Sex Ratios and Long-Term Marriage Trends

José-Víctor Ríos-Rull, Shannon Seitz, Satoshi Tanaka

UPenn, NBER, CAERP, Analysis Group, UQ

November 5, 2016

Introduction

- U.S. marriage features
  1. Women Marry Younger. (22.0 v.s. 24.7)
  2. Women live Longer. (75.5 v.s. 69.4)
  3. The Ratio of Men to Women over 15 is now less than 1. (0.94)
- Why?
- Is there a Systematic Difference in what Men and Women get from marriage?

Purpose of the Paper

- Estimate What and When Men and Women get from Marriage
  1. Utility Modifiers from being married by age of Spouse (different for men and women)
  2. Dispersion. How special is a particular partner
  3. Costs of Marriage and Divorce
- We pose a fully specified equilibrium model.
- Identification strategy: enormous demographic changes since 1870
  1. Changes in life expectancies. (58.9 to 75.5 for females)
  2. Changes in the sex ratio. (1.04 to 0.94)
  3. Which yield large changes in marriage patterns.

     (age gap -Δ32%, married Δ20%, never-married -Δ33%, divorce rate Δ642%)

Men versus Women

- Siow (1998) argues that because of the role of women as child bearers they are especially attractive at relative younger ages than men.
- This logic is biological. We want to use revealed preference to infer from people's behavior how large are the gains that they perceive they have from marriage and at what ages these gains accrue.

Main Fidings

- We confirm Siow's insight:
  1. Women's prime age starts earlier than men's one. (17.4 v.s. 18.3.)
  2. Women's prime age ends earlier than men's one. (29.2 v.s. 31.4.)
  3. Both male and female strongly prefer a prime-aged parter.
- Other insights we found are:
  1. Match quality process has permanent nature.
     (50% of matches turn out to be permanently good.)
  2. Marriage is costly. (The cost amounts to 2 years of a good marriage.)
  3. Divorce is costly. (The cost amounts to 5 years of a good marriage.)

Model

Model: Demographics

1. OLG with stochastic aging. Three ages $i \in \{a, y, o\}$, Adolescent (a), Young (y), and Old (o). Two sexes $g \in \{m, f\}$.
   - Aging transitions $\Gamma^f_{i,i'}$ and $\Gamma^m_{i,i'}$.
2. New entrants due to birth (in equal amounts) and men's migration
   - n^g newborns are born every period.
   - Immigration rate i^m.
3. Differential mortality rates by age and sex. $\{\pi^m, \pi^f\}$.

The Model: Notation, Meeting and Marriage

Marital status: Single, dating or married $q \in \{0, 1, 2\}$.

Random dating: Probability $\psi^f = min\{1, \frac{x^m}{x^f}\}$. x^g measure of singles.

Preferences: If single $u_i^g(0) = 0$. If married, utility depends on the age of partner plus a match quality. $u_i^g(i^*) = \alpha_{i^*}^g + z$.

Match quality z: It has two components a Markov component and an iid component. $z = \mu + \epsilon$, where $\mu \in \{\theta, 0, -\theta\}$ has a Marcov transition matrix Λ . $\epsilon \sim (0, 1)$, with $\Phi(\hat{\epsilon}) = Prob(\epsilon < \hat{\epsilon})$. A paired agent starts with the middle state.

$$\Lambda = \begin{pmatrix} 1-\lambda_1 & \lambda_1 & 0 \\ \lambda_2 & 1-\lambda_2-\lambda_3 & \lambda_3 \\ 0 & \lambda_4 & 1-\lambda_4 \end{pmatrix}$$

Marriage: If both agree they get married, $q = 2$. Else $q = 0$. Agent pay a cost c^m when they become married.

Divorce: Agents pay a cost c^d upon divorce.

Model: Women (Adolescent, Young and Old)

Unpaired (single) woman of age i.

$$V^{f,i}(0,0,0,0) = u^f(0) + \beta\ (1-\pi_i^f) \sum_{i'} \Gamma_{i,i'}^f \Big\{ (1-\psi^f)\ V^{f,i'}(0,0,0,0) + \psi^f \sum_{i^*,\mu,\mu^*} p^f(i^*)\ \Lambda_0(\mu)\ \Lambda_0(\mu^*)\ V^{f,i'}(1,i^*,\mu,\mu^*) \Big\}$$

