The Sex Ratio, Marriage and Bargaining: a Look at China

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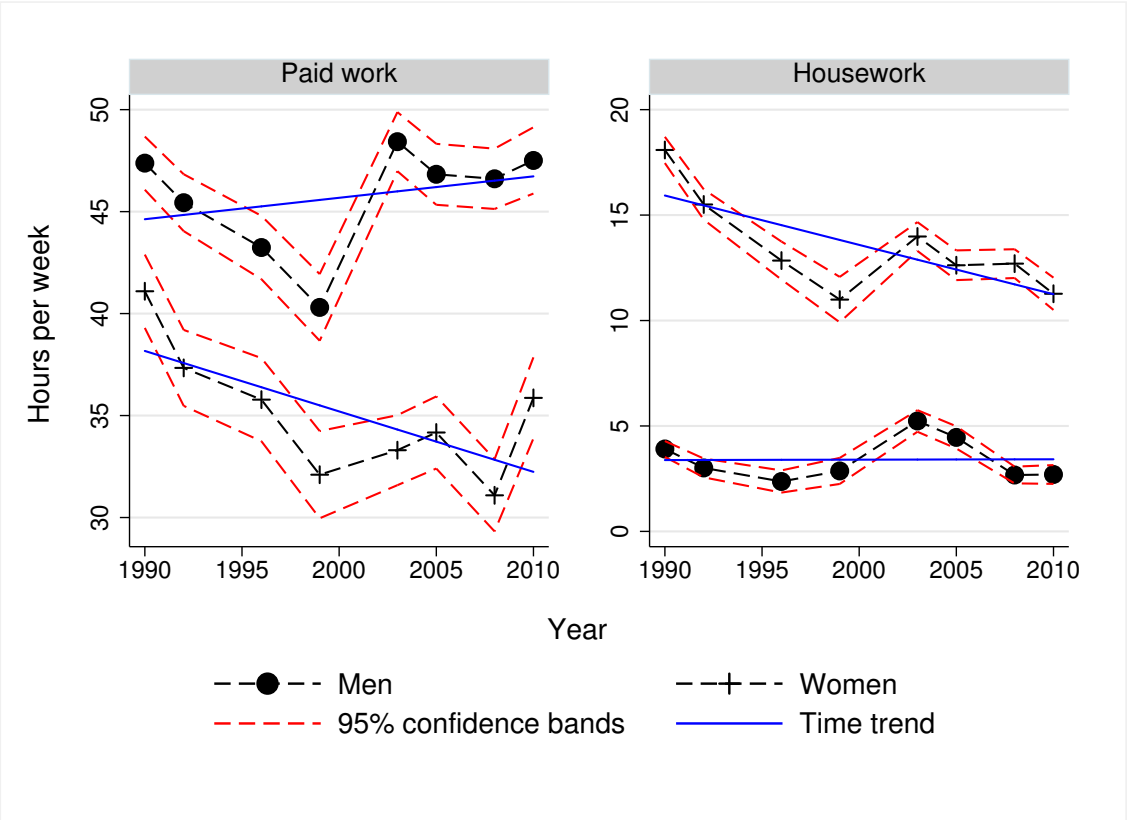
Motivation

- Are (we) macro economists right in modeling households as unitary?
- What are we missing by ignoring intra-household bargaining?
- China offers an exciting opportunity to study this question, for a couple of reasons.

Reason 1: large changes in time allocation patterns among married people

Figure: Time allocation for Chinese married people aged 20-35, 1990-2010



Leisure ratio

Reason 2: an increasingly unbalanced sex ratio

Table: Sex ratio at birth (male births over female births), 1982-2010

Year	Sex ratio at birth
1982	1.085
1990	1.113
2000	1.169
2010	1.179

Source: Tabulation on the Population Census of the People's Republic of China, National Bureau of Statistics.

For reference, the sex ratio at birth for the Unites States was 1.047 in 2017.

▸ Sex ratio marriageable age

The sex ratio and aggregate time allocation

The sex ratio may affect aggregate time allocation through:

- Marital sorting
- Intra-household bargaining

Research question

What is the impact of changes in the sex ratio via marital sorting and intra-household bargaining on aggregate time allocation?

This paper

In this paper I:

- Build and calibrate to Chinese data a **dynamic quantitative model of marriage and time allocation**.
- Perform a **decomposition exercise** to account for the contribution of the sex ratio to changes in time allocation between 1990 and 2010, since other potentially important transformations took place during the period.

Main findings

- The increase in the sex ratio explains about half of the increase in married female leisure.
- Without the increase in sex ratio, married male leisure would have increased too.
- Mostly, the effect of the sex ratio on time allocation operates through the bargaining channel, very little through marital sorting.
- The magnitude of the effects of the sex ratio and the gender wage gap on married female paid work are comparable.

Related literature and contributions

This paper contributes to three lines of literature

- Time allocation:
  - Aguiar & Hurst.
- Marriage:
  - Knowles (2013).
  - Matching, e.g. Chiappori.
  - Frictions, e.g. Greenwood et al. (2016).
- The effect of the sex ratio on socioeconomic outcomes:
  - Reduced form, e.g. Angrist (2002), Abramitzky (2011).
  - Structural, e.g. Seitz (2009), Wang (2018).

Model ingredients

The model features:

- Endogenous marital sorting:
  - Agents heterogeneous in education (exogenous).
  - Marriage market with search frictions.
  - Match quality shock.
- Time allocation decisions:
  - People care about:
    1. Consumption of a private good $\rightarrow$ **Paid work**.
    2. Consumption of a home-produced good $\rightarrow$ **Housework**.
    3. **Leisure**.
  - Married couples' time allocation is the result of bargaining between the spouses.

Model primitives

Four categories:

1. Demographic:
   - The sex ratio.
2. Wage structure:
   - Skill premium.
   - Gender wage premium.
3. Skill distribution:
   - Low skill.
   - Medium skill.
   - High skill.
4. Home production:
   - Efficiency of home production technology.
   - Price of home equipment.

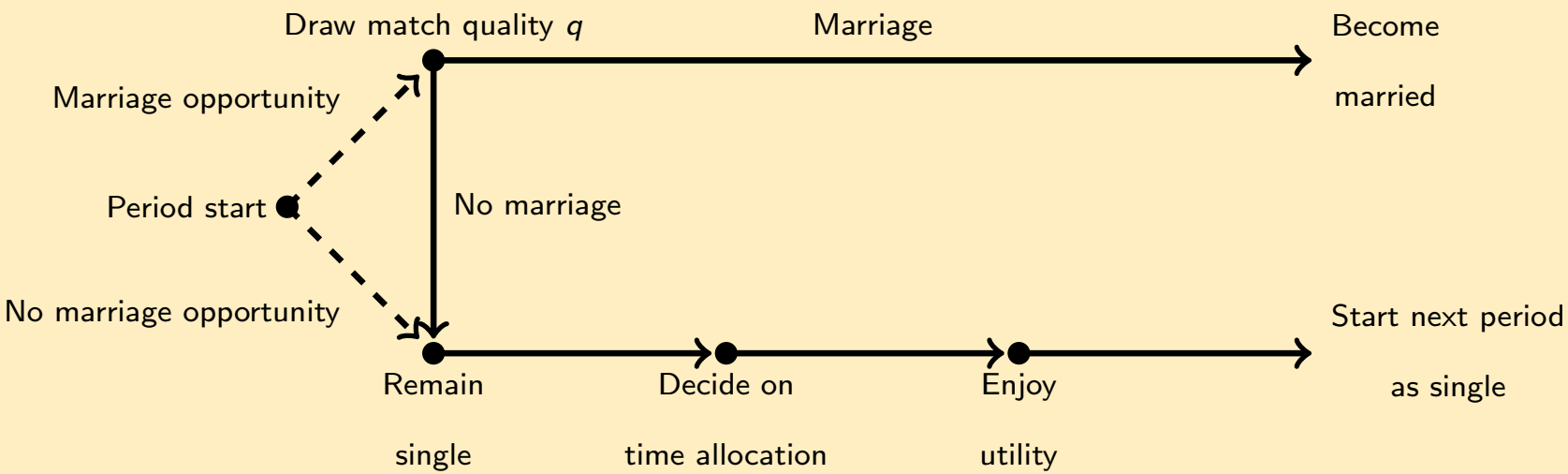
Setup

- Agents characterized by
  - A gender $i \in \{f, m\}$
  - An education level $z \in \mathcal{Z} = \{\text{Low skill}, \text{Medium skill}, \text{High skill}\}$
- Time is infinite, exponential life
  - Effective discount rate $\beta(1-\delta)$
  - Marriage market exit with probability ρ
- Exogenous entry
  - Measure 1 of females
  - Measure $\theta_0 > 1$ of men
  - Exogenous distributions of education among entrants, i.e.

