Technology and the Changing Family

Jeremy Greenwood, Nezih Guner, Georgi Kocharkov and Cezar Santos

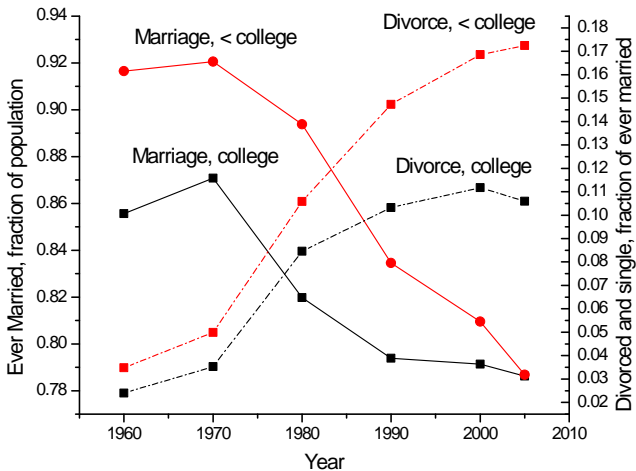UPENN; ICREA-MOVE, U. Autònoma de Barcelona and Barcelona GSE;

Carlos III (Konstanz); and UPENN (Mannheim)

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American households in the last 50 years

1. Decline in marriage and the rise in divorce

   - Differences by education levels

The Decline in Marriage and the Rise in Divorce

American households in the last 50 years

1. Decline in marriage and the rise in divorce

   - Differences by education levels

2. Rise in Assortative Mating

The Rise in Assortative Mating — Contingency Tables

1960		
Husband	Wife	
	< College	College
< Col	0.856 (0.823)	0.024 (0.056)
Col	0.080 (0.113)	0.040 (0.008)
$\chi^2 = 40{,}567$	corr = 0.41	n=241,488

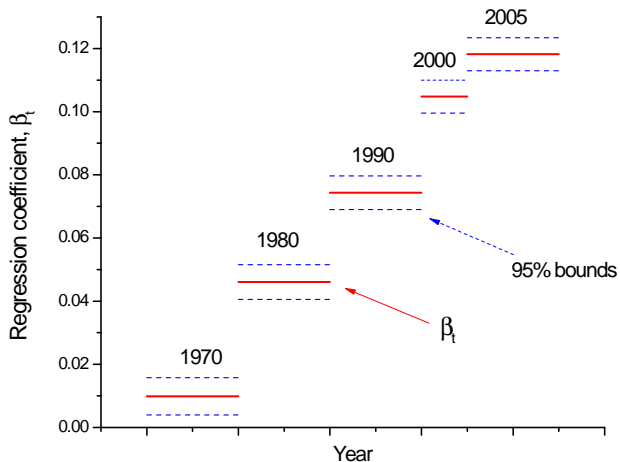| 2005		
Husband	Wife	
	< Coll	Col
< Col	0.565 (0.450)	0.109 (0.223)
Col	0.103 (0.218)	0.223 (0.108)
$\chi^2 = 93{,}446$	corr = 0.52	n=347,210

Consider the following regression

$$e_t^w = \alpha + \sum_{j \in \mathcal{J}} \beta_t e_t^h d_{j,t} + \sum_{j \in \mathcal{J}} \gamma_t d_{j,t} + \varepsilon_t,$$

- $e_t^w \in \{0, 1\}$: wife's education

- $e_t^h \in \{0, 1\}$: husband's education

- $d_{j,t}$: year dummies (1970, 1980, 1990, 2000, 2005)

American households in the last 50 years

1. Decline in marriage and the rise in divorce

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2. Rise in Assortative Mating