Paired (married or dating, $q \in \{1,2\}$) women ($\hat{\epsilon}_{f,i}$ and $\hat{\epsilon}_{m,i^*}$ are cutoff values)

$$V^{f,i}(z,i^*,\mu,\mu^*;\hat{\epsilon}_{m,i^*}) = \max_{\hat{\epsilon}_{f,i}} \int_{\hat{\epsilon}_{f,i}}^{\infty}\int_{\hat{\epsilon}_{m,i^*}}^{\infty} \Big\{ \alpha_{i^*}^g + \mu + \epsilon_f - c^m \mathbf{1}_{[z=1]}$$
$$+ \beta\,(1-\pi_i^f) \Big[(1-\pi_{i^*}^m) \sum_{i',i^{*\prime},\mu',\mu^{*\prime}} \Gamma_{i,i'}^f \Gamma_{i^*,i^*}^m \Lambda_{\mu,\mu'}^{i'} \Lambda_{\mu^*,\mu^{*\prime}}^{i^{*\prime}} V^{f,i'}(2,i^{*\prime},\mu',\mu^{*\prime})$$
$$+ \pi^m \sum_{i'} \Gamma_{i,i'}^f \Big((1-\psi^f) V^{f,i'}(0,0,0,0) + \psi^f \sum_{i^{*\prime},\mu,\mu^*} p^f(i^{*\prime}) \Lambda_0(\mu) \Lambda_0(\mu^*) V^{f,i'}(1,i^{*\prime},\mu,\mu^*) \Big) \Big] \Big\}$$
$$\times\, d\Phi(\epsilon_f)\ d\Phi(\epsilon_m) + \Big\{ V^{f,i}(0,0,0,0) - c^d \mathbf{1}_{[z=2]} \Big\}\ \Phi(\hat{\epsilon}_{f,i})\ \Phi(\hat{\epsilon}_{m,i^*})$$

Estimation

Data We Use

We exploit the large variation in demographics and marital statistics.

- Data for the 1870 and 1950 birth cohorts in the U.S.

Demographics:

- Sex ratio (men per woman) for those between age 20 and 44 from the U.S. Census.
- Life expectancies at age 15 from the National Vital Statistics Report.

Marital statistics:

- Marriage and divorce rates by 6 age groups.
- Calculated by tracking the each cohort in the U.S. Census.
- Never-married by age 50 also taken from the U.S. Census.

Estimation Strategy (Two Steps)

First step: Calibration of demographic parameters.

- $\left(i^m_{70}, \pi^m_{70}, \pi^f_{70}\right)$ and $\left(i^m_{50}, \pi^m_{50}, \pi^f_{50}\right)$ are determined to match:
    1. Sex ratio of those at age 20 - 44 for each cohort.
    2. Life expectancies at age 15 for each gender in each cohort.

Second step: GMM estimation of the rest of the parameters.

1. Two equilibria are solved for the 1870 and 1950 cohorts, respectively, given the demographic parameters exogenously.
2. Parameters are estimated as

$$\hat{\mathbf{\Theta}} = \arg\min_{\mathbf{\Theta}} \left(\hat{\mathbf{g}}^{DATA} - \mathbf{g}^{MODEL}(\mathbf{\Theta})\right)' \mathbf{W} \left(\hat{\mathbf{g}}^{DATA} - \mathbf{g}^{MODEL}(\mathbf{\Theta})\right)$$

where $\mathbf{g}$ denotes the vector of moments that inlcudes marital statistics of both cohorts.

First Step: Calibration for Demographic Parameters

1. Immigration rates (i^m_{70}, i^m_{50}) are targeted to sex ratios.
   - The number of new born is assumed to be same for female and male.
   - Single, prime-aged male immigrants inflow at age 20.
2. Mortality rates $\left(\pi^m_{70}, \pi^f_{70}, \pi^m_{50}, \pi^f_{50}\right)$ are targeted to life expectancies.

Target Name	1870 Data	1870 Model	1870 Data	1870 Model
Sex Ratio for Age 20-44 Group	1.056	1.056	0.974	0.974
Life Expectancy at Age 15 (F)	49.7	49.7	65.1	65.1
Life Expectancy at Age 15 (M)	49.0	49.0	59.9	59.9
Non Targeted Data	**1870 Data**	**1870 Model**	**1870 Data**	**1870 Model**
Sex Ratio for Age 10-14	1.030	-	1.036	-
Sex Ratio for Age 20-24	1.004	1.058	0.920	0.986
Sex Ratio for Age 30-34	1.090	1.055	0.972	0.972
Sex Ratio for Age 40-44	1.121	1.052	0.976	0.959
Sex Ratio for Age 50+	1.107	1.036	0.818	0.878

Second Step: GMM for Preference and Aging Parameters

- We run GMM by setting the weiting matrix $\mathbf{W} = \mathbf{I}$.
- We have 16 parameters and 62 targets (over-identification).

Parameters to Be Estimated (16)	
Preferences (4)	α_y^f, α_o^f, α_y^m, α_o^m
Aging Transition Process (4)	Γ_{ay}^f, Γ_{yo}^f, Γ_{ay}^m, Γ_{yo}^m
Match Process (5)	θ, λ_1, λ_2, λ_3, λ_4
Cost of Marriage and Divorce (3)	c^m, c_{1870}^d, c_{1950}^d
Targeted Moments (62)	
Marriage Rate (24)	6 age groups for each gender in each cohort.
Divorce Rate (24)	6 age groups for each gender in each cohort.
Number of Never Married by Age 50 (4)	One for each gender in each cohort.

