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Incomes and Outcomes: The Dynamic Interaction of The Marriage Market and The Labor Market

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Incomes and Outcomes: The Dynamic Interaction of The Marriage Market and The Labor Market

by

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Dedicated to my parents Fang and Jian.

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Incomes and Outcomes: The Dynamic Interaction of The Marriage Market and The Labor Market

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In this thesis we study the interdependency of individual decisions on work and family, particularly the dynamic interaction of the marriage market and the labor market. My basic idea is that marital status affects individual labor supply decisions, and in turn, labor market condition influences marriage formation and dissolution. While these interactions are evident, the overwhelming majority of research on labor or family economics usually simplifies the individual decision-making by assuming that one of two markets outcomes is given while studying the other one. In the empirical study, endogeneity issues are troublesome, especially under the dynamic setting.

My work takes a different approach. I directly model the individual decision-making, which describes how marriage market and labor market interact with each other; and matching with survey data we empirically recover the underlying economic environments that characterize the structure of the marriage market and the labor market. I further examine to what extent my model explains the observed facts. Very few studies have been conducted to explore work and family issues in this direction partly due to its complexity. The structural models, besides the conventional regression, improve our perceptions on how individuals form decisions on work and family,

which have far-reaching implications on policy designs and welfare evaluations. In my thesis, I explore all these issues in three steps.

In chapter 1, I explains a stylized fact that there exists a positive correlation between rising wage inequality and declining marriage rates. A two-sided matching model is developed to exploit a theoretical channel through which wage inequality affects marriage rates. My model features a steady state equilibrium in which the whole marriage market is divided into groups and only people in the same group will marry each other. Using the Integrated Public Use Microdata Series (IPUMS) data from 1970 to 2000, my estimates indicate that a structural change occurs in the U.S. marriage market. The higher matching efficiency and declining elasticity of men suggest that the nowadays marriage market provides more chance to meet and better gender equity, though higher arrival rates also raise the outside options of getting married. Additionally, I find that wage inequality accounts for over 38% of the decline in marriage rate, which is underestimated in Gould (2003).

Chapter 2 examines household dynamic labor supply after introducing bargaining between husbands and wives, which has not been thoroughly studied previously in literature. Here bargaining between husbands and wives determines the amount of husbands' earnings that are transferred to wives for their private consumption. A household search model that incorporates the intrahousehold bargaining is developed and estimated using panel data from the year 2001 Survey of Income and Program Participation (SIPP). My results show that the portion of household income shared by husbands for private consumption is responsive to their employment status, suggesting the existence of the bargaining between the U.S. couples. My findings also imply that the labor supply of women will increase with higher women wage and lower money transfer from husbands to wives, showing that the income effect dominates for wives. Moreover, the wage frontier of husbands is positively correlated with wives' wages and negatively correlated with husbands' earnings transferred to wives,

highlighting that husbands are subject to both the income effect and intra-household bargaining, and their decisions depend on which effect dominates.

In the third and the last chapter, I study household unemployment duration. Previously, most studies have addressed the topic of job search at the individual level. This chapter studies job search patterns of married couples and in particular compares couple's unemployment duration given their spousal earnings. A household search model is introduced, which includes the bargaining between husbands and wives. I use the year 2001 panel data Survey of Income and Program Participation (SIPP) to estimate the structural model of family decisions. Our findings reveal that there exists a gender asymmetry in job search of the U.S. household: The more husbands earn, the longer wives search for a job; but the more wives earn, the sooner husbands find a job.

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Chapter 1

Money and Marriage: Implications of Wage Inequality on Marriage Outcomes

1.1 Introduction

Increasing wage inequality and declining marriage rate are well observed within U.S. in the past decades. Recent studies by Bergstrom and Schoeni (1996), Bergstrom and Bagnoli (1993), Blau, Kahn and Waldfogel (2000), Burdett and Coles (1999) have drawn our attention to the connection between the labor market performance and individual marital decisions.

Fernández, Guner and Knowles (2005), Fernndez and Rogerson (2001) both mentioned the connection of sorting with inequality. Greenwood, Guner, and Knowles (2003), Hewitt, Western, and Baxter (2002) discussed the relationship between marriage and income distribution, and their emphasis were on how marriage affects income distribution. However, the relationship between wage inequality and marriage is comparatively less studied.

Loughran (2002) empirically estimates found that increasing within-group male wage inequality, raises the expected value of continued marital search, and so lowers female marriage propensities. Gould and Parserman (2003) further showed that there exists a causal link between increasing wage inequality and declining marriage rates, and increasing male inequality amounts to around 30% of the decline in female marriage rate, after controlling for city effects and city-specific time trends.

Our question is, how does wage inequality affect marriage outcomes? Further, empirically how much of the decline in marriage rates is accounted for by increasing wage inequality?

The two goals of this chapter are (1) to theoretically study how wage inequality affects marriage decisions , and (2) to empirically estimate the implication of wage inequality on marriage outcomes. Note that the difficulty in empirical study lies in that declining marriage rates are accompanied with increasing wage inequality across time. It is not straightforward to identify the time trend of marriage market from other time trends. So in the second part of this chapter we recover the efficiency and elasticity of matching function that characterize the economic environments of marriage market across time.

Part 1: Theoretical contribution

To answer the first question, we study the interdependency between wage earnings and marriage formation in a stationary equilibrium. A two-sided matching model is employed. This work is the first to build up a structural model to link marriage outcomes with labor market performance such as wage inequality. It also provides a theoretical support of how marriage choice is made conditional on the level of wage inequality. This model features a steady state equilibrium in which the whole marriage market is divided into distinct classes and individuals are grouped by class: people not only choose whom to marry, but also are pre-determined whom they are able to meet with by their characteristics, for example, wage rates. Individuals search for partners by class, since only those in the same class meet each other and get married.

Wage inequality, under this setting, affects marriage decisions. We take wage as an approximation of individual characteristics, so its inequality represents the pool distribution of potential partners. Wage inequality therefore influences the formation of classes and the individual reservation values of getting married. For example, a mean-preserving spread of wage distribution raises the portion of population falling above the former reservation value of the middle class, so in equilibrium pushes their reservation values up. Higher reservation value will lead to the delay in marriage. Our theory predicts that increasing wage inequality generates more classes in the marriage market with smaller sizes, and then changes the population falling in each class. So even without the changes in reservation values, the disproportional single population of men and women in each class will cause the mismatch.

We adopt the matching function in the form of super-modularity to guarantee the positive assortative matching as in Shimer and Smith(2000). Class defined in this chapter is the population falling between a unique set of wage brackets. All the distinct classes together cover the whole marriage market. The lower bound of each class is the reservation value so that people propose only if the candidates are above their reservation values. The upper bound portrays the best partner candidates that are willing to accept those people in each class. The upper bound is endogenously generated. In the steady state, once the reservation functions are derived from equilibrium, marriage rates as outcomes of aggregate marital choices are determined. With numerical simulation and analysis our model have two predictions on marriage outcomes.

First, the effect of structural change of the U.S. marriage market is bi-directional: higher arrival rates for both genders provide more opportunity to meet and increase probability of being married; meanwhile, higher arrival rates raise the outside option of getting married. Since people are more selective, rising outside options will lower marriage rates. The outcomes of the two-directional effects are mixed and depend on which effect dominates.

Second, as to the effect of wage inequality on marriage rate, our simulation shows that (a) wage inequality generates more classes within marriage market and itself will lead to the delay in marriage. When inequalities of both genders do not grow in the same pace, it leads to the mismatch in marriage market, and lowers marriage rates since in two-sided matching, either side could deny and wait; (b) marriage is likely to be delayed by the above median to high-earning women in the current marriage market. They tend to be more selective and prefer waiting longer to marrying below their economic strata.

Part 2: Empirical Implementation

To empirically estimate the implication of wage inequality, we have to isolate wage inequality from structural change of marriage market at MSA level. The available survey data provide insufficient information to identify and quantify the change of marriage market structure since this change is hard to observe and measure.

The advantage of our model is, by matching data from year 1970, 1980, 1990 and 2000 1% public-use micro-sample of the U.S Decennial Census (IPUMS), we recover the parameters of market structure by decade. Therefore, the time trend of marriage market is replicable at the MSA level. In particular, we look at two key parameters of the matching function – matching efficiency and elasticity of men. With the recovered environments, we are able to decompose the decline of marriage rate.

Our decomposition reveals that, wage inequality amounts to more than 38% of the decline of marriage rate. This effect was underestimated in Gould (2002), since the effect of MSA-specific matching efficiency is not isolated.

Our main empirical findings of the recovered market structure are as followed. Higher matching efficiency suggests that marriage market is getting more efficient across decades, and the declining elasticity of men over women portrays nowadays a more equal market for women. The two trends of rising mating efficiency and increasing favor-women elasticity are rarely discussed or empirically tested in literature. We view these trends as the outcomes of more women receiving higher education, more women participating in labor force and the improvement of gender equity. These two benefits, however, are eclipsed by their side effect of raising the outside option of both genders as well as rising wage inequality. The observed correlation between wage inequality and single ratios is the outcomes of two-directional forces.

Additionally, we test the hypothesis that the sum of elasticity of men and women equals one. The test indicates that the null hypothesis is not rejected, which justifies our assumption of constant return of elasticity in estimating model.

The reminder of this chapter proceeds as follows. In section 2, a two-sided matching model is constructed to capture the formation of marriage, and the existence of equilibrium is proved. Numerical analysis is made of equilibrium properties with simulation methods in section 3. In section 4, we describe the IPUMS data and empirical estimation is displayed. Section 5 presents the implication of estimated results. Finally, we make conclusion in section 6.

1.2 Two-Sided Matching Model

In this section, we formulate a structural model of how marriage is formed under bilateral agreement. Then we impose conditions that guarantee the existence of a steady state equilibrium, and the properties of equilibrium are then presented. The positive assortative mating and two-sided matching induce a steady state equilibrium in which multiple classes coexist and people marry by class.

1.2.1 Model

Environment In our economy, time is discrete and discounted at the rate β. Two types of agents – men m and women w – are infinite lived. Assume that agents are ex ante heterogeneous and characterized in two dimensions: their economic strata, which is approximated by their wage w, and marital status as either married m or single s. Only single people are actively searching for partners.

Preferences Assume that traits of individuals are described by their wages. The singles have utility $u(w) = w$, where $u(\cdot)$ is the utility function and w is the wage level. Married people have $u(w, w') = \frac{ww\prime}{2}$ where men with wage w marry women with w'. Becker (1973, 1974) indicated that empirical evidence shows a positive correlation between the traits of partners, which is termed as positive assortative mating. As noted in Shimer and Smith(2000), Lu and Macfee(1996), this simple assumption on utility form guarantees mating is positive assortative, so agents in this economy are always motivated to match with higher-type ones.

Labor Market Labor market is simplified and individuals are characterized by wages. Each individual here is offered with wage w that is randomly drawn from a log-normal distribution. In the steady state equilibrium, the individual wage distribution remains unchanged. So in the decentralized marriage market, assume that their employment conditions are unchanged and theb the singles have their expectation that to whom they should propose by maximizing utility.

Information The values of two potential partners $\{w_m, w_w\}$ are instantly observed on contact for men with wage w_m and women with w_w, respectively.

Market Structure In the marriage market, singles of opposite sex have the opportunity to contact, and then decide to propose or not. If both sides propose, they will get married and leave the market; otherwise, the singles continue searching for partners. To whom they propose if meet depends on how quickly singles are contacted, how soon marriage dissolves and their expectations of who would propose to them.

Thus marriage market is characterized by offer arrival rates of both genders λ and divorce rate δ. And offer arrival rates and divorce rates are assumed to be exogenous. Offer arrival rates of potential partners $\{\lambda_k, k = m\, w\}$ may differ by gender, and both follow a Poisson process. Marriage dissolves once a divorce shock hits with a rate δ.

Value functions $\{V_k(w), k = m,\ w\}$ denotes the value function for single men or women with wage w. And $W(w,\ w')$ is defined as value function for those married men with wage w and women with w'.

Singles meet each other every now and then. Based on the observed values $\{w,\ w'\}$ both decide to propose or not upon contact. Let $\Delta_{w,w'}$ be the decision rule of whether women with wage w' would like to accept men with wage w, so women with wage w' will only marry those with wage more than $R_w(w')$. The acceptance set of men with wage w is defined as $A_m(w)$ and acceptance set of women with wage w is similarly defined as $A_w(w')$.

$$\Delta_{w,w'} = \begin{cases} 1, & \textit{if } w \in A_w(w') = [R_w(w'), \bar{w}_m]; \\ 0, & \textit{otherwise.} \end{cases}$$

where the reservation set $A_w(w')$ is defined below.

$$\begin{aligned} A_w(w') &= \{w \in Y \mid W(w, w') \geq V_w(w')\} \\ &= \{w \mid w \geq R_w(w')\} \end{aligned}$$

Y denotes the supporting set of potential partners available for men with w. $R_m(w)$ is the reservation value for single men with w and $R_w(w')$ for women with w'. Let $f_m(w)$ and $f_w(w')$ be the wage density functions for men and women, respectively.

For the singles, we discuss the three possible outcomes during the process of search.

- If both meet and propose, which occurs with probability $\lambda_m \int_{R_m}^{\overline{w}'} f_w(w')\Delta_{w,w'}dw'$, then marriage is formed and they left the market with value function $W(w, w')$.
- If both meet but at least one side disagree, with probability $\lambda_m \int_{R_m}^{\overline{w}'} f_w(w')(1 - \Delta_{w,w'})dw' + \int_{\underline{w}'}^{R_m} f_w(w')dw'$, they remain single with value function $V_m(w)$ and $V_f(w')$.
- If no meet occurs, they have to wait another period and remain single.

Then the value function of being single satisfies the below equation.

$$\begin{aligned} V_m(w) \quad = \quad & w + \beta\lambda_m\{\int_{R_m}^{\overline{w}'} W(w,w')f_w(w')\Delta_{w,w'}dw' \\ & + \int_{R_m}^{\overline{w}'} V_m(w)f_w(w')(1-\Delta_{w,w'})dw' \\ & + \int_{\underline{w}'}^{R_m} V_m(w)f_w(w')dw'\} + \beta(1-\lambda_m)V_m(w) \end{aligned}$$

For those married, they stay married until divorce shock strikes.

$$W(w,w') = ww'/2 + \beta\{(1-\delta)W(w,w') + \delta V_m(w)\}$$

After transforming the above equations, the value of being single is

$$V_m(w) = \frac{w + \beta\lambda_m \int_{R_m}^{\bar{w}'} W(w,w')f_w(w')\Delta_{w,w'}dw'}{1-\beta+\beta\lambda_m \int_{R_m}^{\bar{w}'} f_w(w')\Delta_{w,w'}dw'} \tag{1.1}$$

And the value function of men being married to women with w' is

$$W(w,w') = \frac{ww'/2 + \beta\delta V_m(w)}{1-\beta(1-\delta)} \tag{1.2}$$

Optimal policy By definition of reservation value, men with wage w would like to propose for women with $w' \geq R_m(w)$. Similarly, women with wage w' would like to propose if men with $w \geq R_w(w')$.

Given that the steady state equilibrium exists (we will prove this in the next section, and actually the equilibrium is unique under some given conditions), every man has a reservation wage that $W(w,R_m) = V_m(w)$ and every woman has $W(w,R_m) = V_m(w)$. In equilibrium, optimal policy of singles is partitioning the whole population into classes by their wages. Each individual with wage w falls in some specific class denoted by $[R_i(w), M_i(w)], i = m, w$ where $R_i(\cdot)$ denotes the reservation value, and $M_i(\cdot)$ denotes the best candidates they can obtain and it is endogenously generated by the reservation values of the whole population.

From the reservation policy, $W(w,R_m) = V_m(w)$, the reservation value for men with wage w is derived in Appendix A and is displayed as below.

$$R_m(w) = 2 + \frac{\beta\lambda_m}{1-\beta(1-\delta)} \int_{R_m}^{\bar{w}'} (w'-R_m)f_w(w')\Delta_{w,w'}dw' \tag{1.3}$$

By symmetry, the policy function of women with w' is,

$$R_w(w') = 2 + \frac{\beta\lambda_w}{1-\beta(1-\delta)} \int_{R_w}^{\bar{w}_m} (w - R_w) f_m(w) \Delta_{w,w'} dw \tag{1.4}$$

1.2.2 Existence of Equilibrium and Its Properties

In this section, we prove in detail the existence of equilibrium, which is defined as classes under the given conditions. And then we characterize it.

(NE) The Nash equilibrium is defined by a set of response functions $R_m(\cdot)$ for men and $R_w(\cdot)$ for women in the marriage market. The reservation functions give the cut-off rules of marriage decisions and they also satisfy the equations (1.3) and (1.4).

(SSE) The steady state equilibrium is a Nash equilibrium (NE) as above that has a balanced flow, meaning that the population that gets married and exits the marriage market equals those getting divorce and re-entering the market.

Given the definition of equilibrium, we start with studying the Nash equilibrium.

Proposition 1. (Existence of Optimal Policy for Men)

Assume that men have their value function satisfying $W(w, \underline{w}_w) \leq V_m(w)$ and $W(w, \bar{w}_w) \geq V_m(p)$ for any wage w, where the close set $[\underline{w}_w, \bar{w}_w]$ gives the bounds of women's wage, then there exists an unique set of response function $R_m(\cdot)$, as a mapping from men's wages to their reservation values, assuring that $W(w, R_m) = V_m(w)$.

Proof. See the appendix C. □

Similarly, we have for women the proposition of existence of optimal policy as below.

Proposition 2. (Existence of Optimal Policy for Women)

Assume that women have their value function satisfying $W(\underline{w}_m, w') \leq V_w(w')$ and $W(\bar{w}_m, w') \geq V_w(w')$ for any wage w', where the close set $[\underline{w}_m, \bar{w}_m]$ gives the bounds of men's wage, then there exists an unique set of response function $R_w(\cdot)$, as a mapping from women' wages to their reservation values, assuring that $W(R_w, w') = V_w(w')$.

Based on the existence of policy function for both men and women R_m and R_w, we next examine its properties and then the characteristics of equilibrium. Before that we set up one basic assumption.

Assumption 1 The best men and women are desirable, so the rest of population are always willing to propose to them, that is, $\forall w, \Delta_{w,\bar{w}_w} = 1$ and $\forall w', \Delta_{\bar{w}_m,w'} = 1$.

Proposition 3. (Formation of The First Class)

Given assumption 1 that the best wo/men can always get proposal from opposite sex, there exists a unique set of critical wages $\{R_m^1, R_w^1\}$ so that

- Any men falling in $[R_w^1, \bar{w}_m]$ are willing to propose to women in the set of $[R_m^1, \bar{w}_w]$.
- Any women falling in $[R_m^1, \bar{w}_w]$ are willing to propose to men in the set of $[R_w^1, \bar{w}_m]$.

where R_m^1 is defined as the reservation value of the best men and R_w^1 is of the best women. So the men with $w \in [R_w^1, \bar{w}_m]$ and women with $w' \in [R_m^1, \bar{w}_w]$ form a class of people who are willing to accept each other and get married. Since the upper bounds lie in the best men and women, we name this group of men and women the first class.

Proof. See the appendix C. □

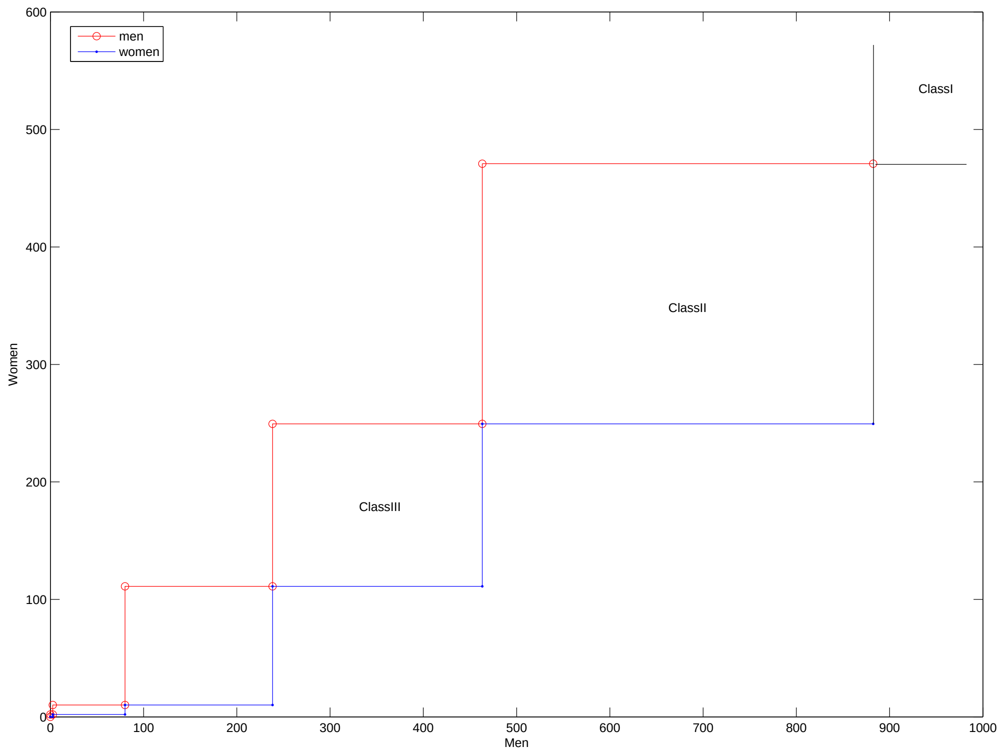

Figure 1.1: Partition of Classes in Marriage Market – Reservation Functions of Both Genders. The x axis gives the reservation value of men and y axis is of women. There are 5 classes displayed as Class I, Class II, Class III and so on. Only men and women in the same class marry each other.