3. Increase in Education and Labor-Force Participation (LFP) by Females
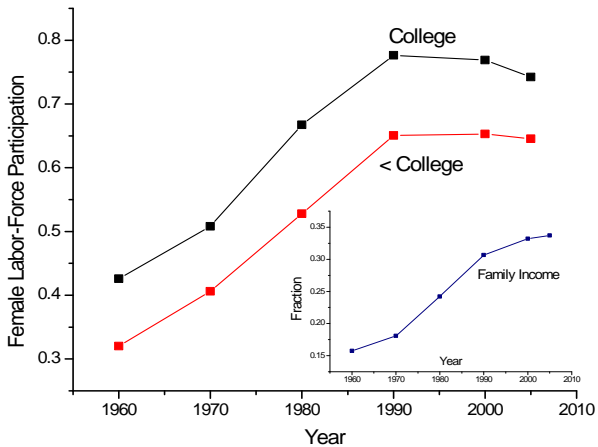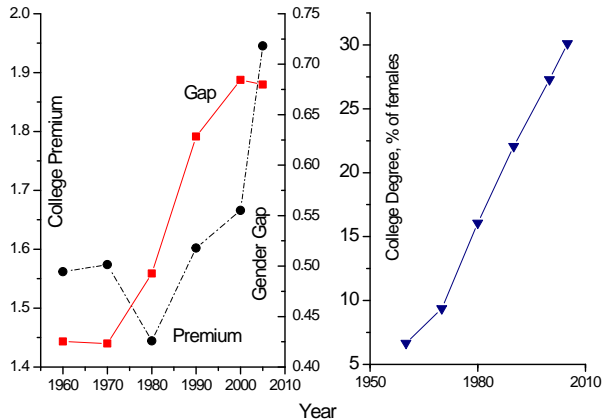
- We develop a model to understand these facts

  - Marriage and divorce

    - different patterns by education
    - rise in assortative mating

  - Female labor supply

  - Education

- All these are treated as endogenous variables

- We develop a model to understand these facts

- Ingridients

    - Economic and non-economic reasons for marriage
        - Economies of scales in household consumption
        - Home production
        - Love

- Forces
    - Technological progress in the household sector
    - Changing wage structure
        - Gender wage gap
        - College premium
        - Growth in wages

    - All these are taken as exogenous variables

- We develop a model to understand these facts

- We estimate the model

  - Match steady state of model with data for 1960 and 2005

- Decompose the effects of different driving forces

  - household technology vs. wages

- Females and males

  - Married or single (divorced or never married)
  - Educated (skilled) or not

- Infinitely-lived agents with probability of death δ

- Agents are born with ability level a
  - Draw from distribution $A(a)$ in the beginning of adult life
  - $\ln a \sim N(0, \sigma_a^2)$

- Based on a, decide whether to get educated or not

  - $C(a)$ – utility cost of education

- Each period singles meet other singles randomly

- Draw a match quality b

- Match quality changes over time

- Agents can divorce,
    - divorced agents have to wait one period before they can match again

- There is a utility bonus from marrying someone who has the same education level.
    - It does not change over time.

- One unit of time per person

  - Housework
  - Market work, $h \in \{ 0, \overline{h} \}$

    - Married males and singles supply $\overline{h}$.
    - Married females make a participation decision
    - Utility cost k associated with female labor force participation

- Wages

  - wage $w_e a$ for a male for $e \in \{0, 1\}$
  - wage $\phi w_e a$ for a female (gender gap $= \phi$)
  - wages change over time, both w_1 / w_0 and ϕ

- Singles

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

c - market goods
$\mathfrak{c}$ - fixed cost of maintaining a household
n - home production

- Couples
  - Consumption:

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

  c is a public good subject to congestion, $\chi < 1$
  - Compatibility for a couple (e, e^*)

  $$M(e, e^*) = \underbrace{\mu_0 (1 - e)(1 - e^*)}_{\text{both non-college}} + \underbrace{\mu_1 e e^*}_{\text{both college}}$$

  - Match quality b
  - Utility cost k if wife works (constant over time)

- Match quality b
  - Singles
  $$b \sim N(\overline{b}_s, \sigma_{b,s}^2)$$
  - Couples
  $$b' = (1 - \rho_{b,m})\overline{b}_m + \rho_{b,m}b + \sigma_{b,m}\sqrt{1 - \rho_{b,m}}\varepsilon, \text{ with } \varepsilon \sim N(0,1)$$