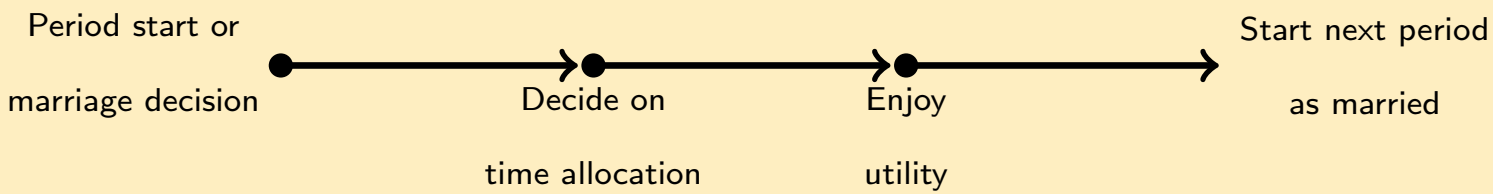
$$\mathcal{P}_i(z) : z \in \mathcal{Z} \to \mathbb{R}^+ : \sum_{z \in \mathcal{Z}} \mathcal{P}_i(z) = 1 \text{ for } i \in \{f, m\}$$

Timing of intra-period decisions

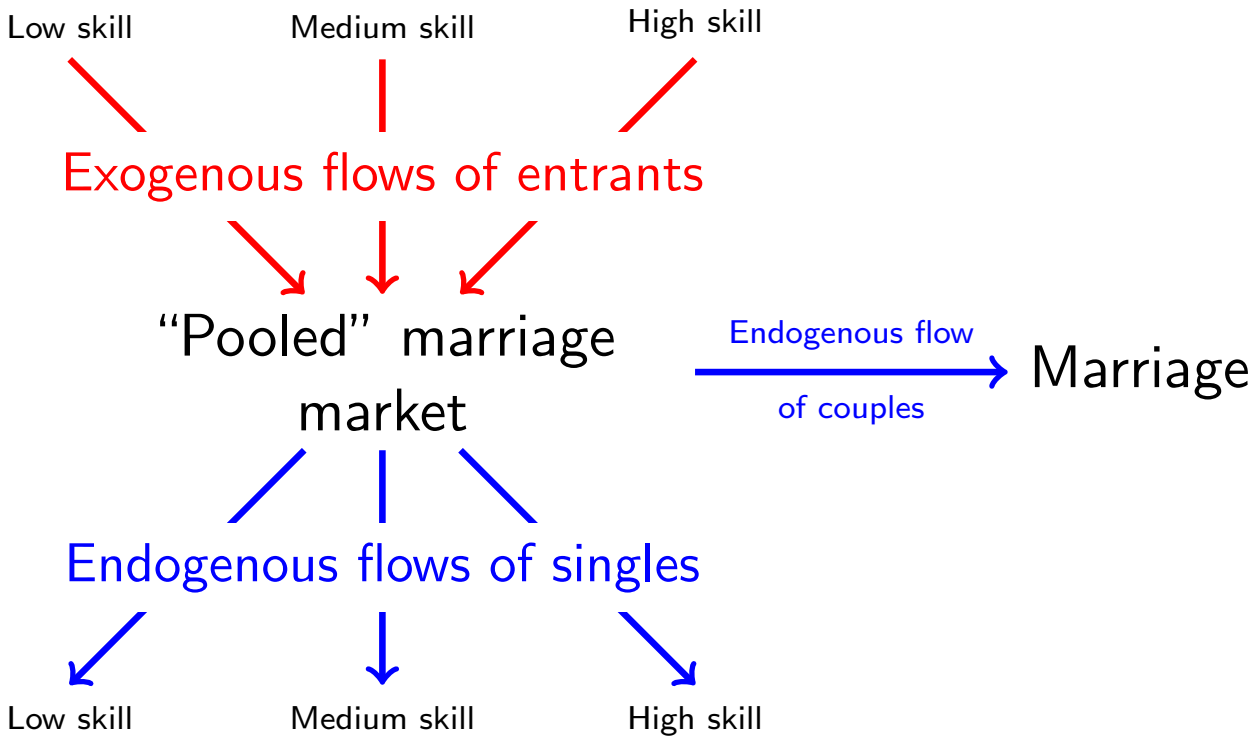
Single agents



Married agents



Structure of marriage markets for entrants



"Segregated" marriage markets
with endogenous sex ratio among singles $\theta_S(z)$

Meeting probabilities

- In the "pooled" marriage market (only entrants):
  - For men: $\frac{1}{\theta_0}$
  - For women: 1
  - Conditional on meeting someone, probability of his or her education level to be z: $\mathcal{P}_{-i}(z)$
- In the "segregated" marriage markets:
  - For men: $\frac{1}{\theta_S(z)}$ if $\theta_S(z) > 1$, 1 otherwise
  - For women: $\frac{1}{\theta_S(z)}$ if $\theta_S(z) < 1$, 1 otherwise

Utility, physical constraints, and technology

Utility function:

$$u(c, l, g) = \frac{\sigma_c}{1-\sigma} c^{1-\sigma} + \frac{\sigma_l}{1-\sigma} l^{1-\sigma} + \frac{\sigma_g}{1-\sigma} g^{1-\sigma}$$

Time constraint:

$$l + n + h = 1$$

Home production technology:

$$G(h, e_q) = A_G \left[e_q^{1-\alpha_G} \right] h^{\alpha_G}$$

Effective housework time for married couples:

$$H(h_f, h_m) = \left[\eta_f h_f^{1-\eta} + (1-\eta_f) h_m^{1-\eta} \right]^{\frac{1}{1-\eta}}.$$

Single agent's problem

$$\max_{c,l,h,n,e_q,g} u(c,l,g)$$

subject to

$$l + n + h = 1$$

$$g = G(h, e_q)$$

$$c = \omega_i(z)\, n - p_e e_q$$

Denote the value of the solution of the above problem by $U_i^S(z)$

Married household's problem

IMPORTANT: the Pareto weight of the wife χ_f will be an equilibrium object that depends on the conditions of the marriage markets

$$\max_{c_f, c_m, l_f, l_m, h_m, h_f, n_f, n_m, e_q, g} \{\chi_f u_f(c_f, l_f, g) + (1 - \chi_f) u_m(c_m, l_m, g)\}$$

subject to

$$l_f + h_f + n_f = 1$$

$$l_m + h_m + n_m = 1$$

$$h = H(h_f, h_m)$$

$$g = G(h, e_q)$$

$$c_m + c_f = \omega_f(z_f) n_f + \omega_m(z_m) n_m - p_e e_q$$

Denote the value of the solution of the above problem for an individual of sex i by $U_i^M(z_f, z_m, \chi_f)$