Proposition 4. (The whole market is divided into n classes.)

The population in marriage market partition themselves into classes. Let $[\underline{w}_m, \bar{w}_m]$ be the bounds for men and $[\underline{w}_w, \bar{w}_w]$ for women. The n partition is represented by $[\underline{w}_m = R_m^{n_m}, R_m^{n_m-1}, ..., R_m^1, R_m^0 = \bar{w}_m]$ for men, and $[\underline{w}_w = R_w^{n_w}, R_w^{n_w-1}, ..., R_w^1, R_w^0 = \bar{w}_m]$ for women, and $n = min\{n_m, n_w\}$, where n_m is the number of partition for men and n_w is for women .

- Class 1 is defined as $[R_w^1, R_w^0 = \bar{w}_m] \times [R_m^1, R_m^0 = \bar{w}_w]$.
- Class k is defined as $[R_w^k, R_w^{k-1}] \times [R_m^k, R_m^{k-1}]$, $\forall k \in \{1, 2, ..., n = min\{n_m, n_w\}\}$.
- In a steady state equilibrium, men in class k only marry women in class k.
- $\delta_n = n_m - n_w \in \{-1, 0, 1\}$. $\delta_n = 0$ means in economy there exists n classes – steady state equilibrium. If $\delta_n = -1$ or 1, one gender has one more class than the other. Then those in $n+1$ class can not be matched and never get married.

Proof. See the appendix C. □

This proposition provides the algorithm to compute the reservation functions for Nash equilibrium. It also gives the existence of a unique set of optimal policy function.

Corollary 5. (Existence of Nash Equilibrium)

There exists a unique Nash equilibrium (NE). All the population are divided into distinct classes and people marry by class. The reservation function is illustrated as in figure 1.1.

So in our model, there exist one and only one Nash equilibrium that satisfies the equations (1.3) and (1.4). And the algorithm to obtain the reservation functions are presented in appendix B.

Next, we give the conditions that guarantee the balanced flow – steady state equilibrium (SSE). Let γ_{mn} denote the proportion of men in class n, which is defined in Nash equilibrium.

Proposition 6. (Special Conditions that Guarantee the Existence of SSE)

Given the distribution for both genders is log concave, then for any class $n > 0$, a unique partition $(\{R_m(\cdot), \gamma_{mn}\}, \{R_w(\cdot), \gamma_{wn}\})$ exists that guarantees a balanced flow and satisfies equations (1.3) and (1.4) and the boundary conditions that (a) best men in class 1 have $\bar{w_m}$, (b)best women in class 1 have $\bar{w_w}$, (c)$R_m(\underline{w_m}) \leq \underline{w_m}$ and (d)$R_w(\underline{w_w}) \leq \underline{w_w}$.

Proof. See the appendix C. □

The log- concavity of survivor function implies that given the current setting, there exists a unique steady state that is the nash equilibrium and also balances the population inflow and outflow of the marriage market. At last we describe the general properties of steady state equilibrium as below.

Lemma 7. (Property of Equilibrium (I))

- $R_m(\cdot)$ is non-decreasing in w.
- $V_m(\cdot)$ is increasing in w.
- $W(\cdot, w')$ is increasing in w.

Lemma 8. (Property of Equilibrium (II))

From equation (1.3) and (1.4), $\{R_m(\cdot), R_w(\cdot)\}$ depends on

- λ – how soon people meet their potential partners
- $f(\cdot)$ – wage distribution of both genders.

1.3 Simulation: What Affects Marriage Outcomes?

Our model generates a steady state equilibrium, which hold as in Burdett and Coles (1997). The reservation functions, as claim in Lemma 8, depend on both the arrival rates – how soon potential partners meet each other – and their wage distribution. Marriage rates the aggregate outcomes of individual marital choices depend on reservation functions and therefore are also determined by arrival rates and wage offer. In this section, we simulate by numerical methods and illustrate the effect of arrival rates and wage inequality on marriage outcomes.

1.3.1 The Effect of Arrival Rate on Marriage Rate

We set constants at the MSA level as in table 1.1. Time discount factor is .99 and divorce rate is at .002. Then following the algorithm describe in appendix B, we will obtain the moments of the single ratios for both genders.

Table 1.1: Constants

Const	Value
Time Discount Factor β	.99
Divorce Rate δ	.002
Sex Ratio r	.49
Mean of Male Hourly Wage σ^m	15.36
Mean of Female Hourly Wage σ^w	9.50
Std. Err of Male Hourly Wage σ^m	8.98
Std. Err of Female Hourly Wage σ^w	6.17

Constants are at MSA level in 1970 for the white men aged from 21-40 and women from 21-35 at year 1990 dollar value.

Sex ratio is the fraction of male in the whole population.

Figure 1.2 shows the effect of arrival rates on female single rate. On average, the higher male arrival rate, the higher female arrival rate, the higher single rate. But when male arrival rate is extremely high, for example .7, and female arrival rate is extremely low, less than .2, then this effect is now reversed. Meanwhile, we have the similar single ratio for men. In figure 1.3 we display a 3-dimension surface plot

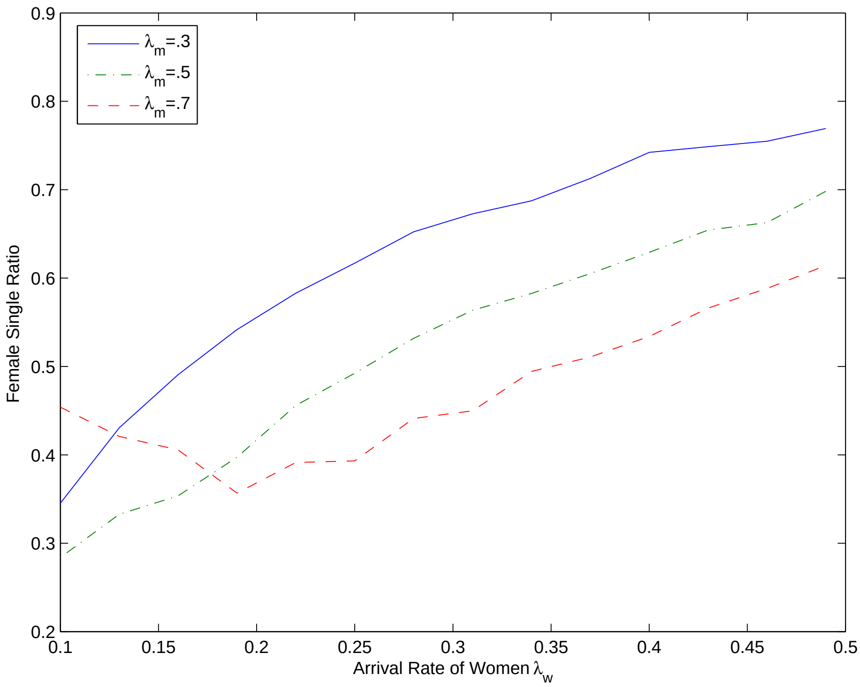

Figure 1.2: Effect of Female Arrival Rate on Female Single Ration Given Male Arrival Rate. The X axis gives the arrival rate of women. The Y axis is the single ratio of the women population. Male Arrival Rates are given at .3, .5 and .7 respectively.

of female single ratio given the arrival rates of men and women. In the low end of arrival rates, when fixing male (female) arrival rate, rising female (male) arrival rate increases female single ratio. When both arrival rate vary, however, the outcome of female single ratio could be mixed.

1.3.2 The Effect of Wage Inequality on Marriage Rate

This subsection makes simple simulations to illustrates the effect of increasing male wage inequality on female marriage choices. We simulate aggregate marriage rate via the process of marriage formation.

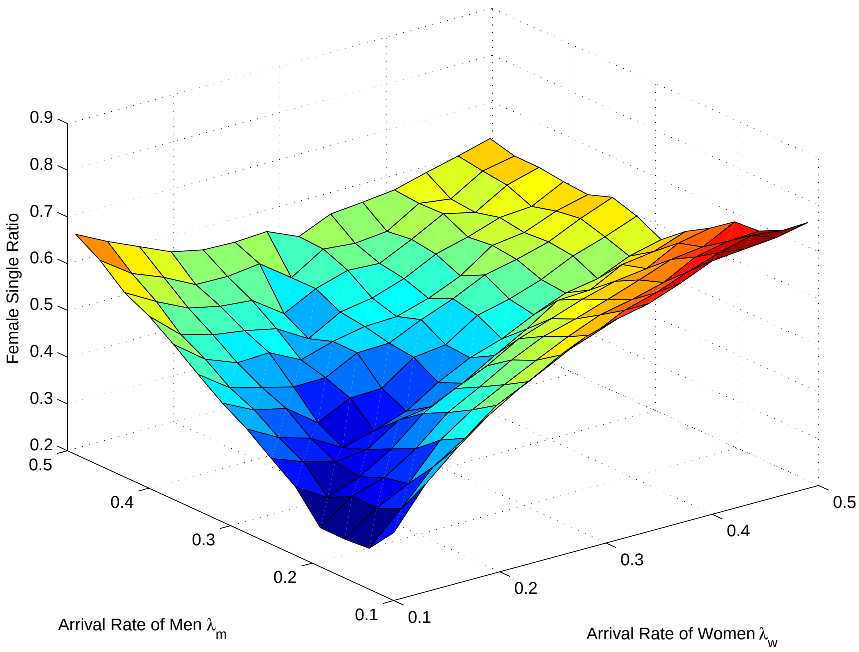

Figure 1.3: 3-Dimension Surface Plot of Female Single Ratio Given Arrival Rates of Men and Women. The X axis gives the arrival rate of women. The Y axis gives the arrival rate of men and the Z axis is the single ratio of the women population.

Table 1.2: Parameters for Simulation

Parameter	Value
Arrival Rate of Men λ_m	.3
Arrival Rate of Women λ_w	.3

Number of Simulation: 10000.

1.3.2.1 Increase in male wage inequality induces the emerging classes in marriage market.

Given the same set of parameters as in table 1.1 and 1.2, we simulate a marriage market with the pool of single men and women with log-normal wage distribution shown in figure 1.4, where the upper row gives the simulated wage distribution for both men and women. The lower row is the reservation function of marriage choice from equilibrium. Figure 1.5 gives the female single ratio as a function of wage

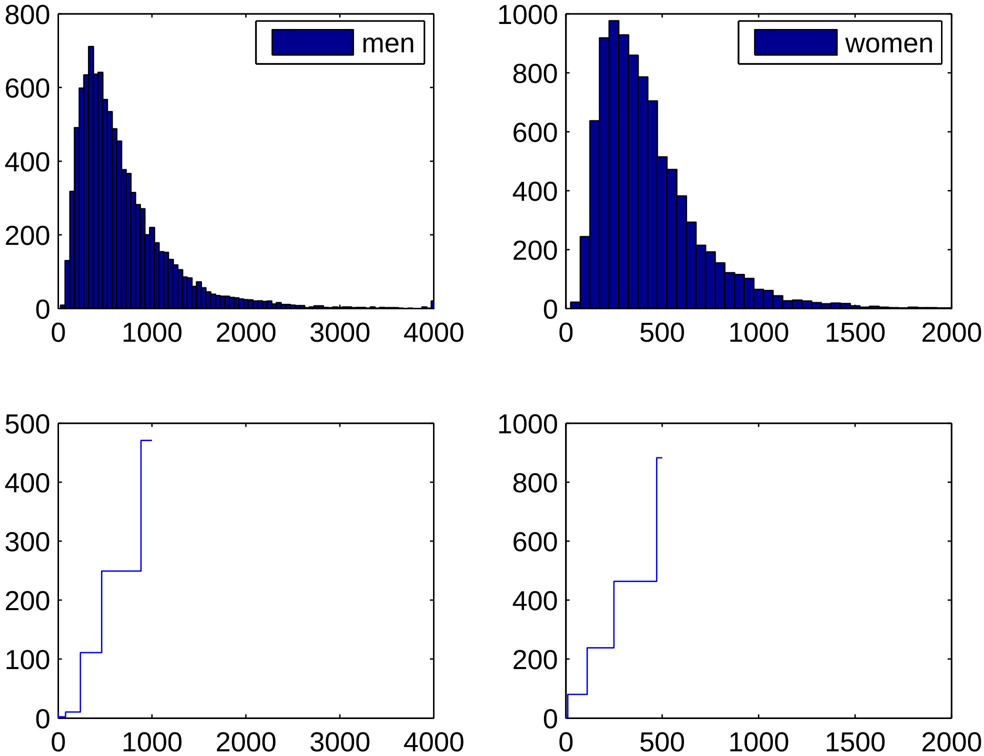

Figure 1.4: Simulated Data at Individual Level. The upper row gives the simulated wage distribution for both men and women. The lower row is the reservation function of marriage choice from equilibrium.

inequality in two separate cases.

- If only male wage inequality rises but female inequality is fixed at the current level (in table 1.1), female single ratio rises to 60% from the recorded 25%.

- If both inequalities rise at the same pace, the former increasing trend vanishes: the female single ratio flats out, staying around 30%.

This observed difference reveals that, wage inequality leads to the mismatch in marriage market only if men and women are driven by asymmetric change in wage distribution. Otherwise – if both reservation value of men and women moves in the same direction from equilibrium – this mismatch effect offsets each other, and none or little mismatch could be observed.

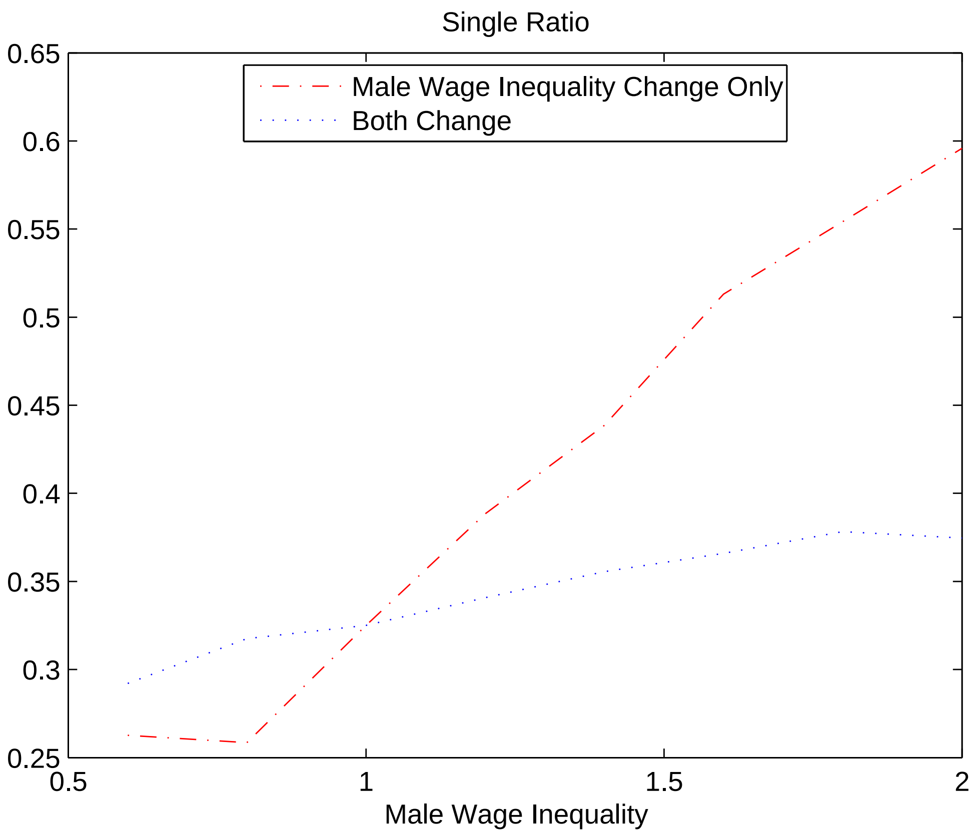

Figure 1.5: Response Simulation: The Effect of Male Wage Inequality on Female Single Ratio.

This mismatch effect caused by gender asymmetry in wage inequality is further interpreted in figure 1.6, where the x axis gives male wage inequality, the y axis gives female wage inequality in form of standard deviation of hourly wage, and the z axis stands for the female single ratio in unit of percentage. When female wage inequality is fixed, raising male wage inequality could increase or decrease female single ratio, depending on at which level inequality is. However, when male and female wage inequality move in the same direction, we observe less increase in female single ratio due to the less mismatch.

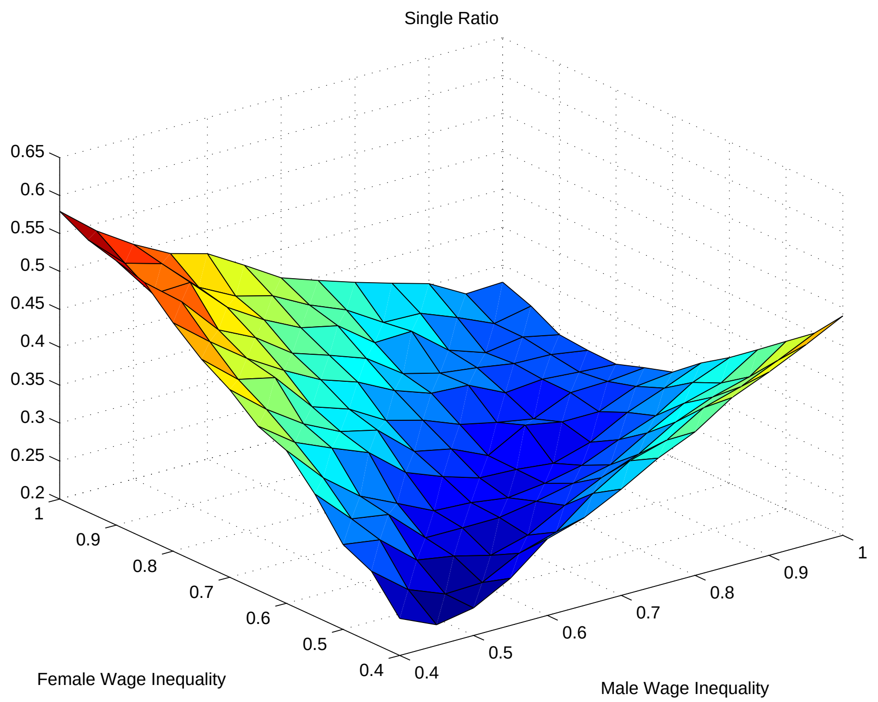

Figure 1.6: Response Simulation: The Effect of Changing Male and Female Wage Inequality on Female Single Ratio. The x axis gives male wage inequality, the y axis gives female wage inequality in form of standard deviation of hourly wage, and the z axis stands for the female single ratio in unit of percentage.

Figure 1.7 shows the class partition as a function of male wage inequality. In the 3-dimension figure, the x axis gives the categories of the classes ranging from 1 to 7, the y axis displays male wage inequality in form of standard deviation of hourly wage, and the z axis stands for the frequency, the number of men out of total population (10,000 simulated sample) that falls in each specific sub-market, given the level of male wage inequality.

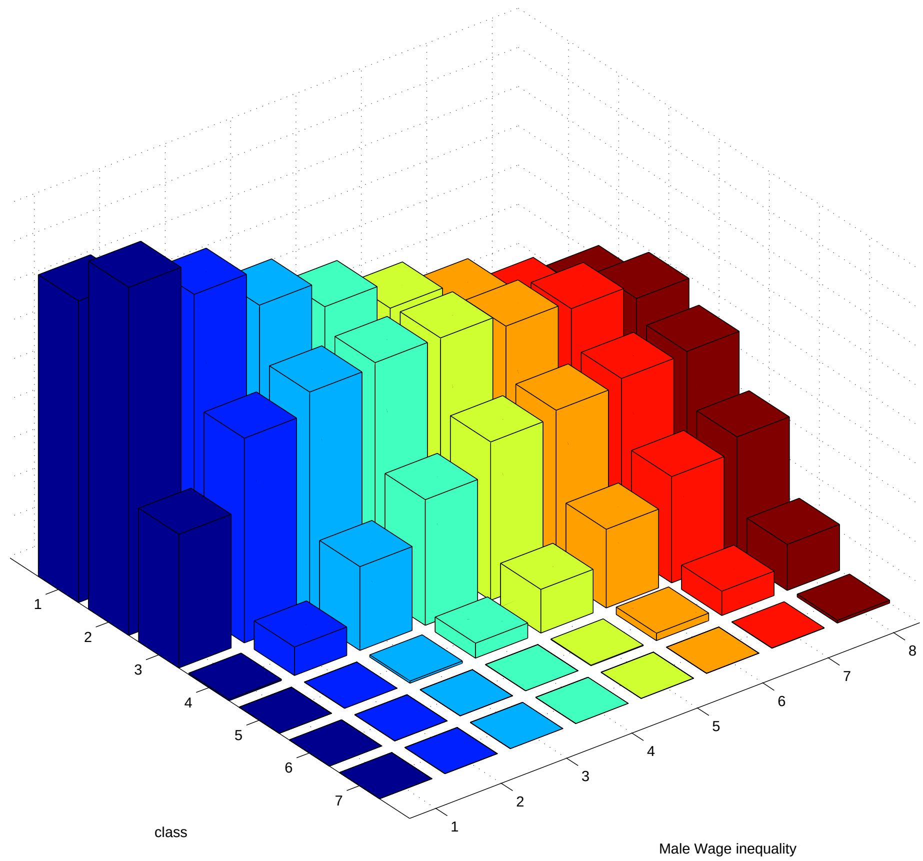

Figure 1.7: The Sub-market Differentiation as the result of increasing male wage inequality. The x axis gives the categories for the classes, the y axis displays male wage inequality in form of standard deviation of hourly wage, and the z axis stands for the frequency, the number of men out of total population (10,000 simulated sample) that falls in each specific class.