- Cost if wife works k
  $$k \sim K(k)$$

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

z – household's time endowment

h_T – total market work

d – purchased household inputs

p – price of purchase household inputs

- household inputs and time are substitutes
- p declines over time

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

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

  subject to

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

  and

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

The static consumption problem for a married couple is

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

subject to

$$c = w_e a \overline{h} + w_{e^*} \phi a^* \overline{h} h^f - pd$$

and

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

$$V_s^g(a, e) \;=\; U_s^g(a, e)$$

$$+\beta \int_{\mathcal{K}} \int_{\mathcal{B}} \int_{\mathcal{A}} \Big\{ \underbrace{1^g(a, e, a^*, E^{\sim g}(a^*), b, k) V_m^g(a, e, a^*, E^{\sim g}(a^*), b, k)}_{\text{get married}}$$

$$+ \underbrace{[1 - 1^g(a, e, a^*, E^{\sim g}(a^*), b, k)] V_s^g(a, e)}_{\text{remain single}} \Big\} d\widehat{\mathbf{S}}^{\sim g}(a^*) dF(b) dK(k)$$

$d\widehat{\mathbf{S}}^{\sim g}(a^*)$ – endogenous distribution of singles of opposite gender

$E^{\sim g}(a^*)$ – education decision for a^*

$1^g(a, e, a^*, e^*, b, k)$ – indicator for a marriage

$V_m^g(a, e, a^*, E^{\sim g}(a^*), b, k)$ – value of being married

- $V_s^g(a, e)$ - Value function, single agent

- At birth

$$\max_{e \in \{0,1\}} \left\{ V_s^g(a, e) - eC(a) \right\}.$$

- Decision rule – $e = E^g(a)$.

- Cost

$$C(a) = \varepsilon / a^\omega$$

$\mathbf{S}^g(a)$ – endogenous distribution of singles

$$
\begin{aligned}
S^g(a') \;=\; & (1-\delta)\int_{\mathcal{K}}\int_{\mathcal{B}}\int_{\mathcal{A}}^{a'}\int_{\mathcal{A}}\underbrace{[1-\mathbf{1}^g(a,E^g(a),a^*,E^{\sim g}(a^*),b,k)]}_{\text{remain single}} \\
& dS^g(a)d\widehat{\mathbf{S}}^{\sim g}(a^*)dF(b)dK(k)
\end{aligned}
$$

$$
\begin{aligned}
& +(1-\delta)\int_{\mathcal{K}}\int_{\mathcal{B}}\int_{\mathcal{A}}^{a'}\int_{\mathcal{A}}\underbrace{[1-\mathbf{1}^g(a,E^g(a),a^*,E^{\sim g}(a^*),b,k)]}_{\text{divorce}} \\
& dM^g(a,a^*,b_{-1},k)dG(b|b_{-1})
\end{aligned}
$$

$$
+\;\underbrace{\delta A(a')}_{\text{replacing death}}
$$

- **Two steady states**: 1960 and 2005
- **Model period:** 1 year
- **Life span:** 30 years
- **Probability of survival:** $1 - 1/30 = 0.97$
- **Discount factor:** $\beta = 0.96 \times 0.97$
- **Work time:** $\overline{h} = 40/112 = 0.36$
- **Household production:** $\theta = 0.206, \lambda = 0.189$
  - McGrattan, Rogerson and Wright (1997)

- **Wages**:
  - College premium in 1960

    $$\boxed{1.34} = \frac{w_{1,1960} \times (\text{average ability for college men})}{w_{0,1960} \times (\text{average ability for non-college men})}$$

    - $w_{0,1960} = 1$
    - $w_{1,1960} = 1.04$
  - Increase in wages: $\boxed{1.14}\times$ for non-college in 1960-2005
    - $w_{0,2005} = 1.18$
  - College premium in 2005: $\boxed{1.76}$
    - $w_{1,2005} = 1.66$
- **Gender gap** – estimate with Heckman correction
  - $\phi_{1960} = \exp(\widetilde{\phi}_{1960}) = \boxed{0.59}$.
  - $\phi_{2005} = \exp(\widetilde{\phi}_{2005}) = \boxed{0.83}$.

