into the dynamic joint maximization framework of Mazzocco and Yamaguchi (2007) in order to explain high remarriage rates among recent divorcees. I show that the standard model without on-the-marriage search cannot match remarriage rates found in the data. This has welfare implications related to consumption smoothing over the lifetime. Given the prevalence of remarriage in the data, this takes us a step closer to understanding how marriage yields benefits to individuals over the life cycle.

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