The results of figure 1.7 show that, when male wage inequality is at the 70% of current value (indexed as 1), there exist only four classes, and the majority of men are in the second class (middle class). As wage inequality rises to the same as the current value (indexed as 4), the number of classes goes up to five: the new class is generated, and more men are observed to spread out along middle class(indexed as 2 and 3). At the very extreme case that wage inequality doubles (indexed as 8), totally seven classes co-exist; the emerging classes take away more population from the former existing classes. The fraction of population falling in each class evolves as a result of changing wage inequality.

1.3.2.2 When wage inequality rises, who delays the marriage?

The argument of who delaying the marriage is of interest to those supporting marriage (compared to anti - marriage), though this question is hard to address in the survey data. Our model contributes in making predictions of women's marriage choice. The predictions improve our perception of the impact of inequality on marriage outcomes and thus is useful for policy evaluation.

The analysis of who delaying marriage is displayed in figure 1.8 under three settings of male wage inequality: { 60% of current value ($.6C_v$), current value (C_v) and double current value ($2C_v$)}, ordering from left to right in Figure 6. The upper row gives the number of observations and number of samples that delay marriage for men and women, respectively.

And the lower row gives the fraction of population that delays marriage or rejects offers. When male wage inequality is at the value of $.6C_v$, men in each submarket are more likely to reject women in response to the increase in wage inequality, because of a better outside options compared to that of women. At the current wage inequality or $2C_v$, high-income women are more likely to reject the proposals, since better outside option they have, more likely they would wait longer rather than marrying someone below their economic strata. This is also interpreted as "marrying down".

1.4 Empirical Estimation and Structure Recovery

To isolate wage inequality from the time trend of marriage market is hard since in empirical study the decline in marriage rates are accompanied with increasing wage inequality across time. So in this section we are to recover the efficiency and elasticity for matching function that characterize the underlying economic environments. Matching with IPUMS data from year 1970 to 2000, we estimates two-sided matching model and recover parameters that characterize the U.S. marriage market for the past decades.

1.4.1 Data

1.4.1.1 The Sample

The data, used for our present analysis, come from Integrated Public Use Microdata Series (IPUMS). We take year 1970 Form 2 Metro sample together with year 1980, 1990 and 2000 1% sample data. The sample is cross-sectional and restricted to include only the white people living in metropolitan areas (MSA). Let the marriage market be counties or combinations of counties centering on a substantial urban area.

We focus on men aged between 21-40 and women between 21-35. This population group is viewed most likely to be affected by the current marriage market conditions. Those aged less than 20 years are excluded since many of them have not complete their education. Being single is defined as never married before, which equals to 1, if women report they have never been married before till the survey year, and 0 otherwise. As a result, we are left with 803,495 female observations ranging over 200 metropolitan areas.

As to the wage information, we consider only those who are not currently in

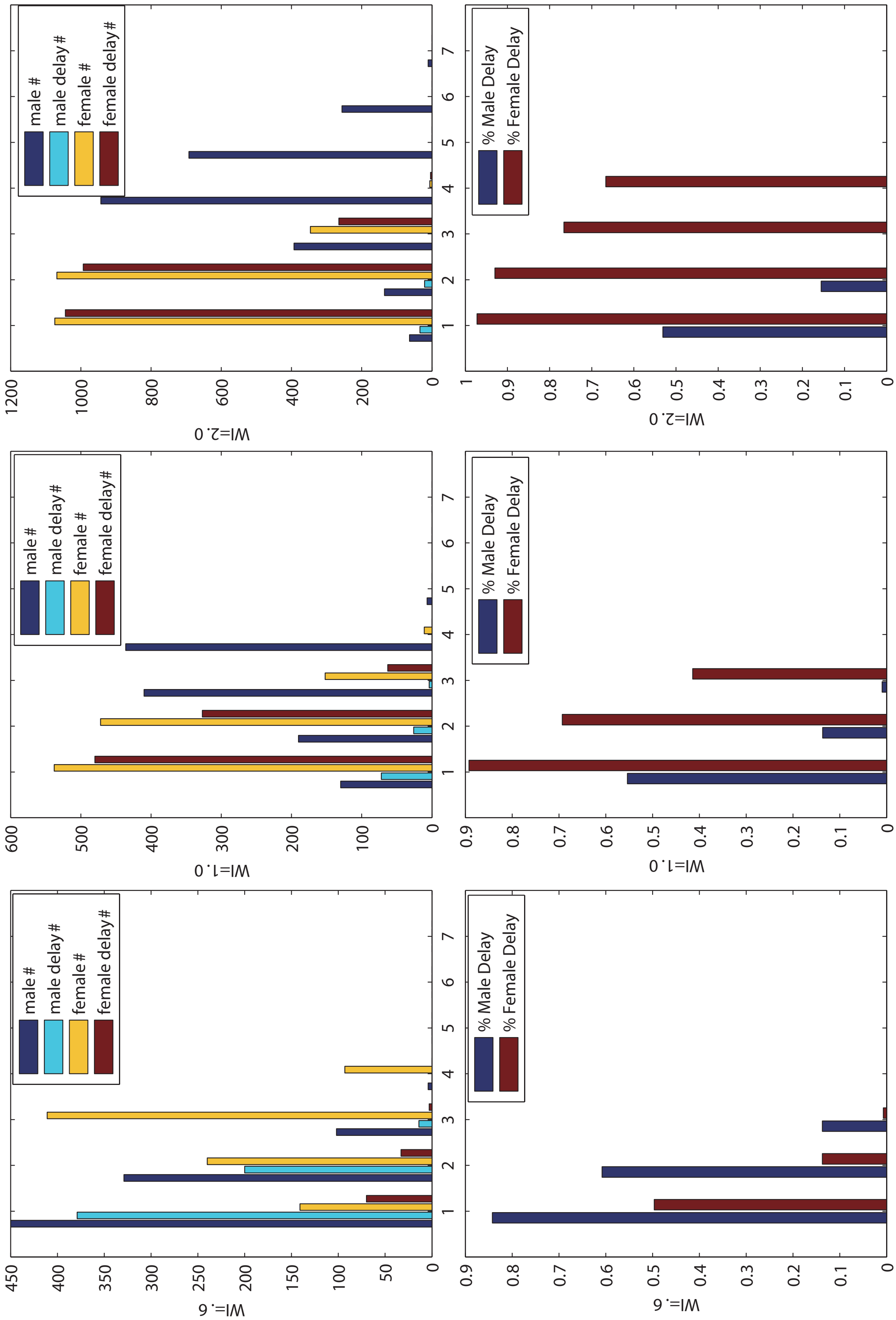

Figure 1.8: Given three settings of male wage inequality: { 60% of current value ($.6C_v$), current value (C_v) and double current value ($2C_v$)}, ordering from left to right in the upper row, the upper row gives the number of observations, and the lower row the number of samples that delay for both men and women, respectively.

school, work full-time and worked at least 1 week in the previous year. A full-time worker supposes to work at least 35 hours per week. People out of labor force are excluded. Measure of wage is constructed on a yearly basis. Total earnings report a respondent's total pre-tax wage and salary income, that is, money received as an employee for the previous year. Log hourly wage is calculated by taking log of the amount of total earnings divided by weeks worked and working hours per week.

Wage inequality here is measured by the standard deviation of log hourly wage, though using other specifications such as 90th-10th percentiles or Gini coefficients reveal the similar increasing trends of wage inequality across time. Note that we use hourly wage, rather than weekly or yearly wage earnings, to eliminate the effect of seasonal variation on labor supply.

1.4.1.2 Descriptive Analysis

This section presents descriptive statistics from year 1970, 1980, 1990 and 2000 1% IPUMS data. Table 1.3 presents summary statistics of age, education, martial status and local labor market information for year 1970, 1980, 1990 and 2000, respectively. The fraction of white women living in metropolitan areas (MSA), aged between 21-35 years who remain single rose from 15% in 1970, to 21% in 1980, to 26% in 1990 and to 32% in 2000.

Male wage inequality, in form of the standard deviation of hourly wage (in 1990 dollar value), grew from 8.98 in 1970, to 12.25 in 1980, to 18.66 in 1990 and 26.86 in 2000. Meanwhile, female wage inequality grew from 6.17 in 1970, to 7.69 in 1980, to 10.11 in 1990 and 18.78 in 2000. The upward trends of both wage inequality and single rate have been quite obvious.

Also, from year 1970 to 2000, the fraction of women participating in labor force rises by 50% of year 1970 value. Fraction of white women that receive college education rises from 28% in 1970 to 64% in 2000. Till year 2000, over one third of women have college degrees.

Table 1.3: Cross-sectional Descriptive Statistics by MSA and Year

Variable	Definition	Y1970	Y1980	Y1990	Y2000
Sex Ratio	Males age 21-35/total 21-35	.46	.49	.49	.50
Age	Average female age	27.5	27.9	28.8	29.0
log N	Mean Log Population in MSA	13.12	12.84	12.84	13.18
Marital Status of Females					
Never Married/Single	% of females never married	.15	.21	.26	.32
Current Married	% of females currently married	.78	.67	.63	.57
Education Level(%)					
Higrad	High School Graduate	.483	.446	.354	.268
Somecoll	Some College	.156	.207	.310	.300
College	College Graduate	.127	.194	.242	.337
Employment Status					
Male EmpStat	Males currently employed/tot	.929	.903	.905	.869
Female EmpStat	Females currently employed/tot	.463	.626	.732	.719
Wage ($)					
Male μ	Mean Male Hourly Wage	15.36	14.30	14.76	16.70
Female μ	Mean Female Hourly Wage	9.50	9.25	10.79	13.06
Male σ	std Male Hourly Wage	8.98	12.25	18.66	26.86
Female σ	std Female Hourly Wage	6.17	7.69	10.11	18.78

Sample is restricted to women aged between 21-35.
Data source: Year 1970, 1980, 1990 and 2000 IPUMS.
Nominal variables were converted to year 1990 dollar value by CPI.

1.4.2 Estimation Strategy

To isolate the change of marriage market from wage inequality, we first recover from the matching function the key parameters such as the matching efficiency and elasticity. Then we make the probit regression of being single on wage inequality as well as market environments.

We start with the matching function. Letting η_t be the elasticity at year t and $\psi_{i,t}$ be the matching efficiency in MSA i at time t, the matching function is

$$m(n_m^{i,t}, n_w^{i,t}) = \psi_{i,t}(n_m^{i,t})^{\eta_t}(n_w^{i,t})^{(1-\eta_t)}.$$

where $n_m^{i,t}$ and $n_w^{i,t}$ denote the population of single men and women, respectively. Note here we assume constant elasticity of substitution, that is, the sum of elasticity for men and women at the MSA level is 1. This assumption is to be revisited and tested after parameterizations of arrival rates in the later section of empirical implementation.

Assume that for each MSA i, the matching efficiency is drawn from a normal distribution,

$$\psi_{i,t} \sim N(\psi_t, \sigma_{\psi,t}).$$

To obtain the market structure for each decade, point estimation of the matching efficiency distribution $\{\psi_t, \sigma_{\psi,t}\}$ on a yearly basis is necessary.

During the process of point estimation we plug the arrival rates in matching function where the MSA-specific demographic information is used. In particular $n_m^{i,t}$ and $n_w^{i,t}$ are obtained via MSA demographic information as sex ratio $r^{i,t}$, single ratio $\{s_m^{i,t}, s_w^{i,t}\}$ and total population $N^{i,t}$. And sex ratio $r^{i,t}$ is defined as the percentage of men, falling in the same range of age, out of the total population for the metropolitan areas i. Following the matching function we have

$$n_m^{i,t} = N^{i,t} r^{i,t} s_m^{i,t}, \quad n_w^{i,t} = N^{i,t}(1 - r^{i,t}) s_w^{i,t}.$$

Here s_m^i, s_w^i are in equilibrium outcomes of single ratios for both men and women. Then transforming the matching function, the arrival rates of marriage market for MSA i are

$$\lambda_m^{i,t} = \frac{\psi_{i,t}(n_m^{i,t})^{\eta_t}(n_w^{i,t})^{(1-\eta_t)}}{n_m^{i,t}},$$
$$\lambda_w^{i,t} = \frac{\psi_{i,t}(n_m^{i,t})^{\eta_t}(n_w^{i,t})^{(1-\eta_t)}}{n_w^{i,t}}.$$

Given a vector of parameters such as arrival rates, we are able to simulate data for each decade at the MSA level by the process presented in appendix B. Note that each MSA has a unique set of demographic information as sex ratio $r^{i,t}$, labor market condition and population that characterize the metropolitan areas. So the single ratio differs by MSA. The scatter plots of the simulated single ratio for each MSA are shown (on the left column) in figure 1.9, compared with those from data (on the right column). The rows represents plots for year 1970, 1980, 1990 and 2000 (from top to bottom), respectively. We present the comparisons of female single ratio between the simulated data and real data, and each circle represents one specific MSA area. The simulated MSA data shares the similar features in mean and standard errors as that of the sample data. It mimics the increasing trend of single ratio for those MSA cities with higher inequality.

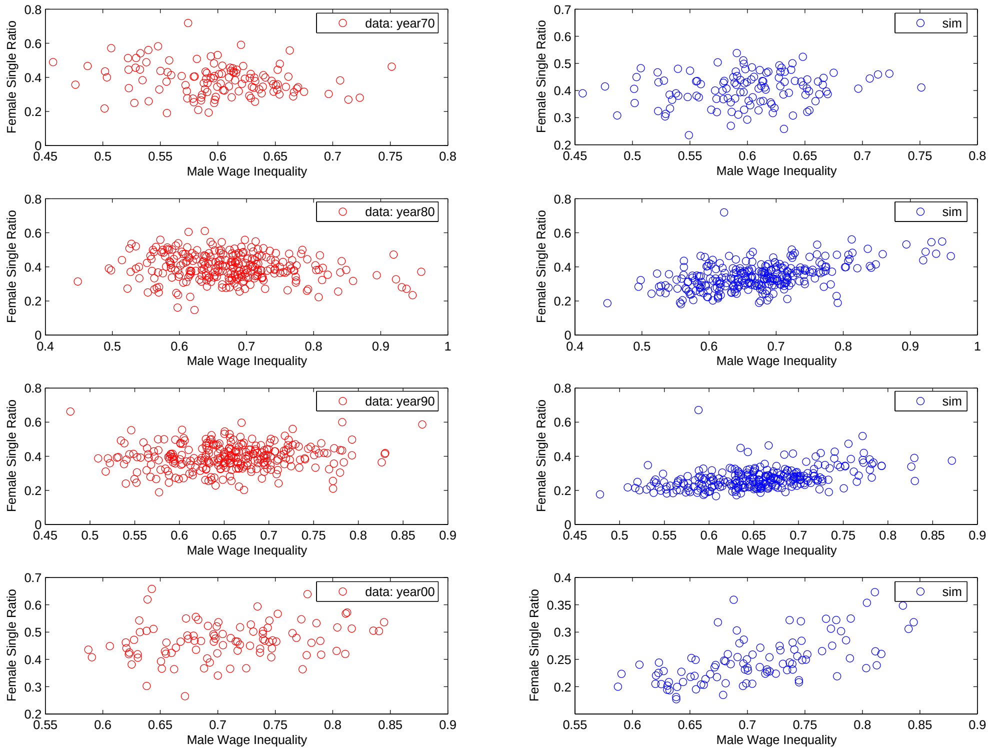

Figure 1.9: Comparison of Single Ratio for Women at MSA level: Simulated data versus real data. The right column gives the simulated MSA data, and each circle represents one MSA city. The left column is that of the real data.

1.4.3 Empirical Implementation

Let the vector of parameters θ be:

$$\theta = \{\psi_t, \sigma_{\psi,t}, \eta_t\}_{t=1970,1980,1990,2000}.$$

where ψ_t and $\sigma_{\psi,t}$ represents at the year t the distribution of matching efficiency. η_t gives the elasticity that represents the return to men.

Meanwhile, for each decade, the cross-sectional mean and standard error of marriage rates at MSA level are used as moments as in table 1.4. Let $\{s_{i,t}^k, k = m, w\}$ be the single ratio at MSA i in year t, the moment vector to be estimated, μ^d, is defined as below and listed in table 1.4.3.

$$\mu^d = \{\bar{s_t^m}, \bar{s_t^w}, \sigma_{s,t}^m, \sigma_{s,t}^w\}_{t=1970,1980,1990,2000}.$$

where

$$\bar{s}_t^m = \frac{1}{n}\sum_{i=1}^n s_{i,t}^m, \quad \bar{s}_t^w = \frac{1}{n}\sum_{i=1}^n s_{i,t}^w,$$

$$\sigma_{s,t}^m = \frac{1}{n-1}\sum_{i=1}^n (s_{i,t}^m - \bar{s}_t^m)^2, \quad \sigma_{s,t}^w = \frac{1}{n-1}\sum_{i=1}^n (s_{i,t}^w - \bar{s}_t^w)^2,$$

Table 1.4: Moments from Cross-Sectional Data at MSA Level

Moment(μ^d)	Year1970	Year1980	Year1990	Year2000
Mean of Male Single Ratio $\bar{s}_t^m$	.2030	.3030	.3622	.4345
Mean of Female Single Ratio $\bar{s}_t^w$	.1788	.2685	.3120	.3923
Std. Dev. of Male Single Ratio $\sigma_{s,t}^m$	.0421	.0547	.0538	.0506
Std. Dev. of Female Single Ratio $\sigma_{s,t}^w$	.0340	.0530	.0579	.0552

Single ratio is at MSA level for the white men aged from 21-40 and women from 21-35.

As indicated by Equation (1, 2), from equilibrium the reservation functions can be derived given a vector of parameters θ. Known the reservation value $\{R_m^{i,t}(\theta), R_w^{i,t}(\theta)\}$, by repeating the simulated matching process 50 times, we arrive at marriage rates for each MSA. Finally, simulated moments of cross-sectional mean and standard error of single rate are obtained.

$$\mu^s(\theta) = \mu^s(\{R_m^{i,t}(\theta), R_w^{i,t}(\theta)\}).$$

Simulated Method of Moments (SMM) are applied to find the parameter vector θ that minimizes the distance between the simulated moments and moments from data. In the meanwhile, data IPUMS of year 1970, 1980, 1990 and 2000, offers the demographic information on sex ratio, mean and standard deviation of hourly wages for men and women for each MSA. Optimal parameter set θ is the point that minimizes the distance.

$$\theta^* = \min_{\theta}(\mu^s(\theta) - \mu^d)W^{*-1}(\mu^s(\theta) - \mu^d)',$$

1.4.4 Parameterization

The recovered parameters of market structure for each decade are listed in table 1.5. And table 1.6 compares the simulated moments and moments from data. The recovered parameters reveal the structure change of marriage market across time. We have two main observations displayed in table 1.5.

First, the mean of matching efficiency, ψ_t, in the upper row of table 1.5, rises from .1066 in year 1970, to .2101 in year 1980, .5021 in 1990 and .6130 in 2000. This increasing trend implies larger arrival rates and more efficient two-sided-matching in marriage market across time.

Second, the elasticity (return to men) in the lower row of table 1.5, falls from .4345 in 1970, to .4153 in 1980, .3543 in 1990 and .3011 in 2000. This phenomenon is barely mentioned in the past studies. It is at least caused in part by the increase of women's participation in labor supply and improved women education.

Table 1.6 lists out the comparisons between the simulated moments and moments from data. The results of simulation match well with sample moments. The

Table 1.5: Parameter Estimates

Moment	Year1970	Year1980	Year1990	Year2000
Mean of Matching Efficiency	.1066	.2101	.5021	.6130
Std. Dev of Matching Efficiency	.0956	.0999	.1037	.1073
Elasticity (Return to Men)	.4345	.4153	.3543	.3011

simulated data mimic the trend of declining marriage rates for both genders and increasing cross-sectional variance of single ratio from year 1970-2000.

The increase in the mean of cross-sectional matching efficiency predicts a higher arrival ratio in the marriage market. Since more options are provided, both men and women could be more selective since they can afford to be more selective in marriage choice; Also marriage could be more easily formed since the improvement of marriage market. In the second application, we will come back to analyzing the influence of these two effects on marriage rates.