Data and Benchmark Model

	1960				2005			
	Data		Model		Data		Model	
Education	Fem	Males	Fem	Males	Fem	Males	Fem	Males
	0.067	0.116	0.086	0.098	0.301	0.284	0.308	0.308
Marriage								
Fraction	Sing	Marr	Sing	Marr	Sing	Marr	Sing	Marr
	0.126	0.874	0.168	0.832	0.348	0.652	0.342	0.658
Rates	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
−Marriage	0.917	0.856	0.871	0.876	0.787	0.786	0.771	0.789
−Divorce	0.034	0.024	0.046	0.038	0.172	0.106	0.166	0.123
Sorting	Wife		Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.856	0.024	0.827	0.072	0.564	0.109	0.571	0.089
Coll	0.080	0.040	0.083	0.018	0.104	0.223	0.121	0.218
Corr, educ	0.410		0.103		0.519		0.521	
Participation								
All	0.315		0.237		0.710		0.740	
< Coll	0.309		0.217		0.684		0.726	
Coll	0.414		0.447		0.763		0.773	
Income, frac	0.157		0.100		0.337		0.347	

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Estimated Parameters

PARAMETERS – ESTIMATED (MINIMUM DISTANCE)

Category	Parameter Values	Standard Error	95% Conf Int
Preferences	$\alpha = 1.18$	0.0030	$[1.170, 1.182]$
	$\xi = 2.99$	0.0094	$[2.968, 3.005]$
	$\zeta = 1.82$	0.0079	$[1.806, 1.836]$
	$\mathfrak{c} = 0.047$	0.0007	$[0.046, 0.049]$
	$\mu_0 = 0.07$	0.0041	$[0.057, 0.073]$
	$\mu_1 = 0.83$	0.0813	$[0.674, 0.993]$
Ability	$\sigma_a = 0.015$	0.0017	$[0.012, 0.018]$
Matching	$\overline{b}_s = -1.21$	0.0794	$[-1.367, -1.056]$
	$\sigma_{b,s} = 2.90$	0.0629	$[2.778, 3.025]$
	$\overline{b}_m = 0.36$	0.0105	$[0.336, 0.377]$
	$\sigma_{b,m} = 0.28$	0.0089	$[0.260, 0.295]$
	$\rho_{b,m} = 0.93$	0.0043	$[0.924, 0.941]$
Cost of Work	$k_l = 0.49$	0.0405	$[0.411, 0.569]$
	$k_h = 2.01$	0.1799	$[1.656, 2.361]$
Prices	$p_{1960} = 20.24$	0.8711	$[18.537, 21.951]$
	$p_{2005} = p_{1960} \times e^{-\gamma \times (2005-1960)}$		
	$\gamma = 0.074$	0.0051	$[0.064, 0.084]$
Cost of Education	$\varepsilon = 45.77$	2.6196	$[40.638, 50.907]$
	$\omega = 14.91$	0.8697	$[13.202, 16.611]$

TABLE 3: PARAMETERS – ESTIMATED (MINIMUM DISTANCE)

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

Education	1960		2005			
	Benchmark		Experiment		Benchmark	
	Fem	Males	Fem	Males	Fem	Males
	0.086	0.098	0.333	0.360	0.308	0.308
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.168	0.832	0.211	0.789	0.342	0.658
Rates	< Coll	Coll	< Coll	Coll	< Coll	Coll
−Marriage	0.871	0.876	0.838	0.846	0.771	0.789
−Divorce	0.046	0.038	0.071	0.043	0.166	0.123
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.827	0.072	0.557	0.062	0.571	0.089
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Corr, educ	0.103		0.628		0.521	
Participation						
All	0.237		0.363		0.740	
< Coll	0.217		0.450		0.726	
Coll	0.447		0.186		0.773	
Income, fraction	0.100		0.177		0.347	