The value of marriage

Upon meeting, individuals with education levels z_f and z_m draw a match quality $q \sim N(\mu_{z_f,z_m}, 1)$. Since q and the wages remain constant in time, in steady state equilibrium there is no divorce, thus:

$$V_i^M(z_f, z_m, \chi_f, q) = \sum_{t=0}^{\infty} [\beta(1-\delta)]^t \left[U_i^M(z_f, z_m, \chi_f) + q \right]$$
$$= \frac{U_i^M(z_f, z_m, \chi_f) + q}{1 - \beta(1-\delta)}$$

The value of being single

The value of remaining single is:

$$V_i^S\left(z,\theta_S^E(z)\right) = \underbrace{U_i^S(z)+\psi_i}_{\text{Flow value for singles}} + \underbrace{\beta(1-\delta)}_{\text{Effective discount rate}} \left\{ \rho \underbrace{\frac{U_i^S(z)+\psi_i}{1-\beta(1-\delta)}}_{\text{Utility of lifelong single}} \right.$$

$$+(1-\rho)\Bigg[\underbrace{\Big[\underbrace{1-\pi_i\left(\theta_S^E(z)\right)}_{\text{No meeting probability}} + \underbrace{\pi_i\left(\theta_S^E(z)\right)Q_{z,z}\left[q_r\left(z,z,\theta_S^E(z)\right)\right]}_{\text{Meeting but no marriage probability}}\Big]}_{\text{Total no marriage probability}} \underbrace{V_i^S\left(z,\theta_S^E(z)\right)}_{\text{Value of being single}}$$

$$\left. + \underbrace{\pi_i\left(\theta_S^E(z)\right)}_{\text{Total marriage probability}} \underbrace{\Big[1-Q_{z,z}\left[q_r\left(z,z,\theta_S^E(z)\right)\right]\Big]}_{\text{Marriage probability conditional on meeting}} \underbrace{\frac{U_i^M(z,z,\chi_f)+\mathbb{E}\left[q \mid q>q_r\left(z,z,\theta_S^E(z)\right)\right]}{1-\beta(1-\delta)}}_{\text{Expected value of marriage}} \Bigg] \right\}$$

Marriage surplus and Egalitarian bargaining

Marriage between agents with education levels z_f and z_m generates a surplus of:

$$W_i\left(z_f, z_m, \chi_f, q, \theta_S^E(z)\right) = V_i^M\left(z_f, z_m, \chi_f, q\right) - V_i^S\left(z, \theta_S^E(z)\right).$$

The Pareto weights result from Egalitarian Bargaining, i.e. they are such that:

$$W_f\left(z_f, z_m, \chi_f, q, \theta_S^E(z)\right) = W_m\left(z_f, z_m, \chi_f, q, \theta_S^E(z)\right).$$

Equilibrium definition

Steady-state equilibrium with Egalitarian bargaining (SSEB)

A SSEB, consists of $q_r(z_f, z_m)$, $\chi_f(z_f, z_m)$, $V_i^M(z_f, z_m, \chi_f, q)$, $V_i^S\left(z, \theta_S^E(z)\right)$, $\theta_S(z)$ and $\theta_S^E(z)$ for all $\{z_f, z_m\} \in \mathcal{Z} \times \mathcal{Z}$, $z \in \mathcal{Z}$ and $i \in \{f, m\}$ such that:

- The value functions solve the Bellman equations for men and women.
- The reservation match qualities set the marriage surplus to 0.
- The allocations implied by the Pareto weights equal those generated by Egalitarian Bargaining.
- Expectations are correct: $\theta_S^E(z) = \theta_S(z)$, $\forall z \in \mathcal{Z}$.

Calibration strategy

- Objective: choose parameters for the model to replicate the observed time allocation and marital sorting patterns of 1990.
- Three sets of parameters, chosen sequentially:
  1. Calibrated externally.
  2. Chosen targeting data moments without having to solve the model.
  3. Chosen targeting data moments in steady-state equilibrium.
- Using said parameters, change the exogenous variables (sex ratio, skill distribution, wages, and home production efficiency and price of home equipment) to 2010 level and assess fit of the model.

Exogenous objects

Table: Exogenous objects in the model, 1990 and 2010

Classification	1990	2010	Male		Female	
			1990	2010	1990	2010
Sex ratio, θ_0	1.07	1.14	-	-	-	-
Home production						
p_e	1.82	1.06	-	-	-	-
A_g	1.00	6.23	-	-	-	-
Skill distribution						
Low skill	-	-	0.33	0.14	0.47	0.18
Medium Skill	-	-	0.63	0.58	0.49	0.51
High skill	-	-	0.04	0.29	0.04	0.31
Wages						
Low skill	-	-	1.00	2.35	0.83	1.77
Medium Skill	-	-	1.06	2.88	0.89	2.16
High skill	-	-	1.29	4.37	1.07	3.29

Calibrated model parameters

Table: Calibrated parameters I

Parameters externally calibrated		
Parameter	Value	Source
β	0.960	Standard
δ	0.020	Life expectancy of 49 years
ρ	0.067	Expected 15 years searching for spouse
σ	1.250	Midpoint between Attanasio et. al (2008) and 1
α_g	0.950	Knowles (2014)
η	0.330	Knowles (2014)
Parameters calibrated before solving the model		
Parameter	Value	Set to match
η_f	0.580	Gender housework ratio, married people in 1990
Single women		
σ_c	0.391	
σ_l	0.570	Single women time allocation
σ_g	0.040	
Single men		
σ_c	0.387	
σ_l	0.607	Single men time allocation
σ_g	0.006	

Calibrated model parameters

Table: Calibrated parameters II

Parameters jointly calibrated by moment matching in steady-state		
Parameter	Value	Target
Married people		
σ_c	0.365	
σ_l	0.573	Married households time allocation
σ_g	0.062	
ψ_f	-0.373	Husband to wife leisure ratio
M	See Table below	Marital sorting contingency matrix

Table: Means of the match quality draws (M)

Female skill level	Male skill level		
	Low	Medium	High
Low	0.753	1.483	-0.004
Medium	0.813	-0.253	4.078
High	-0.698	0.608	-0.785

Calibration results, time allocation

Table: Time allocation 1990, model and data (hours per week)

Statistic	Model	Data
Married women housework	18.09	18.13
Married women paid work	41.10	41.06
Married women leisure	58.82	58.81
Married men housework	3.91	3.81
Married men paid work	47.38	47.48
Married men leisure	66.71	66.71
Single women housework	7.39	7.39
Single women paid work	48.00	48.01
Single women leisure	62.61	62.60
Single men housework	1.66	1.66
Single men paid work	47.55	47.56
Single men leisure	68.79	68.78

Calibration results, marital sorting

Table: Marital sorting 1990, model and data

Wife	Husband					
	Low skill		Medium skill		High skill	
	Data	Model	Data	Model	Data	Model
Low skill	0.251	0.263	0.247	0.206	0.006	0.004
Medium skill	0.074	0.072	0.371	0.400	0.023	0.022
High skill	0.001	0.001	0.011	0.013	0.017	0.020

- Assortative mating data: 1.39
- Assortative mating model: 1.46

▸ Contingency table approach

Model fit, time allocation

Table: Time allocation 2010, model and data

Statistic	Hours per week		Δ% 1990-2010	
	Data	Model	Data	Model
Married women housework	11.27	15.06	-47.32%	-18.58%
Married women paid work	35.87	31.59	-13.61%	-26.22%
Married women leisure	**70.86**	**71.36**	**18.64%**	**19.34%**
Married men housework	2.70	2.56	-37.02%	-39.67%
Married men paid work	47.51	45.42	0.28%	-4.44%
Married men leisure	67.79	70.02	1.60%	4.84%
Single women housework	4.50	5.54	-49.69%	-28.75%
Single women paid work	45.06	43.31	-6.32%	-10.31%
Single women leisure	68.44	69.15	8.91%	9.95%
Single men housework	1.59	1.23	-4.68%	-30.02%
Single men paid work	42.73	41.68	-10.70%	-13.19%
Single men leisure	73.69	75.09	6.88%	8.78%