And the increased favoring towards women is worthy attention, which could be another factor that generates asymmetry of men and women, and it can lead to the decline in marriage rate across time.

1.5 Implication of MSA-Specific Matching Efficiency

Empirical estimation reveals the structural change of the U.S. marriage market in the past decades. But how much of wage inequality, after excluding this time trend, amounts for the decline of marriage rate remains unknown. Once we pin down the matching efficiency $\psi_{i,t}$, we can decompose the decline of marriage rate for women after including the structural change as matching efficiency to study the impact of inequality on marriage outcomes.

1.5.1 Factors that Affect Matching Efficiency

We regress the matching efficiency on city specific information, year, local market condition(mean and standard errors of wage), sex ratio, population, average

Table 1.6: Comparison of Simulated Moments and Sample Moments

Moment Description	Sample Moment	Simulated Moments
Year 1970		
Mean of Male Single Ratio	.2030	.2243
Mean of Female Single Ratio	.1788	.1962
Std. Err of Male Single Ratio	.0421	.0444
Std. Err of Male Single Ratio	.0340	.0397
Year 1980		
Mean of Male Single Ratio	.3030	.2903
Mean of Female Single Ratio	.2685	.2785
Std. Err of Male Single Ratio	.0547	.0603
Std. Err of Male Single Ratio	.0530	.0499
Year 1990		
Mean of Male Single Ratio	.3622	.3207
Mean of Female Single Ratio	.3120	.3199
Std. Err of Male Single Ratio	.0538	.0672
Std. Err of Male Single Ratio	.0579	.0535
Year 2000		
Mean of Male Single Ratio	.4345	.4003
Mean of Female Single Ratio	.3923	.3654
Std. Err of Male Single Ratio	.0506	.0547
Std. Err of Male Single Ratio	.0552	.0530

age and MSA fixed effects to see if it is significant lying on wage inequality.

As shown in Table 1.7, in the first column of the regression case without arrival rates, matching efficiency is positive correlated with sex ratio at the value of .9071, single ratio at .0018 and the fraction of population getting employed at .1400; it also negatively depends on the percentage of college graduate at the value of -.0011. When arrival rates are included in regressors, as in Columns two, matching efficiency now mainly depends on arrival rates of both genders, that is, arrival rates much absorb the effect of other regressors. Meanwhile, no significant correlation is observed between inequality and matching efficiency.

We say arrival rates better represent the market structure than matching efficiency does, which will be further addressed in the next chapter.

Table 1.7: Regression of Matching Efficiency

	Without Arrival Rates	With Arrival Rates
Demographic Variables		
log population in MSA	-.0078	-.0011**
	(.0056)	(.0012)
Sex ratio	.9071**	-.0270*
	(.0760)	(.0143)
Average Single Ratio	.0018**	-.0002**
	(.0004)	(.0001)
Average Age	-.1667	-.0771
	(.4696)	(.0659)
Average Age Squared	-.0027	.0011
	(.0078)	(.0011)
% of Education Level		
High school graduate dummy	.0004	-.0001
	(.0008)	(.0001)
Some college dummy	.0012**	-.0001
	(.0004)	(.0001)
College graduate dummy	-.0011**	-.0002*
	(.0005)	(.0001)
Labor Market Variables		
Standard deviation of male hourly wage in MSA	-.0542*	-.0017
	(.0094)	(.0020)
Standard deviation of female hourly wage in MSA	.0073*	.0056
	(.0161)	(.0033)
Mean male hourly wage in MSA	.0441**	.0036
	(.0118)	(.0031)
Mean female hourly wage in MSA	-.0015	-.0096*
	(.0168)	(.0046)
Average Employment Status	.1400*	.0603*
	(.0721)	(.0303)
Recovered Marriage Market Structure		
Arrival Rate for Men λ_m		.4931**
		(.0148)
Arrival Rate for Women λ_w		.5239**
		(.0105)
Year Dummy		
Year 1980	.2356**	-.0148*
	(.0296)	(.0075)
Year 1990	.3569**	-.0054
	(.0824)	(.0180)
Year 2000	.3120**	.0242**
	(.0331)	(.0066)
MSA Fixed Effects	Yes	Yes
MSA Specific Time Trend	Yes	Yes
R^2	.7684	.9937

Dependent Variable is the recovered matching efficiency. Regression controls for MSA specific information on average age, education level, labor market condition with fixed MSA effects and time trend. And the standard errors are in parentheses. Data Source: IPUMS data from 1970, 1980, 1990, 2000.
* Variables are 5% significant.
** Variable are 1% significant.

1.5.2 Empirical Analysis: What Determines Marriage Decisions?

Given the independency of wage inequality and matching efficiency, we make a Probit regression of women being single on regressors as in Gould (2003). Based on the different purposes, the combination of regressors are categorized into four types as listed in table 1.8. Since wage inequality and matching efficiency are independent with each other, the type (IV) – regression on arrival rates and wage inequality decomposes the decline of marriage rates.

Table 1.8: Regression Type Indexing

Type Index	Combination
Type I	Basic – fixed MSA effect and time trend
Type II	(I)+ recovered arrival rates λ
Type III	(II)+ recovered matching efficiency ψ
Type IV	(II)+ recovered arrival rate λ + its square λ^2.

Table 1.9 gives the regression coefficients of female being single. The estimates for type I is shown in first column in table 1.9. Positive correlation, around value of 0.0107, is observed between male wage inequality and probability of females being single at 5% percent of significant level. Average male hourly wage - labor market for males - raises the propensity of females to marry with the value of .0159, and induces a lower single ratio. We control for age, age squared, year, education dummies and MSA specific effects, and the corresponding coefficients are mostly statistical significant.

Type II regression (in column two) includes arrival rates as the value .0193, greater than that in type I, implying that the added arrival rates isolate the factors that contributes to marriage formation, suggesting that the effect of wage inequality on marriage rates is under-estimated under type I.

Type III use the recovered matching efficiency, instead of arrival rates, as the instruments of marriage market structure for each MSA. Similar results are obtained

Table 1.9: Probit Regression of Women Being Single

	Type I	Type II	Type III	Type IV
Demographic Variables				
log population in MSA	-.0039	.0031	.0048**	.0025
	(.0021)	(.0021)	(.0019)	(.0023)
Sex ratio	.1038**	.0475	-.0092	-.0788*
	(.0303)	(.0338)	(.0331)	(.0368)
% of Population Employed	.2047**	.1903**	.1801*	.1800*
	(.0392)	(.0302)	(.0331)	(.0350)
Education Level and Age				
High school graduate dummy	-.0216**	-.0217**	-.0215**	-.0214**
	(.0044)	(.0044)	(.0044)	(.0044)
Some college dummy	.0201**	.0199**	.0204**	.0204**
	(.0027)	(.0026)	(.0027)	(.0027)
College graduate dummy	.0708**	.0708**	.0716**	.0714**
	(.0044)	(.0044)	(.0044)	(.0043)
Age	-.1152**	-.1154**	-.1153**	-.1154**
	(.0058)	(.0058)	(.0058)	(.0058)
Age squared	.0017**	.0017**	.0017**	.0017**
	(.0001)	(.0001)	(.0001)	(.0000)
Labor Market Variables				
Standard deviation of log male hourly wage in MSA	.0107*	.0193**	.0198**	.0249**
	(.0051)	(.0046)	(.0050)	(.0046)
Standard deviation of log female hourly wage in MSA	-.0116*	-.0113**	-.0270**	-.0255**
	(.0059)	(.0051)	(.0053)	(.0049)
Mean male hourly wage in MSA	-.0159**	-.0224**	-.0253**	-.0284**
	(.0058)	(.0048)	(.0050)	(.0046)
Mean female hourly wage in MSA	.0279**	.0250**	.0429**	.0372**
	(.0072)	(.0060)	(.0057)	(.0053)
Recovered Marriage Market Structure				
MSA matching efficiency $\psi_{i,t}$			.0917	
			(.0647)	
Squared MSA matching efficiency $\psi_{i,t}^2$			.0434	
			(.0527)	
Arrival Rate for Men λ_m		.0414*		-.4396**
		(.0209)		(.1361)
Arrival Rate for Women λ_w		.0977**		.2655**
		(.0145)		(.0923)
Arrival Rate Squared for Men λ_m^2				.5063**
				(.1363)
Arrival Rate Squared for Women λ_w^2				-.0999**
				(.0566)
Year Dummy				
Year 1980	.1166**	.0736**	.1105**	.0942**
	(.0140)	(.0115)	(.0102)	(.0101)
Year 1990	.0894**	.0556*	.0855*	.1030**
	(.0308)	(.0290)	(.0262)	(.0305)
Year 2000	.1652**	.1139**	.1658*	.1550**
	(.0168)	(.0154)	(.0145)	(.0137)
MSA Fixed Effects	Yes	Yes	Yes	Yes
MSA Specific Time Trend	Yes	Yes	Yes	Yes

Dependent Variable is probit variable for female being single. Regression controls for age, year, education and MSA effects. And standard errors are in parentheses. Sample restricted to women age between 25-35. Data Source: IPUMS 1970, 1980, 1990, 2000
* Variables are 5% significant.
** Variable are 1% significant.

as type I and II. But the coefficients of matching efficiency and its squared are not statistically significant, therefore, arrival rates better represent the structural change of marriage market.

The above types give the similar results as did in Gould(2003), Blau and Kahn(2000). In type (II) to (IV), we incorporate the recovered marriage market structural $\psi_{i,t}$ or arrival rates λ, which are in general unobservable from data, to examine the effect of marriage structure as well as wage inequality on people's marriage decisions.

In type IV, we add the squared arrival rates $\psi_{i,t}$ besides those regressors in type (II). The coefficient on male wage inequality is with an increasing magnitude at value of .0198 for type (III) and .0249 for type (IV). Wage inequality remains significant at the 1% level. The robustness of positive correlation show that, part of the decline in female marriage rate is caused alone by wage inequality. The most interesting thing is, the added market structure in type IV implies that, MSA with higher female arrival rate is accompanied with higher probability of female being single (with coefficient .2655), and MSA with higher male arrival rate is with less probability of female being single (with coefficient -.4396). Meanwhile, when arrival rates are higher than some critical points, these trends are reversed, because for the coefficient of squared male arrival rate is at the value of .5063 but that of squared male arrival rate is -.0999, which are significant at the 1% level.

This observation reveals a two-directional effect, because MSA with higher probability of being single also has higher arrival rates. So increasing arrival rates lead to greater opportunity until over some point $\lambda^{(0)}$, and thereafter reverses the trend.

This probit analysis also applies for men, as shown in Table 1.11. Different from that of women, the probability of male being single is independent of male wage inequality, but negatively depends on female wage inequality. Similar bi-directional effect of arrival rates are observed. And college men are less likely to remain single, which is consistent with the past literature.

1.5.3 Decomposition of Marriage Rate

One standard application of our regression results is the decomposition of the observed average marriage rates of females into the portion attributable to the declining trends in the average values of explanatory variables.

In this subsection we decompose the decline of marriage rates to show how much of the decline is due to increasing wage inequality, and how much is due to change of marriage market such as arrival rates. In table 1.10 I present the decompositions using estimates from the various procedures mentioned the previous regression.

The first row gives the coefficient of marginal effect of male inequality and the next three rows give the average percentage of marriage rates that is explained by inequality. The column of regression types are same as defined in table 1.8. In particular without marriage market factors, only 21.02% of the overall decline in marriage rates during year 1970 to 2000 is accounted by trends in inequality. Considering the marriage market change across time and including factors as arrival rates, more than 38% is explained by inequality. This shows that ignoring the change of marriage market could underestimate the impact of inequality on marriage outcomes.

Table 1.10: Predicted Effects of Inequality on Marriage Trends

	Type I	Type II	Type III	Type IV
Coefficient of Std. Dev. of Male Log Hourly Wage	.0107	.0193	.0198	.0249
Average % of Marriage Rates Explained				
Year 1970-2000	0.2102	0.3792	0.3890	0.4892

Predicted effects are calculated by multiplying the marginal effect coefficient in table 1.9 by the change in male inequality and dividing by the average change of single ratio of white women aged 21-35.

1.5.4 Test of Constant Return on Elasticity

Here we test if the return of elasticity is constant, given the recovered arrival rates and MSA-specific information such as the number of single people. Now we relax the assumption of matching function so that constant return is not necessary. That is,

$$\lambda_m^{i,t} = \frac{\psi_{i,t}(n_m^{i,t})^{\alpha_t}(n_w^{i,t})^{\beta_t}}{n_m^{i,t}},$$

where α_t represents the elasticity of men and β_t is that of women. Then by regress the arrival rates on MSA-specific fixed effect and number of single people, implying the coefficients of matching function.

$$\begin{aligned} \log \lambda_m^{i,t} &= b_0 + b_1 e^{i,t} + b_2 \log n_m^{i,t} + b_3 \log \frac{n_w^{i,t}}{n_m^{i,t}}, \\ &= b_0 + b_1 e^{i,t} + (\alpha_t + \beta_t - 1) \log n_m^{i,t} + \beta_t \log \frac{n_w^{i,t}}{n_m^{i,t}}, \end{aligned}$$

where $e^{i,t}$ denotes the MSA fixed effect, generated by dummy MSA and time trend. $n_m^{i,t}, n_f^{i,t}$ are defined as the number of single men and women in MSA i at period t. Then we test the hypothesis that the sum of α and β equals to 1 by checking whether the second coefficient $b_2 = \alpha + \beta - 1$ equals 0.

$$\begin{aligned} H_0 : &\qquad \alpha + \beta = 1, or, \alpha + \beta - 1 = 0 \\ H_1 : &\qquad \alpha + \beta \neq 1, \end{aligned}$$

H_0 is not to be rejected since

$$\frac{\hat{b_2} - 0}{\sigma_{b_2}} = \frac{-.080 - 0}{.044} = -.181 > -1.96,$$

the critical value falls within the 95% confidence interval of the student t-statistic. So, the null hypothesis of constant return of elasticity, $\alpha + \beta = 1$, can not be rejected.

1.6 Conclusions

This work explores the effect of wage inequality on marriage decisions. In a stationary equilibrium, studies in this area are far from complete. The main difficulty lies in isolating wage inequality from other factors such as the time trend of marriage market. This is partly due to the limitation of the survey data

I built up a two-sided matching model to simulate the process of marriage formation. And this model bridges labor market performance and marriage outcomes, which helps to derive from data the time trend of the U.S. marriage market. Using the recovered parameters that characterize marriage market, we effectively isolate this time trend from wage inequality.

Both my theoretical predictions and empirical results show that, structural change of marriage market across time and increasing wage inequality contribute to the decline in marriage rate. Rising wage inequality decrease the marriage rates by producing more classes with smaller size in the marriage and leading to the mismatch.

Meanwhile, the effect of structural change of the U.S. marriage market is bi-directional. Larger matching efficiency for both genders, and more gender equity provide a more efficient and fairer marriage market with higher arrival rates. Yet higher arrival rates raise the outside option of getting married. From theory the aggregate outcomes are subject to two forces and could be mixed. Our empirical results suggest that higher outside option and increasing wage inequality dominate those benefits from improvements of marriage market in the past decades.

Finally, The decomposition of the decline of marriage rate shows that, controlling for marriage market structure such as arrival rates, over 38% of the decline in marriage rate is due to wage inequality, which effect is underestimated in Gould (2003).

Table 1.11: Probit Regression of Men Being Single

	Type I	Type II	Type III	Type IV
Demographic Variables				
log population in MSA	-.0096**	.0080**	.0091**	.0082**
	(.0023)	(.0025)	(.0023)	(.0024)
Sex ratio	-.0758**	-.1813**	-.1569**	-.1948**
	(.0280)	(.0362)	(.0351)	(.0372)
% of Population Employed	-.0792	.1042		
	(.0777)	(.0752)		
Education Level and Age				
High school graduate dummy	.0110**	.0109**	.0110**	-.0110*
	(.0047)	(.0047)	(.0047)	(.0047)
Some college dummy	-.0252**	-.0252**	-.0262**	-.0252*
	(.0029)	(.0029)	(.0029)	(.0029)
College graduate dummy	-.0312**	-.0312**	-.0312**	-.0312**
	(.0036)	(.0036)	(.0036)	(.0036)
Age	-.0895**	-.0895**	-.0895**	-.0895**
	(.0038)	(.0038)	(.0038)	(.0038)
Age squared	.0012**	.0012**	.0012**	.0012**
	(.0001)	(.0001)	(.0001)	(.0001)
Labor Market Variables				
Standard deviation of log male hourly wage in MSA	-.0031	.0019	.0007	.0046
	(.0047)	(.0047)	(.0047)	(.0048)
Standard deviation of log female hourly wage in MSA	-.0193**	-.0190**	-.0201**	-.0215**
	(.0068)	(.0066)	(.0067)	(.0068)
Mean male hourly wage in MSA	.0012	-.0021	-.0012	-.0040
	(.0053)	(.0053)	(.0053)	(.0053)
Mean female hourly wage in MSA	.0330**	.0318**	.0335**	.0335**
	(.0070)	(.0072)	(.0071)	(.0074)
Recovered Marriage Market Structure				
MSA matching efficiency $\psi_{i,t}$			.0714	
			(.0536)	
Squared MSA matching efficiency $\psi_{i,t}^2$			.0169	
			(.0474)	
Arrival Rate for Men λ_m		.0430*		-.2381*
		(.0203)		(.1170)
Arrival Rate for Women λ_w		.0638**		.1368
		(.0154)		(.0793)
Arrival Rate Squared for Men λ_m^2				.2978*
				(.1172)
Arrival Rate Squared for Women λ_w^2				-0.0421
				(.0512)
Year Dummy				
Year 1980	.0530**	.0274	.0268	.0218
	(.0143)	(.0147)	(.0144)	(.0144)
Year 1990	-.0743**	-.0868**	-.0990**	-.0945**
	(.0305)	(.0326)	(.0301)	(.0316)
Year 2000	.0294**	-.0053**	.-.0091	-.0156
	(.0122)	(.0137)	(.0128)	(.0126)
MSA Fixed Effects	Yes	Yes	Yes	Yes
MSA Specific Time Trend	Yes	Yes	Yes	Yes

Dependent Variable is probit variable for male being single. Regression controls for age, year, education and MSA effects. And standard errors are in parentheses. Sample restricted to men age between 25-40. Data Source: IPUMS 1970, 1980, 1990, 2000
* Variables are 5% significant.
** Variable are 1% significant.

Chapter 2

Search and Household Labor Supply

2.1 Introduction

Until now most studies pertaining to job search are addressed at the individual level. Majority of the empirical work, however, is based on household data. The discrepancy between individual-level search theory and household-level data invokes noteworthy questions: to conduct empirical study on dynamic household labor supply, can we simply treat household as two independent individuals, or take household as a decision unit run by a single header?

The answers for both questions can be negative. Research on intra-household allocation, in microeconomics, is quite rich. Lundberg and Pollak (1993) pointed out that the uneven distribution within a family, caused by gender roles they played, depends on the bargaining between husbands and wives. Meanwhile, Chiappori (1992), Browning and Chiappori (1994, 1998) proposed the collective model, in which multi-agent household is not treated as a single-header decision unit, and consumption of each spouse is the outcomes of bargaining. As Chiappori (1992, 1998) mentioned, the traditional treatment of household as a decision unit represented by the household header, though attractive and convenient, failed in family internal decision; yet, the collective model – agents are characterized by their own preferences and household decisions are Pareto efficient – provides an alternative. Since no evidence shows households behave the same as individuals, the previous empirical tests based on individual-level models are questionable.

To explore dynamic household decisions on labor supply, we need to scrutinize how household income is shared within household, and via what channel this allocation affects job search behaviors of dual-earners. To probe the strategic decision-making, I build up a discrete household search model under the collective framework. To my best knowledge, it is the first one to connect the household dynamic labor supply with intra-household allocation.

The main contribution of this chapter is two-fold. First, this work fills in the research gap on couples' job search. Flinn (2006) and Mabli (2006) examined the household job search in the form of household utility. This chapter, however, provides a theoretical avenue to relax the traditional assumption on household utility. Instead, under the collective framework I study household decision. What distinguishes our work from theirs is the use of individual utility, suggesting intra-household income distribution the outcomes of intra-family bargaining. As intra-household income distribution depends on spousal labor market performance as employment status or wage income, a theoretical investigation on intra-household decision becomes possible.

Second, this search model is adequate for empirical estimation at the household level. Family problem was complicated, as Lundberg (2007) indicated, especially after labor supply decision came in. The difficulty comes from two aspects. (1) Endogeneity issue. Under dynamic setting, intra-household distribution – the share of household income distributed to husbands and wives – depends on couples' employment status and earnings; meanwhile, decisions of labor supply also depend on intra-household bargaining and wage offered. (2) Data limitation. The available data have limited information on intra-household income allocation because private consumption of husbands and wives is unobservable. In addition, panel data at household level are required to track the job search. The unobserved consumption data together with endogeneous dynamic decisions make this task intractable.

This chapter provides an alternative to this problem: a structural model is formulated to simulate household job search and formation of their reservation wages, which can infer couples' employment status and realized wages; such information is available from data. Matching inferred household behaviors with empirical data, we can recover household preferences and intra-household allocation. This approach overcomes the limits of survey data, and enables empirical tests on intra-household allocation.