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- Labor force participation of married females do not increase
  - Indeed, for college educated women, it declines
  - Income effect due to higher wages

- Higher marriages and lower divorces in 2005

- Still females get educated
  - Insurance against being single
  - Matching benefits

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

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Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.827	0.072	0.809	0.105	0.571	0.089
Coll	0.083	0.018	0.062	0.024	0.121	0.218
Corr, educ	0.103		0.139		0.521	
Participation						
All	0.237		0.799		0.740	
< Coll	0.217		0.791		0.726	
Coll	0.447		0.851		0.773	
Income, fraction	0.100		0.306		0.347	

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

Education	1960		2005			
	Benchmark		Experiment		Benchmark	
	Fem	Males	Fem	Males	Fem	Males
	0.086	0.098	0.111	0.086	0.308	0.308
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.168	0.832	0.339	0.661	0.342	0.658
Rates	< Coll	Coll	< Coll	Coll	< Coll	Coll
−Marriage	0.871	0.876	0.771	0.804	0.771	0.789
−Divorce	0.046	0.038	0.152	0.103	0.166	0.123
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.827	0.072	0.809	0.105	0.571	0.089
Coll	0.083	0.018	0.062	0.024	0.121	0.218
Corr, educ	0.103		0.139		0.521	
Participation						
All	0.237		0.799		0.740	
< Coll	0.217		0.791		0.726	
Coll	0.447		0.851		0.773	
Income, fraction	0.100		0.306		0.347	

Only Home Technologies

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

Education	1960		2005			
	Benchmark		Experiment		Benchmark	
	Fem	Males	Fem	Males	Fem	Males
	0.086	0.098	0.111	0.086	0.308	0.308
Marriage						
Fraction	Sing	Marr	Sing	Marr	Sing	Marr
	0.168	0.832	0.339	0.661	0.342	0.658
Rates	< Coll	Coll	< Coll	Coll	< Coll	Coll
−Marriage	0.871	0.876	0.771	0.804	0.771	0.789
−Divorce	0.046	0.038	0.152	0.103	0.166	0.123
Sorting	Wife		Wife		Wife	
Husband	< Coll	Coll	< Coll	Coll	< Coll	Coll
< Coll	0.827	0.072	0.809	0.105	0.571	0.089
Coll	0.083	0.018	0.062	0.024	0.121	0.218
Corr, educ	0.103		0.139		0.521	
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All	0.237		0.799		0.740	
< Coll	0.217		0.791		0.726	
Coll	0.447		0.851		0.773	
Income, fraction	0.100		0.306		0.347	

- No increase in education

- No increase in assortative mating

- We develop an equilibrium model consistent with:
  - a decline in marriage and a rise in divorce
  - increasing assortative mating
  - increasing education and female LFP
- Results:
  - Technological progress in the household:
    - increases married female LFP
    - decline of marriage and rise of divorce
  - Changes in the wage structure:
    - increase education
    - increase assortative mating.

Married Female Labor-Force Participation

	Experiment/G.E. Effects	Experiment/No G.E. Effects	Benchmark
Participation	0.336	0.363	0.740

$$V_m^g(a, e, a^*, e^*, b, k) \;\; = \;\; U_m^g(a, e, a^*, e^*, k) + b + M(e, e^*)$$

$$+\beta\{\int_{\mathcal{B}} \underbrace{[\mathbf{1}^g(a, e, a^*, e^*, b', k) V_m^g(a, e, a^*, e^*, b', k)}_{\text{stay married}}$$

$$+ \underbrace{[1 - \mathbf{1}^g(a, e, a^*, e^*, b', k)] V_s^g(a, e)}_{\text{divorce}}] dG(b'|b)\}$$