Model fit, marital sorting

Table: Marital sorting 2010, model and data

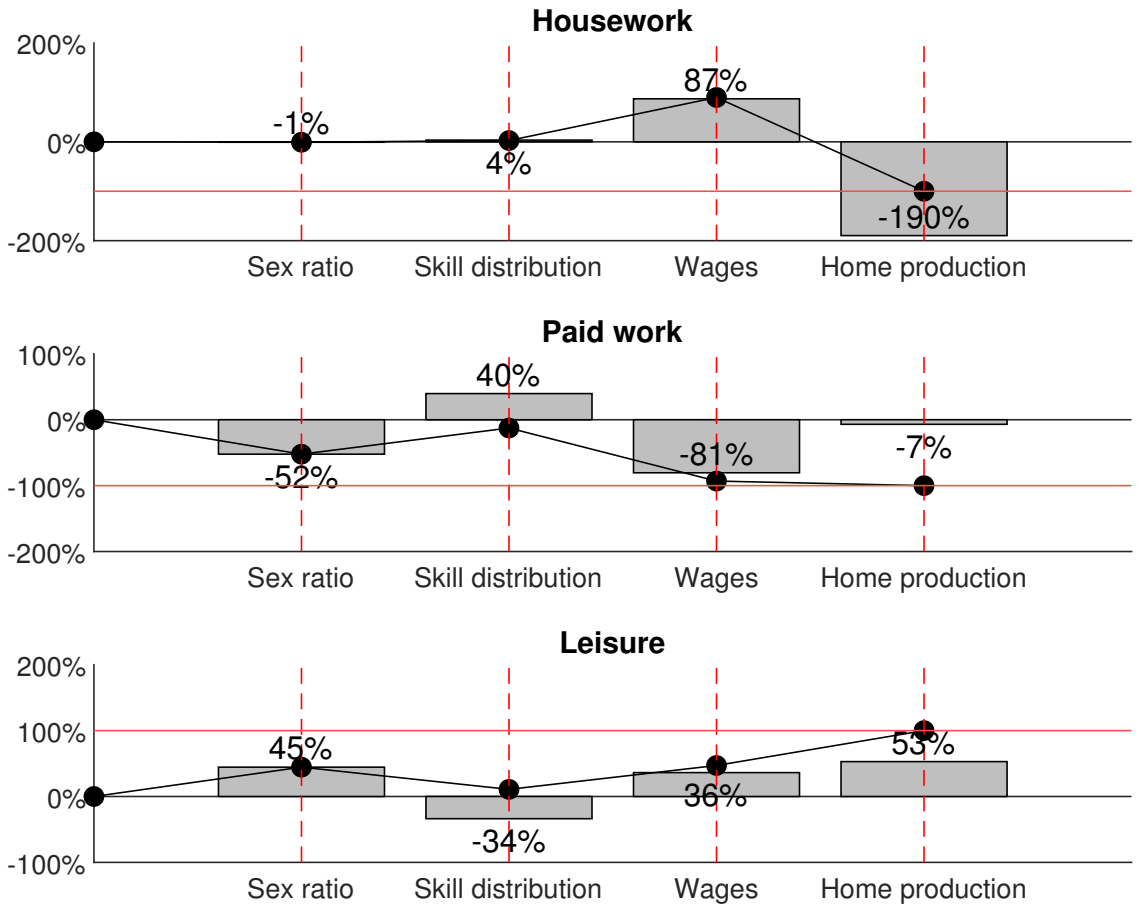
Wife	Husband					
	Low skill		Medium skill		High skill	
	Data	Model	Data	Model	Data	Model
Low skill	0.099	0.100	0.101	0.072	0.002	0.010
Medium skill	0.051	0.036	0.433	0.362	0.068	0.143
High skill	0.005	0.005	0.079	0.114	0.162	0.158

- Assortative mating data: 1.62
- Assortative mating model: 1.52

▸ Contingency table approach

Decomposition: married women's time allocation

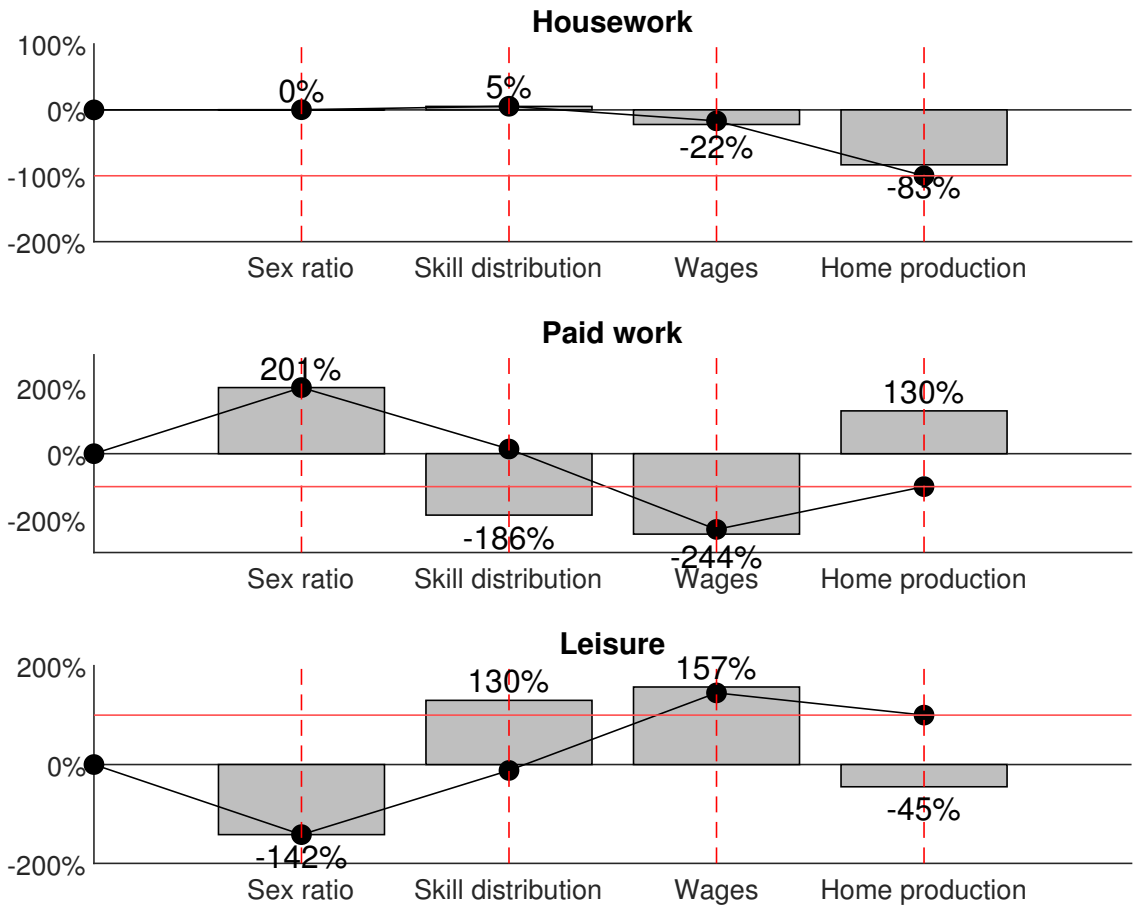
Figure: Contributions to changes in married women's time allocation, 1990-2010