Estimated Preference Parameters

Parameter	Value
Female's preferences over adolescent spouse (α_a^f)	-4.17
Female's preferences over young spouse (α_y^f)	-0.37
Female's preferences over old spouse (α_o^f)	-0.66
Male's preferences over adolescent spouse (α_a^m)	-5.17
Male's preferences over young spouse (α_y^m)	-0.16
Male's preferences over old spouse (α_o^m)	-0.69
Marriage cost (c^m)	-2.87
Divorce cost in 1870 (c^d_{1870})	6.32
Divorce cost in 1950 (c^d_{1950})	3.20
Value in good state (θ)	1.23

Estimated Aging Process

Parameter	Value
Probability adolescent women become young (Λ^f_{ay})	0.688
Probability young women become old (Λ^f_{yo})	0.054
Probability adolescent men become young (Λ^m_{ay})	0.418
Probability young men become old (Λ^m_{yo})	0.034
Average age at which women become young	17.4
Average age at which women become old	29.2
Average age at which men become young	18.3
Average age at which men become old	31.4

Estimated Shock Process

- The values of 3 states:

$$\begin{pmatrix} \theta \\ 0 \\ -\theta \end{pmatrix} = \begin{pmatrix} 1.20 \\ 0.00 \\ -1.20 \end{pmatrix}$$

- The initial drawing probabilities (not estimated):

$$\begin{pmatrix} \pi_H \\ \pi_M \\ \pi_L \end{pmatrix} = \begin{pmatrix} 0.00 \\ 1.00 \\ 0.00 \end{pmatrix}$$

- The transition matrix:

$$\begin{pmatrix} 1-\lambda_1 & \lambda_1 & 0 \\ \lambda_2 & 1-\lambda_2-\lambda_3 & \lambda_3 \\ 0 & \lambda_4 & 1-\lambda_4 \end{pmatrix} = \begin{pmatrix} 1.00 & 0.00 & 0.00 \\ 0.47 & 0.36 & 0.16 \\ 0.00 & 0.24 & 0.76 \end{pmatrix}$$

Properties of the Estimates

REWRITE

- Women's prime age starts earlier than men's one. (17.4 v.s. 18.3.)
- Women's prime age ends earlier than men's one. (29.2 v.s. 31.4.)
- Both male and female strongly prefer a prime-aged parter.
- Match quality process has permanent nature.

  (50% of matches turn out to be permanently good.)
- Marriage is costly. (The cost amounts to 2 years of a good marriage.)
- Divorce is costly. (The cost amounts to 5 years of a good marriage.)

Data v.s. Model

- INSERT A GRAPH

Data v.s. Model

	1870 F		1870 M		1950 F		1950 M	
	Data	Model	Data	Model	Data	Model	Data	Model
Marriage Rates								
Age								
16-19	97.8	127.9	20.5	50.3	123.1	130.5	58.7	65.7
20-24	120.0	165.8	97.7	95.2	170.3	170.5	148.7	124.7
25-29	89.5	80.8	90.9	82.9	95.6	97.2	111.7	108.4
30-34	65.4	37.3	70.2	62.8	46.4	62.2	55.8	84.0
35-40	28.2	24.2	42.7	46.6	32.1	47.4	39.2	67.8
40-44	24.6	20.3	48.7	36.1	16.0	39.0	24.6	58.2
Never-Married by Age 50								
	11.3	10.2	13.0	13.9	7.6	9.3	9.3	8.5

Data v.s. Model

	1870 F		1870 M		1950 F		1950 M	
	Data	Model	Data	Model	Data	Model	Data	Model
				Divorce Rates				
Age								
16-19	2.6	2.9	2.6	3.5	16.4	19.2	18.5	17.5
20-24	1.8	3.0	1.6	3.5	25.5	17.9	23.6	16.8
25-29	1.4	3.2	0.6	3.5	16.0	15.9	17.0	15.8
30-34	1.4	3.3	1.1	3.5	16.7	14.0	14.8	14.6
35-40	0.3	3.4	0.6	3.5	16.2	12.6	14.2	13.5
40-44	0.2	3.5	1.2	3.5	7.6	11.4	7.9	12.6
				Age at First Marriage				
	21.9	21.9	25.9	25.8	22.0	21.9	24.7	24.7

Data v.s. Model (Non-Targeted Stats)

	1870		1950	
	Data	Model	Data	Model
Divorce rate, per 1,000 of population	0.7	0.9	5.2	3.1
Percent of the married aged 16 to 49				
Women	59.7	68.2	60.8	65.7
Men	50.8	54.5	56.0	58.5

Summary of the Results

WRITE

Counter-Factual Experiment

Role of Sex Ratios and Life-Expectancies

WRITE

Counter-Factual Experiment Results

WRITE

Conclusion

Summary

WRITE

Next Things to Do

WRITE