Our results reveal that, husbands consumption is sensitive to their employment status. This sensitivity indicates the existence of bargaining between husbands and wives. We also find that on average the monthly transfer from husbands to wives is \$1355. The recovered women labor supply indicates that higher women wage and lower share from family raises women labor supply, suggesting that for wives, here the income effect dominates. Moreover, the wage frontier of husbands are positively correlated to wives wages and negatively correlated to the transfer to wives, meaning that husbands decisions are subject to both income effect and intra-household bargaining.

The paper is organized as follows. Section 2 presents our theoretical framework. Section 3 gives baseline results from model in section 3. Data is described in section 4, and econometric specifications are displayed in section 5. Section 6 and 7 analyzes estimation results and its applications. The conclusions are discussed in section 8.

2.2 Household Job Search Model

2.2.1 Environments

To study the individual behaviors in household job search, we develop a discrete-time model in which husbands and wives search for jobs and make labor supply decisions. Only the steady state is considered. Under our setting, husbands and wives play a Nash game and make individual decisions, taking the spousal response as given.

Only two types of individuals – husbands m and wives f – are considered. They are married, infinitely-lived and discount the future at the rate β where $\beta \in (0, 1)$. Agents are characterized by their employment status and if working, their wage level. Therefore, their states are described either employed with wage w, or not working. In particular, wage equals zero, $w_{i=\{m,f\}} = 0$, if they are not working. Let w_m represent wage of husbands and w_f of wives. During job search,job offer arrival follows a Poisson process with λ. If employed, individuals could lose jobs with the probability of δ.

Household income (I) is the sum of couples' wage income and their non-labor income, $I = w_m h_m + w_f h_f + y$, where y denotes the exogenous non-labor income of a family. If both work full-time, then $h_m > 0$ and $h_f > 0$,

2.2.2 Intrahousehold Bargaining

To describe the bargaining between husbands and wives, we adopt collective model as in Chiappori (1992, 2002). Intra-household income allocation between husbands and wives is therefore defined as the sharing rule ϕ, which represents the proportion of household income consumed by husbands as a function of labor market status of couples. The intuition is that, husbands private consumption out of total household income depends on their wage income, spousal wage income as well as family non-labor income. The intrahousehold income allocation is the outcomes of bargaining. In particular, the sharing rule is termed as below.

$$\phi = \phi(E_m, E_f, w_m, w_f, y),$$

where $E_{\{h=m,f\}} \in \{0, 1\}$ represents the employment status of husbands, and it equals 1 if they are employed and 0 otherwise. Then private consumption of husbands is

$$c_m = \phi(E_m, E_f, w_m, w_f, y)$$

and that of wives is

$$c_f = w_m h_m + w_f h_f + y - \phi(E_m, E_f, w_m, w_f, y).$$

Husbands and wives, therefore, share household income according to the sharing rule, a function $\phi(.)$. Private consumption is subjected to budget constraint, $c_m + c_f = I$ and defined to be positive, $c_i \geq 0$. The sharing rule $\phi(.)$ same as in Chiappori (2002) denotes the resource transferred among couples.

2.2.3 Individual Optimization

Assume that individual utilities depend on their private consumptions and leisure. Private consumption of couples, c_m and c_f, rely on couples' income (w_m, w_f, y) and their sharing rule ϕ. Finally, the individual utility maximization is shown as below.

$$\begin{aligned}
\max_{\{c_i^t, l_i^t\}} \quad & \sum \beta^t u_i(c_i^t, l_i^t) \\
s.t. \;\; c_m^t &= \phi(E_m^t, E_f^t, w_m^t, w_f^t, y^t) \\
c_f^t &= w_m^t h_m^t + w_f^t h_f^t + y^t - \phi(E_m^t, E_f^t, w_m^t, w_f^t, y^t) \\
l_i^t &= 1 - h_i^t
\end{aligned}$$

where c_i^t is the individual private consumption, $l_i^t \in [0, 1]$ is the time spent on leisure. Note that under the dynamic setting, individual decision of working or not is based not only on their expectation of future income, but also their current consumption – the share of household income determined by their employment status. With this in mind, we next consider the value function in equilibrium.

2.2.4 Value Function

In this subsection, we describe the value function of couples given their state variables. Consider an individual i, $i = m, f$, in a household where husband has the wage at the value of w_m and wife has w_f.

Each spouse i has private consumptions c_i by sharing part of non-labor income y and the transfer from spousal wage income w_{-i}. The private consumption is determined by the sharing rule, which as a decision rule of family is contingent on employment status and wage earnings of couples.

We define $\{W^i(w_m, w_f), i = m, f\}$ as the value function of married couples i, where w_m stands for husband's wage and w_f is that of wife. Decision rule of husband working, $D_m(w', w_f)$, is a function of his wife's wage w_f and his job offer w'.

$$D_m(w', w_f) = \begin{cases} 1, \textit{work if } W^m(w', w_f) \geq W^m(0, w_f); \\ 0, \textit{otherwise.} \end{cases}$$

The decision rule of wife is

$$D_f(w_m, w'') = \begin{cases} 1, \textit{if } W^f(w_m, w'') \geq W^f(w_m, 0); \\ 0, \textit{otherwise.} \end{cases}$$

Value function differs by couples' employment status. In total, there exist four combinations of states: {both unemployed $(0, 0)$, husband employed but wife not employed $(w_m, 0)$, wife employed but husband not employed $(0, w_f)$, both employed (w_m, w_f)} as in table 2.1.

Table 2.1: Available States for Couples

	Wife work	Wife not work
Husband work	(w_m, w_f)	$(w_m, 0)$
Husband not work	$(0, w_f)$	$(0, 0)$

Husbands and wives in our model play a Nash game in deciding dynamic labor supply. Here we take the case of wife being employed but husband not, $(0, w_f)$, as an example to discuss the process of husbands decision-making. The timing of husband decision is also displayed in figure 2.1. The husband utility given that his private consumption is c_m and leisure is l_m, is a function of husbands and wives' income. That is, $u_m(c_m, l_m) = u_m(c_m(0, w_f), l_m(0, w_f)) = u_m(0, w_f)$. Husband sets the criteria to accept wage offer – reservation wage – based on his rational expectation of the future job opportunity and the expected response of his wife.

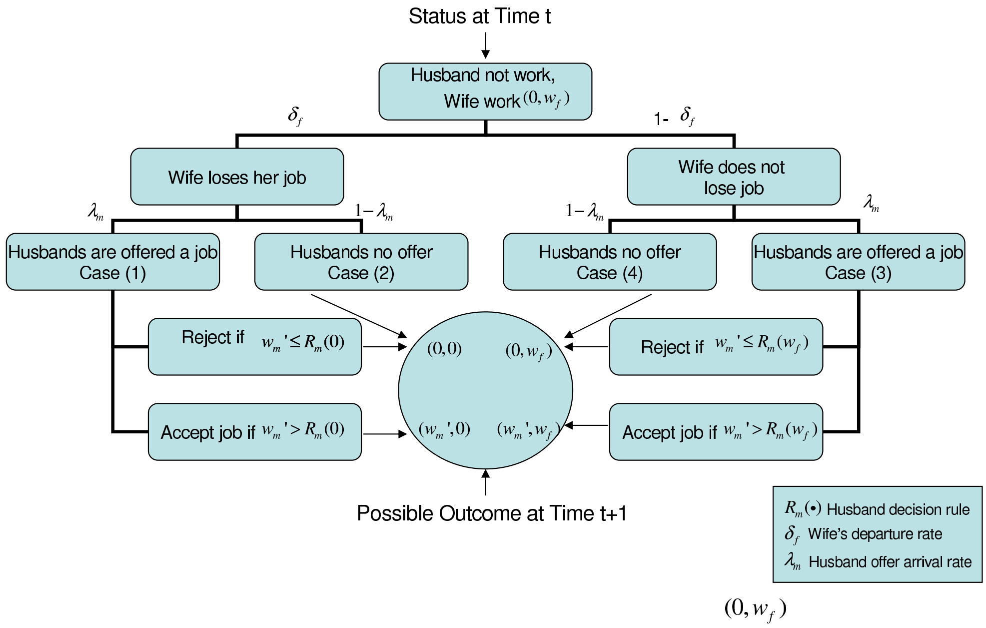

Figure 2.1: Timing of Husband Employment Decision when Wives with Wage w_f

Case (1) If the wife loses her job (with $\Pr = \delta_f$) and he is offered a job (with $\Pr = \lambda_m$), the husband will set his reservation wage based on the status that his wife is unemployed; he will accept an offer w' if and only if it is above his reservation wage $R_m(0)$, where $R_m(0)$ denotes the husband's reservation wage when his wife is not working. Then with probability $\delta_f \lambda_m$, his utility is

$$\int_{R_m(0)} W^m(w'_m, 0)dF(w'_m) + \int^{R_m(0)} W^m(0,0)dF(w'_m).$$

Case (2) If the wife loses her job at δ_f, the husband has no offer at $(1 - \lambda_m)$. Then both of them are unemployed. His future utility is $W^m(0,0)$, with probability $\delta_f(1 - \lambda_m)$

Case (3) If the wife does not lose her job and her husband gets an offer, the husband will consider the possible response from his wife: will she quit the current job or remain employed? Then he will set his reservation wage as a function of his wife's possible employment status and her wage rate. With probability $(1 - \delta_f)\lambda_m$, the husband's utility is

$$\int_{R_m(w_f)} W^m(w'_m, w_f)dF(w'_m) + \int^{R_m(w_f)} W^m(0, w_f)dF(w'_m).$$

If he expects his wife will not quit the current job, that is $w_f \geq R_f(0,0)$, where $R_m(w_f)$ denotes the husband's reservation wage when his wife works with wage w_f and $R_f(0)$ the wife's reservation wage when her husband is not working.
Otherwise his utility is

$$\int_{R_m(0)} W^m(w'_m, 0)dF(w'_m) + \int^{R_m(0)} W^m(0, 0)dF(w'_m)$$

Case (4) If the wife does not lose her job at $(1-\delta_f)$ and her husband has no offer $(1-\lambda_m)$, they will stick to their current jobs. His utility is $W^m(0, w_f)$ with probability $(1-\delta_f)(1-\lambda_m)$.

Finally, summing up all the possible outcomes of wife currently employed but husband not, we obtain the value function of husband as below.

$$\begin{aligned} W^m(0, w_f) &= u_m(0, w_f) + \beta\{\delta_f\lambda_m(\int_{R_m(0)} W^m(w'_m, 0)dF(w'_m) \\ &\quad + \int^{R_m(0)} W^m(0,0)dF(w'_m)) \\ &\quad + \delta_f(1-\lambda_m)W^m(0,0) \quad + (1-\delta_f)\lambda_m \\ &\quad \left(\begin{array}{c} (w_f \geq R_f(0))[\int_{R_m(w_f)} W^m(w'_m, w_f)dF(w'_m) + \int^{R_m(w_f)} W^m(0, w_f)dF(w'_m)] \\ +(w_f < R_f(0)) \int_{R_m(0)} W^m(w'_m, 0)dF(w'_m) + \int^{R_m(0)} W^m(0,0)dF(w'_m) \end{array} \right) \\ &\quad + (1-\delta_f)(1-\lambda_m)((w_f \geq R_f(0))W^m(0, w_f) + (w_f < R_f(0))W^m(0,0)))\} \end{aligned}$$

Similarly, we get the value functions of the rest of three other states: { both unemployed, husband employed but wife not employed, both employed}, which are displayed in appendix D. By the symmetry of husbands and wives, wives also have a similar set of value functions.

2.2.5 Equilibrium

An equilibrium is characterized by a set of reservation wages for husbands and wives contingent on their spousal wage. The decision rules for each spouse $\{R_m(\cdot), R_f(\cdot)\}$ satisfy the cut-off rule.

$$W^f(0,0) = W^f(0, R_f(0)); \quad (2.1)$$

$$W^m(0,0) = W^m(R_m(0), 0); \quad (2.2)$$

$$W^f(w_m, 0) = W^f(w_m, R_f(w_m)); \quad (2.3)$$

$$W^m(0, w_f) = W^m(R_m(w_f), w_f). \quad (2.4)$$

$\{R_i(w_{-i}), i, -i = m, f\}$ denotes the offered wage that individual i is willing to accept and work full-time given spousal wage being at the rate of w_{-i}. Note that the value functions $\{W^m(\cdot,\cdot), W^f(\cdot,\cdot)\}$ are defined as in the section of value function.

Compared with the individual job search, taking equation (3) as an example, the reservation wage of wife makes her indifferent between working with wage $R_f(w_m)$ and being unemployed. What makes wife decision different from singles is that with the spouse present, her value function thus depends on the spousal wage. So instead of a reservation wage in individual job search, wife has a reservation function of her spousal wage.

The complexity of our model lies in endogenous decision of household labor supply, in which family members not only make individual decisions but also bargain over private consumption determined by their labor market performance. A simple close-form solution might not be easy to obtain. Therefore, in the coming section, we are to look into the properties of equilibrium by numerical methods.

2.2.6 Numerical Analysis of Equilibrium: A Simplified Example

To catch the feature of our model and perceive some properties of equilibrium, I start with numerical analysis on a simplified version of household model.

We start with simplifying the original model. Instead of the original sharing rule ϕ as a function of couples labor market status such as wages and employment status, I let the private consumption shared by husbands, ψ, be a fraction of household income. This example focuses on family Nash game in labor supply by simplifying the bargaining. It aims to study individualized household decisions without bargaining. We will discuss later that some important features remains even after simplifying the original sharing rule.

So we have

$$\begin{aligned} c_m &= \psi I = \psi(w_m + w_f + y), \\ c_f &= (1-\psi)I = (1-\psi)(w_m + w_f + y). \end{aligned}$$

Letting in utility function $\{u_i(c_i, l_i)\}_{i=m,f}$ the consumption and leisure are separable and addictive. With constant elasticity of substitution (CES) with risk aversion $\gamma_{i=m,f}$, individual utility from consumption has $u(c_i) = \frac{c_i^{1-\gamma_i}}{1-\gamma_i}$. And utility from leisure is $v(l_i) = log(l_i)$. The weighting index of consumption over leisure, $\{\alpha_{i=m,f}\}$, is set between 0 and 1. Larger the weighting index, less preference geared toward leisure over consumption. For each individual i, the individual optimization problem is

$$\begin{aligned} \max_{\{c_i^t, l_i^t\}} & \quad \sum \beta^t u_i(c_i^t, l_i^t) \\ s.t. \;\; u_i(c_i^t, l_i^t) &= \alpha_i \frac{c_i^{1-\gamma_i}}{1-\gamma_i} + (1-\alpha_i) log l_i \\ c_m^t &= \psi(E_m^t, E_f^t, w_m^t, w_f^t, y^t) \\ c_f^t &= w_m^t h_m^t + w_f^t h_f^t + y^t - \psi(E_m^t, E_f^t, w_m^t, w_f^t, y^t) \\ l_i^t &= 1 - h_i^t \end{aligned}$$

where the disutility of working is given in log format, γ is risk aversion, c the individual private consumption, $l \in [0,1]$ the time spent on leisure and I the household income. And the weighting index of consumption over leisure, $\{\alpha_{i=m,f}\}$ could vary by gender.

This baseline model aim to improve our understand the properties of equilibrium. Some important features remain even after simplifying the original sharing rule.

Next, numerical analysis is made on the reservation function for several specific sceneries. The detailed algorithm of numerical process is given in appendix E, and the constants used are listed in table 2.2.

Table 2.2: Constants

Constant	Description	Value
β	Time Discount Factor	.996
λ	Job Arrival Rate	.4
δ	Job Destruction Rate	.004

2.2.6.1 Symmetric Couples: Income Effect Dominates

First, we consider that couples are perfectly symmetric: identical log-normal wage offer distribution with $\{\mu_{i,j}, \sigma_{i,j}\}$, identical offer arrival rates $\{\alpha_m = \alpha_f\}$. Most importantly of all, household income is equally split between husbands and wives, $\psi = .5$, suggesting no bargaining within a family. Let the risk averse parameter equal one, $\gamma = 1$. The reservation wages of couples being a function of spousal wage are displayed in figure 2.2.

When husbands and wives are set to be identical in individual preferences and private consumption, the reservation wage they set are expected to be symmetric. And without intrahousehold bargaining, the income effect dominates. So if the spouse is employed, individual reservation wage is symmetric for husbands and wives, and it is an increasing function of spousal wage. These predictions agree with our outcomes from figure 2.2: if spouses earn more, individuals set higher reservation wages.

To further illustrate our model prediction and explore the increasing trend of reservation function, we compare the reservation function for risk averse wives and

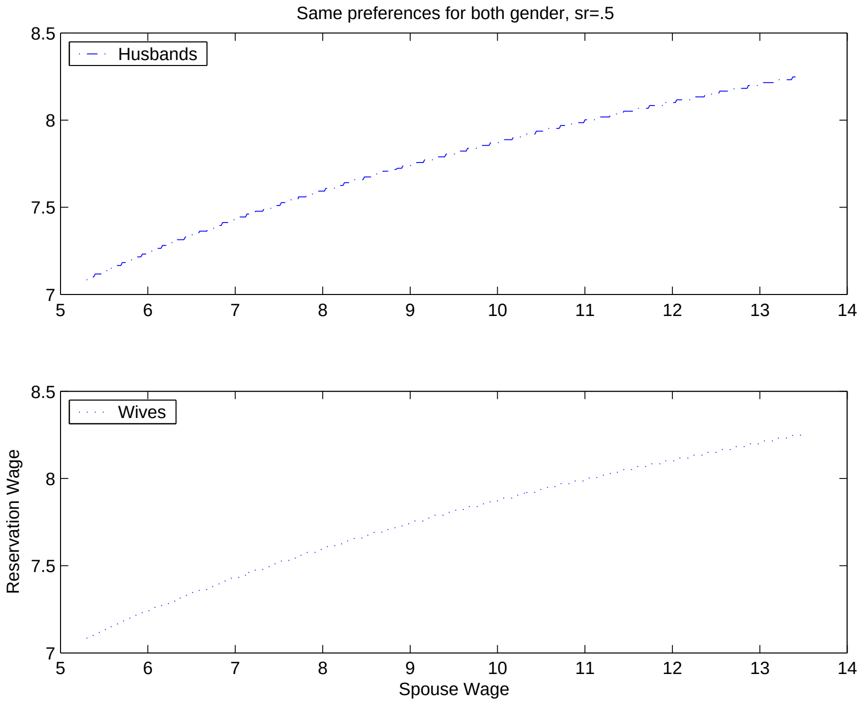

Figure 2.2: Reservation Wage of Both Genders. The upper chart is for Husbands and lower is for wives. The horizontal axis is spousal wage level, and the vertical axis is reservation wage.

risk neutral ones. In particular, for those risk averse γ is set to be 1, but for risk neutral ones γ is 0.

As shown in figure 2.3, for the risk-neutral individuals ($\gamma = 0$, in dash line), their reservation function is a flat line of spousal wage; yet, for those risk averse ($\gamma > 0$, in solid line), their reservation function is an increasing function of spousal wage. This comparison demonstrates that it is individual risk aversion – the risk sharing within a family – plays a central role in producing the upward slopping reservation function. The income effect of second earner is supported by the assumption of individuals being risk averse. This is consistent with the Danish study of wives by Lentz and Trans (2005) that wives experience a longer unemployment duration if husbands earn more.

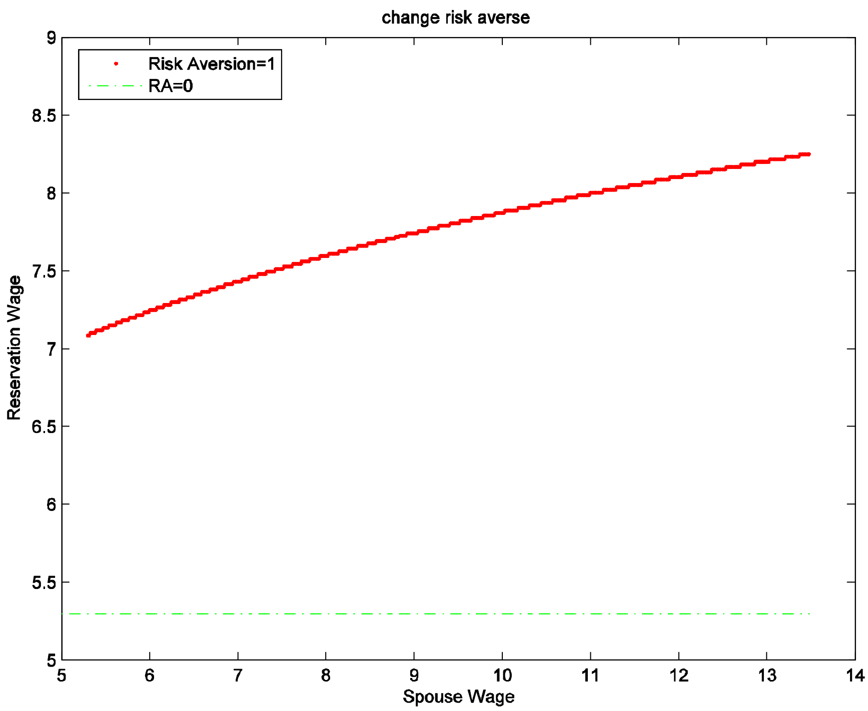

Figure 2.3: Comparison of Reservation Functions for Individuals: Risk Averse vs. Risk Neutral.