▸ Backward decomposition

Decomposition: married men's time allocation

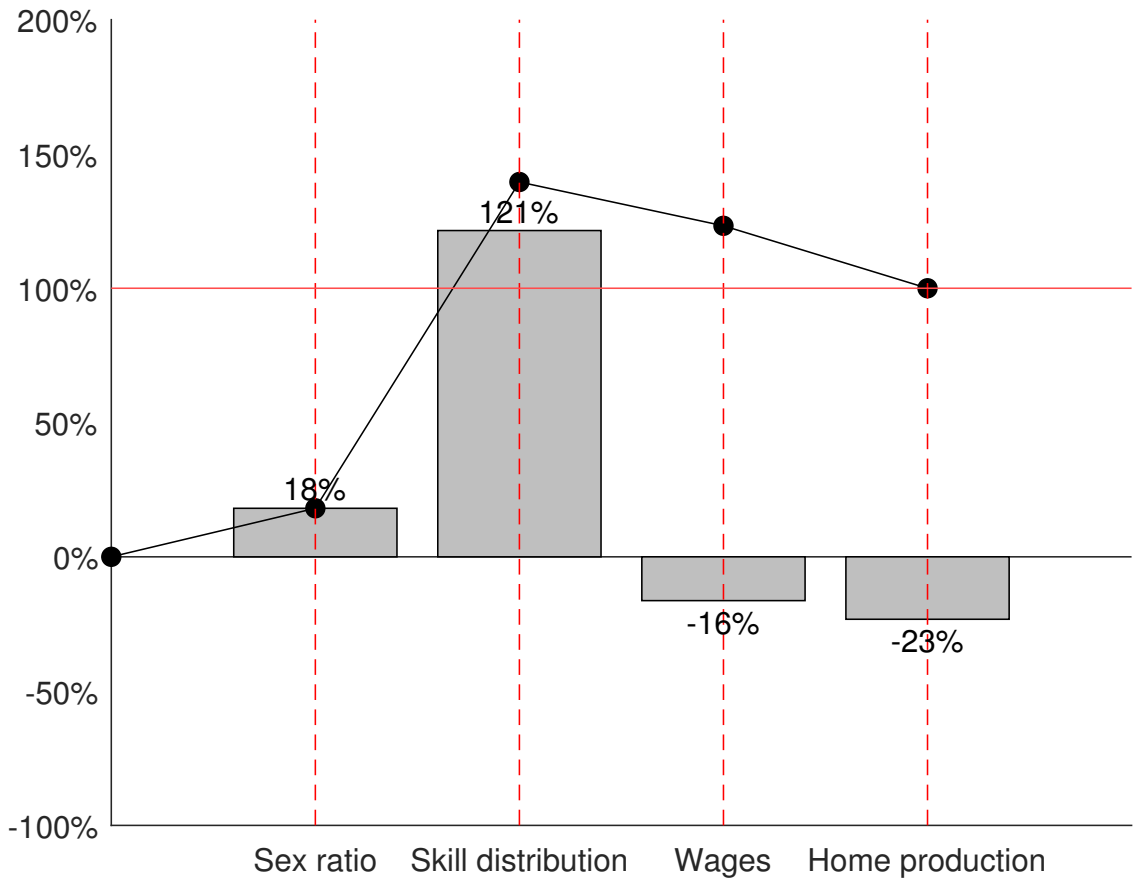
Figure: Contributions to changes in married men's time allocation, 1990-2010



▸ Backward decomposition

Decomposition: assortative mating

Figure: Contributions to changes in assortative mating, 1990-2010



▸ Backward decomposition

Further decomposition: bargaining versus marital sorting channel

Table: Decomposition of the effect of the sex ratio on time allocation for married people

Statistic	Bargaining	Sorting
Married women housework	-44.10%	-55.90%
Married women paid work	-105.15%	5.15%
Married women leisure	104.27%	-4.27%
Married men housework	-96.98%	196.98%
Married men paid work	104.35%	-4.35%
Married men leisure	-104.54%	4.54%

A sex ratio of 1.2

Table: The effects of a sex ratio of 1.2 in 2010

Statistic	Baseline 2010	$\theta_0 = 1.2$	% change
Married women housework	15.06	14.97	-0.54%
Married women paid work	**31.59**	**28.90**	**-8.90%**
Married women leisure	71.36	74.13	3.81%
Married men housework	2.56	2.58	0.91%
Married men paid work	45.42	47.81	5.12%
Married men leisure	70.02	67.61	-3.50%
Married women consumption	0.83	0.87	4.65%
Married men consumption	1.08	1.05	-3.14%
Average wife Pareto weight	0.44	0.46	5.35%
Assortative mating measure	1.52	1.55	2.15%

The role of the gender wage gap

Table: The model in 2010 with no gender wage gap

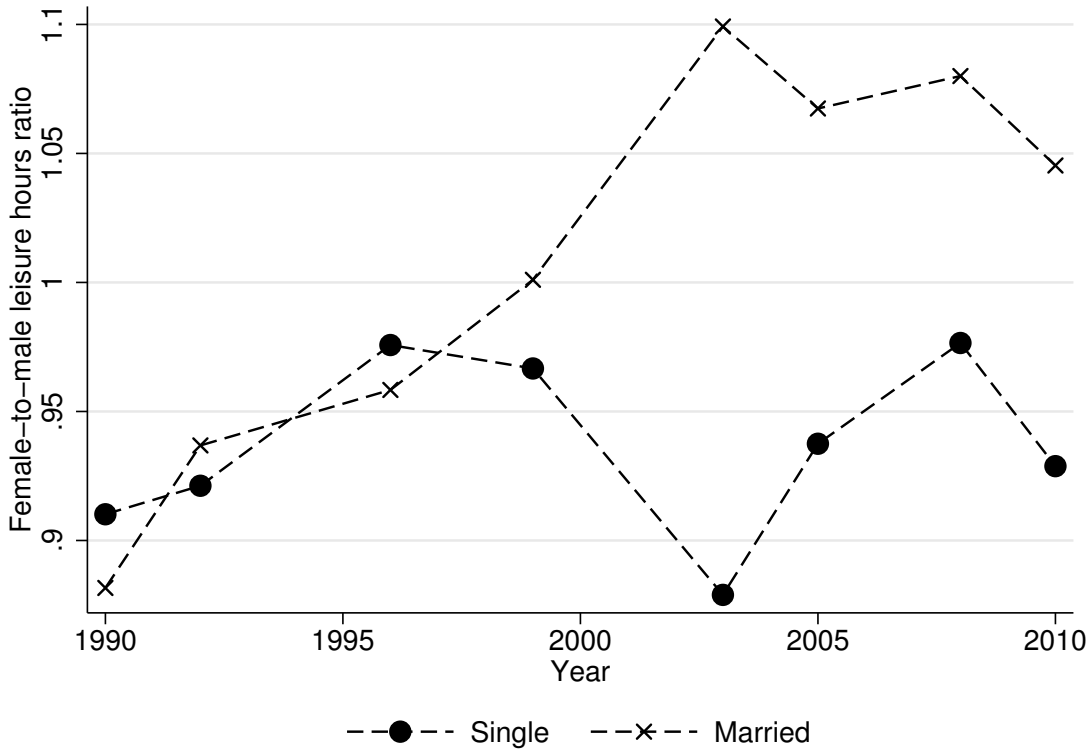
Statistic	Baseline 2010	No gender wage gap	% change
Married women housework	15.06	11.82	-24.17%
Married women paid work	**31.59**	**34.37**	**8.45%**
Married women leisure	71.36	71.80	0.63%
Married men housework	2.56	4.50	56.41%
Married men paid work	45.42	42.81	-5.91%
Married men leisure	70.02	70.68	0.95%
Married women consumption	0.83	1.04	22.51%
Married men consumption	1.08	1.09	1.12%
Average wife Pareto weight	0.44	0.50	14.10%
Assortative mating measure	1.52	1.52	0.16%