- $\mathbf{1}^g(a, e, a^*, e^*, b, k) = 1$ if

$$V_m^g(a, e, a^*, e^*, b, k) \geq V_s^g(a, e) \text{ and}$$

$$V_m^{\sim g}(a^*, e^*, a, e, b, k) \geq V_s^{\sim g}(a^*, e^*)$$

- Fixed point problem

$\mathbf{S}^g(a)$ – endogenous distribution of singles

$$S^g(a') = (1-\delta) \int_{\mathcal{K}} \int_{\mathcal{B}} \int_{\mathcal{A}}^{a'} \int_{\mathcal{A}} \underbrace{[1 - \mathbf{1}^g(a, E^g(a), a^*, E^{\sim g}(a^*), b, k)]}_{\text{remain single}}$$

$$dS^g(a) d\widehat{\mathbf{S}}^{\sim g}(a^*) dF(b) dK(k)$$

$$+ (1-\delta) \int_{\mathcal{K}} \int_{\mathcal{B}} \int_{\mathcal{A}}^{a'} \int_{\mathcal{A}} \underbrace{[1 - \mathbf{1}^g(a, E^g(a), a^*, E^{\sim g}(a^*), b, k)]}_{\text{divorce}}$$

$$dM^g(a, a^*, b_{-1}, k) dG(b|b_{-1})$$

$$+ \underbrace{\delta A(a')}_{\text{replacing death}}$$

$$\mathbf{M}^g\left(a', a^{*\prime}, b', k'\right) =$$

$$(1-\delta) \int_{\mathcal{K}}^{k'} \int_{\mathcal{B}}^{b'} \int_{\mathcal{A}}^{a'} \int_{\mathcal{A}}^{a^{*\prime}} \underbrace{\mathbf{1}^g\left(a, E^g\left(a\right), a^*, E^{\sim g}\left(a^*\right), b, k\right)}_{\text{new marriages}}$$

$$d\widehat{\mathbf{S}}_{e^*}^{\sim g}\left(a^*\right) d\mathbf{S}^g\left(a\right) dF\left(b\right) dK\left(k\right)$$

$$+(1-\delta) \int_{\mathcal{K}}^{k'} \int_{\mathcal{B}}^{b'} \int_{\mathcal{B}} \int_{\mathcal{A}}^{a'} \int_{\mathcal{A}}^{a^{*\prime}} \underbrace{\mathbf{1}^g\left(a, E^g\left(a\right), a^*, E^{\sim g}\left(a^*\right), b, k\right)}_{\text{stay married}}$$

$$d\mathbf{M}^g\left(a, a^*, b_{-1}, k\right) dG\left(b|b_{-1}\right)$$

Parameters

Parameters – A Priori information

Category	Parameter Values	Criteria
Preferences	$\beta = 0.96 \times (1-\delta), \chi = 0.70$	A priori information
Household Technology	$\theta = 0.21, \lambda = 0.19$	McGrattan et al (1997)
Life span	$1/\delta = 30$	A priori information
Wages	$w_{0,1960} = 1, w_{1,1960} = 1.04$	Data
	$w_{0,2005} = 1.18, w_{1,2005} = 1.66$	Data
	$\phi_{1960} = 0.59, \phi_{2005} = 0.83$ (gender gap)	Data
Hours	$\bar{h} = 0.36$	Data

Estimation

- Match a set of data moments for the 1960 and 2005.
- Let DATA represent a vector of data moments.
- Let $\mathcal{M}(\omega)$ be model moments for a set of parameters ω
- Define $G(\omega) \equiv \text{DATA} - \mathcal{M}(\omega)$.
- Minimum distance estimation

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

  where W is some positive semi-definite matrix.
- Standard errors, $\text{se}(\widehat{\omega})$

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

  where $J(\widehat{\omega}) \equiv \partial\mathcal{M}(\widehat{\omega})/\partial\widehat{\omega}$, $\Sigma \equiv \text{DATA}' \bullet \text{DATA}$, and n is the total number of observations.