Wage earnings of the spouse at least partly insures the potential earner against unemployment risk. In addition, non-labor income (including wealth earnings and home production) reinforces the income effect. So unemployed individuals afford to set a higher reservation wage. Given all else the same, they will experience a longer unemployment spell since a higher reservation wage is set. This upward-sloping trend of reservation function is consistent with our intuition that family functions as an insurance and it provides financial support and security.

2.2.6.2 Asymmetric Couples

We realize that the assumption of couples being symmetric and splitting household income equally are too simple to reveal family internal decision. It needs to be relaxed.

In this section, without complicating this problem by introducing intrahousehold bargaining, we extend the simplest example to asymmetric couples in two dimensions: different preferences for leisure, and different income allocation within a family. We will see later that even without bargaining between couples, household members are responsive to the changing preferences and household income allocation.

A. More Preference Towards Leisure, Lower Reservation Wage Individuals Set.

Here our model shows how the change of couples preferences in leisure α_m and α_f affects the reservation function. Figure 2.4 points out that, when more weight is put on leisure, that is, the weighting index of consumption over leisure α_m is larger, husbands will value leisure less, and have a lower reservation wage – they are more motivated to work.

We observe here the income effect on the reservation function same as in the previous sections. Note that this extension shows that even without intrafamily bargaining, the different preferences towards leisure between husbands and wives make

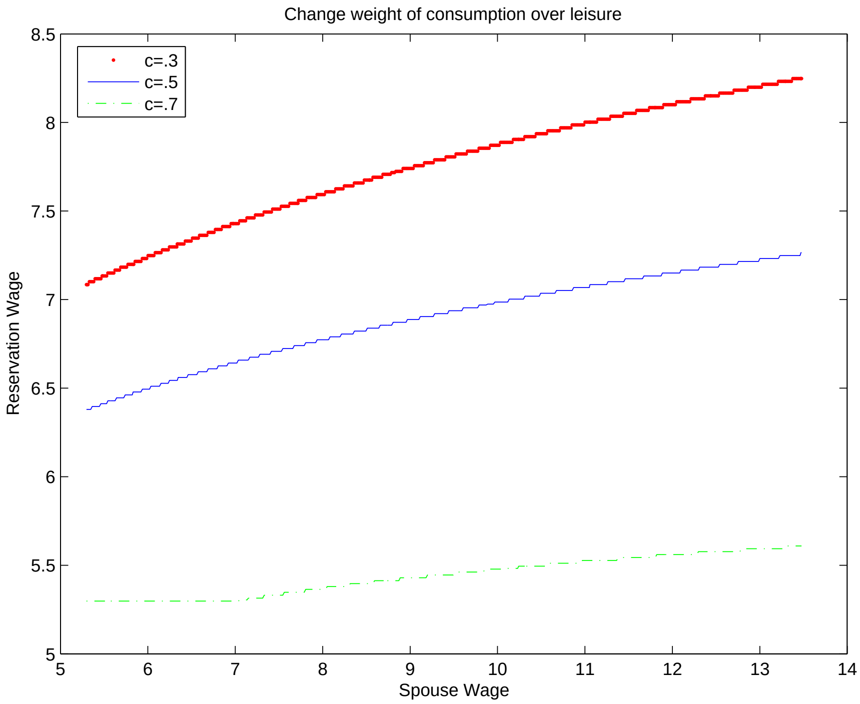

Figure 2.4: Reservation Function Given Varying Weighting Index of husbands Preference of Leisure Over Consumption: the effect of α changes on reservation wage.

them different in reservation wages.

B. More Income Shared, More Likely to Work

We let the portion of income shared by husbands, ψ, vary from .5 to .47 and .53, respectively. It examines the effect of the simplified intra-household income distribution, ψ, on husbands' reservation wages.

Figure 2.5 reveals that, with the fractions of household income distributed to husbands ψ rising from 47% to 53%, the more income is shared by husbands and the lower the reservation wage husbands set. The reason is that, the more income is shared more by husbands, they are more willing to work, even at a relative lower wage.

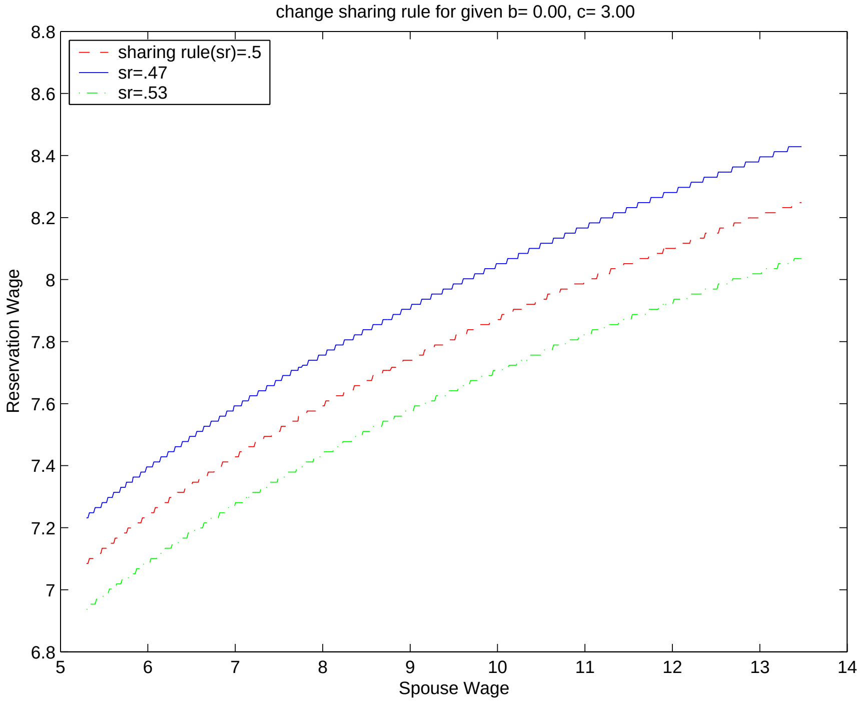

Figure 2.5: Reservation Function Given Varying Income Shared by Husbands: the effect of ψ changes on the shift of reservation wage.

2.2.7 Confronting Data

To quantify the sharing rule–intrahousehold bargaining, we next bring in data and estimate the original model instead of the simplified ones.

This discussion highlights some key components of married individual labor supply decisions and their sharing within the family. Our goal is to use household search model to analyze the impact of sharing rule on dynamic family labor supply decisions. By matching with data, we can recover the decision rules as well as the sharing rule, and further examine family job search pattern in the U.S..

Since individual-level consumption data is not available, direct calibration of private consumption and further the sharing rule is not feasible. The sharing rule is derived from dynamic household labor supply by estimation model with the real data. With these in mind, we first turn to a description of the U.S. household data and then to the estimation of our richer model.

2.3 Data

2.3.1 The Sample

To estimate model, the year 2001 panel data of Survey and Income Program Participation (SIPP 2001) are used. SIPP data provide accurate and comprehensive information about principal determinants of income and program participation of individuals within households in the United States. In SIPP 2001, individuals from primary households are interviewed every 4 months for 9 consecutive waves, which sum up to a 3-year panel data. Interviewed individuals are asked about their monthly information on employment status, job earnings, working hours per week and weeks worked per month. Therefore, information on job change and unemployment duration on a monthly basis can be derived from data.

The advantages of SIPP data are as follows: (1) panel data track dynamic labor supply records and unemployment duration; (2) 3-year panel is short enough so structural changes are less likely to occur on social institutions and individual preferences, and 4-month visit interval gives more reliable records on a monthly basis than yearly in PSID data; (3) symmetric information is available for husbands and wives, so couples' employment information is collected; (4) large original sample size make it possible to obtain a sizable target sample.

In summary, SIPP data give sufficient information on household labor supply and wage earnings from 2001 to 2003, and provide testable restrictions that are used to recover private consumption of each spouse.

We focus on white couples. The criteria that I apply to restrict data are described in appendix F. If any spouse within a household fails to satisfy the restrictions, this household is excluded. After imposing all the restrictions, the sample is left with 2297 households.

2.3.2 Descriptive Statistics

In our sample, 60.9% of husbands have college degree and so do 65.1% of wives. Wives with high school diplomas, on average have hourly pay rate at 14.18 in 2001 dollar; meanwhile, wives with college diplomas, on average have hourly rate at 20.65. For working husbands, the average hourly rate of those with high school diplomas is 16.94, and with college diplomas is 25.49. On average, college graduates husbands earn \$8.50 more than high school graduates per hour; college graduates wives have a smaller gap and earn \$6.50 more than their peers of high school graduates. Table 2.3 gives the mean and standard error of hourly wages of couples and their education level, respectively.

Table 2.3: Education and Wage Information for Both Genders

	Husband		Wife	
Education Level	HighGrad	College	HighGrad	College
% of Total Population	39.1	60.9	34.9	65.1
Hourly Wage for Those Work				
Mean	16.94	25.49	14.18	20.65
Std. Err.	(13.26)	(17.32)	(16.46)	(18.68)

2001 Dollar Value

Table 2.4: Employment Rates for Husbands and Wives

(%)	Husband	Wife
Unemployment Rate	3.14	13.68
Employment Rate if Spouse Working	97.12	86.55
Fraction of Full Time if Employed	98.15	73.11
Fraction of Working Full-Time if Spouse also FT	97.97	72.84

Values are given by percentage.
As in SIPP, individuals are working full-time if hours they worked are more than 35 hours and otherwise part-time.

Table 2.4 presents the fraction of sample population who get employed. 3.14% of husbands are currently unemployed, compared to 13.68% of wives who are unemployed. If employed, the probability of husbands working full-time is 98.15%, while that of wives is 73.11%.

If one's spouse is employed, 97.12% of husbands and 86.55% of wives are also working, respectively. Particularly, if the spouse is working full-time, the fraction of husbands working full-time increases to 97.97%, but working wives have full-time jobs decreases to 72.84. add in comments.

Table 2.5 pools unemployment duration of husbands and wives. It shows that around 78% of unemployed husbands get employed after 12 months, however, 60% of unemployed wives remain not employed. The survival rate of being unemployed declined over time, and it drops to 13.92% for husbands and to 48.38% for wives.

Meanwhile, the transition rate from unemployment to full-time jobs is increasing along time. Obvious asymmetry is observed between husbands and wives: after 20 months, around half of once-unemployed husbands are settled with full-time jobs, and so are only 6% wives.

Table 2.5: Transition Rate of Unemployment

(%)	Husband		Wife	
k	$Prob(U_t\|U_{t+k})$	$Prob(U_t\|FT_{t+k})$	$Prob(U_t\|U_{t+k})$	$Prob(U_t\|FT_{t+k})$
1	81.39	17.12	93.21	3.15
2	64.74	18.16	87.08	3.26
3	50.06	19.20	81.50	3.44
4	36.70	20.39	76.52	3.58
5	32.54	20.98	73.61	3.68
6	29.50	21.78	70.92	3.82
7	26.63	22.49	68.69	3.96
8	24.14	23.42	66.60	4.12
9	23.11	23.96	64.83	4.29
10	22.83	25.09	63.26	4.53
11	23.06	26.55	61.79	4.76
12	23.46	28.27	60.50	5.00
13	22.50	28.80	59.13	4.91
14	21.73	30.28	57.64	5.14
15	20.64	32.62	56.17	5.42
16	19.85	35.74	54.76	5.64
17	18.79	35.35	53.28	5.61
18	17.42	37.80	51.92	5.86
19	15.46	40.27	50.34	6.34
20	13.92	43.46	48.38	6.64

k gives monthly intervals from time t.
First two columns give unemployment duration of couples and the last two columns are transition rates from unemployment to full-time jobs.

2.4 Estimation

To recover individual decision rules, in this section we estimate the original model with data SIPP 2001. The sharing rule is a function of couples' wages and non-labor income as in Chiappori (1998, 2002).

$$\phi(w_m, w_f, y) = a_0 + a_1 w_m + a_2 \log w_f + a_3 y,$$

where w_m are husbands' wage earnings, w_f are that of wives and y is the exogenous non-labor family income. We directly use the level of male wage earnings to nest out the income pooling hypothesis.

We define the sharing rule is in the form of semi-log specification, not only because it is a popular form to use seen in Blundell, Duncan and Meghir (1998), also also because this form is never rejected by the previous data work of Chiappori (1998, 2002). So we take this form as a starting point to study the intra-household bargaining.

2.4.1 Constant Setting

Table 2.6: Some Basic Indices for Married Couples

Variables	Value
Average Age Gap	1.70
Average Weeks Worked per Month if Employed	4.33
Average Hours Worked if Part Time Working	20.8
Average Hours Worked if Full Time Working	44.3
Correlation of Hourly Wage for Husband and Wife	.2248

The household in our sample have an average age gap of 1.7 years between couples, which justifies our selection criteria of 2-year age gap between husbands and wives. As in the SIPP data, individuals are defined to work full-time if hours they worked per week are more than 35, and part-time if hours worked per week are less than 35 hours. Our sample have on average hours worked full-time are 44.3 and part-time are 20.8. So in estimation, instead of continuous working hours, employment status is categorized to be either employed part-time or full-time or not working. Assume that the per week endowed time is 80 hours. Working part-time is defined as working hours $h_{pt} = \frac{22.8}{80} = .28$, and working full-time $h_{ft} = \frac{44.3}{80} = .54$. And then leisure enjoyed of not working is 1.

The correlation of couples' hourly wage if both work is positive with the value .2248, suggesting the positive assortative mating, which we use as a moment to indicate the interaction of couples' decisions.

The wage-related constants used for estimation are listed in table 2.7.

Table 2.7: Constants

Constant	Description	Value
	Accepted hourly wage for husband by education	
$\mu_{m,h}$	high school graduate	16.94
$\sigma_{m,h}$		(13.26)
$\mu_{m,c}$	at least college graduate	25.492
$\sigma_{m,c}$		(17.32)
	Accepted hourly wage for wife by education	
$\mu_{f,h}$	high school graduate	14.18
$\sigma_{f,h}$		(16.46)
$\mu_{f,c}$	at least college graduate	20.65
$\sigma_{f,c}$		(18.68)

2.4.2 Estimation Strategy: Simulated Method of Moments

We start with characterizing the underlying economic environments (offer arrival rates, preferences, departure rates, sharing rule, etc.) through a vector of parameters θ. Given a set of θ, we solve the individual optimization problem by the dynamic programming. By aggregating across all the heterogeneous individuals in our economy, we can generate the simulated variables as model predictions to match with those observed variables from data.

Using simulated method of moments, I estimate parameter vector θ by matching simulated moments with sample moments. The estimated parameters aim to minimize the distance between a set of simulated moments and sample moments, and bring them as close as possible.

$$\min_{\theta} (\psi_d - \psi_s(\theta))' {W_T}^{-1} (\psi_d - \psi_s(\theta))$$

where ψ_d are sample moments, and $\psi_s(\theta)$ are the simulated moments from model conditional on a set of parameters, θ. W_T is the optimal weighting matrix that accounts for the scale differences of moments, and it places greater weights to moments with less variance. The algorithm of estimation is described in appendix E.

2.4.3 Econometric Specification

So our model is characterized by a vector of parameters.

$$\theta = (\lambda_{ft}, \lambda_{pt}, \alpha_m, \alpha_f, \gamma, \delta_m, \delta_f, a_0, a_1, a_2, a_3, D_a).$$

Wage offer is drawn from a log-normal distribution with mean $\mu_{i,j}$ and standard error $\sigma_{i,j}$, where $\{\mu_{i,j}, \sigma_{i,j}\}$ denotes the mean and standard error of wage offer distribution for spouse $i \in \{m, f\}$ with education level $j \in$ {high school graduate, college graduate}. The wage offer distribution differs by gender and education as in table 2.7.

Job offer arrival rates $\{\lambda_k, k = ft, pt\}$ define a Poisson process for full-time and part-time jobs. Spousal i preference of consumption over leisure is characterized by the weighting index $\{\alpha_i, i = m, f\}$, and γ denotes the risk aversion in the form of Constant Elasticity of Substitution (CES). And $\{\delta_k, k = m, f\}$ give job destruction rates of men and women, respectively.

$a_0 - a_3$ define the sharing rule that the income allocated to husbands for consumption as a function of wage incomes and non-labor income as in Chiappori (2002). And D_a give the depreciation rate of the income-related coefficients if husbands not working.

Finally, the moments we used for estimation relating to employment rates and wages correlation are presented as in table 2.8. Identification issues are discussed in appendix G.

Table 2.8: Moments from Data

Moment	Value
% of unemployed husband	.0314
% of unemployed wife	.1368
% of employed husbands if wives employed	.9712
% of employed wives if husbands employed	.8655
% of full-time husbands if wives employed full-time	.9797
% of full-time wives if husbands employed full-time	.7284
% of full-time working husband if employed	.9811
% of full-time working wife if employed	.7311
% of working husband get unemployed in 5 periods	.0167
% of working wife get unemployed in 5 periods	.0345
% husbands remain not employed after 5 periods	.3754
% wives remain not employed after 5 periods	.7361
% husbands full-time employed after 5 periods from unemployment	.2098
% wives full employed after 5 periods from unemployment	.0368
Wage Correlation between husbands and wives	.2248

2.5 Results and Discussion

2.5.1 The Estimates

This section discusses the estimated results and their economic interpretations. In total we have 15 moments from data and 11 parameters to estimate.

The simulated moments compared to sample moments is presented in table 2.9. It depicts the fitness of model. Moreover, the t-statistics of estimates indicates that model predictions are significant, and estimates are quite close for moments.

Table 2.10 contains the estimates of parameters. Overall, our model matches closely between simulated moments and sample moments and most estimates are significant at the 5% level.

Offer arrival rate for full-time jobs, λ_{ft}, is .3731; and for part-time job, λ_{ft}, is .1966. This means on average every three months unemployed people have one

Table 2.9: Estimation Results

	Sample Moment	Simulated Moment
% of unemployed husband	.0314	.0348
% of unemployed wife	.1368	.1266
% of employed husbands if wives employed	.9712	.9687
% of employed wives if husbands employed	.8655	.8867
% of full-time husbands if wives employed full-time	.9797	.9642
% of full-time wives if husbands employed full-time	.7284	.7394
% of full-time working husband if employed	.9811	.9510
% of full-time working wife if employed	.7311	.7357
% of working husband get unemployed in 5 periods	.0167	.0147
% of working wife get unemployed in 5 periods	.0345	.0233
% husbands remain not employed after 5 periods	.3754	.4297
% wives remain not employed after 5 periods	.7361	.7741
% husbands full-time employed after 5 periods from unemployment	.2098	.1787
% wives full employed after 5 periods from unemployment	.0368	.0484
Wage Correlation between husbands and wives	.2248	.2344

Within the parentheses are standard deviations of hourly wage respectively.

Table 2.10: Parameters Estimates

Parameter	Definition	Estimated Value	Standard Error
λ_{ft}	offer arrival rate for full-time job	.3731	.0008
λ_{pt}	offer arrival rate for part-time job	.1966	.0010
α_m	Husbands preference for consumption over leisure	.1540	.0003
α_f	Wives preference	.1523	.0007
γ	Risk Aversion Index	1.3133	.0040
δ_m	Job Destruction Rate for Husbands	.0041	.0000
δ_m	Job Destruction Rate for Wives	.0038	.0000

Parameter estimates are from data SIPP 2001.
Assume that time discount factor is .996 on a monthly basis.

full-time offer; every five months there comes one part-time offer. The risk aversion is 1.3133 with standard error .004.

As to individual preference of consumption over leisure, the weighting index for husbands, α_m, is .1540, greater than that of wives α_f with the value of .1523, while the standard error are .0003 and .0007, respectively. We next test the null hypothesis that husbands and wives have the same preferences over leisure.

$$H_0: \quad \alpha_m - \alpha_f = 0, or, \alpha_m - \alpha_f \leq 0,$$

$$H_1: \quad \alpha_m - \alpha_f \geq 0,$$

since the t value

$$\frac{\alpha_m - \alpha_f}{\sqrt{\frac{s^2_{\alpha_m}}{n_m} + \frac{s^2_{\alpha_f}}{n_f}}} = \frac{.1540 - .1523}{\sqrt{\frac{s^2_{.0003}}{n_m} + \frac{s^2_{.0007}}{n_f}}} = 20.3119$$

is greater than t-statistics $t_{\infty,.05} = 1.645$, the null hypothesis is rejected. That is, husbands and wives have different priority for leisure and wives prefer leisure.

Table 2.11: Sharing Rule $\phi(w_m, w_f, y) = a_0 + (E_m + (1 - E_m)D_a)(a_1 w_m + a_2 \log w_f + a_3 y)$

Coefficient of Quasi- Sharing Rule	Definition	Estimated Value	Standard Error
a_0	constant	12.0805	.0189
a_1	husband wage	.5097	.0011
a_2	of wife employment	-1.9257	.0038
a_3	if both employed	.5426	.0005
D_a	Depreciation of Unemployed Husbands	.8201	.0007

Employment status of husbands E_m is 1 when employed and 0 otherwise.