Conclusions

- Built a model of marriage and time allocation that features endogenous marital sorting and bargaining between spouses
- Calibrated said model to Chinese data
- Found that the sex ratio explains a significant fraction of the changes in time allocation for married people, especially on paid work and leisure
- Moreover that the effect of the sex ratio works mainly through bargaining instead of marital sorting
- Eliminating the gender wage gap offsets the reduction of the increasing sex ratio on female labor supply
- Further work: explore other bargaining solutions (Nash), make education decisions endogenous

Leisure ratio

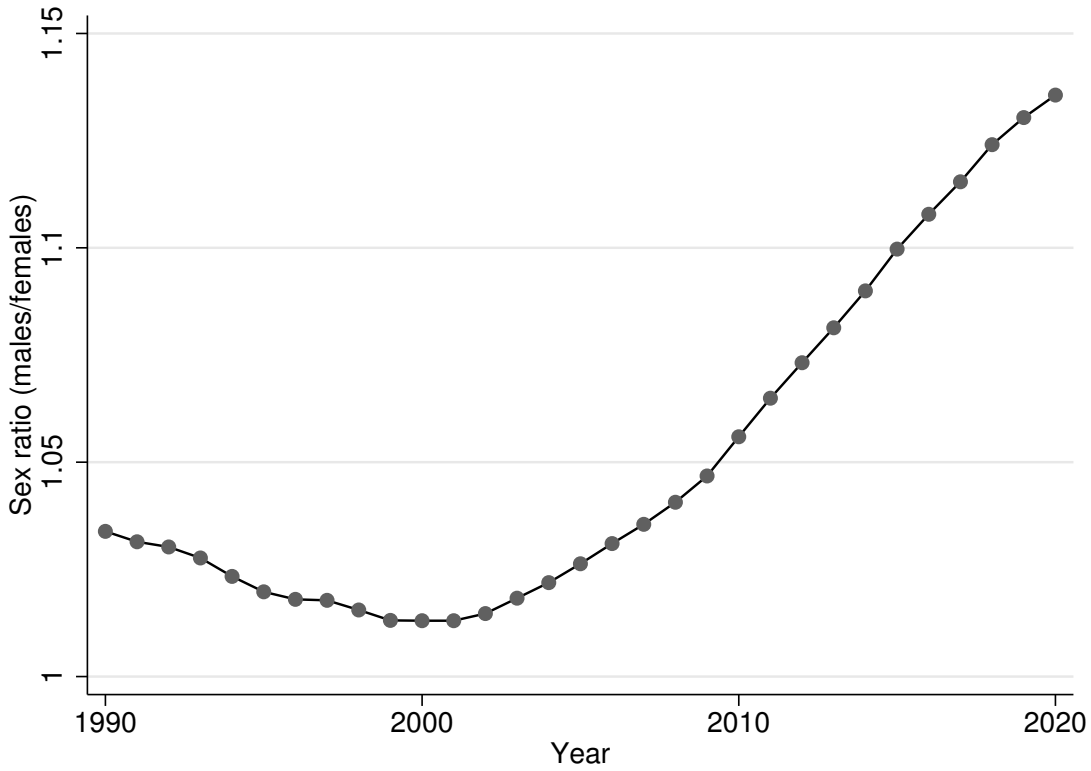
Figure: Leisure ratio by marital stauts among Chinese people aged 20-35, 1990-2010



◂ Changes in time allocation patterns

China's increasingly unbalanced sex ratio

Figure: Sex ratio in China for population aged 20-35, 1990-2020



Source: Projected from the 2000 Population Census.

◂ Sex ratio at birth

Wage structure

Table: Changes in wage structure in China, 1992-2007

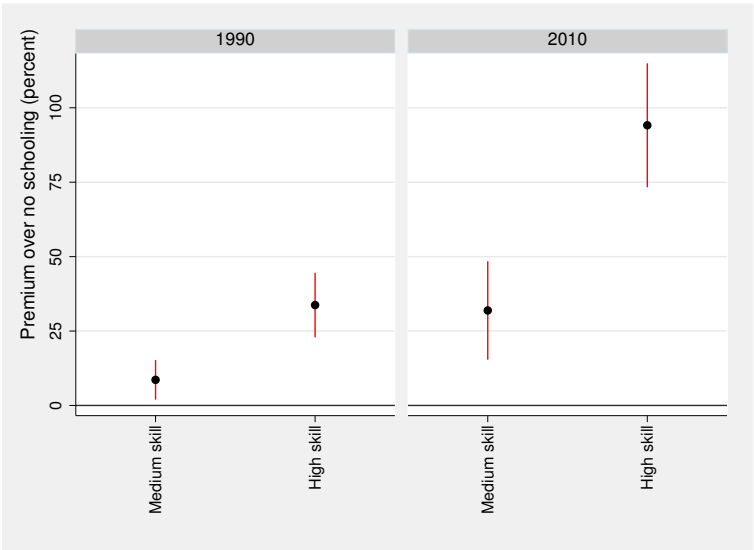
	Annual growth	Premium	
Classification	1992-2007	1992	2007
Overall	7.6%	-	-
By skill			
Low	5.9%	-	-
Medium	6.9%	6.44%	22.46%
High	8.5%	28.63%	86.08%
By sex			
Female	7.2%	-	-
Male	7.9%	20.01%	33.04%

Source: Author's calculations using the data presented in Table 1 of Ge & Tao (2014).

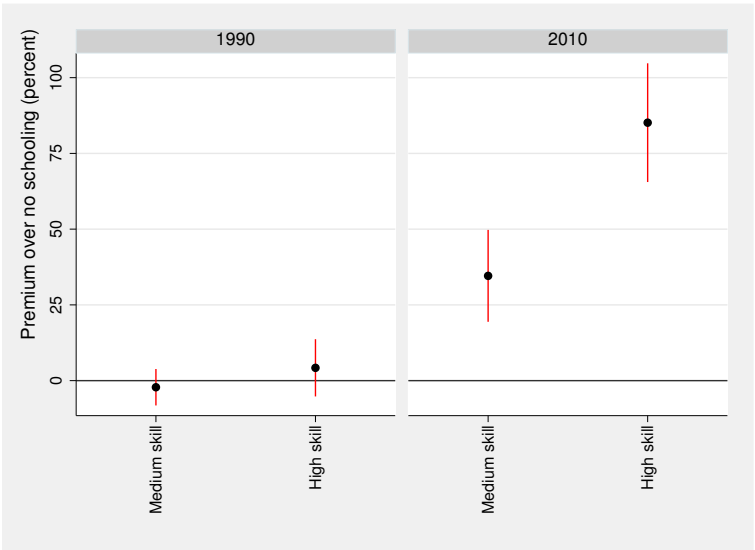
▸ Skill premium in the CHNS ▸ Gender wage ratio in the CHNS

Skill premium in the CHNS

Figure: Skill premium in China by sex, 1990 and 2010



(a) Women



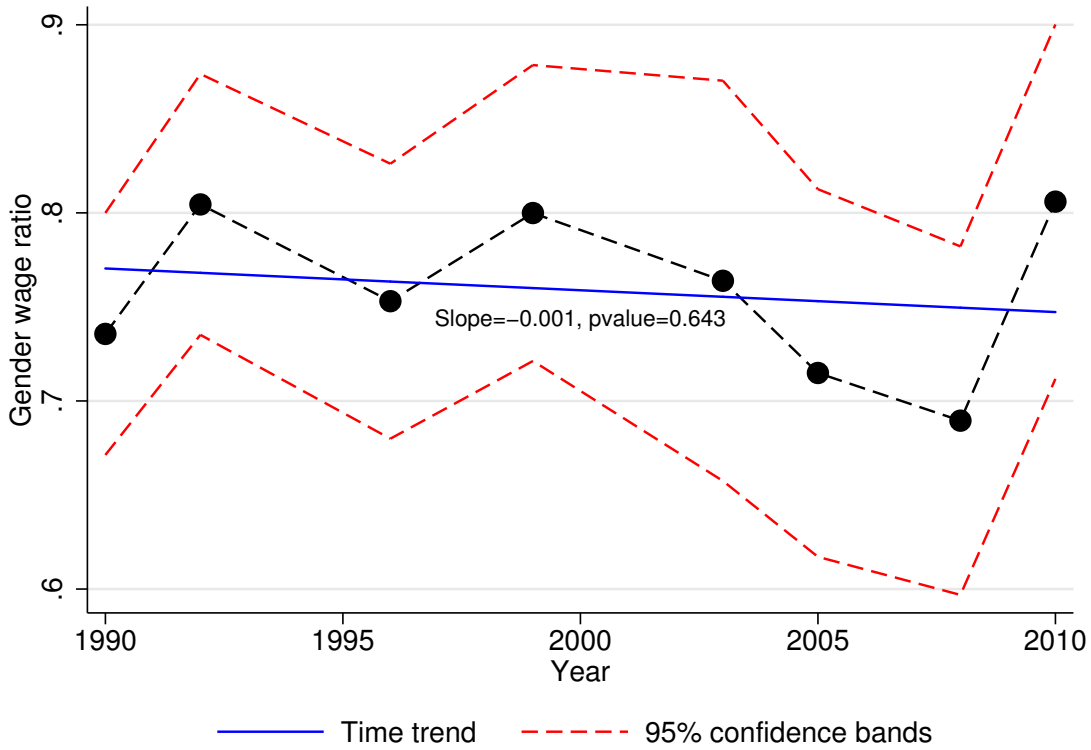
(b) Men

Source: Author's calculations using the China Health and Nutrition Survey.

◂ Wage structure

The gender wage ratio in the CHNS

Figure: Gender wage ratio in China, 1990-2010

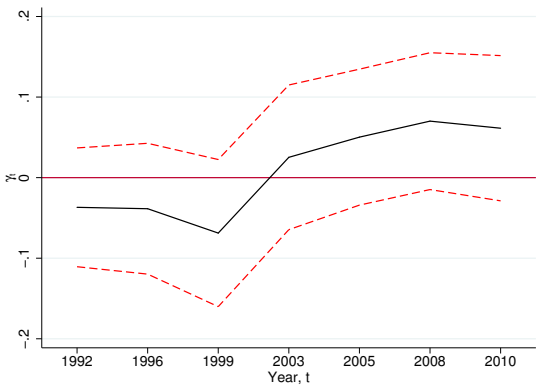


Source: Author's calculations using the China Health and Nutrition Survey.

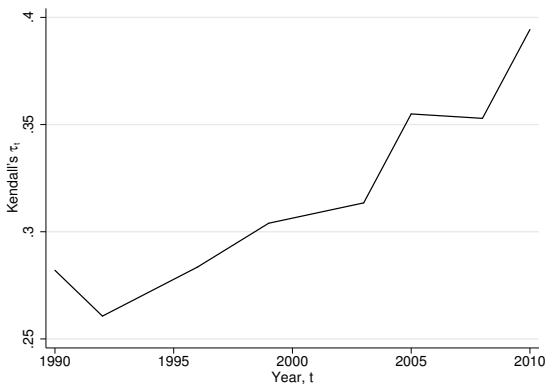
◂ Wage structure

Assortative mating

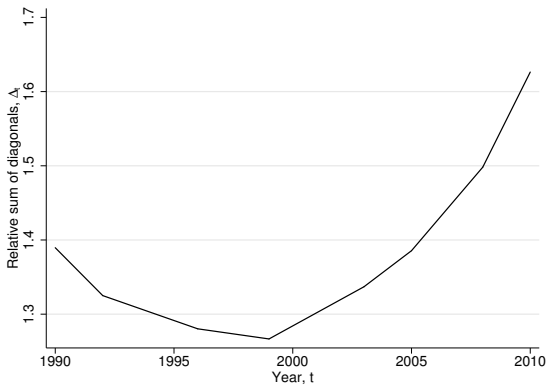
Figure: Assortative mating in China among people aged 20-35, 1990-2010



(a) Regression approach



(b) Rank correlation approach



(c) Contingency table approach

▸ Regression approach ▸ Contingency table approach

Assortative mating measures: regression approach

I regress wife's education level on her husband's:

$$EDU^{w}_{my} = \alpha + \beta \times EDU^{h}_{my} + \sum_{t \in T} \gamma_t \times EDU^{h}_{my} \times YEAR_{ty} + \sum_{t \in T} \theta_t \times YEAR_{ty} + \epsilon_{my}$$

I am interested in the γ_t's which measure the difference between wife and husband's correlation in year t and the baseline year. If γ_t rises with t, there's evidence of increasing assortative mating over time.

◂ Assortative mating

Assortative mating measures: contingency table approach

Table: Contingency matrix, 1990

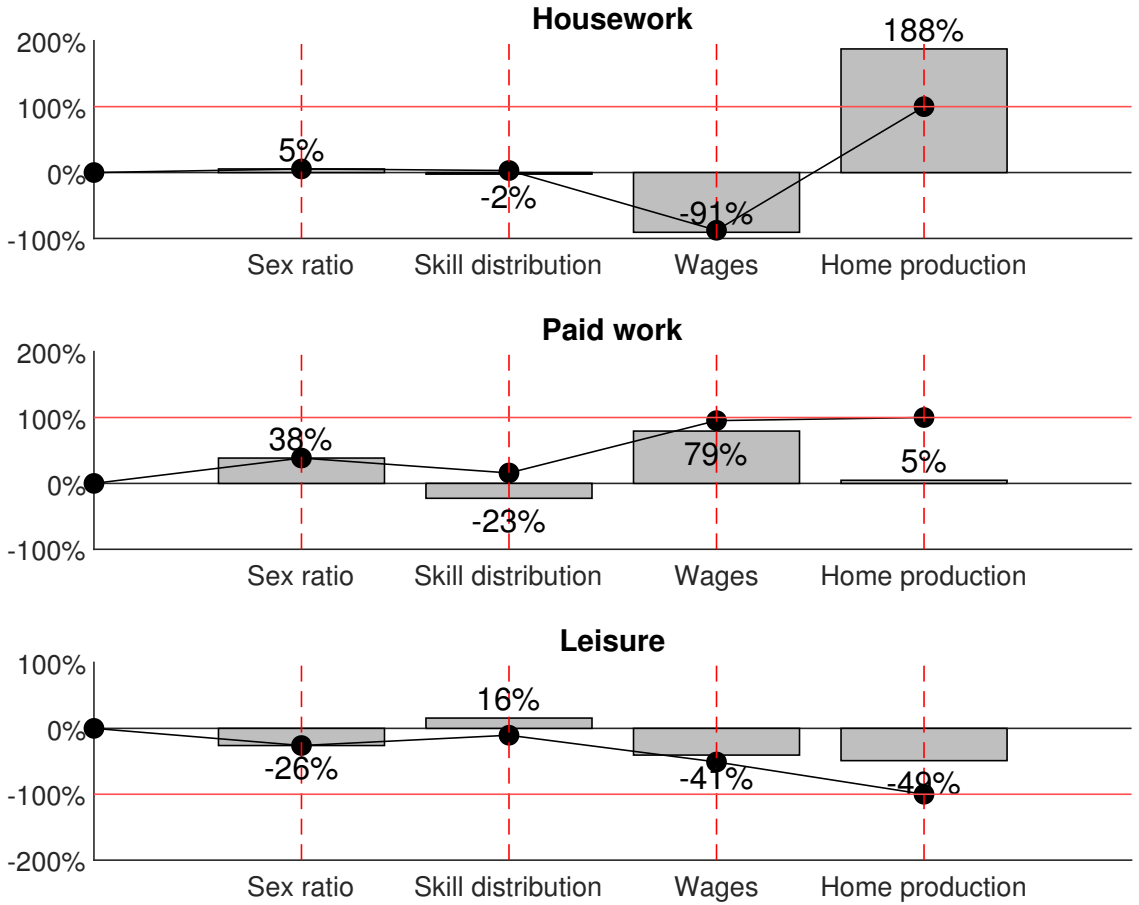
Wife	Husband						
	Low skill		Medium skill		High skill		Marginal
Low skill	**0.251**	**0.164**	0.247	0.317	0.006	0.023	0.504
Medium skill	0.074	0.153	**0.371**	**0.294**	0.023	0.021	0.468
High skill	0.001	0.009	0.011	0.018	**0.017**	**0.001**	0.028
Marginal	0.326		0.629		0.046		

$$\Delta_{1990} = \frac{0.251+0.371+0.017}{0.164+0.294+0.001} = 1.39$$

◂ Assortative mating ◂ Calibration results: marital sorting ◂ Fit: marital sorting