The sharing rule, $\phi(w_m, w_f, y)$, gives the proportion of household income used by husband for private consumption as in table 2.11. If husbands are working, the sharing rule is in the form of the equation below.

$$\phi(w_m, w_f, y) = \underset{(.0189)}{12.0805} + \underset{(.0011)}{.5097 w_m} - \underset{(.0038)}{.1981\ log w_f} + \underset{(.0005)}{.5426 y}. \tag{2.5}$$

But if husbands are not working, we have

$$\phi(w_m, w_f, y) = 12.0805 + \underset{(.0007)}{.8201} \quad (.5097 w_m - \ .1981\ log w_f + .5425 y). \tag{2.6}$$

At the 5% level, the estimates of sharing rule are significant. Here w_m and w_f are wage earnings of husbands and wives. From equation (2.5), higher husbands wage earnings, more private consumption they enjoy. One percent rise in husbands' wages raises .51 percent of their private consumption. But when wives earns more, more money is shared by wives.

Finally, we discuss the bargaining aspects within household. As shown in table 2.11, if husbands work, around 54% of household other income is consumed by husbands, and husbands transfer the rest of non-labor income to their wives. If husbands do not work, as in equation (2.6), they take only 45% of the other income.

This difference implies that the non-labor income shared by husbands is responsive to his employment status. This partly explains why husbands are more likely to work. Ignoring the intra-household income distribution between husbands and wives, we could make misleading remarks.

2.5.2 Overidentification Test

The number of moments, 15, is larger than that of parameters to estimate, 12. So our model is over-identified. Only 12 moments are required to just identify the vector of parameters, therefore, the remaining restrictions are used to evaluate this model. Under the null hypothesis of the model being the true one, the added moments are supposed to be closed to the true value of parameters. The overidentification test is specified as below.

$$T(\psi_d - \psi_s(\theta))' {W_T}^{-1} (\psi_d - \psi_s(\theta)) \rightarrow \chi^2(15-12).$$

In practice, we get the computed criterion function at the estimated parameters, 6.99, is less than a chi-square critical value 7.81 at the 5% significance level. So the null hypothesis is not rejected.

2.6 Implication of Sharing Rule: Back to SIPP 2001 Data

In this section, we further explore the implication of the recovered sharing rule. Assume y_f is the money transfer from husbands to wives, that is,

$$y_f = w_m - c_m = w_m - \phi$$

. The money transfer from husbands to wives is therefore equal to

$$\begin{aligned} y_f &= w_m - (a_0 + (E_m + (1 - E_m)D_a)(a_1 w_m + a_2 \log w_f + a_3 y)) \\ &= -a_0 + (1 - (E_m + (1 - E_m)D_a)a_1)w_m \\ &\quad -(E_m + (1 - E_m)D_a)(a_2 \log w_f + a_3 y). \end{aligned}$$

The monthly transfer from husbands to wives, based on estimation in our sample, is \$1355.30 in 2001 dollar with standard error being \$2292.21.

The female labor supply implied by the estimates is

$$\begin{array}{l} h_f = -.5472 \quad +.1981 \; log w_f - \quad .000024 \; y_f. \\ \qquad\quad (.0094) \qquad (.0012) \qquad (6.14e-7) \end{array}$$

where $h_f \in [0, 1]$ and $h_f = 1$ if working full-time, w_f are wages of wives.

All the three estimates are significant at the 1% level. As we have expected, the coefficient of other income of wives has a negative sign, suggesting the income effect. Higher wage increases the hours worked. The implied wage elasticity is 0.57.

Also the implied participation frontiers are

$$\begin{array}{l} w_m* = 2.8637 + \quad .2614 \; log w_f - . \quad 0085 \; y_f. \\ \qquad\qquad (.3058) \qquad (.0403) \qquad (.0002) \end{array}$$

Then we make the derivative of husband reservation wage over that of wives to further analyze the incentive of wives' wage onto husbands within the family.

$$\frac{\partial w_m*}{\partial w_f} = .2614\frac{1}{w_f} - .0085\frac{\partial y_f}{\partial w_f} = .2614\frac{1}{w_f} - .0085(-D_a a_2\frac{1}{w_f}) = \frac{.2600}{w_f} > 0$$

If wives have higher wages, husbands tend to hold higher reservation wages. More money husbands transfer to their wives, lower reservation wage they set.

2.7 Conclusion

Overwhelming majority of research on household labor supply ignored the bargaining among couples. This simplification, though convenient, causes endogeneity issue, especially for household job search decision. This chapter builds up a structural model to simulate the dynamic household labor supply decisions, and provides an empirical alternative to deal with this complex problem.

Our recovered sharing rule shows that, higher male wage earning and lower female earnings and more non-labor income, husbands consume more. The most notable result is that, husbands share of household income is responsive to their employment status: when husbands work, they take away 54% of household other income; but when they do not work, they are left with only 45% of other income. Husbands private consumption shrink to around 82% of their original amount when they are working. This sensitivity of husbands consumption to employment status shows the existence of bargaining within a family.

Chapter 3

Intrahousehold Bargaining and Gender Asymmetry in Household Unemployment Duration

3.1 Introduction

This chapter examines the household unemployment duration in the U.S. The literature on individual-level unemployment duration is rich. Several empirical work used structural search models to study the individual search behaviors as in Yoon (1981), Lancaster (1979), Lancaster and Chesher (1983), Lynch (1983), Narendranathan and Nickell (1985), Wolpin (1987), Pissarides (1982) and Burdett (1979). So is the thereafter research of unemployment insurance, which is based on the individual-level theoretical framework as in Meyer (1990), Katz and Meyer(1990 I and 1990 II), Gibbons and Katz (1991). Household unemployment duration, however, is comparatively not thoroughly studied.

Our question is, for those married, does the spousal wage affect their job search and unemployment spells? The importance of looking into this issue lies in the following. If household search decisions can be simplified to two independent individuals, then we are safe to work with this question. Otherwise, household job search might deviate from the standard individual search model. In this case, studying of unemployment duration need further scrutiny. With this in mind, we need to study whether husbands and wives share the same pattern in job search.

Ahn and Ugidos-Olazabal (1995) mentioned that in Spain household heads have twice larger job-finding probability than non-heads, and having other working household members improves employment probability, suggesting that family connections in the labor market are important determinants of unemployment duration.

Danish data, as claimed in Lentz and Trans (2005), show a gender asymmetry in job search. That is, if husbands earn more, wives experience a longer unemployment duration; but if wives earn more, husbands find jobs sooner. There arises a natural question – does this pattern also apply to the U.S.? We realize that empirical tests of the household unemployment duration requires a sizable observation of unemployment spells for both husbands and wives, which is hard to guarantee based on the available survey data in the U.S.. This chapter provides an alternative to this problem.

Our strategy is as follows. First we build up a household search model, and after parameterization with SIPP 2001 data we could recover household decision rules. Using estimated underlying economic environments and individual decision rules, we simulate a sizable observations of unemployment spells that are finally used to derive the pattern of the U.S. couples in job search.

The main contribution of this chapter is three-fold. (1) This work fills in the existing gap on household job search. Until now most studies pertaining to job search are addressed at the individual level, while the majority of the empirical work is based on household data. The discrepancy between individual-level search theory and household-level data invokes needs to study a household search model.

Flinn (2006) and Mabli (2006) examined the dynamic household labor supply in the form of household utility. What distinguishes our work from theirs is the use of individual utility. This chapter relaxes the traditional assumption of household utility and introduces intra-household bargaining between husbands and wives through the collective model.

Research on intra-household allocation, in microeconomics, is quite rich. Chiappori (1992), Browning and Chiappori (1994, 1998) proposed the collective model, in which multiple agents in household are characterized by their own preferences, and consumption of each spouse is the outcomes of bargaining. The traditional treatment of household as a decision unit represented by the household header, though attractive and convenient, failed in family internal decision as mentioned in Chiappori (1992, 1998). In this chapter we adopt the collective framework, letting the sharing rule be husbands private consumption. Under this framework I build up a discrete household search model. To the best of my knowledge, it is the first model to study dynamic couples Nash game in labor supply.

(2) This search model is adequate for empirical estimation at the household level. The household decision rules and sharing rule that we recovered support the existence of the bargaining between husbands and wives, and show how intra-household bargaining affects household labor supply decisions. In the past literature the difficulty of empirical tests come from two aspects. One aspect is the endogeneity issue. Under dynamic setting, intra-household distribution – the share of household income distributed to husbands and wives – depends on couples' employment status and earnings. Moreover, decisions of labor supply depend on intra-household bargaining and wage offered. The other aspect is, the available data contain limited information on intra-household income allocation because private consumption of husbands and wives is mostly unobservable. In addition, panel data at the household level are required to track household job search. The unobserved consumption data together with endogenous dynamic decisions make this task intractable.

In estimation by Simulated Methods of Moment (SMM), we use a set of key parameters to describe the underlying economic environment and individual decisions such as arrival rate and the sharing rule. Given one set of parameters, we simulate a group of variables on household employment transition and realized wage. Our goal is to find the set of parameters so that the simulated variables are as close as possible to those variables from SIPP data. This approach efficiently utilizes the available survey data of labor market performance, and enables further empirical tests on intra-household allocation.

(3) We derive the job search behaviors of the U.S. couples. Using the empirical estimation of dynamic household labor supply, and the sharing rule – the compromised decision of married couples – we simulate a sizable observations of household unemployment spells that mimic the original data. Semiparametric estimation techniques as in Meyer (1990) are used to derive the pattern of household unemployment duration.

Our results reveal that, husbands consumption is sensitive to their employment status. If husbands are working, they take 54% of non-labor income, but unemployed husbands suffer a loss in the share of household income and his share falls to 45% of non-labor income. This difference indicates the existence of bargaining between husbands and wives. The social norm that men are breadwinners could explain the decrease of the bargaining power of husbands.

We also find that on average the monthly transfer from husbands to wives is $1355. The recovered women labor supply indicates that higher women wage and lower share from family raises women labor supply, suggesting that for wives, the income effect dominates their labor supply decisions. Meanwhile, the wage frontier of husbands are positively correlated to wives wages and negatively correlated to the transfer to wives, meaning that husbands decisions are subject to both income effect and intrahousehold bargaining.

Finally, the calculated household unemployment duration shows that when husbands earn more, wives search longer for jobs; if wives earn more, the impact on husbands unemployment duration is mixed. In particular, without controlling the unobserved individual heterogeneity, husbands find jobs sooner.

The chapter is organized as follows. Directly applying the family decision rules recovered in chapter 2, in section 2 we derive job search pattern of the U.S. couples and make conclusions in section 3.

3.2 Derive Unemployment Duration of the U.S. Couples

At the household level, unemployment duration based on the U.S. data is little empirically tested. In SIPP 2001, we have come to a limited number of observation for unemployed spells. It is large enough to recover the underlying economic environments of our model, but not sufficient to directly conduct the empirical tests of household unemployment duration.

Here we provides an alternative to this problem. Using the family decision rules and sharing rule we recovered in chapter 2, we simulate a large size ($n = 5000$) of data that mimic the property of SIPP 2001 sample. We realize that families with different number of children and education level might differ in their decision rules. But given that our sharing rule is recovered as that of the representative family, our simulated data attempt to derive household unemployment duration for the representative family in the U.S. Further work is required to study the sharing rule for groups of families with different education level and number of children. And I will leave this for the future work. So in this chapter, we derive the unemployment duration of the U.S. couples from the simulated data.

3.2.1 Duration Model

To examine the impact of spousal wage on the hazard rate of unemployment spells of individual workers, we use the estimation approach that is discussed in Meyer (1986, 1990). The shape of the hazard is estimated nonparametrically. The hazard is parameterized using a proportional hazards form.

$$\Lambda_i(t) = \Lambda_0(t)e^{z_i' b}$$

where $\Lambda_0(t)$ is the baseline hazard at time t, z_i is a set of explanatory variables for individual i, and b gives a vector of coefficients of explanatory variables.

The probability of a spell lasting until $t+1$ given that it lasts t periods already is written as a function of hazard.

$$P[T_i \geq t+1 | T_i \geq t] = e^{-e^{(z_i{}'b + \Gamma(t))}},$$

where

$$\Gamma(t) = ln(\int_t^{t+1} \Lambda_0(u)du)$$

is unknown. Let $\Delta_i = 1$ if the unemployment spell is right censored and 0 otherwise, and k_i is the observed unemployment duration of individual i. As is discussed in Meyer (1990), the corresponding log-likelihood function is now a function of Γ and coefficient vector b.

$$L(\Gamma, b) = \sum_{i=1}^{N} [\Delta_i log(1 - e^{-e^{(\Gamma(k_i) + z_i(k_i)'b)}}) - \sum_{t=1}^{k_i - 1} e^{\Gamma(t) + z_i(t)'b}].$$

If we consider the unobserved heterogeneity, which is assumed to be independent of explanatory variables z_i, the hazard is

$$\Lambda_i(t) = \Theta_i \Lambda_0(t) e^{z_i{}'b},$$

where Θ_i is the unobserved heterogeneity. Assume that Θ follows the gamma distribution with mean ones and variance Σ^2 . By Prentice and Gloeckler (1978) model, the likelihood function is

$$L(\Gamma, b, \Sigma) = \sum_{i=1}^{N} [-\Delta_i (1 + \Sigma^2 \sum_{t=0}^{k_i} e^{\Gamma(t) + z_i(t)'b}) + (1 + \Sigma^2 \sum_{t=0}^{k_i - 1} e^{\Gamma(t) + z_i(t)'b})].$$

3.2.2 Results

Using Maximum Likelihood Estimation, we obtain the measures of coefficients and Γ distribution. Besides education level and gender, spousal wage and the number

Table 3.1: Hazard Model Estimates

Variables	Without Unobserved Heterogeneity	With Unobserved Heterogeneity
Is Female	.0069**	.0038**
	(.0027)	(.0016)
College Graduate	-.0664	-.0426
	(.0601)	(.0315)
Spousal Wage	-.0011**	.0002
	(.0004)	(.0022)
Number of Children (age $\leq$ 7)	.0002	.0035
	(.0017)	(.0036)
Number of Children (age 7 $\leq, \leq$ 18)	-.0013	.0034
	(.0067)	(.0126)
Is Female $\times$ Spousal Wage	.0029**	.0086**
	(.0007)	(.0039)
Estimates of Σ		.2207**
		(.0037)
Controlling for Unobserved Heterogeneity	No	Yes

Standard errors are shown in parentheses.
** Variables are 5% significant.

of children are included in the explanatory variables z_i. The results for estimation with and without heterogeneity are reported in table 3.1.

The coefficient of interaction of being female and spousal wage shows that for wives, higher spousal wages increase the hazard. Using the coefficient estimates of without heterogeneity, a 10 percent increase in spousal wage is associate with an .029 percent increase in the hazard.

Meanwhile, the estimate of being women is positive significantly at the value of .0069 and .0038, respectively, suggesting that wives are more likely to endure a longer unemployment.

The impact of spousal wage only is mixed. The coefficient of spousal wage, using the specification of without unobserved heterogeneity, is at the value of -.0011. This estimate is significant at the 5% level. It reveals that for husbands, on the contrary, higher spousal wages decrease the hazard and therefore husbands are expected to find jobs sooner as their wives earn more.

When wives' wage increases by 10 percent, the hazard falls by .011 percent. For wives, the total effect of spousal wage is at the value of .0018, the sum of coefficients of both specifications $-.0011 + .0029$, suggesting that the increase in spousal wage raises wives' hazard rate. This is consistent with our former analysis of coefficient of interaction item.

But using specification of including the unobserved heterogeneity of individuals in our model, the estimates do not show that spousal wage is significant. So under this setting, we are uncertain of the impact on husbands.

Overall, from the simulated data we find that in the U.S., higher spousal wage increases the hazard of wives, and this effect is due to the insurance of spousal income against unemployment risk, which makes it more affordable for wives to search longer until they find a more desirable job with higher reservation wage. For wives, their decisions are dominated by income effect.

However, the impact of spousal wage on husbands is mixed, and as far as we study, it depends on the specifications. So both income effect and intrahousehold bargaining take into effect. The final effect depends on which force dominates.

3.3 Conclusion and Future Work

Overwhelming majority of research on household labor supply ignored the bargaining among couples. This simplification, though convenient, fails to deal with the family internal decisions.

This chapter makes a theoretical contribution in constructing an individualized household search model that fills in the existing gap between the individual-level search model and the household-level data. We simulate the dynamic household labor supply decisions, and provides an empirical alternative to study the unemployment duration of the U.S. couples.

Our recovered sharing rule shows that, the more husbands earn, the lower wives earn and the more non-labor income that the family produces, husbands consume more. The most notable result is that, husbands share of household income is responsive to their employment status: when husbands work, they take away 54% of household other income; but when they do not work, they are left with only 45% of other income. Husbands private consumption shrink to around 82% of their original amount when they are working. This sensitivity of husbands consumption to their employment status reveals the existence of bargaining within a family.

By estimating the simulated data with maximum likelihood methods, our study indicates that in the U.S. when husbands earn more, wives take a longer time to find jobs. But the effect of spousal income on husbands unemployment duration is mixed. Further study is needed to scrutinize this issue when home production are considered.

Appendices

Appendix A

Reservation Value of Being Married

In this section, we present the process of men to obtain reservation value by the cut-off rule that marrying to those with reservation value is equivalent to being single.

$$\begin{array}{ccc} V_m(w) & = & W(w, R_m), \\ & = & \frac{wR_m/2+\beta\delta V_m(w)}{1-\beta(1-\delta)}, \\ & \Longrightarrow \frac{wR_m}{1-\beta}. & \end{array} \tag{A.1}$$

From the value function of being single, we have

$$V_m(w) = \frac{w + \beta\lambda_m \int_{R_m}^{\bar{w}_m} W(w, w') f_w(w') \Delta_{w,w'} dw'}{1 - \beta + \beta\lambda_m \int_{R_m}^{\bar{w}_m} f_w(w') \Delta_{w,w'} dw'.} \tag{A.2}$$

Then we plug the above equation (A.2) into equation (A.1), we get

$$\begin{array}{rcl} (1-\beta)V_m(w) + \beta\lambda_m \int_{R_m}^{\bar{w}_m} [V_m(w) - \frac{ww'+\beta\delta V_m(w)}{1-\beta(1-\delta)}] f_w(w') \Delta_{w,w'} dw' & = & w \\ \Longrightarrow & & \\ wR_m/2 + \beta\lambda_m \int_{R_m}^{\bar{w}_m} \frac{w(R_m - w')}{1-\beta(1-\delta)}] f_w(w') \Delta_{w,w'} dw' & = & w \\ \Longrightarrow & & \end{array}$$

$$R_m(w) = 2 + \frac{\beta\lambda_m}{1-\beta(1-\delta)} \int_{R_m}^{\bar{w}_m} (w_w - R_m) f_w(w') \Delta_{w,w'} dw'.$$

By symmetry, we could get the reservation function for women in the form as below.

$$R_w(w') = 2 + \frac{\beta\lambda_w}{1-\beta(1-\delta)} \int_{R_w}^{\bar{w}_m} (w - R_w) f_m(w) \Delta_{w,w'} dw$$

Appendix B

Algorithm of Computing Steady State Equilibrium (SSE)

We describe below the algorithm we use to compute the steady state equilibrium given a vector of parameters θ. Here the definition of parameter vector θ is same as in the estimation section of empirical implementation.

1. Define a set of parameters θ,

$$\theta = \{\lambda_m, \lambda_w, \delta, \beta, \mu, \sigma\}.$$

It provides the key economic environments such as arrival rate, divorce rate, time discount factor and wage offer distribution.

2. Compute the reservation function of Nash Equilibrium (NE) for men and women by finding solution to the below equations.

$$\begin{aligned} R_m(w) &= 2 + \frac{\beta\lambda_m}{1-\beta(1-\delta)} \int_{R_m}^{\bar{w}_m} (w_w - R_m) f_w(w') \Delta_{w,w'} dw', \\ R_w(w') &= 2 + \frac{\beta\lambda_w}{1-\beta(1-\delta)} \int_{R_w}^{\bar{w}_m} (w - R_w) f_m(w) \Delta_{w,w'} dw. \end{aligned}$$

- Randomly draw wage offer from log-normal distribution defined by $\{\mu_i, \sigma_i\}_{i=m,w}$.

$$log(w_i) \sim N(\mu_i, \sigma_i).$$

So we generate $f_{\{w_i\}_{i=m,w}}(\cdot)$. In particular, we use the algorithm given in Proposition 4.

- Based on reservation wage equations from cut-off rules, we derive the reservation function $R_m(p)$ that is the solution of the function below.

$$0 = R_m(w) - 2 - \frac{\beta\lambda_m}{1-\beta(1-\delta)}\int_{R_m}^{\bar{w}_w}(w_w - R_m)f_w(w_w)\Delta_{w,w_w}dw_w \ = 0.$$

Similarly I have for $R_f(w)$.