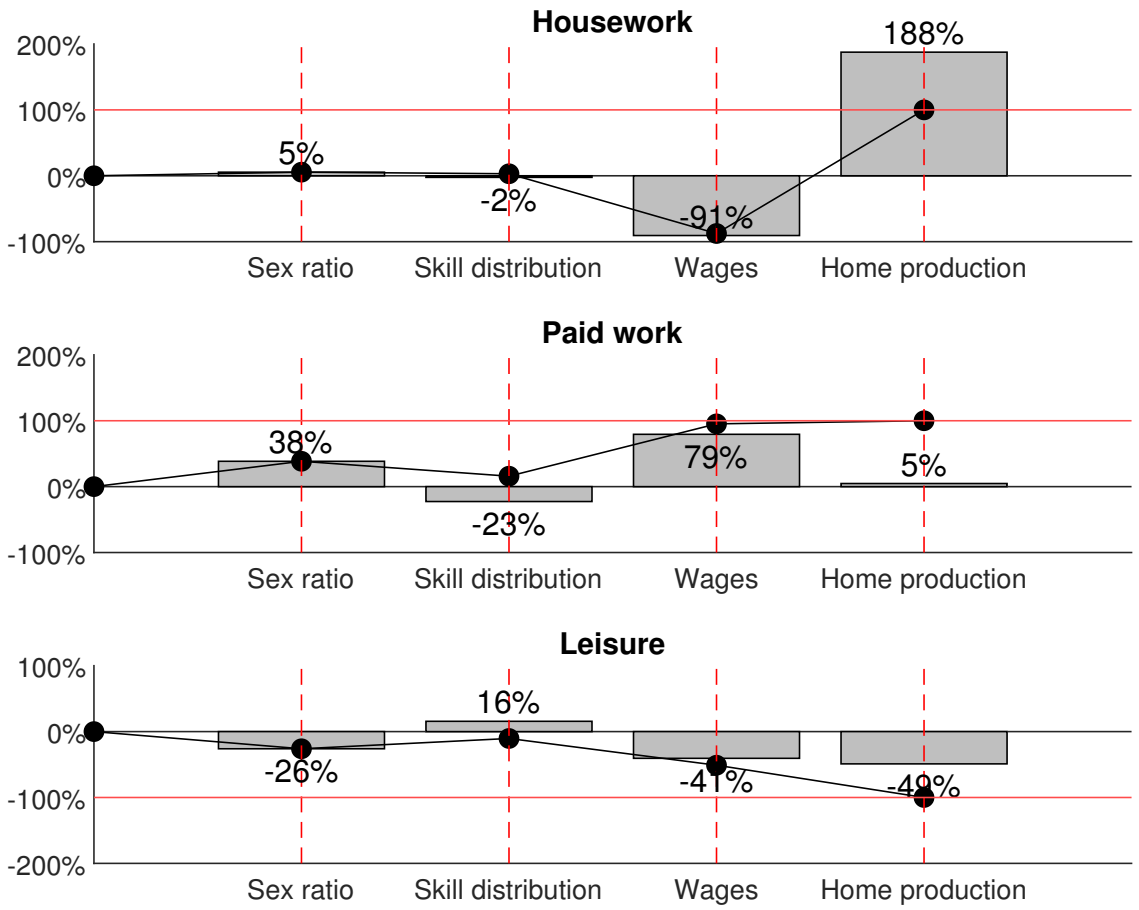
Decomposition: married women's time allocation (backward)

Figure: Contributions to changes in married women's time allocation, 1990-2010



Decomposition: married men's time allocation (backward)

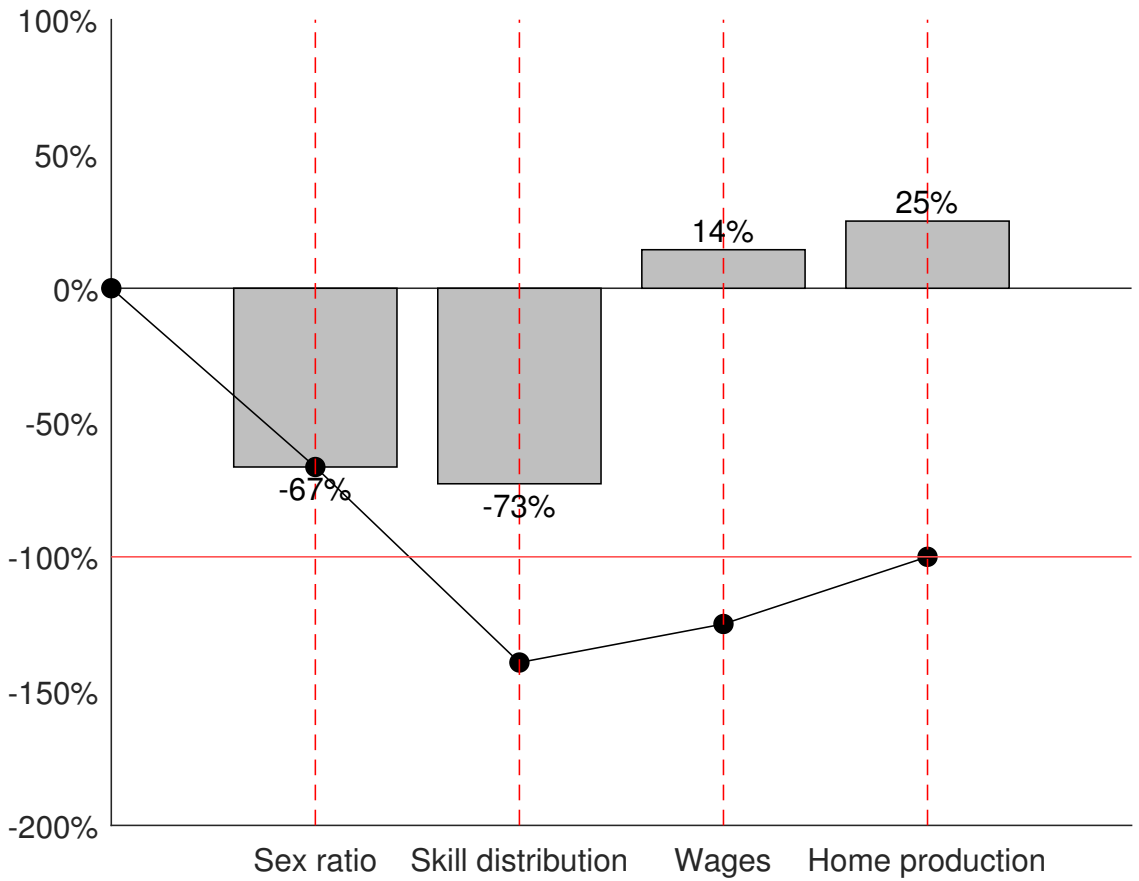
Figure: Contributions to changes in married men's time allocation, 1990-2010



▸ Forward decomposition

Decomposition: assortative mating (backward)

Figure: Contributions to changes in assortative mating, 1990-2010



▸ Forward decomposition