3. Simulate the matching process given the reservation functions from Nash Equilibrium.

   - Simulate the offer of marriage arrival between $[0, 1]$ for 5000 men and women from time t=1 to t=500, so we get a matrix M in the size of $5000(1 + sex\ ratio) \times 500$. If the element of M is greater than the arrival rates, an offer arrives; otherwise, this period the individual meet nobody.
   - Initially at t=1, individuals are randomly endowed the wage drawn from a log-normal distribution $N(\mu, \sigma)$. And they are assumed to be single.
   - At t=2, based on the mating offer matrix $M(:, 2)$, if mating offer arrives and the potential partner is above the reservation value, the individual will get married and quit the marriage market. Otherwise, the individual remains single and wait for the next period.
   - At time t, $t \geq 2$, we start with probability δ that married individuals get divorce and re-enter the marriage market. Then, the singles decide to propose or not if meet someone. Finally, the singles quit the marriage market if both sides agree to marry.

4. Repeat the above simulated matching process until a balanced flow is obtained: the population that enter the marriage market equals the population that exit the marriage market. If the stationary equilibrium (convergence) is obtained, return the moments of single ratio for both genders. These moments are used to match those moments from data and estimate the model.

Appendix C

Proof of Propositions

Here we presents the proof of proposition in the existence of equilibrium.

Proposition 1

Proof. The value function of being single as equation (1.1),

$$V_m(w) = \frac{w + \beta\lambda_m \int_{R_m}^{\bar{w}_w} W(w, w'')f_w(w'')\Delta_{w,w''}dw''}{1 - \beta + \beta\lambda_m \int_{R_m}^{\bar{w}_w} f_w(w'')\Delta_{w,w''}dw''}$$

From equation (1.2), the value function of marrying women with wage w' is

$$W(w, w') = \frac{ww'/2 + \beta\delta V_m(w)}{1 - \beta(1 - \delta)}.$$

Since $W(w, w')$ is increasing in w', and $W(\cdot, \cdot), V_m(\cdot)$ are continuous, the continuity and increasing property guarantee the existence and uniqueness of $w'^* = R_m$ that holds equations (1.1) and (1.2). □

Proposition 3

Proof. Since the best men are always accepted, i.e., $\forall w', \Delta_{\bar{w}_m,w'} = 1$ holds. we substitute the decision rule of the best men into equation (1.3),

$$R_m(\bar{w}_m) = 2 + \frac{\beta\lambda_m}{1 - \beta(1 - \delta)} \int_{R_m}^{\bar{w}_w} (w' - R_m)f_w(w')dw' \qquad \text{(C.1)}$$

here R_m is short for $R_m(\bar{p}_m)$. By definition, we know that $R_m^1 = R_m(\bar{p}_m)$. Then we have partial derivatives with respect to reservation value R_m for both sides of equation (1.3).

Left hand side of equation has *lhs*: $= 2 > 0$,

while right hand side *rhs*: $= -\frac{\beta\lambda}{1-\beta(1-\delta)}(1 - F_w(R_m)) < 0$,

Define

$$L = -R_m(\bar{w}_m) + 2 + \frac{\beta\lambda_m}{1-\beta(1-\delta)}\int_{R_m}^{\bar{w}_w}(w' - R_m)f_w(w')dw'. \tag{C.2}$$

By continuity of function L, there exists an unique value of $R_m^1 = R_m(\bar{w}_m)$ so that $L = 0$. Then the best men with $\bar{w}_m$ are willing to propose to all the women in the acceptance set $[R_m^1, \bar{w}_w]$.

Since women with $w' \in [R_m^1, \bar{w}_w]$ are accepted by the best men, the rest of men are also willing to propose to them, i.e., $\forall w, \Delta_{w,w'} = 1$. The reservation function of these women is

$$R_w(w') = 2 + \frac{\beta\lambda_w}{1-\beta(1-\delta)}\int_{R_w}^{\bar{w}_m}(w - R_w)f_m(w)dw \tag{C.3}$$

In the special case that $w' = \bar{w}_w$, by the same logic of reaching equation (5) and (6), an unique value of $R_w^1 = R_w(\bar{w}_w)$ satisfies equation (7). Since the solution of equation (7) is unique, all the women falling in $[R_m^1, \bar{w}_w]$ share the same reservation value with the best women at R_w^1.

Similarly, men in $[R_w^1, \bar{w}_m]$ are shown to have the same reservation as the men with $\bar{w}_m$. That is,

$$R_m(R_w(\bar{w}_w)) = 2 + \frac{\beta\lambda_m}{1-\beta(1-\delta)}\int_{R_m(R_w(\bar{w}_w))}^{\bar{w}_w}(w' - R_m)f_w(w')dw' \tag{C.4}$$

By the uniqueness of $R_m(\cdot)$, hereby $R_m(R_w(\bar{p}_w)) = R_w(\bar{p}_m) = R_w^1$.

Therefore, all the men falling in $[R_w^1, \bar{w}_m]$ are willing to propose to women in the set of $[R_m^1, \bar{w}_w]$ by equation (3) and $\forall w \in [R_w^1, \bar{w}_m] and \forall w' \in [R_m^1, \bar{w}_w], \Delta_{w,w'} = 1$.

As illustrated in figure 1.1, all the population falling in $[R_m^1, \bar{w}_w] \times [R_w^1, \bar{w}_m]$ accept each other. They are categorized as people in Class 1. $\square$

Proposition 4

Proof. Class 1 is defined as $[R_w^1, R_w^0 = \bar{w}_m] \times [R_m^1, R_m^0 = \bar{w}_w]$ and people in Class 1 marry each other, which is proved in proposition 4. We can reach the similar form of other classes by backward induction. The process is shown as follows.

After excluding the people falling in class 1 from the whole population, nowadays the best men and women available are $\{\bar{w}'_m = R_w^1, \{\bar{w}'_m = R_m^1\}$. As proved in Proposition 4, we can define a new class by $[R_w^2, R_w^1] \times [R_m^2, R_m^1]$ – Class 2, where $\{R_m^2, R_w^2\}$ can be obtain from equations (5) and (7). We repeat the process of exclusion and generating new classes. Finally, we stop until all the people are falling in some class.

If one sex have one more class than the other, i.e., $\delta_n = -1$ or 1, those in the final class have no opportunity to match. $\square$

Appendix D

Value Functions

The formulae are displayed below are the value functions for husbands under the three other states: {both unemployed, husband employed but wife not employed, both employed}. The definition of value function and reservation function are same as described in the contexts.

- Both unemployed

$$W^m(0,0) = u_m(0,0) + \beta\{(1-\lambda_m)(1-\lambda_f)W^m(0,0)$$

$$+(1-\lambda_m)\lambda_f[\int_{R_f(0,0)} W^m(0,w'_f)dF(w'_f) + \int^{R_f(0,0)} W^m(0,w'_f)dF(w'_f)]$$

$$+\lambda_m(1-\lambda_f)[\int_{R_m(0,0)} W^m(w'_m,0)dF(w'_m) + \int^{R_m(0,0)} W^m(0,0)dF(w'_f)]$$

$$+\lambda_m\lambda_f\{\int_{R_f(0,0)}\int_{R_m(0,w'_f)} W^m(w'_m,w'_f)dF(w'_m)dF(w'_f)+\int_{R_f(0,0)}\int^{R_m(0,w'_f)} W^m(0,w'_f)dF(w'_m)d$$

$$+\int^{R_f(0,0)}\int_{R_m(0,0)} W^m(w'_m,0)dF(w'_m)dF(w'_f)+\int^{R_f(0,0)}\int^{R_m(0,0)} W^m(0,0)dF(w'_m)dF(w'_f)]\}$$

- Husband employed but wife not employed

$$W^m(w_m,0) = u_m(w_m,0)$$

$$+\beta\{\delta_m[\lambda_f(\int_{R_f(0,0)} W^m(0,w'_f)dF(w'_f) + \int^{R_f(0,0)} W^m(0,0)dF(w'_f))$$

$$+(1-\lambda_f)W^m(0,0)]$$

$$+(1-\delta_m)[\lambda_f\begin{pmatrix} \int_{R_f(w_m,0)} \max\{W^m(w_m,w'_f),W^m(0,w'_f)\}dF(w'_f) \\ +\int^{R_f(w_m,0)} \max\{W^m(w_m,0),W^m(0,0)\}dF(w'_f)\end{pmatrix}$$

$$+(1-\lambda_f)\max\{W^m(w_m,0),W^m(0,0)\}]\}$$

- Both employed

$$W^m(w_m,w_f) = u_m(w_m,w_f) + \beta\{\delta_m\delta_f W^m(0,0)$$

$$+\delta_m(1-\delta_f)((w_f \geq R_f(0,0))W^m(0,w_f) + (w_f < R_f(0,0))W^m(0,0))$$

$$+(1-\delta_m)\delta_f \max\{W^m(w_m,0), W^m(0,0)\}$$

$$+(1-\delta_m)(1-\delta_f)((w_f \geq R_f(w_m,0)) \max\{W^m(0,w_f), W^m(w_m,w_f)\}$$

$$+ (w_f < R_f(w_m,0)) \max\{W^m(0,0), W^m(w_m,0)\})\}$$

Appendix E

Algorithm

To estimate parameters of our model, we need have the number of moments to be equal to, or more than the dimension of parameter vector.

1. From the original sample data, calculate moments as mentioned in table 2.8.

2. For a given set of parameters, θ, and other demographic information from data such as education levels of couples and non-labor income, we deduce a unique set of reservation functions conditional on spousal employment status and wage rates. Reservation function is derived from value function, which is obtained by the fixed point methods.

3. Simulated data are generated from calculated reservation function. Individuals from generated sample are subject to random shocks of losing jobs or receiving wage offers. I, at the initial period, $t = 1$, endow couples in the simulated sample with the same labor market conditions as they are in sample data. Then labor market history for each household i are generated. Thus we can track their employment status transitions across time, where $i = 1, .., 1086$ and $t = 2, .., 36$.

4. Repeating simulation $N_s = 1,000$ times, I obtain simulated moments, and therefore, distance between the simulated moments and sample moments are calculated.

5. We search for the parameters that are constantly updated until minimum distance is received.

$$\theta_{SMM} = arg \min_{\theta} (\psi_d - \psi_s(\theta))' W_T (\psi_d - \psi_s(\theta)) \tag{E.1}$$

Here, weighting matrix is initially generated by bootstrapping the sample moments N_b times, and then the inverse of variance matrix of moments is taken, where $N_b = 1,000$. The standard errors of all the parameter estimates are calculated using the optimal weighting matrix.

Appendix F

Selection Criteria

The criteria that I apply to restrict data are described as below. In light of these, if either husband or wife fails to satisfy the restrictions below, the corresponding household is excluded.

1. Only nuclear family, which is composed of married couples.
2. Only couples who gave complete interviews. The case that only one spouse "present" is excluded
3. Husbands aged between 25 to 50 years, and wives aged between 23-48 years at the beginning wave (wave 1)
4. Neither in armed force now
5. No physical or mental limitation to work
6. Not currently enrolled in school, so no concerns of human capital accumulations
7. Neither receives Food Stamps or AFDC or TANF
8. Exclude families with grandparents or other relatives or disabled children
9. Exclude households whose composition changes occurred due to marriage or divorce
10. Exclude household with a broken history. Husband and wife are required to stay in the sample over all the waves

Appendix G

Identification

We consider the identification issue here. We aim to recover the parameters of wage offered arrival rate. The fraction of unemployed husbands and wives infers arrival rate of job offer and household non-labor income. Household non-labor income is assumed to be exogenous and provided by data. Meanwhile, arrival rates of full-time and part-time jobs can be identified by the proportion of full-time workers compared to that of part-time.

Hazard rate of unemployment is adopted to identify utility function. In static model, employment status is actually labor participation. Under a dynamic model, value of unemployment as well as of being employed can be identified by individuals' employment transition across time. I set a monthly rate for time discount factor $\beta = .996$ and job destruction rate $\delta = .004$. The dynamic transition identifies the marginal utility for working. For example, a wife may quit job when her husband gets a good job offer; and her marginal benefit from working are offset by her value for leisure and private consumption from the husband's income.

Couples preferences for leisure are captured by education information from data. It is also featured by intra-household sharing rule and their preferences of consumption over leisure. The latter two, as in a standard job search model, without data on their actual value, have to be identified by function form. And the sharing rule can be estimated by combining percentage of no-working population and unemployment duration.

Bibliography

Ahn, Namkee and Arantza Ugidos-Olazabal, "Duration of Unemployment in Spain: Relative Effects of Unemployment Benefit and Family Characteristics," *Oxford Bulletin of Economics and Statistics*, 1995, *57(2).*

Apps, Patricia F. and Ray Rees, "Taxation of Couples," *IZA Discussion Paper No. 2910. Available at SSRN: http://ssrn.com/abstract=1000899*, July 2007.

Becker, Gary S, "A Theory of Marriage: Part I," *Journal of Political Economy*, 1973.

_ , "A Theory of Marriage: Part II," *Journal of Political Economy*, 1974, *82(2).*

Becker, Gary S., "A Theory of Social Interactions," *Journal of Political Economy*, 1974, *82(6).*

_ , "Altruism in the Family and Selfishness in the Market Place," *Economica*, 1981, *48(189).*

_ , *A Treatise on the Family*, Enlarged edition. Cambridge, MA: Harvard University Press, 1991.

Becker, Gary S, Elisabeth M Landes, and Robert T Michael, "An Economic Analysis of Marital Instability," *Journal of Political Economy*, December 1977, *85(6).*

Bergstrom, T and RF Schoeni, "Income prospects and age-at-marriage," *Journal of population economics*, 1996, *9(2).*

Bergstrom, Theodore C and Mark Bagnoli, "Courtship as a Waiting Game," *Journal of Political Economy*, 1993, *101(1).*

Blau, F.D., L.D. Kahn, and J. Waldfogel, "Understanding Young Women's Marriage Decisions: The Role of Labor and Marriage Market Conditions," *Industrial and Labor Relations Review*, 2000, *53.*

Browning, M. and P. A. Chiappori, "Efficient Intra-Household Allocations: A General Characterization and Empirical Tests," *Econometrica, Econometric Society*, November 1998, *66(6).*

Burdett, Ken and Melvyn Coles, "Long-Term Partnership Formation: Marriage and Employment," *Economic Journal*, 1999, *109.*

_ **and Melvyn G Coles**, "Marriage and Class," *The Quarterly Journal of Economics*, 1997, *112(1).*

_ **, Ricardo Lagos, and Randall D. Wright**, "Crime, Inequality, and Unemployment, Second Version," *PIER Working Paper No. 03-029*, 2003, *September.*

Burdett, Kenneth, "Unemployment Insurance Payments as a Search Subsidy: A Theoretical Analysis," *Economic Inquiry*, 1979, *17(3).*

Chiappori, Pierre-Andre, "Collective labor supply and welfare," *Journal of Political Economy*, 1992, *100.*

_ **, Bernard Fortin, and Guy Lacroix**, "Marriage Market, Divorce Legislation, and Household Labor Supply," *Journal of Political Economy*, February 2002, *110(1).*

_ **, R. Blundell, and C. Meghir**, "Collective Labor Supply With Children," *Journal of Political Economy*, 2005, *113(6).*

Eckstein, Zvi and Kenneth I Wolpin, "Dynamic Labour Force Participation of Married Women and Endogenous Work Experience," *Review of Economic Studies*, 1989, *56(3).*

Fernàndez, Raquel, Nezih Guner, and John Knowles, "Love and Money: A Theoretical and Empirical Analysis of Household Sorting and Inequality," *The Quarterly Journal of Economics*, 2005, *120(1).*

Fernndez, Raquel and Richard Rogerson, "Sorting And Long-Run Inequality," *The Quarterly Journal of Economics*, November 2001, *116(4).*

Flinn, Christopher. and Daniela Del Boca, "Modes of Spousal Interaction and the Labor Market Environments," *Working Paper*, 2006.

Gibbons, Robert and Lawrence F Katz, "Layoffs and Lemons," *Journal of Labor Economics*, 1991, *9(4).*

Gould, Eric D., "Rising Wage Inequality, Comparative Advantage, and the Growing Importance of General Skills in the United States," *Journal of Labor Economics*, 2002, *20(1).*

_ **and M. Daniele Paserman**, "Waiting for Mr. Right: rising inequality and declining marriage rates," *Journal of Urban Economics*, 2003, *53 (2).*

Greenwood, Jeremy, Nezih Guner, and John Knowles, "More on marriage, fertility, and the distribution of income," *International Economic Review*, 2003, *44(3).*

Hewitt, Belinda, Mark Western, and Janeen Baxter, "Marriage and Money: The Impact of Marriage on Men's and Women's Earnings," *Negotiating the Life Course Discussion Paper Series, DP-007*, 2002.

Katz, Lawrence F. and Bruce D. Meyer, "The impact of the potential duration of unemployment benefits on the duration of unemployment," *Journal of Public Economics*, 1990, *41(1).*

Katz, Lawrence F and Bruce D Meyer, "Unemployment Insurance, Recall Expectations, and Unemployment Outcomes," *The Quarterly Journal of Economics*, 1990, *105(4).*

Kremer, M., "How Much Does Sorting Increase Inequality?," *Quarterly Journal of Economics*, 1997, *112.*

Kremer, Michael, "How Much Does Sorting Increase Inequality?," *The Quarterly Journal of Economics*, February 1997, *112(1).*

Lancaster, Tony, "Econometric Methods for the Duration of Unemployment," *Econometrica*, Jul., 1979, *47(4).*

_ **and Andrew Chesher**, "An Econometric Analysis of Reservation Wages," *Econometrica*, 1983, *51* (6), 1661–1676.

Lentz, Rasmus and Torben Trans, "Marriage, Wealth, and Unemployment Duration: A Gender Asymmetry Puzzle," *IZA Discussion Papers 1607*, 2005.

Lippman, Steven A and John J McCall, "The Economics of Job Search: A Survey," *Economic Inquiry*, September 1976, *14(3).*

Loughran, David S., "The Effect of Male Wage Inequality on Female Age at First Marriage," *Review of Economics and Statistics*, May 2002, *84(2).*

_ **and Julie M Zissimopoulos**, "Are there gains to delaying marriage? : the effect of age at first marriage on career development and wages," *Labor and Population Program (Rand Labor and Population Program working paper ; no. WR-207)*, November 2004.

Lu, X. and R. McAfee, "Matching and expectations in a market with heterogeneous agents," *Advances in Applied Microeconomics*, 1996, *6.*

Lundberg, Shelly J. and Robert A. Pollak, "Separate Spheres Bargaining and the Marriage Market," *Journal of Political Economy*, 1993, *101(6).*

_ **and** _ , "The American Family and Family Economics," *Journal of Economic Perspectives*, 2007, *21(2).*

LYNCH, LISA M., "JOB SEARCH AND YOUTH UNEMPLOYMENT," *Oxf. Econ. Pap.*, 1983, *35* (supp), 271–282.

Mabli, James, "Dynamic Household Labor Supply: An Application of Household Search over Wages and Hours," *PhD Thesis*, 2006.

Meyer, Bruce D, "Unemployment Insurance and Unemployment Spells," *Econometrica, Econometric Society*, July 1990, *58(4).*

Mortensen, Dale T., "Unemployment Insurance and Job Search Decisions," *Industrial and Labor Relations Review*, 1977, *30* (4), 505–517.

_ , "Job search and labor market analysis," in O. Ashenfelter and R. Layard, eds., *Handbook of Labor Economics*, Vol. 2 of *Handbook of Labor Economics*, Elsevier, October 1987, chapter 15, pp. 849–919.

Murphy, Kevin M and Robert H Topel, "Unemployment and Nonemployment," *American Economic Review, American Economic Association*, 1997, *87(2).*

Narendranathan, Wiji and Stephen Nickell, "Modelling the process of job search," *Journal of Econometrics*, April 1985, *28* (1), 29–49.

_ **and** _ , "Modelling the process of job search," *Journal of Econometrics*, April 1985, *28* (1), 29–49.

Oppenheimer, Valerie Kincade, Matthijs Kalmijn, and Nelson Lim, "Men's Career Development and Marriage Timing During a Period of Rising Inequality," *Demography*, August, 1997, *34(3).*

Petrongolo, Barbara and Christopher A. Pissarides, "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature*, June 2001, *39(2).*

Pissarides, Christopher A, "Job Search and the Duration of Layoff Unemployment," *The Quarterly Journal of Economics*, 1982, *97(4).*

Shimer, Robert and Lones Smith, "Assortative Matching and Search," *Econometrica*, 2000.

van den Berg, Gerard J., "Search Behaviour, Transitions to Non-participation and the Duration of Unemployment," *The Economic Journal*, 1990, *100* (402), 842–865.

Weiss, Yoram, "The formation and dissolution of families: Why marry? Who marries whom? And what happens upon divorce?," in "Handbook of Population and Family Economics," Elsevier, 1993.

_ **and Robert J Willis**, "Match Quality, New Information, and Marital Dissolution," *Journal of Labor Economics*, January 1997, *15(1).*

Wolpin, Kenneth I., "Estimating a Structural Search Model: The Transition from School to Work," *Econometrica*, 1987, *55* (4), 801–817.

Wong, Linda Y., "Structural Estimation of Marriage Models," *Journal of Labor Economics, Econometric Society*, 2003, *21(3).*

Yoon, Bong Joon, "A Model of Unemployment Duration with Variable Search Intensity," *The Review of Economics and Statistics*, 1981, *63* (4), 599–609.

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